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Growth Performance of Foodgrains in India: A State Level Analysis

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Abstract: ***The Indian agriculture sector is an important sector of the economy, contributing significantly to the country's gross domestic product (GDP) and employing a major portion of the workforce. The present study attempts to focus on the growth performance of food grains like; Rice, Wheat, Coarse Cereals and Pulses. This study selected those states whose contribution to rice production is more than 2% of the selected states in India, tests for the presence of structural breaks in the foodgrains using Sen's (2003) approach of endogenous structural break over the period 1980-81 to 2023-2024. The whole analysis reveals that there are positive and significant growth rates for all the foodgrains after the breakpoint in each state in India, owing to numerous crop-specific schemes implemented by the central and state governments from time to time to enhance the productivity of land.***

Keywords: Agriculture Sector; Foodgrains; Growth rate; Structural Break

1. Introduction

At the time of independence, India was predominantly an agrarian economy, with more than 70% of the population reliant on agriculture for their sustenance. Indian agriculture sector played a crucial role in poverty reduction, food security, and export earnings. Around 40% of Indian workers are still employed in the agriculture industry, demonstrating its ongoing significance in creating jobs and fostering rural development. Thus agriculture sector is a vital part of the Indian economy, contributing significantly to the nation's GDP and employing a large portion of the workforce. In India, agriculture produce both food grain and non-food grains. Foodgrains have been considered as the principal component of human diet for thousands of years in India. They constitute rice, wheat, and coarse cereals and for a vegetarian population like India pulses are the major source of proteins. Under these circumstances, higher growth in agriculture assumes great importance and is a matter of concern for policy planners and research scholars in recent times (Chand et al., 2007; Balakrishnan et al., 2008; Bhalla and Singh, 2009; Reddy and Mishra, 2009; Vaidyanathan, 2010).

The Indian government realized the crucial importance of agriculture and took numerous significant initiatives to encourage this sector. The most important initiatives was Green Revolution launched in the 1960s which was self-sufficiency in food grain production by the 1970s and moved from being a food-deficit country to a food-surplus nation. Along with it Government initiatives like; the National Food Security Mission (NFSM), Rashtriya Krishi Vikas Yojana (RKVY) (2007–08), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Soil Health Card Scheme (2015), e-NAM (National Agriculture Market) etc. have further strengthened the sector. Additionally, schemes like PM-KISAN Rythu Bandhu, and crop insurance programs such as PMFBY (Pradhan Mantri Fasal Bima Yojana) have provided financial security and stability, encouraging farmers to adopt modern practices and boost food grain production sustainably.

The production of agriculture sector has increased dramatically throughout the years. The production of food grains, increase more than six fold from 50 million tonnes in 1950–51 to 330 million tons in 2022–23. As of the 2023–24 agricultural year, India's food grain production reached a record 332.22 million tonnes, driven primarily by high yields in wheat and rice. Uttar Pradesh continues to be the largest food grain producer in India, with an estimated output of around 592.91 lakh tonnes. Madhya Pradesh also recorded significant growth, producing around 398.43 lakh tonnes, thanks to both expanded cultivation and better yields. Punjab, known for its high per-hectare productivity, produced approximately 325.86 lakh tonnes, maintaining its reputation as one of India's top agricultural states. A notable development is the rapid rise of Telangana, which posted the highest average annual growth rate in food grain production between 2018–19 and 2023–24, at 16.42%**.** In contrast, West Bengal showed the slowest growth rate among the top-producing states, with a mere 0.14% annual increase in production.

2. Literature Review

The survey of literature relating to Indian agriculture reveals that several works has been done relating to various issues of agriculture in India. In this connection, mention should be made of the names like Mitra (1968) , Bhalla and Singh (1997), Kumar and Jain (2013), Gerber and Donald (2015), Mishra (2016), Prasad (2016), Narayanan (2016), Kumar (2022), Sutradhar (2022), Rani and Kaur (2023) among others.

Mitra (1968) estimated the growth rates of foodgrains production. This study found food grains production has declined after the second five year plan. Bhalla and Singh (1997) analyses the state level data on area and output of 43 crops for the 30 years from 1962-65 to 1992-95. This study reveals that there was a marked acceleration in the growth rate of agricultural output in India during 1980-83 to 1992-95 as compared with the earlier periods. Furthermore, agricultural growth had become regionally much more diversified. They found the period 1980-83 to 1992-95 was

