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Food Grain Trade Prospect of India: Markov Chain Analysis

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ABSTRACT

Background: This research delves into the pivotal role of agriculture in the Indian economy, emphasizing its influence on industrial growth and employment. Despite declining GDP share, agriculture remains essential for food security and jobs. The study explores the factors contributing to the significant improvement in food grain production, highlighting technological advancements, irrigation, and seed varieties since the Green Revolution.

Methods: The study employs decomposition analysis to assess the relative contributions of area, yield, and their interaction with overall lentil crop output. Instability in food grain production is measured using the coefficient of variation, focusing on the period from 1950 to 2020. Additionally, the research employs Markov chain analysis to analyze the trade directions of Indian pulses and assess the stability of food grain exports.

Results: Decomposition analysis reveals varying contributions of area, yield, and interaction effects on food grain production during different periods. Correlation coefficients indicate a strong relationship between area and output, while yield significantly influences production. Instability analysis demonstrates fluctuations in the area, production, and yield of food grains over different periods.

Conclusion: The study concludes that despite the growth in food grain production, there is a need to address instability issues, particularly in the area and yield components. The research sheds light on the evolving dynamics of India's food grain exports through Markov chain analysis, emphasizing the reliability of certain importing countries and the potential for instability in others. The findings call for sustainable practices to mitigate production risks and enhance the competitiveness of food grain growers.

Key-words: Agriculture, Indian economy, Decomposition analysis, Instability, Markov chain analysis

INTRODUCTION

Agriculture is the foundation and the mainstay of the Indian economy. Because it provides raw materials to the industrial sector, the performance of the agriculture sector influences the economy's growth and aids in the development of the industrial sector [1]. As a result, the expansion of the industrial sector is likewise dependent on the growth of the agricultural industry.

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According to CSO forecasts for 2020-21, it accounts for around 18.12% of Gross Value Added and directly or indirectly employs 58.2% of the total population. The agricultural sector's contribution to the country's GDP steadily drops, from 55.1% in 1950-51 to 20.19 % in 2021-2022. Despite a steady decline in its GDP share, agriculture remains the most crucial sector for the country's economy for two reasons: first, it provides food security to the growing population, and second, it provides employment to the workforce, as government policies in India also focus on self-sufficiency and self-reliance in food grains. Food grain production and productivity have increased because of the availability of high-yielding varieties of seeds, new technology, and improved irrigation infrastructure since the introduction of the green revolution [2]. India's output of food grains

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climbed from 51.99 million tonnes in 1951–1952 to 308.65 million tonnes in 2020–21, a 7% increase over the 251.57 million tonnes produced in 2019–20. During the same period, there was also an increase in the production of rice, lentils, and cereal grains. Food grain output in 2020–2021 totaled 25.46 million tonnes, while rice production was 122.27 million tonnes and food grain production were 109.52 million tonnes [3]. The leading causes of the striking improvement in the production of food grains were better irrigation infrastructure, the pre-monsoon, and the introduction of new technology.

From the sustainability point of view, the rate of increase in area, production, and productivity of food grains should be steady or stable. Still, in reality, numerous fluctuations/instabilities in the area, production, and productivity of food grains must be researched, and the causes that cause them. The diminishing productivity trend may impact foodgrain growers' future competitiveness; hence, it must be explored. Food grain production insecurity is wreaking havoc on farm revenue and the supply of sugarcane to sugar mills. It raises the risk of food grains output and impacts price stability [4-7] and the vulnerability of food grains growers. It means variability in food grain production that influences the prices of food grains and automatically affects the profit level of food grain crops [8]. The food grains production system would become even more unsustainable as risk and instability increased. Food grain growers are increasingly concerned about greater variability in food grain yield, productivity, and farm revenue. Some changes have occurred in the country's industry due to rapid investment, and these changes must be considered from a sustainability standpoint [9].

MATERIALS AND METHODS

The methodologies for the significant approaches to the research problem are discussed below:

Data source- The data source is entirely secondary—Agricultural Statistics at a Glance collected data on food grain production from 1950 to 2020.

Decomposition analysis- Supriya *et al.* [10] The decomposition analysis model, shown below, was used to determine the relative contribution of area and yield to the overall output of the lentil crop.

