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Estimation of growth rates and decomposition analysis of rice and wheat production in India

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Abstract
The paper investigates the trends in production, area and yield of rice and wheat in India from 1950-51 to 2015-16. The study divides the data into five intervals namely, 1950-51 to 1966-67, 1967-68 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-01 to 2015-16. The study clearly finds that production Compound annual growth rate (CAGR) of rice was highest at 3.61 percent during the period of 1980-81 to 1989-90. During this period the yield CAGR of rice was also highest at 3.18 percent while area CAGR was at merely 0.41 percent. The production CAGR of wheat was highest at 5.40 percent during the period 1967-68 to 1979-80. During the same period area and yield CAGR of wheat was also highest at 3.11 percent and 2.29 percent respectively. CAGR of rice and wheat production was minimal at 1.83 percent and 2.49 percent respectively in the period of 2000-01 to 2015-16. During this period yield CAGR of wheat is minimum at 1.15 percent while area CAGR of rice minimum at 0.02 percent. The decomposition analysis of production suggest that during 1980-81 to 1989-90 and 1990-91 to 1999-2000, the yield effect was major source of both rice and wheat production growth while interestingly the area effect was dominating for both rice and wheat during the period of 1967-68 to 1979-80. During the period 2000-01 to 2015-16 the area effect for rice production growth was negative while yield effect was 116.42 percent. However for wheat production area effect was dominating the yield effect for wheat production.

Keywords: wheat, rice, India, CAGR, decomposition, yield and area

1. Introduction
Rice and wheat are the staples of the Indian diet, and therefore their production and production growth are in the center of food security in India. The production of these two crops was insufficient and stagnant before the green revolution in the mid-1960s. During the same period the size of population was increasing very rapidly which results in decrease in food availability per person (Aggarwal, Talukdar and Mall 2000) [5]. However after introduction of green revolution the production of these two crops increased considerably. The production of rice has increased from 37.61 MT in 1967-68 to 93.34 MT in 2001-02 and to 104.32 MT in 2015-16 whereas the production of wheat has increased from 16.54 MT in 1967-68 to 72.77 MT in 2001-02 and to 93.50 MT in 2015-16. Production trend of rice and wheat are plotted in figure 1, where solid line is for the wheat production and thin line is for rice production.

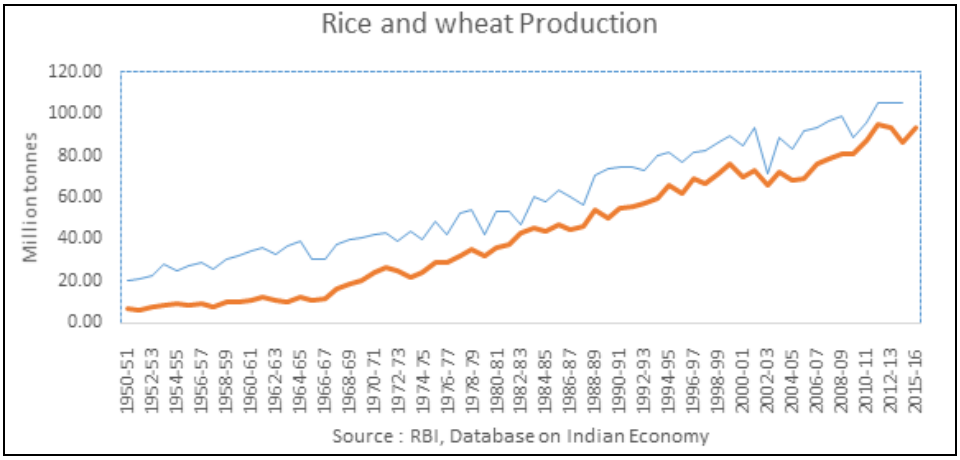

Fig 1

2. Review of Literature
Shadmehri (2008) [4] examine the trends in area, production and yield along with analysis of decomposition of output growth of main crops of Iran's agriculture for the period 1970-71 to 1999-2000. Compound annual growth has calculated from semi-log model and decomposition of output growth examined by fitting component analysis model. The study concludes that main source of agricultural production growth during the study period has been the growth in yield per hectare and expansion in irrigated area.

Singh, Das, Roy and Tripathy (2015) [3] investigates the trend in area, production and yield along with decomposition analysis of production growth of oil seeds in the northwest states of India during the period of 1982-83 to 2011-12. The study concludes that more than half of the area under oilseeds cultivation suffered from low growth in production. Nagaland and Arunachal Pradesh showed the better performance for the growth in area and yield comparison to other north east states. Decomposition analysis of growth suggest that yield effect is the major source of output growth during the study period.