also characterised by important cropping pattern changes away from coarse cereals towards rice and wheat cultivation on the one hand and towards oilseeds on the other. This study also observed the 1980s also witnessed a widespread acceleration in per male agricultural worker productivity in many Indian states. It suggest if it sustained, high labour productivity growth is likely not only to result in higher wages but also to trigger growth in the non-agricultural sector through input output and consumption linkages. Kumar and Jain (2013) examined the trends in growth and instability in Indian agriculture at the district level and has identified distinctive features and drivers of productivity growth across districts. They found productivity of crop sector has tremendous variations across districts both for the country as a whole and within a state. They suggest to mitigate the consequences of persisting instability, large-scale promotion of stabilization measures like insurance should be pursued vigorously. The study found that fertilizers has turned out to be the most important input. Along with fertilizer-use, rainfall, irrigation, source of irrigation, better human resources and road connectivity have emerged as the other critical determinants of agricultural productivity. These results signify the importance of use of modern inputs and prudent management of rainfall water, particularly in the low productivity districts. Gerber and Donald (2015) examined the role of mean climate change in agriculture, but an understanding of the influence of inter-annual climate variations on crop yields in different regions remains elusive. This study found relationship between climate variability and crop yield variability, highlighting where variations in temperature, precipitation or their interaction explain yield variability.Mishra (2016) investigated the impact of globalization on the area, production, and productivity of food grains in India. According to the study, 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. Prasad (2016) evaluates the performance and progress of Indian Agriculture since Independence. In addition, this paper also analyses sources of agricultural growth and determinants of agricultural production. This study used the decomposition test to analyse sources of agricultural growth and the production function approach to analyse determinants of agricultural production over the period 1950-51 through 2005-06. The study indicates that there is scope to increase both net sown area and gross sown area. The decomposition analysis indicates that rising output per hectare is the predominant source of agricultural growth for most of the crops and crop groups. The result suggest that land significantly affected the agricultural output growth during 1950-51 to 1964-65 and after that land became less significant and now labour and capital are significantly affecting the agricultural output growth. Narayanan (2016) examines the nature of the relationship between formal agricultural credit and agricultural Gross Domestic Product (GDP) in India using state level panel data covering the period 1995-1996 to 2011-2012. The findings suggest that over this period, all the inputs are highly responsive to an increase in institutional credit to agriculture. It is observed that input use is sensitive to credit flow, whereas GDP of agriculture is not. Priscilla et al. (2017) observed that during 1995–96 to 2004–05, the contribution of yield to foodgrains production be higher and even offsetting the area effect and interaction effect which can be attributed to the increased use of high yielding varieties and fertilizers. Kumari et,al. (2020) found that the country's food grain output increased, owing to a small rise in area and productivity over the study period. The production of food grains has shown that main cereals have shown steady improvement, except pulses. Kumar (2022) analyse the growth patterns of Himalayan Mountain states and also investigate the key elements of the mountain regions for quick expansion of Food Grain Crops. This study found, agricultural production growth (rice, wheat, coarse cereals, and total food grains) rose in yield from 1991-92 to 2016-17. With the exception of wheat, average growth rates in rice, coarse cereals, pulses, and total food grain were all positive from 1991-92 to 2016-17, according to the research. Except for Arunachal Pradesh, Jammu and Kashmir, Meghalaya, and Nagaland, food grain yield growth rates in five states i.e., Assam, Himachal Pradesh, Mizoram, Sikkim, and Tripura improved from 1991-92/1999-00 to 2010-11/2016-17.Sutradhar (2022) provide overall insights of the status of macro-level food self-sufficiency and food security in India. This study reveals that this growth has helped India to transit from being a food-deficit nation to a self-sufficient food-producing country and tremendous progress has been made in food self-sufficiency, and even exports of food. Rani and Kaur (2023) analyse the growth of foodgrains production in India and identifies the factors that have an impact on the growth of foodgrains production. They found that the production of wheat and rice has increased year by year, whereas the production of coarse cereals and pulses fluctuates during the study period. They also found that the overall foodgrains production has been on a rising trend with a minor variation in the study period. The study discovered that increased food grain production was primarily driven by increased area, yield per hectare, and shifts in production patterns. Finally, they suggest yield increased through technical innovation, agricultural research, and training, as well as boosting policy implementation in India.

The perusal of the literature revels that Food grains are essential crops that form the backbone of India’s agriculture, occupying a significant portion of the country’s cultivated land. Owing to the importance of the foodgrains in the country, analysis of growth of foodgrain was always important in Indian research. In the light of this, the present study tries to understand the picture of the different Indian Food grain crops and identify the relative positions of the states. Literature survey also suggests that lots of studies have been done on different aspect of foodgrains in India but very little attempt has been taken to perform econometric analysis using the state level data.

Given this background the present study attempts to focus on the growth performance of the Foodgrains of the selected states in India, tests for the presence of Structural Break of the foodgrains using Sen (2003) approach of endogenous structural break over the period 1990-91 to 2023-24.

