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Using ARIMA Models to Forecasting of Economic Variables of Wheat Crop in Afghanistan

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Authors' contributions

This work was carried out in collaboration between both authors. Authors MKA and ME designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors MKA and ME collected the data. Authors MKA and ME managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Wheat is considered the main food crops in Afghanistan, whether to use it for majority of the population consumption or to use it in some industries and others.

Problem: Afghanistan suffers from a large gap between production and consumption, so the current research investigates the problem arising from a shortage of wheat production to meet self-sufficiency of the population.

Methods: The time series analysis can provide short-run forecast for sufficiently large amount of data on the concerned variables very precisely. In univariate time series analysis, the ARIMA models are flexible and widely used. The ARIMA model is the combination of three processes: (i) Autoregressive (AR) process, (ii) Differencing process and (iii) Moving-Average (MA) process. These processes are known in statistical literature as main univariate time series models and are commonly used in many applications. Where, Estimation of future wheat requirement is one of the

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essential tools that may help decision-makers to determine wheat needs and then developing plans that help reduce the gap between production and consumption. A solid strategy that widely applying of improved seeds and fertilizers, an effective research and extension system for better crop management is necessary to eliminate this gap for self-sufficiency in wheat production, besides providing the necessary financial sums for that. Where most prediction methods are valid for one-year prediction. However, moving prediction methods have been found to measure and predict the future movement of the dependent variable.

Aims: The current research aims to prediction for Area, Productivity, Production, Consumption and Population over the period (2002-2017), to estimate the values of these variables in the period of (2018-2030).

Results: The results showed that through the drawing of the historical data for Planted area, Productivity, Production, Consumption and Population of wheat crop it was evident that the series data is not static due to an increasing or a decreasing of general trend, which means the instability of the average, by using Auto-correlation function (ACF) and Partial Correlation Function to detect the stability of the time series, The results showed also, the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Keywords: ARIMA models; forecasting; economic variables; wheat crop; Afghanistan.

1. INTRODUCTION

Wheat is the primary staple food of most Afghanistan households [1], that has low productivity in contrast to its neighbors, Tajikistan (2.97t/ha) and Pakistan (2.82 t/ha). Therefore, it is need to increase the yield and production to fill the current gap and to achieve self-sufficiency in wheat production. To meet the staple food requirement of an increasing Afghanistan population, it is necessary to develop wheat cultivars, which are high yielding and stable over the locations [2].

Food shortages are the result of minimum yield, climate change, financial constraints and postharvest losses are remarkable [3]. Over the past three decades, 95 percent researches have been led to increasing productivity and only 5 percent by reducing postharvest losses [4]. Wheat is grown throughout the country in a wide variety of microclimatic environment. These range from the arid desert lowlands of Helmand province to the temperate high-altitude mountain valleys in provinces like Ghor and Bamyan. This crop is typically planting in the autumn and harvesting in early summer. More than half of the national wheat crop is entirely dependent on rainfall, while nearly 45% of total area has access to irrigation. Irrigated wheat is grown in virtually every province; however total acreage is insufficient to certify national wheat self-sufficiency. Afghanistan is exceptionally arid country which experiences wide fluctuations in seasonal rainfall and is prone to periodic shortage [5].

During the main growing period there is slight, if any reliable rainfall, sense that to cover the majority of its crop water requirements Afghanistan must depend on irrigated agriculture. Hindu Kush range is the primary storehouse for the basic irrigation to their fields in the country [6]. Spring is a major source of irrigation in case of the snowmelt, flowing rivers, streams and lakes that originate in the mountains. Given the lack of sufficient rainfall during the growing season, the length and duration of the annual snowmelt period is an important factor in determining the amount of irrigation water and the duration of time that is available [1]. The growth in wheat yields reflects long-term efforts at seed development and availability supported in Afghanistan initially by the United States Agency for International Development (USAID), the Food and Agricultural Organization of the United Nations (FAO) and the International Center for Agricultural Research in the Dry Areas (ICARDA). The increases in yield also indicates that the seed and fertilizer markets have remain to presence and functioning, despite significant obstacles and under major complications [7,8 and 9]. This has acceptable the crop to reach a number of new levels when growing conditions are favorable. The timing of Central Asian including Afghanistan the wheat harvests varies depending on the country. In northern Central Asia both spring and winter wheat are cultivated in rain-fed areas. Winter wheat planting starts in October, while spring wheat planting takes place in March. Harvesting starts as early as June and continues until late September [8].

Table 1. Planting and harvesting period in different countries

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Pakistan				Harvest						Planting		
Afghanistan			S. planting			Harvest				W. Planting		
Tajikistan			S. planting			Harvest				W. Planting		
Kazakhstan					Planting				Harvest			

Source: FEWS NET calculations based on data from GIEWS
Note: S. planting refers to spring planting and w. planting refers to winter planting

The Ministry of Agriculture, Irrigation and Livestock (MAIL) has estimated that Afghanistan would need up to seven million tons of wheat by 2022 to attain self-sufficiency [10]. The success of two million tons increasing in wheat production seems very bleak and misery to the current scenario where only 45% of wheat is irrigated [11], which is the main source of wheat production in the country. A solid strategy that widely applying of improved seeds and fertilizers, an effective research and extension system for better crop management is necessary to eliminate this gap for self-sufficiency in wheat production [10].

Nearly one-third of domestic requirements for country wheat are met through imports to cover the gap of demand. On average over the past 5 years, Afghanistan produced 4.7 million ton and imported about 2.1 million ton annually. During this period, imports of Afghanistan wheat have been mainly distributed between Kazakhstan and Pakistan, while the proportion of imports varied each year. For instance, from 2008 to 2010, Pakistan banned exports of wheat.

Wheat flows north from Kazakhstan through Uzbekistan by Road to Afghanistan and Tajikistan. From Pakistan there are two main border ways to enter Afghanistan (Fig. 1). Railway is the key method of transportation of wheat in the region [12]. However, in Afghanistan, once wheat reaches its borders, it is transported by truck due to the presence country's backward rail system and mountainous terrain.

To bridge this gap between market supply and demand Afghanistan still imports a large amount of wheat and flour annually. There are five fundamental issues or factors namely, weak financial status, inefficient irrigation system, farmers' illiteracy or low level of knowledge, small amount of land yield and the uniqueness or individuality of the farmers has led to the deterioration of the country's wheat production respectively. Thus, excluding mentioned factors are accessed timely, Afghanistan will never reach to the peak of self-sufficiency in this statement [13].

Rural Afghanistan has big unemployment and underemployment problem. There is also low absorption for it. High growth of youth population is facing Afghanistan with unemployment obstacles [14].

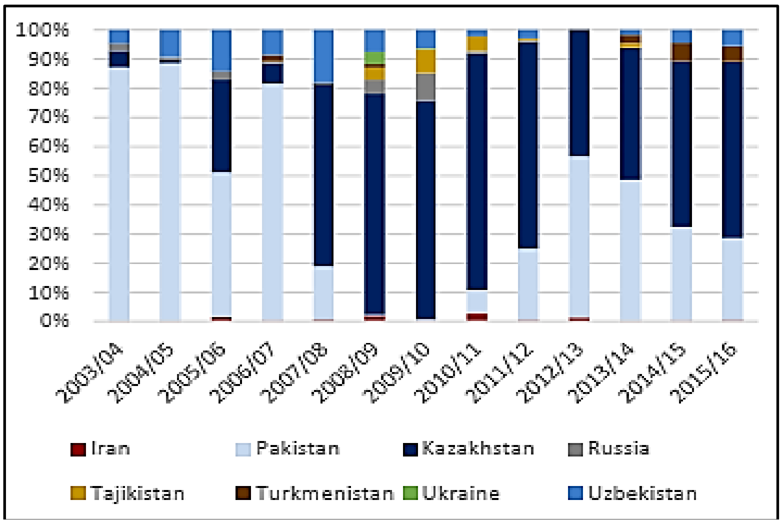

Fig. 1. Production yield in different countries
Source: Central Statistics Organization of Afghanistan (2016)

Fig. 2. Map showing study location
Source: FEWS NET

Wheat is considered the main food crops in Afghanistan, whether to use it for population consumption or to use it in some industries and others. Where Afghanistan suffers from a large gap between production and consumption. So, the research investigates the problem arising from a shortage of production to meet the needed of population. Therefore, the estimation of future wheat needs is one of the essential tools that may help decision-makers to determine wheat needs and then developing plans that help reduce the gap between production and consumption besides providing the necessary financial sums for that. Where most prediction methods are valid for one-year prediction. However, moving prediction methods have been found to measure and predict the future movement of the dependent variable. The current research aims to prediction for Area, Productivity, production, consumption and Population over the period (2002-2017), to predict the values of these variables in the period (2018-2030).

2. MATERIALS AND METHODS

The time series analysis can provide short-run forecast for sufficiently large amount of data on the concerned variables very precisely, see Granger and Newbold [15]. In univariate time series analysis, the ARIMA models are flexible and widely used. The ARIMA model is the combination of three processes: (i) Autoregressive (AR) process, (ii) Differencing process and (iii) Moving-Average (MA) process. These processes are known in statistical literature as main univariate time series models, and are commonly used in many applications.

