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A Trend Analysis on Area, Production and Productivity of *Kharif/winter* Rice in Assam

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ABSTRACT

Background: With the growing population of Assam self sufficiency is important to fulfill the demand of food grains as well as nutritional security of the people is another challenge. Cultivation of winter rice, locally known as “Sali dhan”, is an important agricultural practice in the state.

Methods: The study was conducted for the state of Assam to analyse the trend in area, production and productivity of kharif/winter rice for a period of 50 years. The discussion was based on the secondary data collected from 1970-71 to 2019-20. The study period was divided into three sub-periods, *viz*., period I (1970-71 to 1994-95), period II (1994-95 to 2019-20) and overall period (1970-71 to 2019-20). Compound annual growth rates were computed for estimating the growth trends of area, production and productivity of rice in Assam whereas Cuddy-della Valle index of instability was used to estimate the instability.

Result: Instability indices for production have been found highest which indicates a lees peril in growing of kharif/winter rice in Assam. Positive growth rate and low instability have been recorded for area, production and productivity for all the periods. It was also observed from the analysis that the area effect and productivity effect was more than that of interaction effect. Amongst area and productivity effect, the productivity effect was found greater than area effect.

Key words: Area, Production, Productivity, Self sufficiency, Trend analysis.

INTRODUCTION

Rice is the most dominant food grain of India and it feeds nearly 60 per cent of population. It is a means of livelihood for millions of people living mostly in rural areas providing food security. In India rice is grown in 72.06 million ha, the production level is 149.56 million tones and the productivity is about 2076 kg/ha (Agricultural Statistics at a Glance-2021). It is the world’s second-largest producer after China. Around 90% of the world’s total rice production has been recorded from Asian nations (Ashkra *et al.,* 2023). A consistent increase in the yield of rice was noted for many years. It is mostly grown in Eastern and Southern parts of India as it is a staple food in these areas. It is fundamentally a *kharif* crop and is mainly grown in *rainfed* areas that receive heavy annual rainfall. Rice is also grown through irrigation in those areas that receive comparatively less rainfall. In fact, food security of our nation depends upon the production of rice through irrigated system (Nagarajan *et al.,* 2024). West Bengal, Uttar Pradesh and Andhra Pradesh are the leading rice producing states in India and Assam is the leading producer of rice in North Eastern Region. North Eastern Region accounts for 10.48% of country’s total area and 6.46%of the total rice production. (Bujarbaruah, 2004). Amongst the North Eastern states, Assam contributes 5.24 percent towards production and 5.26 percent towards productivity (Agricultural Statistics at a glance- 2021). Rice of Assam provides both food and nutritional security to 3 crore population residing in the state. It is grown in sloppy hills to deep water areas all over Assam. 40 % of area in Assam is fragile in nature making farming in these areas organic.

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Almost all parts of India are suitable for raising rice during the *Kharif* season provided that water is available. *Kharif*/Winter rice crop is raised preferably in low-lying areas that remain flooded mainly during the rainy season. The sowing time is June-July and it is harvested in November-December. It is known as winter rice as per the harvesting time.In Assam it is also known as ‘*Sali*’ (Package of Practices for *kharif* crops of Assam, 2023). Among all the different types of rice, winter or *Sali* rice is the main rice in respect of area and production (Mech, 2017). About 84% of the country’s rice crop is grown in this season and generally medium to long duration varieties are grown. In Assam rice is mainly grown under *rainfed* condition in *Kharif*/winter season in the basins of Brahmnaputra river that receives very heavy rainfall.

