Rice Production in India : Trend and Decomposition Analysis

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Abstract

The present paper attempted to study the growth rates in area, production, and yield of rice crop in India during four sub periods, mainly pre - green revolution period : 1950 - 51 to 1964 - 65 ; green and post - green revolution period : 1965 - 66 to 1989 - 90 ; post reforms period: 1990 - 91 to 2016 - 17, and overall period : 1950 - 51 to 2016 - 17 based on time series data collected from RBI and CMIE databases. The techniques like coefficient of variation, compound growth rates (CGR), and decomposition analysis were used for the analysis. The results of descriptive statistics showed that mean area, production, and yield of rice crop exhibited an increasing trend during different sub-periods and it was highest during the post - reforms period. Area displayed more volatility during different periods of the study. CGR results showed significant growth in area during pre and post green revolution periods, but during the post reforms period, it was yield, which showed significant growth as compared to area. Decomposition analysis indicated that area effect in enhancing the rice production declined over a period of time, but that of yield effect increased. Since land is limited in supply, more emphasis should be given to yield enhancement in order to meet the increasing demand for rice in the future.

Keywords: **decomposition, coefficient of variation, compound growth rate, area**

JEL Classification: C190, Q100, Q110

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India is the second most populous country in the world next only to China. The population of the country has been increasing over the years, posing a lot of challenges to the nation in respect of equitable allocation of resources among the people, food security, employment creation, poverty, health, and many other welfare aspects. Among all these, the most pressing task is to feed the ever increasing population, especially the poor, that is, ensuring food security for all is the major task in front of the government. Increasing population results into increased demand for food, and also, the rise in incomes of the people over a period of time further puts pressure on demand. Inelastic supply of land poses a major hurdle for the sustained increase in the supply of food grains. Rice is a staple food item consumed by all the people in the country. Hence, increasing the supply of rice in order to meet the increasing demand has become a major task for the government. Considering the importance of rice in the Indian economy, an attempt has been made in the present paper to analyze the growth status of rice area, production, and yield over a period of time. Secondly, how area, yield, and their interaction effects are contributing to rice production in the country during different periods is also examined.

Literature Review

In this section, the relevant literature has been reviewed, which has given the required direction for the present study. A number of studies have been conducted on various aspects of the rice economy in India. Some of the

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important and relevant works are discussed here. A study was conducted based on the time series data (1980 - 2014) to measure the contribution of area, yield, and their interaction to the rice production in India using decomposition analysis (Laitonjam, Singh, Yumnam, Kalai, & Meena, 2018). The authors also used exponential growth model to calculate the compound growth rates (CGR) of area, production, and yield of rice crop for the study period across different states in the country. The results of decomposition analysis revealed that yield effect contributed more compared to area for the growth of rice production. Increase in area under rice was meagre during the study period. Growth analysis indicated that Haryana registered highest growth rates in area and production and Odisha exhibited the highest growth in yield rates compared to other states. Many studies attempted to project the supply and demand of cereals in India (Ganesh - Mehta, Mehta, Pullabhotla, Prasad, Ganguly, & Gulati, 2012 ; Kumar, Joshi, & Mittal, 2016).

These studies opined that as far as rice production is concerned, India is in a position to manage the future demand for rice through its domestic supply, but felt that the management of surplus will be the biggest challenge before the government. Instability analysis of rice production in Gujarat state was done using coefficient of variation based on time series data (Singh, Dikshit, Reddy, & Kuthe, 2014). Though the area under crop cultivation increased during the study period, but high variability in yield resulted into fluctuating production of rice in the state. The results suggested for increased spending on research for enhancing the yield and to bring region - specific technology to achieve the same. It was further recommended for popularization of HYV seeds to enhance production of rice in the state.

Sub-period wise growth analysis of rice and wheat crops was done with the help of compound annual growth rates (CAGR) along with the decomposition analysis (Kumar & Shekhar, 2017). It was observed from the decomposition analysis that the rice area effect was negative compared to yield effect which was positive during 2000-01 to 2016. The study was conducted in two municipalities of Ghana to explore the impact of technological change on rice production based on the primary data collected from a sample of 216 small farmers growing rice crop (Tsinigo, Ohene - Yankyera, Fialor, & Asante, 2016). The modified decomposition technique and Cobb - Douglas production function were used for the analysis. The results showed that yield was significantly influenced by the seed, fertilizer, and herbicide in case of both improved and unimproved rice varieties. It was opined that technological change impacted the rice production in the study area and stressed upon the need of effective and appropriate extension activities and capacity building strategies for the farmers. The study on millet crops in Tamil Nadu was conducted based on secondary data using growth rates, instability, and decomposition analysis (Narmadha & Kandeepan, 2017). Based on the analysis, the need of effective policies aiming at enhancing the area under millet crops in Tamil Nadu was suggested.

