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LINEAR TREND LINE ANALYSIS BY THE METHOD OF LEAST SQUARE FOR FORECASTING RICE YIELD IN BANGLADESH

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Abstract

The method of curve fitting by the principle of the Least Square (L.S) method is a relevant and well-received method of trend analysis, especially to make a project for the future time. The Least Square (L.S) method helps to fit mathematical functions to a given data set. For this research, we accumulated data from the Yearbook of Agricultural Statistics of Bangladesh for the year 2007-08 to 2019-20 with the help of the Bangladesh Bureau of Statistics (BBS) website. We arranged the data according to the proposed method and graphically represented it. This research aimed to forecast the production of rice in Bangladesh with trend line analysis by the method of Least Square (L.S) for the years 2020-21 to 2024-25. As a result, we found an upward trend line for the production of rice in Bangladesh. Therefore the production will be maximum in the year 2024-25.

Keywords: Least Square Method, Linear Trend Line, Forecasting, Time series, Bangladesh.

I. Introduction

A time series is a set of observations collected at specified times, usually at equal intervals. It is arranged in chronological order. In addition, a time series is a set of time quantitative readings of some various recorded at equal intervals of time. The interval may be an hour, a day, a week, a month, or a calendar year. Weekly sales in a super shop, monthly production in a factory, yearly agricultural production,

population growth, are examples of time series. The analysis of time series is done mainly for forecasts and for evaluating past performances. The chronological variations will be the object of our study in time series analysis.

The requirements of a time series are:

1. The time gap between various values must be as far as possible, equal.
2. It must consist of a homogeneous set of values.
3. Data must be available for a longer period.

The analysis of time series is of great significance not only to economists and businessmen but also to scientists, geologists, sociologists, biologists, research workers, etc. It helps to understand past behavior and plan future operations. It helps to evaluate current accomplishments. The secular trend, seasonal movements, cyclical movements, and irregular movements are the components or elements of time series. The measurement trend can be measured by many methods like the graphic method, method of semi-average, method of curve fitting by the principle of least squares, and method of moving average. In this research, we will discuss the method of curve fitting by the principle of least squares.

Rice is widely cultivated in warm climates, especially in East Asia. Rice cultivation is said to have started about 10,000 years ago under the patronage of the kings of China and Japan. Due to its extensive adaptability, rice grows from North Korea to South Australia, even at an altitude of 2,600 meters above sea level (Joomla, Nepal). The rice-producing countries are China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, Brazil, and Pakistan [XXX]. According to the US department of agriculture (USDA), in the 2019-20 fiscal Bangladesh produced 52.6 million (5 crores 26 lakh) tons of rice, the fourth-highest production in the world. China ranked first, producing 148.5 million (14 crores 85 lakh) tons and India drew up second 116.4 million (11 crores 64 lakh) tons. Bangladesh, being an agro-based developing country, is striving hard to expand its economy rapidly. Agriculture is the main department of the country's economic development. In 2020, the share of agriculture in Bangladesh's gross domestic product (GDP) was 12.65%, the industry contributed approximately 28.79% and the services sector contributed about 54.63%. The agricultural sector employs nearly 66% of Bangladesh's workforce. In the agriculture sector, the crop sub-sector dominates with 10.74% of the GDP of which rice alone contributes about 53% [VII]. Rice is also the staple food of Bangladesh, occupies nearly 90% of the total net cropped area of the country and nearly 99% of the people consume rice as their primary food. (HIES, 2010). In a year, Bangladesh has three rice crop seasons: the Aus crop, the Aman crop, and the Boro crop, which account for nearly 50%, 43%, and 7% of total annual rice yield, respectively [XXV].