2.1 Autoregressive (AR) Model

An autoregressive model of order p, AR (p), can be expressed as:

$$X_t = c + \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \cdots + \alpha_p X_{t-p} + \varepsilon_t; \quad = 1,2, \ldots T, \quad (1)$$

Where ε_t is the error term in the equation; where ε_t a white noise process, a sequence of independently and identically distributed (iid) random variables with $E(\varepsilon_t)$ = 0 and $var(\varepsilon_t)$ = σ^2; i.e. ε_t ~iid N (0, σ^2). In this model, all previous values can have additive effects on this level Xt and so on; so, it's a long-term memory model.

2.2 Moving-average (MA) Model

A time series $\{X_t\}$ is said to be a moving-average process of order q, MA (q), if:

$$X_t = \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2} - \cdots - \theta_q\varepsilon_{t-q}. \quad (2)$$

Forecasting using ARIMA models: This model is expressed in terms of past errors as explanatory variables. Therefore, only q errors will effect on X_t, however higher order errors don't effect on X_t; this means that it's a short memory model.

2.3 Autoregressive Moving-average (ARMA) Model

A time series $\{X_t\}$ is said to follow an autoregressive moving-average process of order p and q, ARMA (p, q), process if:

$$X_t = c + \alpha_1X_{t-1} + \cdots + \alpha_pX_{t-p} + \varepsilon_t - \theta_1\varepsilon_{t-1} - \cdots - \theta_q\varepsilon_{t-q}. \quad (3)$$

This model can be a mixture of both AR and MA models above.

2.4 ARIMA Models

The ARMA models can further be extended to non-stationary series by allowing the differencing of the data series resulting to ARIMA models. The general non-seasonal model is known as ARIMA (p, d, q): Where with three parameters; p is the order of autoregressive, d is the degree of differencing, and q is the order of moving-average. For example, if X_t is non-stationary series, we will take a first-difference of X_t so that ΔX_t becomes stationary, then the ARIMA (p, 1, q) model is:

$$\Delta X_t = c + \alpha_1\Delta X_{t-1} + \cdots + \alpha_p\Delta X_{t-p} + \varepsilon_t - \theta_1\varepsilon_{t-1} - \cdots - \theta_q\varepsilon_{t-q}, \quad (4)$$

where $\Delta X_t = X_t - X_{t-1}$. But if p = q = 0 in equation (4), then the model becomes a random walk model which classified as ARIMA (1, 1, 2).

2.5 Box-Jenkins Approach

In time series analysis, the Box-Jenkins [16]. approach, named after the statisticians George Box and Gwilym Jenkins, applies ARIMA models to find the best fit of a time series model to past values of a time series. For more details about Box–Jenkins time series analysis, see for example Young [17], Frain [18], Kirchgässner, et al. [19], and Chatfield [20]. Fig. 3 shows the four iterative stages of modeling according this approach.

2.6 Model Identification

Making sure that the variables are stationary, identifying seasonality in the series, and using the plots of the Autocorrelation Function (ACF) and Partial Auto-Correlation Function (PACF) of the series to identification which autoregressive or moving average component should be used in the model.

2.7 Model Estimation

Using computation algorithms to arrive at coefficients that best fit the selected ARIMA model. The most common methods use Maximum Likelihood Estimation (MLE) or non-linear least-squares estimation.

2.8 Model Checking

By testing whether the estimated model conforms to the specifications of a stationary univariate process. In particular, the residuals should be independent of each other and constant in mean and variance over time; plotting the ACF and PACF of the residuals are helpful to identify misspecification. If the estimation is inadequate, we have to return to step one and attempt to build a better model. Moreover, the estimated model should be compared with other ARIMA models to choose the best model for the data. The two common criteria used in model selection: Akaike's Information Criterion (AIC) and Bayesian Information Criteria (BIC) which are defined by:

$$AIC = 2m - 2\ln(\hat{L}),\ BIC = ln(n)m - 2\ ln(\hat{L}),(5)$$

2.9 Forecasting Using Arima Models

Where $\hat{L}$ denotes the maximum value of the likelihood function for the model, m is the number of parameters estimated by the model, and n is the number of observations (sample size). Practically, AIC and BIC are used with the classical criterion: The Mean Squared Error (MSE).

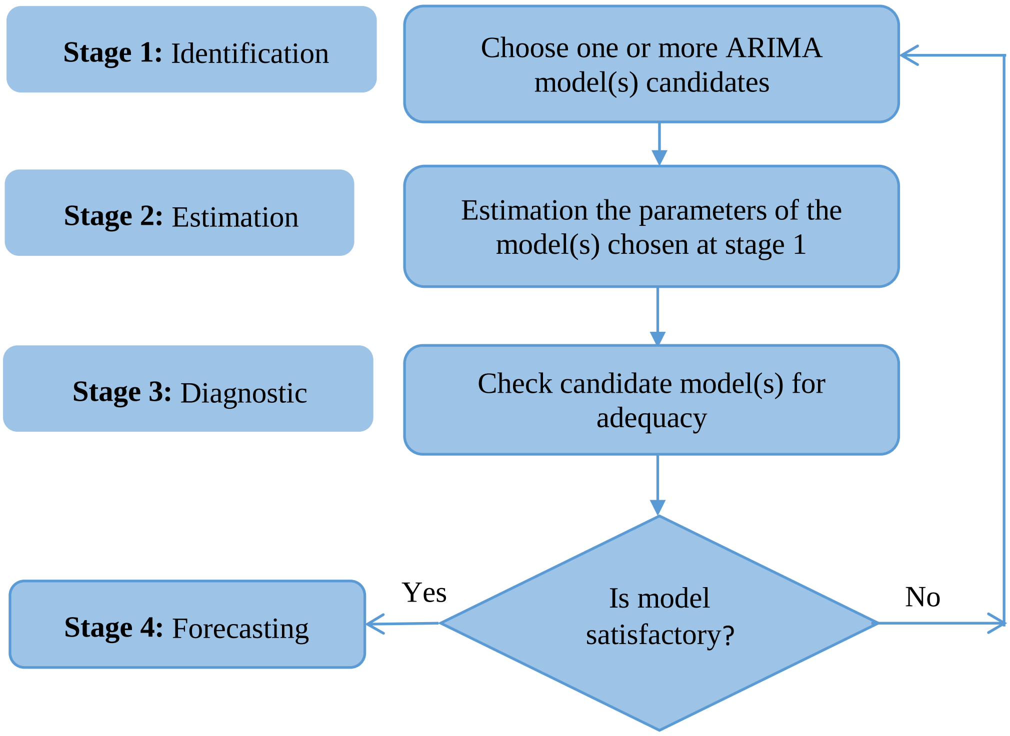

Fig. 3. Stages in the box-Jenkins iterative approach

Forecasting: When the selected ARIMA model conforms to the specifications of a stationary univariate process, then we can use this model for forecasting.

3. RESULTS AND DISCUSSION

3.1 Area

3.1.1 Identification

Through the drawing of the historical data for planted area of wheat crop we get the Fig. 4, it's also evident that the series data is not static due to a decreasing of general trend, which means the instability of the average, by using Auto-correlation Function (ACF) and Partial Correlation Function to detect the stability of the time series, The results indicate in (Table 2), the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Also by drawing the original data of the ACF we get (Fig. 4) and then by making the drawing of

Table 2. Autocorrelation and partial correlation of wheat area

<table>
<tr><th>Prob</th><th>Q-Stat</th><th>PAC</th><th>AC</th><th></th><th>Partial correlation</th><th>Autocorrelation</th></tr>
<tr><td>0.007</td><td>7.1559</td><td>-0.644</td><td>-0.644</td><td>1</td><td>*****| . |</td><td>*****| . |</td></tr>
<tr><td>0.021</td><td>7.7299</td><td>-0.410</td><td>0.175</td><td>2</td><td>.***| . |</td><td>. |* . |</td></tr>
<tr><td>0.047</td><td>7.9650</td><td>-0.437</td><td>-0.107</td><td>3</td><td>.***| . |</td><td>. *| . |</td></tr>
<tr><td>0.046</td><td>9.6854</td><td>0.051</td><td>0.277</td><td>4</td><td>. | . |</td><td>. |** . |</td></tr>
<tr><td>0.054</td><td>10.886</td><td>0.238</td><td>-0.220</td><td>5</td><td>. |** . |</td><td>. **| . |</td></tr>
<tr><td>0.084</td><td>11.149</td><td>-0.184</td><td>-0.097</td><td>6</td><td>. *| . |</td><td>. *| . |</td></tr>
<tr><td>0.049</td><td>14.140</td><td>0.080</td><td>0.306</td><td>7</td><td>. |* . |</td><td>. |** . |</td></tr>
<tr><td>0.034</td><td>16.641</td><td>-0.109</td><td>-0.259</td><td>8</td><td>. *| . |</td><td>. **| . |</td></tr>
<tr><td>0.044</td><td>17.321</td><td>-0.056</td><td>0.123</td><td>9</td><td>. | . |</td><td>. |* . |</td></tr>
<tr><td>0.033</td><td>19.607</td><td>-0.258</td><td>-0.202</td><td>10</td><td>. **| . |</td><td>. *| . |</td></tr>
<tr><td>0.005</td><td>27.023</td><td>-0.187</td><td>0.315</td><td>11</td><td>. *| . |</td><td>. |** . |</td></tr>
<tr><td>0.001</td><td>33.315</td><td>-0.009</td><td>-0.237</td><td>12</td><td>. | . |</td><td>. **| . |</td></tr>
</table>