To fulfill the growing demand of rice with increase in population a rapid increase in production is needed. Cost escalation is the most important factor, which makes rice cultivation a relatively less remunerative enterprise and it suggest that mechanization should be followed wherever possible and which will reduce the cost of human labour and cost of production (Mohandas and Thomas, 1997). Increasing land holding and farm size has substantial benefits for efficiency improvement in cultivation of rice and regional factors were also found to be important in influencing technical efficiency (Linh, 1994).The scope to increase the area under paddy is limited, hence more emphasis should be given to increase the production so that increase in productivity can be achieved

Keeping in view these factors the objective of the study was to analyse the scenario of *Kharif*/Winter rice in Assam and to analyse the trend in area, production and productivity as well. In addition to this the study will examine the relative contribution of area and productivity and their interaction effect of production of *Kharif*/winter rice in Assam. The study will be very useful for understanding the variations at state level over a period of time. Further, this study may be very useful for identifying the different causes for the increase/ decrease in area, production and productivity of rice for recommending some suggestions towards decision making and for policy recommendations.

MATERIALS AND METHODS

Assam is located in northeastern India, south of the eastern Himalayas. Geographically the state is extending from 22°19' to 28°16' North Latitude and 89°42′ to 96°30′ East Longitude between the foot hills of the Eastern Himalayas and the Patkai and Naga Hill Ranges. In Assam rice crop is grown in the basins of Brahmnaputra river. This region receives very heavy rainfall and rice is grown under *rainfed* condition. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37°C.

The study was conducted by using secondary data. The secondary data were obtained from various publications of Directorate of Economics and Statistics, Government of Assam (Anonymous, 2014; Anonymous, 2018).The time series data on area, production and productivity of *kharif*/ winter rice were collected for a period of 50 years from 1970-71 to 2019-20. The trends in area, production and productivity were examined for the overall period as well as analysis for two periods, Period-I (1970-71 to1994-95) and Period-II (1994-95 to 2019-20) were done and the compound annual growth rates (CAGR) of area, production and productivity were estimated. For estimating the CAGR we have considered exponential functional form to be fitted to the collected data set for trend analysis of area, production and productivity of *kharif*/winter rice in Assam.

Exponential function:

$$y = ab^x$$

Where,

Y = The area/production/productivity.

X = Time variable in years.

a = Intercept.

b = Slope coefficient.

The compound annual growth rate (CAGR) is estimated using the following exponential function as explained below:

$$y = ab^x$$

Taking the logarithm on both the sides it takes the linear form:

$$\log y = \log a + x \log b$$

which can be written as:

$$\log y = b_0 + b_1 x \quad \text{(i)}$$

Where,

b_1 = Regression coefficient of the linear regression equation (i).

The compound annual growth rate (CAGR) is calculated as:

$$\text{CAGR (\%)} = (\text{Anti log } b_1 - 1) \times 100$$

Instability analysis in the area, production and productivity of *kharif*/winter rice in Assam were done by using Cuddy-Della Valle index of instability. John Cuddy and Della Valle developed this index for measuring the instability in time series data (Cuddy and Della Valle, 1978). Although Coefficient of Variation (C.V) is the simplest measure of instability, there are some limitations in its use in time series data. It over-estimates the level of instability in time-series data which exhibits any trend. Cuddy-Della Valle index is considered as a better measure to evaluate instability in time series data. A low value of this index indicates low instability and vice-versa. The Cuddy-Della Valle index is given by

Cuddy - Della Valle Instability Index (CDVI) =

$$CV \times \sqrt{1 - R^2}$$

The range of Cuddy - Della Valle Instability Index (Sihmar, 2014) are as stated below:

Low instability = $0 < CDVI < 15$

Medium instability = $15 < CDVI < 30$

High instability = $CDVI > 30$

The coefficient of variation (CV) is obtained by dividing standard deviation by the mean and expressed in percentage as:

$$\text{Coefficient of variation (CV)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