3. Methodology and the Data Source

Nelson and Plosser (1982) suggested that the nature of macroeconomic data follows two types of process: Difference Stationary and Trend Stationary. The conclusion about the growth rate must be based on Trend Stationary

series because Difference Stationary series basically implies stochastic trend where variability of the series depends on time. The test for detecting Difference Stationary or Trend Stationary series is called Unit root test (Dickey-Fuller (1979, 1989) or Augmented Dickey fuller test). Perron (1989) proved that in the presence of structural break the standard unit root test is not consistent against Trend Stationary and has suggested a procedure for testing unit root in the presence of one time structural break in the series. Zivot and Andrews (1992) criticized Perron procedure for finding out the break point, as it was based primarily on visual inspection of data and argued that break point should be endogenously determined. Sen (2003) proved that the power of Zivot and Andrews (1992) test procedure is low and it can be improved by considering maximum F statistic.

To calculate the maximum F-statistic for the null hypothesis, Sen (2003) applied the F-statistic in accordance with

$$F_T^{Max} = Max_{T_b \in \{[\lambda_0 T],[\lambda_0 T]+1,\ldots,T-[\lambda_0 T]\}} F_T(T_b)$$

Here T_B is the break point which is a constant fraction of the sample size T i.e. $T_B = \lambda^C T$ with the current break fraction $\lambda^C \in (0,1)$ and the smallest integer function.

In the present study Sen (2003) approach is adopted. The following equation which admits both changes in the level and growth of the series have been employed:

$$\Delta \ln Y_t = a + bDU_t + ct + gDT_t + d\ln Y_{t-1} + \Sigma ej \Delta \ln Y_{t-j} + e_t$$

Logarithms of the dependent variables are taken as regressands. In this equation c i.e., the co-efficient of time represent growth rate for the entire sample period if g, the co-efficient of DT_t is not statistically significant. But if g is statistically significant c represent growth rate for the period before structural break whereas the growth rate after structural break is captured by the term c+g, provided g is statistically significant.

DUt =1 if t>T_γ
=0 otherwise
DT_t= t-T_γ if t>T_γ
=0 otherwise

Here T stands for period and γ stands for time break i.e, γ = TB/T, TB being break to determine the nature of the series, the test criteria is to select the series as Trend Stationary if the estimated value of F is significant at the chosen level (compared with the critical values provided by Sen (2003)) and is Difference Stationary otherwise.

The study relies on secondary data have been collected from various issues of "The Handbook of Statistics on Indian States" published by Reserve Bank of India. The present study collected data only for food crops like; Rice, Wheat, Coarse Cereals and Pulses for the period 1990-91 to 2023-24. For, Rice those states are selected whose contribution in rice production is more than 2% in this way we have selected 9 states; namely, Andhra Pradesh (28%), Uttar Pradesh (11%), West Bengal (11%), Punjab (9%), Bihar (5%), Odisha (5%), Assam (4%), Madhya Pradesh (4%), and Tamil Nadu (3%). Together, these 9 states consistently account for around 80–85% of national rice production. For, Wheat those states are selected whose contribution in Wheat production is more than 2% in this way we have selected 8 states; namely, Uttar Pradesh (31%), Madhya Pradesh (20%), Punjab (15%), Haryana (10%), Rajasthan (9%), Bihar (7%), Gujarat (4%), and Maharashtra (2.2%). Together, these 8 states consistently account for around 98% of national wheat production. For, Coarse Cereals those states are selected whose contribution in coarse cereals production is more than 2% in this way we have selected 8 states; namely, Rajasthan (17%), Karnataka (16%), Maharashtra (12%), Madhya Pradesh (10%), Uttar Pradesh (9%), Tamil Nadu (7%), Andhra Pradesh (6%), and Gujarat (4%). Together, these 8 states consistently account for around 81% of national coarse cereals production. For Pulses, those states are selected whose contribution in Pulses production is more than 2% in this way we have selected 6 states; namely, Madhya Pradesh (25%), Maharashtra (15%), Karnataka (8%), Uttar Pradesh (10%), Andhra Pradesh (4%), and Gujarat (4%); together, these 10 states consistently account for around 70% of national coarse cereals production.

4. Results and Discussion

For finding out the growth rate of Yield of various food grains, Sen (2003) approach is adopted. For this purpose the present study taken variables yield of food crops like; Rice, Wheat, Coarse Cereals and Pulses. Log of the variables are taken as a dependent variable and regression are run separately for each variables.

Results of estimation of Growth of Yield of Rice

In case of Rice, those states are selected whose contribution in Rice production is more than 2% in this way we have selected 9 states; namely, Andhra Pradesh (AP), Uttar Pradesh (UP), West Bengal (WB), Punjab (PU), Bihar (BH), Odisha (OR), Assam (AS), Madhya Pradesh (MP), and Tamil Nadu (TN).

The series' nature i.e. whether growth process of Yields of Rice converges to a path having trend preserving properties are determined found for different Indian states which can be found in **Table 1**. Result about the type of growth process suggesting that all the 9 states follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime.