Source: Calculated from Table 1 in the Annex

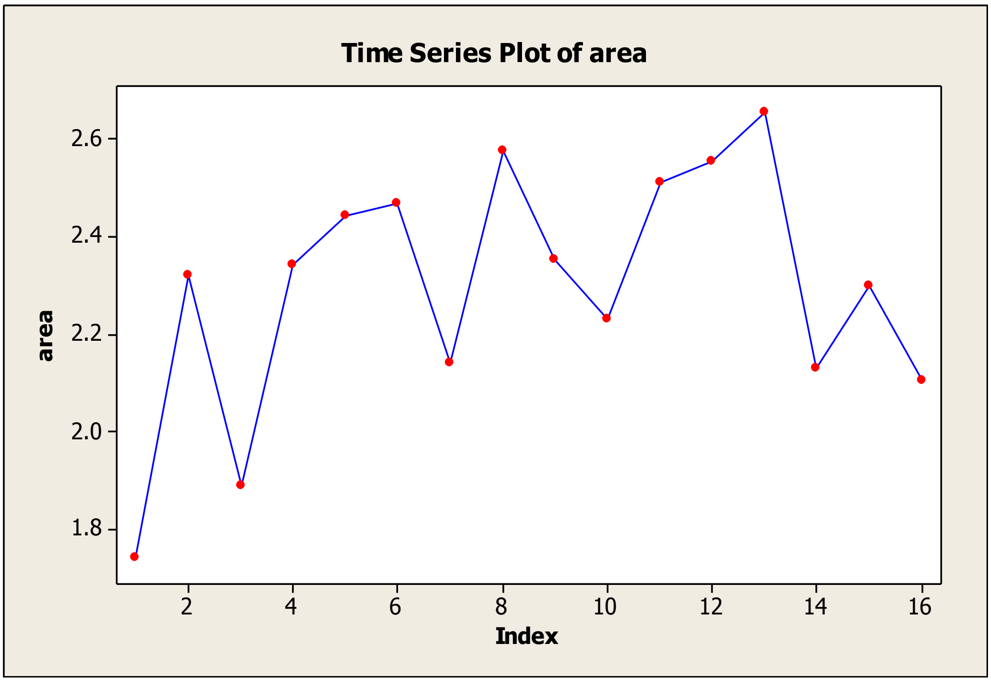

Fig. 4. Time series plot of wheat area
Source: Calculated from Table 1 in the Annex

the original data of the PACF for planted area of wheat crop, we get (Fig. 5), The results showed the significance of the Partial Auto-correlation Coefficient, Function (PACF), which means rejecting the basic assumption " that the sum of the squares of single correlation coefficients are significant" it is mean there are correlations and it is called a general test.

3.1.2 Estimation

By examining the PACF with historical data as shown (Fig. 5), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and moving average model (MA) must be applied. Finally, the best model is shown in (Table 3).

3.1.3 Diagnostic checking

By estimating (PACF), (ACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figs. 4 and 5 that there is no specific behavioral pattern for the PACF and ACF of the Residuals and this indicates the quality of the model.

3.1.4 Forecasting

By using the appropriate and previously estimated model, Forecasting is performed for 13 years, ensuring that the most suitable model can predict in Tables 4 and 5.

3.2 Yield

3.2.1 Identification

Through the drawing of the historical data [21], for productivity of wheat crop we get the Fig. 7, it's also clear that the series data is not static due to an increasing of general trend, which means the instability of the average, by using Auto-correlation Function (ACF) and Partial

Table 3. Final estimates of parameters for AREA (1-1-2)

Type	Coef	SE Coef	T-value	P-value
AR 1	-0.9949	0.1213	-8.21	0.000
MA 1	0.1736	0.2762	0.63	0.543
MA 2	0.6561	0.2741	2.39	0.036
Constant	0.02999	0.01461	2.05	0.065

Source: Calculated from Table 1 in the Annex

Table 4. Forecasts from period 2018-2030 for AREA 95% limits

Period	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast	2.53	2.32	2.56	2.35	2.59	2.389	2.62	2.41	2.65	2.45	2.68	2.48	2.71
Lower	2.01	1.79	1.79	1.79	1.99	1.78	1.99	1.78	1.999	1.79	2.00	1.79	2.00
Upper	3.06	2.85	3.12	2.92	3.18	2.98	3.24	3.04	3.30	3.109	3.36	3.16	3.41

Source: Calculated from Table 1 in the Annex

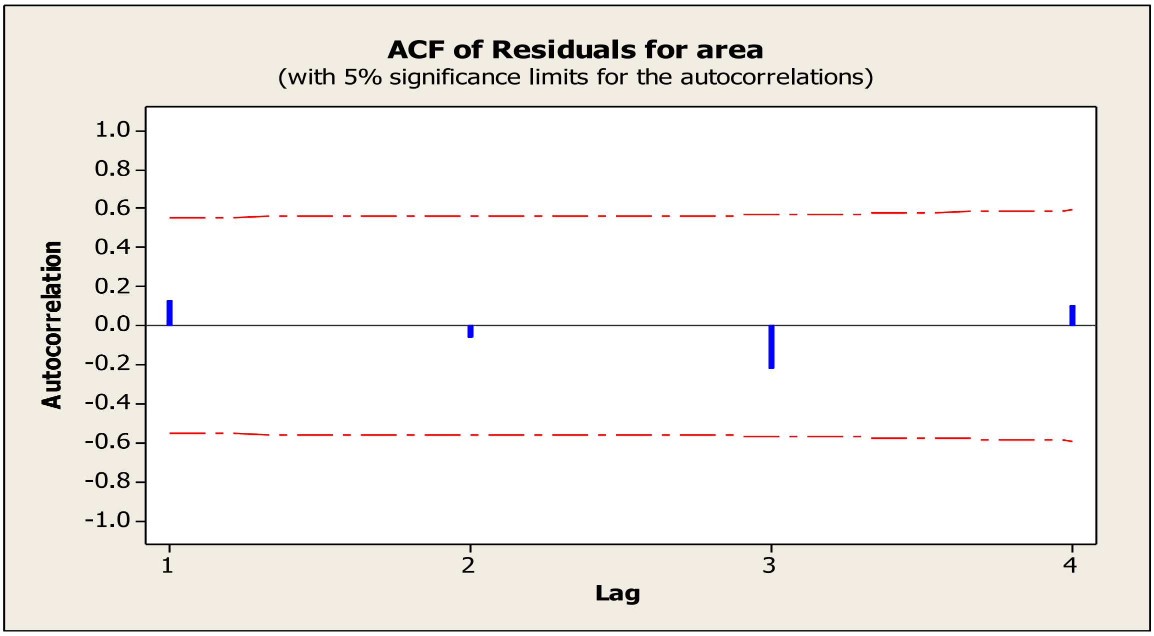

Fig. 5. Autocorrelation of residuals for wheat area
Source: Table 1 in the Annex

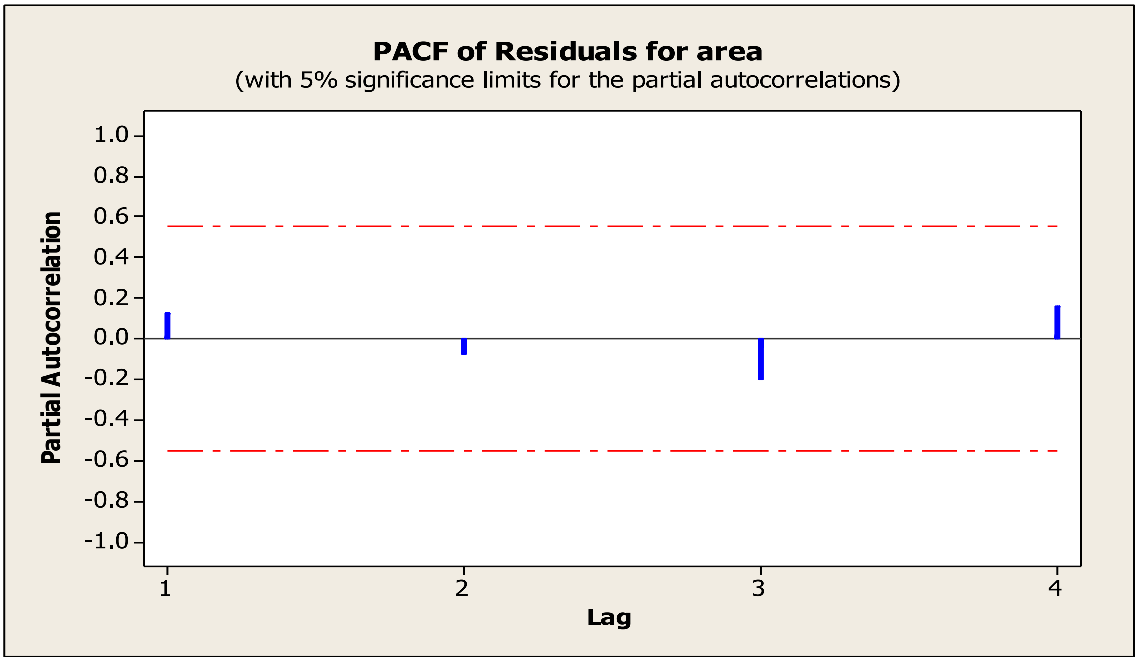

Fig. 6. Partial correlation of residuals for wheat area
Source: Table 1 in the Annex

