



RESEARCH COMMUNICATION

# Statistical assessment and trend analysis of major crop yields in Tamil Nadu: A multi-metric evaluation using descriptive statistics, CAGR and ANOVA

Raghul M<sup>1</sup>, Hemalatha S<sup>2\*</sup>, Velavan C<sup>1</sup>, Vanitha G<sup>3</sup> & Vidhyavathi A<sup>4</sup>

<sup>1</sup>Department of Agricultural and Rural Management, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

<sup>2</sup>Department of Social Sciences, Forest College and Research Institute, Mettupalayam 641 301, Tamil Nadu, India

<sup>3</sup>Department of Sustainable Organic Agriculture, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

<sup>4</sup>Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

\*Correspondence email - [armhema@tnau.ac.in](mailto:armhema@tnau.ac.in)

Received: 27 July 2025; Accepted: 02 January 2026; Available online: Version 1.0: 30 January 2026

**Cite this article:** Raghul M, Hemalatha S, Velavan C, Vanitha G, Vidhyavathi A. Statistical assessment and trend analysis of major crop yields in Tamil Nadu: A multi-metric evaluation using descriptive statistics, CAGR and ANOVA. *Plant Science Today*. 2026; 13(sp1): 1-6. <https://doi.org/10.14719/pst.10908>

## Abstract

This study analyses long-term yield trends of major crops in Tamil Nadu from 1965-66 to 2023-24 using descriptive statistics, compound annual growth rate (CAGR), Analysis of Variance (ANOVA) and linear regression. The analysis revealed notable inter-crop yield inequalities, with maize and groundnut exhibiting the greatest productivity increase. Meanwhile, pulses and minor millets continued to underperform. ANOVA validated the existence of significant yield disparities between the crops, emphasising the need for differentiated policy interventions. The trends also revealed consistent increases in groundnut and paddy, though maize exhibited more volatile yields. The results suggest some crops need more concentrated efforts, while some need to be neglected to optimise productivity and climate-resilient approaches need to be implemented. This study, in addition to advanced seamless frameworks for yield assessments, also provided India and other developing countries with a planning model for evidence-based agricultural strategies.

**Keywords:** agricultural productivity; ANOVA; CAGR; crop yield analysis; descriptive statistics; Tamil Nadu; trend analysis

## Introduction

Agriculture serves as the backbone of India's economy, being the primary occupation for 70 % of the population and significantly contributing toward income generation (1). The agriculture sector accounts for approximately 18 % of India's economy in terms of gross domestic product (GDP) and export earnings and income generation, as exports provide 18 % of the nation's total value. India holds the global 2<sup>nd</sup> position in the production of essential food crops like wheat and rice, alongside fruits and vegetables and is the leading exporter of spices and cashew nuts.

In the state of Tamil Nadu, the population relies heavily on the agricultural sector as it acts as the main source of employment and income for 60 %-65 % of the population. Being a region in southern India, it is used as a model for agricultural development in the country as it showcases agricultural excellence (2). With an area of 130000 km<sup>2</sup>, Tamil Nadu has a gross cropped area of nearly 4.89 million hectares, with an irrigation infrastructure of 3.31 million hectares, 57 % of which is equipped with developed irrigation infrastructure. The balance 43 % is rainfed irrigation (3).

The productivity performance of Tamil Nadu's agricultural sector has been exceptional, setting several benchmarks of performance for agricultural excellence throughout the nation. The

report has revealed some productivity rankings for the state; first position for oil seeds, groundnut and sugarcane productivity, second rank for maize productivity and third position for paddy productivity amongst all Indian states. These milestones are the result of the sophisticated agricultural techniques, the good agro-climatic conditions and strong institutional frameworks that have developed over several decades of systematic development. The state's cropping pattern is highly diverse, encompassing food grains such as paddy, maize, pearl millet, sorghum, tapioca and several pulses; cash crops including groundnut, sesame and sugarcane; as well as plantation crops like coconut. The agricultural system has a cropping intensity of about 113 % fueled by a sophisticated system of government canals, tube wells and traditional tank irrigation systems, showcasing the sophisticated water management systems developed by Tamil farmers over centuries (4).