Sen (2003) approach also suggests the break point of the yield of rice presented in **Table 2.** For AP and TN the break point corresponds to the year 2005-06 and 2004-05 respectively. System of rice intensification (SRI), is a climate-smart agro ecological methodology for increasing the productivity of rice by changing the management of the plant, soil, water, and nutrients. Research on SRI was promoted in 2002-03 by the state agricultural universities in TN and AP. This may be possible reason for this break point for these two state. For the state MP and PU the break points found in the year 2008-09 and for UP the break point found in 2010-11. This break may be due the fact that in 2007-08, National Food Security Mission (NFSM) launched with the aims to increase the production of rice, wheat, and pulses. The NFSM-Rice component specifically focuses on enhancing rice production through various interventions. It

focuses on enhancing productivity, restoring soil health, and improving farm-level economics. The mission provides support to farmers through various initiatives like demonstrations, training, and access to improved seeds and technologies. In PU, NFSM also promotes crop diversification to reduce reliance on water-intensive paddy cultivation. For BH and WB the break year found in the year 2012-13. This may be due to Bringing Green Revolution to Eastern India (BGREI) launched in the year 2010. In case of OR the break point correspond with the year 2011-12 this may be due to the State Rice Mission in Odisha, launched in 2010, aimed to increase rice production through the adoption of improved technologies and extension methods. Key objectives included enhancing rice productivity, promoting the use of quality seeds, and providing certified seeds at a 50% subsidy. The mission also encouraged the adoption of the System of Rice Intensification (SRI) method, which is known for its potential to increase yields with reduced input requirements. For AS the break point is 2015-16 may be due to Assam State Rice Mission launched in the year 2012 which is focused on Sali and Boro rice cultivation.

Sen (2003) approach also reveals the coefficient of intercept dummy is positive and significant for the three states (AP, AS, and WB) but rest of the others states there is no significant impact on level of yield after break point (**Table 1**). The coefficient of time and of slope dummy for all the states is positive and significant implying that a significant growth observed after the break the break point. The result of Sen (2003) approach reveals that for among the 9 states, growth of yield negative as coefficient of time (t) is negative for the 5 states like; BH, MP, OR, TN and UP, but after break point growth has increased.

The growth rate before and after break point for the 9 states are found out which can be obtained in **Table 2** The result shows that growth rate is negative before the break point for the 4 states (BH, MP, OR, and UP**)** but a positive growth rate observed before the break point for 4 states (AP, AS, PU, and WB) and the growth rate is positive for all the states after the break point except for 1 states (TN). TN have negative growth rate before and after the break point but it is observed that after break point the performance of yield of rice improve for all the 9 states.

Results of estimation of Growth of Yield of Wheat

In case of Wheat, those states are selected whose contribution in wheat production is more than 2% in this way we have selected 8 states; namely, Uttar Pradesh (UP), Madhya Pradesh (MP), Punjab (PU), Haryana (HA), Rajasthan (RA), Bihar (BH), Gujarat (GU), and Maharashtra (MH).

The series' nature i.e. whether growth process of Yields of wheat converges to a path having trend preserving properties are determined found for different Indian states which can be found in **Table 3**. Result about the type of growth process suggesting that out of 8 sample states, 7 sample states follow Trend Stationary Process implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. And only 1 states (MH) follow Difference Stationary Process. Variability of the series depends on time. No conclusion can be made about the growth of Yield of this state.

Sen (2003) approach also suggests the break point of the yield of wheat presented in **Table 4**. For HA and PU the break point corresponds to 1992-93, for UP the break point corresponds to the year 1993-94. During the 1990s, the government implemented the Integrated Cereal Development Programme in wheat-based cropping systems. This program was designed to enhance productivity through improved seed distribution, training, and extension services. This policy focused on major wheat-producing states like PU, HA, UP and MP. This may be possible reason for this breakpoint. For the state GU and MP the break points found in the year 2008-09, and for RA this become 2009-10. In 2007, the National Food Security Mission –Wheat was a landmark program targeting increased wheat production through area expansion, better seeds, integrated nutrient and pest management, and mechanization. Initially, it covered UP, MP, RA, BH, and GU. The program was highly effective in increasing wheat yields, especially in rain fed and semi-arid zones. This may be possible reason for this break point for the state GU, MP and RA. In case of BH the break point correspond with the year 2011-12 this may be due to Bringing Green Revolution to Eastern India (BGREI) (2010). The program promoted short-duration wheat varieties and off-season cultivation techniques in these less traditional wheat areas.

Sen (2003) approach also reveals the coefficient of intercept dummy is positive and significant for the three states (GU, RA, and MP) but rest of the others states it is negative and insignificant implies no significant impact on level of yield after break point (**Table 3**). The result also revels coefficient of time and of slope dummy is positive and significant implying that a significant growth observed before and after the break the break point. The result of Sen (2003) approach reveals that for all the7 states, growth of yield negative as coefficient of time (t) is negative but after break point growth has increased (**Table 3**).