Table 5. Modified box-pierce (Ljung-Box) chi-square statistic forecasts from period 2018-2030 for AREA 95% limits

Lag	12	24	36	48
Chi-Square	11.3	*	*	*
DF	8	*	*	*
P-Value	0.183	*	*	*

Source: Calculated from Table 1 in the Annex

Correlation Function to detect the stability of the time series, the results indicate in (Table 6), the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

In addition, by drawing the original data of the ACF we get (Fig. 8) and then by drawing the original data of PACF for productivity of wheat crop, we get (Fig. 9), The results showed the significance of the partial self-correlation coefficient (PACF), which means rejecting the basic assumption "that the sum of the squares of single correlation coefficients are significant" it is mean there are correlations and it is called a general test.

3.2.2 Estimation

Besides, to investigate the PACF with historical data as shown (Fig. 9), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and moving average model (MA) must be applied. Finally, the best model is shown in (Table 7).

3.2.3 Diagnostic checking

Through the Checking of (PACF), (ACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figs. (8 and 9) that there is no specific behavioral pattern for the PACF and ACF of the Residuals, and this indicates the quality of the model.

3.2.4 Forecasting

Besides using the appropriate and previously estimated model, Forecasting is performed for 13 years, ensuring that the most suitable model can predict in Tables 8 and 9.

3.3 Production

3.3.1 Identification

Through the drawing of historical data for production of wheat crop we get the Fig. 10, it's also evident that the series data is not static due to a decreasing of general trend, which means the instability of the average, by using

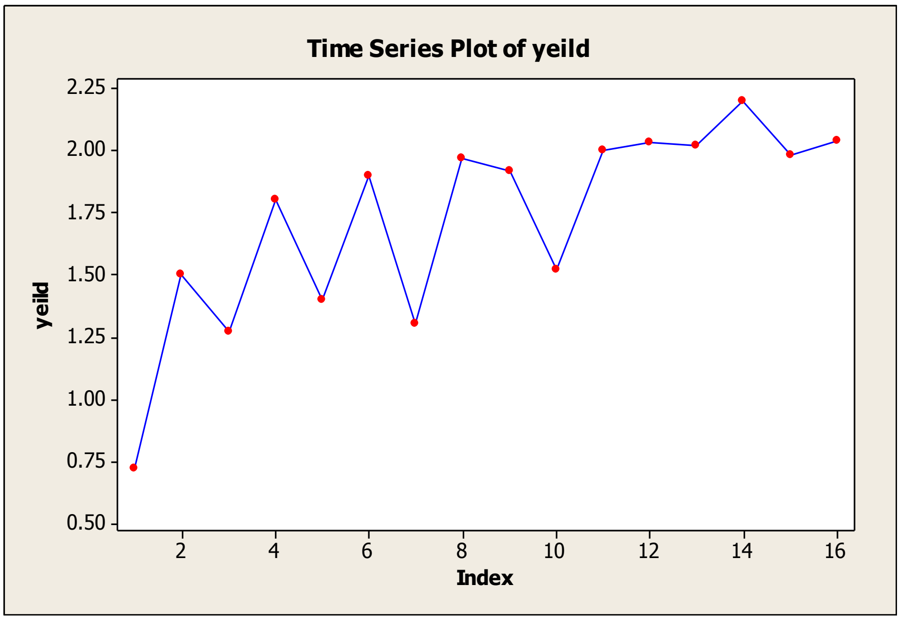

Fig. 7. Time series plot of wheat yeild
Source: Calculated from Table 1 in the Annex

Table 6. Autocorrelation and partial correlation of wheat yeild

Prob	Q-Stat	PAC	AC		Partial correlation	Autocorrelation
0.001	10.625	-0.785	-0.785	1	******| . |	******| . |
0.001	14.420	-0.432	0.451	2	.***| . |	. |***. |
0.002	15.038	-0.021	-0.174	3	. | . |	. *| . |
0.005	15.079	0.111	0.043	4	. |* . |	. | . |
0.010	15.079	0.067	0.003	5	. | . |	. | . |
0.019	15.136	-0.106	-0.045	6	. *| . |	. | . |
0.033	15.247	-0.103	0.059	7	. *| . |	. | . |
0.054	15.269	0.069	-0.024	8	. | . |	. | . |
0.079	15.446	-0.084	-0.063	9	. *| . |	. | . |
0.099	16.022	-0.127	0.101	10	. *| . |	. |* . |
0.114	16.788	-0.089	-0.101	11	. *| . |	. *| . |
0.134	17.432	0.004	0.076	12	. | . |	. |* . |

Source: Calculated from Table 1 in the Annex

Table 7. Final estimates of parameters for productivity (1-1-2)

Type	Coef	SE Coef	T-value	P-value
AR 1	-0.6085	0.3054	-1.99	0.072
MA 1	1.0333	0.5641	1.83	0.094
MA 2	0.1974	0.4833	0.41	0.691
Constant	0.097362	0.002117	46.00	0.000

Source: Calculated from Table 1 in the Annex

Table 8. Forecasts from period 2018-2030 for yield 95% limits

Period	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast	2.29	2.27	2.38	2.41	2.49	2.54	2.60	2.66	2.72	2.78	2.84	2.90	2.96
Lower	1.94	1.857	1.96	1.97	2.05	2.10	2.16	2.21	2.27	2.33	2.39	2.45	2.50
Upper	2.64	2.687	2.80	2.84	2.92	2.98	3.05	3.11	3.17	3.23	3.30	3.36	3.42

Source: Calculated from Table 1 in the Annex

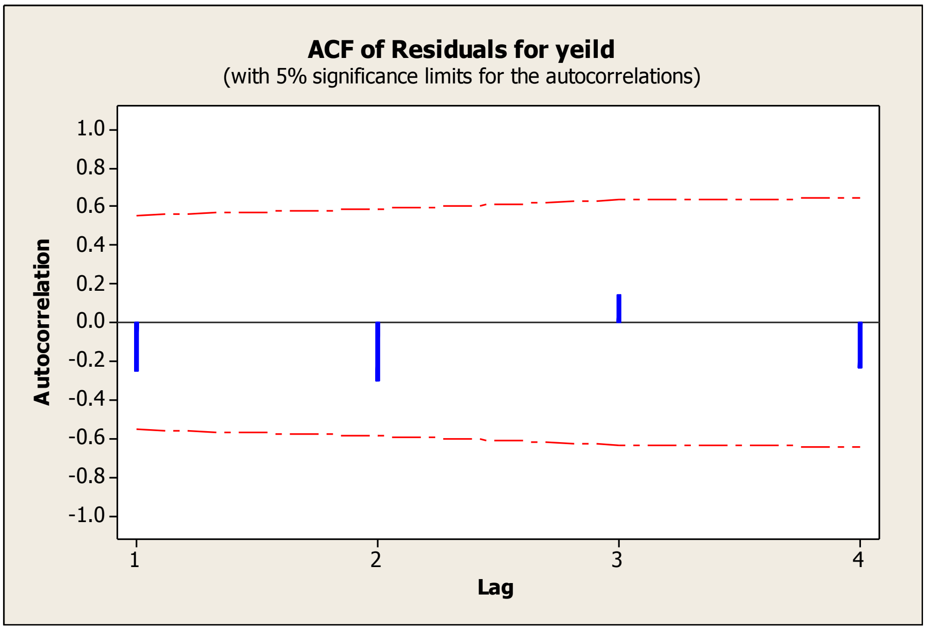

Fig. 8. Autocorrelation of residuals for wheat yield
Source: Table 1 in the Annex