Po = Ao x Yo and

Pn = An x Yn -- (1)

Area, production, and yield in the base year are Ao, Po, and Yo, respectively, whereas An, Pn, and Yn are the relevant variable values in the nth-year item.

where, Ao and An = Area Yo and

Yn = yield in the base year and nth year, respectively.

Pn - Po = ΔP An - Ao = ΔA Yn - Yo = ΔY-- (2)

For equations (1) and (2) we can write

Po + ΔP = (Ao + ΔA) (Yo + ΔY)

Hence,

$$P = \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{\Delta Y \Delta A}{\Delta P} \times 100$$

Production = Yield effect + area effect + interaction effect [11]

As a result, the overall change in production can be broken down into yield effect, area effect, and interaction effect due to yield and area changes.

Instability and Its Measure- For assessing the instability in the production, the index certain by Cuddy and Della and used by Srivastava *et al.* [12] Supriya *et al.* [13]; CV_t = (CV) x $\sqrt{1-R^2}$

$$C.V = \frac{\sigma}{\bar{X}} \times 100$$

Where, σ= Standard Deviation

$\bar{X} = Mean$

R^2 = coefficient of determination of the variable's linear trend model.

CV_t = Coefficient variant around the trend

Period of study- The time series data for this sub-section is taken from 2005 to 2021 of foodgrains of seven major importing countries on a volume basis.

Nature and sources of data- The time series data were obtained from secondary sources regarding the export of Indian food grain to significant importing nations. The data were obtained from a publicly accessible source.

Analytical Framework- The trade directions of Indian pulses (export) were analyzed using the first-order Markov Chain Analysis. Calculating the P matrix representing the transitional probability is the core component of Markov Chain Analysis. The matrix P's Pij entries represent the likelihood that exports will

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eventually shift from country i to country j. The matrix's diagonal elements calculate the probability that a country will keep its export market share. In other words, a closer look at the diagonal components of the transitional probability matrix reveals how loyal a country is to its exports. The column elements show the likelihood of trade gains from other competing countries, while the row elements show the possibility of trade losses due to competing nations [14-16].

Markov chain analysis

$$E_{jt} = \sum_{i=1} E_{it-1} P_{ij} + e_{jt}$$

where,
E jt represents India export to the j th country in the year t,
E jt-1 represents the export of the i th country in year t-1,
Pij represents the likelihood that exports will transition from i th country to j th country
ejt defines error term, which is statistically independent of E jt-1,
n signifies the number of importing countries and
t signifies the number of years incorporated for the analysis
The transitional probabilities P_{ij}, which can be arranged in a (c*r) matrix have the following properties.

$$0 \le P_{ij} \le 1$$

$$\sum_{i=1}^{n} \text{Pij} = 1 \text{ for all i}$$

By multiplying the exports to these nations in the preceding period (t-1) with the transitional probability matrix, the predicted export share of each country during the period "t" may then be calculated [17-19].

Statistical Analysis- The analysis assessed the instability and trade in food grain production. The decomposition, instability, and Markov chain analysis were employed to quantify the changes in the production and export of food grains.

RESULTS

The growth analysis of the food grain crop's area, production, and yield revealed the general growth pattern and direction of change. This analysis, however, did not assess the precise contribution of area and yield to food grain production growth. It was required to identify the sources of change in food grain production to discover which factor was trailing and its causes or restrictions. It will also help us understand the drivers of increased food grain production. As a result, it was necessary to investigate the sources of food grain output. To investigate food grain output sources, the overall change in production was separated into five components (area, yield, and interaction effects). In Periods II, III, IV, and V the area effect was the most critical driver of change in India's food grain production (Table 1). As for food grain production in India during Periods I and II, it was found that the yield effect was responsible for the most significant change in food grain production. The highest yield effect was observed during the period I (34.90%) with an area and interaction effect of 53.98 and 10.78%.

While during Period II (18.77%) with an area and interaction effect of 74.65 and 6.12%. Similarly, in periods III, IV, and V, the yield effects were (5.01, 2.45, and 9.37%, respectively), with area effects (of 84.90, 84.21, and 85.11%, respectively) and interaction effects (9.85, 13.0, and 5.63%, respectively). During the overall period, area, yield, and interaction effects were recorded at 70.23, 6.01, and 24.11%, respectively.

