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Exploring trends and constraints of maize production in Odisha

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Abstract
Maize, an essential crop in India, plays a significant role in the agricultural landscape of Odisha. This paper explores the recent trends in maize agriculture in the state of Odisha, focusing on the adoption of new technologies, changes in farming practices, and production patterns. Maize productivity is 47361(kg/ha) over the entire study period of India and 10205(kg/ha) in Odisha. It is one of the types of evidence that the introduction of maize increases productivity significantly. India's compound growth rates for area and productivity were all positive and statistically significant at the 1% level of probability. But production is negativity and statistically significant at the 1% level of probability. Similarly, Odisha's compound growth rates for area, production and productivity were all positive and statistically significant at the 1% level of probability. The outcome also showed that area allocation during study period, the maize was more stable in Odisha than India. It also delves into the constraints faced by farmers, such as unavailability of labour, inadequate irrigation facilities, pests and diseases, nutrient in soil, latest technical knowledge and sufficient financing. The constraints were studied for production. The results revealed that on average, non-availability of agricultural labour during peak seasons was the most severe problem felt by most of the growers (72.22%). Through a combination of qualitative and quantitative data, this research provides a comprehensive overview of the current state of maize farming in Odisha and offers policy recommendations to address the challenges and improve production efficiency.

Keywords: Maize, state of Odisha, compound growth

Introduction
Maize, a widely cultivated cereal crop in India, is a crucial food staple with high nutritional value. Originating from Central America, it is used in various forms, including whole grains, processed foods, and animal feed. Maize is known as the queen of cereals due to its genetic yield potential. It is cultivated in 160 countries with diverse soil, climate, biodiversity, and management practices, contributing 36% to global grain production [Maletta, H. E. (2024)] [1]. The United States is the largest producer, contributing 35% of the world's total production and driving the US economy.

The maize industry faces challenges such as climate change, pests, and diseases, which affect yields and quality. Technological advancements like genetically modified varieties and improved agricultural practices can enhance productivity and resilience [Asfaw, D. M. *et al.*, 2024] [2]. Maize is the cheapest source of calorie intake, costing about 0.068 ETB per calorie. It is the most important staple crop for rural Ethiopians, providing domestic food supply, income generation, and employment [Alemu, D, et. Al., 2014] [3]. Maize is primarily composed of carbohydrates and has a low-fat content, making it beneficial for health [Finkenstadt, V. L. (2019)., Yokamo, S., *et al.*, 2022] [5, 4]. Seed is a crucial input in agricultural production, and its availability and successful use can improve the standard of living and income for rural dwellers (Langyintuo, 2005; Maredia & Howard, 1998) [6, 7].

India's southern states, Madhya Pradesh and Karnataka, have the highest percentage of maize land planted, accounting for 15%. Maize production is primarily used for chicken feed, animal feed, food, industrial use, starch industry, processed foods, and export. In 2020-21, 9.86 million ha of maize were grown, yielding 31.51 million tons and 29.51 q/ha of productivity in India. In

Odisha state, Nabarangpur and Gaiapati districts ranked first and second in maize production due to suitable Agro-climatic conditions.

Methodology

Growth analysis

The study analyzes Maize cultivation in India and Odisha from 2000 to 2020, estimating growth, instability, area, production, and yield using linear and compound growth rates.

