From Agricultural Data into Knowledge Services: A Statistical Analysis of Paddy Yield Trends in Northern Sri Lanka (2004–2024)

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ABSTRACT

Understanding long-term yield trends and variability in paddy cultivation is crucial for enhancing agricultural productivity, ensuring food security, and guiding strategic policy interventions in Northern Sri Lanka. Despite the agricultural importance of this region, comprehensive district-level analyses of yield trends and irrigation scheme performance remain limited. This study aimed to analyze yield trends, stability, seasonal variability, and irrigation scheme performance, providing evidence-based insights for policy formulation and farmer support. Two decades (2004/2005–2023/2024) of district-wise paddy data (Vavuniya, Kilinochchi, Mullaitivu, Mannar, and Jaffna) covering both *Yala* and *Maha* seasons were statistically analyzed using linear regression to quantify yield trends and coefficient of variation (CV) to assess yield stability. Comparative analyses across irrigation schemes (major, minor, rain-fed) and seasons were performed using SPSS statistical software (version 26). The results were compared with the data of Anuradhapura; an adjacent district with a strong reliance on irrigation schemes for paddy cultivation. Findings revealed a significant upward yield trend in Mullaitivu district (55.1 kg/ha per year; R^2=0.224, $p<0.05$), while Vavuniya consistently exhibited the highest average yields (4478 kg/ha) with exceptional stability (CV=11.3%). Yield recovery post-2010 was notably strong in Kilinochchi (22.5%) and Mullaitivu (20.2%). Major irrigation schemes significantly outperformed minor schemes (4197 vs. 3781 kg/ha) and rain-fed cultivation (3158 kg/ha), displaying superior yield stability (CV=19.6%). Interestingly, the *Yala* season consistently achieved higher yields than *Maha* across all irrigation schemes, suggesting advantages in controlled irrigation conditions.

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Anuradhapura district data further contextualizes these findings, revealing consistently high productivity in major irrigation schemes (e.g., 4549 kg/ha in 2004/2005) and demonstrating the critical role of large-scale infrastructure in sustaining yields. The district's long-term trends highlight the resilience of irrigated systems compared to rain-fed cultivation when considering the trends in rainfall vary in terms of distribution and amount over the past decade. This study provides critical evidence supporting strategic investments in irrigation infrastructure and optimized seasonal management practices. It highlights the value of transforming open agricultural datasets into actionable insights, promoting sustainable agriculture, and informed decision-making in Northern Sri Lanka.

Keywords: Paddy Yield Trends, Statistical Analysis, Irrigation Schemes, Agricultural Policy, Open Data, Northern Sri Lanka

Introduction

An accurate understanding of agricultural yield dynamics is crucial not only for localized productivity improvements but also for addressing national and global food security goals. Like many countries in South Asia, Sri Lanka is facing mounting pressure due to climatic fluctuations changing rainfall patterns, and rising demand for staple foods such as rice. These challenges underscore the urgency for data-driven decision-making in agricultural planning. Within Sri Lanka, the Northern Province presents a distinct agroecological and socio-economic landscape. While it contributes significantly to the country's paddy production, especially in dry zone conditions, it has remained examined regarding long-term, district-specific yield analysis. National statistics often aggregate data, ignoring intra-regional disparities and the influence of water availability, irrigation schemes, and seasonal patterns. In this context, our study focuses on the Northern Province as a case study to explore how open-access agricultural data can be utilized to create actionable insights that support sustainable agriculture and smart policy formulation at both local and national levels for effective planning, policy formulation, and ensuring food security. In Northern Sri Lanka, despite its significant agricultural potential, comprehensive district-level analyses of paddy yield trends, especially concerning seasonal and irrigation scheme performance, remain sparse. Most national studies present aggregated trends without considering local discrepancies, seasonal yield variations, or the differential impact of

irrigation types. Furthermore, the limited use of open-access agricultural datasets restricts researchers' and policymakers' ability to generate evidence-based insights. Our study seeks to fill these gaps by providing a detailed statistical analysis of two decades of paddy cultivation data across five Northern districts. This research is particularly significant for understanding yield behaviour in dry zones, guiding future irrigation investments, and strengthening the use of agricultural open data in planning processes. The scope of this study is limited to secondary datasets provided by government sources; yield data for the Jaffna district being unavailable due to historical data disruptions.

Objectives

The primary objective of this study was to statistically analyze long-term paddy cultivation trends (2004–2024) across Northern Sri Lanka's five districts-Vavuniya, Kilinochchi, Mullaitivu, Mannar, and Jaffna. Specific objectives included:

- Identifying district-wise yield trends and stability.
- Evaluating performance variations across irrigation schemes (major, minor, rain-fed).
- Assessing seasonal differences in productivity between the Yala (dry) and Maha (wet) seasons.