The above literature review paves the way for the research methodology for the present study, which is discussed in the following section.

Research Methodology

(1) Data : The present study is based on the secondary data collected from the Data Base of Indian Economy (DBIE), RBI database, and Centre for Monitoring Indian Economy (CMIE) data sources. The data were collected on the variables: area, production, and yield of rice crop in India. The annual time series data pertained to the period from 1950 - 51 to 2016 - 17. The area, production, and yield of rice are measured in million hectares, million tonnes, and kg/hectare, respectively. The data analysis is carried out for different sub-groups. The data have been divided into three sub-periods keeping in view the important events that happened in the history which have influenced the rice crop in India. On the eve of independence, India was suffering from scarcity of food to feed its millions of people to avoid hunger deaths. So, the main objective was to increase food production by enhancing the area under food grains, but with limited success. During the late 1960s, agricultural scientists

developed high yield variety (HYV) seeds (rice, wheat, millets, and corn). This combined with increased use of fertilizers, pesticides, and irrigation facilities resulted into record food - grains production needed for India to achieve self-sufficiency in food grains production, which collectively is termed as green revolution (Green Revolution, n.d.). To study the impact of green revolution on rice crop, the analysis has been done for two sub periods, mainly pre-green revolution period and second as green and post-green revolution periods. Another major policy change that was witnessed in the Indian economy was introduction of reforms in the economic policies which were termed as liberalization policies that embraced all sectors, including agriculture.

This resulted into establishment of the World Trade Organization (WTO) and the agriculture sector was brought into the orbit of liberalization all over the world. To study the impact of these reforms, the third sub-period termed as post-reforms period was examined. The analysis was carried out taking into account the entire study period, and it is termed as over-all period. The details of the grouping of the data is given below :

(i) Pre-green revolution period : 1950 - 51 to 1964 - 65,

(ii) Green and post - green revolution period: 1965 - 66 to 1989 - 90,

(iii) Post reforms period: 1990 - 91 to 2016 - 17,

(iv) Overall period: 1950 - 51 to 2016 - 17.

(2) Techniques Employed: The tools and techniques used for the data analysis are discussed in this section:

(i) Descriptive Statistics : The descriptive statics like mean, standard deviation, and coefficient of variation have been used to read the time series data collected for the various periods. The coefficient of variation (CV), which is a measure of variation in the variables, is calculated by using the following formula :

$$CV = \frac{\sigma}{\bar{x}} * 100 \quad \text{.....(1)}$$

where, σ = standard deviation ; x = arithmetic mean

(ii) Compound Growth Rate (CGR) Analysis : The variables under consideration are area, production, and yield of rice in India. The performance of these variables during different study periods has been analyzed with the help of CGR that has been calculated as follows (Savadatti, 2017) :

$$X_t = ab^T \varepsilon_t \quad \text{.....(2)}$$

where,
X_t = value of the variable (area, production, and yield) at time *'t'*,
T = time variable assumes values for the years like 1950 - 51 = 1, 1951 - 52 = 2, ... 2016 - 17 = 68,
ε_t = random disturbance term,
a = intercept,
b = regression coefficient of T variable.

The compound growth rate is calculated as mentioned :
Convert the non-linear equation (2) into log-linear equation, which may be written as follows :

$$\ln X_t = \ln a + \ln b(T) + \ln \varepsilon_t \quad \text{.....(3)}$$

The equation (3) is linear in parameters ; hence, the ordinary least squares method is applied to estimate the equation. Then, CGR is calculated as follows :

$$CGR = (b - 1) \quad 100 \quad \text{.....(4)}$$

where, b is the antilog of ln b.

(iii) Decomposition Analysis : How area, yield, and the interaction between them have contributed to the change in the production of rice during different study periods have been analyzed with the decomposition technique and it is explained below (Bhovi & Savadatti, 2017) :

Change in Production = Area effect + Productivity effect + Interaction effect

$$\Delta P = \left[\frac{A_0.\Delta Y}{P}\right] + \left[\frac{A_0.\Delta A}{P}\right] + \left[\frac{\Delta A.\Delta Y}{P}\right] \quad \text{.....(5)}$$

where,

A_0 = Area under the rice crop in the base period,

Y_0 = yield of rice crop in the base period.