Rahaman, Saeed and Salam (2011) [2] investigate the trends in area, production and yield of major crops (wheat, rice, sugarcane, and cotton) of Pakistani agriculture by using component analysis model. The study also use decomposition analysis of production growth of individual crops for the period of 1972-2009. The study concludes that major source of output growth in case of wheat and cotton was yield effect but for sugarcane and rice the main growth source was area effect.

Kalamkar (2003) [1] analyses the agriculture growth and the contribution of various components to the overall output growth in agriculture of the Maharashtra state for the period from 1961-62 to 1997-98. For the overall period of study, except jowar, bajra and wheat all other crops recorded a growth in area. The growth in production and productivity of all these crops was visible in the period of 1971-72 to 1980-81 whereas commercial crops recorded remarkable increase during third period 1981-82 to 1997- 98 of the study.

3. Objectives of the Study

a. To examine Compound Annual Growth Rates (CAGR) of production, area and yield of Rice and wheat.
b. To examine the sources of rice and wheat growth using the Decomposition analysis.

4. Data and Methodology

The study is based on secondary data (annual) for the 66 years period from 1950-51 to 2015-16. Data on production, yield and area under rice and wheat cultivation has collected from RBI website. The time period has been divided into five intervals namely 1950-51 to 1966-67, 1967-68 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-2000, and 2000-01 to 2015-16.

The CAGR is estimated by fitting a semi-log model as follows:

$$\mathbf{LogY} = \boldsymbol{\alpha} + \boldsymbol{\beta}\mathbf{t} + \mathbf{u}$$

Where Y defines the time series data on production, area and yield of rice and wheat and‘t’ is the trend term. “The slope coefficient β measures the relative change in Y for a given change in the value of independent variable‘t’. If we multiply the relative change in Y by 100, we will get percentage change or growth rate in Y for an absolute change in variable‘t’ ” (Rehman, Ikram and Salam 2011) [2]. The compound growth rate can be calculated by using the following formula:

$$\boldsymbol{CAGR = (antilog\ \beta - 1) * 100}$$

To measure the relative contribution of area and yield towards the total production change of rice and wheat, the technique of decomposition has been adopted. As per this technique the change in the production between any time periods can be expressed as –

$$\boldsymbol{\Delta P = Y_0 \Delta A + A_0 \Delta Y + \Delta A \Delta Y}$$

$$\textit{Change in total production} = \textit{Area effect} + \textit{Yield effect} + \textit{Interaction effect}$$

Thus, “the total change in production can be decomposed into three effects viz. yield effect, area effect and the interaction effect due to change in yield and area”(Kalamkar,2003) [1].

5. Results and Discussion

Table I show the production, yield and acreage CAGR of rice and wheat for different time period namely, 1950-51 to 1966-67, 1967-68 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-01 to 2015-16. During the period of 1950-51 to 1966-67, the period before green revolution, the compound annual growth rate of production of rice and wheat was 3.16 percent and 3.59 percent respectively. During this period area growth was the main source of production growth for wheat while yield growth was the main source of production growth of rice. However during the late sixties, high yield varieties seeds (HYVS) along with fertilizer, improved coverage of irrigation, institutional reforms results in increase in yield for both rice and wheat. During the period from 1967-68 to 1979-80, the CAGR of rice and wheat were 1.94 percent and 5.40 percent respectively. During this period area growth and yield growth both were higher in case of wheat. Which result in higher CAGR for wheat than that of rice. During the period of 1980-81 to 1989-90 the CAGR of rice and wheat were 3.61 percent and 3.57 percent respectively. The main source of the growth for both rice and wheat were the yield growth while area growth was limited. Yield CAGR for rice and wheat were 3.18 percent and 3.09 percent respectively. During the period just after economic reform i.e. from 1990-91 to 1999-2000, the CAGR registered by rice and wheat were 2.04 percent and 3.60 percent respectively. In this period both area growth and yield growth play almost equal role in the growth of wheat production. During 2000-01 to 2015-16 the CAGR registered by rice and wheat were 1.83 percent and 2.49 percent respectively. The yield CAGR during this period was merely 0.02 percent therefore area growth was the main source of the production growth of rice.

