*ISSN: 2249-7862 (Print) : 2455-877X (Online)*
www.aureoleonline.in

# Seasonal Analysis of Cumulative Growth in Area, Production, and Productivity of Paddy in Kottayam District, Kerala (2005–2024)

**Dr. Radhika K.[1], Dr. Thomas K. C.[2]**

[1]Assistant Professor (Guest Faculty), Department of Economics, St. Stephen's College, Uzhavoor
Email: radhikaarrow@gmail.com

[2]Associate Professor, Department of Economics, St. Stephen's College, Uzhavoor
Email: tkckulangara@gmail.com

## Abstract

The key aim of the study is the cumulative growth dynamics of paddy production in Kottayam District over the period 2005–2024, with a focus on seasonal variations across Autumn (Virippu), Winter (Mundakan), and Summer (Puncha). To identify the relative contributions of area and production effects, changes in production were disaggregated into area, yield, and interaction effects by the five-year block decomposition framework. The results of the study reveals that the area expansion driven by growth in all season but in contrast improvement of yield remained inconsistent and often lesser. The season growth in autumn season was mostly area dependent, the highly fluctuations of yield gains showed in winter season, early declines and later stabilized. In the case of summer season exhibited with volatile early growth from expansion of cultivated area but recently declines the yield which offset the expansion of area. The season-level decomposition of area, yield, and interaction effects, which provides a more understanding of the resilience in production trend. Although, the study admits its limitations, including dependence on secondary data and the accounting nature of the framework, which does not establish causal determinants. These results provide a guidance for regional agricultural planning and accentuate the need to prioritize yield enhancement strategies over further land expansion.

**Keywords:** Seasonal, Paddy cultivation, Production, Kottayam District, Kerala

## Introduction

Globally, rice is the most vital staple crops and cultivated on nearly 170 million hectares and producing approximately 525 million tonnes each year **(FAO, 2024).** More than 90 percent cultivation is predominantly concentrated in Asia, the world's rice area and output. According the study of **(IRRI, 2023; FAO, 2024)** China and India together contributing close to half of the total production. But unfortunately, the share of agriculture in Kerala's Gross State Value Added (GSVA) has declined to 11.2 percent at constant prices in 2023–24, **(Kerala State Planning Board, 2025).**

For the past four decades, Kerala agrarian economy has experienced structural changes in various sectors. The decline of Kerala agriculture sector due to the mostly in dominance growth of service sectors and migration. Subsequence of these effects, the state has evolved into the consumer-oriented economy, wherein agricultural production has progressively receded in both priority and policy attention. Further, Kerala has gradually remained a food -deficit state as evidenced by the sharp contraction in rice production from more than 13 lakh tonnes during the 1980s to merely 3.65 lakh tonnes in 2022-23 **Prasad and Kuruvila, (2024).** In contrast, Kerala produces only about 3.65 lakh tonnes of rice annually, while consumption remains around 40.68 lakh tonnes creating a massive shortage of rice that forces the state to depend heavily on imports from Tamil Nadu and Andhra Pradesh *(***Government of Kerala, 2023; Prasad and Kuruvila, 2024; Arun, 2025).**

In Kerala rice economy, Kottayam District secure a distinctive position for paddy cultivation having integration with the Kuttanad region. Therefore, internationally recognized as a Globally Important Agricultural Heritage System (GIAHS) by the FAO. According into the report of (**Government of Kerala, State Planning Board, 2019).** This paddy system is cultivated below sea level using bunds and polder systems. seasonal diversity, ecological linkages, and socio-economic relevance distinguish Kottayam's paddy production from other districts and make it a critical case for studying sustainability and food security in Kerala.

