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Seasonal Swings and Graphical Tale of Growth and Productivity of Wheat in Gujarat State in Comparison with National Market (India)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study comprehensively analyzes the growth and variability in the area, production, and productivity of wheat, a staple food grain in Gujarat state, India, for the period 2001-2022. Wheat holds significant importance in India's agricultural landscape, being one of the staple crops vital for food security. Gujarat, known for its diverse agro-climatic conditions, plays a pivotal role in contributing to the nation's wheat production. Understanding the seasonal dynamics, growth patterns, and productivity trends of wheat in Gujarat which is the broader national market provides valuable insights into the agricultural dynamics of the region. Utilizing exponential fitting and statistical regression techniques, the research presents compound growth rates for India and

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Gujarat, revealing significant positive correlations between wheat cultivation area, production, and productivity. Graphical representations depict trends and fluctuations, highlighting periods of deviation from trend lines. Instability analyses for India and Gujarat shed light on the consistency and fluctuations in wheat cultivation, production, and productivity. Additionally, the study explores seasonal variations in wheat prices across markets in Gujarat, providing insights into intra-year price cycles and coefficient variations. The findings contribute valuable insights into the dynamics of wheat agriculture in Gujarat, offering implications for policy and agricultural practices.

Keywords: Instability; regression; seasonal variation etc.

1. INTRODUCTION

In the world of economics, wheat holds a significant place as a staple food grain, crucial for feeding populations and driving economic activity. This study focuses on the seasonal swings and growth patterns of wheat cultivation in Gujarat state, India, compared to the broader national market dynamics. From 2001 to 2022, we'll explore how wheat farming in Gujarat fluctuates over different seasons and compare it with trends across India. By looking at things like how much wheat is grown, how productive the farms are, and how these factors change over time, we can gain valuable insights into the economic health of Gujarat's wheat industry. Through simple graphs and charts, we'll see the story of wheat's journey in Gujarat, noticing times of growth, decline, and unexpected changes. Understanding these patterns not only helps us grasp the economics of wheat farming in Gujarat but also gives us a glimpse into how it fits into the larger picture of wheat production in India.

2. METHODOLOGY

2.1 Compound Growth Rate

$$Y = A B^t$$

Taking log on both sides

$$\log Y = \log A + t \log B$$

Assuming, log Y = y, log A = a, log B = b

We get, $y = a + bt$

Where, t = 1, 2, 3 ……n

y = area/production/productivity of wheat [1].

After regression between y and t We have value of a and b

Where, a = Constant, b= regression coefficient

As, b = 1 + r

Hence, r = b – 1

Therefore,

r = (Anti-log of b-1) ×100

Where,

r = Compound growth rate [2,3]

2.2 Instability

Cuddy-Della Valle index = $C.V.*(1 - R^2)^{0.5}$ Mahammadhusen et al. [4,5]

Where C.V. = Coefficient of Variation i.e. CV % = $\frac{SD}{Mean} * 100$

SD=Standard Deviation = $(Variance)^{1/2}$

Variance = $\frac{\sum_{i=1}^{n}(x_i - \bar{x_i})\text{^}2}{n-1}$

R^2 = ESS/TSS i.e. ratio of explained variation to total variation.

ESS = Variation explained by explanatory variable.

TSS = Total Variation.

2.2.1 Different range of instability are as follows

- Low instability = between 0 to 15
- Median instability = greater than 15 and lower than 30
- High instability = greater than 30[6]

2.3 Computation of Seasonal Variation

The seasonal variation will be calculated by multiplicative model of following form.

P = T*C*S*I

Where,

P = Monthly prices.
T = Trend values.
C = Cyclic variation.
S = seasonal variation.
I = Irregular variation.

The seasonal indices of whole period for each crop will be calculated. To remove the effect of trend and cyclic variation, moving average of 12 months will be calculated and centered. Further to obtain the combined effect of S*I ratio of original price to centered moving average will be obtained. And to remove the effect of I, these ratios will be averaged and adjusted seasonal indices will be obtained [7].

2.3.1 Coefficient of average seasonal variations

Highest and lowest values will be compared by plotting the seasonal indices graph and coefficient of the average seasonal price index variation will be obtained by using the following formula.

