Growth trends of Food Grains in India; Yield, Area and Production: An Approach to Structural Stability Regression Model

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ABSTRACT— The growth, trend, and structural stability of agricultural production – food grains, as well as the area and yield of agricultural production reflect the contribution and stability of an economy. The objective of this research is to evaluate the growth, trend, and the structural stability of food grain production, area under cultivation, and yield per hectare in India before (1980-2000) and after the new agricultural policy (2001-2020). To accomplish the objectives, secondary data was gathered from the Handbook of statistics on the Indian economy (2020–21) by RBI. To estimate and compare the growth of production, area, and yield of the food grain, the structural stability regression model, t test, and trend line were used. According to the study, average production and yield increased by 42.54 percent and 44.23 percent, respectively, from 1980 to 2000 to 2001-2020, although the area decreased by -1.50 percent. Food grain production and yield are increasing, although the compound annual growth rates for production, area, and yield are -14.41 percent, -265.13 percent, and -28.69 percent, respectively. The study also discovered that food grain production and area under cultivation in India has a structural change over time. Increased food grain production was primarily driven by increased area, yield per hectare, and shifts in production patterns. As a result, the focus should be on expanding the area by utilizing adequate land and increasing yield through technical innovation, agricultural research, and training, as well as boosting policy implementation in India.

KEYWORDS: Regression, Structural Stability, Production, Food grains, Yield

1. INTRODUCTION

Agriculture makes a significant contribution to the Indian economy, accounting for over 17% of total GDP and employing more than 60% of the population. Agriculture is the primary source of income for approximately for 58 percent of India's population. On a sector-by-sector basis, agriculture and related sectors account for 20.19 percent of GDP. The agricultural sector ensures food security and nutrition for India's vast population, as well as supplies of massive amounts of raw materials for strengthening the country's industrial base and creating surpluses for export. Better irrigation systems, pre-monsoon rainfall, the introduction of new technologies, investment, mechanization, seeds, pricing policies, and other factors all contributed to the massive increase in food grain and commercial crop production. The crops section calculated that food grain production increased from 1295.9 million tonnes in 1980–81 to 2975 million tonnes in 2019–20, with a growth rate of 129.57 percent. During the same period, the area under food grain cultivation (in lakh hectares) and yield (kg per hectare) were 1267 to 1270 lakh hectares and 1023 to 2343 kg per hectare, respectively, with growth rates of 0.236 percent and 129.03 percent. Given the usual monsoon projection, India's food grain production increased at a rate of 129.57 percent. Drought and unseasonal rainfall wreaked havoc on crops in a number of states throughout the country. The National Food Security Mission is being implemented in all

states of the country to increase food grain production and productivity. Rice is an important staple food in India, and it continues to play a significant part in the country's food and livelihood security system. Rice, on the other hand, has lower productivity than the global average. Rice production, area, and yield were 536.3, 402, and 1336, respectively, in 1980–81; in 2019–20, they were 1188.7, 437, and 2722, with growth rates of 121.6, 8.7%, and 103.7 percent, respectively. Similarly, wheat output, area, and yield were 363.1, 223 and 1630, respectively, in 1980–81; in 2019–20, they were 1078.6, 314, and 3440, with growth rates of 197.1 percent, 40.8 percent, and 111.1 percent, respectively. Coarse cereals, like coarse cereals, are used as human food, as well as feed and fodder for cattle. In 1980-81, production, area, and yield were 290.2, 418, and 695, respectively, while in 2019-20, they were 477.5, 240, and 1991, with growth rates of 64.5 percent, -42.6 percent, and 186.5 percent. Pulses are a vital source of protein for humans, and India is one of the world's major producers and consumers. Pulse output, area, and yield increased by 116.7 percent, 24.4 percent, and 73.9 percent, respectively, from 106.3, 225, and 473 in 1980–81 to 230.3, 280, and 823 in 2019–20. As a result, total output, area, and yield of coarse cereals have increased by 130.7 percent, -5 percent, and 142.7 percent, respectively, from 1189.6, 1042, and 1142 in 1980–81 to 2744.8, 990, and 2772 in 2019–20. The Indian government unveiled the New Agricultural Policy in July 2000. The government purposefully and consciously created this policy to promote the growth and development of agricultural production and productivity, thereby increasing income, employment, and living standards. This policy aimed to promote the agriculture sector's overall development. The goal of the policy was to promote the agriculture sector to attain more than in 4% each year. Other goals include increasing input productivity, increasing value added per hectare, safeguarding the interests of impoverished farmers, modernizing agricultural sectors, preventing environmental degradation, agricultural research and training, and removing bureaucratic barriers, among others. The new agricultural strategy aims to promote the ideals of sustainability in the agricultural sector by introducing economically feasible, technically sound, environmentally non-degrading, non-hazardous, and socially acceptable use of the country's natural resources. After the new agricultural policy, Rice output, area, and yield increased by 39.88 percent, 2.24 percent, and 43.2 percent, respectively, from 849.8, 447, and 1901 in 2000-01 to 1188.7, 437, and 2722 in 2019–20. Wheat output, area, and yield increased by 54.8 percent, 22.2 percent, and 27 percent, respectively, from 696.8, 257, and 2708 in 2000-01 to 1078.6, 314, and 3440 in 2001-02. In the case of coarse cereals, output, area, and yield increased from 310.8, 303, and 1027 in 2000-01 to 477.5, 240, and 1991 in 2019-20, respectively, with growth rates of 53.6, 20.8, and 93.8 percent. Similarly, production, area, and yield of pulse food grains increased by 108 percent, 37.2 percent, and 51.3 percent, respectively, from 110.7, 204, and 544 in 2018-19 to 230.3, 280, and 823 in 2019-20. Total coarse cereals output, area, and yield increased by 48.3%, 1.69 percent, and 50.3 percent, respectively, from 1857.4, 1007, and 1844 in 2000-01 to 2744.8, 990, and 2772 in 2019-20. As a result of the new agricultural policy (2000), total food grain production (in lakh tonnes), area under cultivation (in lakh hectares), and yield (kg per hectare) have changed from 1968.1, 1211, and 1626 in 2000-01 to 2975, 1270, and 2343 in 2019-20; and the growth rate of production, area, and yield per hectare of food grain has been 51.2 percent, 4.87 percent, and 44.1 percent, respectively. Therefore, the purpose of this research was to assess the growth trend in agricultural production – production of food grain, area, and yield per hectare before and after the new agricultural policy, as well as the structural stability of agricultural production—food grains, from 1980–81 to 2019–20.