$\Delta P = P_1 - P_0$

Change in production = Production in current period - Production in base period.

$\Delta Y = Y_1 - Y_0$

Change in yield = Yield in current period - Yield in base period.

Analysis and Results

(1) Graphical Analysis : The Figure 1 depicts the plots of area, production, and yield of rice during the pre - Green Revolution period (1950 - 51 to 1964 - 65). Area under the crop showed a steady increase with a slight decline at the end of the period. During this period, area increased from 30.81 million hectares (mhs) to 36.46 mhs, which may be due to the government's efforts to increase the rice production during this period by bringing in more land under rice cultivation to meet the food requirements of post-independent India. Production showed an increasing trend (Figure 1), though with fluctuations during the pre-Green Revolution period (20.58 million tonnes in 1950-51 to 39.31 million tonnes in 1964-65), which was mainly due to increased area under the crop as the productivity during this period was low and exhibited a discouraging trend as evidenced by the Figure 1. The productivity marginally increased from 668 kg/hectare in 1950-51 to 1078 kg/hectare in 1964 - 65.

The Figure 2 depicts the scenario of rice crop during the second period (Green Revolution). All the three variables showed an increasing trend with fluctuations, but increase in area was low as compared to production and yield of rice. Area during this period showed an increase of 18.89% compared to production and yield, which showed an increase of 140.50% and 102.43%, respectively. During this period, yield showed a very impressive growth, which increased from 862 kg/hectare during 1965 - 66 to 1745 kg/hectare during 1989-90. This rise in yield was mainly due to introduction of HYV seeds in rice crop, increased land under cultivation, and bringing in more irrigational facilities combined with use of more fertilizers and pesticides - all contributed to an impressive increase in the yield of rice crop and in turn enhanced production, which was the main objective of the government as a part of the Green Revolution programme.

The post reforms data are presented in the Figure 3. During the post reforms period, area under rice cultivation was almost stagnant (Figure 3) and the increase was only around 1% ; hence, the increase in production (48.27%)

Figure 1: Area, Production and Yield of Rice Cultivation during Pre-Green Revolution Period

