

District-Level Growth Dynamics of Cropping Intensity: A Comparative Time-Series Analysis of Bargarh and Sambalpur

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Abstract:

Agricultural intensification is a crucial indicator of land-use efficiency and structural transformation in agrarian economies. This study examines the trend and growth pattern of cropping intensity in Bargarh and Sambalpur districts over the period 1994-95 to 2019-20. The analysis is based on secondary data collected from official agricultural records. Cropping intensity was calculated using the ratio of gross cropped area to net sown area, and growth performance was evaluated using annual growth rates, compound annual growth rate (CAGR), and a semi-log regression model. The results reveal considerable inter-annual fluctuations in both districts, with Sambalpur exhibiting greater volatility compared to Bargarh. The semi-log regression analysis indicates a positive, statistically significant growth trend in cropping intensity in both districts. The estimated CAGR is 0.39 per cent for Bargarh and 1.05 per cent for Sambalpur, suggesting relatively stronger growth in Sambalpur during the study period. However, moderate R^2 values indicate that factors beyond time, such as irrigation expansion, climatic variability, and technological adoption, also influence cropping intensity. The study concludes that while agricultural intensification has progressed in both districts, stability and sustainability remain critical challenges. The findings emphasise the need for improved irrigation management, climate-resilient farming practices, and strengthened institutional support to ensure balanced and sustained agricultural development.

Keywords: CAGR, Cropping Intensity, Log-linear

1. Introduction

Agriculture plays a vital role in the economic development of developing countries, particularly in India, where a large proportion of the population depends on farming for livelihood. Increasing cropping intensity is considered an important indicator of agricultural intensification and improved land use efficiency (World Bank, 2008). In the context of limited land availability, enhancing cropping intensity through multiple cropping and better resource utilisation becomes essential for sustaining agricultural growth and food security (Rao, 2005). Irrigation development, technological advancement, and public investment have been identified as key determinants influencing agricultural productivity and cropping patterns in India (Fan et al., 2000; Hazell & Ramasamy, 1991).

Cropping intensity reflects the extent to which agricultural land is utilised for raising crops more than once in a year. Changes in cropping patterns are often driven by institutional support, irrigation infrastructure, market incentives, and policy interventions (Desai & Namboodiri, 1997; Vaidyanathan, 1999). Several studies have emphasised that agricultural growth during the reform period has been uneven across regions, with significant inter-district variations (Chand, 2004; Sharma, 2011). Therefore, district-level analysis becomes crucial for understanding localised trends and structural changes in agriculture.

Odisha, being predominantly agrarian, exhibits considerable regional disparities in agricultural performance. Bargarh and Sambalpur districts are important agricultural regions, yet their cropping intensity trends and growth patterns may differ due to variations in irrigation facilities, technological adoption, and climatic conditions. While agricultural statistics provide aggregate information (Government of India, 2019; Directorate of Economics and Statistics, 2020), a systematic econometric analysis is necessary to examine long-term growth trends and statistical significance.

In this context, the present study attempts to analyse the trend and growth pattern of cropping intensity in Bargarh and Sambalpur districts over the period 1994-95 to 2019-20 using annual growth rates, compound annual growth rate (CAGR), and a semi-log regression model (Gujarati & Porter, 2009; Wooldridge, 2016). By comparing the magnitude and significance of growth across districts, the study seeks to provide insights into the dynamics of agricultural intensification and its stability over time.

2. Research Gap

While several studies examine agricultural growth and productivity at the national or state level, relatively limited attention has been paid to long-term district-wise dynamics of cropping intensity in Odisha, particularly over an extended time horizon. Existing research often integrates multiple indicators such as irrigation, yield, or credit, but fewer studies isolate cropping intensity as a central analytical variable to understand spatial disparities and temporal shifts. Moreover, the distinction between agricultural intensification and structural transformation remains insufficiently explored at the sub-state level. By focusing exclusively on district-wise cropping intensity from 1994 to 2020, this study attempts to fill this gap by providing a systematic temporal and comparative analysis of land-use intensification across districts, thereby contributing to a more nuanced understanding of regional agricultural development.

3. Research Objectives

The present study aims to examine the growth and trend pattern of cropping intensity in Bargarh and Sambalpur districts during the period 1994-95 to 2019-20. Specifically, it seeks to estimate the growth rate of cropping intensity in both districts using a log-linear (semi-log) trend model and to examine the statistical significance of

the estimated growth trends. The study further intends to compare the growth trajectories of cropping intensity between Bargarh and Sambalpur to understand relative performance over time. Additionally, it aims to analyse inter-district variations in agricultural intensification and assess the extent of changes in cropping intensity across the study period.