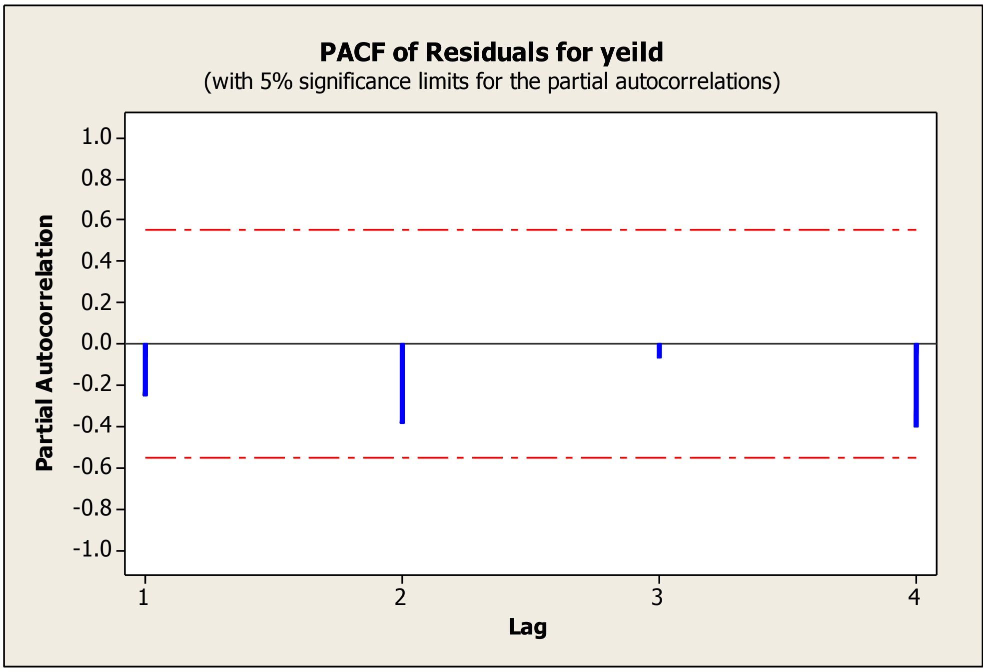

Fig. 9. Partial correlation of residuals for wheat yield
Source: Table 1 in the Annex

Table 9. Modified box-pierce (Ljung-box) chi-square statistic forecasts from period 2018-2030 for Yield 95% limits

Lag	12	24	36	48
Chi-Square	15.3	*	*	*
DF	8	*	*	*
P-Value	0.054	*	*	*

Source: Calculated from Table 1 in the Annex

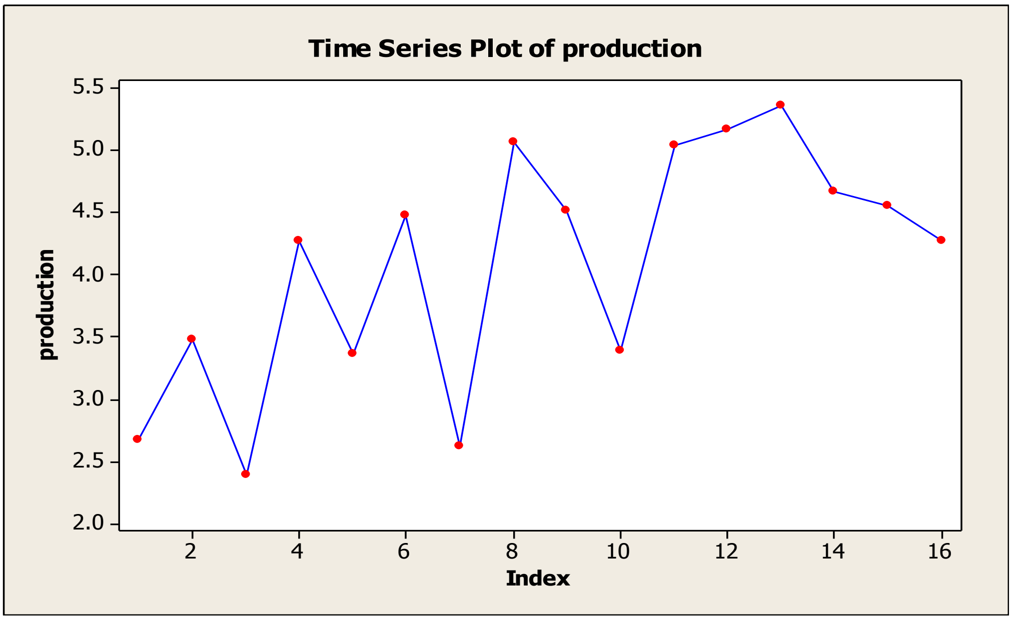

Fig. 10. Time series plot of wheat production
Source: Calculated from Table 1 in the Annex

Table 10. Autocorrelation and partial correlation of wheat production

Prob	Q-Stat	PAC	AC		Partial correlation	Autocorrelation
0.001	10.411	-0.777	-0.777	1	******| . |	******| . |
0.001	13.360	-0.523	0.397	2	****| . |	. |***. |
0.003	14.316	-0.530	-0.217	3	****| . |	. **| . |
0.005	15.011	-0.462	0.176	4	.***| . |	. |* . |
0.010	15.049	0.101	-0.039	5	. |* . |	. | . |
0.014	15.941	0.005	-0.179	6	. | . |	. *| . |
0.011	18.247	-0.051	0.268	7	. | . |	. |** . |
0.012	19.660	-0.061	-0.195	8	. | . |	. *| . |
0.017	20.073	-0.176	0.096	9	. *| . |	. |* . |
0.026	20.309	-0.117	-0.065	10	. *| . |	. | . |
0.039	20.503	-0.072	0.051	11	. *| . |	. | . |
0.057	20.547	-0.208	-0.020	12	. **| . |	. | . |

Source: Calculated from Table 1 in the Annex

Table 11. Final estimates of parameters for production (1-1-2)

Type	Coef	SE Coef	T	P-value
AR 1	-0.1291	0.9079	-0.14	0.889
MA 1	1.3544	0.9868	1.37	0.197
MA 2	-0.3974	1.0864	-0.37	0.721
Constant	0.15644	0.01992	7.85	0.000

Source: Calculated from Table 1 in the Annex

Auto-correlation Function (ACF) and Partial Correlation Function to detect the stability of the time series, the results indicate in (Table 10), the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Also we use the original data to draw the ACF we get (Fig. 11) and then use original data to draw the PACF for production of wheat crop, we get (Fig. 12), The results showed the significance of the Partial Auto-correlation Coefficient Function (PACF), which means rejecting the basic assumption "that the sum of the squares of single correlation coefficients are significant" it is mean there are correlations and it is called a general test.

3.3.2 Estimation

To examine the PACF we use historical data as shown (Fig. 12), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and moving average model (MA) must be applied. Finally, the best model is shown in (Table 11).

3.3.3 Diagnostic checking

By estimating (PACF), (ACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figs. (11 and 12) that there is no specific behavioral pattern for the PACF and ACF of the Residuals, and this indicates the quality of the model.

3.3.4 Forecasting

In addition, to use the appropriate and previously estimated model, Forecasting is performed for 13 years, ensuring that the most suitable model can predict in Tables 12 and 13.

3.4 Consumption

3.4.1 Identification

In addition, to draw the historical data for consumption of wheat crop we get the Fig. 13, it's also evident that the series data is not static due to an increasing of general trend of consumption, which means the instability of the average, by using Auto-correlation Function (ACF) and Partial Correlation Function to detect the stability of the time series, The results indicate in (Table 14), the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Also, by draw the original data of ACF we got it (Fig. 14) and then use the original data to draw PACF for consumption of wheat crop, we get (Fig. 15), The results showed the significance of

Table 12. Forecasts from period 2018-2030 for production 95% limits

Period	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast	5.85	5.35	5.57	5.70	5.84	5.98	6.12	6.25	6.39	6.53	6.67	6.81	6.95
Lower	4.32	3.64	3.86	3.98	4.12	4.26	4.40	4.54	4.67	4.81	4.95	5.09	5.22
Upper	7.39	7.05	7.28	7.41	7.55	7.69	7.83	7.97	8.11	8.25	8.39	8.53	8.67

Source: Calculated from Table 1 in the Annex

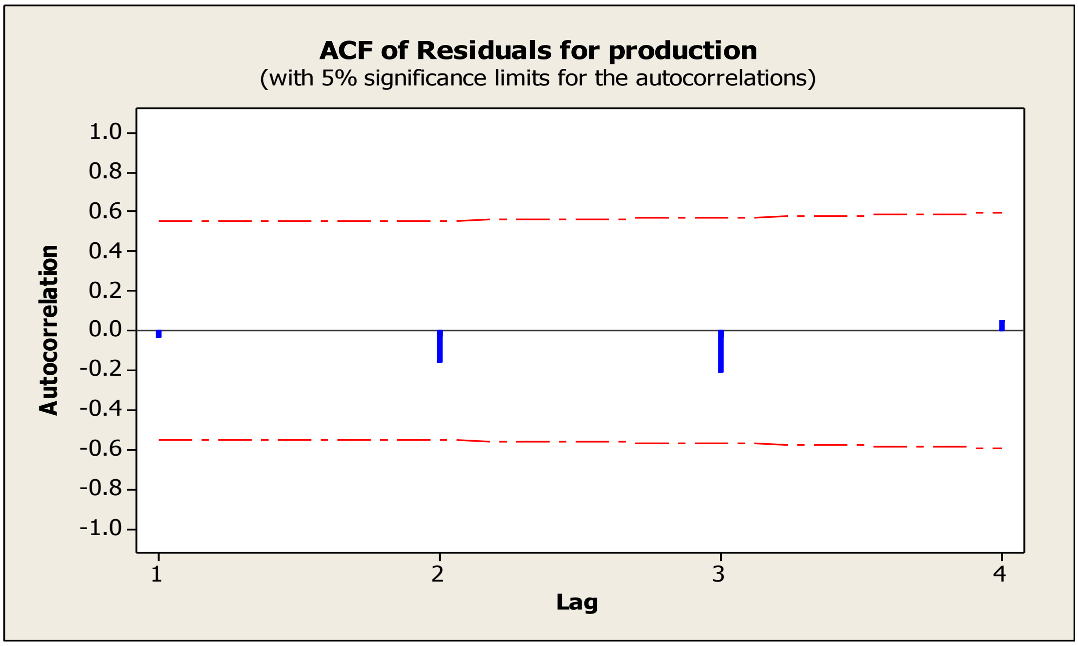

Fig. 11. Autocorrelation of residuals for wheat production
Source: Table 1 in the Annex