The growth rate before and after break point for the 7 states are found out which can be obtained in **Table 4**. The result shows that growth rate is negative before the break point for all the 6 states but it is observed that after break point the performance of wheat improve for all the 6 states.

Results of estimation of Growth of Yield of Coarse Cereals

In case of Coarse Cereals , those states are selected whose contribution in coarse cereals production is more than 2% in this way we have selected **8 states;** namely, Rajasthan (RA), Karnataka (KA), Maharashtra (MH), Madhya Pradesh (MP), Uttar Pradesh (UP), Tamil Nadu (TN) , Andhra Pradesh (AP), and Gujarat (GU).

The series' nature i.e. whether growth process of Yields of Coarse Cereals converges to a path having trend preserving properties are determined and Break Point are found for different Indian states which can be found in **Table 5**. Result about the type of growth process suggesting that all the **8** states follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime.

Sen (2003) approach also suggests the break point of the yield of Coarse Cereals presented in **Table 6**. For the state KA, MH and UP the break point corresponds to the year 1995-96. Whereas for the state MP and RA the break point found in the year 1997-98 and 1996-97 respectively**.** The Integrated Cereals Development Programme (ICDP), Launched during 1994-95 to boost coarse cereal production through improved seeds, farm equipment, and extension services. This scheme was implemented in several states like RA, KA, MH, MP, and UP—especially in Bundelkhand, eastern, and central UP, where maize and bajra are grown. This may be possible reason for this break point for these 5 states. For the state AP and GU the break points found in the year 2017-18 and for TN the break point found in 2016-17. This break may be due the fact that in 2014-15, the state government of GU and TN implemented National Food Security Mission – Coarse Cereals with aimed at increasing area and productivity of Coarse Cereals like jowar, bajra, ragi, and maize and this program, initiated in 2015-16 in 45 mandals of AP. The result also reveals that (**Table 5**) the coefficient of intercept dummy is positive and significant for the four states like; AP, GU, RA and TN but rest of the other 4 states (KA, MH, MP and UP) there is no significant impact on level of yield after break point. The coefficient of time and of slope dummy for all the states is positive and significant implying that a significant growth observed after the break the break point.

The growth rate before and after break point for the 8 states are found out which can be obtained in **Table 6**. The result of Sen (2003) approach reveals that for among the 8 states, growth of yield negative as coefficient of time (t) is negative for the 4 states like; MH, MP, TN and UP, but after break point growth has increased. The Coefficient of time (t) is positive and significant for the 3 states like; AP, KA, and RA. For the 3 states like; AP, KA, and RA the growth rate before and after the break point is positive. For the state GU no significant growth observed before the break point but after the break point a positive growth observed. Rest of the other 4 states; MH, MP, TN and UP the growth rate negative before the break point but positive after the break point. For all the 8 states it is observed that growth of yield increased after the break point.

Results of estimation of Growth of Yield of Pulses

In case of Pulses, those states are selected whose contribution in Pulses production is more than 2% in this way we have selected 6 states; namely, Madhya Pradesh (MP), Maharashtra (MH), Karnataka (KA), Uttar Pradesh (UP), Andhra Pradesh (AP), and Gujarat (GU).

The series' nature i.e. whether growth process of Yields of pulses converges to a path having trend preserving properties are determined and Break Point are found for different Indian states which can be found in **Table 7**. Result about the type of growth process suggesting that out of 6 sample states, 5 sample states follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. And only 1 states (KA) follow Difference Stationary Process. Variability of the series depends on time. No conclusion can be made about the growth of Yield of this state.

Sen (2003) approach also suggests the break point of the yield of pulses crop presented in **Table 8**. For MH, RA, UP and GU the break point corresponds to 1991-92, for MP the break point corresponds to the year 1992-93. The possible reason for break may be 'The Technology Mission on Pulses (TMP)', initiated in 1990.

The result also reveals that (**Table 7**) the coefficient of intercept dummy is positive and significant for the four states like; AP, GU, RA and TN but rest of the other 4 states (KA, MH, MP and UP) there is no significant impact on level of yield after break point. The coefficient of time and of slope dummy for all the states is positive and significant implying that a significant growth observed after the break the break point. The result of Sen (2003) also reveals that the coefficient of intercept dummy is positive but insignificant no significant impact on level of yield after break point for all the 5 states (**Table 7**). The coefficient of time for all the states is negative and significant implying that a negative significant growth before the break the break point but coefficient of slope dummy positive and significant for all the 5 states implies significant positive growth after the break point.

The growth rate before and after break point for the **5** states are found out which can be obtained in **Table 8**. The result of Sen (2003) approach reveals that for all the 5 states, growth of yield before the break point negative but the performance is improved after the break point.