Coeff. of av. seasonal price index = (highest index-lowest index)/((highest index + lowest index)/2)*100

3. RESULTS AND DISCUSSION

3.1 Growth in Area, Production and Productivity

The assessment of growth rates have been done by exponentially fitting the time series data of area, production and productivity. The assessed growth rates for area, production and productivity of selected major cereals are presented in Table 1 and results are discussed thoroughly crop wise in the succeeding paragraph for selected major cereals. The data used in this analysis covers a specific period and region, capturing variations in these variables [8]. The variables are represented as follows:

- Area (ha) under Wheat cultivation.
- Production (tons) of Wheat.
- Productivity (kg/ha) of Wheat.

Wheat is a crucial cereal crop that forms the basis of many diets worldwide the graph 1 showed the graphical depiction of the data pf area, production and productivity for the studied period (2001-2022). The graph showed that the production and productivity was not upto their respective trend line from 2003 – 2006 and 2013 – 2016. Apart from this they moved parallel to each other and along their respective trend line. The area of wheat in india do not change much through the study period when compared to production and productivity, it moved along with its trend line. The study's findings revealed significant insights into the relationship between agricultural practices and wheat crop growth. Firstly, the area of land dedicated to wheat cultivation showed a robust positive correlation with crop growth, with a Cgr% of 1.04. This suggests that increasing the land area for wheat farming results in a proportionate increase in overall crop growth. Additionally, wheat production exhibited a strong positive connection, as indicated by a Cgr% of 2.53. This signifies that greater efforts in production lead to a substantial boost in wheat yield.

Table 1. Compound growth rate of India of wheat for year 2001-2022

Crop	Particulars	Cgr%
Wheat	Area	1.04*** (0.0004)
	Production	2.53*** (0.0006)
	productivity	1.57*** (0.0006)

Furthermore, the study delved into wheat productivity, which was found to have a noteworthy impact on crop growth. The Cgr% for productivity stood at 1.57, emphasizing that higher productivity rates contribute significantly to improved wheat crop growth. This implies that adopting advanced agricultural techniques, such as efficient irrigation and modernized fertilization methods, can lead to enhanced wheat productivity, ultimately bolstering overall crop growth. The study's findings revealed significant insights into the relationship between agricultural practices and wheat crop growth. Firstly, the area of land dedicated to wheat cultivation showed a robust positive correlation with crop growth, with a Cgr% of 1.04. This suggests that increasing the land area for wheat farming results in a proportionate increase in overall crop growth. Additionally, wheat production exhibited a strong positive connection, as indicated by a Cgr% of 2.53. This signifies that greater efforts like efficient use of inputs and man & technical power in production lead to a substantial boost in wheat yield. Furthermore, the study delved into wheat productivity, which was found to have a noteworthy impact on crop growth [9]. The Cgr%