Table 1: Compound Annual Growth Rates of Area, Production and Yield of rice and wheat

Crops	1950-51 to 1966-67		1967-68 to 1979-80		1980-81 to 1989-90		1990-91 to 1999-2000		2000-01 to 2015-16	
	rice	wheat	Rice	Wheat	Rice	wheat	rice	Wheat	Rice	wheat
Production	3.16	3.59	1.94	5.40	3.61	3.57	2.04	3.60	1.83	2.49
Area	1.27	2.05	0.76	3.11	0.41	0.46	0.69	1.72	0.02	1.38
Yield	1.85	1.50	1.17	2.29	3.18	3.09	1.34	1.83	1.79	1.15

Source: Computed by authors from RBI, Database on Indian Economy

6. Decomposition and Output Growth of Rice and wheat

The growth analysis of area, production and yield of rice and wheat revealed the general pattern of growth and direction of changes in yield and area. However this analysis does not evaluate the contribution of area and yield towards the production growth. So, it is necessary to examine the sources of output growth. To appraise the sources of output growth for major crops, the change in production is divided in to three effects i.e., area effect, yield effect and interaction effect. The relative contribution of area, yield and their interaction to changes in production of individual crops is presented in Table II.

Table 2

Decomposition of growth in production of Rice and Wheat (1950-51 to 1966-67)				
Crop	Area Effect	Yield Effect	Interaction effect	Change in Output
Rice	30.14%	61.05%	8.80%	100%
Wheat	41.59%	44.83%	14.05%	100%
Decomposition of growth in production of Rice and Wheat (1967-68 to 1979-80)				
Crop	Area Effect	Yield Effect	Interaction effect	Change in Output
Rice	65%	32.35%	8.80%	100%
Wheat	51.75%	32.62%	14.05%	100%
Decomposition of growth in production of Rice and Wheat (1980-81 to 1989-90)				
Crop	Area Effect	Yield Effect	Interaction effect	Change in Output
Rice	13.53%	82.33%	4.16%	100%
Wheat	14.70%	80.87%	4.43%	100%
Decomposition of growth in production of Rice and Wheat (1990-91 to 1999-2000)				
Crop	Area Effect	Yield Effect	Interaction effect	Change in Output
Rice	27.89%	68.16%	3.94%	100%
Wheat	35.67%	56.56%	7.77%	100%
Decomposition of growth in production of Rice and Wheat (2000-01 to 2015-16)				
Crop	Area Effect	Yield Effect	Interaction effect	Change in Output
Rice	-12.99%	116.42%	3.43%	100%
Wheat	51.14%	41.57%	7.27%	100%

Source: Computed by authors from RBI, Database on Indian Economy

Decomposition analysis shows that during the period of pre green revolution i.e. from 1950-51 to 1966-67 the yield effect was dominating for both rice and wheat growth. The contribution of yield in the growth of rice and wheat was 61.05 percent and 44.83 percent while that of area effect was 30.14 percent and 41.59 percent respectively. In the period of just after green revolution i.e. from 1967-68 to 1979-80 the area effect was dominating for both rice and wheat. The area effect and yield effect were 65 percent and 51.75 percent whereas yield effect was 32.35 percent and 32.62 percent for rice and wheat respectively. In the period during 1980-81 to 1989-90, the yield effect was dominating for both rice and wheat. The yield effect was 82.33 percent and 80.87 percent for rice and wheat respectively. During the period of 1990-91 to 1999-2000 the yield effect was dominating but its contribution has decreased relative to its contribution in the period of 1980-81 to 1989-90. The yield effect for rice and wheat was 68.16 percent and 56.56 percent respectively. During the period from 2000-01 to 2015-16 the area effect was negative (-12.99%) for rice but yield effect was 116.42 percent. For wheat area effect and yield effect was 51.14 percent and 41.57 percent respectively.

7. Conclusion

The study clearly finds that production CAGR of rice was highest at 3.61 percent during the period of 1980-81 to 1989-90. During this period the yield CAGR of rice was also highest at 3.18 percent while area CAGR was at merely 0.41 percent. The production CAGR of wheat was highest at 5.40 percent during the period 1967-68 to 1979-80. During the same period area and yield CAGR of wheat was also highest at 3.11 percent and 2.29 percent respectively. The minimum CAGR of rice and wheat production was at 1.83 percent and 2.49 percent respectively in the period of 2000-01 to 2015-16. During this period yield CAGR of wheat is minimum at 1.15 percent while area CAGR of rice minimum at 0.02 percent. The decomposition analysis of production suggest that during 1980-81 to 1989-90 and 1990-91 to 1999-2000, the yield effect was major source of both rice and wheat production growth while interestingly the area effect was domination for both rice and wheat during the period of 1967-68 to 1979-80. During the period 2000-01 to 2015-16 the area effect for rice production growth was negative while yield effect was 116.42 percent. However for wheat production area effect was dominating the yield effect for wheat production.

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