Assessing the Growth and Structural Stability of Food Grain Production in India: An Approach to Structural Stability Regression Model

Sreeanandan[1*], Baranipriya A[2], Usha K[3], Saranya A.R[4], Resmi CP[5]

[1]Assistant Professor, PSG Institute of Management, PSG College of Technology, Coimbatore,
Email: sreeanandanpsg@gmail.com
[2]Assistant Professor of Economics, Sri Ramakrishna College of Arts & Science, Coimbatore,
Email: baranipriya27@gmail.com
[3]Assistant Professor, Department of Statistics, Govt. College Ambalapuzha, Kerala,
Email: ushakandathil@gmail.com
[4]Assistant Professor, Department of Commerce, Jain (Deemed-to-be University), Kochi Campus,
Email: saranya.ar@jainuniversity.ac.in
[5]Assistant Professor, Department of Economics, Jain (Deemed-to-be University), Kochi Campus,
Email: c.resmi@jainuniversity.ac.in
*Corresponding Author

Received: 01.01.2024 Revised : 15.01.2024 Accepted: 20.01.2024

ABSTRACT
The growth and structural stability of agricultural production, particularly in food grains, along with the area under cultivation and yield per hectare, are key indicators of an economy's contribution and stability. This research aims to assess the growth and structural stability of food grain production, the cultivated area, and yield per hectare in India during two periods: before the implementation of the new agricultural policy (1980-2000) and after its introduction (2001-2023). Secondary data for this analysis was sourced from the "Handbook of Statistics on the Indian Economy (2022-23)" published by the Reserve Bank of India (RBI). To estimate and compare the growth of production, cultivated area, and yield, the structural stability regression modelemployed for the analysis.The findings indicate that, between 1980-2000 and 2001-2020, the average production and yield of food grains increased by CAGR of 3.99 and 3.70, respectively, despite only0.11 in the area under cultivation. The study reveals a structural shift over time in food grain production and the area under cultivation in India. The increase in food grain production is attributed mainly to the expansion of cultivated area, improvements in yield per hectare, and changes in production patterns. Therefore, it is crucial to focus on expanding the cultivated area by utilizing available land more effectively and enhancing yield through technological innovations, agricultural research, and training, alongside strengthening policy implementation in India.

Keywords: Regression, Structural Stability, Production, Food grains, Area, Yield

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 allstates 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 of121.6, 8.7%, and 103.7 percent, respectively. Similarly, wheat output, area, and yield were 363.1, 223 and1630, 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 1901in 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.

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. Sharma (2013) 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 Elumalai (2011). 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.

Kumar and Mittal (2006), "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 Sulochna (2016), "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 Arora (2013) "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 Acharya (2009), "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 Borthakur and Singh (2012). 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," Tripathi and Prasad (2009). 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.
Ruchi (2017) Growth, instability, and decomposition of food grains in India, Although the Indian economy isdeveloping, 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.
Kumari et,al. (2020). The Production of Food Grains in India: Trends and Decompositions, Food grains are cultivated on123.22 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.

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.

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.

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.

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.

Yt = Z1 + Z2 Xt + Et

Where Y stands for the amount of food grains produced, t for the time period, Z1 for the intercept, Z2 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.

Yt = V1 + V2 Xt + Et

Where Y is the amount of food grains produced in the I period, t is the time period, V1 is the intercept, V2 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.

Yt = U1 + U2 Xt + Et

Where Y denotes the amount of food grains produced in period II, t denotes the time period, V1 denotes the intercept, V2 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.

$$F = \frac{S5/k}{s4/(n1+n2-2k)}$$

S1 is the pooled sample's residual sum of squares (RSS1), S2 is the I period's residual sum of squares (RSS2), S3 is the II period's residual sum of squares (RSS3), and S4 is the sum of S2 and S3. The difference between S1 and S4 is S5, n1 and n2 is the number of observations; and the number of parameters is k.

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	AGR	Area	AGR	Yield	AGR
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-2022-23.