From the literature view, we observed that many researchers have endeavored to discuss time series forecasting. There are many models in time series to forecast. [XX] C. L. Karmaker et al. described some important time series forecasting models with applications in jute yarn demand. In [V], [XVII], [XXIII], [XXVI], [XXI] the researchers are analyzing the time series forecasting techniques with different models. [XIV] J. G. De Gooijjer et al. review 25 years of time series forecasting in different journals. In [XI], [XXVIII], [II], [XXIX] the researchers relate the fundamental

knowledge of time series modeling and forecasting in their books. [IV] J. Ara et al. have a study with the aim of determining the profitability position of several dairy farms in Bangladesh by break-even analysis. In [XXX], [XXV] has a comparison of forecasting and development opportunities with non-identical models and methods. We accumulate our data from the yearbook of agricultural statistics of Bangladesh [VII], Bangladesh economic review [XV], Bangladesh rice research institute (BRRI) [VIII], and Ricepedia [IX]. [VI]M. A Awal et al. exhibited the production of rice in Bangladesh employing by ARIMA model. [XIX] M.S Kabir et al. addressed the issues to achieve the SDG 2 and move forward by doubling rice production in Bangladesh. In [XXVII], [XII], [XIII], [X] the researchers explore the relation of the production of rice with different stuff and analyze the curve fitting in the least square method. [I] M. Abdulkabir et al. illustrated the trend analysis on traffic accidents and [XXIV] A. Paul et al. on rainfall. [XVI], [III], [XXII] explained the estimation of rice by depending on different weather indicators. [XVIII] M. S Kabir et al. presented a rice vision for Bangladesh leading to 2050 and beyond. They analyzed and synthesized the collected data to develop models or model parameters to generate outputs such as future population, rice production, and rice requirement.

In this study, our purpose is to exhibit the linear trend line analysis for collected data by the least square method and forecast the production of rice (Aus, Aman, and Boro) in Bangladesh.

II. Proposed Method

The method of curve fitting by Least Square (L. S) is very popular and widely used for fitting mathematical functions to a given set of data. Determining the mathematical functions are usually done by plotting the data graphically or by a theoretical understanding of the mechanism of the variable change. The various types of curves that may be used to describe the given data in practice are as follows:

i. A straight line: $Y_t = a + bt$
ii. Second-degree parabola: $Y_t = a + bt + ct^2$
iii. nth degree polynomial: $Y_t = a_0 + a_1 t + a_2 t^2 + \cdots + a_n t^n$
iv. Exponential: $Y_t = ab^t$
v. Growth curves: $Y_t = a + bc^t$ (Modified exponential curve)
$Y_t = abc^t$ (Gompertz curve)
$Y_t = \frac{k}{1+e^{a+bt}}$ (Logistic curve)

For linear trend, we take the equation of a straight line

$$Y_t = a + bt \tag{1}$$

Where,

Y_t is a projected value of Y for a selected value of t.

a is Y intercept.

b is the slope of the line.

t is any time that is selected.

The sum of squares of the deviations of the observed values of Y_t from the estimated values defined in equation (1) is given by

$$S = \sum(y_t - a - bt)^2 \quad (2)$$

Now partially differentiate equation (2) concerning a and b separately and equating to zero we get

$$\frac{\partial S}{\partial a} = 0$$

$$\frac{\partial S}{\partial b} = 0$$

Which gives two normal equations as

$$\sum y_t = na + b\sum t \quad (3)$$

$$\sum ty_t = a\sum t + b\sum t^2 \quad (4)$$

Now by solving equations (3) and (4) we get the values of a and b

By putting these values in equation (1) we get the required trend line.

To calculate Trend values we need to know about the origin is the middlemost period and $t = \frac{year-origin}{interval}$

III. Data Representation

Bangladesh is a large flat delta island formed by the influence of natural features of three major rivers namely Ganga, Brahmaputra, and Meghna where abundant water, plains, and an almost tropical climate have created an excellent fertile land for paddy. Aus, Aman, and Boro are the main three cultivated rice in Bangladesh. The rapid population growth of the country is creating a huge gap between rice production and food demand. To prevent this we need effective research and modern agricultural technology. Our research has an aim on it.

We have some methods to calculate the trend line and forecasting, among these we discussed the Method of curve fitting by the principle of least square. We acquired data from the Yearbook of Agricultural Statistics of Bangladesh for the year 2007-08 to 2019-20 with the help of the Bangladesh Bureau of Statistics (BBS) website.

Table 1: The production (in Metric Tons) of Aus, Aman and Boro rice in Bangladesh from 2007-08 to 2019-20.