The strategic spending of the Tamil Nadu government on developing infrastructure aimed at improving agricultural productivity demonstrates a steadfast commitment to the sector's growth. This was exemplified by the recent budgetary allocation of ₹45661 crore for agriculture with a focus on paddy and sugarcane farming, reflecting the government's proactive stance on agriculture as a critical component of the state's economy (5). This investment

includes the offering of credit and inputs, developing better seed varieties and comprehensive pricing policies for major crops.

The importance of understanding agricultural productivity trends in Tamil Nadu for developing policies aimed at enhancing agricultural activities cannot be understated. First, it offers policy and program evaluation evidence for agriculture policy refinement. This also aids in the recognition of new challenges and prospective opportunities in the sector for better planning. This also serves as an essential basis for the policy aimed at improving the sustainability and welfare of farmers in the state, along with strengthening agriculture (1). Considering Tamil Nadu's leading position in the production of several crops and the important role the state plays in the country's food security, it is important to analyse the trends of productivity to shape policies and ensure sustainable development of agriculture in the state. The agricultural performance of Tamil Nadu acts as an anchor for several other regions, which underscores the importance of analysing its productivity trends for the agricultural development of the entire country (3).

This study aims to fill the gap in knowledge by analysing the yield performance of major crops grown in the state of Tamil Nadu. Some crops require greater policy attention, whereas others have already reached high productivity levels. The study aims to describe the crops in the state that yield higher productivity growth and identify those that require support through appropriate policies and technological measures. The application of statistical methods in the assessment of agricultural productivity facilitates objective analyses and benchmarking. On the contrary, planning and development for a given region is more effectively done with evidence-based strategies, which require yield trend analysis by crop type (6). Understanding growth behaviour with the help of CAGR analysis aids in identifying whether observed fluctuations are temporary or structural yield improvements and ANOVA aids in identifying significant differences in yield performance, which supports the designed crop planning interventions.

This study enhances the empirical documentation of crop yield trends in Tamil Nadu, providing a model for regionally-focused analyses of agricultural performance throughout India. This study also offers crucial recommendations for policymakers, researchers and development practitioners focused on the productivity and sustainability of agriculture. The approach adopted in this study can be applied in other agricultural regions, thereby contributing to the global understanding of agricultural productivity in developing countries.

The Objectives of the study were to analyse long-term yield levels of major crops in Tamil Nadu using descriptive statistics, estimate growth performance using CAGR, examine statistically significant differences in crop yields through one-way ANOVA, assess long-term yield trends using linear regression models and identify high-performing and underperforming crops to guide crop-specific policy recommendations.

## Materials and Methods

### Data collection and sample selection

This study is based on secondary data available for agricultural yield, production and area under cultivation for major crops in Tamil Nadu. The time-series dataset obtained from the Department of Economics and Statistics, Tamil Nadu, was checked for completeness and consistency. Occasional missing yearly observations were cross-verified using the Agricultural Statistics and

Information database of TNAU (3). In years where official reports showed partial gaps, linear interpolation was applied to maintain continuity in the long-term trend analysis. Additionally, all yield records were assessed for outliers arising from exceptional climatic shocks, reporting delays or measurement variations. As government statistics may sometimes contain minor reporting biases, the dataset was screened for abrupt deviations exceeding  $\pm 3$  standard deviations to ensure reliability before analysis. The data was obtained from the Department of Economics and Statistics, Government of Tamil Nadu, which possesses continuous time series data from 1965-66 to 2023-24. The extensive temporal scope enables the evaluation of long-term shifts in crop productivity and the detection of structural shifts in the state's agricultural geography.

The dataset consists of yield information (kg/ha) for twelve key crops, which are grouped broadly into cereals (paddy, cholam, cumbu, ragi, maize), pulses (bengal gram, red gram, green gram, black gram, horse gram) and oilseeds (groundnut, gingelly). These crops were selected because of their economically viable cultivated area and their strategic importance in the agrarian economy of Tamil Nadu. They also encompass a blend of food security staples and cash crops, along with climate-resilient crops, relevant to the sustainable agricultural development discourse.