2. LITERATURE REVIEW
Recent literature on the area, production, and yield of agricultural production of the food grains are mainly concentrated in this study. Some recent contributions are presented below.

In a paper published by [9], he investigated the impact of globalization on the area, production, and productivity of food grains in India. According to the report, the post-reform period had a negative impact on

India's food grain acreage, output, and productivity. As the area under which food grains are grown has shrunk, so has the amount of food grains produced. [18] discovered favourable trends in food grain production and yield in the North Eastern states in the study "Trends of Area, Production, and Productivity of Food Grain in the North Eastern States of India."

Trends in India's Agricultural Growth and its Determinants," by [10]. According to the study, India's cropping patterns have changed dramatically over time, with a clear shift away from food grain production and toward commercial crops. Cultivation of coarse cereals fell by 13.3 per cent throughout the study period. The output and area of pulses were not working properly during this time. Increased crop yields were aided by modern seed varieties, fertilizers, irrigation systems, and other factors.

[11], "Agricultural Productivity Trends in India: Sustainability Issues" The long-term viability of crop production is becoming more critical. The post-green revolution era is characterized by high input utilization and a slowing rise in total factor productivity. increases in agricultural R & D spending, which boosts total factor output. Agriculture research and development receives a lot of focus in the Indian economy. In India, cropping patterns have evolved away from food grain production to commercial crop development.

According to [21], "Analysis of growth trends in the Indian agricultural sector". Food grain yields grew as a result of the use of high-quality seeds, higher fertilizer doses, plant protection agents, and irrigation systems. Careful planning and investment were required to bring the agricultural sector's productivity up to speed. After nearly achieving self-sufficiency in basic food production, Indian agriculture is becoming export-oriented, according to [23] "Agricultural Policies in India: Retrospect and Prospect" study. India currently exports rice and wheat, as well as cattle goods, in addition to the conventional export commodities. The direction of commerce is shifting as well. Although commerce with the region's neighbours continues to dominate, trading with OECD countries is becoming increasingly vital, particularly for high-value food exports.

According to [17], "food security in Indian agriculture: Policies, output performance, and marketing environment," average incremental production was roughly 4 MT per year for two decades, from the triennial ending in 1974-75 to the triennial ending in 1994-95. The rate of increase in cereal output has kept up with the population and demand for cereals. India has become the world's leading cereal exporter. Improvements in households' physical access to food in various parts of the country, as well as continuing improvements in consumers' economic access to food" Agricultural research in India: An exploratory study, "by [2]. In terms of growth and development, agricultural research in India has a fascinating past. It began during the colonial era with agricultural research, making it the world's largest research system. At the national level, the Indian Council of Agricultural Research (ICAR) primarily assists, promotes, and coordinates research and education efforts across the country. The State Agricultural Universities are in charge of research and education at the state level. In India, five-year plans are very important in terms of investment, technology transfer, and other aspects of agricultural growth.

Research on "Agricultural Development in India Since Independence: A Research on Progress, Performance, and Factors," [22]. As per this study, the agricultural workforce has shifted from cultivators to agricultural labourers, the number of uneconomic holdings is on the rise, the area under food crops has shifted to nonfood crops, and within food crops, the area under cereals has shifted to non-cereals, and the overall growth trend of agriculture, with the exception of forestry, has been declining since the WTO. Instability in the area has become a major element in production instability.

[8] Growth, instability, and decomposition of food grains in India, Although the Indian economy is

developing, it remains an agrarian economy because agriculture is the primary source of income for the vast majority of the population. The current study employed time series data from 2001-02 to 2015-16 to look at the area, production, and yield of food grains in India. The findings found that the increase in production was due to an increase in area or a combination of area and yield in India's food grains. Furthermore, the study found that the production of food grains has increased over time due to an increase in area under food grains, which has been supplemented by an increase in crop yield. Because it is not possible to increase the area in the long run, it is critical to adopt appropriate/alternative production technologies that will improve the productivity of food grains.

[13]. The Production of Food Grains in India: Trends and Decompositions, Food grains are cultivated on 123.22 million hectares in India, with a yield of 251.57 million tonnes, according to the current study. The study's findings revealed that the country's food grain output increased at a pace of 1.73 percent per year, owing to a small rise in area and productivity over the study period. The production of food grains has shown that main cereals such as rice, wheat, and maize have shown steady improvement, but pulse output has not. Maize, as a coarse cereal, ranks third after rice and wheat in terms of yield, with yields increasing from roughly 1595 kg per hectare in 1995-96 to 2563 kg per hectare in 20015-16.

3. OBJECTIVE

To analyze the growth and trends in the production, area and the yield of food grains in before and after the new agricultural policy

To evaluate the structural stability of agricultural production and the area under cultivation of food grains.

4. HYPOTHESIS

There is no structural change in the agricultural production and area under cultivation before and after the new agricultural policy in India.

There is no difference between the average (Mean) of production, area and yield of food grains before and after the new agricultural policy of India.

5. METHODOLOGY

For the study, we have been used the secondary data were used to carry out the objectives of production, area under cultivation and the yield per hectares of food grains in India. The data on the area under cultivation (in lakh hectares), production of crops (in lakh tonnes) and yield per hectares of food grains (Kg/hectare) were collected from the [14] and the Ministry of Agriculture and Farmers' Welfare of the Government of India. The data covered two distinct periods related to the before and after the agricultural policy in India, a period of (1980-2000) and (2001-2020) respectively. Both periods need separate investigation, as from 1980 to 2020 in India. To estimate the structural stability of agricultural production, the structural stability regression model-The Chou test (Gregory Chou) is used and calculated by pooled sample, period I and period II separately at a 5% level of significance. The average, compound annual growth rate (CAGR), t test and F test were used to estimate, compare and growth trend in the production, area and the yield per hectares of food grains before and after the new agricultural policy in India.