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	AGR	Area	AGR	Yield	AGR
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	2975.0	4.309	1270	1.763	2343	2.493
2020-21	3107.0	4.437	1298	2.204	2394	2.176
2021-22	3156.2	1.583	1302	0.308	2425	1.295
2022-23	3305.4	4.727	1322	1.536	2500	3.092

Source: Hand book of Statistics on Indian Economy, publication of RBI-2022-23.

Table 2 shows that food grain output has increased significantly from 1968.1 million tonnes in 2000-01 to 3305.4 million tonnes in 2022-23. That is, the during Period II, food grain output increased more than50 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 1322 lakh hectares in 2022-23. During this time, the yearly growth rate was 8.43 percent in 2003-04. Foodgrain yields grew from 1626 kg per hectare in 2000-01 to 2500 kg per hectare in 2022-23. 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 became8.15 percent to 4.727 percent, 1.404 percent to 1.536 percent, and 6.642 percent, 3.092 percent, respectively.

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

Average Production of Food Grains (Million Tonnes)						
	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)	1027.02	880.026	405.543	2312.589	180.647	2493.24
t – test	23.089	27.135	6.323	25.192	5.214	22.403
P- value	2.335	1.188	4.675	4.672	0.0115	4.067
Pearson "r"	0.9071	0.9344	0.2162	0.9327	0.7067	0.932
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)	435.573	286.023	273.773	995.33	243.923	1239.25
t – test	4.128	13.206	-13.113	-5.18	2.286	-1.606
P-value	0.1237	6.066	5.047	0.123	0.1665	0.2229
Pearson "r"	435.573	286.023	273.773	989.873	243.923	1233.523
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)	2567.1	3331.6	1766	7564.7	644	8208.7
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

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 demonstrates a positive association. There was a positive association between the items in the food grains, just as there wasin the case of yield per hectare.

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

CARG of Food Grains Production (Million Tones)	
CAGR (Period I)	2.45
CAGR (Period II)	2.23

Overall CAGR	3.99
CAGR of Area under Cultivation of Food Grains	
CAGR (Period I)	-0.14
CAGR (Period II)	0.33
Overall CAGR	0.11
CAGR of Yield per Hectare of Foods Grains(KG per Hectare)	
CAGR (Period I)	2.57
CAGR (Period II)	3.05
Overall CAGR	3.70

Source: Authors calculation.

Food Grains Production

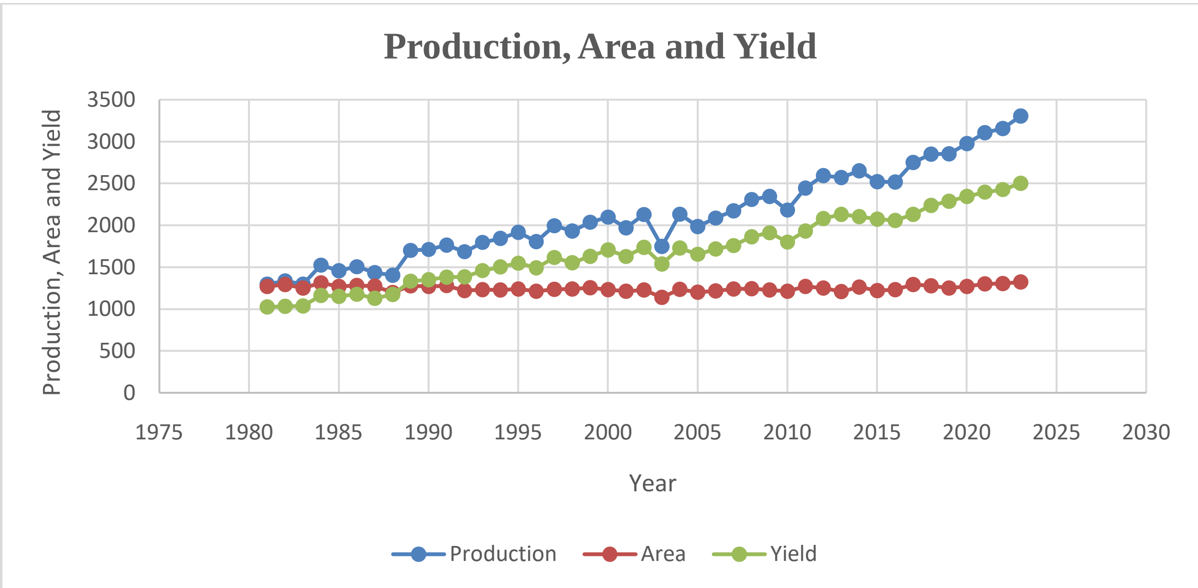
Period I and Period II show positive growth rates in food grains production, indicating that the production increased over these periods, but the growth rate decreased slightly in Period II.
The Overall CAGR of 3.99% is higher than both Period I and Period II, suggesting an overall stronger growth trend when considering the entire timeframe. he production of food grains has been growing steadily, with a notable increase in the overall CAGR, indicating a strong long-term growth trend.