1. **Linear growth rate (LGR):** To determine the, the linear function of the form

$$Y = A + Bt --------(1)$$

$$LGR = \frac{B}{\bar{Y}} \times 100 -------(2)$$

2. **Compound growth rates (CGR):** Compound growth rates (CGR) of area, production and productivity of Maize were worked for different periods as well as for entire period by fitting exponential function given below

$$Y = A \times B^t e^u ---------(3)$$

Upon logarithmic transformation the function gets converted into a linear form,

$$Y = A \times B^t e^u ---------(3)$$

Where, Y = Area / production/ and productivity of Maize
t = time variable in years (1,2,3, ...),
A = intercept,
B = trend co-efficient, and
u = disturbance or error term

While estimating compound growth rate, Dandekar (1980) observed that when the exponential form is used,

$$CGR(r) = [Antilog\,(log\,B) - 1] \times 100$$

Where, CGR = Compound growth rate t = period in year Y = area/ production / productivity A and B = Regression parameters The performance of agricultural output affected by climatic factors, the growth rate has been calculated based on three years average data (Dandekar, 1980; Minhas, 1966; Singh and Rai, 1997; Deosthali and Chandekar, 2004. The coefficient of time $\hat{B}$ was tested by t-test statistic

$$t = \frac{\hat{B}}{SEofB}$$

$$S.E\ of\ B = \sqrt{\frac{\Sigma(Y-\hat{Y})^2}{N}}$$

Instability analysis

Della Valle and John Cuddy, 1978 developed the Cuddy-Della Valle index (CDVI) to measure instability in area, production, and productivity in rice. This index, developed by Cuddy and Della Valle, excludes deviation due to secular trends or growth, ensuring consistency in estimating dispersion across units.

Cuddy-Della Valle index (CDVI)

This method is used to examine the extent of risk involved in Maize production. The instability in area, production and yield was estimated using the following Cuddy-Della Valle Index.
The estimable form of the equation is as follows:

$$CDVI = CV \times \sqrt{(1 - Adj.R^2)} ------------------------ (7)$$

$Where, CDVI = Cuddy - Della\ Valle\ Instability\ index\ in\ per\ cent$

$CV = Coefficient\ of\ variation\ in\ per\ cent$

$Adj.R^2 = Coefficient\ of\ determination\ from\ time\ trend\ regression$ $adjusted\ by\ the\ number\ of\ degree\ of\ freedom.$

The value of (CDVI) has a range of 0-15 is categorized as low, 15-30 as moderate and above 30 as high

Problems in production of bt- cotton: The problems were presented with the help of percentages

Results and Discussion

Descriptive statistics

The results for maize area, production, and productivity are shown in Table 1. The study analysed maize area, production, and productivity in India and Odisha. India had 165.31 thousand ha of maize planted, while Odisha had 4.50 thousand ha. India had 398.61 million tons of maize production, while Odisha produced 43.19 thousand tons. The results suggest that if India's maize cultivation area increases to 398.61 thousand tons, Odisha's production decreases.

Table 1: Descriptive statistics of maize Crop in India & Odisha

Category	Period	Total	Mean	Range	SE	CV
Area (thousand ha)	India	165.31	8.27	-3.05	0.22	11.81
	Odisha	4.50	0.23	0.12	0.01	17.66
Production (thousand tons)	India	398.61	19.93	17.62	1.27	28.49
	Odisha	43.19	2.16	1.88	0.16	32.70
Productivity (kg/ha)	India	47361.00	2368.05	1389.00	96.14	18.16
	Odisha	10205.18	510.26	601.21	50.91	44.62

Maize productivity is 47361(kg/ha) over the entire study period of India and 10205(kg/ha) in Odisha. It is one of the types of evidence that the introduction of Maize increases productivity significantly.

Compound growth rate

Regression analysis, as stated above, was used to estimate the compound growth rate of maize production, yield, and area in India. The analysis was performed for the years 2000–01 to 2019–20. The data for the years 2000–2001 to 2019–2020 illustrates the maize industry's compound growth rate for India and Odisha in Table 2. India's compound growth rates for area and productivity were all positive and statistically significant at the 1% level of probability. But production is negativity and statistically significant at the 1% level of probability. Similarly, Odisha's compound growth rates for area, production and productivity were all positive and statistically significant at the 1% level of probability