Table 1: Decomposition analysis

Period	Area effect	Yield effect	Interaction effect
I	53.98	34.90	10.78
II	74.65	18.77	6.12
III	84.90	5.01	9.85
IV	84.21	2.45	13
V	85.11	9.37	5.63
Overall Period	70.23	6.01	24.11

Sum of all three effects =100

Relationship of Food Grain Production to Area and Yield- Table 2 shows a standard way of assessing changing attitudes. The correlation coefficient (r) of area and production of food grain was in the range of (0.05to 0.97) for all five periods, which was statistically significant. In contrast, the correlation coefficient (r) of yield and production was in the range of (0.94 to 0.99) for all five periods, which was significant but less than the values of association between area and production. It meant that food grain output had increased due to an increase in its area in India.

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Table 2: Relationship between area and production and yield and production of food grain

Period	Area production	Yield production
I	0.97**	0.99***
II	0.94***	0.99***
III	0.05**	0.98**
IV	0.47***	0.94**
V	0.70***	0.98**

***** and ** Significant at 0.01 level and 0.05 level.*

Instability analysis- During the instability analysis, the detrend coefficient of variation was measured for Period I (1950 to 1963), Period II (1964 to 1977), Period III (1978-1991) Period IV (1992-2005), Period V (2006-2020) and Overall period (1950-2020). The results of such an exercise were discussed.

Instability of food grain- An examination of the food grain area depicted the volatility of food grains in India (Table 3). The results showed that the coefficient variant around trend (CV_t) in the area of food grain decreased from 2.2671 (Period I) to 1.6102 (Period V), indicating that the highest instability was sown in Period III from 1978 to 1991. Still, after 1991, instability began to decline, indicating that the area had expanded. An examination of food grain production revealed that the coefficient variant around trend (CV_t) first increased from Period I to II but decreased from 6.2665 (period 3) to 3.6037 (period 5), indicating that the most Instability was planted in Period II from 1964 to 1977 (Table 1). In the analysis of foodgrain yield in India, the coefficient variant around trend (CV_t) increased from 4.5918 (Period I) to 6.4472 (Period II). At the same time, it started declining from period III to period V. Thus, based on the analysis of the food grain area, production, and yield instability, it can be concluded that Instability was recorded in the area, and yield had decreased. Still, production had increased instability, implying a greater emphasis was placed on minimizing volatility and optimizing processes in the food grain area and yield.

On the other hand, the advent of new technologies has increased the insecurity of food grain production. It raises the risk of farm output and impacts farmer income and the decision to invest in high-paying agricultural technologies. It also affected price stability and the susceptibility of low-income households.

Table 3: Instability in area, production, and yield of Food grain in India

Statistics	Period 1	Period 2	Period 3	Period 4	Period 5	Overall Period
AREA ('000 ha)						
R2	0.87	0.62	0.12	0.15	0.38	0.39
CV	6.44	3.38	2.57	2.24	2.05	5.83
Cv_t	2.26	2.08	2.41	2.06	1.61	4.52
PRODUCTION ('000 tonnes)						
R2	0.84	0.72	0.77	0.30	0.88	0.96
CV	15.20	15.19	13.29	6.54	10.70	45.53
Cv_t	6.02	7.96	6.26	5.44	3.60	8.41
YIELD (kg/ha)						
R2	0.76	0.72	0.87	0.59	0.88	0.96
CV	9.43	12.19	13.43	5.81	9.33	43.24
Cv_t	4.59	6.44	4.66	3.69	3.20	8.33

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Transition Probability Matrix for the number of food grain crops exported from India- Markov chain model analysis using quantitative data from the most recent ten years has studied the trade direction and stability of the food grain crops (2011-12 to 2019-20). The Transitional Probability Matrix shown in Table 4 gives a general sense of changes in the direction of food grain crops in export. The primary quantity-importing countries were the USA, Australia, Sri Lanka, New Zealand, South Africa, Bangladesh, and Nepal. All other importing countries were clustered under the category of the other countries. The transitional probability matrix's row elements reveal how much trade is lost due to rival nations, and the diagonal element shows how likely each nation will keep its trade volume from the prior year.

