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Trends and impact of agricultural production on population dynamics for selected crops in Assam

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Abstract
Agriculture in Assam plays an important role for livelihood of the people residing in the State. Widespread practice of traditional farming techniques and correspondingly low usage of modern farm inputs, low levels and low growth in productivity and incomes in the sector, effects about 75 per cent of the state's population directly or indirectly dependent on agriculture, while about 69 per cent of the workforce in the state is actually engaged in agricultural activities. So, to find out the impacts of the production of Selected crops on population growth, the trend of production of the Selected crops (Winter Rice, Summer Rice, Autumn Rice, Jute, Sugarcane, Potato, Rape and Mustard, Wheat, Matikalai) have been analysed by using Mann-Kendall test which confirmed an upward rising trend. Among the Selected crops production of winter rice is more followed by other crops. After the box plot technique have been used for outlier detection and have been removed the outliers from winter, summer, Autumn Rice and Sugarcane. Distplot and pair plot for normality checking and bivariate analysis have been used in this study. At the end Spearman's correlation coefficient at 0.05 level of significance have been calculated which is again shown with a heatmap and then regression line is fitted after testing the assumptions.

Keywords: Mann-Kendall test, box-plot, Distplot, pair plot, Heatmap, multiple regression

1. Introduction
In a developing agriculture-based economy, agricultural production and population growth plays significant role. Bagchi (1997) [1] found that Assam population is mostly dependent on Agriculture. Penn *et al*. (1998) [2] suggested policy alternatives, to get insight into the economic impact on population dynamics. Majority of the population in developing countries lives in the rural areas and depend on agriculture for their livelihood (Ray 2007) [4]. The agricultural productivity growth is considered as an important strategy for poverty reduction in the rural areas of developing countries (World Bank, 2008) [4]. According to Sustainable Development Goal (SDG) 8, poverty and hunger is a vital indicator for economic growth and development and that can be attained to some extent through increasing agricultural production. Assam is a state in north-eastern India, south of the eastern Himalayas along the Brahmaputra and Barak River valleys. In Assam more than 80% of the total population is dependent on Agriculture (86% population live in rural areas & 14% population live in urban areas of the state). Assam comprising of various religions Hindu, Muslim, Christian etc. being one of the peaceful states of north-eastern region. The input of agriculture and allied sector to the Gross State Domestic Product at constant (2004-05) price was more than 20% during 2014-15 which recorded a gradual fall since 2005-06(Economic survey, Assam, 2014-15). The trend of development of the agriculture and allied sector (GSDP at constant (2004-05) prices) was fluctuating. The average growth rate of GSDP in agriculture and allied sector in Assam during the period 2005-06 to 2013-14 at constant (2004-05) price was 3.65% compared to 3.97% in India. According to Census 2011, Assam has population of 3.12 Crores, an increase from figure of 2.67 Crore in 2001 census. The total population growth in this decade was 17.07% which accounts 2.58% population of India. From the above facts and figures it is clear that while during the last 10 years population was erratic during the period 2005-06 to 2011-12 and finally fixed at 3.53% in 2014-15 has increased by 17.07% as against national growth 17.64%. The average output of agricultural production in Assam during the period has risen by only 3.65%. From above data we can see that, although Assam's population growth is keeping pace with national growth, Agriculture based economy is not able to do so. If we add the fact that in 2014-15 only 58% of India population is dependent on Agriculture and Agriculture GDP counted only about 14% of total GDP, we are looking at even grimmer economic picture.

According to Ray (2010) [10], in his research paper observed that, "Rapid population growth in a country like India is threatening the environment through expansion and intensification of agriculture, uncontrolled growth of urbanization and industrialization, and destruction of natural habitats". Karim (2013) [6] said that "impact of growing population on agricultural resources around the world, creating depressing pressure on sustainable environmental management". Agarwal *et al*. (2017) [8] studied that farmer 's satisfaction is important in terms of wellbeing for agricultural productivity. Me Kuria (2018) [9] discloses that "growths of population and agricultural production have increased over time. However, production growth shows oscillating trends compared to population growth".