According to the **FAO, (2013)** these methods of cultivation reflecting both indigenous knowledge and resilience against floods and waterlogging. This region has certain features, paddy fields are closely connected to the Vembanad wetland ecosystem, therefore ecological are significant and severely impact to salinity intrusion, flood and climate variability. However, area of cultivation has decline massively in Kerala. Even though among the districts Kottayam remains a headlock of paddy farming communities, reinforced by cooperative societies and government interventions such as the *Kuttanad Package* **(Government of Kerala, State Planning Board, 2019).**

The trend of the agriculture sector in Kottayam District quite relevant for understanding the resilience capacity in the modern economy. Therefore, aim of the study is examining the cumulative growth rates of area, production, and productivity of paddy in Kottayam District from 2005 to 2024, using a five-year block decomposition framework. The article attempts to identify the dominant sources of growth or decline across seasons by disaggregating production changes into area, yield, and interaction effects.

Following studies of (**Parmar and Devi, 2020; Shende et al., 2011**) stated that the well-established method of growth and decomposition analysis in agricultural economics to understand the relative contributions of area, yield, and interaction effects to overall production change. Former applications of this framework were used to identify the utility in the crop such as soybean and other cereals, whether growth is primarily land-driven or yield-driven, and to highlighting periods of stagnation and instability.

## Literature Review

To understand the drivers of crop output, Growth and decomposition analysis has been widely applied in agricultural economics. The agricultural growth in the early stages of development was largely area-driven, while yield improvements became dominant with technological progress have shown in global studies. For example, the study of **Hayami and Ruttan (1985)** during the mid-20th century, confirmed that land expansion explained much of agricultural growth in Asia whereas yield gains from improved varieties and input use later became the primary source. Similarly, **Evenson and Gollin, (2003**) emphasized the role of modern crop in rice and wheat varieties driving productivity growth worldwide. More recent global analyses of **(Pingali, 2012; FAO, 2021)** highlight the climate adaptation and importance of technological innovation in sustaining productivity under land constraints

In India, decomposition studies disclose that growth of crop output was historically dominated by area expansion, predominantly before the Green Revolution. From the studies of **Minhas and Vaidyanathan, (1965) and Sikka, (1980)** most of the growth in cereals during the 1950s and 1960s have showed that land expansion. The major driver of growth in rice and wheat are the beginnings of high-yielding varieties, irrigation, and fertilizer use, yield improvements (**Hazell and Ramasamy, 1991; Bhalla and Singh, 2001**). In Contrast, regional studies show uneven patterns but states like Punjab and Haryana achieved sustained yield-driven growth. The studies of **Kumar and George, 2010; Devika and Nair, 2016** have experienced stagnation due to declining area under rice and inconsistent productivity gains.

From the study of **(Prasad et al., 2019; Thomas and Mathew, 2021)** emphasised the climate variability such as rainfall, temperature also a major challenge for sluggish growth in production. Most analyses dominating aggregate annual growth data in area and production in studies in Kerala agriculture. In the case of season-level decomposition, the paddy growth dynamics in Kerala remains unfamiliar. But this study addresses this gap, and offering an understanding of interaction effects has evolved over time in area and production in Kottayam District agriculture system.

## Methodology

The district lies between north latitude 9° and 10° East. longitude 76° and 77°. It is bounded on the north by Ernakulam district, on the east by Idukki and on the west by Alappuzha district **(District irrigation Plan).** These areas are part of Kerala's "rice bowl," characterized by below-sea-level farming practices, extensive wetlands, and a long tradition of community-based water management **(Thomas K.C, 2019).** Climate and non-climate drivers cause rice area has sharply declined in the Upper and Lower Kuttanad regions.

This study employs a decomposition framework to analyse the cumulative growth rates of area, production, and productivity across seasonal datasets over the period 2005–2024. The methodology is structured in two stages: (i) Estimation of cumulative growth

rates, and (ii) Decomposition of production change into its constituent effects.

### *1. Cumulative Growth Rate Estimation*

Cumulative growth rates for area, production, and productivity were calculated for each five-year block using the following formula:

$$\text{Growth rate} = \frac{X_t - X_0}{X_0} \times 100$$

Where:

$\mathbf{X_t}$ denotes the value of the variable (area, production, or productivity) in the final year of the block

$\mathbf{X_0}$ denotes the corresponding value in the base year.