5.1 Structural Stability Regression Model

The structural stability regression model was used to testing the stability of the growth parameter; the stability of growth parameters between before and after new agricultural policy period was tested by using the following F statistics.

$$Y_t = Z_1 + Z_2 X_t + E_t$$

Where Y stands for the amount of food grains produced, t for the time period, Z_1 for the intercept, Z_2 for the growth parameter to be estimated, X for the area under cultivation of food grains, and E for the stochastic term in the pooled sample.

$$Y_t = V_1 + V_2 X_t + E_t$$

Where Y is the amount of food grains produced in the I period, t is the time period, V_1 is the intercept, V_2 is the growth parameter to be estimated, X is the area under food grain cultivation in the I period, and E is the stochastic term in the I period; in the sample.

$$Y_t = U_1 + U_2 X_t + E_t$$

Where Y denotes the amount of food grains produced in period II, t denotes the time period, V_1 denotes the intercept, V_2 denotes the growth parameter to be estimated, X denotes the area under food grain cultivation in the second period, and E denotes the stochastic term in the II period; in the sample.

$$F = \frac{S5/k}{S4/(n1 + n2 - 2k)}$$

S_1 is the pooled sample's residual sum of squares (RSS_1), S_2 is the I period's residual sum of squares (RSS_2), S_3 is the II period's residual sum of squares (RSS_3), and S_4 is the sum of S_2 and S_3. The difference between S_1 and S_4 is S_5, n_1 and n_2 is the number of observations; and the number of parameters is k.

6. RESULTS AND DISCUSSION

The study revealed that the annual average growth rate of agricultural production – food grains, area under cultivation of food grains and the yield per hectares of food grains before the new agricultural policy (2000) as shown in the table 1.

Table 1 Growth Rate of Production, Area and Yield of Food Grains in India from Period I

Year	Production	Simple Growth Rate	Area	Simple Growth Rate	Yield	Simple Growth Rate
1980-81	1295.9		1267		1023	
1981-82	1333	2.863	1291	1.894	1032	0.880
1982-83	1295.2	-2.836	1251	-3.098	1035	0.291
1983-84	1523.7	17.642	1312	4.876	1162	12.271
1984-85	1455.4	-4.483	1267	-3.430	1149	-1.119
1985-86	1504.4	3.367	1280	1.026	1175	2.263
1986-87	1434.2	-4.666	1272	-0.625	1128	-4.000
1987-88	1403.5	-2.141	1197	-5.896	1173	3.989
1988-89	1699.2	21.069	1277	6.683	1331	13.470
1989-90	1710.4	0.659	1268	-0.705	1349	1.352
1990-91	1763.9	3.128	1278	0.789	1380	2.298
1991-92	1683.8	-4.541	1219	-4.617	1382	0.145
1992-93	1794.8	6.592	1232	1.066	1457	5.427
1993-94	1842.6	2.663	1228	-0.325	1501	3.020
1994-95	1915	3.929	1237	0.733	1546	2.998
1995-96	1804.2	-5.786	1210	-2.183	1491	-3.558
1996-97	1994.3	10.537	1236	2.149	1614	8.249

1997-98	1931.2	-3.164	1239	0.243	1552	-3.841
1998-99	2036.1	5.432	1252	1.049	1627	4.832
1999-00	2098	3.040	1231	-1.677	1704	4.733

Source: Hand book of Statistics on Indian Economy, publication of RBI-2020-21.

Food grain production increased significantly from 1295.9 lakh tonnes in 1980-81 to 2098 lakh tonnes in 1999-00, as shown in Table 1. During period I, the production of food grains increased by 61.90 percent. The highest average yearly growth rate (21.07 percent) was found in 1988-89. The area under cultivation of food grains has remained relatively steady, rising from 1267 lakh hectares in 1980-81 to 1231 lakh hectares in 1999-00. In period I, this is a -2.841 percent drop. In 1988-89, the average annual growth rate was at its highest (6.7 percent). Food grain yields increased from 1023 kg per hectare in 1980-81 to 1704 kg per hectare in 1999-00. In period I, the yield per acre of food grains increased by 66.57 percent. The year 1988-89 had the greatest annual average growth rate (13.5%). The area, production, and yield of food grains all have a positive relationship. That is, the area under cultivation of food grains changed over time, resulting in changes in food grain production and yield per hectare. During this time, the annual average growth rate of food grain production, area, and yield was 2.863 percent and 3.040 percent, 1.894 percent and -1.677 percent, and 0.880 percent and 4.733 percent, respectively.

Table 2 Growth Rate of Production, Area and Yield of Food Grains in India from Period II

Year	Production	Simple Growth Rate	Area	Simple Growth Rate	Yield	Simple Growth Rate
2000-01	1968.1		1211		1626	
2001-02	2128.5	8.150	1228	1.404	1734	6.642
2002-03	1747.8	-17.886	1139	-7.248	1535	-11.476
2003-04	2131.9	21.976	1235	8.428	1727	12.508
2004-05	1983.6	-6.956	1201	-2.753	1652	-4.343
2005-06	2086	5.162	1216	1.249	1715	3.814
2006-07	2172.8	4.161	1237	1.727	1756	2.391
2007-08	2307.8	6.213	1241	0.323	1860	5.923
2008-09	2344.7	1.599	1228	-1.048	1909	2.634
2009-10	2181.1	-6.977	1213	-1.221	1798	-5.815
2010-11	2444.9	12.095	1267	4.452	1930	7.341
2011-12	2592.9	6.053	1248	-1.500	2078	7.668
2012-13	2571.3	-0.833	1207	-3.285	2129	2.454
2013-14	2650.4	3.076	1260	4.391	2101	-1.315
2014-15	2520.2	-4.912	1220	-3.175	2070	-1.475
2015-16	2515.7	-0.179	1232	0.984	2056	-0.676
2016-17	2751.1	9.357	1292	4.870	2129	3.551
2017-18	2850.1	3.599	1275	-1.316	2235	4.979
2018-19	2852.1	0.070	1248	-2.118	2286	2.282
2019-20	2975	4.309	1270	1.763	2343	2.493

Source: Hand book of Statistics on Indian Economy, publication of RBI-2020-21.