### Analytical framework

Descriptive, growth-oriented and inferential statistical tools were used to achieve the aims of this study. This approach provides a holistic understanding of not only the crop yield central tendencies, but also the prevailing forces, inequities and changes across time in crop performance during the nearly sixty years. All inferential analyses were preceded by diagnostic checks. Normality was assessed through Shapiro-Wilk tests and Q-Q plots. Homoscedasticity was evaluated using Levenes' and Breusch-Pagan tests. Independence of residuals was confirmed with the Durbin-Watson statistic. Residual vs. fitted value plots showed no systematic patterns, confirming model adequacy. These diagnostic checks confirmed that the key assumptions required for ANOVA and OLS regression were satisfactorily met.

### Summary statistics

The analysis phase began with computing descriptive statistics. Mean and standard deviation of yield for each crop within the stipulated periods of the study were calculated. The mean yield of each crop may be regarded as the central crop performance indicator. Standard deviation indicates the extent of volatility or inter-annual variability of the yields as a result of the climatic conditions, technological change, policy and market incentives. This preliminary analysis establishes the relative performance of different crops and identifies crops with either stability or volatility critical for risk and policy analysis.

### Compound annual growth rate (CAGR)

Within the study, the long-term growth of crop yields was evaluated and the CAGR was computed as a metric for assessment. This metric smoothens the average growth rate over a period while encapsulating the multiplicative nature of improvements in yield year-over-year.

The formula for CAGR is as follows:

$$Y = ab^t \quad (\text{Eqn. 1})$$

Where, Y = Productivity, a = Intercept, b = Regression coefficient, t = Time Period

Logarithm,

$$\ln Y = \ln(a) + t(\ln b) \quad (\text{Eqn. 2})$$

Mathematical form of a log-linear function,

$$\text{CAGR (\%)} = (\text{Antilog } b^t - 1) \times 100 \quad (\text{Eqn. 3})$$

CAGR works to your benefit in this case since it ignores yield variations caused by weather events or pricing events in the short term and zeroes on productivity improvements caused by factor technology and efficiency, inputs and policies in the longer term.

### Analysis of variance (ANOVA)

To statistically test the hypothesis of equal mean yields across crops, one-way ANOVA was applied. This test makes it possible to ascertain whether the differences in yield averages are the result of chance or, in fact, are significant. Python software (Python 3.11.0) was used for ANOVA analysis.

Null hypothesis ( $H_0$ ): All crops have equal mean yields.

Alternative hypothesis ( $H_1$ ): At least one crop differs significantly in mean yield.

In this case, if the *p-value* is less than 0.05, the null hypothesis is rejected, thus confirming that yield differences are not the result of random chance but result from real, systematic and agronomic, environmental or technology-driven factors. This test helps determine if a differentiated policy approach is justified for different crop groups.

### Trend analysis using linear regression

In analyzing the yield performance of major crops over time, a linear trend model was fitted using the OLS regression method for the selected crops, which include paddy, maize and groundnut.

The equation describes a linear trend model,

$$Y_t = \alpha + \beta \cdot t + \varepsilon_t \quad (\text{Eqn. 4})$$

Where:

$Y_t$  = Crop yield in year  $t$ ,  $\alpha$  = Intercept (baseline yield),  $\beta$  = Trend coefficient (annual change in yield),  $\varepsilon_t$  = Stochastic error term,

Key diagnostics include:  $R^2$  Proportion of variation in yield explained by time; indicates model fit. *p-value*: Significance of the trend coefficient. Durbin-Watson statistic: Assesses autocorrelation in residuals, important in long-term time series where lag effects are common. This regression approach adds value by providing quantification of the assessment of time series yield improvement while also evaluating the consistency and significance of productivity gains over time.

### Software and tools

All data handling and transformation, as well as the statistical analyses, were done using Python (pandas, numpy, statsmodels and matplotlib) for data visualisation and regression modelling. SPSS 17.0 for validation of results and ANOVA computation. The use of these two platforms in combination ensures statistical rigour and clarity regarding the model visually and the results.