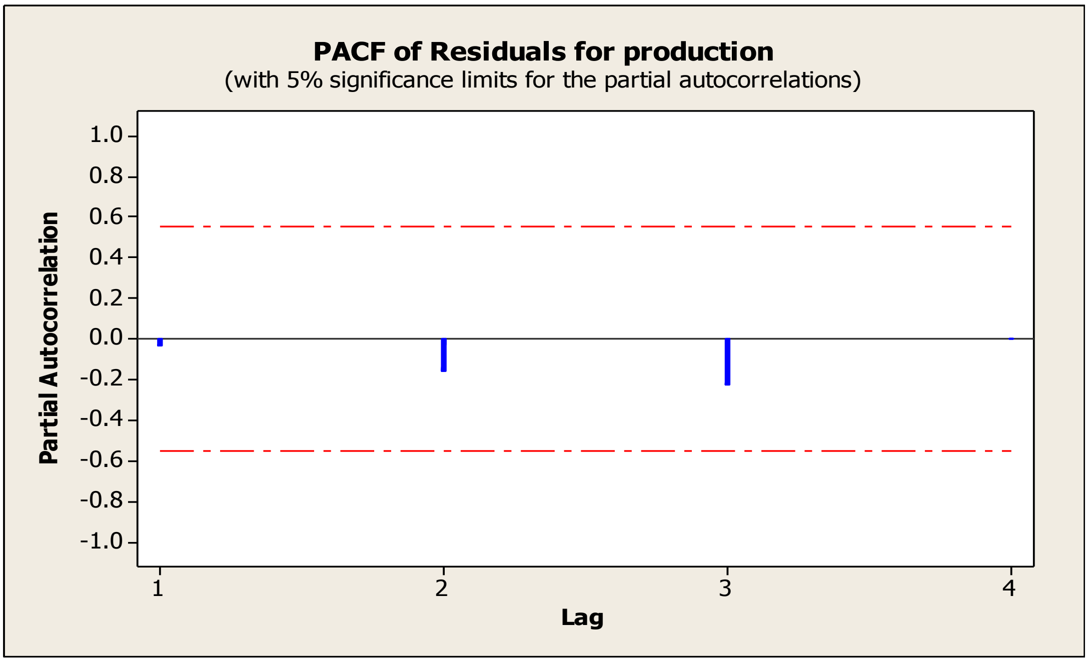

Fig. 12. Partial correlation of residuals for wheat production
Source: Table 1 in the Annex

Table 13. Modified box-pierce (Ljung-box) chi-square statistic forecasts from period 2018-2030 for production 95% limits

Lag	12	24	36	48
Chi-Square	5.0	*	*	*
DF	8	*	*	*
P-Value	0.759	*	*	*

Source: Calculated from Table 1 in the Annex

Fig. 13. Time series plot of wheat consumption
Source: Calculated from table 1 in the Annex

Table 14. Autocorrelation and partial correlation of wheat consumption

<table>
<tr><th>Prob</th><th>Q-Stat</th><th>PAC</th><th>AC</th><th></th><th>Partial correlation</th><th>Autocorrelation</th></tr>
<tr><td>0.002</td><td>9.3420</td><td>0.698</td><td>0.698</td><td>1</td><td>. |***** |</td><td>. |***** |</td></tr>
<tr><td>0.001</td><td>14.350</td><td>0.013</td><td>0.493</td><td>2</td><td>. | . |</td><td>. |**** |</td></tr>
<tr><td>0.002</td><td>15.377</td><td>-0.260</td><td>0.215</td><td>3</td><td>. **| . |</td><td>. |** . |</td></tr>
<tr><td>0.004</td><td>15.504</td><td>0.022</td><td>0.073</td><td>4</td><td>. | . |</td><td>. | . |</td></tr>
<tr><td>0.008</td><td>15.538</td><td>-0.015</td><td>-0.036</td><td>5</td><td>. | . |</td><td>. | . |</td></tr>
<tr><td>0.015</td><td>15.700</td><td>-0.021</td><td>-0.075</td><td>6</td><td>. | . |</td><td>. *| . |</td></tr>
<tr><td>0.028</td><td>15.738</td><td>0.252</td><td>0.035</td><td>7</td><td>. |** . |</td><td>. | . |</td></tr>
<tr><td>0.046</td><td>15.747</td><td>-0.183</td><td>0.015</td><td>8</td><td>. *| . |</td><td>. | . |</td></tr>
<tr><td>0.066</td><td>16.020</td><td>-0.309</td><td>-0.081</td><td>9</td><td>. **| . |</td><td>. *| . |</td></tr>
<tr><td>0.026</td><td>20.366</td><td>-0.290</td><td>-0.301</td><td>10</td><td>. **| . |</td><td>. **| . |</td></tr>
<tr><td>0.002</td><td>28.751</td><td>0.045</td><td>-0.382</td><td>11</td><td>. | . |</td><td>.***| . |</td></tr>
<tr><td>0.000</td><td>39.251</td><td>0.165</td><td>-0.382</td><td>12</td><td>. |* . |</td><td>.***| . |</td></tr>
</table>

Source: Calculated from Table 1 in the Annex

Table 15. Final estimates of parameters for consumption (1-1-2)

Type	Coef	SE Coef	T-value	P-value
AR 1	-0.2990	1.1487	-0.26	0.799
MA 1	0.7783	1.0787	0.72	0.486
MA 2	0.6688	1.3247	0.50	0.624
Constant	0.370561	0.000698	530.59	0.000

Source: Calculated from Table 1 in the Annex

the Partial Auto-correlation Coefficient Function (PACF), which means rejecting the basic assumption “that the sum of the squares of single correlation coefficients are significant” it is mean there are correlations and it is called a general test.

3.4.2 Estimation

Besides, to investigate the PACF with historical data as shown (Fig. 12), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and moving average model (MA) must be applied. Finally, the best model is shown in (Table 15).

3.4.3 Diagnostic checking

Through the Checking of (PACF), (ACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figs. (14 and 15) that there is no specific behavioral pattern for the PACF and ACF of the Residuals, and this indicates the quality of the model.