Area under Cultivation of Food Grains

Period I shows a slight decline in the area under cultivation, indicating a reduction in the land dedicated to food grain cultivation during that period.
Period II shows a modest increase, suggesting a recovery or expansion in the area under cultivation.
The Overall CAGR of 0.11% reflects a slight average growth in the area under cultivation over the entire period, indicating a very gradual increase. Area under Cultivation: The area under cultivation had a slight decrease in the initial period but increased in the subsequent period, resulting in a very modest overall growth.

Yield per Hectare of Food Grains

Period I and Period II both show positive growth in yield per hectare, with Period II showing an acceleration in the growth rate.
The Overall CAGR of 3.70% indicates a robust average growth rate in yield per hectare over the entire period. The yield per hectare has been improving consistently, with the rate of increase accelerating over time, indicating significant progress in agricultural efficiency.
Overall, while the area under cultivation shows only a slight increase, the production and yield improvements suggest that gains in productivity and efficiency are driving the overall positive trends in food grains.



Source: Authors calculation.

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

	Production	Area	Yield
Rice	Y= 16.665X-31384	Y=1.0503X-1582.6	Y=33.559X-63161
	R^2 = 0.931	R^2=0.571	R^2=0.9581
Wheat	Y= 17.498X-33198	Y= 2.2438X-4312.6	Y=41.493X-79314
	R^2=0.9661	R^2=913	R^2=0.9443
Coarse Cereals	Y=4.3750X-8296.6	Y=4.7739X-9755.5	Y=32.739X-63222.9
	R^2=0.6679	R^2=0.8680	R^2=0.9087
Pulses	Y=2.5359X-4813	0.9995X-2874	Y=7.2489X-14771
	R^2=6395	R^2=0.2940	R^2=0.8753

Source: Hand book of Statistics on Indian Economy, publication of RBI – 2022-23. Authors Calculation.

Rice

Production has a strong positive relationship with X, with R^2 indicating that 93.1% of the variation in production can be explained by the model.

Area has a weaker relationship with X, with R^2 suggesting that only 57.1% of the variation in the area under cultivation can be explained by the model.

Yield has a very strong positive relationship with X, with R^2 indicating that 95.81% of the variation in yield can be explained by the model.

Wheat

Production has an excellent fit with X, with R^2 meaning 96.61% of the variation in production can be explained by the model.

Area also has a strong relationship with X, with R^2 suggesting that 91.3% of the variation in the area can be explained by the model.

Yield has a very strong relationship with X, with R^2 indicating that 94.43% of the variation in yield can be explained by the model.

Coarse Cereals

Production has a moderate relationship with X, with R^2 meaning 66.79% of the variation in production can be explained by the model.

Area has a strong relationship with X, with R^2 suggesting that 86.8% of the variation in the area can be explained by the model.

Yield has a very strong relationship with X, with R^2 indicating that 90.87% of the variation in yield can be explained by the model.

Pulses

Production has a moderate fit with X, with R^2 meaning 63.95% of the variation in production can be explained by the model.

Area has a weak relationship with X, with R^2 suggesting that only 29.4% of the variation in the area can be explained by the model.

Yield has a strong relationship with X, with R^2 indicating that 87.53% of the variation in yield can be explained by the model.

