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Trend analysis of area, production and productivity of banana in India and Tamil Nadu

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Abstract

Banana is one of the most important fruit crops in India, known for its nutritional value, year-round availability, and affordability. India is the world's largest producer of banana, and Tamil Nadu is a major contributor to national production. The present study was undertaken to analyse the long-term trends, growth and instability in area, production and productivity of banana in India and Tamil Nadu for a period of 22 years from 2003-04 to 2024-25. Secondary data collected from APEDA and DA&FW was analysed using linear trend analysis, Compound Annual Growth Rate (CAGR) and Cuddy-Della Valle Instability Index (CDVI). The results revealed a contrasting picture between national and state levels. At the national level, area and production showed a consistent upward trend with a significant growth rate of 4.07 percent and 3.84 percent per annum respectively, indicating steady expansion driven by market demand and technology adoption. Productivity showed a slight but non-significant decline of -0.22 percent per annum, suggesting that national production growth was mainly area-led. Instability was low for all three parameters in India after removing the trend effect. In Tamil Nadu, the scenario was different. Both area (0.42%) and production (-0.34%) showed stagnant and non-significant growth, while productivity declined significantly at 0.75 percent per annum. The state also recorded high instability in production (CDVI 25.99%) compared to the national level (10.24%), reflecting its vulnerability to climatic variability, water scarcity, and disease incidence. The study concludes that while India has witnessed steady growth, Tamil Nadu's banana sector needs a shift in focus from area expansion to yield stabilization through climate resilient varieties, better irrigation, and climate-smart management practices.

Keywords: Banana, trend analysis, cagr, instability index, cdvi, Tamil Nadu, India.

Introduction

Banana (*Musa sp.*) is one of the oldest and most widely consumed fruits in India, valued for its nutritional benefits and year-round availability. It is a rich source of carbohydrates, along with essential minerals such as calcium, potassium, magnesium, phosphorus, and sodium. The fruit is consumed both in ripe form and as a vegetable in its raw stage. In addition, the pseudostem of the banana plant is used as a vegetable, and its leaves serve as traditional plates in many parts of the country (Mishra *et al.*, 2018). Given its nutritional content and overall fruit value, banana is often called the "poor man's apple." It also remains the most affordable fruit available in the country (Madhunaik & Yogish, 2020) ^[4].

It ranks as India's second most important fruit crop after mango. Because it is available throughout the year, affordable, comes in many varieties, tastes good, and offers nutritional as well as medicinal benefits, it is popular across all income groups. The fruit also holds strong potential for export. Adopting hi-tech cultivation methods makes banana farming economically viable, as it boosts yields, improves fruit quality, and enables earlier maturity, allowing growers to fetch premium prices in the market (National Horticulture Board [NHB], 2002) ^[6].

India is the world's largest producer of banana, accounting for 26.98 percent of worldwide production and 16.13 percent of the world's total area under banana cultivation. China, Indonesia, Nigeria and Ecuador are other major producers (Food and Agriculture Organization [FAO], 2024) ^[3]. Among India's fruit crops, banana ranks first in terms of production and third in terms of area. This makes for about 12.37 percent of the total cultivated area and 32.57

percent of the total production of fruit crops. In India, banana is cultivated under total area of 0.9 million hectares, with a total production of around 38.32 million metric tons and a productivity of 42.5 metric tons per hectare in the fiscal year 2024-25 (Department of Agriculture & Farmers Welfare [DA&FW], 2025) [2].

The leading banana producing state is Uttar Pradesh followed by Andhra Pradesh. The states of Tamil Nadu, Maharashtra, Telangana, West Bengal, and Karnataka are the other major banana producers (Agricultural and Processed Food Products Export Development Authority [APEDA], 2025). Among Indian states, Tamil Nadu ranks second in area and third in production of banana among Indian states. The state contributes about 9.06 percent to India's total banana production. At present, banana is cultivated over 114.26 thousand hectares in Tamil Nadu, with a total production of 4793.57 thousand MT and an average productivity of around 41.95 MT per hectare (DA&FW, 2025). Despite its economic importance, the banana sector has witnessed considerable fluctuations over the years due to climate variability, water scarcity, pest and disease outbreaks and market price volatility. In this context, it becomes essential to analyse the long-term trends, growth rates and instability in area, production and productivity of banana both at the national and state level. Therefore, the present study was undertaken with the specific objectives to estimate the trends in area, production and productivity of banana in India and Tamil Nadu over the period from 2003-04 to 2024-25.

Materials and Methods

The present study is based entirely on secondary data. Time series data on area, production and productivity of banana at the national level and for the state of Tamil Nadu were collected for a period of 22 years, from 2003-04 to 2024-25. The data was compiled from reliable secondary sources including the Agricultural and Processed Food Products Export Development Authority (APEDA) and the Department of Agriculture and Farmers Welfare (DA&FW), Government of India.

Trend analysis

For estimating the trend in a time-series variable, the linear trend method was adopted.

$$Y_t = a + bt + e_t$$

Where,

Y_t = Trend values at time 't'

t = Time period in years

a = Intercept

b = Slope

e_t = Error term

The estimated equation was,

$$\hat{Y}_t = \hat{a} + \hat{b}t$$

The coefficient 'b' represents the average annual absolute change in the variable.