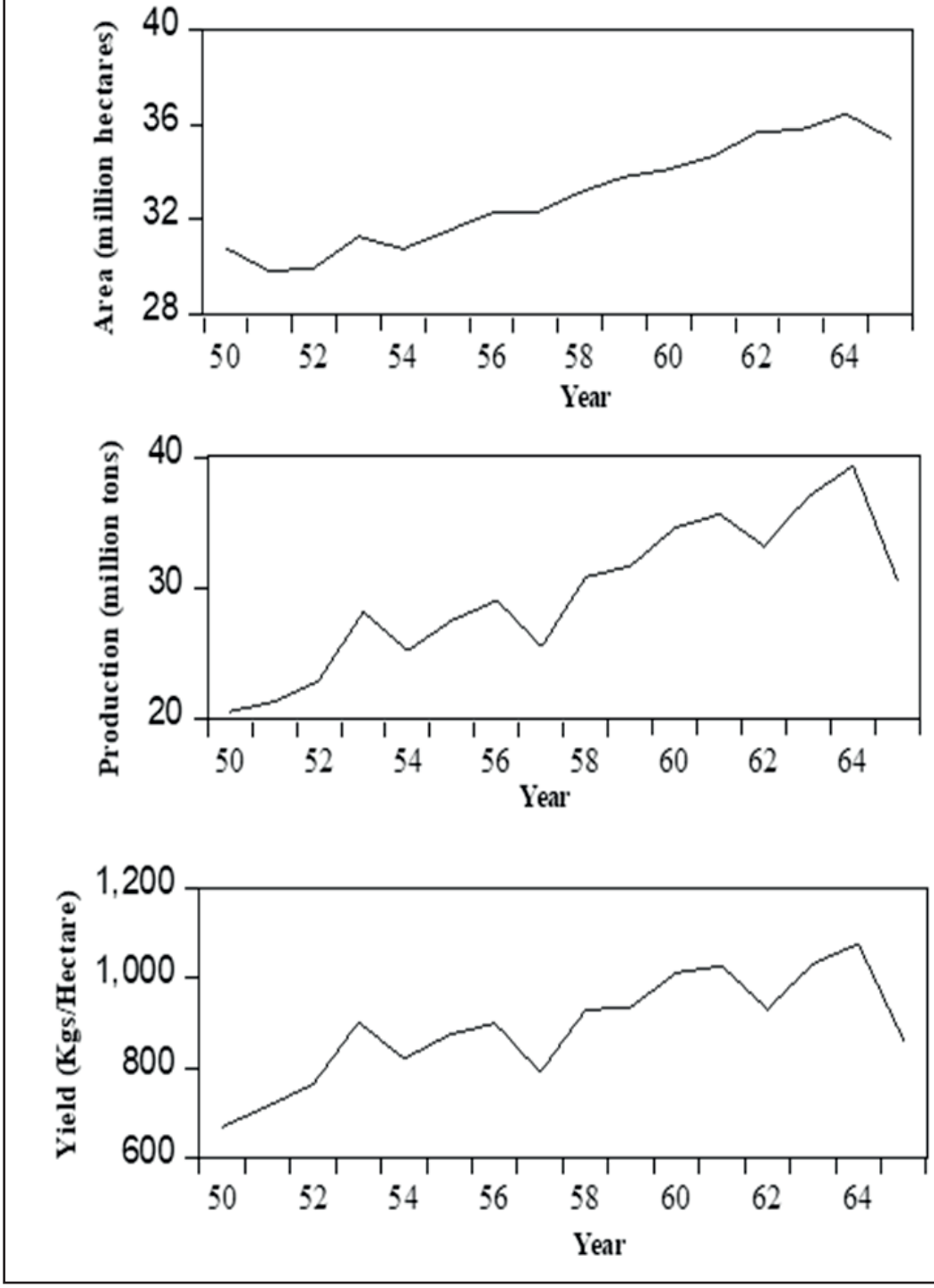


Figure 2: Area, Production & Yield of Rice in India during Green and Post Green Revolution Period