The dataset was divided into successive five-year blocks (2005–2010, 2010–2015, 2015–2020, 2020–2024) to capture medium-term dynamics rather than year-to-year fluctuations. Cumulative growth rates for area, production, and productivity were estimated using the formula $(X_t - X_0)/X_0 \times 100$, where $X_t$ represents the value in the final year of the block and $X_0$ the value in the base year. To identify the drivers of production change, the decomposition identity $\Delta P = \Delta A \cdot Y_0 + \Delta Y \cdot A_0 + \Delta A \cdot \Delta Y$ was applied, where the three components represent the area effect, yield effect, and interaction effect respectively. Each effect was expressed as a percentage share of total production change, with positive values indicating expansion and negative values indicating contraction. Seasonal classification followed Kerala's official terminology, with Autumn (Virippu) Winter (Mundakan), and Summer (Puncha). The secondary data was employed from the Kerala Agricultural Statistics published by the Department of Economics and Statistics. The units are area measured in hectares, production in tonnes, and yield in kilograms per hectare. This methodological framework allowed for a clear comparison of seasonal growth dynamics and the relative importance of land expansion and productivity improvements.

### *2. Decomposition of Production Change*

To identify the drivers of production change, the following decomposition identity was applied:

$$\Delta P = \Delta A \cdot Y_0 + \Delta Y \cdot A_0 + \Delta A \cdot \Delta Y$$

where:

$\Delta P$ = change in production between base and final year,

$\Delta A$ = change in area,

$\Delta Y$ = change in yield (productivity),

$A_0$ = area in the base year,

$Y_0$= yield in the base year.

The three components are interpreted as:

- **Area Effect** ($\Delta A \cdot Y_0$): contribution of changes in cultivated area holding yield constant.
- **Yield Effect** ($\Delta Y \cdot A_0$): contribution of changes in productivity holding area constant.
- **Interaction Effect** ($\Delta A \cdot \Delta Y$): combined effect of simultaneous changes in both area and yield.

A standard analytical technique was rescaled the large absolute values, the effects of area, yield, and their interaction to enhance the interpretability of decomposition results and avoid the distortion. First, each effect was expressed as a percentage contribution to the total change in production (ΔP), thereby highlighting relative importance rather than magnitude. Second, normalization to index numbers was applied by fixing the base year at 100 and scaling subsequent values proportionally, which facilitated comparison across periods. Finally, each effect was shown as a relative share of the total decomposition (Area + Yield + Interaction), emphasizing the proportional contribution of each factor to production change. Similar approaches have been adopted in earlier studies on vegetable production (**Nayak et al., 2025),** soybean growth dynamics **(Parmar and Devi, 2020)** and cropping pattern sustainability in Andhra Pradesh **Venkatesh and Sen, (2018),** which emphasize the importance of expressing decomposition results in relative terms for clarity and comparability.

## Results and Discussion

**Table 1. Five-Year Cumulative Growth and Decomposition of Production Change (Autumn Season)**

| Period | Area Growth (%) | Production Growth (%) | Productivity Growth (%) | $\Delta P$ (Change in Production) | Area Effect (%) | Yield Effect (%) | Interaction Effect (%) |
|---|---|---|---|---|---|---|---|
| 2005–2010 | +38.8 | +75.7 | +26.6 | +6927 | +51 | +35 | +14 |
| 2010–2015 | −38.5 | −30.3 | +13.3 | −3874 | −127 | +44 | −17 |
| 2015–2020 | −6.6 | −45.7 | −41.9 | −5575 | −14 | −92 | +6 |
| 2020–2024 | −43.4 | −28.7 | +26.0 | −1893 | −152 | +91 | −39 |

Source: Estimated from Kerala Agricultural Statistics, Department of Economics & Statistics.