4. Data Source and Methodology

The study is based on secondary data collected for a period of 26 years, from 1994–95 to 2019–20. The required data on gross cropped area and net sown area were obtained from official district statistical handbooks and agricultural records. Cropping intensity was calculated using the standard formula:

$$\text{Cropping Intensity (\%)} = (\text{Gross Cropped Area} / \text{Net Sown Area}) \times 100.$$

Also, the study is analytical and quantitative in nature. It examines the trend and growth pattern of cropping intensity in Bargarh and Sambalpur districts over a specified time period. The study focuses on understanding long-term changes and comparative growth performance between the two districts. To examine whether cropping intensity has shown a significant growth trend over the study period, the following hypotheses were formulated:

Hypotheses

Null Hypothesis (H_0): There is no significant trend in cropping intensity in Bargarh and Sambalpur districts during the study period (i.e., the growth coefficient $\beta = 0$).

Alternative Hypothesis (H_1): There is a significant positive trend in cropping intensity in Bargarh and Sambalpur districts during the study period (i.e., the growth coefficient $\beta > 0$).

5. Data Analysis

To analyse the growth pattern and trend of cropping intensity, the following statistical and econometric tools were used:

(i) Annual Growth Rate (AGR): Year-to-year percentage change in cropping intensity was calculated to examine short-term fluctuations.

(ii) Compound Annual Growth Rate (CAGR): To measure the average annual growth over the entire study period, CAGR was estimated using the semi-log trend model.

(iii) Semi-Log Regression Model: The semi-log regression model is widely used for growth estimation (Gujarati & Porter, 2009; Wooldridge, 2016).

To estimate the long-term growth trend, the following model was employed:

$$\ln(Y) = \alpha + \beta t$$

Where:

Y = Cropping Intensity, α = Intercept, β = Growth coefficient, t = Time variable

The coefficient ' β ' represents the growth rate. The statistical significance of the trend was tested using t-statistics and p-values. The goodness of fit of the model was measured using the coefficient of determination (R^2).

Table 1: District-wise Cropping Intensity and Annual Growth Rate in Bargarh and Sambalpur (1994-95 to 2019-20)

Year	Bargarh Cropping Intensity (%)	Bargarh Annual Growth Rate (%)	Sambalpur Cropping Intensity (%)	Sambalpur Annual Growth Rate (%)
1994-95	144	-----	140	-----
1995-96	138	-4.1	148	5.7
1996-97	125	-9.4	132	-10.8
1997-98	128	2.4	132	0.0
1998-99	126	-1.5	122	-7.6
1999-00	129	2.3	131	7.4
2000-01	124	-3.8	121	-7.6
2001-02	132	6.4	149	23.1
2002-03	128	-3.03	124	-16.8
2003-04	137	7.03	136	9.7
2004-05	133	-2.9	153	12.5
2005-06	133	0	156	2.0
2006-07	138	3.7	156	0.0
2007-08	151	9.4	188	20.5
2008-09	149	-1.3	172	-8.5
2009-10	150	0.67	168	-2.3
2010-11	151	0.66	158	-6.0
2011-12	153	1.3	152	-3.8
2012-13	137	-10.4	154	1.3
2013-14	142	3.6	153	-0.6
2014-15	143	0.70	162	5.9
2015-16	129	-9.79	183	13.0
2016-17	147	13.95	164	-10.4
2017-18	140	-4.76	238	45.1
2018-19	140	0	140	-41.2
2019-20	137	-2.14	130	-7.1

Source: Author Calculation from Five decades of Odisha Agriculture statistics 2020.

Table 1 presents the year-wise cropping intensity and corresponding annual growth rates for Bargarh and Sambalpur districts from 1994-95 to 2019-20, revealing noticeable inter-annual fluctuations and contrasting growth behaviour between the two districts. In Bargarh, cropping intensity fluctuated within a relatively moderate