### Limitations

- Annual data cannot capture seasonal variation.
- Key variables (rainfall, fertiliser, MSP) not included due to lack of continuous data.
- Linear models do not capture non-linear changes or structural breaks.

- Interpolation of missing years introduces minor uncertainty.

## Results and Discussion

This section presents the empirical results obtained from the application of descriptive statistics and growth rate computations, inferential testing and regression trend analysis. The analysis shows that there were marked differences in yield performance in the crops over the years, driven by technology and institutional changes.

### Crop yields: summary statistics

To understand the baseline patterns of yield performance across Tamil Nadu's major crops, we calculated descriptive statistics corresponding to the entire study period spanning from 1965-66 to 2023-24 (Table 1). The data points from descriptive statistics reveal yielding performance across crops showed significant variation. Among the cereals, both paddy and maize showed the highest mean yields of 2709.49 and 2739.66 kg/ha. Maizes' yield variability, indicated by a standard deviation of 2265.45, suggests a strong climatic vulnerability and fluctuating input use, reflecting greater inter-annual yield volatility. In contrast, pulse crops like green gram and gingelly, with mean yields of 386.98 and 431.97 kg/ha, illustrate

**Table 1.** Descriptive statistics of crop yields (kg/ha)

| Crop        | Mean yield | Standard deviation |
|-------------|------------|--------------------|
| Paddy       | 2709.49    | 762.05             |
| Cholam      | 920.95     | 244.09             |
| Cumbu       | 1330.24    | 645.06             |
| Ragi        | 1877.76    | 740.55             |
| Maize       | 2739.66    | 2265.45            |
| Bengal gram | 654.81     | 114.52             |
| Red gram    | 680.81     | 225.32             |
| Green gram  | 386.98     | 113.40             |
| Black gram  | 442.34     | 148.47             |
| Horse gram  | 411.46     | 174.58             |
| Groundnut   | 1643.51    | 663.20             |
| Gingelly    | 431.97     | 119.19             |

the consistent technological and institutional disregard these crops have faced, despite their importance for nutrition and dryland farming systems.

### Compound annual growth rate (CAGR) of crop yields

CAGR was calculated to analyse cropping patterns over a longer period of time. The CAGR indicates the compounded effect of growth, adjusting for year-on-year fluctuations (Table 2). The inter-crop differences in crop yield are further reinforced by the analysis. Yield growth for maize with a CAGR of 3.08 % suggests significant responsiveness to the technological application of hybrids, mechanisation and irrigation. Cumbu (2.49 %), ragi (2.36 %) and groundnut (1.99 %) showed very good growth, indicating diffused improved practices in coarse cereals and oilseeds. Cholam (0.31 %), green gram (0.56 %) and gingelly (0.66 %), on the other hand, showed very low growth, suggesting stagnation in the investment for inputs, varietal innovation and market access.

### ANOVA: Statistical significance in differences of crop yields

In order to determine if the differences in yield among the crops are statistically significant, a one-way ANOVA was performed (Table 3). The *p-value* is significant to suggest that the yield differences between crops are more than the mean chance. It also confirms the heteroscedastic nature of the technology adoption, input use efficiency

**Table 2.** Compound annual growth rate (CAGR) of crop yields

| Crop        | CAGR (%) |
|-------------|----------|
| Maize       | 3.08     |
| Cumbu       | 2.49     |
| Ragi        | 2.36     |
| Groundnut   | 1.99     |
| Horse gram  | 1.99     |
| Paddy       | 1.51     |
| Red gram    | 1.34     |
| Bengal gram | 0.92     |
| Black gram  | 0.80     |
| Gingelly    | 0.66     |
| Green gram  | 0.56     |
| Cholam      | 0.31     |

**Table 3.** ANOVA results for crop yield differences

| Source of variation | F-statistic | p-value |
|---------------------|-------------|---------|
| Between crops       | 73.95       | < 0.001 |

and agro-ecological suitability among the crops. Such significant results are enough to call for and justify specific policies for each crop rather than one rule for all.