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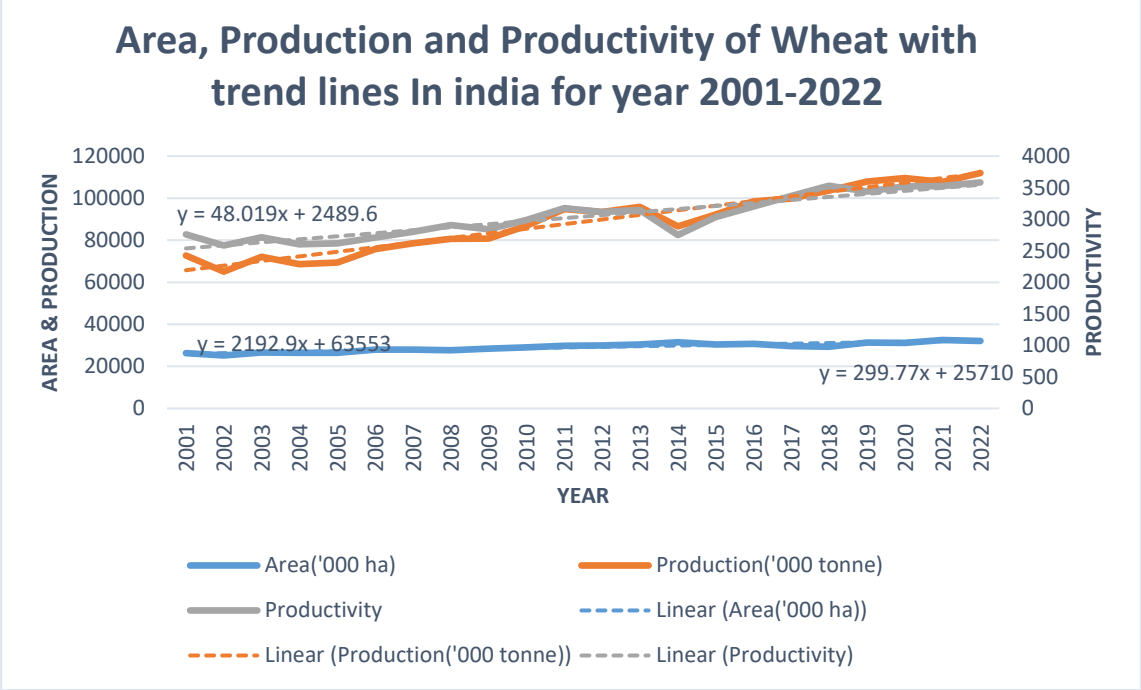
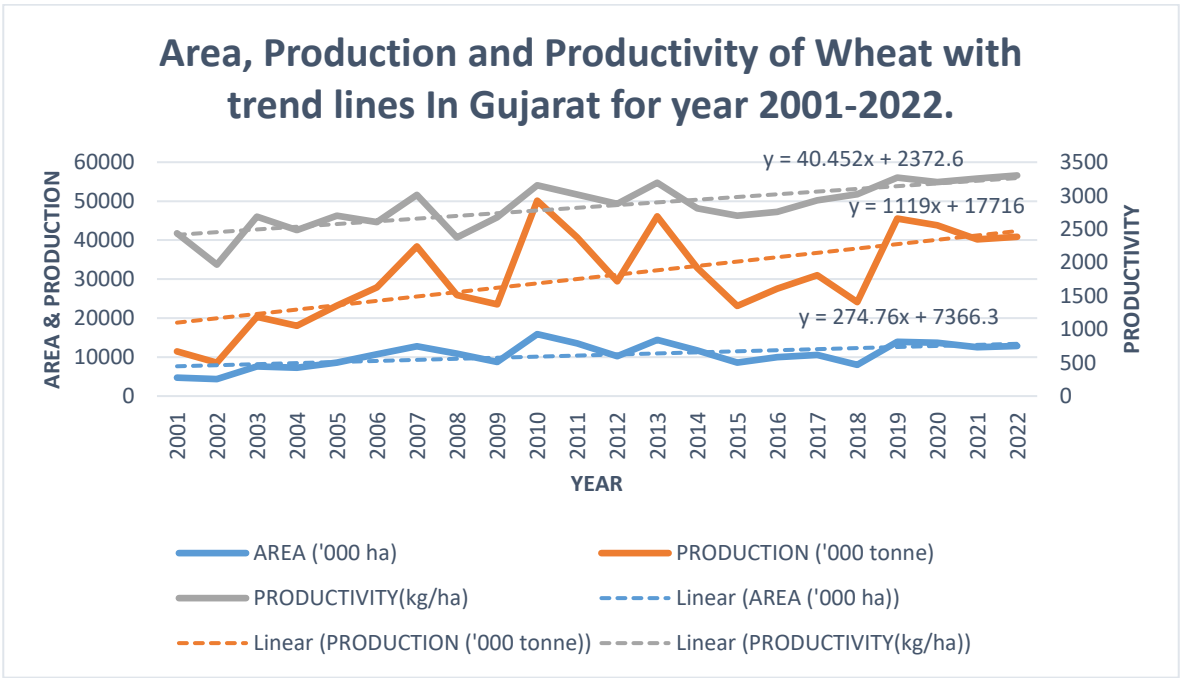


Graph 1. graphical representation of area, production and productivity of wheat with trend - lines in India for year 2001-2022



Graph 2. Graphical representation of area, production and productivity of wheat with trend lines in Gujarat for year 2001-2022

Table 2. compound growth rate of Gujarat of selected cereals for year 2001-2022

Crop	particulars	Cgr%
Wheat	Area	3.31***
	Production	4.80***
	productivity	1.50***

The study utilizes statistical analysis, primarily regression, to assess the relationship between Wheat crop performance indicators: Area, Production, and Productivity [10]. The data used in this analysis covers a specific period and region, capturing variations in these variables. The variables are represented as follows:

- Area (ha) under Wheat cultivation.
- Production (tons) of Wheat.
- Productivity (kg/ha) of Wheat.