2. Objectives of the Study

The aim of this paper is to study the trends and impact of agricultural production on population dynamics for selected crops in Assam. Based on this the following objectives are formulated:

i. Studying the trends of agricultural production over the last 15 years
ii. Examining the relationship between agricultural production and population growth

3. Materials and Methods

3.1 Data Source: The study area considered in this paper is 'Assam' because no studies have been found on population and agricultural production about this state. The production data of the Selected crops which are used in this study has been collected from the Statistical Handbook of Assam, Directorate of Economics and Statistics and SRS during 2003 to 2017, District wise demographic profiles of Assam, 2011 census. The Selected crops of Assam are Winter Rice (MT), Autumn Rice (MT), Summer Rice (MT), Jute (MT), Sugarcane (MT), Potato (MT), Rapeseed and Mustard (MT), Wheat (MT), Matikalai (MT).

The null hypotheses with respect to the above two objectives are:

H_{01}: There is no effect of time on agricultural production

H_{02}: There is no causality between agricultural production and population growth

3.2 Trend Analysis: *Mann-Kendall Test:* If a monotonic upward or downward trend in the variable of interest over time exists, it can be statistically determined using the Mann-Kendall (MK) test. A monotonic trend, which may or may not be linear, indicates a constant increase (down) in the variable through time.

The Mann-Kendall test statistic is calculated according to:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(X_j - X_k) \quad (1)$$

With

$$\text{SGN}(X_j - X_k) = \begin{Bmatrix} +1 \; if \; (X_j - X_k) > 0 \\ 0 \; if \; (X_j - X_k) = 0 \\ -1 \; if \; (X_j - X_k) < 0 \end{Bmatrix} \quad (2)$$

The mean of S is E[S] = 0 and the variance V[S] is given as:

$$V[S] = \{n(n-1)(2n+5) - \sum_{j=1}^{p} t_j(t_j-1)(2t_j+5)\}/18 \quad (3)$$

Where, p is the number of tied groups in the data set and t_j is the number of data points in the j^{th} tied group.

The statistics S is closely related to Kendall's τ as given by:

$$\tau = \frac{S}{D} \quad (4)$$

Where,

$$D = \left[\frac{1}{2}n(n-1) - \frac{1}{2}\sum_{j=1}^{p} t_j(t_j-1)\right]^{\frac{1}{2}} \left[\frac{1}{2}n(n-1)\right]^{\frac{1}{2}} \quad (5)$$

If the estimated value of Z is smaller than the critical value of Z at the specified level of significance for a two-sided test, H_0 should be accepted. The values of S will indicate an increasing or decreasing trend if positive or negative respectively.

In this study Distplot has been used to depict the distribution of the production of selected crops. Pair plot is used for bivariate comparison between the variables under study along with their distributions and Boxplot shows the outliers of the productions.

The Karl Pearson's Correlation coefficient has been found between population growth and the production of selected crops. The multiple linear Regression Analysis has been used to see the impact of productions on population growth during the period 2003-17. The Results are found using python programming.

4. Results and Discussion

4.1 Summery Statistics and Trend Analysis

Table 1 represents the summary statistics of the production of selected crops of Assam during 2003-17 where the production of winter rice is seen to be more followed by sugarcane, summer rice, jute, potato, rapeseed and mustard, wheat and matikalai in terms of average. The range of the variables with respect to maximum and minimum observed difference are also given.

Fig. 1 depicts the trend of the production of the selected crops of Assam during 2003-17.

From the Mann-Kendall test (p-value=0.00604), an increasing trend have been seen in terms of production with respect to time.

Table 1: Summery Statistics of the Selected Crops of Assam from 2003 to 2017

	count	mean	std	min	25%	50%	75%	max
Winter	14.0	3.515777e+06	5.501633e+05	2238765.0	3234882.00	3682255.5	3757277.50	4426729.0
Jute	14.0	6.553870e+05	1.156171e+05	410409.0	586149.25	652138.0	716269.25	865805.0
Sugarcane	14.0	1.036477e+06	8.697229e+04	871219.0	993060.25	1053925.5	1076041.75	1207167.0
Summer	14.0	1.293739e+06	1.113937e+06	731851.0	901237.25	1017918.0	1158583.75	5127375.0
Autumn	14.0	4.014474e+05	1.610102e+05	228146.0	298016.25	343003.5	463752.75	742198.0
Potato	14.0	6.165516e+05	1.205341e+05	353696.0	526392.25	628890.0	698608.50	783768.0
RapeM	14.0	1.414246e+05	2.754642e+04	96992.0	123344.75	134889.5	162398.00	189233.0
Wheat	14.0	5.137286e+04	1.712996e+04	23454.0	41380.50	54143.0	66885.00	73186.0
Matikalai	14.0	2.535057e+04	5.478792e+03	17331.0	20750.50	25115.5	29178.00	34237.0