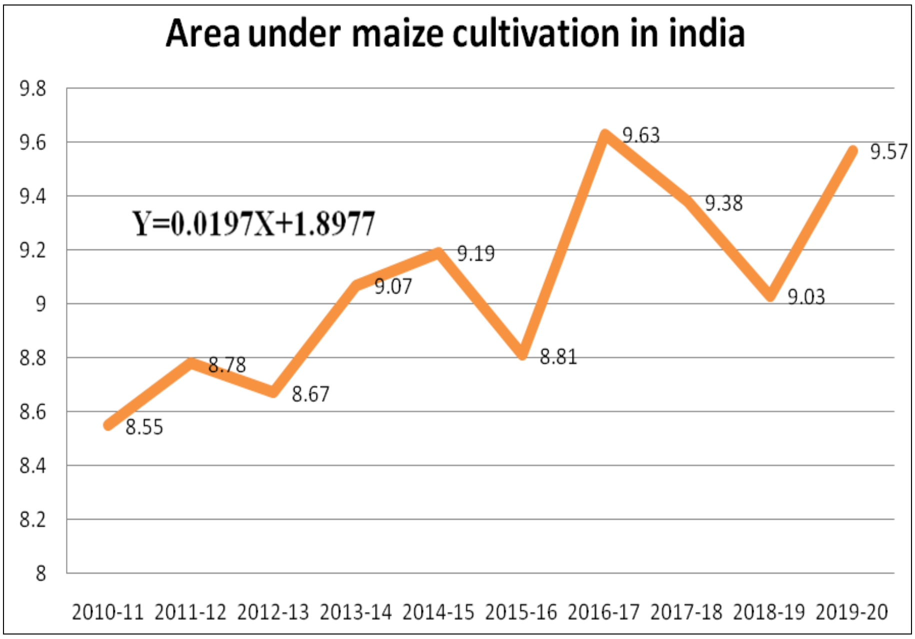

Fig 1: Trend of covered maize area in India

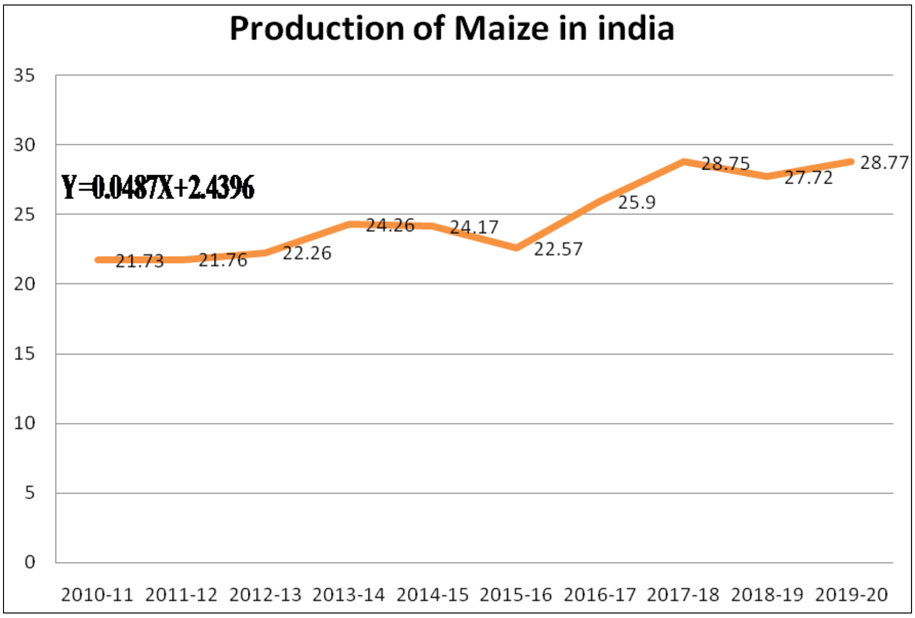

Fig 2: Trend of maize production in India

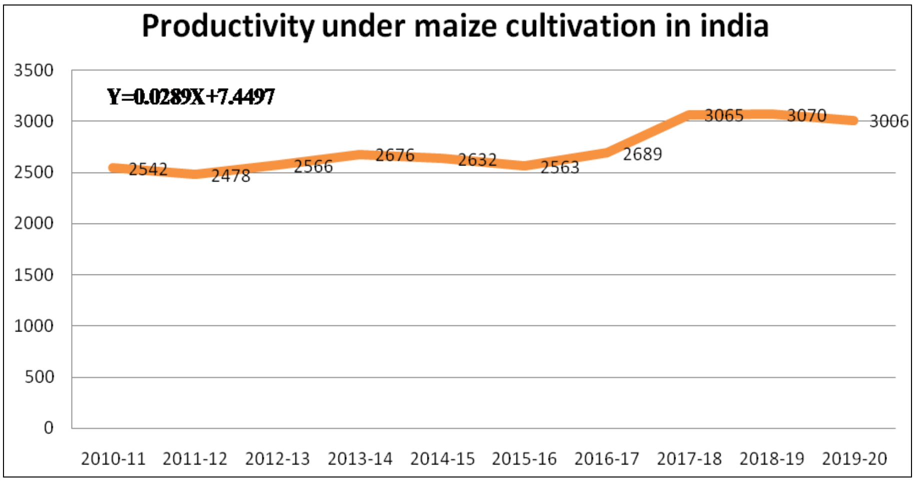

Fig 3: Trend of maize productivity in India

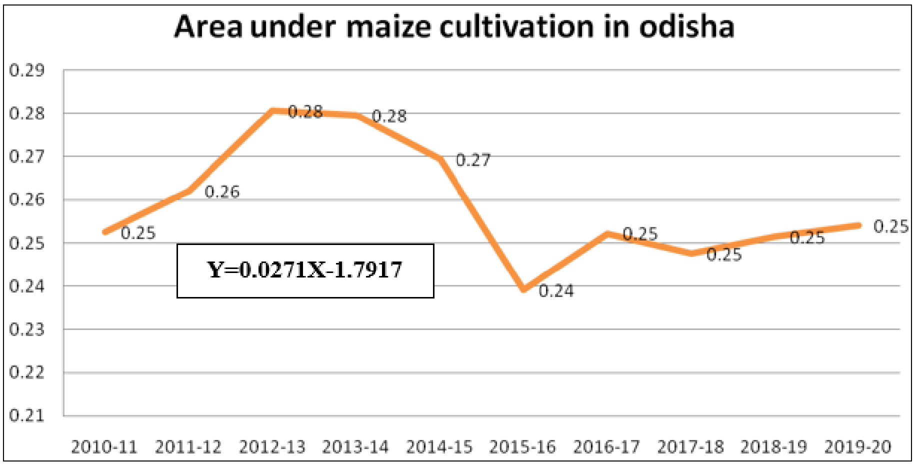

Fig 4: Trend of Covered Maize Area in Odisha

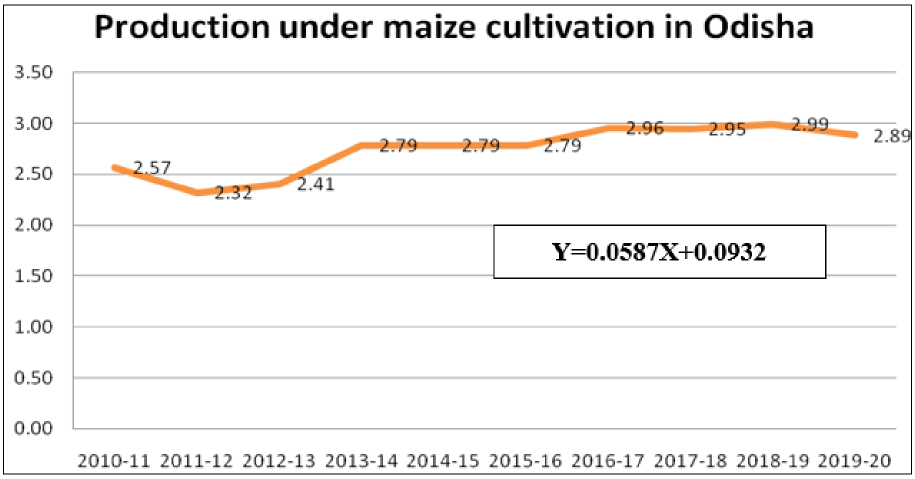

Fig 5: Trend of maize production in Odisha

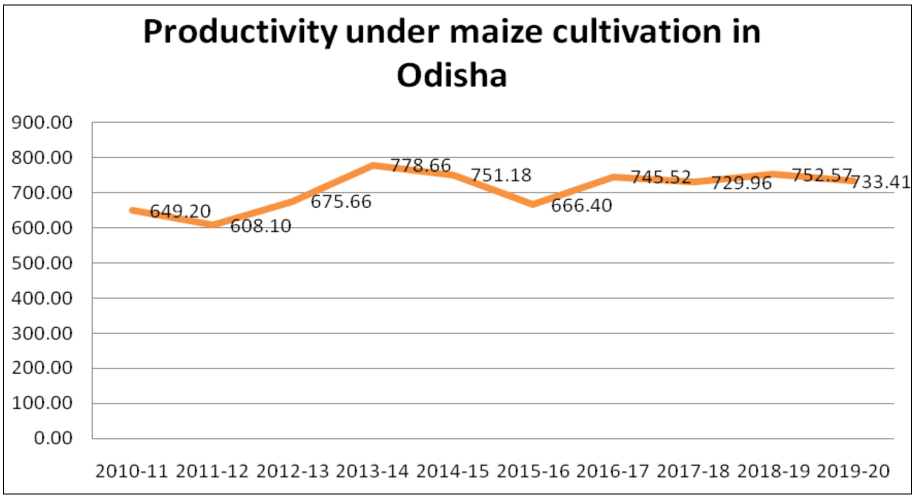

Fig 6: Trend of maize productivity in Odisha

Table 2: Compound growth rate for maize crop in India and Odisha during period of 2000-20

S. No	Periods	CGR		
		Area	Production	Productivity