In this study we have observed that year wise more area has been allotted for *kharif*/winter rice for the period starting from 1970-71 to 2019-20. It has been increased from 1404.68 thousand hectares in 1970-71 to 1863.90 thousand hectares in 2019-20. Likewise production also increased from 1525.84 thousand tones to 3960.55 thousand tones and also productivity from 1103kg/ha to 2157 kg/ha. An attempt was also made to study the relative contribution of area, productivity and their interaction in increased production of *kharif*/winter rice in the state. The relative contribution of area, productivity and their interaction in increased production of *kharif*/winter rice was estimated with the help of the following measures (Sharma, 2015; Angeles and Sundar, 2012; Dhakre and Bhattacharya, 2013; Agarwal *et al.* 2016; Sood *et al.,* 2020).

$$\Delta P = Y_0\Delta A + A_0\Delta Y + \Delta A\Delta Y \qquad \text{(ii)}$$

Where,

$\Delta A = A_n - A_0$

$\Delta Y = Y_n - Y_0$

$\Delta P = P_n - P_0$

A_0, P_0 and Y_0 = Area, production and productivity in the base year.

A_n, P_n and Y_n = Corresponding area, production and productivity in the n^{th} year.

The first term, $Y_0\Delta A$, the second term $A_0\Delta Y$ and the third term $\Delta A\Delta Y$ in the above equation (ii) represents area effect, the productivity effect and the interaction effect respectively. The total change in production can thus be decomposed into three effects *viz.* productivity effect, area effect and the interaction effect due to the changes in productivity and area.

RESULTS AND DISCUSSION

From the graph (Fig 1) of trend analysis of area for overall period (19710-71 to 2019-20), it was observed that there was a increasing trend in area in case of *kharif*/winter rice showing lowest value of 1405 thousand ha in 1970-71 and highest of 1889 thousand hac in 2014-15. There was variation in production during the study period. The trend of production was increasing having the lowest production of 1526 thousand tones in 1970-71 and highest production of 4083 thousand tones was observed in 2017-18. The increasing trend in production may be due to good climatic conditions and availability of inputs including good seeds, fertilizers and irrigation facility *etc.* The productivity for the said period follows the similar trend. Likewise for period I (19710-71 to 1994-95) and Period II (1995-96 to 2019-20) similar kind of trend in area, production and productivity were observed (Fig 2 and Fig 3).

This study considered exponential functional form and the coefficients of determination (R^2) was computed for this functional form and are presented in the Table 1.

It was observed from the Table 1 that the R^2 value of exponential function of area, production and productivity of *kharif*/winter rice in Assam were high during the entire period (1970-71 to 2019-20) as well as in both the periods Period-I (1970-71 to 1994-95) and Period-II (1994-95 to 2019-20). The lowest value of R^2 was observed in case of area under Period-II.

The values of b_1 in the fitted exponential trend for area, production and productivity of *kharif*/winter rice in Assam were also found positive for the overall period and the periods taken individually as Period I and Period II (Table 1). It revealed a positive growth in terms of area, production and productivity which implies that along with self sufficiency the farmers are getting benefit by selling their produce. That may be because of growing some new recommended varieties, use of fertilizers, pesticides *etc* and adoption of new technologies and good marketability. Similar kind of findings was observed in case of area, production and productivity of rice in Assam for a period from 1972 to 2014 (Mech, 2017). From another study it was observed that over the period from 1980-81 to 2014-15, there was positive growth rate in area, production and productivity of rice in India and across states position of Assam in growth rate was 5th in area and production and 6th in productivity with positive growth rates (Laitonjam *et al.,* 2018).

With the help of this fitted exponential trend the Compound Annual Growth Rates (CAGR) were calculated for area, production and productivity of *kharif*/winter rice for the overall period (1970-71 to 2019-20) and period I (1971-72 to 1994-95) and Period II (1994-95 to 2019-20) respectively as given in Table 2.

Table 2 depicts the increase CAGR in case of area of *kharif*/winter rice in Assam for the overall period (1970-71 to 2019-20) with a value of 1% and for period I and Period II also the CAGR values were higher *i.e* 2.09% and 1.16% respectively. Likewise area, the production and productivity of *kharif*/winter rice was also shown an upward trend as a whole and for both the periods separately with highest in production of 5.68% in case of period II.