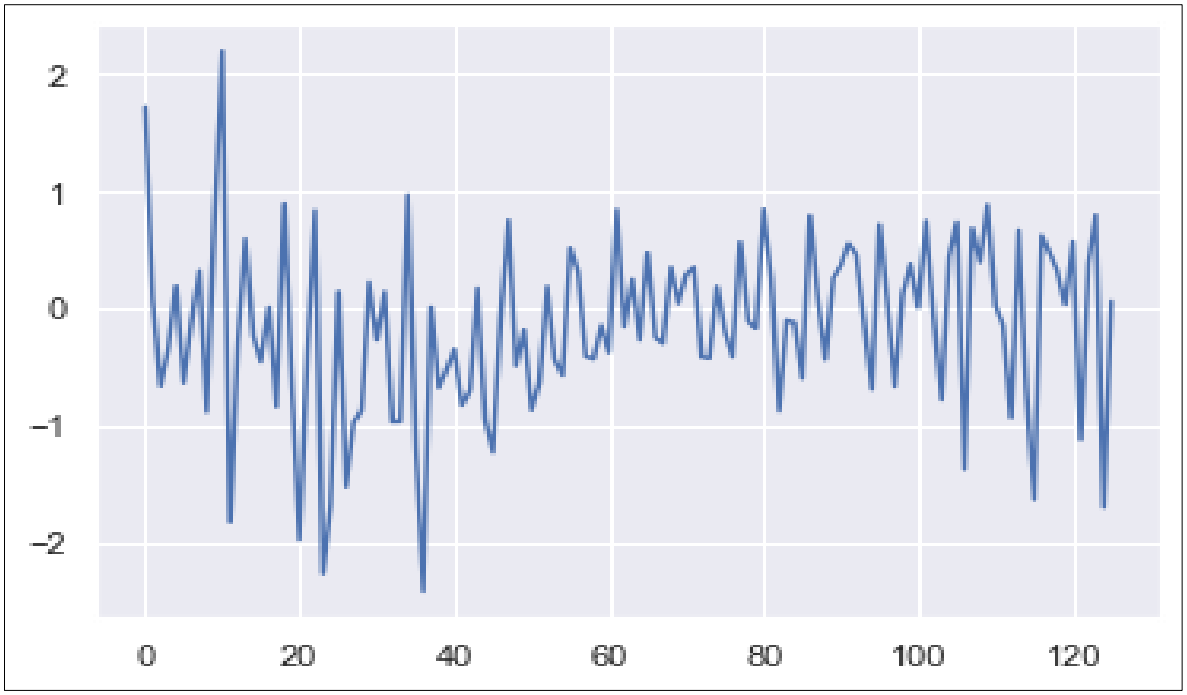

Fig 1: Trend of Production of Selected Crops of Assam during 2003-17

Table 2: Mann-Kendall Test of Production Data

Trend	Increasing	S	1303
p-value	0.00604	var(s)	224875
z	2.74562	Slop	0.00508
Tau	0.16546	Intercept	-0.42921

4.2 Distplot, Pairplot and Boxplot

Fig. 3 represents pairplot and scatter plot of the production of Selected crops of Assam during 2003-17. It can be seen from the Fig. 3 that the production of Jute is normally distributed. The pairwise comparison of the variables through scattered plot can also be observed.