1	India	2.00*** (0.00001)	-95.13*** (0.00006)	2.94*** (0.00002)
2	Odisha	2.75*** (0.00002)	6.05*** (0.00001)	8.96*** (0.00005)

#Parenthesis indicates the P value; NS indicates non-significance at 5%, *** indicates significance at 1%

Instability analysis

Table 3: CDVI index for area of maize crop during period of 2000-20

	CV	Adj. R^2	SQRT (1-Adj. R^2)	CDVI
	India			
Area	11.81	0.91	0.30	3.56
Production	28.49	0.93	0.27	7.69
Yield	18.16	0.86	0.37	6.76
	Odisha			
Area	17.66	0.74	0.51	9.01
Production	32.70	0.87	0.37	11.94
Yield	44.62	0.85	0.39	17.41

The value of (CDVI) has a range of 0-15 is categorized as low, 15-30 as moderate and above 30 as high.

When comparing the CDVI (Table 3) value in India and Odisha indicated that the area and production Instability is low in both Odisha and India. In terms of productivity, Odisha is moderate, but the India's instability is low during the study period. The outcome also showed that area allocation during the Maize was more stable in Odisha than India. The reasons for increasing trend in maize area and production over time may be attributed due to high-quality varieties of maize and improper managerial abilities of maize industry in the state. It also reflects that there was a greater degree of diversification to vegetables and pulses crops because of inadequate irrigation facilities.