The graphical representation of area, production and productivity for year 2001-2002 of wheat crop is depicted in graph 2. The trend lines of all the heads showed increasing trend. The graph lines of production and productivity showed wide fluctuations over years from their respective trend lines. Over most of the years the area line graph moved above the trend line.

Results: The outcomes of the regression analysis for compound growth rate of maize for year 2001-2022 are summarized as follows:

The growth rate of 3.31 percent reveals a significant positive correlation between the area under Wheat cultivation and the influencing factors. The growth rate of 4.80 percent signifies a substantial positive relationship between production and the factors analysed. The growth rate of 1.50 percent implies a noteworthy positive relationship between productivity and the factors considered.

3.2 Trends in Area, Production and Yield of wheat in India

The trends in area, production and yield of wheat have been examined through growth rate and instability analysis [11] for the period from 2001-2022.

The instability analysis has been carried out by generation cuddy Della valle index.[12] This study dives into the concept of "instability percentages" to shed light on the variations in these crops' Area, Production, and Productivity.The results of instability in area, production and production of major selected cereals during the study period are represented in Table 3.

Table 3. Instability in area, production and yield of selected cereals in India for year 2001-2022

Crop	particulars	instability %	Level of instability
Wheat	Area	2.66	Low instability
	Production	4.39	Low instability
	productivity	4.35	Low instability

The low instability in wheat cultivation area (2.66%) for the period of 2001-2022 suggests a relatively consistent age under wheat cultivation. Wheat's low production instability (4.39%) for the period of 2001-2022 indicates fluctuations in harvest quantities. The low productivity instability in wheat (4.35%) for the period of 2001-2022 highlights variations in yield per unit of land.

Table 4. Instability in area, production and yield of selected cereals in Gujarat for year 2001-2022

Crop	particulars	Instability %	Level of instability
Wheat	Area	23.80	Medium instability
	Production	28.80	Medium instability
	Productivity	7.72	Low instability

The analysis in Table 4 reveals varying levels of instability across different cereals in Gujarat. Factors influencing instability include climate, agricultural practices, and regional dynamics. Strategies to address these instabilities may involve improved crop management, climate-resilient practices, and tailored interventions for each cereal.

Area Instability (23.80%) the cultivation area for wheat shows a moderate level of instability, indicating variability in the land allocated for wheat cultivation. Production Instability (28.80%), Wheat production experiences a moderate level of fluctuation, suggesting variations in the quantity of wheat harvested. Productivity Instability (7.72%), Wheat productivity demonstrates a low level of instability, indicating relatively stable yields per unit of cultivation area.

3.3 Seasonal Variations in Cereal Prices

3.3.1 Indices of seasonal variation

A multiplicative model was used to isolate seasonal variation from the original composite series [13]. Centred twelve months averages and ratio of original price indices to these centred averages worked out for each month of eleven years period. These ratios were averaged for each of the twelve months for the whole period and were adjusted to make the twelve month's total at 1200 points.

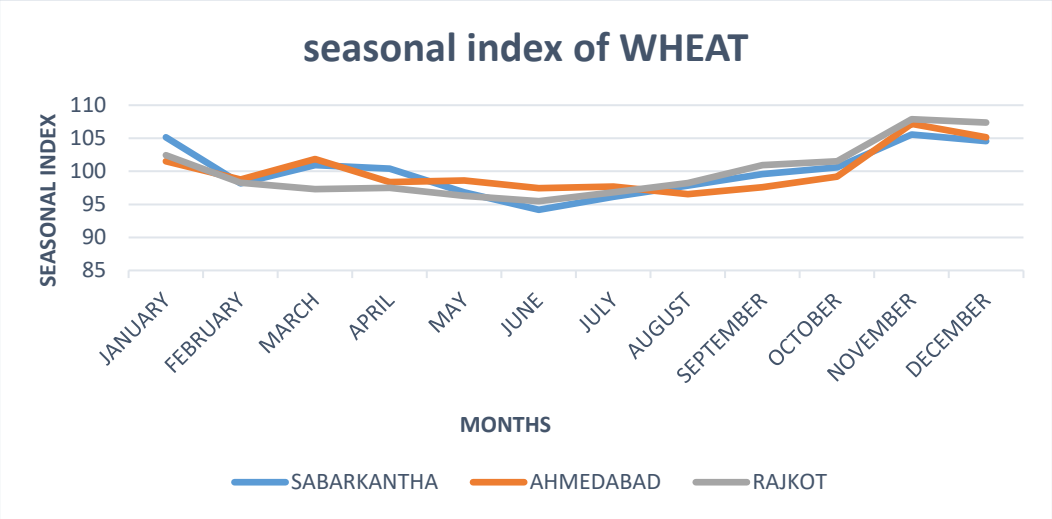
The adjusted monthly seasonal indices for Wheat are presented in Table 5. In Sabarkantha, Ahmedabad and Rajkot market the seasonal index reaches its maximum level in November (105.56, 107.17 and 107.88 respectively) and falls to its minimum level in June (94.17, 97.43 and 95.47 respectively). It indicated that there was one intra year cycle of price variation in case of Sabarkantha, Ahmedabad and Rajkot market for Wheat crop respectively during the period under study i.e., 2001 to 2022.