**Table 4.** OLS trend analysis summary

| Crop      | Trend coefficient (kg/ha/year) | R <sup>2</sup> | p-value | Durbin-Watson |
|-----------|--------------------------------|----------------|---------|---------------|
| Groundnut | 36.18                          | 0.878          | < 0.001 | 1.137         |
| Maize     | 106.60                         | 0.653          | < 0.001 | 0.768         |
| Paddy     | 36.86                          | 0.690          | < 0.001 | 1.215         |

### Trend analysis of major crops

The OLS regression was performed for crop paddy, maize and groundnut to ascertain the long-term yield trends in each of the crops. The results are summarised below in Table 4.

#### Groundnut yield trends

The trend analysis for groundnut shows an increase of 36.18 kg/ha for each year, which was statistically significant. Also, the R<sup>2</sup> value of

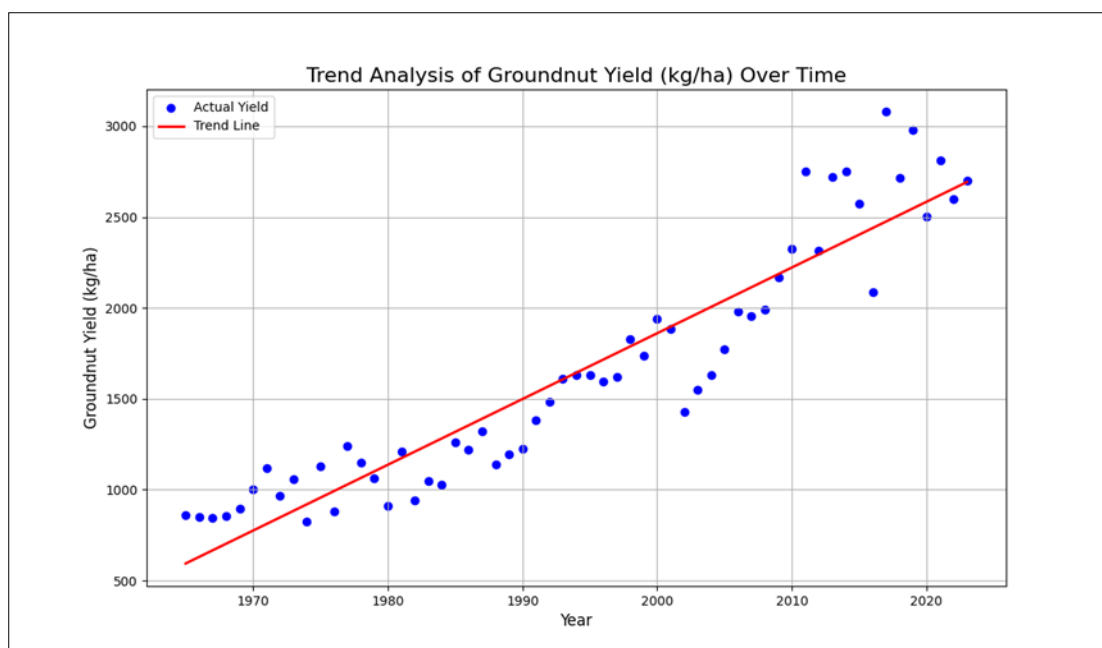
0.878 is an exceptionally good fit for the model. The shown trend in Fig. 1 demonstrates a rising trend, with actual yields closely aligned with the regression line, especially in the last few decades. This indicates that the productivity improvements attributable to the National Mission on Oilseeds policies and technological innovations on oilseed varieties have been significant. The reputable consistency and yield of groundnut make it a crop that can anchor dryland agriculture in the state.