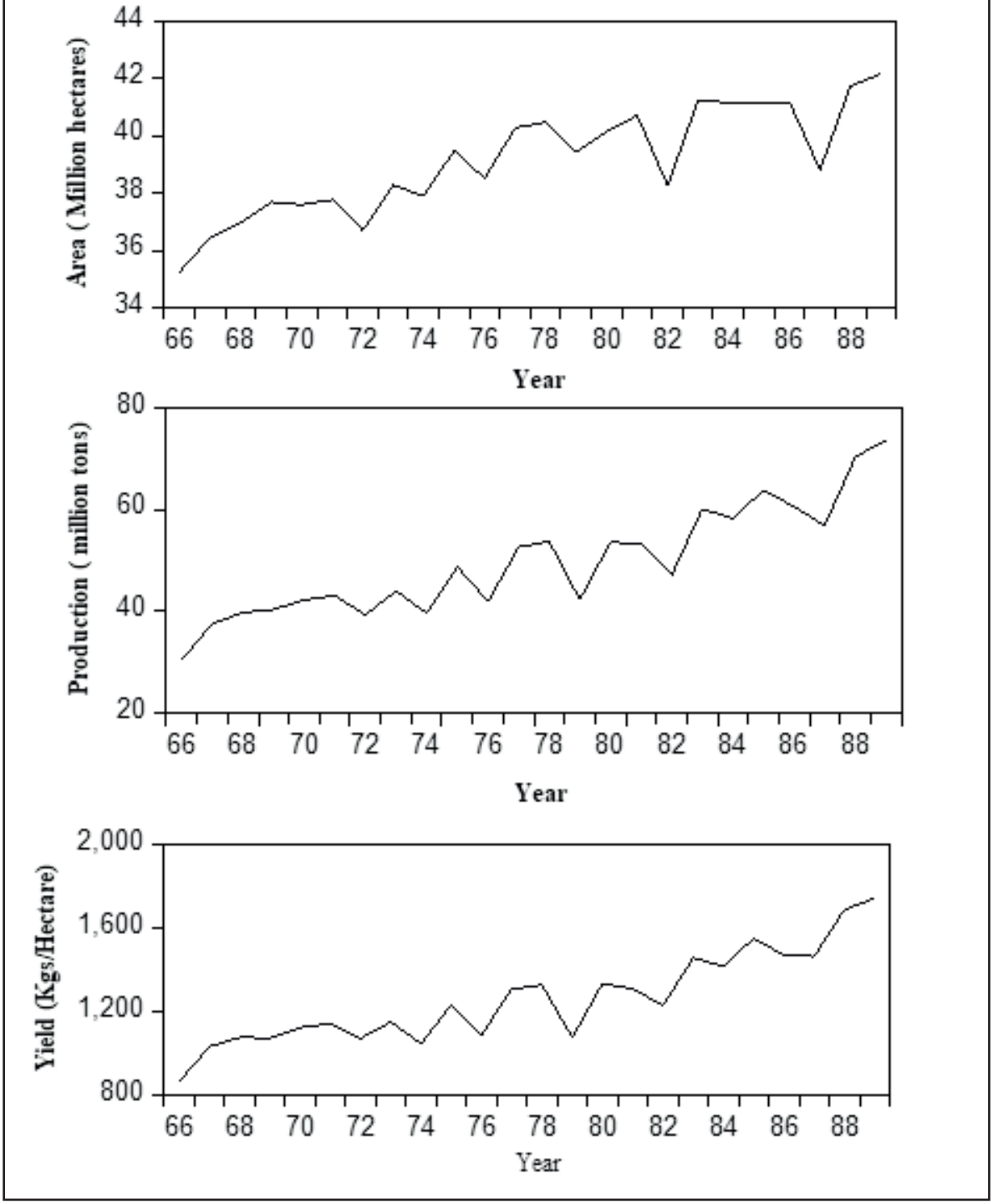


Figure 3: Area, Production & Yield of Rice in India during Post-Reforms Period

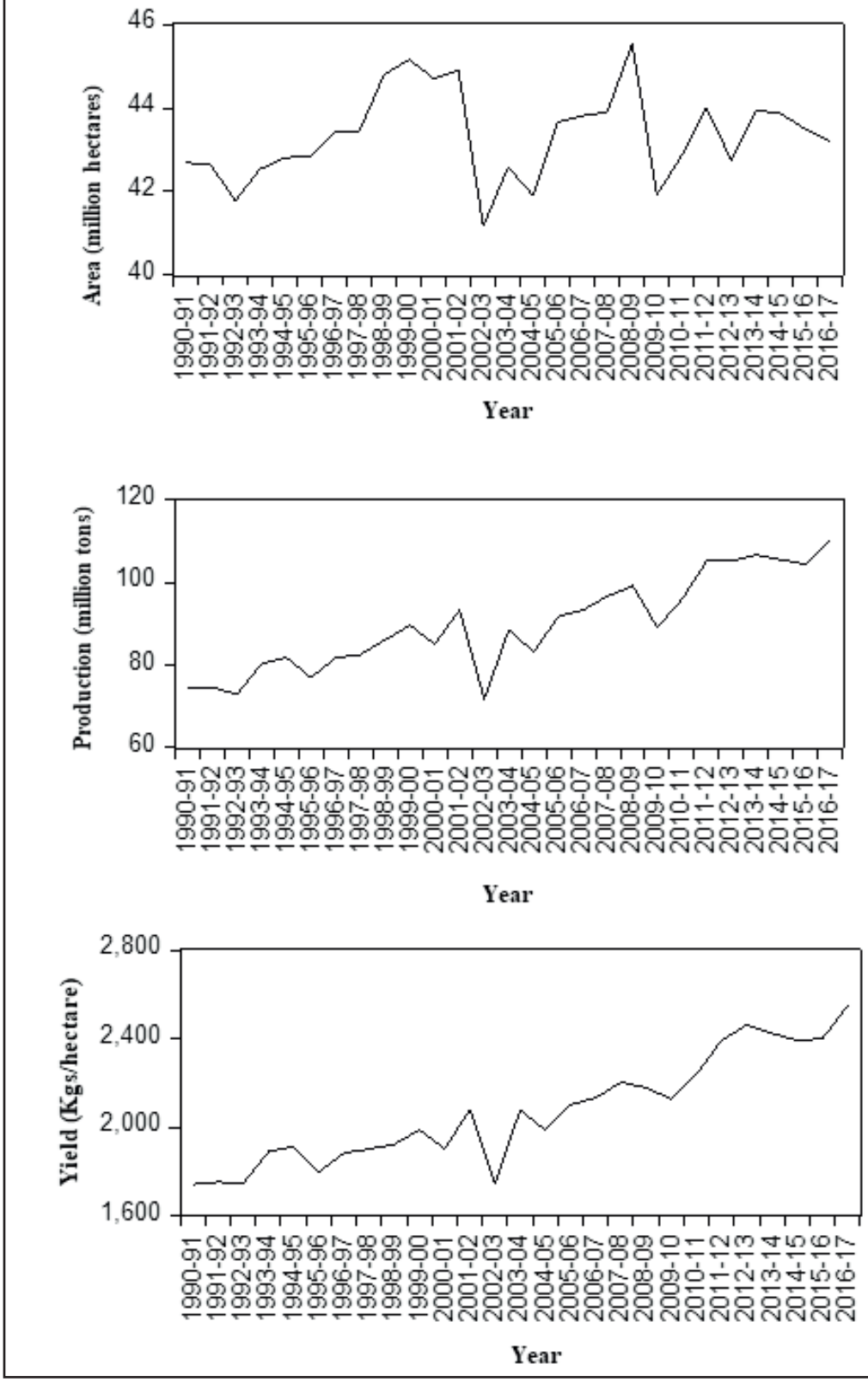