The Table 6 provides information on the coefficient of average seasonal price index variation for Wheat across various markets in the period from 2001 to 2022.

Sabarkantha exhibits a coefficient of 11.40%. Ahmedabad has a slightly lower coefficient of 10.44%. Rajkot shows a higher coefficient of 12.20%.

Table 5. Variation in seasonal index of wholesale prices of Wheat in Sabarkantha, Surat, and Rajkot markets at Gujarat during period 2001 to 2022

	Sabarkantha	Ahmedabad	Rajkot
month	**seasonality index (SI)**	**seasonality index (SI)**	**seasonality index (SI)**
January	105.1394	101.5112	102.4484
February	98.18283	98.758	98.27285
March	100.9464	101.8462	97.28812
April	100.4204	98.37295	97.50531
May	96.8152	98.59288	96.29421
June	94.17629	97.432	95.47714
July	96.14929	97.69497	96.83695
August	97.85846	96.5442	98.21457
September	99.57531	97.61594	100.9148
October	100.5927	99.20684	101.5066
November	105.5657	107.1798	107.8842
December	104.5779	105.171	107.3568
	1200	1199.926	1200



Graph 3. Average seasonal variation in wholesale prices of Wheat in Sabarkantha, Ahmedabad and Rajkot

Table 6. Co-efficient of average seasonal price index variation from period 2001 to 2002

Crops	Markets	Coefficient of average seasonal Price index (%)
Wheat	Sabarkantha	11.40
	Ahmedabad	10.44
	Rajkot	12.20

4. CONCLUSION

This comprehensive study aimed to assess the growth and variability in the area, production, and productivity of wheat, a staple food grain in Gujarat state, India, for the period 2001-2022. The analysis included both national and state-level perspectives, providing valuable insights into the dynamics of wheat cultivation.

4.1 National Trends

The compound growth rate (Cgr%) analysis for wheat in India revealed positive correlations in area, production, and productivity. The study highlighted the significance of increasing wheat cultivation area, production efforts, and productivity rates for overall crop growth. However, notable deviations from trend lines were observed during specific periods, indicating the need for further investigation into factors influencing production and productivity fluctuations.

4.2 Gujarat-Specific Analysis

The state-level analysis for Gujarat exhibited higher growth rates compared to the national averages, indicating a more pronounced positive trend in wheat cultivation. The regression analysis emphasized the influence of factors such as improved varieties, market demand, and policy incentives in expanding wheat cultivation area and increasing production. The findings underscore the success of agricultural interventions and advancements in promoting wheat cultivation in Gujarat.

4.3 Instability Analysis

Instability analysis using the generation cuddy Della Valle index provided insights into the consistency and fluctuations in wheat cultivation, production, and productivity. While India showed low instability across these parameters, Gujarat exhibited varying levels, with moderate instability in area and production but low instability in productivity.

4.4 Seasonal Price Variations

The study delved into seasonal variations in wheat prices across markets in Gujarat, utilizing a multiplicative model to isolate seasonal variation. The results indicated an intra-year cycle of price variation, with prices reaching maximum levels in November and minimum levels in June. Coefficients of average seasonal price index variation provided insights into price stability, with Gujarat markets showing moderate to low variability for wheat.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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