As shown by the probability of retention at 85.97%, Bangladesh was the most reliable and devoted market among the major importers of food grain commodities, followed by the USA (41.55%), Australia (31.62%), Sri Lanka (22.98%), and Nepal (20.13%). New Zealand and South Africa were the only two importing nations, which suggests that India's exports to these nations are unstable. New Zealand lost 35.69% from the USA whereas, in the future, gained from other countries 3.69%. South Africa lost about 45.38% of its previous share to Australia and approximately 29.87% to other countries, which means South Africa can gain its share from other countries, New Zealand and USA.

Nepal has a low retention probability of its share of imports, about 0.20136, but is likely to gain from the USA (21.50%), Bangladesh (12.85%), Sri Lanka (11.16%), and other countries (4.04%).

Table 4: Transition Probability Matrix for the quantity of food grains export from India (2011-2012 to 2020-2021)

Year	U S A	Australia	Srilanka	New Zealand	South Africa	Bangladesh	Nepal	Others
U S A	0.41	0.05	0.44	0.00	0.06	0.09	0.21	0.03
Australia	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.69
Srilanka	0.32	0.00	0.22	0.00	0.00	0.00	0.11	0.40
New Zealand	0.35	0.00	0.23	0.00	0.32	0.00	0.00	0.21
South Africa	0.00	0.45	0.00	0.00	0.00	0.25	0.00	0.29
Bangladesh	0.00	0.07	0.00	0.00	0.00	0.85	0.12	0.00
Napal	0.39	0.00	0.00	0.00	0.00	0.00	0.20	0.40
Others	0.26	0.10	0.27	0.03	0.35	0.00	0.04	0.08

DISCUSSION

The discussion section is focus on the findings related to the growth and instability in foodgrain production, the relationship between area and yield, and the transition probability matrix for foodgrain exports.

The growth analysis of the foodgrain crop's area, production, and yield in India revealed that the area effect was the most critical driver of change in foodgrain production during the study period. Similar results were obtained by Mishra *et al.*[20].

The highest yield effect was observed during Period I (1950-1963), with an area and interaction effect of 53.98% and 10.78%, respectively. Periods II, III, IV, and V showed a decreasing trend in yield effect, indicating that yield improvements were less significant in later periods. The analysis also found that foodgrain production was most unstable during Period II (1964-1977), with a coefficient of variation (CVt) of 6.2665, and the least unstable during Period V (2006-2020) with a CVt of 3.6037. According to Sharma [21] and Pandey and Rai [22], Similar results were reported, but there was a drastic change in the V period.

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The relationship between area and production and yield and production of food grains was also assessed. The correlation coefficient (r) of area and production of foodgrain was in the range of (0.0570 to 0.9754) for all five periods, which was statistically significant. In contrast, the correlation coefficient (r) of yield and production was in the range of (0.9451 to 0.9955) for all five periods, which was significant but less than the values of association between area and production. This suggests that foodgrain output had increased due to an increase in its area in India. The transition probability matrix for the number of foodgrain crops exported from India showed that Bangladesh was the most reliable and devoted market among major importers, followed by the USA, Australia, Sri Lanka, and Nepal. India's exports to New Zealand and South Africa were unstable, with both countries losing a significant share of their previous trade.

CONCLUSIONS

From the above fact, the study underscores the importance of area expansion over productivity growth in enhancing food grain production in India. The correlation analysis reveals a strong positive relationship between area and output, emphasizing the pivotal role of expanding cultivation areas in driving production increases. Despite low instability in area and yield, there is a notable rise in production instability, partly attributed to introducing new technologies. The linear programming analysis identifies stable and unstable export markets, emphasizing the need for increased output supported by export-friendly policies.

To ensure a sustainable food grain production system, policymakers must adopt development-oriented measures, and researchers should focus on investigative projects to expand cultivation areas and promote overall agricultural resilience.