The instability indices for area, production and productivity were low according to CDVI for overall period as shown in Table 2. For period I and period II also lower value of CDVI were noticed. As a whole only in case of production, instability indices were highest. This indicates that growing of *kharif*/winter rice is less risky in Assam. This is an indicative of the fact that in case of *kharif*/winter rice in Assam there is positive growth and less instability. (Dhakre and Sharma, 2009)

Another way the increase in production of rice has been noticed from 1525.84 thousand tones to 3960.55 thousand tones over the entire period of study. The relative co ntribution of area and productivity on this production of *Kharif*/winter rice from 1970-71 to 2019-20 were obtained as given below:

$$\Delta P = Y_0\Delta A + A_0\Delta Y + \Delta A\Delta Y$$

$$= 1.103\times459.21+1404.68\times1.054+459.21\times1.054$$

$$= 506.51+480.533+484.007$$

$$= 2471.058 \text{ thousand tones}$$

Here, the area effect and productivity effect is more than that of interaction effect. The productivity effect is found greater than area effect on production of *kharif*/winter ice in the state during 50 years period.

Again, we have analysed the area effect, productivity effect and interaction effect for period I (1970-71 to 1994-95) and period II (1994-95 to 2019-20). For period I (1970-71 to 1994-95) we have observed the equations as mentioned below.

$$\Delta P = Y_0\Delta A + A_0\Delta Y + \Delta A\Delta Y$$

$$=1.103\times355.16+1404.68\times0.410+355.16\times0.410$$

$$=391.7415+575.919+145.616$$

$$=1113.2765 \text{ thousand tones}$$

For period II (1995-96 to 2019-20) the equations are

$$\Delta P = Y_0\Delta A + A_0\Delta Y + \Delta A\Delta Y$$

$$=1.471\times127.62+1736.28\times0.686+127.62\times0.686$$

$$=187.729+1191.089+87.54$$

$$=1466.365 \text{ thousand tones}$$

For both the periods, period I and Period II, the area effect and productivity effect were higher than that of interaction effect. The productivity effect was found greater than area effect on production of *kharif*/winter rice in the state from the study of both periods.