Table 2 shows that food grain output has increased significantly from 1968.1 million tonnes in 2000-01 to 2975 million tonnes in 2019-20. That is, the during Period II, food grain output increased by 51.16 percent. In 2003-04, the yearly average growth rate in food grain production was the greatest at 21.98 percent. The area under cultivation of food grains increased by only 4.87 percent from 1211 lakh hectares in 2000-01 to 1270 lakh hectares in 2019-20. During this time, the yearly growth rate was 8.43 percent in 2003-04. Food

grain yields grew from 1626 kg per hectare in 2000-01 to 2343 kg per hectare in 2019-20. This represents a 44.10 percent gain over the previous year. The highest yearly average growth rate in 2003-04, ie, 12.51 percent. During this period, the annual average growth rates of food grain production, area, and yield became 8.15 percent, 4.309 percent, 1.404 percent, 1.763 percent, and 6.642 percent, 2.493 percent, respectively.

Table 3 Average Production, Area and Yield of Food Grains: Period I, Period II, and Pooled

	Cereals			Total Cereals	Pulses	Total Food Grains
	Rice	Wheat	Coarse Cereals			
Average (Period I)	699.35	543.355	304.87	1547.58	128.37	1675.9
Average (Period II)	986.39	846.995	387.79	2221.18	167.63	2388.8
Grand Average	842.87	695.18	346.33	1884.38	148.0	2032.35
t – test	23.078	27.124	6.312	25.181	5.203	22.392
P- value	2.324	1.177	4.664	4.661	0.0005	4.056
Pearson "r"	0.8961	0.9234	0.2052	0.9217	0.6957	0.921
Average Area Under Cultivation of Food Grains (Lakh Hectares)						
Average (Period I)	419.4	244.35	359.5	1023.1	229	1252.2
Average (Period II)	435.45	285.9	273.65	989.75	243.8	1233.4
Grand Average	427.43	265.13	316.58	1006.43	236.4	1242.8
t – test	4.005	13.083	-13.236	-5.303	2.163	-1.729
P-value	0.0007	5.943	4.924	0.0000	0.0435	0.0999
Pearson "r"	0.2411	0.7016	0.7548	0.1474	-0.129	-0.208
Average Yield Per Hectare of Food Grains (Kg per Hectare)						
Average (Period I)	1659.6	2206.8	861.3	1515.6	559.0	1340.6
Average (Period II)	2263.0	2953.7	1464.8	2244.5	679.6	1933.5
Grand Average	1961.3	2580.2	1163.1	1880.0	619.3	1637.0
t – test	25.832	18.425	12.567	32.14	8.609	35.121
P -value	2.917	1.416	1.183	4.999	5.542	9.529
Pearson "r"	0.9132	0.8477	0.8330	0.9485	0.782	0.947

The table header spans: "Average Production of Food Grains (Million Tonnes)" covers the first block.

Source: Authors calculation.
Significant at 5% level of Probability

Table 3 displays average production of food grains such as rice, wheat, coarse cereals, total cereals, and total food grains; the null hypothesis is retained because the p value is greater than 0.05. That is, no statistically significant difference in output exists between periods I and II. As with pulses, the p value is less than 0.05, hence the null hypothesis is rejected. That is, during periods I and II, statistically significant in the generation of pulses. The null hypothesis is rejected when the p value is less than 0.05, as it is when the average area under cultivation of food grains; rice, pulses, and total cereals. The difference in the area under cultivation between periods I and II is statistically significant. However, if the p value is greater than 0.05 for wheat, coarse cereals, and total dietary grains, keep the null hypothesis. That is, there is no statistically significant difference between Period I and Period II in terms of the area under cultivation. The average yield per hectare of food grains; the p value for rice, wheat, coarse cereals, total cereals, pulses, and total food grains is larger than 0.05. As a result, the null hypothesis remains. That is, throughout periods I and II, there is no statistically significant variation in yield per hectare. For the average production of food grains, the Pearson coefficient of correlation is positive. Similarly, the average area under cultivation of food grains (-0.129) demonstrates a positive association. There was a positive association between the items in the food grains, just as there was
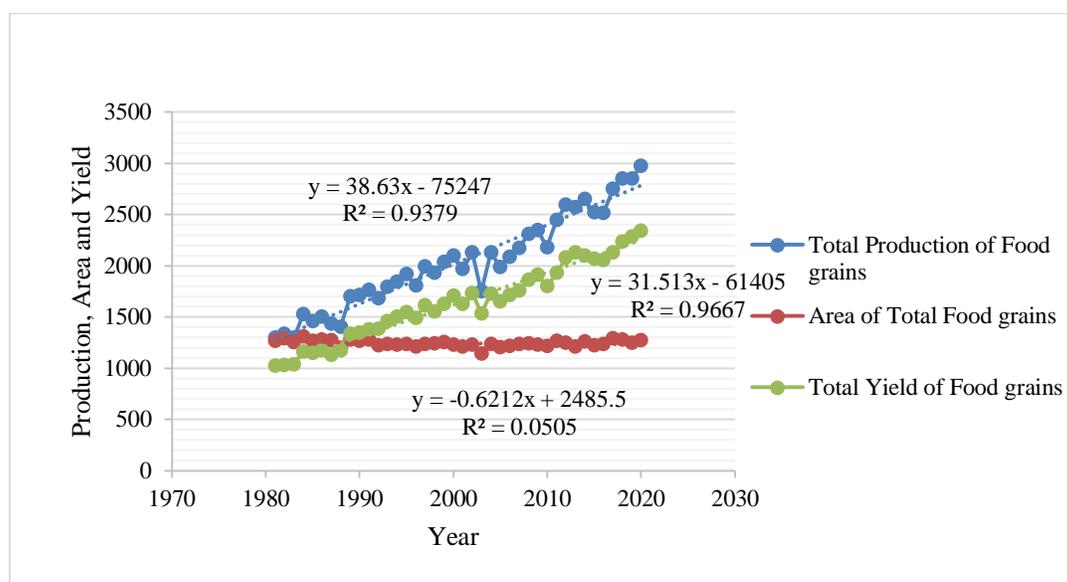
in the case of yield per hectare.