In another way 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 16.665, 1.0503, and 33.559; wheat production, area, and yield are 17.498, 2.2438 and 41.493; coarse cereals production, area, and yield are 4.3750, 4.7739 and 32.739 ; Pulses production, Area, and Yield are 2.5359, 0.9995 and 7.2489 respectively.

Table 6. The Structural Stability of Regression Model - Production and Area of Food Grains

	Pooled Sample	Period I	Period II
Rice	$\hat{Y}t$ = -3106.75 + 9.241Xt R^2 = 0.6368 S1 = 503940.8 D f = 41	$\hat{Y}t$ = -2106.46 + 6.690Xt R^2 = 0.871133 S2 = 37400.14 D f = 18	$\hat{Y}t$ = -1426.84 + 5.5419Xt R^2 = 0.21785 S3 = 359787.9 D f = 21
	S4 = 245668.34	S5 = 258272.46 F = 18.92	P-value = 0.001

Wheat	$\hat{Y}t = -1126.8 + 6.87218Xt$ $R^2 = 0.929143$ S1 = 106094.2 D f = 41	$\hat{Y}t = -1101.54 + 6.7317Xt$ $R^2 = 0.856076$ S2 = 36588.43 D f = 18	$\hat{Y}t = -852.91 + 5.9458Xt$ $R^2 = 0.813799$ S3 = 59791.16 D f = 21
	S4 = 96379.59	S5 = 9714.61 F = 1.81	P-value = 0.001
Coarse Cereals	$\hat{Y}t = 569.529 - 0.7051Xt$ $R^2 = 0.45484$ S1 = 80472.85 D f = 41	$\hat{Y}t = 328.498 – 0.22568Xt$ $R^2 = 0.00943$ S2 = 16737.2 D f = 18	$\hat{Y}t = 629.549 – 0.8834Xt$ $R^2 = 0.30823$ S3 = 42861.8 D f = 21
	S4 = 59598.99	S5 = 20873.86 F = 6.304	P-value = 0.001
Pulses	$\hat{Y}t = -196.06 + 1.455Xt$ $R^2 = 0.796563$ S1 = 10145.19 D f = 41	$\hat{Y}t = 28.0611 + 0.488Xt$ $R^2 = 0.106201$ S2 = 2383.2132 D f = 18	$\hat{Y}t = -169.072 + 1.3811Xt$ $R^2 = 0.90533$ S3 = 3009.026 D f = 21
	S4 = 5392.2387	S5 = 4752.9513 F = 15.86	P-value = 0.001
Total Food Grains	$\hat{Y}t = 2738.6 – 0.5683Xt$ $R^2 = 0.001552$ S1 = 8466878.1 D f = 41	$\hat{Y}t = 5831.97 – 3.3988Xt$ $R^2 = 0.15142$ S2 = 1052490.7 D f = 18	$\hat{Y}t = -7386.9 + 7.9258Xt$ $R^2 = 0.610083$ S3 = 841460.8 D f = 21
	S4 = 1893951.5	S5 = 6572926.5 F = 62.49	P-value = 0.001

Source: Hand book of Statistics on Indian Economy, publication of RBI – 2022-23. Authors Calculation.

Rice

Pooled Sample:The pooled regression model shows that rice production has a positive relationship with Xt with a slope of 9.241.The R^2 value of 0.6368 indicates that approximately 63.68% of the variability in rice production can be explained by this model. S1 is the sum of squares for the model, showing the total variation explained by the regression.Period I: During Period I, the regression model has a positive relationship with Xt (slope of 6.690), but the effect is less pronounced compared to the pooled sample.The R^2 value of 0.8711 is higher than that of the pooled sample, indicating that 87.11% of the variability in rice production during Period I is well explained by the model. S2 is the sum of squares for the regression in Period I, reflecting the variation explained by the model during this period. Period II: During Period II, the model still shows a positive relationship between rice production and Xt but the effect is smaller (slope of 5.5419). The R^2 value of 0.21785 is quite low, indicating that only 21.785% of the variability in rice production during Period II is explained by the model. This suggests that other factors may be influencing production during this period. S3 is the sum of squares for the regression in Period II. The F-statistic of 18.92 indicates the overall significance of the regression models. A high F-statistic suggests that the models significantly explain the variation in rice production.The P-value of 0.001 is very low, indicating that the results are statistically significant, and there is a strong likelihood that the observed relationships are not due to random chance.