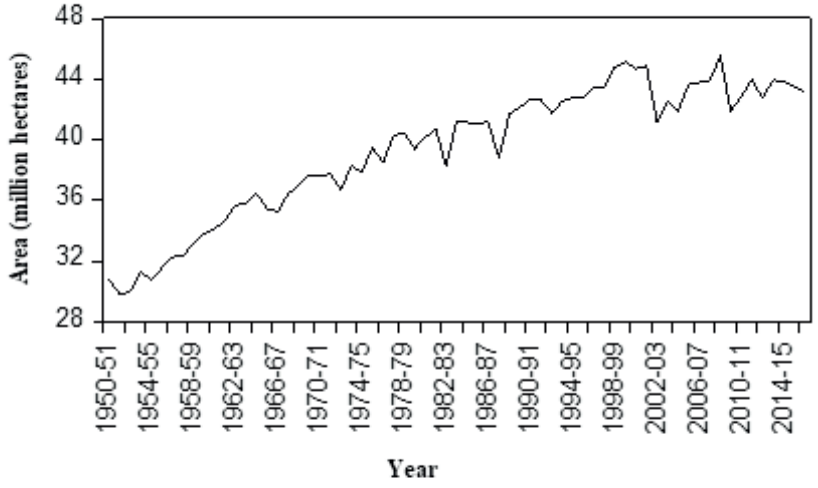
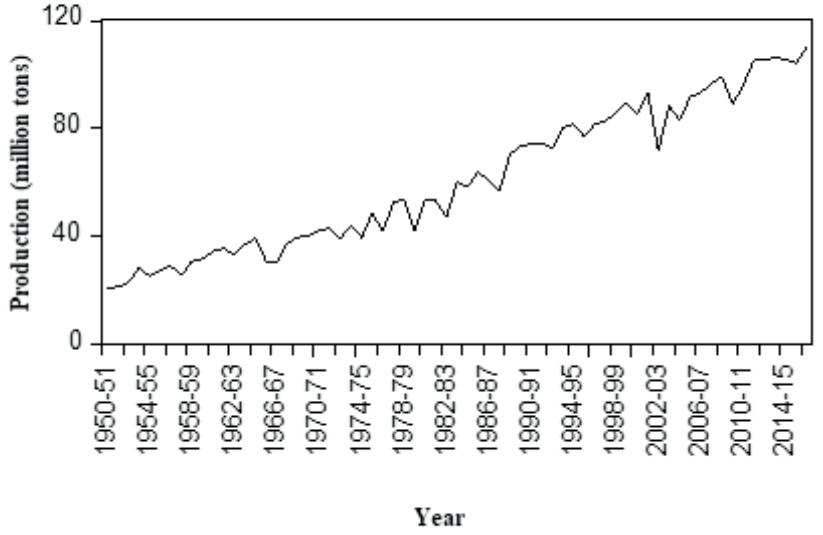
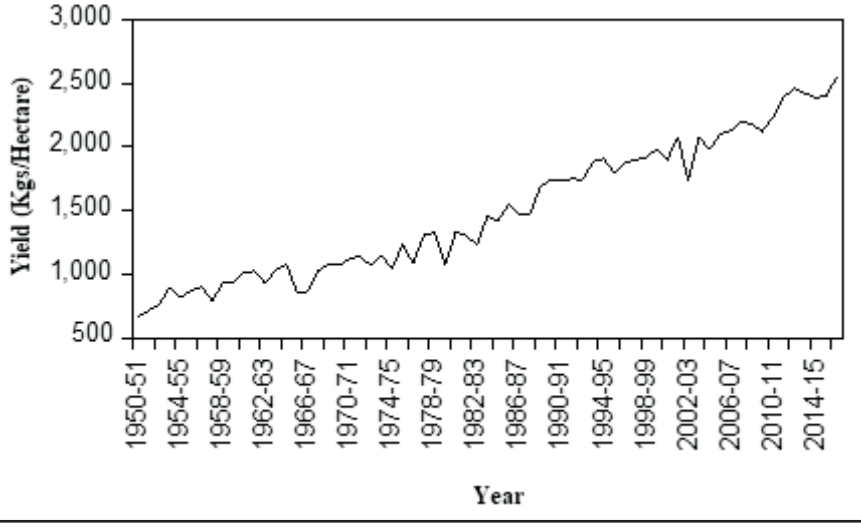