Table 4 CAGR of Food Grains Production and Area – Period I, Period II, and Pooled

	Cereals			Total Cereals	Pulses	Total Food Grains
CAGR of Food Grains Production (Million Tonnes)						
	Rice	Wheat	Coarse Cereals	Total Cereals	Pulses	Total Food Grains
CAGR (Period I)	2.743	3.991	0.234	2.674	1.230	2.568
CAGR (Period II)	1.782	2.326	2.286	2.077	3.931	2.198
Overall CAGR	2.062	2.831	1.285	2.167	2.002	2.154
CAGR of Area Under Cultivation of Food Grains (Lakh Hectares)						
CAGR (Period I)	0.619	1.109	-1.853	-0.112	-0.338	-0.152
CAGR (Period II)	-0.119	1.060	-1.219	-0.090	1.681	0.251
Overall CAGR	0.214	0.881	-1.413	-0.131	0.562	0.006
CAGR of Yield Per Hectare of Food Grains (Kg per Hectare)						
CAGR (Period I)	2.108	2.846	2.113	2.786	1.562	2.722
CAGR (Period II)	1.907	1.267	3.546	2.169	2.203	1.941
Overall CAGR	1.842	1.934	2.735	2.300	1.430	2.148

Source: Authors calculation.

Table 4 illustrates that the CAGR of food grain output and area under food grain cultivation from period I to period II, indicating that coarse cereals and pulses outperformed rice and wheat, while overall cereals and total food grain rates have been declined. The CAGR of area under cultivation of coarse cereals and total cereals has been negative over the two periods, but positive and somewhat improving in rice, wheat, pulses, and total food grains. In Period II, the rate of total food grains increased slightly over Period I. The overall CAGR of food grain production per hectare was positive and improving.

Source: Authors calculation.

Figure 1. Trend in the Total Production, Area and Yield of food grains in Pooled Period. It shows the trend line of food grain output, area under cultivation, and yield per hectare for periods I and II together. Food grain output climbed by 129.57 percent from 1295.9 in 1980-81 to 2975 in 2019-20, yield per hectare increased by 129.03 percent from 1023 in 1980-81 to 2343 in 2019-20, and area increased by 0.24 percent from 1267 in

1980-81 to 1270 in 2019-20. Similarly, the trend in food grain output, area, and yield per hectare was 38.63, -0.6212 and 31.513 respectively. The coefficient denotes a high level of production and yield but a low level of food grain cultivation area.

Table 5 Trend in the Total Production, Area and Yield of Food Grains Items in Pooled Period

	Production	Area	Yield
Rice	Y =15.554X-30273 R^2 = 0.9292	Y = 0.9492X-1471.5 R^2 = 0.469	Y = 32.448X-62950 R^2 = 0.9471
Wheat	Y = 16.387X-32087 R^2 = 0.9559	Y = 2.2327X-4201.5 R^2 = 0.902	Y = 40.382X-78203 R^2 = 0.9332
Coarse Cereals	Y = 4.2649X-8185.5 R^2 = 0.6568	Y = 4.6628X+9644.4 R^2 = 0.8579	Y = 31.629X-62111 $9R^2$ = 0.8976
Total Cereals	Y = 36.206X-70546 R^2 = 0.9462	Y = 1.6061X-4219.4 R^2 = 0.479	Y = 38.828X-75796 R^2 = 0.9659
Pulses	Y = 2.4248X-4702.9 R^2 = 0.6284	Y = 0.9994X-1763 R^2 = 0.2839	Y = 7.1378X-13660 R^2 = 0.7652

Source: Hand book of Statistics on Indian Economy, publication of RBI – 2020-21. Authors Calculation.

The trend in food grain production, area, and yield per hectare during the pooled period shows the item wise trend of rice, wheat, coarse cereals, total cereals, and pulses in the pooled; from period I to period II, rice production, area, and yield are 15.554, 0.9492, and 32.448; wheat production, area, and yield are 16.387, 2.2327, and 40.382; coarse cereals production, area, and yield are 4.2649, 4.6628 respectively.
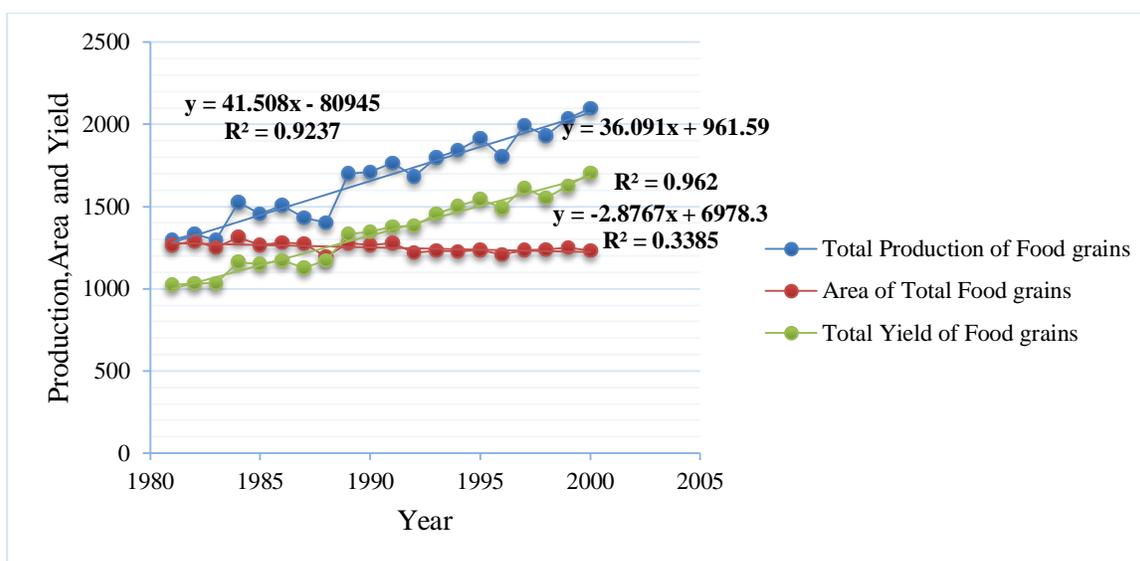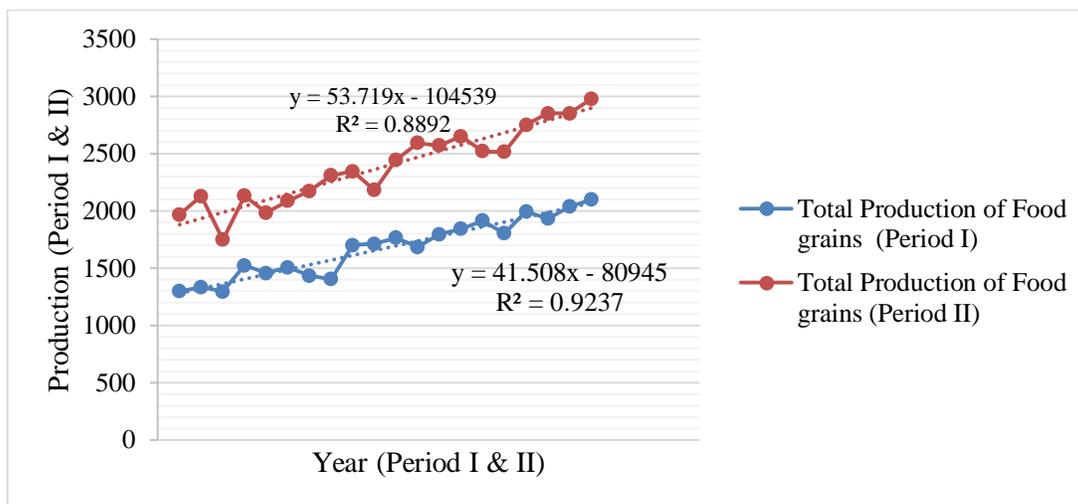