Wheat

Pooled Sample: The pooled regression model indicates that wheat production has a positive relationship with Xt with a slope of 6.87218. The R^2 value of 0.929143 suggests that approximately 92.91% of the variability in wheat production can be explained by this model, indicating a very good fit.

S1 represents the sum of squares for the regression, showing the total variation in production explained by the model. Period I: During Period I, the regression model shows a positive relationship with Xt (slope of 6.7317), but slightly less pronounced than the pooled sample. The R^2value of 0.856076 indicates that 85.61% of the variability in wheat production during Period I is explained by the model, reflecting a strong fit. S2 is the sum of squares for the regression in Period I, showing the variation explained by the model during this period. Period II: During Period II, the model shows a positive relationship with Xt (slope of 5.9458), with a somewhat reduced rate compared to Period I. The R^2 value of 0.813799 indicates that 81.38% of the variability in wheat production during Period II is explained by the model, still reflecting a good fit but slightly weaker than Period I. S3 is the sum of squares for the regression in Period II. The F-statistic of 1.81 suggests that the overall regression model is significant. However, the F-statistic here appears relatively low, which may imply the model's effectiveness could be marginal, but this is context-dependent. The P-value of 0.001 is very low, indicating that the results are statistically significant, and the observed relationships are unlikely to be due to random chance.

Coarse Cereals

The pooled regression model shows a negative relationship between coarse cereals production and Xt, with a slope of -0.7051. This suggests that as Xt increases, production decreases. The R^2 value of 0.45484 indicates that approximately 45.48% of the variability in coarse cereals production is explained by the model, which shows a moderate fit. Period I: In Period I, the regression model shows a weaker negative relationship with Xt, with a slope of -0.22568. This implies a smaller decrease in production compared to the pooled sample. The R^2 value of 0.00943 is very low, indicating that the model explains less than 1% of the variability in production. This suggests that the relationship between coarse cereals production and Xt in Period I is negligible or almost non-existent. Period II: In Period II, the model shows a stronger negative relationship with Xt, with a slope of -0.8834, indicating a more pronounced decline in coarse cereals production as Xt increases compared to both the pooled sample and Period I.The R^2value of 0.30823 suggests that about 30.82% of the variability in production is explained by the model in this period, indicating a moderate fit.

Pulses

Pooled Sample:The pooled sample model shows a positive relationship between pulses production and Xt, with a slope of 1.455, indicating that pulses production increases as Xt increases. The R^2 value of 0.796563 means that approximately 79.66% of the variability in pulses production can be explained by the model, which is a strong fit. Period I: In Period I, the regression model shows a positive but much weaker relationship between pulses production and Xt, with a smaller slope of 0.488. The R^2 value of 0.106201 is quite low, indicating that only 10.62% of the variability in pulses production during this period is explained by the model, which suggests a weak fit and that other factors may be influencing production. Period II: During Period II, the model shows a strong positive relationship between pulses production and Xt, with a slope of 1.3811, suggesting a more pronounced increase in production compared to Period I. The R^2 value of 0.90533 indicates that about 90.53% of the variability in pulses production can be explained by the model, indicating a very strong fit in this period.

Total Food Gains

Pooled Sample: The pooled sample model shows a weak negative relationship between total food grains production and Xt with a slope of -0.5683. This suggests a slight decrease in production as Xt increases. The R^2 value of 0.001552 is extremely low, indicating that the model explains only 0.15% of the variability in food grains production. This implies that the model has almost no explanatory power in the pooled sample. Period I: In Period I, the model shows a steeper negative relationship between total food grains production and Xt, with a slope of -3.3988. This suggests that production declines more sharply as Xt increases. The R^2 value of 0.15142 indicates that the model explains only about 15.14% of the variability in production, which is still quite low but better than in the pooled sample. Period II: In Period II, the model shows a positive relationship between total food grains production and Xt , with a slope of 7.9258. This indicates a significant increase in production as Xt rises, reversing the negative trend from Period I. The R^2 value of 0.610083 suggests that about 61.01% of the variability in production is explained by the model in Period II, which indicates a much stronger fit than in both the pooled sample and Period I.