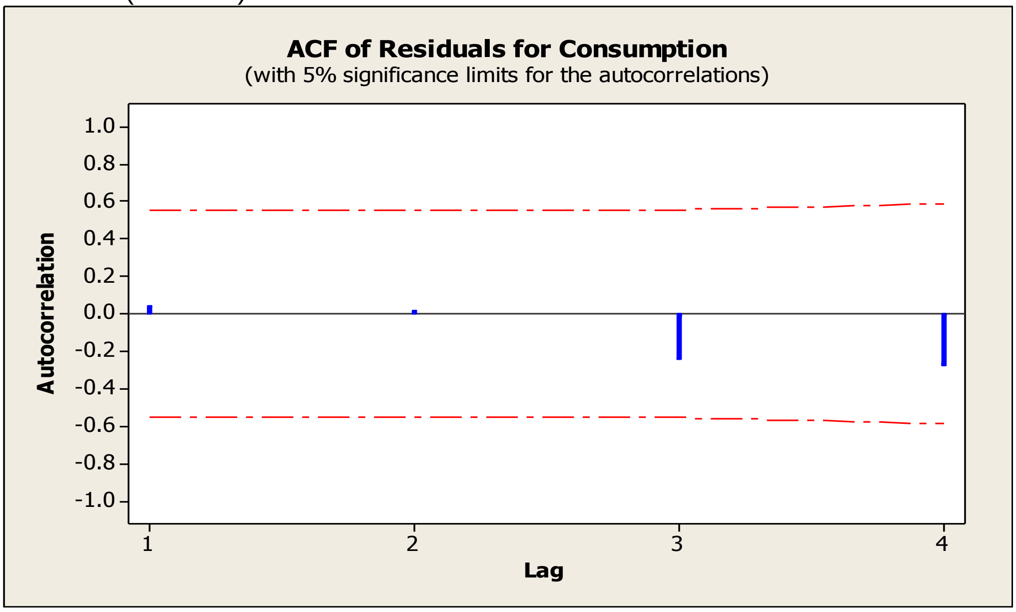

Fig. 14. Autocorrelation of residuals for wheat consumption

Source: Table 1 in the Annex

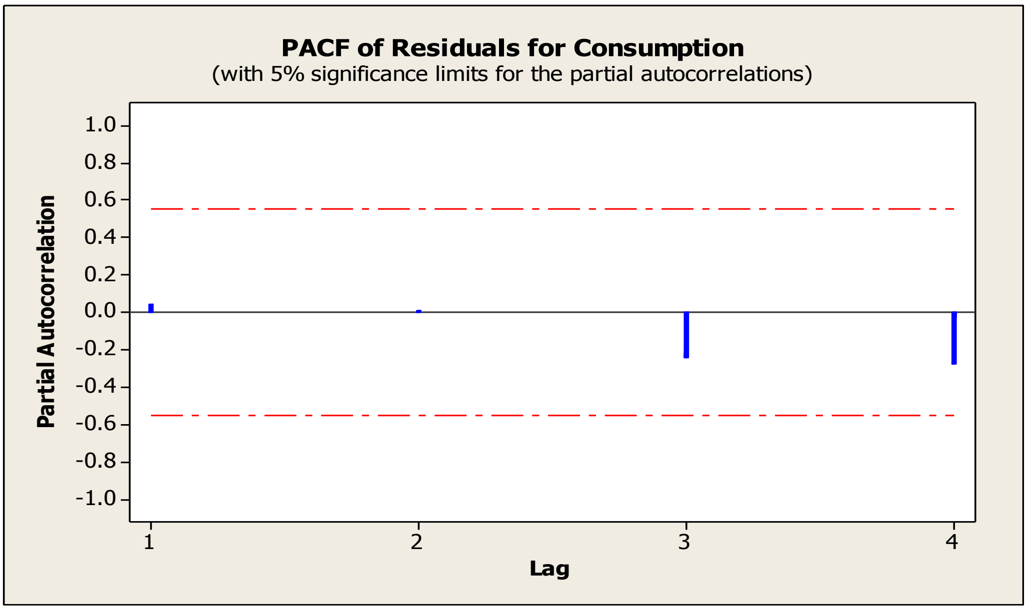

Fig. 15. Partial correlation of residuals for wheat consumption

Source: Table 1 in the Annex

Table 16. Forecasts from period 2018-2030 for consumption 95% limits

Period	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast	7.48	7.83	8.10	8.39	8.67	8.96	9.24	9.53	9.81	10.10	10.38	10.67	10.95
Lower	6.47	6.82	6.99	7.24	7.47	7.71	7.94	8.18	8.42	8.67	8.91	9.15	9.40
Upper	8.49	8.85	9.20	9.54	9.87	10.21	10.54	10.87	11.20	11.53	11.86	12.18	12.51

Source: Calculated from Table 1 in the Annex

Table 17. Modified box-pierce (Ljung-Box) chi-square statistic forecasts from period 2018-2030 for consumption 95% limits

Lag	12	24	36	48
Chi-Square	5.7	*	*	*
DF	8	*	*	*
P-Value	0.679	*	*	*

Source: Calculated from Table 1 in the Annex

Fig. 16. Time series plot of population
Source: Calculated from table 1 in the Annex

Table 18. Autocorrelation and partial correlation of population

<table>
<tr><th>Prob</th><th>Q-Stat</th><th>PAC</th><th>AC</th><th></th><th>Partial correlation</th><th>Autocorrelation</th></tr>
<tr><td>0.001</td><td>11.594</td><td>0.777</td><td>0.777</td><td>1</td><td>. |******|</td><td>. |******|</td></tr>
<tr><td>0.000</td><td>18.877</td><td>-0.022</td><td>0.595</td><td>2</td><td>. | . |</td><td>. |**** |</td></tr>
<tr><td>0.000</td><td>22.855</td><td>-0.080</td><td>0.424</td><td>3</td><td>. *| . |</td><td>. |***. |</td></tr>
<tr><td>0.000</td><td>24.502</td><td>-0.092</td><td>0.262</td><td>4</td><td>. *| . |</td><td>. |** . |</td></tr>
<tr><td>0.000</td><td>24.925</td><td>-0.057</td><td>0.127</td><td>5</td><td>. | . |</td><td>. |* . |</td></tr>
<tr><td>0.000</td><td>24.925</td><td>-0.105</td><td>-0.004</td><td>6</td><td>. *| . |</td><td>. | . |</td></tr>
<tr><td>0.001</td><td>25.470</td><td>-0.121</td><td>-0.130</td><td>7</td><td>. *| . |</td><td>. *| . |</td></tr>
<tr><td>0.001</td><td>27.404</td><td>-0.084</td><td>-0.232</td><td>8</td><td>. *| . |</td><td>. **| . |</td></tr>
<tr><td>0.000</td><td>31.354</td><td>-0.079</td><td>-0.310</td><td>9</td><td>. *| . |</td><td>. **| . |</td></tr>
<tr><td>0.000</td><td>37.456</td><td>-0.056</td><td>-0.357</td><td>10</td><td>. | . |</td><td>.***| . |</td></tr>
<tr><td>0.000</td><td>46.045</td><td>-0.078</td><td>-0.386</td><td>11</td><td>. *| . |</td><td>.***| . |</td></tr>
<tr><td>0.000</td><td>57.553</td><td>-0.077</td><td>-0.400</td><td>12</td><td>. *| . |</td><td>.***| . |</td></tr>
</table>

Source: Calculated from Table 1 in the Annex

3.4.4 Forecasting

Besides using the appropriate and previously estimated model, Forecasting is performed for 13 years, ensuring that the most suitable model can predict in Tables 16 and 17.

3.5 Population

3.5.1 Identification

In addition, to draw the historical data for Annual growth of population in Afghanistan we get the Fig. 16, it's also evident that the series data is not static due to an increasing of general trend of Annual growth of population, which means the instability of the average, by using Autocorrelation function (ACF) and Partial Correlation to detect the stability of the time series, The results indicate in (Table 18), the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Also, by use the original data to draw ACF and PACF we get (Figs. 17 and 18), The results showed the significance of the Partial Auto-correlation Coefficient Function (PACF), which means rejecting the basic assumption " that the sum of the squares of single correlation coefficients are significant" it is mean there are correlations and it is called a general test.

3.5.2 Estimation

To investigate PACF comparing with the historical data as shown (Fig. 18), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and moving average model (MA) must be applied. Finally, the best model is shown in (Table 19).

3.5.3 Diagnostic checking

Through the Checking of (PACF), (ACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figs. (17 and 18) that there is no specific behavioral pattern for the PACF and ACF of the Residuals, and this indicates the quality of the model.

Table 19. Final estimates of parameters for consumption (1-1-2)

Type	Coef	SE Coef	T-value	P-value
AR 1	0.3833	0.2524	1.52	0.157
MA 1	-0.0019	0.3153	-0.01	0.995
MA 2	0.9694	0.2733	3.55	0.005
Constant	0.41455	0.01270	32.64	0.000

Source: Calculated from Table 1 in the Annex

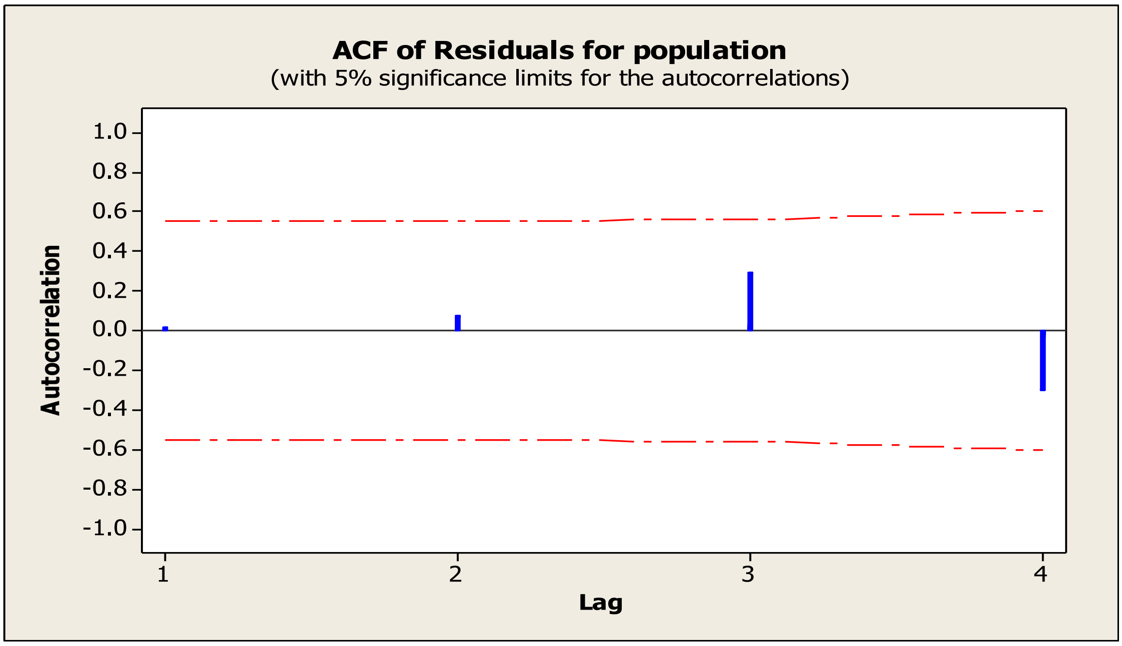

Fig. 17. Autocorrelation of residuals for population
Source: Table 1 in the Annex