Source: Authors calculation.

Figure 2. Trend in the Total production, Area and Yield in Period I. This figure depicts the trend in food grain production, area, and yield from 1980-81 to 1999-00, indicating that the coefficients of production, area, and yield of food grains throughout the period were 41.508, -2.8767 and 36.091 respectively, with an intercept of

80945, 961.59, and 6978.3.
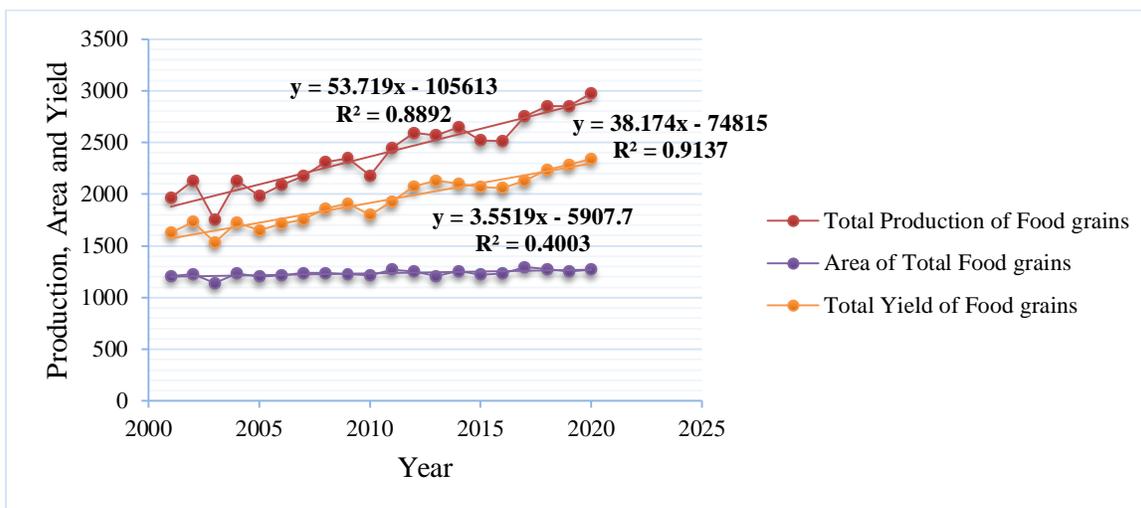
Source: Authors calculation.

Figure 3. Trend line of Total production, Area and Yield in Period II. In this figure, the trend of food grain output, area, and yield per hectare from 2000-01 to 2019-20, with coefficients of 53.719, 3.5519 and 38.174, and, and intercepts of 105613, 74815, and 5907.7, respectively.
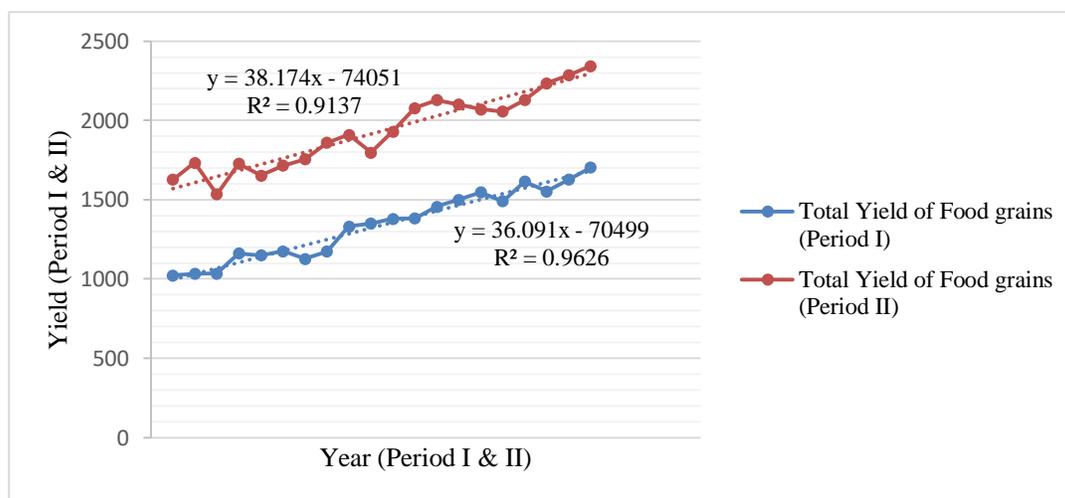

Source: Authors calculation.