Summary on Rice

The pooled sample model explains a moderate amount of the variation in rice production. Period I shows a stronger relationship between rice production and Xt compared to the pooled sample, while Period II has a much weaker relationship.The models for Period I are more effective at explaining the variation in production of rice compared to those for Period II.The overall regression analysis indicates that the models are statistically significant, with a strong F-statistic and low p-value for the Rice.

Summary on Wheat

Pooled Sample: The model for wheat production fits very well, explaining about 92.91% of the variability in production. Period I: Shows a strong fit, with 85.61% of the variability explained, though slightly less than the pooled sample. Period II: The model still explains a good portion of the variability (81.38%) but shows a slight decrease in the fit compared to Period I. The models are statistically significant with a low p-value, although the F-statistic is somewhat lower, indicating that while the models are significant, their effectiveness may vary slightly across periods for wheat.

Summary of Coarse Cereals

Pooled Sample: The model shows a moderate negative relationship between coarse cereals production and Xt explaining about 45.48% of the variability. Period I: The model shows a very weak relationship, with only 0.943% of the variation in production explained, indicating almost no significant trend in this period. Period II: The model shows a stronger negative relationship, with 30.82% of the variability explained, reflecting a more consistent downward trend in production. The regression models are statistically significant, as indicated by the low p-value, but the explanatory power varies significantly across periods, with Period I having a particularly weak fit.

Summary of Pulses:

Pooled Sample: The model fits well, explaining 79.66% of the variability in pulses production. Period I: The relationship between pulses production and Xt is weak, with the model explaining only 10.62% of the variability, indicating little predictive power in this period. Period II: The model shows a very strong relationship, explaining 90.53% of the variability in pulses production, making it a highly effective model for this period. The regression models are statistically significant across all periods, as indicated by the F-statistic and low P-value. Period II shows the strongest relationship between Xt and pulses production, while Period I show the weakest.

Summary of Total Good Grains

Pooled Sample: The model explains very little variability (only 0.15%) in total food grains production, suggesting that the pooled regression has almost no predictive power. Period I: The model explains slightly more variability (15.14%) in total food grains production, but it is still a weak fit, indicating a moderate decline in production over time. Period II: The model shows a strong positive relationship, with 61.01% of the variability in production explained, reflecting a significant improvement in food grains production during this period. The regression models are statistically significant, but their explanatory power varies greatly between periods, with Period II showing the strongest fit and the pooled sample showing almost none.

CONCLUSION

For the great majority of people in India, agriculture continues to be their main source of income, despite the country's young economy. India's vast population depends on the agricultural sector for food security and nutrition. It also provides a considerable amount of raw materials to other sectors, strengthening the nation's industrial foundation and producing excess goods for export. The analysis indicates that there is a growing tendency in agricultural production, area, and yield in India over both periods. Following the implementation of the new agricultural strategy, there has been an upward trend in the average output of grains, including wheat, rice, and coarse cereals. While there is no statistically significant change in output between periods I and II, the average area under cultivation is trending upward overall. Furthermore, there are no appreciable differences in the yield per hectare, indicating that the Indian agricultural industry has not changed substantially in recent years. The rates of all cereals and food grains are trending downward, despite the fact that these perform better in coarse cereals and pulses than in wheat and rice. The output of food grains and the area under cultivation in India have undergone a structural shift as a result of the new agricultural policy.