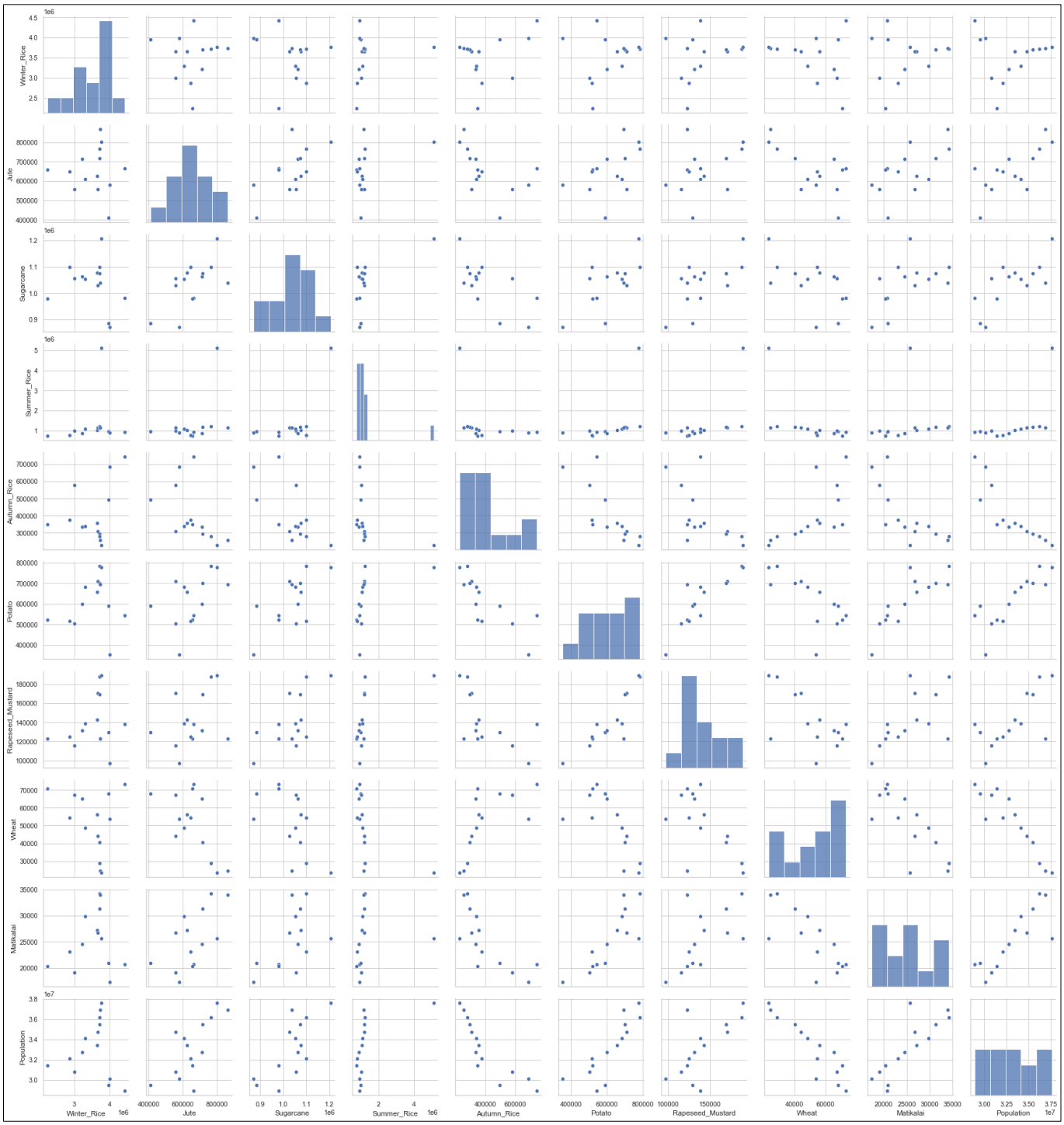

Fig 3: Pair plot of the Production of Selected Crops of Assam during 2003-17

Fig. 4 depicts the distplot of the production of selected crops of Assam during 2003-17. It can be observed from the Fig. 4 that apart from production of Jute the productions of other crops are approximately positively or negatively skewed.