5. Conclusion

The present study attempts to focus on the growth performance of the Food grains of the selected states in India, tests for the presence of Structural Break of the foodgrains using Sen (2003) approach of endogenous structural break over the period 1980-81 to 2023-2024. To full fill the mentioned objectives the present study collected data only for foodgrains like**;** Rice, Wheat, Coarse Cereals and Pulses. The study is based on those states whose contribution in specified foodgrain production is more than 2%.

In case of Rice, all the **9** states **AP, AS, BH, MP, OR, PU, TN, UP, and WB** follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. For **AP and TN** the break point corresponds to the year 2005-06 and 2004-05 respectively. This may be due to Research on System of rice intensification (SRI) was promoted in 2002-03 by the state agricultural universities in TN and AP. For the state **MP and PU** the break points found in the year 2008-09 and for **UP** the break point found in 2010-11. The reasons of these break years may be National Food Security Mission (NFSM) - Rice implemented in the year 2007-08. For **BH** and **WB** the break year found in the year 2012-13. This may be due to Bringing Green Revolution to Eastern India (BGREI) launched in the year 2010 and for **AS** the break point is 2015-16 may be due to Assam State Rice Mission launched in the year 2012 which is focused on Sali and Boro rice cultivation. The present study also found that the growth rate before and after break point for the **9** states are found out which can be obtained in **Table 4.3**. The result shows that growth rate is negative before the break point for the 4 states (**BH, MP,**

OR, and **UP)** but a positive growth rate observed before the break point for 4 states (**AP, AS, PU, and WB)** and the growth rate is positive for all the states after the break point except for **1** states (TN). **TN** have negative growth rate before and after the break point but it is observed that after break point the performance of yield of rice improve for all the 9 states.

In case of Wheat, among the **8** sample states, **7** sample states **AS, BH, GU, HA, MH, MP, PU, RA and UP** follow Trend Stationary Process implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. And only 1 states (**MH**) follow Difference Stationary Process. Variability of the series depends on time. No conclusion can be made about the growth of Yield of this state.The break point for the states **HA and PU** the break point corresponds to 1992-93, for **UP** the break point corresponds to the year 1993-94. During the 1990s, the government implemented the Integrated Cereal Development Programme in wheat-based cropping systems. This policy focused on major wheat-producing states like PU, HA, UP and MP. This may be possible reason for this breakpoint. For the state **GU and MP** the break points found in the year 2008-09, and for **RA** this become 2009-10. The National Food Security Mission –Wheat implemented in the year 2007 this policy may be possible reason for this break point for the state **GU, MP** and **RA**. In case of **BH** the break point correspond with the year 2011-12 this may be due to Bringing Green Revolution to Eastern India (BGREI) (2010). The program promoted short-duration wheat varieties and off-season cultivation techniques in these less traditional wheat areas. The growth rate is negative before the break point for all the **7** states (**AS, BH, GU, HA, MH, MP, PU, RA and UP)** but it is observed that after break point the performance of wheat improve for all the 7 states.

In case of Coarse Cereals, all the **8** states (**AP**, **GU KA, MH, MP, RA, TN** and **UP**) follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. The break point for the state **KA, MH and UP** corresponds to the year 1995-96. Whereas for the state **MP** and **RA** the break point found in the year 1997-98 and 1996-97 respectively**.** Integrated Cereals Development Programme (ICDP) was implemented during 1994-95 to boost coarse cereal production in several states like RA, KA, MH, MP, and UP—especially in Bundelkhand, eastern, and central UP, where maize and bajra are grown. This may be possible reason for this break point for these 5 states. For the state **AP and GU** the break points found in the year 2017-18 and for **TN** the break point found in 2016-17. This break may be due the fact that in 2014-15, and for AP it is in 2015-16 National Food Security Mission – Coarse Cereals implemented with aimed at increasing area and productivity of Coarse Cereals.For all the 8 states it is observed that growth increased after the break point. For the 3 states like; **AP, KA**, and **RA** the growth rate before and after the break point positive. For the state **GU** no significant growth observed before the break point but after the break point a positive growth observed. Rest of the other 4 states; **MH, MP, TN** and **UP** the growth rate negative before the break point but positive after the break point. For all the 8 states it is observed that growth of yield increased after the break point.

In case of Pulses, out of **6** states, **5** states **GU, KA, MH, MP, RA** and **UP** follow Trend Stationary Process (TS) implying convergence towards stationary process. Further existence of TS series implies variability of the series remain constant overtime. And only 1 states (**KA**) follow Difference Stationary Process. Variability of the series depends on time. No conclusion can be made about the growth of Yield of this state. For **MH, RA, UP and GU** the break point corresponds to 1991-92, for **MP** the break point corresponds to the year 1992-93. The possible reason for break may be 'The Technology Mission on Pulses (TMP)', initiated in 1990.All the 5 states, growth of yield of Pulses before the break point negative but the performance is improved after the break point.