Figure 4: Area, Production & Yield of Rice in India (1950-51 to 2016-17)







was mainly from the enhanced yield which showed a 46.55% increase during the period. As the land is limited, the increase in production of rice came from the enhanced yield that happened during the post reforms period.

The graph of area, production, and yield of rice for the entire study period is presented in the Figure 4. During the overall period, all the variables showed an increasing trend, though the area trend showed more fluctuations compared to production and yield of rice. The area showed an increase of around 40% compared to production and yield, which exhibited 331% and 281% increase, respectively during the study period. The increase in production was mainly from yield, though area also contributed for the same.

(2) Descriptive Statistics : The descriptive statistics calculated for area, production, and yield shown in Table 1 throw more light on the analysis.

Mean area, production, and yield increased from the pre - Green Revolution period to green, post - green, and post-reforms periods. Mean area, production, and yield were highest during the post reforms period compared to other periods. Area under rice crop was more stable during the post-reforms period compared to the pre-Green Revolution, Green-Revolution, and post-Green Revolution period as evidenced by the values of *SD* and CV. This could be due to the fact that during the pre - Green Revolution period, India was facing huge food grain scarcity; wherein, the government tried to enhance food grain production in general and rice production, in particular, by bringing in more land under the crop. Secondly, during the Green Revolution period, rice production enhanced by bringing in more land under cultivation and use of HYV seeds of rice, which resulted into more rice yield that encouraged the farmers to expand the land under rice cultivation. Because of these measures, the volatility in area was more during these periods compared to what it was in the post reforms period. During the overall period, volatility in the area variable was high.

Table 1. Descriptive Statistics

Period	Description	Area	Production	Yield
Pre - Green Revolution	Mean	33.00	29.58	890.25
	SD	2.138351	5.406924	113.9559
	CV	6.479728	18.2813	12.80043
Green and Post - Green Revolution	Mean	39.14	49.73	1261.63
	SD	1.89	10.98	222.67
	CV	4.84	22.09	17.65
Post - Reforms	Mean	43.35	89.85	2070.37
	SD	1.087847	11.49937	246.1532
	CV	2.509579	12.79777	11.88933
Overall	Mean	39.37	61.09	1498.85
	SD	4.343408	26.76771	532.7984
	CV	11.03278	43.81856	35.54713

Note. **SD* : Standard deviation, CV : coefficient of variation

(3) Compound Growth Rate Analysis : How the area, production, and yield have grown over a period of time has been studied with the help of CGR analysis, and the results are detailed in the Table 2.

It can be seen from the Table 2 that the area grew significantly during the pre-green, green, and post-green revolution period (significant at the 1% level), which could be due to the government's efforts and effect of Green Revolution programs, which encouraged the farmers to increase the area under rice crop cultivation, which is the

Table 2. Compound Growth Rate Results

Period	Particulars	Area	Production	Yield
Pre - Green Revolution	CGR	1.37223	3.694097	2.288698
	Probability	0.0000	0.0000	0.0000
	R^2	0.9408	0.7903	0.6246
Green & Post - Green Revolution	CGR	0.602407	2.875363	2.258834
	Probability	0.0000	0.0000	0.0000
	R^2	0.7615	0.8375	0.8241
Post - Reforms	CGR	0.061819	1.464216	1.395954
	Probability	0.3284	0.0000	0.0000
	R^2	0.9938	0.8090	0.8752
Overall	CGR	0.552923	2.446139	1.88362
	Probability	0.0000	0.0000	0.0000
	R^2	0.8510	0.9600	0.9621

staple food consumed by more than 60% of the population. This analysis reinforces the above discussion. Yield of rice also showed significant growth during pre - green, green, and post - Green Revolution period, which resulted into high production of rice. During the post-reforms period, a significant production of rice observed was mainly due to impressive growth in yield, which was significant at the 1% level. However, growth of area under rice crop cultivation was insignificant. During the overall period, all the three variables: area, production, and yield showed significant (at 1% level) positive growth.