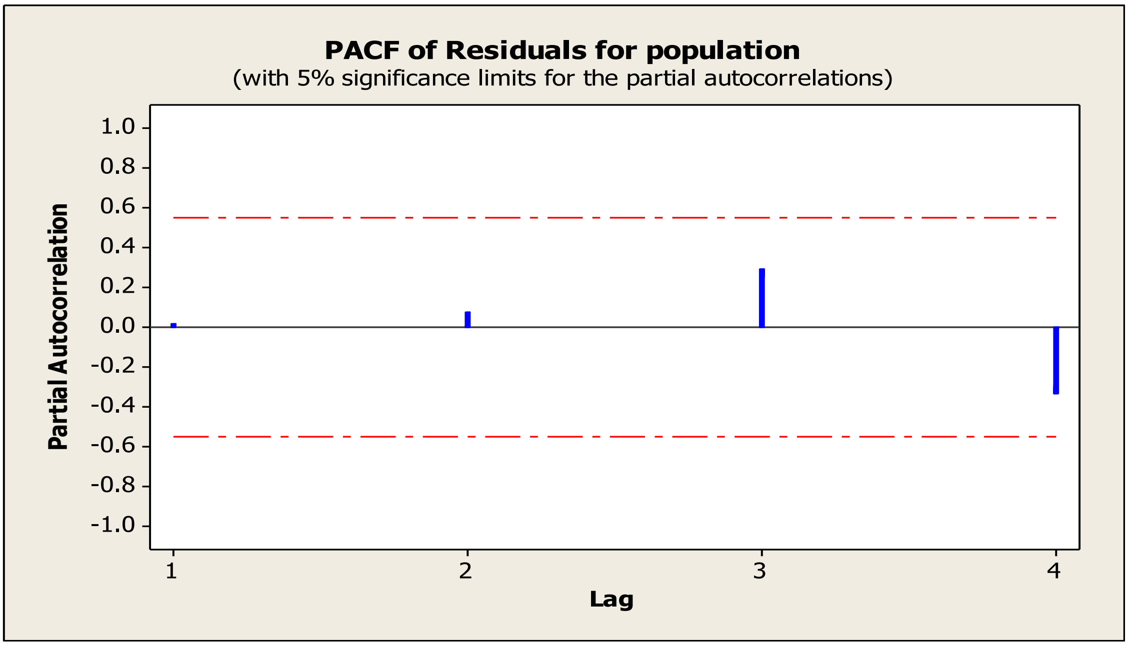

Fig. 18. Partial correlation of residuals for population
Source: Table 1 in the Annex

Table 20. Forecasts from period 2018-2030 for population 95% limits

Period	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecast	34.77	35.31	35.94	36.59	37.25	37.92	38.59	39.27	39.94	40.61	41.28	41.95	42.63
Lower	34.447	34.75	35.34	35.99	36.66	37.32	37.99	38.67	39.34	40.01	40.68	41.35	42.02
Upper	35.10	35.88	36.53	37.19	37.85	38.52	39.20	39.88	40.54	41.21	41.88	42.56	43.23

Source: Calculated from Table 1 in the Annex

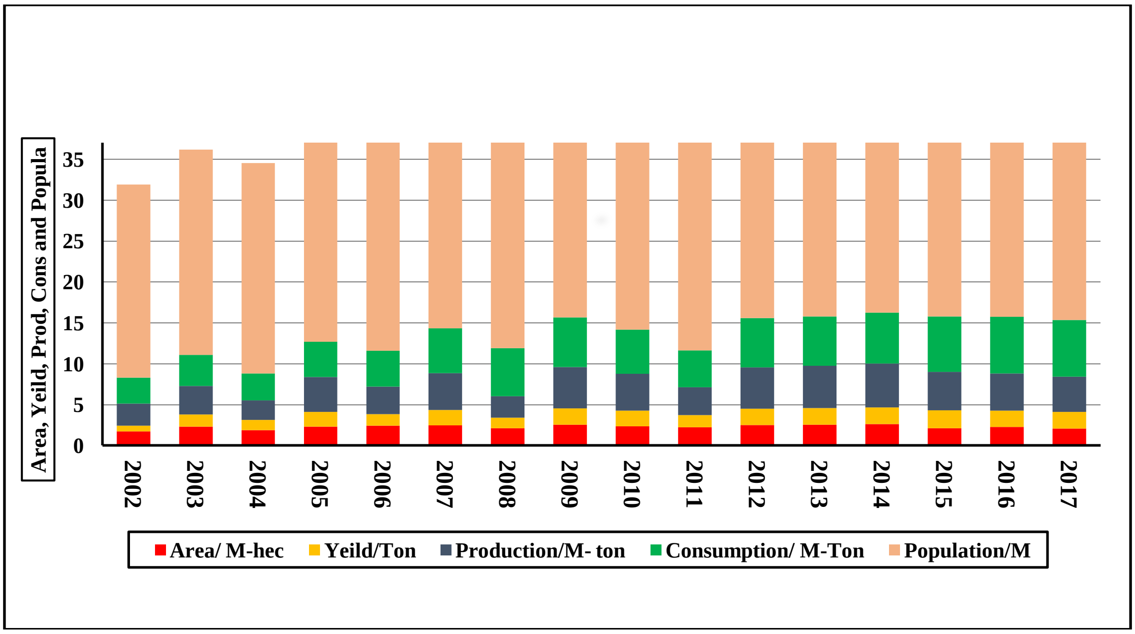

Fig. 19. Wheat (Area/yeild/production/consumption) and population of Afghanistan (2002-2017)
Source: Table 1 in the Annex

Table 21. Modified box-pierce (Ljung-box) chi-square statistic forecasts from period 2018-2030 for population 95% limits

Lag	12	24	36	48
Chi-Square	8.1	*	*	*
DF	8	*	*	*
P-Value	0.427	*	*	*

Source: Calculated from Table 1 in the Annex

3.5.4 Forecasting

Besides using the appropriate and previously estimated model, Forecasting is performed for 13 years, ensuring that the most suitable model can predict in Tables 20 and 21.

4. CONCLUSION AND RECOMMENDATIONS

Wheat is an important and major crop in terms of both production and consumption in Afghanistan. It accounts near 59% daily calories intake and almost 164 kg consumption per capita. With the rapid growth rate of the world population, food scarcities and poverty threatening low-income countries, such as Afghanistan. in addition, Wheat is considered the main food crops in Afghanistan, whether to use it for population consumption or to use it in some industries and others. Where Afghanistan suffers from a large gap between production and consumption. So, the research investigates the problem arising from a shortage of production to meet the needed of population. Therefore, the estimation of future wheat needs is one of the essential tools that may help decision-makers to determine wheat needs and then developing plans that help reduce the gap between production and consumption besides providing the necessary financial sums for that. Where most prediction methods are valid for one-year prediction. However, moving prediction methods have been found to measure and predict the future movement of the dependent variable. The current research aims to prediction for Area, Productivity, production, consumption and Population over the period (2002-2017), to predict the values of these variables in the period (2018-2030). The results showed that Through the drawing of the historical data for planted area, Productivity, Production, Consumption and Population of wheat crop it was evident that the series data is not static due to an increasing or a decreasing of general trend, which means the instability of the average, by using Autocorrelation function (ACF) and Partial Correlation to detect the stability of the time series, The results showed also, the significance of Autocorrelation coefficient and partial correlation coefficient values, which indicates that the time series is not static.

Based on the research results, we recommend the following:

The Afghans government must invest in agriculture and provide for farmers machines, tools, technology, improved seeds and water they need, so the country can rely on its agricultural products and create job opportunities in rural areas. In order to prevent the environmental degradation and increase land productivity, the government must plant trees, improve water management, reduce soil erosion and increase soil and water conservation. Investing in the reconstruction of irrigation infrastructure will increase the availability of water for farmers. Farmers should be helped and encouraged to grow more than one crop and cultivate the total land volume and value of the crops which they produced. More investment and work in the agricultural sector will increase the incomes of Afghan farmers, which will be a huge success for the Afghan government and for all Afghans in general.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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ANNEX

Table 1. Economic variables of wheat crop growing in Afghanistan over the period 2002-2017

Year	Area/M-Ton	Yield/Ton	Production/M-Ton	Consumption/M-Ton	Population/M
2002	1.742	0.72	2.67	3.19	23.6
2003	2.320	1.5	3.48	3.80	25.1
2004	1.888	1.27	2.39	3.29	25.7
2005	2.342	1.8	4.27	4.30	26.3
2006	2.444	1.4	3.37	4.40	27.15
2007	2.466	1.9	4.48	5.50	27.39
2008	2.139	1.3	2.62	5.85	27.71
2009	2.575	1.97	5.07	6.05	28.48
2010	2.354	1.92	4.52	5.40	29.12
2011	2.232	1.52	3.39	4.50	29.76
2012	2.512	2.0	5.05	6.04	30.42
2013	2.553	2.03	5.17	6.04	31.11
2014	2.654	2.02	5.37	6.20	31.83
2015	2.128	2.2	4.68	6.80	32.56
2016	2.300	1.98	4.56	6.90	33.34
2017	2.104	2.04	4.28	6.95	34.13

Source: 1- Central Statistics Organization of Afghanistan (CSO), Different yearly Book; 2- World Bank, Different Issues

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