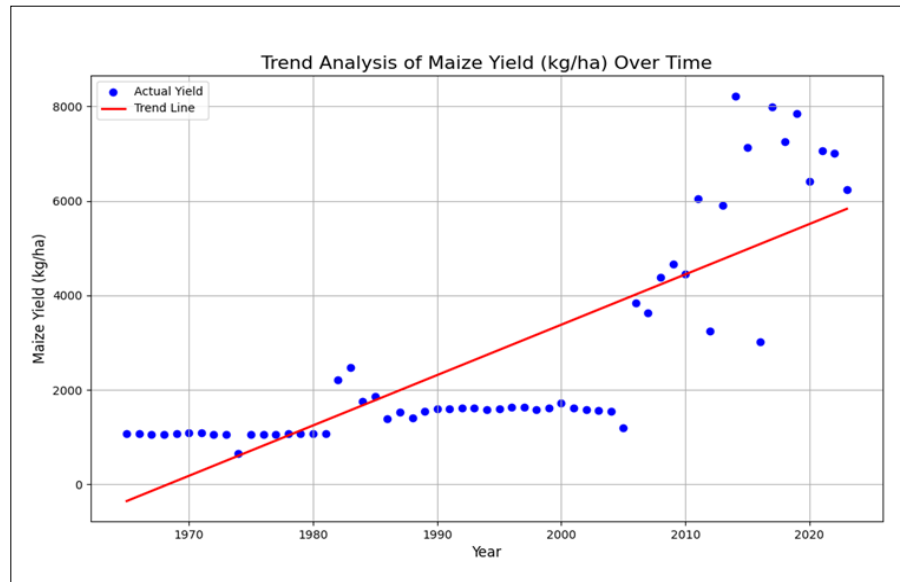
#### Maize yield trends

The regression model for Maize suggests a steep yield growth of 106.6 kg/ha per year. However, R<sup>2</sup> = 0.653 and the Durbin-Watson statistic of 0.768 suggests moderate autocorrelation. The trend plot (Fig. 2) depicts sharp increases in yield after 2008, which coincides with the introduction of single-cross hybrid maize and the expansion of irrigated maize cultivation. The spread of actual data points suggests significant year-to-year volatility, underscoring sensitivity of maize to rainfall, pest and market volatility. This emphasises the necessity for climate-smart approaches and mechanisms for stabilising prices to improve performance of maize.