Figure 4. Production of food grains in Periods I and II. The coefficient of production changes from 41.508 to 53.719, which is a 29.42 percent increase in food grain production; and the intercept changes from 80945 to 104539, which is a 29.15 percent increase in the intercept of food grain production in India before and after the new agricultural policy.
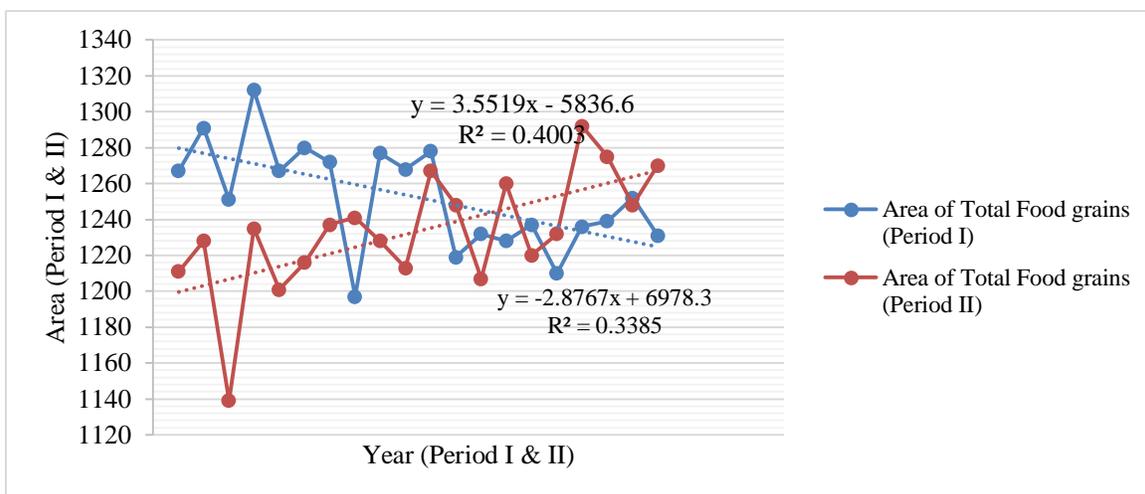
Source: Authors calculation.

Figure 5. The area of food grains in Periods I and II is compared. This figure indicates that the comparison of the area under cultivation of food grains before and after the new agricultural policy in India shows that the coefficient of the area was 3.5519 and -2.8767, that is-180.99 percent changes from period I to II, and the intercepts were 5836.6 and 6978.3, i.e., 19.56 percent changes.

Source: Authors calculation.

Figure 6. Comparison of Yields of Food Grains in Period I & II. which shows that when comparing yield per hectares of food grains in periods I and II, the coefficient of yield changed from 38.174 to 36.091, indicating a 5.46 percent decrease in yield per hectare. The intercept was changed from 74051 to 70499, a -4.80% change in India between periods I and II.

Table 6 Trend line of Total Production, Area and Yield of Food Grains items in Period I and II

		Production	Area	Yield
Rice	Period I	Y = 19.954X-39019 R^2 = 0.9123	Y = 2.4947X-4546.4 R^2 = 0.7327	Y = 37.772X-73526 R^2 = 0.9093
	Period II	Y = 18.383X-35972 R^2 = 0.8216	Y = 0.2865X-140.49 R^2 = 0.0257	Y = 40.809X-79784 R^2 = 0.9093
Wheat	Period I	Y = 19.104X-37483 R^2 = 0.9547	Y = 2.3526X-4438.6 R^2 = 0.7664	Y = 56.271X-109802 R^2 = 0.9497
	Period II	Y = 20.918X-41209 R^2 = 0.9062	Y = 3.0466X-5839.3 R^2 = 0.835	Y = 42.743X-82981 R^2 = 0.8006

Coarse Cereals	Period I	Y = 1.0662X-1817.3 $R^2 = 0.0447$	Y = 7.2797X+14850 $R^2 = 0.9551$	Y = 20.621X-40185 $R^2 = 0.7449$
	Period II	Y = 8.1785X-16055 $R^2 = 0.9292$	Y = 4.2729X+8864.4 $R^2 = 0.4962$	Y = 51.383X-101842 $R^2 = 0.9152$
Total Cereals	Period I	Y = 40.124X-78319 $R^2 = 0.9314$	Y = 2.3955X+5791.3 $R^2 = 0.3687$	Y = 42.599X-83278 $R^2 = 0.9659$
	Period II	Y = 47.481X-93239 $R^2 = 0.8832$	Y = 0.4474X+1889.2 $R^2 = 0.0184$	Y = 49.377X-97029 $R^2 = 0.9233$
Pulses	Period I	Y = 1.3837X-2625.9 $R^2 = 0.4775$	Y = 0.4647X+1153.9 $R^2 = 0.0973$	Y = 6.8549X-13086 $R^2 = 0.6923$
	Period II	Y = 6.2426X-12383 $R^2 = 0.8153$	Y = 4.0241X-7846.6 $R^2 = 0.7137$	Y = 14.069X-27606 $R^2 = 0.8018$
Total Food Grains	Period I	Y = 41.577X-8095 $R^2 = 0.9241$	Y = -2.8786X+6978.3 $R^2 = 0.3391$	Y = 36.091X-70498 $R^2 = 0.963$
	Period II	Y = 53.723X-10562 $R^2 = 0.8892$	Y = 3.5527X-5907.7 $R^2 = 0.4003$	Y = 38.174X-74821 $R^2 = 0.914$

Source: Hand book of Statistics on Indian Economy, publication of RBI – 2020-21. Authors Calculation

Table 6 shows the trend in output, area, and yield per hectares for the pooling period, indicating a decline in production (-7.87 percent) and area (-88.52 percent) and improved yield per hectares of food grains as compared to period I and period II (8.04 percent). Wheat output (9.5 percent) and area (29.5 percent) both increased, while wheat yield (-24.04 percent) decreased. Food grain output increased by 667.07 percent and yield increased by 149.18 percent, but wheat area decreased by 41.3 percent. The total production and yield of coarse cereals grew marginally (18.34 percent and 15.91 percent, respectively), but the area under cultivation of coarse cereals decreased (-81.32 percent). Production, area, and yield (351.15 percent, 765.96 percent, and 105.24 percent, respectively) were all greatly enhanced. Since then, the coefficients of total output and yield per hectare of food grains have improved somewhat to 29.42 percent and 5.77 percent, respectively, but the coefficient of area under food grains has decreased to -223 percent.