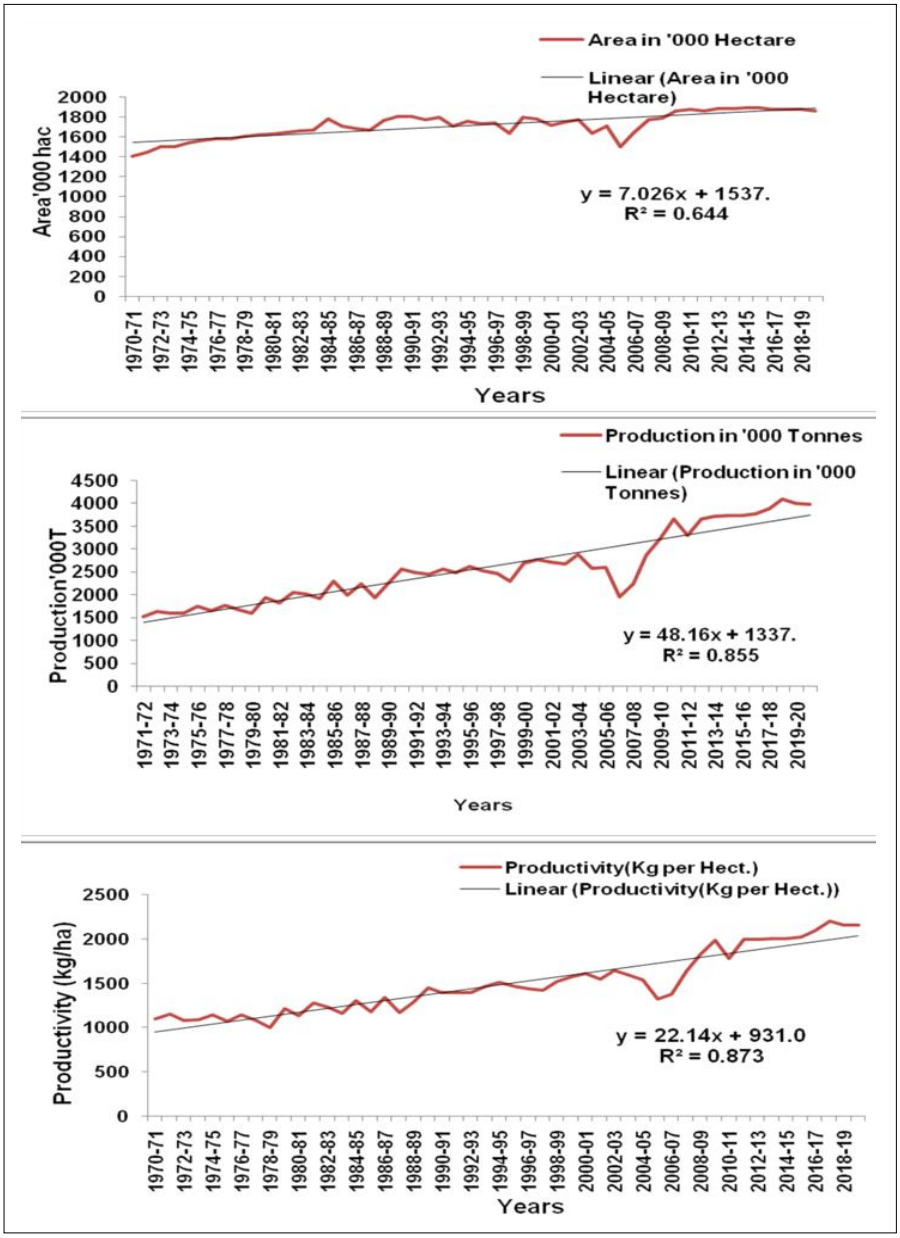

Fig 1: Trend of area, production and productivity of *kharif*/winter rice for overall period (1970-71 to 2019-20).