The table 1 represents the decomposition of Autumn season (June-September) paddy production in Kottayam District between 2005 and 2024 which clearly shows how area, yield, and interaction effects shaped outcomes across the various Phases. The five-year cumulative growth decomposition reveals dissimilar phases in the performance of paddy cultivation in autumn area, production, and productivity. During 2005–2010, marking a balanced expansion phase. The production expanded strongly (+75.7%), supported by

area growth (+38.8%) and yield improvement (+26.6%). The result of decomposition shows that area contributed the largest share (51%), yield accounted for 35%, and interaction effects is 14%. The production declined (–30.3%) despite modest yield gains (+13.3%), as sharp area contraction (–38.5%) dominated the outcome in during the period of 2010–2015. The decomposition confirms that the area effect (–127%) overwhelmingly drove the decline, while yield contributed positively (+44%) and interaction effects (–17%) worsened the contraction. The period 2015–2020 marked the most severe collapse (–45.7%), where yield deterioration (–41.9%) was the primary driver. Decomposition shows yield effect (–92%) was the critical factor dragging production down, area contributed slightly negatively (–14%), and interaction effects (+6%) provided only a minor cushion. Finally, in 2020–2024, production continued to declined (–28.7%), largely due to area contraction (–43.4%). Yield showed some recovery (+26.0%), but decomposition reveals that the area effect (–152%) again dominated the decline, yield effect (+91%) partly offset losses, and interaction effects (–39%) the reduction. Overall, the analysis pointed out that land area changes have historically been the most volatile and influential driver, yield effects remain inconsistent but increasingly important for stabilization, and interaction effects act as positive when both area and yield improve, negative when they move in opposite directions underlining the need to alleviate productivity for sustainable growth in the Autumn season.

**Table 2. Five-Year Cumulative Growth and Decomposition of Production Change (Winter Season)**

| Period | Area Growth (%) | Production Growth (%) | Productivity Growth (%) | $\Delta P$ (Change in Production) | Area Effect (%) | Yield Effect (%) | Interaction Effect (%) |
|---|---|---|---|---|---|---|---|
| 2005–2010 | −74.9 | −78.1 | −12.8 | −12354 | −96 | −16 | +12 |
| 2010–2015 | +176.8 | +253.7 | +27.7 | +8799 | +70 | +11 | +19 |
| 2015–2020 | +42.1 | +47.3 | +3.7 | +5806 | +89 | +8 | +3 |
| 2020–2024 | −22.9 | −17.9 | +6.6 | −3233 | −128.6 | +37.1 | −8.5 |

Source: Estimated from Kerala Agricultural Statistics, Department of Economics & Statistics.

The Table 2 shows that the represents the decomposition of Winter season (October-December) paddy production in Kottayam District between 2005 and 2024 which clearly shows the area, productivity and interaction effects shaped outcomes across the distinct Phases.

During 2005–2010, the percentage of (-78) has severely declined in production growth, determined mostly by severe area reduction (–74.9%). The effects of area reduction (–96%) overwhelmingly dominated the decline, although yield contributed negatively (–16%) and interaction effects is (+12%). In 2010–2015, resilience in production (+253.7%), supported by considerable area expansion (+176.8%) and improvement of yield (+27.7%). The decomposition reveals area effect (+70%) as the major driver, yield effect (+11%) strengthening growth, and interaction (+19%) adding to the gains. The

sustained moderate growth (+47.3%), with area expansion (+42.1%) are the dominant factor in the period between 2015–2020. The result indicates the both area effect (+89%) and yield effects (+8%) are contributed positively, whereas interaction effects is (+3%). Finally, in 2020–2024, further production declined (–17.9%), largely due to area shrinkage (–22.9%). The yield showed modest improvement (+6.6%), but the effect of area (–128.6%) drove the losses, yield effect (+37.1%) partly offset the decline, and interaction (–8.5%) amplified the reduction.

Overall, the Winter season analysis underlines the cyclical nature of paddy cultivation in Kottayam sharp highly fluctuations such as early decline, strong mid-period recovery, moderate stabilization, and renewed contraction. Area changes remain the most critical factor, while yield improvements increasingly act as a stabilizer. This result indicates the need to strengthen the productivity to confirm resilience measures against fluctuations of these effects.