Table 7 The Structural Stability of Regression Model - Production and Area of Food Grains

	Pooled Sample	Period I	Period II
Rice	$\hat{Y}_t = -3106.75 + 9.241X_t$ $r^2 = 0.6368$ $S_1 = 503940.8$ D f = 38	$\hat{Y}_t = -2106.46 + 6.690X_t$ $r^2 = 0.871133$ $S_2 = 37400.14$ D f = 18	$\hat{Y}_t = -1426.84 + 5.5419X_t$ $r^2 = 0.21785$ $S_3 = 359787.9$ D f = 18
	$S_4 = 245668.34$	$S_5 = 258272.46$ F = 18.92	P-value = 0.001
Wheat	$\hat{Y}_t = -1126.8 + 6.87218X_t$ $r^2 = 0.929143$ $S_1 = 106094.2$ D f = 38	$\hat{Y}_t = -1101.54 + 6.7317X_t$ $r^2 = 0.856076$ $S_2 = 36588.43$ D f = 18	$\hat{Y}_t = -852.91+ 5.9458X_t$ $r^2 = 0.813799$ $S_3 = 59791.16$ D f = 18
	$S_4 = 96379.59$	$S_5 = 9714.61$ F = 1.81	P-value = 0.001
Coarse Cereals	$\hat{Y}_t = 569.529 - 0.7051X_t$ $r^2 = 0.45484$ $S_1 = 80472.85$ D f = 38	$\hat{Y}_t = 328.498 – 0.22568X_t$ $r^2 = 0.00943$ $S_2 = 16737.2$ D f = 18	$\hat{Y}_t = 629.549 – 0.8834X_t$ $r^2 = 0.30823$ $S_3 = 42861.8$ D f = 18
	$S_4 = 59598.99$	$S_5 = 20873.86$ F = 6.304	P-value = 0.001
Total Cerea.	$\hat{Y}_t = 11007.92 – 9.066X_t$ $r^2 = 0.31944$ $S_1 = 5025509.1$	$\hat{Y}_t = 6185.703 - 4.5334X_t$ $r^2 = 0.18504$ $S_2 = 936813.4$	$\hat{Y}_t = 666.581 + 1.5718X_t$ $r^2 = 0.010511$ $S_3 = 1679575.3$

	D f = 38	D f = 18	D f = 18
	$S_4 = 2616388.7$	$S_5 = 2409120.3 \quad F = 16.57$	P-value = 0.001
Pulses	$\hat{Y}_t = -196.06 + 1.455X_t$ $r^2 = 0.796563$ $S_1 = 10145.19$ D f = 38	$\hat{Y}_t = 28.0611 + 0.488X_t$ $r^2 = 0.106201$ $S_2 = 2383.2132$ D f = 18	$\hat{Y}_t = -169.072 + 1.3811X_t$ $r^2 = 0.90533$ $S_3 = 3009.026$ D f = 18
Pulses	$S_4 = 5392.2387$	$S_5 = 4752.9513 \quad F = 15.86$	P-value = 0.001
Total Food Grains	$\hat{Y}_t = 2738.6 - 0.5683X_t$ $r^2 = 0.001552$ $S_1 = 8466878.1$ D f = 38	$\hat{Y}_t = 5831.97 - 3.3988X_t$ $r^2 = 0.15142$ $S_2 = 1052490.7$ D f = 18	$\hat{Y}_t = -7386.9 + 7.9258X_t$ $r^2 = 0.610083$ $S_3 = 841460.8$ D f = 18
Total Food Grains	$S_4 = 1893951.5$	$S_5 = 6572926.5 \quad F = 62.49$	P-value = 0.001

Source: Hand book of Statistics on Indian Economy, publication of RBI – 2020-21. Authors Calculation.

Table 7 shows the structural stability of the regression equation used to estimate agricultural production and the area under the cultivation of food grains-cereals such as rice, wheat, coarse cereals, pulses, total cereals and total food grain. Rice (18.92), wheat (1.81), coarse cereals (6.304), pulses (15.86), total cereals (16.57), and total food grains are among the food grains with computed values (62.49). When the level of significance is set to 5%, the crucial $F_{2,38}$ is computed to be 0.001, which is less than 0.05. As a result, the null hypothesis should be rejected because the observed test values for rice, wheat, coarse cereals, and pulses were all higher than the critical value, indicating structural stability. As a result of the new agricultural strategy, there has been a structural change in the production of food grains and the area under cultivation in India.

7. CONCLUSION

Although the Indian economy is still in its early stages, agriculture remains the primary source of income for the vast majority of the population. The agricultural sector ensures food security and nutrition for India's massive population, as well as supplies a large quantity of raw materials to various industries, and having an increased industrial base of the country and creating production surplus for export. As per the study, we have found that, the agricultural production, the area and the yield have a growth pattern in India during in both periods. After the new agricultural policy there is having an increasing trend in the average production of cereals ie, rice, wheat and coarse cereals. The average area under cultivation has an increasing trend in total though there is no statistically significant difference in output exists between period I and II. Also, there are no significant variations in the yield per hectare; which shows Indian agricultural sector doesn't have much change during these years. Though these have a better performance in coarse cereals and pulses over wheat and rice, the overall cereals and total food grains rates have a declining tendency. As a result of the new agricultural strategy, there has been a structural change in the production of food grains and the area under cultivation in India.

8. ACKNOWLEDGMENT

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