Years	Aus	Aman	Boro
2007-08	1506852	9662191	17761781
2008-09	1894557	11613169	17809051
2009-10	1709127	12207162	18058962
2010-11	2132821	12791498	18616740
2011-12	2332152	12798268	18759212
2012-13	2158238	12897210	18778155
2013-14	2326037	13023312	19007201
2014-15	2328090	13190163	19192164

2015-16	2288642	13483437	18937581
2016-17	2133617	13656054	18013749
2017-18	2709643	13992874	19575819
2018-19	2775478	14054872	19560546
2019-20	2755396	14203197	19645334

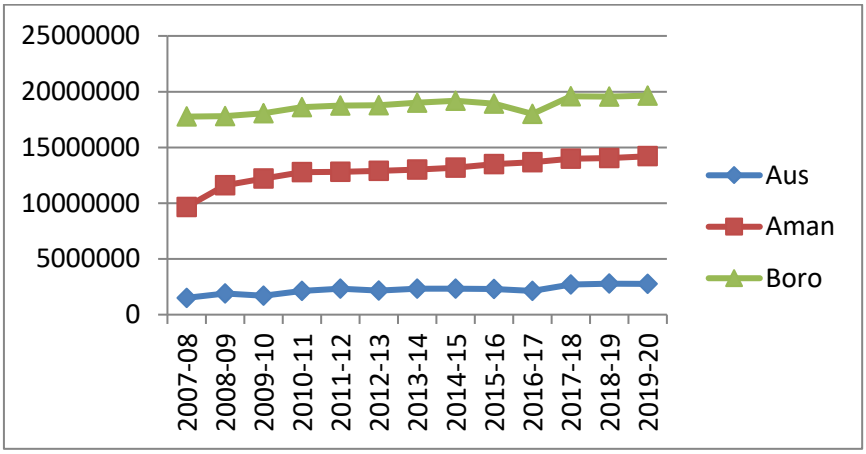

Fig. 1. The Production of Aus, Aman, and Boro rice.

Table 2: Calculation of linear trends equation for Aus rice.

Years	t	**Production (Aus)** y_t	t^2	ty_t
2007-08	-6	1506852	36	-9041112
2008-09	-5	1894557	25	-9472785
2009-10	-4	1709127	16	-6836508
2010-11	-3	2132821	9	-6398463
2011-12	-2	2332152	4	-4664304
2012-13	-1	2158238	1	-2158238
2013-14	0	2326037	0	0
2014-15	1	2328090	1	2328090
2015-16	2	2288642	4	4577284
2016-17	3	2133617	9	6400851
2017-18	4	2709643	16	10838572
2018-19	5	2775478	25	13877390
2019-20	6	2755396	36	16532376
Total	**0**	**29050650**	**182**	**15983153**

The linear trend equation for Aus rice is

$$\widehat{Y_{Aus_t}} = 2234665.385 + 87819.523t$$

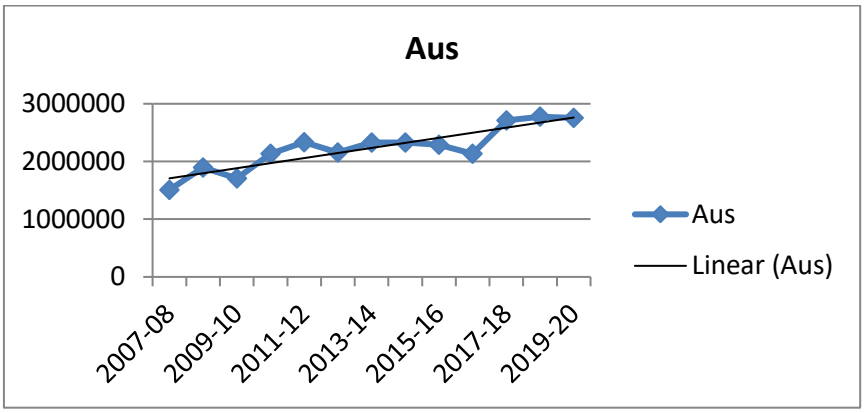

Fig.2. Linear trend line of Aus rice.

Table 3: Calculation of linear trends equation for Aman rice.