**Table 3. Five-Year Cumulative Growth and Decomposition of Production Change (Summer Season)**

| Period | Area Growth (%) | Production Growth (%) | Productivity Growth (%) | $\Delta P$ (Change in Production) | Area Effect (%) | Yield Effect (%) | Interaction Effect (%) |
|---|---|---|---|---|---|---|---|
| 2005–2010 | +209.6 | +240.2 | +9.8 | +15136 | +87 | +4 | +9 |
| 2010–2015 | +7.5 | +16.8 | +8.7 | +3611 | +45 | +52 | +3 |
| 2015–2020 | +25.7 | +33.2 | +5.9 | +8294 | +77 | +18 | +5 |
| 2020–2024 | +3.4 | −3.6 | −6.8 | −1201 | +93.6 | −187.3 | −6.4 |

Source: Estimated from Kerala Agricultural Statistics, Department of Economics & Statistics.

Table 3 shows that the Summer Season five-year cumulative growth decomposition highlights four distinct phases in production dynamics. The decomposition of summer season paddy production in Kottayam District between 2005 and 2024 highlights the area expansion is dominance features in driving growth, and followed by a recent phase of stagnation.

The production raises (+240.2%) as area expanded intensely (+209.6%) and yield improved modestly (+9.8%) during the period of 2005–2010. The results show area effect (+87%) as the dominance driver, the percentage of yield effects is (+4%) and interaction (+9%) contributing very slightly. During the period of 2010–2015, cultivation of area expanded (+7.5%) but growth slowed in production (+16.8%), yield improvement (+8.7%). Decomposition indicates yield effect (+52%) slightly outweighed area effect (+45%), while interaction (+3%) remained minor. The reviving production growth by the percentage of (+33.2%), further dominated by area expansion (+25.7%). Decomposition confirms area effect (+77%) as the main driver, yield effect (+18%) strengthening gains, and interaction (+5%) adding a small increase during the period of 2015-2020.

In the period of 2020–2024, production has declined by the percentage of (–3.6%) in

spite of continued with the expansion of area (+3.4%), as yield worsening (–6.8%) offset gains. Decomposition shows yield effect (–187.3%) as the serious factor slow down the production and area effect (+93.6%) providing partial support, and interaction (–6.4%) intensifying the deviation.

Overall, the summer season analysis emphasizes that area expansion has been the dominant drivers of growth, but its effectiveness has diminished in recent years due to the instability in yield.

## Conclusion

The analysis of decomposition of paddy production across Autumn, Winter and Summer seasons in Kottayam District offers an understanding of the area, production and its interaction effects from 2005 to 2024. From this period area of cultivation has been frequently volatile and becomes critical factor. Further, inconsistent growth of yields deteriorating growth of production growth. These combined effects of area and yield outcomes effects intensified the interaction effects when the growth of production and area are improved and on the other hand its worsening when they moved in opposite directions.

While analysing the season level decomposition effects, Autumn was recurring declines, with unstable area of cultivation and yield trends unsustainability. The cyclical pattern of collapse and recovery fluctuation decomposition effects, has been in winter season and largely formed by area changes but with yield maintain stabilizing role during recovery phases. Summer experienced strong growth driven by area expansion until recent years, when yield deterioration offset gains and exposed the limits of land-based growth.

Overall, the findings emphasize that focussing on area expansion alone is unsustainable for long-term resilience. The results give the insights to policy makers that the expansion of area cultivation is not delivered the productivity enhancement for long term resilience. Therefore, for ensuring the long-term resilience of summer paddy cultivation policy makers have to be focus the factors to be consider such as water quality and soil health, development of long and short-term crops, irrigations facilities etc. These are primary facilities are necessary for reducing the volatility in yields and production growth thereby safeguard the agro-ecological system, and ensure the livelihoods in Kottayam District.