range, declining from 144 per cent in 1994-95 to a low of 124 per cent in 2000-01, and later reaching a peak of 153 per cent in 2011-12 before slightly tapering to 137 per cent by 2019-20. The annual growth rates show alternating periods of increase and decline, with notable contractions in 1996-97 (−9.4%), 2012-13 (−10.4%), and 2015-16 (−9.79%), while the highest positive growth was observed in 2016-17 (13.95%). These fluctuations indicate that although Bargarh experienced gradual long-term improvement in cropping intensity, the growth pattern was not smooth and remained sensitive to year-specific factors such as rainfall variability, irrigation availability, and cropping pattern adjustments. In contrast, Sambalpur exhibited much greater volatility throughout the study period, with cropping intensity ranging from 121 per cent in 2000–01 to an exceptionally high 238 per cent in 2017–18, followed by a dramatic decline of −41.2 per cent in 2018–19. The district recorded several sharp expansions, including 23.1 per cent growth in 2001–02, 20.5 per cent in 2007–08, and an extraordinary 45.1 per cent in 2017–18, alongside significant negative growth in years such as 2002–03 (−16.8%) and 2018–19 (−41.2%). This pattern suggests that Sambalpur experienced rapid but unstable changes in cropping intensity, possibly due to temporary expansion of double cropping, changes in irrigation infrastructure, or climatic and policy-related shocks. Overall, the comparison indicates that Bargarh followed a relatively steady yet modest growth trajectory, whereas Sambalpur displayed higher growth potential accompanied by pronounced instability, thereby justifying the need for further trend and regression analysis to understand the underlying long-term growth dynamics beyond short-term fluctuations.

Table 2: Descriptive Statistics of Cropping Intensity (1994–95 to 2019–20).

District	Mean (%)	Std. Dev.	Minimum	Maximum	CV (%)
Bargarh	137.27	8.69	124	153	6.33
Sambalpur	152.38	24.95	121	238	16.37

Source: Author Calculation from Five decades of Odisha Agriculture statistics 2020.

The descriptive statistics reveal notable inter-district differences in cropping intensity patterns. Sambalpur recorded a higher mean cropping intensity (152.38 per cent) compared to Bargarh (137.27 per cent), indicating relatively greater land-use intensification. However, Sambalpur also exhibited substantially higher variability, with a coefficient of variation of 16.37 per cent, compared to only 6.33 per cent in Bargarh. The wider range in Sambalpur (121–238 per cent) reflects significant inter-year fluctuations, suggesting episodic intensification. In contrast, Bargarh demonstrates greater stability in cropping intensity over time, with relatively moderate variation and a narrower range (124–153 per cent).

Table 3: Semi-Log Trend Growth Results of Cropping Intensity (1994–95 to 2019–20).

District	Growth Coefficient (β)	CAGR (%)	t-value	p-value	R ²
Bargarh	0.00394	0.39	2.61	0.015	0.22
Sambalpur	0.01049	1.05	3.07	0.005	0.28

Source: Author Calculation from Five decades of Odisha Agriculture statistics 2020.

For Bargarh District

From your regression results:

- Intercept (α) = 4.8732
- Growth Coefficient (β) = 0.00394
- t = Time variable (1, 2, 3 ... 26)
- Y = Cropping Intensity (%)
- $\ln(Y)$ = Natural log of cropping intensity

Estimated Model for Bargarh:

$$\ln(Y) = 4.8732 + 0.00394t$$

Meaning of Values:

- Y = Cropping Intensity of Bargarh
- α (4.8732) = Log value of cropping intensity when t = 0
- β (0.00394) = Annual growth rate in log form
- t = Time in years (1994–95 = 1, ... , 2019–20 = 26)

The CAGR derived from this is 0.39% per year.

For Sambalpur District

From your regression output:

- Intercept (α) = 4.8732 (approx 4.87 based on output)

- Growth Coefficient (β) = 0.01049
- t = Time variable (1 to 26)
- Y = Cropping Intensity (%)

Estimated Model for Sambalpur:

$$\ln(Y) = 4.8732 + 0.01049t$$

Meaning of Values:

- Y = Cropping Intensity of Sambalpur
- α (4.8732) = Log value when time is zero
- β (0.01049) = Annual growth rate in log form
- t = Time variable

The CAGR derived from this is 1.05% per year.

In the semi-log regression model $\ln(Y) = \alpha + \beta t$, the intercept (α) represents the estimated logarithmic value of cropping intensity when the time variable (t) is equal to zero. For Sambalpur district, the estimated value of α is 4.8732. When this value is converted into its antilogarithmic form ($Y = e^{4.8732}$), the estimated base level of cropping intensity is approximately 130.7 per cent. Similarly, for Bargarh district, the intercept value ($\alpha \approx 4.87$) gives an antilog of nearly 130 per cent. This indicates that, according to the fitted regression equation, the theoretical starting level of cropping intensity at the base period is around 130 per cent in both districts. However, this does not represent the actual observed value in any specific year; rather, it reflects the model's estimated baseline from which the growth trajectory begins. Thus, α provides the foundational level of cropping intensity, while the slope coefficient (β) captures the rate of change over time, determining the direction and magnitude of the long-term growth trend during the study period.