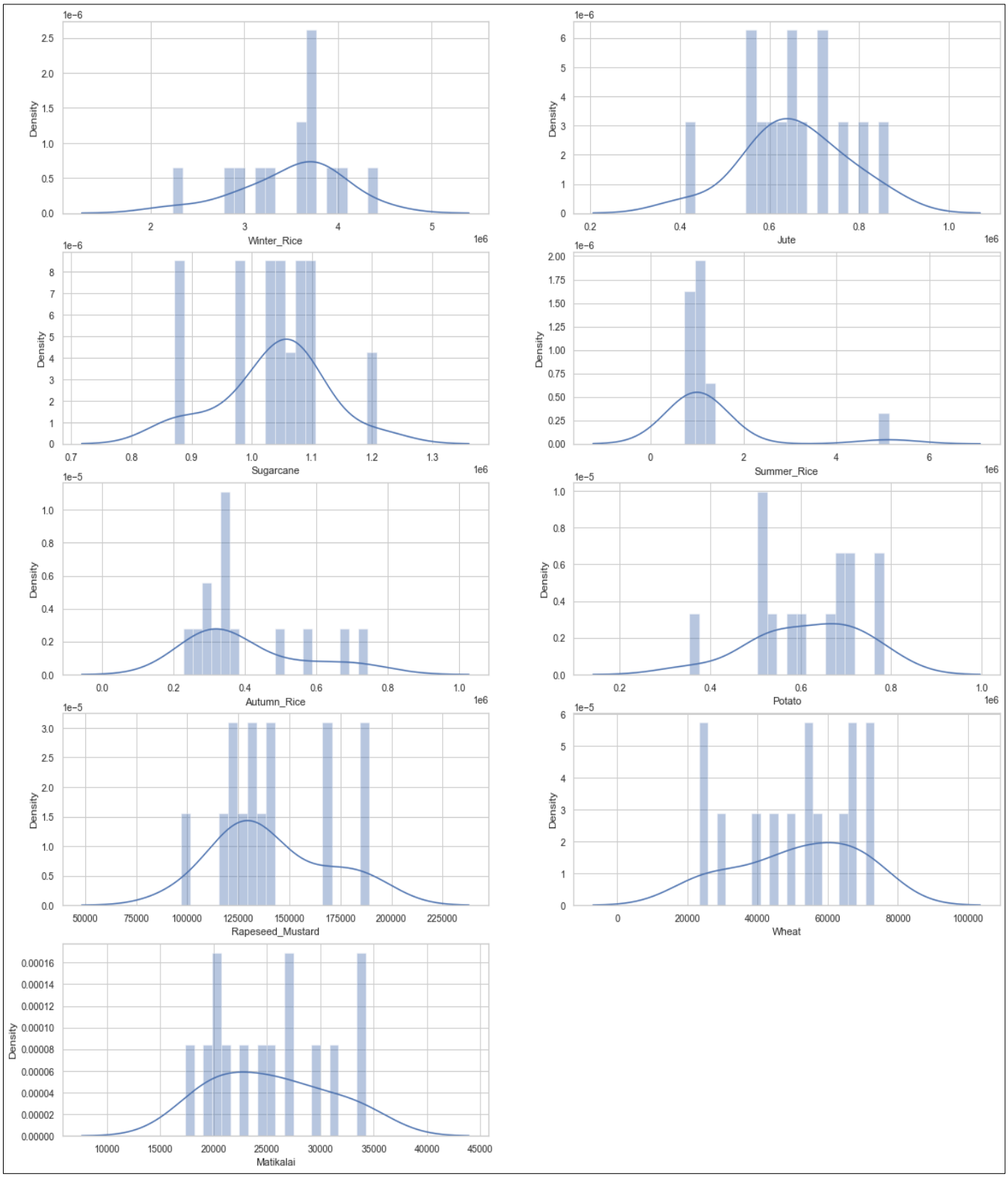

Fig 4: Distplot of the Production of Selected Crops of Assam during 2003-17

Fig. 5 and Fig. 6 depicts the boxplot of the production of selected crops of Assam during 2003-17. From the Fig. 5, it can be seen that there are outliers in the production of winter rice, summer rice, autumn rice and sugarcane. These outliers have been removed and the boxplots are presented in Fig. 6.