Constraints faced by maize growers

The developments of new agricultural technologies do not yield benefits by itself. The new technologies are required to be transferred to the farmer's field. In the past, improved technologies were developed at a fast pace. But the adoption of technologies occurred at desired pace was only in case of some specific regions and crops. There have been some constraints in the adoption of technology in Maize. Though some farmers can achieve high yields with the help of new technologies, they have hardly reached near the success attained at experimental level. The problems of Maize growers were identified through close ended questions. Based on the frequency and percentage of the respondents, intensity of problems was assessed, and ranking was done as shown in Table 4. In the process of agricultural development, the gene is the new farming technology. The benefit of such technology is derived only when individual farmers in his local situation efficiently utilize it. Many constraints are faced by the farmers, which are ultimately responsible for the low yield particularly in case of maize production. The constraints were studied for production. The results revealed that on an average, non-availability of agricultural labour during peak seasons was the most severe problem felt by most of the growers (72.22%). It could be attributed to the reason that majority of the laborers were not willing to work at the prevailing wage rate as they were much interested to work in non-agricultural sector as they received good number of wages comparatively. Problems like high incidence of sucking insect-pests were faced by 53.33% of farmers and they claimed that with the introduction of Maize, though *Turcicum leaf blight* damaged had declined, there was an increased damage of sucking pests such as Aphids, Termites and Stem borer. Problems of lack of technical guidance were faced by 32.22% of farmers. Other major production problems faced by the Maize growers were irrigation facilities 91.11%.

Table 4: Constraints Faced by Maize Growers

Rank	Problems/Constraints	Small (30)	Medium (30)	Large (30)	Overall (90)
	Production Constraints				
1	Unavailability of training and demonstration	18 (60.00)	23 (76.67)	20 (66.67)	61 (67.78)
2	Crop affected by insect pest and dieses and bad whether side effects	16 (53.33)	16 (53.33)	16 (53.33)	48 (53.33)
3	Unavailability of labour at time	22 (73.33)	26 (86.67)	17 (56.67)	65 (72.22)
4	Lack of sufficient financing problem	28 (93.33)	29 (96.67)	25 (83.33)	82 (91.11)
5	Lack of nutrient in soil and lack of sufficient soil testing facilities	11 (36.67)	11 (36.67)	7 (23.33)	29 (32.22)
6	Knowledge about recommended package of practices for the crop	15 (50.00)	13 (43.33)	11 (36.67)	39 (43.33)
7	Lack of improved and high yielding varieties of maize	8 (26.67)	10 (33.33)	9 (30.00)	27 (30.00)
8	Lack of latest technical knowledge about the crop	11 (36.67)	11 (36.67)	7 (23.33)	29 (32.22)
9	Lack of irrigation facilities	28 (93.33)	29 (96.67)	25 (83.33)	82 (91.11)

Note: Figures in the parentheses indicate the percentage to average of total sample size

Opportunities and policy recommendations

- Government initiatives promoting micro-irrigation systems like drip and sprinkler irrigation can enhance water use efficiency in maize cultivation to mitigate climate change impacts.
- Extension services are essential for enhancing farmer education and modern agricultural practices, thereby improving maize production and disseminating knowledge about the latest technologies and farming techniques.
- Improved market infrastructure, farmer-producer organizations, cold storage facilities, and transportation can enhance farmers' access to markets, improve prices, and reduce post-harvest losses.
- Investing in research to develop drought- and pest-resistant maize varieties and region-specific hybrid varieties will enable farmers to adapt to changing environmental conditions.

Conclusion

The maize growth in Odisha, India, is statistically significant, with positive growth rates for area, productivity, and productivity at the 1% level of probability. However, production is negatively and statistically significant in India. Factors such as unavailability of labour, inadequate irrigation facilities, pests, diseases, and soil nutrient levels affect farmers' productivity. Addressing these constraints through policy interventions, technological innovations, and improved market infrastructure can improve maize production in Odisha, benefiting both farmers and the state's agricultural economy.

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