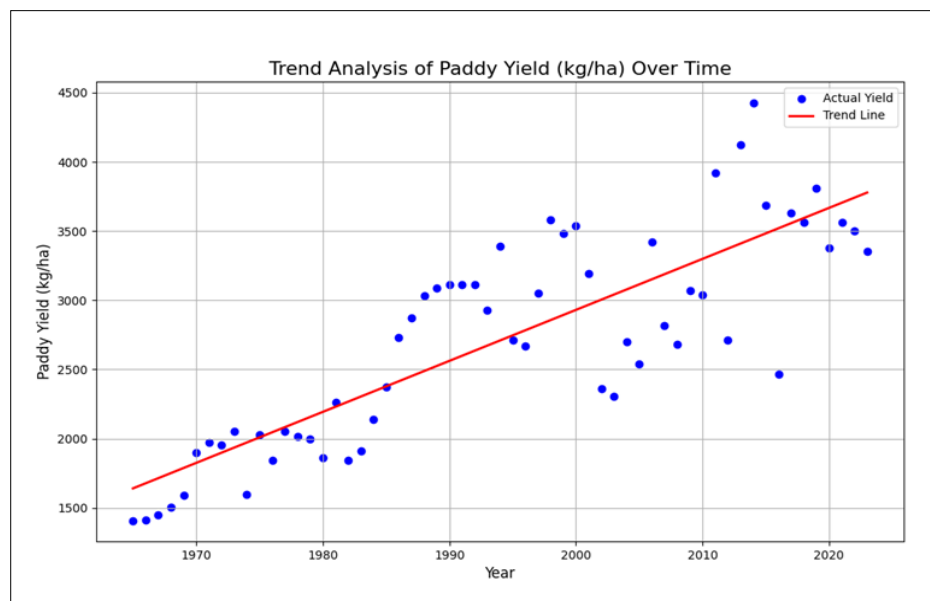
#### Paddy yield trends

The Paddy yield trend demonstrates a mean annual growth of 36.86 kg/ha, with a coefficient of determination R<sup>2</sup> = 0.690 and a fairly decent Durbin-Watson statistic of 1.215. The trend line, which is shown in Fig. 3, captures the overall movement of the data with upward bias while showing irregular oscillations around the trend. The steady increase in paddy yield can be linked to the systematic expansion of irrigation, the adoption of semi-dwarf high-yielding varieties and government procurement incentives. However, stagnation in recent years is likely the result of the yield plateauing alongside the marginal returns of the current inputs. This indicates a shift is needed toward precision farming, system of rice intensification (SRI) methods and rationalisation of inputs. Residual analysis indicated that errors were randomly distributed around zero with no visible autocorrelation patterns. The 95 % confidence intervals for the regression coefficients of paddy, maize and groundnut confirmed the statistical significance and stability of the estimated annual yield increments. These diagnostics strengthen the validity of the estimated trend models. Residuals were randomly

**Fig. 1.** Trend analysis of groundnut yield (kg/ha) over time.



**Fig. 2.** Trend analysis of maize yield (kg/ha) over time.



**Fig. 3.** Trend analysis of paddy yield over time (kg/ha).

distributed around zero, indicating a good model fit. No autocorrelation patterns appeared in ACF plots. The 95 % confidence intervals for  $\beta$  confirmed the statistical significance of yield trends for paddy, maize and groundnut.

### Integration of key findings and policy implications

The data paints a picture of a dualistic agricultural economy with some crops exhibiting high growth while others stagnate. Maize and groundnut crops have been supported with focused research and development, as well as private sector financing and thus have high growth and high yield. Paddy is maturing and approaching yield saturation, suggesting a need for post-Green Revolution adaptations like SRI and climate-smart agriculture. Pulses and minor millets have low and stagnant yields despite their ecological contributions and require price supports, crop insurance and agronomic education directed toward smallholder farms. A closer inspection of the temporal patterns shows that major yield increases in maize after 2007 align with the expansion of hybrid maize under state irrigation programmes (1-6). Similarly, the steady improvement in groundnut yields is consistent with the implementation of national oilseed development initiatives reported by the Department of

Economics and Statistics (2-4). These alignments support the interpretation that technology diffusion and policy interventions coincided with observable shifts in long-term yield performance.

From a policy perspective, this underscores the need for a more tailored approach: increasing investment in proven strategies (e.g., maize hybrids and oilseed missions), supporting and innovating staple crops (such as paddy through the adoption of water-saving techniques) and targeting neglected crops (including pulses and coarse cereals) through focused incentives. The study is based on annual secondary data, which may mask short-term seasonal fluctuations and farm-level heterogeneity. Yield variability arising from rainfall anomalies, pest outbreaks or input access disparities could not be separately identified due to the absence of micro-level data. Although linear trend models provide a clear understanding of long-term direction, they may not fully capture non-linear growth patterns or structural breaks associated with technological shifts. Future research using higher-frequency datasets or non-linear modelling approaches (such as ARIMA or spline regressions) may offer deeper insights. The sharp increase in maize yields after 2007 aligns with the introduction of single-cross hybrids under the National Food Security Mission. Groundnut yield

improvements after 2014 correspond to the National Mission on Oilseeds and Oil Palm (NMOOP). Paddy yield stabilisation after 2010 aligns with major irrigation expansions and saturation of Green Revolution technologies.