Years	t	Production (Aman) y_t	t^2	ty_t
2007-08	-6	9662191	36	-57973146
2008-09	-5	11613169	25	-58065845
2009-10	-4	12207162	16	-48828648
2010-11	-3	12791498	9	-38374494
2011-12	-2	12798268	4	-25596536
2012-13	-1	12897210	1	-12897210
2013-14	0	13023312	0	0
2014-15	1	13190163	1	13190163
2015-16	2	13483437	4	26966874
2016-17	3	13656054	9	40968162
2017-18	4	13992874	16	55971496
2018-19	5	14054872	25	70274360
2019-20	6	14203197	36	85219182
Total	**0**	**167573407**	**182**	**50854358**

The linear trend equation for Aman rice is

$$\widehat{Y_{Aman_t}} = 12890262.076 + 279419.549t$$

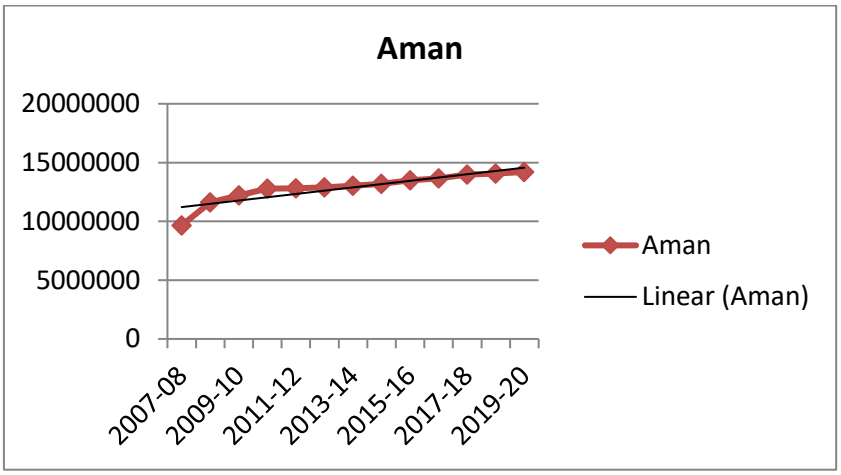

Fig. 3. Linear trend line of Aman rice.

Table 4: Calculation of linear trends equation for Boro rice.

Years	t	Production (Boro) y_t	t^2	ty_t
2007-08	-6	17761781	36	-106570686
2008-09	-5	17809051	25	-89045255
2009-10	-4	18058962	16	-72235848
2010-11	-3	18616740	9	-55850220
2011-12	-2	18759212	4	-37518424
2012-13	-1	18778155	1	-18778155
2013-14	0	19007201	0	0
2014-15	1	19192164	1	19192164
2015-16	2	18937581	4	37875162
2016-17	3	18013749	9	54041247
2017-18	4	19575819	16	78303276
2018-19	5	19560546	25	97802730
2019-20	6	19645334	36	117872004
Total	**0**	**243716295**	**182**	**25087995**

The linear trend equation for Boro rice is

$$\widehat{Y_{Boro_t}} = 18747407.308 + 137846.126t$$

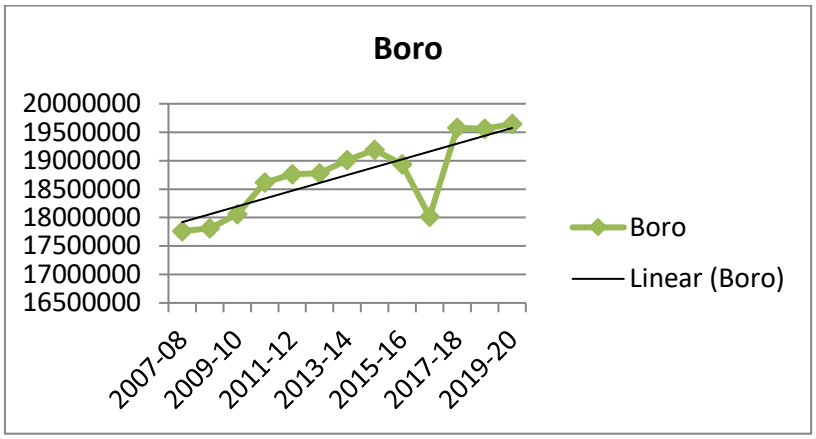

Fig. 4. Linear trend line of Boro rice.

Table 5: The trend values of Aus, Aman and Boro rice from 2007-08 to 2019-20.