The whole analysis reveals that there is positive and significant growth rates for all the foodgrains in each states in India, owing to numerous crop specific schemes implemented by central and state government both during time to time to enhance the productivity of land.

Tables

Table 1: Results of One time Endogenous Structural Break Using Sen (2003) Approach (For Rice):

State	Constant	t	DU_t	DT_t	Y_{t-1}	Underlying Series
AP	-0.01 (-0.09)+	-0.0004 (-3.37)	0.41 (4.81)*	0.01 (3.89)*	0.05 (4.43)*	TS
AS	0.01 (-0.12)+	0.001 (3.27)*	0.6 (4.51)*	0.4 (4.51)*	0.002 (6.20)*	TS
BH	1.10 (5.42)*	-1.10 (-6.73)*	0.26 (1.51)+	2.07 (7.73)*	1.99 (5.96)*	TS
MP	0.002 (0.07)+	-0.001 (1.84)***	-0.03 (-1.06)+	0.001 (1.99)***	0.01 (2.38)**	TS
OR	3.91 (6.97)*	-0.96 (-5.13)*	0.07 (0.68)+	1.04 (7.79)*	0.83 (5.61)*	TS
PU	0.06 (2.03)**	0.37 (4.13)*	0.14 (0.72)+	1.21 (6.18)*	0.87 (6.29)*	TS
TN	1.92 (7.86)*	-1.26 (-8.34)*	0.16 (0.94)+	0.91 (6.34)*	1.01 (8.71)*	TS
UP	2.08 (5.75)*	-0.001 (-4. 08)*	0.03 (0.57)$^{+}$	0.005 (5.77)*	0.81 (5.79)*	TS
WB	0.12 (2.99)*	0.15 (3.55)*	0.15 (3.42)*	0.74 (1.98)**	0.02 (1.98)**	TS

*Significant at 1% level, ** Significant at 5% level, ***Significant at 10% level, $^{+}$ insignificant.

Table 2: Break year, the Possible Reasons and the growth rate before and after the break point of the selected states (For Rice)

State	Break Year	Possible Reason	Growth Before Break	Growth after Break
AP	2005-06	System of rice intensification (SRI) (2002-03)	0.004	0.10
AS	2015-16	Assam State Rice Mission (2012)	0.001	0.40
BH	2012-13	Bringing Green Revolution to Eastern India (BGREI) (2010)	-1.10	0.97
MP	2008-09	The National Food Security Mission (NFSM) 2007	-0.001	0.009
OR	2011-12	State Rice Mission 2010	-0.96	0.08
PU	2008-09	National Food Security Mission (NFSM) (2007-08)	0.37	1.58
TN	2004-05	System of Rice Intensification (SRI) (2002-03)	-1.26	-0.35
UP	2010-11	National Food Security Mission (NFSM) (2007-08)	-0.001	0.004
WB	2012-13	Bringing Green Revolution to Eastern India (BGREI) (2010)	0.15	0.89

Table 3: Results of One-time Endogenous Structural Break Using Sen (2003) Approach (For Wheat):

State	Constant	t	DUt	DTt	Yt-1	Underlying Series
BH	3.53 (3.42)*	-0.25 (-3.46)	0.02 (0.11)+	1.01 (3.46)*	0.13 (3.49)*	TS
GU	2.05 (3.03)*	-0.01 (-1.81)***	0.24 (2.16)**	0.09 (2.12)**	0.17 (2.55)*	TS
HA	8.25 (9.81)*	-0.25 (-5.82)*	-0.01 (-0.26)+	1.04 (10.82)*	0.93 (6.86)*	TS
MH	-0.02 (-0.22)+	0.0004 (0.11)+	0.21 (3.03)*	-0.02 (-2.44)	0.004 (0.35)+	DS
MP	6.02 (6.38)*	-0.01 (-6.49)*	0.05 (3.04)*	0.03 (5.97)**	0.86 (6.56)*	TS
PU	7.67 (6.37)*	-0.17 (-5.28)*	-0.01 (-0.33)+	1.41 (6.36)*	0.93 (7.34)*	TS
RA	8.59 (9.56) *	-0.33 (7.19)*	0.09 (1.83)***	0.47 (9.59)*	1.11 (9.61)*	TS
UP	6.40 (5.56)*	-0.61 (-4.97)*	-0.02 (0.71)+	0.75 (5.58)*	0.83 (5.60)*	TS

*Significant at 1% level, ** Significant at 5% level, ***Significant at 10% level, + insignificant.