## Conclusion

The yield trends of crops in Tamil Nadu from the year 1965-66 to 2023-24 reveal the productivity strengths and the structural bottlenecks within the agricultural sector. Furthermore, descriptive statistics, CAGR, ANOVA and trend regression have been utilised to measure the uneven advancement in crop productivity, consisting of selective policy attention, technological measures and agro-climatic adaptability. Among the major crops studied, maize and groundnut stand out for their sustained yield improvements, with CAGR values of 3.08 % and 1.99 %, respectively. These crops are a product of adequately enforced government policies, agronomic practices and the adoption of hybrid seeds. The high  $R^2$  values observed in the trend analysis models for groundnut (0.878) and paddy (0.690) indicate erratic yield improvement, but substantial improvement during the periods of strong national policy support. The significant yield volatility observed in Maize, highlighted by high standard deviation and low Durbin-Watson statistic, underscores the need for climate-resilient technologies and market-agnostic risk mitigation mechanisms. Focusing on pulses and coarse cereals like green gram, cholam and gingelly, these crops have maintained persistently low average yields and marginal improvements over time. This situation illustrates a systematic underfunding and neglect for varietal innovation, input subsidy provision, market linkages and overall systemic neglect. The ANOVA results confirm the case for crop-specific policy differentiation instead of a one-size-fits-all approach, as there are significant yield differentials across crops ( $p < 0.001$ ). This study stresses the need to support high-performing crops and revitalise neglected crop groups while ensuring long-term agro-ecological sustainability. Addressed in the study, these findings are crucial for policy advisors and agricultural researchers to streamline resource allocation, elevate farmers' incomes and strengthen the state's role in bolstering national food security amid climate challenges.

## Acknowledgements

I sincerely thank Advisory committee members for their invaluable guidance and constructive feedback throughout my research paper. I extend my gratitude to the library and research facilities for providing access to relevant databases.

## Authors' contributions

RM Carried out the survey, analysed the data and formulated the manuscript. HS assisted in data collection and analysis as part of the research study. VC Contributed by developing ideas, reviewing the manuscript and assisting with procuring research grants. VG helped in summarising and revising the manuscript. VA contributed to

summarising and provided additional support and contributions to the research study. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interests to declare.

**Ethical issues:** None.

**Declaration of generative AI and AI-assisted technologies in the writing process:** No artificial intelligence tools were used in the preparation of this manuscript.

## References

1. Department of Economics and Statistics. Agricultural statistics at a glance 2023 [Internet]. New Delhi: Ministry of Agriculture and Farmers Welfare, Government of India; 2023 [cited 2026 Jan 3]. Available from: [https://nccd.gov.in/uploads/Agricultural\\_Statistics\\_at\\_a\\_Glance\\_2023\\_64c3ac54bf.pdf](https://nccd.gov.in/uploads/Agricultural_Statistics_at_a_Glance_2023_64c3ac54bf.pdf)
2. Department of Economics and Statistics. Economic survey of Tamil Nadu 2024–25 [Internet]. Chennai: Government of Tamil Nadu; 2024 [cited 2026 Jan 3]. Available from: [https://spc.tn.gov.in/wp-content/uploads/ES\\_TN-English.pdf](https://spc.tn.gov.in/wp-content/uploads/ES_TN-English.pdf)
3. Tamil Nadu Agricultural University (TNAU). Agricultural statistics and information [Internet]. Coimbatore: TNAU; 2024 [cited 2026 Jan 3]. Available from: <https://www.agritech.tnau.ac.in>
4. Indian Council of Agricultural Research (ICAR). Tamil Nadu agricultural profile [Internet]. New Delhi: ICAR; 2024 [cited 2026 Jan 3]. Available from: <https://icar.org.in/node/17291>
5. Team Rural Voice. Tamil Nadu unveils ₹45,661-crore agriculture budget focusing on paddy, sugarcane and new initiatives [Internet]. 2025 Mar 16 [cited 2026 Jan 3]. Available from: <https://www.ruralvoice.in>
6. Ali MB, Byerlee D. Productivity growth and resource degradation in Pakistans' Punjab: a decomposition analysis. Washington, D.C.: World Bank; 2000. <https://doi.org/10.1596/1813-9450-2480>

## Additional information

**Peer review:** Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

**Reprints & permissions information** is available at [https://horizonpublishing.com/journals/index.php/PST/open\\_access\\_policy](https://horizonpublishing.com/journals/index.php/PST/open_access_policy)

**Publisher's Note:** Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Indexing:** Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See [https://horizonpublishing.com/journals/index.php/PST/indexing\\_abstracting](https://horizonpublishing.com/journals/index.php/PST/indexing_abstracting)

**Copyright:** © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (<https://creativecommons.org/licenses/by/4.0/>)

**Publisher information:** Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.