## References

Arun, R. (2025). Dynamics of paddy cultivation in Kerala (2005–2020): An analysis of declining area, rising productivity, and future of food security. *EPRA International Journal of Agriculture and Rural Economic Research, 13*(1), 45–56.

Bhalla, G. S., & Singh, G. (2001). *Indian agriculture: Four decades of growth*. Sage Publications.

Devika, J., & Nair, S. (2016). Agrarian change and rice decline in Kerala. *Journal of Agrarian Studies*.

Evenson, R. E., & Gollin, D. (2003). Assessing the impact of the Green Revolution, 1960–2000. *Science, 300*(5620), 758–762. https://doi.org/10.1126/science.1078710

Food and Agriculture Organization of the United Nations (FAO). (2013). *Kuttanad below sea level farming system: Globally important agricultural heritage systems (GIAHS)*. FAO.

Food and Agriculture Organization of the United Nations (FAO). (2021). *The state of food and agriculture 2021*. FAO.

Food and Agriculture Organization of the United Nations (FAO). (2024). *The state of food and agriculture 2024: Value-driven transformation of agrifood systems*. FAO.

Government of Kerala, Department of Economics & Statistics. (Various years). *Agricultural statistics*. Thiruvananthapuram: Department of Economics & Statistics.

Government of Kerala, State Planning Board. (2019). *Post flood Kuttanad package report*. Thiruvananthapuram: State Planning Board.

Government of Kerala. (2023). *Final estimates of area and production of rice in Kerala, 2022–23.* Directorate of Economics & Statistics.

Hayami, Y., & Ruttan, V. W. (1985). *Agricultural development: An international perspective*. Johns Hopkins University Press.

Hazell, P., & Ramasamy, C. (1991). *The Green Revolution reconsidered: The impact of high-yielding rice varieties in South India*. Johns Hopkins University Press.

International Rice Research Institute. (2023, October 16). *IRC 2023 discussion focuses on sustainable and farmer-inclusive policies to improve current global rice trends*. IRRI.

Kerala State Planning Board. (2025). *Economic review 2024*. Government of Kerala.

Kumar, A., & George, P. S. (2010). Paddy cultivation in Kerala: Trends and challenges. *Economic and Political Weekly*.

Minhas, B. S., & Vaidyanathan, A. (1965). Growth of crop output in India, 1951–54 to 1958–61. *Journal of the Indian Society of Agricultural Statistics*.

Nayak, S., Patil, R., & Desai, P. (2025). To analyse area effect, yield effect and interaction effect in change in production of major vegetables. *International Journal of Research in Agronomy, 8*(9), 1142–1144.

Parmar, P., & Devi, G. (2020). Growth and decomposition analysis of area, production and yield of soybean in Gujarat. *International Journal of Agriculture Sciences, 12*(6), 100–105.

Pingali, P. (2012). Green Revolution: Impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences, 109*(31), 12302–12308.

Prasad, A., & Kuruvila, A. (2024). Vanishing paddies: Tracing the transformation of rice cultivation in Kerala, India. Asian Journal of Agricultural Extension, Economics & Sociology, 42(11), 1–12.

Prasad, R., et al. (2019). Climate variability and paddy productivity in Kerala.

*Agricultural Economics Research Review*.

Shende, N. V., Thakare, S. S., & Roundhal, P. S. (2011). Acreage response and decomposition analysis of soybean in Western Vidarbha. *Journal of Food Legumes, 24*, 133–137.

Sikka, B. K. (1980). Decomposition analysis of crop output growth. *Indian Journal of Agricultural Economics*.

Thomas, J., & Mathew, K. (2021). Decomposition of rice output growth in Kerala. *Indian Journal of Agricultural Economics*.

Thomas, K. C. (2019). Paddy cultivation in the Kuttanad region of Kerala: An analysis of trend in area, production and productivity. *JETIR Research Journal*.

Venkatesh, S., & Sen, C. (2018). Decomposition analysis and sustainability of cropping pattern in Andhra Pradesh, India. *The Pharma Innovation Journal, 7*(10), 408–410.