Years	Aus	Aman	Boro
2007-08	1707748.247	11213744.782	17920330.552
2008-09	1795567.77	11493164.331	18058176.678
2009-10	1883387.293	11772583.88	18196022.804
2010-11	1971206.816	12052003.429	18333868.93
2011-12	2059026.339	12331422.978	18471715.056
2012-13	2146845.862	12610842.527	18609561.182
2013-14	2234665.385	12890262.076	18747407.308
2014-15	2322484.908	13169681.625	18885253.434
2015-16	2410304.431	13449101.14	19023099.56
2016-17	2498123.954	13728520.723	19160945.686
2017-18	2585943.477	14007940.272	19298791.812
2018-19	2673763	14287359.821	19436637.938
2019-20	2761582.523	14566779.37	19574484.064
Total	**29050650**	**167573407**	**243716295**

Table 6: The estimated production of Aus, Aman and Boro rice for 2020-21 to 2024-25.

Year	Aus	Aman	Boro
2020-21	2849402.046	14846198.919	19712330.19
2021-22	2937221.569	15125618.468	19850176.316
2022-23	3025041.092	15405038.017	19988022.442
2023-24	3112860.615	15684457.566	20125868.568
2024-25	3200680.138	15963877.115	20263714.694

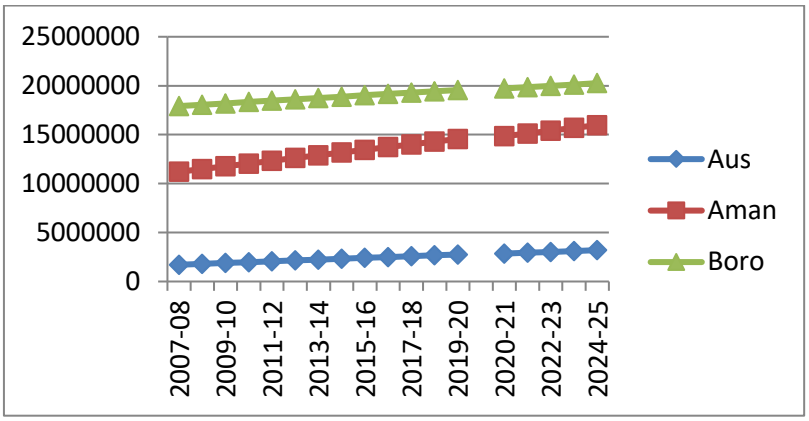

Fig. 5. The estimated production (in metric tons) of Aus, Aman, and Boro rice from 2020-21 to 2024-25.

IV. Result Analysis

We have the data set of production rice in Bangladesh from 2007-08 to 2019-20 that we represent in Table 1. We get the graphical view of the production of rice in Bangladesh in Figure 1. We find the trend line equations to calculate the trend values for Aus, Aman, and Boro rice by using Tables 2, 3, and 4. In Figures 2, 3, and 4 we show the trend line for Aus, Aman, and Boro rice and we get an upward trend for those items. Table 5 represents the trend values for three rice items. By using the trend line equations and depending on Table 5 we estimated the production of rice in Bangladesh from 2020-21 to 2024-25 in Table 6. A graphical representation of the estimated production of rice in Bangladesh is portrayed in Figure 5. It is an upward trend line. So we will get the maximum production of rice in Bangladesh in the year 2024-25.

V. Conclusion

Trend refers to the general directions of the data indicating the increase or decrease during a long period of time. A trend can be measured by many methods. The method of curve fitting by the principle of least squares is one of them. This method is a very popular and well-received method for fitting mathematical functions to a given set of data. It projects future times. The form of the mathematical function is generally determined by plotting the time series graphically or by previous experiences and the reliability of the projection mainly depends on it. In this research, we presented the data for Aus, Aman, and Boro rice for a while and we found the linear trend line for these three items. In the analysis of the trend line by the proposed method, we forecasted the production of rice (Aus, Aman, and Boro) in Bangladesh. The estimated production of Aus, Aman, and Boro rice from 2020-21 to 2024-25 is always gives an upward linear trend line. So we conclude that the production of rice will be increased with time. This research paper can help in research to forecast in time series.

Conflict of Interest:

There was no relevant conflict of interest regarding this paper.

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