CONTRIBUTION OF AUTHORS

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REFERENCES

[1] Ramdas S, Kumar TK, Singh GP. Wheat production in India: Trends and prospects. Recent Adv Grain Crops Res., 2019.
[2] Kumar P. Growth and Instability in paddy production in Tamil Nadu: An inter-district analysis. Int J Manag Soc Sci Res Rev., 2015; 1(17): 288-97.
[3] PARI. People's Archive of Rural India GOI 2021. Agricultural Statistics at Glance. Available at: https://ruralindiaonline.org/en/library/resource/agricultural-statistics-at-a-glance-2021/#:~:text=For%20the%20year%202020%2D2021,followed%20by%20livestock%20at%20Rs.
[4] Chand R, Raju SS. Instability in Indian agriculture during different phases of technology and policy. Indian J Agric Econ., 2009; 64(2): 283-88.
[5] Mishra P, Sahu PK, Padmanaban K, Vishwajith KP, Dhekale BS. Study of Instability and forecasting of food grain production in India. Int J Agric Sci., 2015; 7(3): 474-81.
[6] Sahu A, Nahatkar S, Kolar P. Variability and growth in production of wheat in India. Econ Affairs, 2020; 65(2): 255-60.
[7] Devi M, Kumar J, Malik DP, Mishra P. An interdistrict analysis of instability and sustainability for major crops in Haryana. Econ Affairs, 2021; 2: 217-23.
[8] Sharma A. Trends of Area, Production, and Productivity of Food grain in the North Eastern States of India. Indian J Agric., 2013; 47(4): 341-46.
[9] Pandey E and Rai VN. Growth of food grain production: A zone-wise analysis in Eastern Uttar Pradesh. J Pharma Phytochem., 2019; 8(6): 2020-22.
[10] Supriya, Srivastava AB, Kumari B, Yadav S, Shrivastava A, et al. Comparative Analysis of Sugarcane Production for South East Asia Region. Sugar Tech., 2023a; 1-10.
[11] Srivastava AB, Supriya, Kushwaha RR, Yadav S, Verma SK, et al. Source of Growth for wheat in Uttar Pradesh. Indian J Econ Dev., 2022b; 18(4): 976-80.

DOI: 10.21276/SSR-IIJLS.2024.10.2.8

[12]Srivastava AB, Supriya, Mishra P, et al. Instability and production scenario of food grain production in Uttar Pradesh using ARIMA Model and its role in food security. Indian J Econ Dev., 2022a; 18(1): 181-88.

[13]Supriya, Srivastava AB, Raghav YS, Devi M, Kumari P, et al. Modeling and Forecasting of Lentil Production in India and its Instability. J Animal Plant Sci., 2023b; 33(4), 817-28.

[14]Kusuma DK and Basavaraja H. Stability Analysis of Mango Export Markets of India: Markov Chain Approach. Karnataka J Agril Sci., 2014; 27: 36-39.

[15]Kumar K. Direction of trade of major agricultural commodities from India. Agribusiness Information Manag., 2020; 12(1), 36-49.

[16]Sharma L, Burark SS. Structural Changes in Basmati Rice Exports from India: A Markov Chain Analysis. Indian J., 2021; 66(2); 35-43.

[17]Odey G, Adelodun B, Lee S, Adeyemi KA, Cho G, et al. Environmental and Socioeconomic Determinants of Virtual Water Trade of Grain Products: An Empirical Analysis of South Korea Using Decomposition and Decoupling Model. Agron., 2022; 12(12): 3105.

[18]Srivastava AB, Singh, KK, Supriya, Verma SK, Mishra H, Ahmad R. Production and export dynamics of wheat in India. Int J Stat Appl Mat., 2023c; 8(3): 206-09. doi: 10.22271/maths.2023.v8.i3Sc.1023.

[19]Singh SP, Nandi AK, Adarsha LK. Production, export dynamics and future prospects of fresh mango of India. J Crop Weed., 2018; 14(2): 105-11.

[20]Mishra P, Sahu PK, Padmanaban K, et al. Study of Instability and forecasting of food grain production in India. Int J Agric Sci., 2015; 7(3): 474-81.

[21]Sharma A. Trends of Area, Production, and Productivity of Foodgrain in the North Eastern States of India. Indian J Agric., 2013; 47(4): 341-46.

[22]Pandey E, Rai VN. Growth of foodgrain production: A zone-wise analysis in Eastern Uttar Pradesh. J Pharmacognosy Phytochem., 2019; 8(6): 2020-22.

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