REFERENCES

[1] Agricultural Statistics at Glance. Government of India, Ministry of Agriculture & Farmers Welfare, New Delhi, 2020-21.
[2] Borthakur, A., and P. Singh. (2012).” Agricultural research in India: An exploratory study” International Journal of Social Science & Interdisciplinary Research, Vol.1 Issue 9, September 2012, ISSN 2277 3630.
[3] C.S. Ruchi. (2014). “Comparative Study on Institution - wise Credit Flow to Agriculture Sector in India”. International Journal of Economics Law and Social Sciences.1 (8): 5 -9. ISSN: 2348 -165X.
[4] Dr. N. Eswaran. (2017)."A Study on Growth and Performance of Food Grains in India with Special Reference to Maize.” IOSR Journal of Humanities and Social Science (IOSR-JHSS). vol. 22 no. 12, pp. 28- 36.
[5] Gangwar, B. (1999). “Technical Advances for Increasing Crop Productivity in Diara Areas”, Agricultural Situation in India, Vol.LV, No. 10, pp:615-620. Government of India. Economic Survey of India, Various Issues, Ministry of Finance, New Delhi.
[6] Ghosh, Nilabja and Chiranjib Neogi. (1995). “Supply Response of Food grains and Policy Actions: A Model with Rational Exceptional Hypothesis”, Indian Journal of Agricultural Economics, Vol. 50, No. 2, pp: 135-152.

[7] K. K, Prashar D. (2012). "An Analysis on Changing Trends on Food grains in Himachal Pradesh" International Journal of Pharmacy & Life Sciences. 3(6):1739 -1742. ISSN: 0976 -7126.
[8] Malik, Ruchi. (2017). "Food grains in India: Growth, instability and decomposition analysis", International Journal of Multidisciplinary Research and Development, Volume 4; Issue 6; June 2017; Page No. 304-308.
[9] Mishra (2016) VK. (2016). "Impact of Globalization on the Area, Production and Yield of the Food grains in India", 3rd International Conference on Science, Technology and Management, 978 -81 - 932074 - 0 -6, 2016; 36 -43.
[10] Kannan, Elumalai. (2011). "Trends in India's Agricultural Growth and its Determinants," Asian Journal of Agriculture and Development, Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), vol. 8(2), pp 1-21.
[11] Kumar, P., and S. Mittal. (2006). "Agricultural productivity trends in India: Sustainability issues", Agriculture economics research review, Vol.19, pp 71-88.
[12] Economic Affairs, Vol. 65, No. 3, pp. 333-342, September 2020 DOI: 10.46852/0424-2513.3.2020.3
[13] Kumari, N., Mehta, V.P. and Bhatia, J.K. (2020). "Food grains Production in India: Trend and Decompositions Analysis". Economic Affairs, 65(3): 333-342.
[14] Reserve Bank of India Handbook of Statistics on Indian Economy, Mumbai, 2020-21.
[15] Ruchi. (2014). "A Study on Agricultural Credit System in India". International Journal of Business, Management & Social Sciences. 2 (1):41 -45. ISSN: 2249 -7463.
[16] Ruchi. (2017)." Food grains in India: Growth, instability and decomposition analysis", International Journal of Multidisciplinary Research and Development, Impact Factor: RJIF 5.72 www.allsubjectjournal.com Volume 4; Issue 6, Page No. 304-308.
[17] S. S. Acharya. (2009). "Food security and Indian agriculture: Policies, Production performance andmarketing environment", Agricultural economic research review – Vol.22, pp 1-19.
[18] Sharma A. (2013). "Trends of Area, Production and Productivity of Food grain in the North Eastern States of India", Indian J. Agric; 47(4):341 -346.
[19] Sharma, H. R., Kamlesh Singh and Shanta Kumari. (2006). "Extent and Source of Instability in Food Grains Production in India", Indian Journal of Agricultural Economics, Vol. 61, No. 4, pp: 647-666.
[20] Sinha, D. K., and Jawahar Thakur. (1993). "An Economic Analysis of Growth Performance of Major Food Crops in Bihar", Agricultural Situation of India, Vol. XLVIII, No. 7, pp: 543-548.
[21] Sulochna Meena. (2016). "Analysis of growth trends in Indian agricultural sector", Asian Resonance-Vol, Issue: IV, RNI No. VPENG/2012/42622.
[22] Tripathi, A., and A R. Prasad. (2009). "Agricultural development in India since independence: A study on progress, performance and determinants" journal of emerging knowledge on emerging markets, Vol. 1, issue 1, pp 63-92.
[23] V.P.S Arora. (2013). "Agricultural Policies in India: Retrospect and Prospect", Agricultural Economics Research Review Vol. 26 (No.2), pp 135-157.