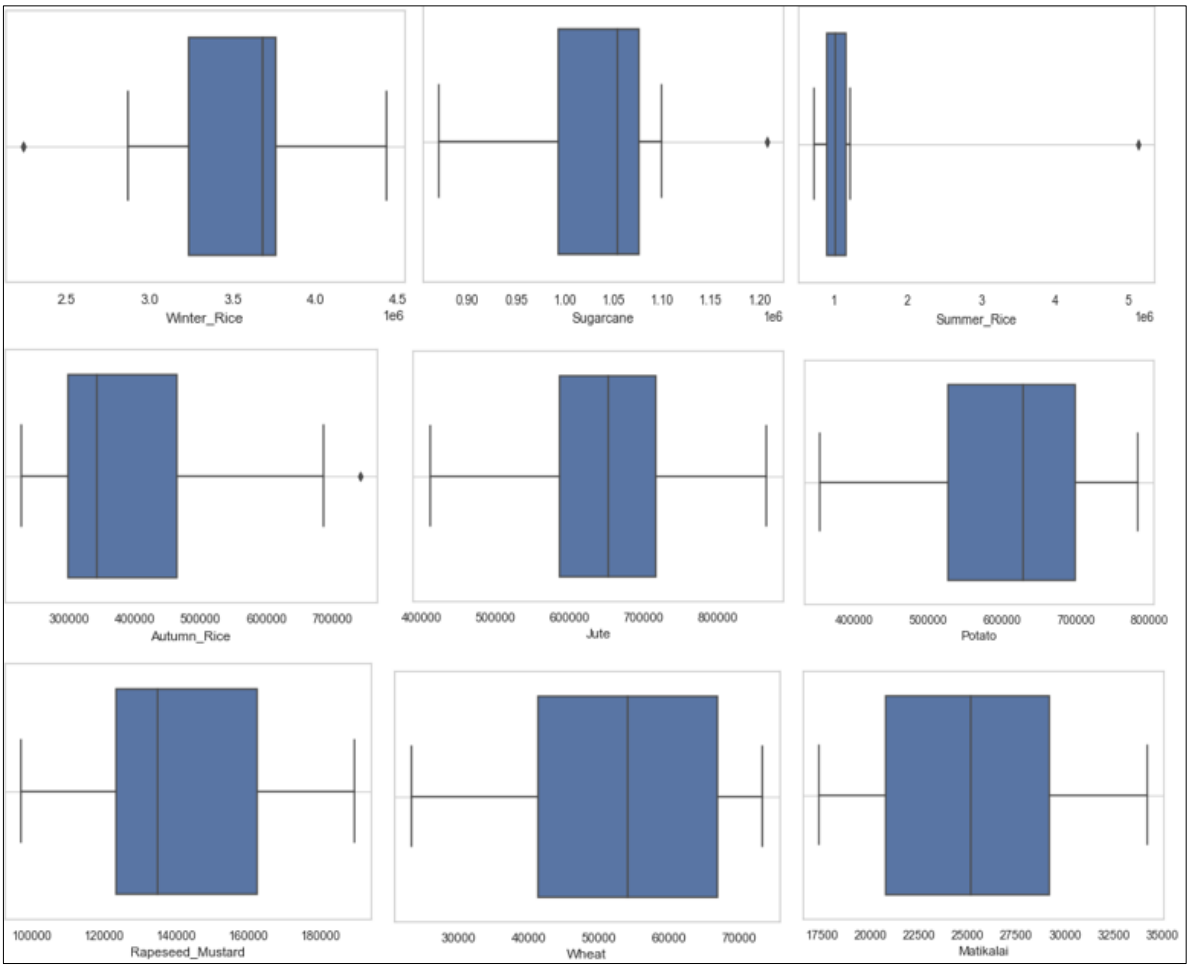

Fig 5: Boxplot of the Production of Selected Crops of Assam during 2003-17

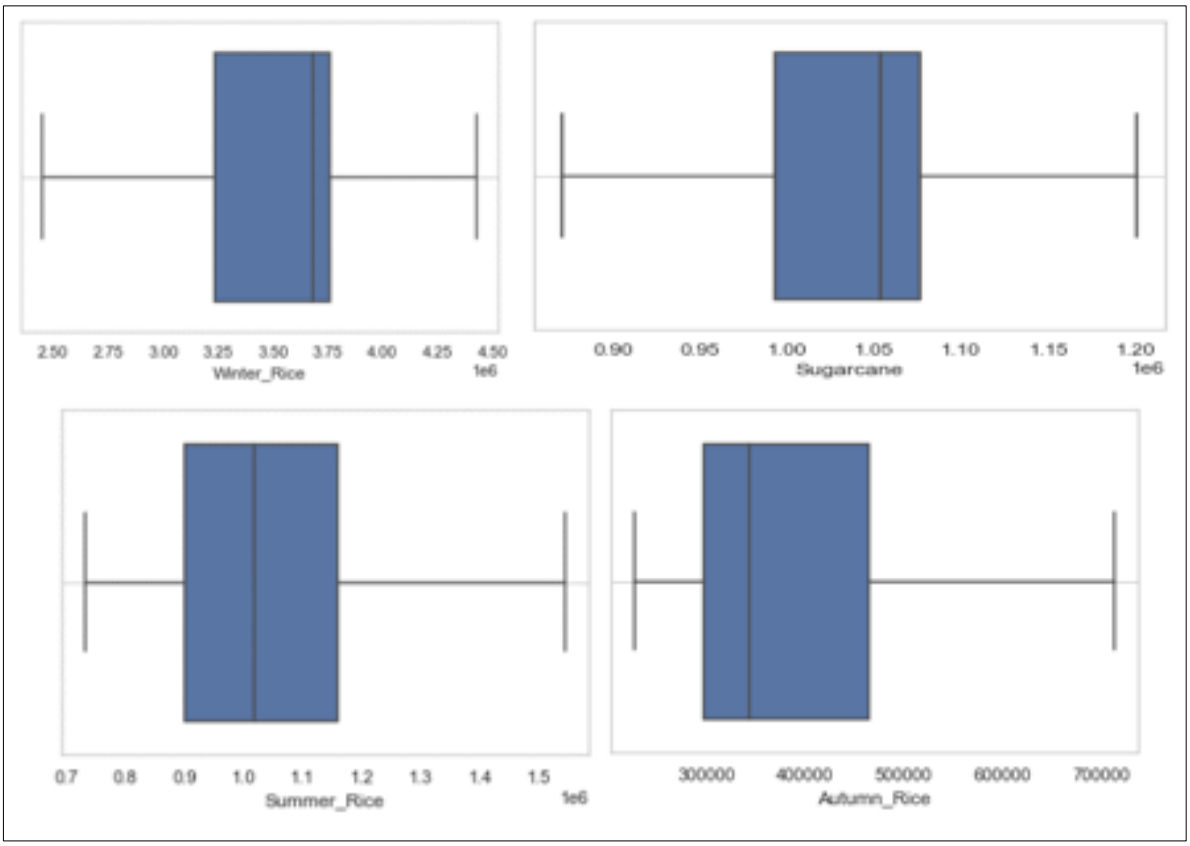

Fig 6: Boxplot of the Crops after removing the Outliers

4.3 Correlation and Regression Analysis

The correlation between the production of selected crops and the population growth of Assam during 2003-17 has been given in the Fig. 7. From the Fig. it can be seen that apart from winter rice production and population growth (p-value=0.952), productions of all other Selected crops are highly associated (p-value<0.05) with population growth. Though productions of autumn rice and wheat are negatively correlated with population growth but productions of jute, sugarcane, summer rice, rapeseed and mustard and matikalai are positively correlated with population growth. This means that there is sufficient amount of these selected crops in Assam to feed the people of the state.