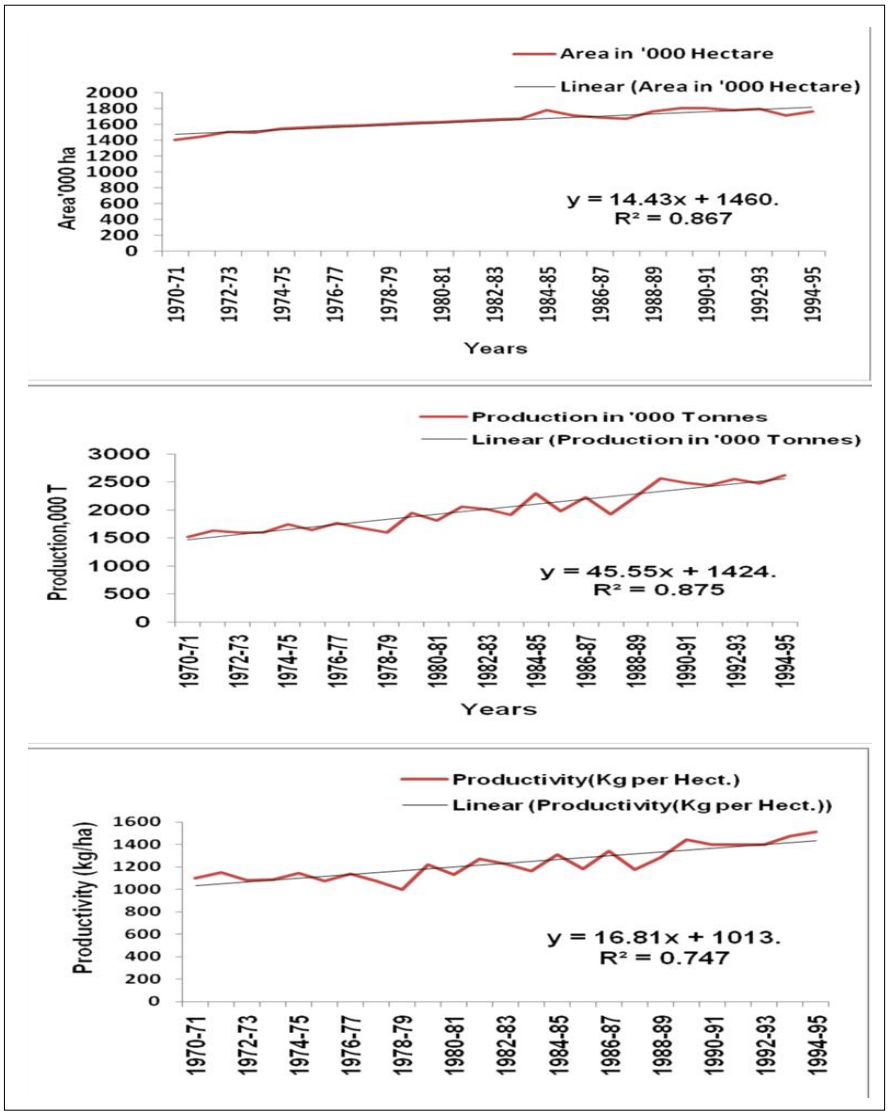

Fig 2: Trend of area, production and productivity of *kharif*/winter rice for period I (1970-71 to 1994-95)**.**

Table 1: Results of the fitted exponential function for area, production and productivity of *kharif*/winter rice in Assam during the study period.

Aspects	Period I (1970-71 to 1995-96)			Period II (1995-96 to 2020-21)			Overall period (1970-71 to 2020-21)		
	R^2	b_0	b_1	R^2	b_0	b_1	R^2	b_0	b_1
Area	0.863	0.000	0.009	0.405	0.057	0.005	0.632	0.433	0.004
Production	0.885	0.000	0.022	0.695	0.000	0.024	0.879	0.000	0.019
Productivity	0.740	0.000	0.013	0.768	0.000	0.019	0.896	0.000	0.015

Table 2: Compound annual growth rate (CAGR), CV and instability index (CDVI) for area, production and productivity of *kharif*/winter rice in Assam during the study period.

Aspects	Period I (1970-71 to 1995-96)			Period II (1995-96 to 2020-21)			Overall period (1970-71 to 2020-21)		
	CAGR (%)	CV (%)	CDVI	CAGR (%)	CV (%)	CDVI	CAGR (%)	CV (%)	CDVI
Area	2.09	6.92	2.56	1.16	5.78	4.46	1	7.434	4.510
Production	5.20	17.76	6.023	5.68	20.81	11.49	4.5	29.580	10.290
Productivity	3.04	11.62	5.925	4.47	15.94	7.68	3.5	23.095	7.448