Methodology

District-level secondary data on Gross Extent Sown, Extent Harvested, Average Yield (kg/ha), and Total Production (MT) were collected from government statistical databases (Department of Census and Statistics, Sri Lanka). Statistical analyses employed linear regression to quantify yield trends, with significance tested at $p<0.05$. Yield stability was assessed using the coefficient of variation (CV). Seasonal and irrigation scheme performances were compared using descriptive and inferential statistics. Data analysis were performed using SPSS software (version 26). Limitations include a reliance on secondary sources, lack of complete yield data for Jaffna, and the exclusion of qualitative farm-level factors, such as pest outbreaks or and fertilizer use.

Results

Linear regression analyses revealed a significant positive yield trend in Mullaitivu (55.1 kg/ha per year; R^2=0.224, $p<0.05$), whereas Kilinochchi (64.0 kg/ha/year; p=0.063) displayed upward but non-significant trends. Vavuniya consistently reported the highest average yield (4478 kg/ha) with the lowest yield variability (CV=11.3%). Post-2010 yield analysis showed notable recovery and improvements in Kilinochchi (22.5%) and Mullaitivu (20.2%), aligning with post-conflict agricultural rehabilitation efforts documented by FAO (2018).

Table 1. Average Yield and Stability by District (2004–2024)

District	Average Yield (kg/ha)	Yield Trend (kg/ha/year)	R^2	CV (%)	Significant Trend
Vavuniya	4478	27.3	0.096	11.3	No
Kilinochchi	4050	64.0	0.189	21.0	No
Mullaitivu	4108	55.1	0.224	16.4	Yes
Mannar	4255	-1.6	0.000	20.3	No

Scheme-wise analyses highlighted major irrigation schemes consistently outperforming minor schemes and rain-fed areas, averaging yields of 4197 kg/ha (CV=19.6%) versus minor schemes (3781 kg/ha; CV=22.9%) and rain-fed areas (3158 kg/ha; CV=29.0%). Unexpectedly, Yala season yields consistently exceeded Maha yields across all schemes, likely due to improved water management and reduced pest pressure during controlled irrigation conditions (Ranasinghe et al., 2004).

Discussion

These findings clearly indicate the critical benefits of investing in major irrigation infrastructure, which aligns with national and international research. National-level data from Sri Lanka indicate that areas under assured irrigation consistently produce higher yields-often exceeding 5.0 t/ha-compared to 3.0–3.5 t/ha in rain-fed regions (Weerakoon et al., 2011). Globally, the role of irrigation in stabilizing rice yields has been widely documented, particularly in other South and Southeast Asian countries

where dry-season irrigation enables double cropping and mitigates monsoon variability (FAO, 2018). These comparative findings affirm that the observed yield enhancements in Northern Sri Lanka are not isolated but reflect broader patterns of irrigation-driven productivity gains. given their significantly higher yields and stability compared to minor and rain-fed schemes (Dhanapala, 2003). The seasonal productivity benefits observed during the Yala season suggests that controlled irrigation practices significantly enhance resource-use efficiency and reduce crop losses, offering valuable insights for regional agricultural management (Weerakoon et al., 2011). Our findings align with global trends emphasizing irrigation as a buffer against climatic variability (FAO, 2018; Ranasinghe et al., 2004). Furthermore, this study contributes to the growing body of research advocating for the integration of open agricultural data into smart farming practices. Initiatives like Sri Lanka's GeoGoviya platform illustrate the role of digital systems in disseminating timely, location-specific guidance to farmers and policymakers (Amarnath et al., 2025). The evidence provided here supports the design of district-specific intervention strategies and highlights the importance of seasonal crop planning using long-term data.

Conclusion

This study highlights the pivotal role of comprehensive statistical analyses of agricultural data in guiding strategic investments in irrigation infrastructure and optimizing seasonal management practices. It emphasizes the value of open agricultural data in transforming raw datasets into knowledge services that guide well-informed decision-making. By identifying regional yield patterns, quantifying stability, and highlighting seasonal performance disparities, the research provides practical insights to improve productivity and resilience in Northern Sri Lanka's paddy sector. From a policy perspective, the findings underscore the need for focused investments in irrigation infrastructure, particularly in districts and schemes with greater yield volatility. Additionally, the observed advantages of the Yala season suggests the importance of expanding dry-season irrigation capacity to enhance overall production. Future research studies should aim to integrate satellite-based environmental data, farmer-level socio-economic information, and climate projections to refine planning tools. There is also a need to explore digital literacy and institutional readiness to expand open data platforms like GeoGoviya in under-resourced districts.

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