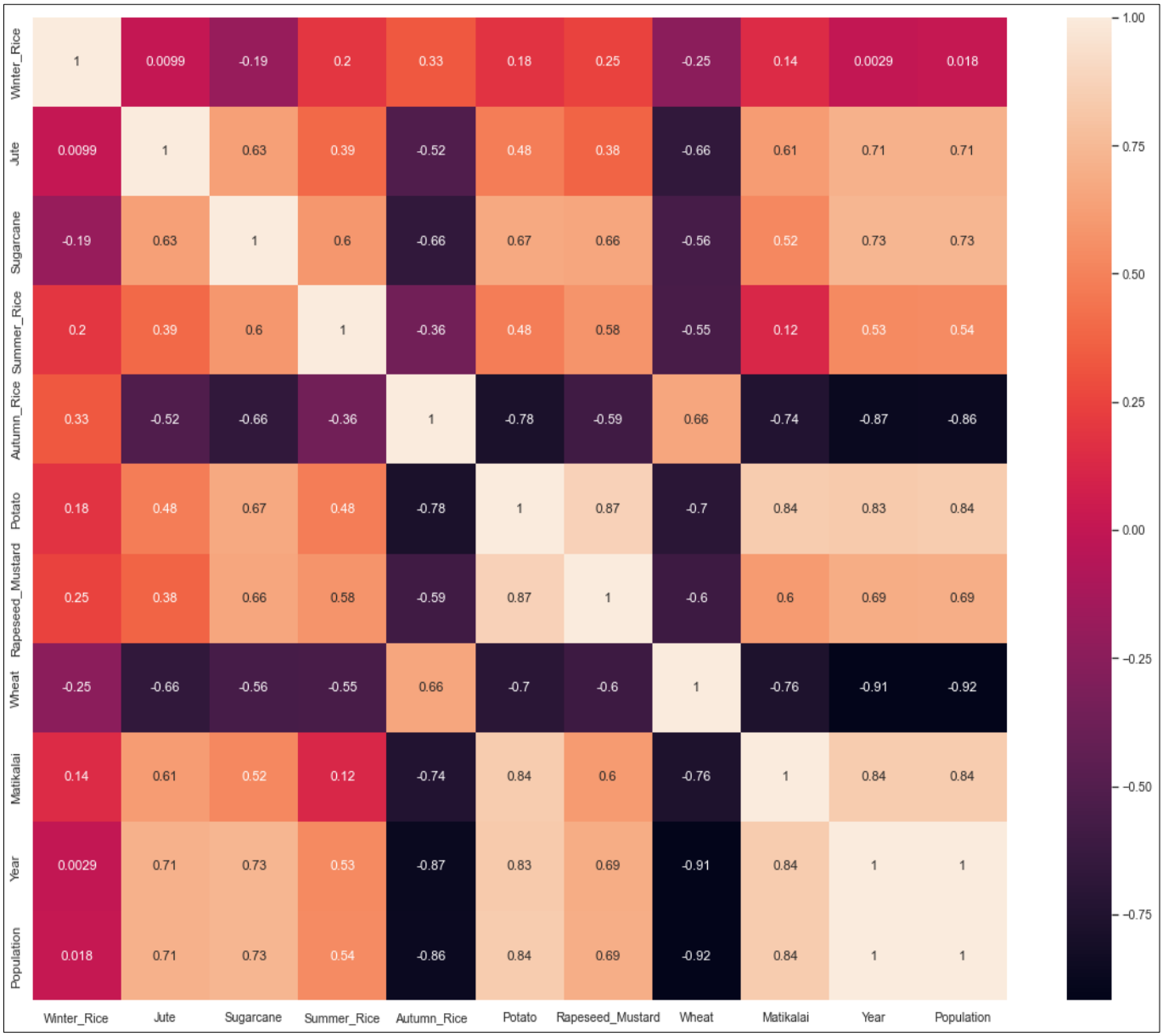

Fig 7: Correlation between Production of Selected Crops and Population of Assam during 2013-17

A multiple linear regression line has been fitted after normalizing the variables with Z score transformation where population growth is the dependent variable and the productions of the selected crops are independent variables. Since the correlation between winter rice and population growth is non-significant so this parameter has been removed. The adequacy of the model has been checked by following all the properties of a regression line. Table 3 represents the important results of the model.

The VIF values of the independent variables are found to be less than 5 and Durbin-Watson test statistic is almost equal to 2 which indicates no multicollinearity and no auto correlations between the independent variables respectively. The R-squared value is 99.8% and adjusted R-squared is 99.6% which indicates that the model fits well with the predicted variables in predicting the dependent variable.

Table 3: Regression Analysis of Production of Selected Crops on Population Growth of Assam during 2003-17

VIF	Crops
1.707	Wheat
0.488	Rapeseed Mustard
-0.001	Summer Rice
-0.004	Autumn Rice
-0.024	Jute

	coef	std err	t	P>|t|	[0.025	0.975]
Jute	5.4298	8.004	0.678	0.517	-13.026	23.886
Sugarcane	27.3224	9.258	2.951	0.018	5.974	48.671
Summer_Rice	-0.7249	0.724	-1.001	0.346	-2.394	0.945
Autumn_Rice	2.3292	5.022	0.464	0.655	-9.251	13.910
Rapeseed_Mustard	26.5361	32.856	0.808	0.443	-49.230	102.302
Wheat	-49.5098	61.515	-0.805	0.444	-191.363	92.343

R-squared (uncentered):	0.998
Adj. R-squared (uncentered):	0.996

In the linear Regression model Coefficient of the const term is 32886.393 and the Durbin Watson test Statistic is 2.13 which is nearly equal to 2. The R square is 99.8% and the adj R Square is 99.6% respectively.

From the model it can be seen that only the production of sugarcane has a significant impact (p-value<0.05) on population growth where the line of regression can be fitted as:

$Y_{Population}$= 32886.393+ 26.93*(Sugarcane Production)

Thus, we have seen that 1-unit (MT) change in Sugarcane production can serve the population which changes by 26.93 lakh

5. Conclusion

Growth rates for population are increasing along with agricultural production in terms of crop productions particularly sugarcane in Assam. As population increases, the share of agricultural contribution for GDP declines. Apart from Sugarcane we have not seen any significant impact of other selected crops on growth. The growing population pressure is a threat for social insecurity and environmental risk on the existing land resources. This problem can be tackled through increasing productivity of land. The productivity levels of selected crops could be increased significantly with improved cultivation practices and technologies. Therefore, new technologies and sustainable land management are the key opportunities of agricultural production in Assam, Climate-smart agriculture with diverse agriculture can help to feed the growing population in the contemporary world.

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