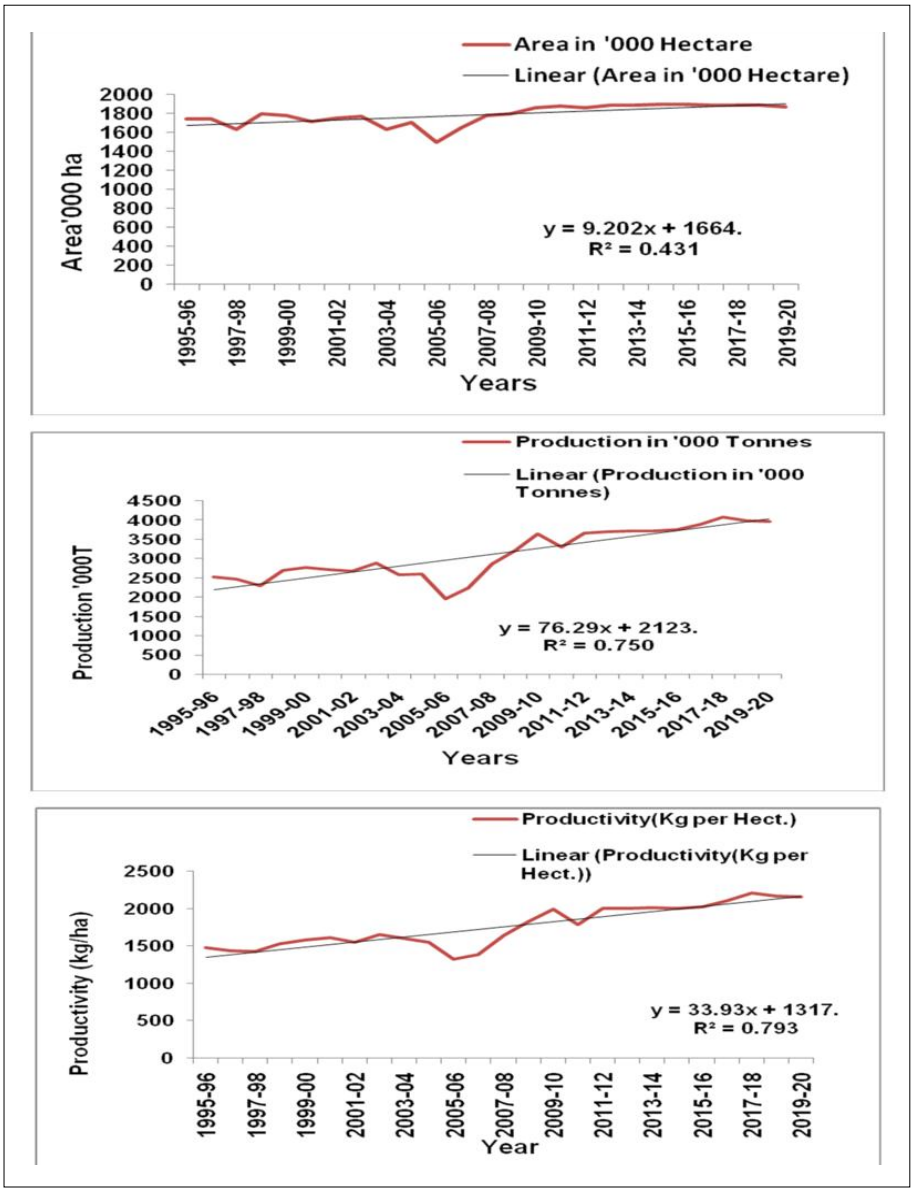

Fig 3: Trend of area, production and productivity of *kharif*/winter rice for period II (1995-96 to 2019-20).

CONCLUSION

The above discussion has revealed that the growth rate for area, production and productivity of *kharif*/winter rice is positive in our state for the last 50 years (1970-71 to 2019-20). The Compound Annual Growth Rate (CAGR) for production is highest with a value of 4.5% and CAGR for area and productivity is 1% and 3.5% respectively. The highest growth rate was observed in case of production for both the periods Period-I and Period-II**.** In case of instability studies, only production instability indices were highest indicating less risk involvement in growing of *kharif/winter* rice in Assam. The area effect and productivity effect was having higher contribution in increased production of *kharif*/winter rice in the state. Amongst area and productivity effect, the productivity effect has more contribution towards the growth. Also, productivity effect has been found higher for both the periods. The analysis overall indicates that the production is increasing positively and that may be because of farmers adaption of new developed varieties as well as adoption of new scientific technologies, fertilizers, pesticides *etc.* So, as *kharif*/winter rice is very important in terms of food and employment generation in our state Government can take the issue in concern and can formulate various policies appropriate to make our state self sufficient.

Conflict of interest

All authors declared that there is no conflict of interest.

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