The semi-log trend results indicate positive and statistically significant growth in cropping intensity in both districts. However, Sambalpur exhibits a substantially higher compound annual growth rate (1.05 per cent) compared to Bargarh (0.39 per cent). The growth trend in Sambalpur is significant at the 1 per cent level, while Bargarh is significant at the 5 per cent level. Additionally, the R^2 values suggest that time explains a slightly

greater proportion of variation in Sambalpur than in Bargarh. These findings indicate relatively stronger but more dynamic intensification in Sambalpur compared to the relatively stable yet slower growth pattern in Bargarh.

The hypotheses were tested using a semi-log trend regression model, where time was taken as the independent variable and cropping intensity as the dependent variable. The estimated growth coefficients for both districts were found to be positive and statistically significant. In Bargarh, the growth coefficient (β) is 0.00394 with a t-value of 2.61 and a p-value of 0.015, which is significant at the 5 per cent level. Similarly, in Sambalpur, the growth coefficient is 0.01049 with a t-value of 3.07 and a p-value of 0.005, also significant at the 5 per cent level. Since the p-values for both districts are less than 0.05, the null hypothesis of no significant growth is rejected in both cases, and the alternative hypothesis is accepted.

The compound annual growth rate (CAGR) further supports these findings, indicating a positive annual growth of 0.39 per cent in Bargarh and 1.05 per cent in Sambalpur. Although the R^2 values (0.22 for Bargarh and 0.28 for Sambalpur) suggest that time explains a moderate proportion of variation in cropping intensity, the statistical significance of the coefficients confirms the presence of a meaningful upward trend. Comparatively, Sambalpur has experienced a stronger and more significant growth in cropping intensity than Bargarh during the study period.

6. Conclusion

The present study examined the trend and growth pattern of cropping intensity in Bargarh and Sambalpur districts over the period 1994–95 to 2019–20 using annual growth rates, compound annual growth rate (CAGR), and a semi-log regression model. The analysis of year-wise data revealed considerable inter-annual fluctuations in both districts, with Sambalpur exhibiting significantly higher volatility compared to Bargarh. While Bargarh showed relatively moderate and gradual changes in cropping intensity, Sambalpur experienced sharp expansions and contractions, particularly in certain years marked by exceptionally high positive and negative growth rates.

The semi-log regression results confirmed the presence of a positive long-term growth trend in both districts. The estimated growth coefficient (β) was positive and statistically significant for Bargarh as well as Sambalpur, leading to the rejection of the null hypothesis of no growth trend. The compound annual growth rate further indicated that cropping intensity increased at an average annual rate of 0.39 per cent in Bargarh and 1.05 per cent in Sambalpur. This suggests that although both districts experienced growth in cropping intensity, Sambalpur recorded comparatively stronger growth during the study period. However, the moderate R^2 values indicate that time alone does not fully explain variations in cropping intensity, implying the influence of other factors such as irrigation expansion, technological adoption, rainfall variability, and policy interventions.

Overall, the findings suggest that cropping intensity has improved over time in both districts, reflecting gradual agricultural intensification. However, the instability observed, particularly in Sambalpur, highlights the need for more consistent agricultural planning, improved irrigation management, and climate-resilient farming practices to sustain long-term growth. Strengthening institutional support and ensuring stable resource availability may help reduce fluctuations and promote balanced agricultural development in the region.

7. Policy Implications

The findings of the study carry important policy implications for agricultural planning and sustainable intensification in Bargarh and Sambalpur districts. Although both districts have exhibited a positive growth trend in cropping intensity over the study period, the presence of significant inter-annual fluctuations, particularly in Sambalpur, indicates structural instability in agricultural performance. Therefore, policies should focus not only on enhancing cropping intensity but also on stabilizing agricultural growth.

First, strengthening irrigation infrastructure is essential to ensure consistent multiple cropping. Expansion and modernization of canal irrigation, groundwater management, and micro-irrigation systems such as drip and sprinkler irrigation can help reduce dependence on erratic rainfall and minimize year-to-year volatility. Second, the promotion of climate-resilient agricultural practices, including drought-resistant crop varieties and diversified cropping systems, can mitigate the impact of climatic shocks that contribute to sharp fluctuations in cropping intensity.

Third, extension services should be improved to promote efficient input use, adoption of modern technologies, and better farm management practices. Providing timely access to credit, quality seeds, fertilisers, and market information can further enhance productivity and encourage sustainable intensification. In districts like Sambalpur, where growth has been relatively higher but unstable, targeted interventions are needed to stabilise production and avoid sudden contractions.

Finally, long-term agricultural planning should integrate water resource management, infrastructure development, and institutional support mechanisms to ensure balanced and sustained growth in cropping intensity. By adopting a comprehensive, region-specific approach, policymakers can transform short-term growth into stable, sustainable agricultural development.

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