(4) Decomposition Analysis : The production of rice showed an impressive growth during different sub-periods and also during the entire study period. Hence, it is interesting to study how the area and yield have contributed to the production of rice during different sub-periods ; hence, the decomposition analysis has been used, and the results of the same are discussed in this section. The results of decomposition technique for different periods are shown in the Table 3. The observation of the results presented in Table 3 indicates some interesting facts. The area effect in enhancing the production declined over a period of time through pre - Green Revolution period (31%) to post-reforms period (2.4%), but that of yield effect increased during the same period from 59.7% to 96.4%, signalling that the yield effect played a significant role in increasing the production of rice during the study period.

The pre - Green Revolution period witnessed that area effect and yield effect contributed to a greater extent in enhancing the production of rice, though the yield effect was greater than the area effect. Interaction effect also contributed for the production. Green and post Green Revolution period results showed that yield effect contributed significantly (72%) in enhancing the rice production followed by interaction effect and area effect

Table 3. Results of Decomposition Analysis

Period	*ΔP	Area Effect	Yield Effect	Interaction Effect
Pre - Green Revolution	10.01	31.0977	59.71169	9.031369
Green & Post - Green Revolution	43.13	13.84642	72.08556	14.15126
Post - Reforms	35.86	2.426102	96.4275	1.129392
Overall	89.57	9.232823	64.73643	26.01224

Note. *absolute change in production in million tonnes.

(around 14%). This was mainly due to the adoption of new agricultural strategy that resulted into use of modern technology and replacing old agricultural practices by new practices. Introduction of HYV seeds, enhancing irrigational facilities available for cultivation, use of fertilizers and pesticides, multiple cropping systems, all these resulted into an increase in rice cultivation during this period, which helped the country to overcome its food crisis problem. The results of decomposition analysis amply support this point as the yield effect is quite high compared to the area effect, and the area effect declined during the post - green period compared to pre - Green Revolution period. However, the interaction effect also contributed sufficiently for the increase in production. The post-reforms period exhibited increase in absolute production, which was lower compared to the post - Green Revolution period. So, the production rate decreased, which is not good for the country as rice is a staple food for majority of the population in India. This increase in production was mainly from yield effect as the area effect and interaction effect are very meagre. During this period, area under the rice cultivation was stagnant as the increase in production came from increased yield as the interaction effect was also very small.

The entire study period analysis reveals that rice production increased over a period of time, and this increase was due to yield effect and interaction effect (area and yield) and area effect was meagre (9%). Over the period, area under the rice crop cultivation was stagnant, especially during the post reforms period compared to other sub-periods due to crop diversification and inelastic nature of land supply ; hence, any increase in production came from yield, which is reflected in yield effect during the overall period. The interaction effect also contributed to some extent for production enhancement during the study period.

Conclusion and Policy Implications

The analysis of area, production, and yield of rice crop for different sub-periods presented above clearly indicate that rice production increased significantly during the study period, and Green Revolution played an important role in this. However, it is observed from the results that over a period of time, the increase in rice production came from enhanced yield as the area under rice cultivation became stagnant. However, the demand for rice will continue to increase due to factors like increasing population, rising income levels of people, growing urbanization, increasing demand for dairy products due to diversification in the consumption pattern resulting into rising demand for feed, etc. India may likely face a deficit in rice production to the tune of 3 to 5 million tonnes in the near future (Kumar et al., 2016). Rice will continue to be an important source of nutrition and energy to the millions of people in India, necessitating the emergency in enhancing the production of rice. Hence, more focused efforts are required to increase rice production by bridging the gap between the potential yield and actual yield.

Limitations of the Study and Scope for Further Research

The present analysis is an attempt to understand the rice scenario of India based on the secondary data with the help of trend and decomposition analysis, but the study did not focus its attention on the other important aspects like factors influencing rice production, demand, supply, and marketing aspects. More in-depth analysis focusing on the factors influencing the present trends in the area, yield, and production of rice using econometric modelling could throw more light on the analysis and may be useful for the policy makers. Also, analysis based on the primary data focusing on farmers' problems in production and marketing of rice would be an area for further research.

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