Table 4: Break year, the Possible Reasons and the growth rate before and after the break point of the selected states (For Wheat)

State	Break Year	Possible Reason	Growth Before Break	Growth after Break
BH	2011-12	Bringing Green Revolution to Eastern India (BGREI) (2010)	-0.25	0.12
GU	2008-09	National Food Security Mission – Wheat (2007)	-0.01	0.08
HA	1992-93	Integrated Cereal Development Programme in wheat-based cropping systems-(1990)	-0.25	0.79
MP	2008-09	National Food Security Mission – Wheat (2007)	-0.01	0.02
PU	1992-93	Integrated Cereal Development Programme in wheat-based cropping systems (1990)	-0.17	1.24
RA	2009-10	National Food Security Mission – Wheat (2007)	-0.33	0.14
UP	1993-94	Integrated Cereal Development Programme in wheat-based cropping systems (1990)	-0.61	0.14

Table 5: Results of One-time Endogenous Structural Break Using Sen (2003) Approach (For Coarse Cereals):

State	Constant	t	DUt)	DTt	Yt-1	Underlying Series
AP	-0.06 (3.52)*	0.02 (1.97)**	0.21 (2.14)**	0.18 (3.38)*	0.003 (3.52)*	TS
GU	0.26 (0.32)+	0.02 (1.58)+	0.22 (2.38)*	0.001 (5.46)*	0.41 (2.43)**	TS
KA	4.99 (5.92)*	1.06 (-6.20)*	-0.11 (-0.96)+	5.87 (7.82)	0.88 (6.09)*	TS
MH	4.08 (9.37)*	-2.36 (6.31)*	0.09 (0.92)+	3.62 (7.95)*	0.89 (9.88)*	TS
MP	3.13 (3.23)*	-0.13 (-3.31)	0.14 (0.99)+	1.23 (4.32)*	0.47 (3.37)*	TS
RA	3.93 (6.81)*	1.93 (12.28)*	0.49 (4.05)*	4.13 (8.12)*	1.22 (12.63)*	TS
TN	-0.04 (-0.26)+	-0.02 (-2.13)**	0.10 (1.88)***	0.19 (1.91)***	0.03 (2.38)**	TS
UP	5.50 (5.84)	-2.5 (-4.88) *	0.07 (1.30)+	5.49 (5.78)*	0.77 (3.89)*	TS

*Significant at 1% level, ** Significant at 5% level, ***Significant at 10% level, + insignificant.

Table 6: Break year, the Possible Reasons and the growth rate before and after the break point of the selected states (For Coarse Cereals)

State	Break Year	Possible Reason	Growth Before Break	Growth after Break
AP	2017-18	National Food Security Mission (NFSM) – Coarse Cereals (2015-16)	0.02	0.20
GU	2017-18	National Food Security Mission (NFSM) – Coarse Cereals (2014-15)	-	0.001
KA	1995-96	Integrated Cereals Development Programme – Coarse Cereals (1994)	1.06	6.93
MH	1995-96	Integrated Cereals Development Programme – Coarse Cereals (1994)	-2.36	1.26
MP	1997-98	Integrated Cereals Development Programme – Coarse Cereals (1994)	-0.13	1.10
RA	1996-97	Integrated Cereals Development Programme – Coarse Cereals (1994)	1.93	6.06
TN	2016-17	National Food Security Mission (NFSM) – Coarse Cereals (2014-15)	-0.02	0.17
UP	1995-96	Integrated Cereals Development Programme – Coarse Cereals (1994)	-2.5	2.99

Table 7: Results of One time Endogenous Structural Break Using Sen (2003) Approach (For Pulses):

State	Constant	t	DUt	DTt	Yt-1	Underlying Series
GU	4.98 (4.79)*	-4.98 (-4.97)*	0.22 (1.27)+	5.07 (4.97)*	0.77 (5.09)*	TS
KA	5.85(38.49)*	-0.01 (-0.44)+	0.17 (1.48)+	0.03 (2.22)**	0.02 (0.73)+	DS
MH	6.39 (11.10)*	-6.38 (11.49)*	0.03 (0.34)+	6.3 (11.50)*	1.05 (11.78)*	TS
MP	6.40 (5.56)*	- 6.40 (5.58)*	0.02 (0.36)+	6.39 (5.58)*	0.83 (5.60)*	TS
RA	5.42 (6.66) *	-5.42 (7.19)*	0.13 (0.70)+	5.47 (7.19)*	1.01 (7.62)*	TS
UP	6.33 (6.42)*	-6.33 (6.53)	0.11 (0.92)+	6.51 (6.64)*	0.93 (6.62)*	TS

*Significant at 1% level, ** Significant at 5% level, ***Significant at 10% level, + insignificant.

Table 8: Break year, the Possible Reasons and the growth rate before and after the break point of the selected states (For Pulses)

State	Break Year	Possible Reason	Growth Before Break	Growth after Break
MH	1991-92	**Technology Mission on Pulses (TMP) – 1990**	-4.98	0.09
MP	1992-93		-6.38	-0.08
RA	1991-92		-6.4	-0.01
UP	1991-92		-5.42	0.05
GU	1991-92		-6.33	0.18

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