Compound annual growth rate (CAGR)

The growth pattern of area, production, and productivity of banana in India and Tamil Nadu was assessed using compound growth rates. For this, an exponential function was employed by considering time as the independent variable, while area, production, and productivity served as dependent variables. The

CAGR was obtained by fitting a semi-log trend equation with the help of the following formula:

$$Y = ab^t e \dots (1)$$

Where,

Y = The area/production/productivity

a = Intercept or constant

t = Time variable in years

e = Error term

b = (1+r)

Where,

r = Compound Growth Rate

The CAGR was obtained by transforming equation (1) to logarithmic form as below:

$$\ln Y = \ln a + t(\ln b) + e$$

By multiplying the relative change in Y by 100, the percentage change or growth rate in Y for an absolute change in variable 't' was obtained. The instantaneous growth rate is also measured by the slope coefficient 'b'. Therefore, the CAGR was then estimated using the following equation:

$$CAGR = (\text{Antilog } b - 1) \times 100$$

Instability index

Instability in area, production, and productivity of banana was estimated with the help of the Cuddy-Della Valle Index (CDVI). The index provides a measure of variation and risk involved in these variables over time.

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

Where,

CV = Coefficient of Variation

R^2 = Coefficient of Determination

The ranges of CDVI are given as follows:

- Low instability = 0 to 15
- Medium instability = 15 to 30
- High instability = 30 and above, (Sihmar, 2014) [7].

Results and Discussion

Trend analysis of area, production and productivity of banana in India

The long-term trends in area, production and productivity of banana in India were analysed for the period from 2003-04 to 2024-25 using the linear trend model.

Area under banana cultivation showed a consistent upward trend throughout the study period. The estimated trend equation was found to be $y = 26.521x + 459.27$ (Fig 1). Here, the intercept value of 459.27 indicates the base level area, while the slope coefficient of 26.52 implies that area under banana expanded at an average rate of about 26.52 thousand hectares per year. In absolute terms, the area increased from 390 thousand hectares in 2003-04 to 902 thousand hectares in recent years. Although minor fluctuations were observed during 2010-11 to 2013-14, the overall pattern was clearly positive.

Production of banana also exhibited a strong increasing trend over the 22-year period. The fitted equation $y = 963.73x + 17189$ (Fig 2) indicates an average annual addition of about

963.73 thousand MT to total production. Banana output in the country rose from around 13,311 thousand MT in 2003-04 to over 38,322 thousand MT by 2024-25. This growth closely followed the expansion in cultivated area, indicating that area increase has been a major driver of production.

In contrast to area and production, productivity showed a slightly declining trend overall. The estimated trend line - $0.0932x + 38.417$ (Fig 3) reveals an average annual decrease of about 0.093 MT per hectare. After a sharp increase in the initial years with yields crossing 44 MT per hectare during 2005-07, productivity dropped and remained stagnant between 34 to 36 MT per hectare for most of the next decade. However, a positive turnaround has been observed from 2021-22 onwards, with yields recovering to nearly 42 MT per hectare in 2024-25, suggesting improvement due to better varieties and management practices.

Overall, the trend analysis suggests that the remarkable growth in banana production in India over the last two decades has been largely area-driven rather than yield-driven. While both area and production grew steadily at average annual rates of 26.52 thousand hectares and 963.73 thousand tonnes respectively, productivity remained stagnant or showed a marginal decline when viewed over the entire period.

Trend analysis of area, production and productivity of banana in Tamil Nadu

The area under banana in Tamil Nadu showed a very slow but positive long-term trend. The estimated trend equation is $y = 0.3395x + 97.677$ (Fig 4). The intercept of 97.677 indicates the base level area, while the slope value of 0.3395 shows that the area increased on an average by only about 0.34 thousand hectares per year. Though the overall trend line is positive, there was high year-to-year fluctuation. The area grew from around 71 thousand hectares in 2003-04 to a peak of 125 thousand hectares in 2010-11, then declined sharply to about 83 thousand hectares in 2017-18. In recent years, there has been a gradual recovery, with area reaching about 114 thousand hectares by 2024-25.

In contrast, banana production in the state showed a negative trend over the 22-year period. The fitted equation $y = -26.903x + 4829.2$ (Fig 5) indicates an average annual fall of about 26.90 thousand MT. Production was highly volatile. It increased from nearly 2,515 thousand MT in 2003-04 to an all-time high of over 8,253 thousand MT in 2010-11, and then dropped drastically to around 3,000 tonnes during 2017 to 2019. Although production has stabilized and improved slightly after 2020-21, it is still much lower than the peak achieved in 2010-11.

Similarly, productivity of banana in Tamil Nadu also registered a declining trend. The estimated equation $y = -0.3585x + 48.112$ (Fig 6) shows an average annual decline of 0.3585 MT per hectare. Yield peaked at more than 65 MT per hectare in 2010-11, which was the best year for all three parameters. After that, productivity fell sharply and remained low between 35 to 40 MT per hectare from 2017-18 onwards, with only a small recovery to 42 MT per hectare by 2024-25.

Overall, the analysis shows that the banana sector in Tamil Nadu has suffered from yield instability and production shocks in the last two decades. Unlike the all India picture where growth in production came mainly from area expansion, Tamil Nadu witnessed a fall in both production and productivity even though area remained more or less stable with a slight positive growth. The common peak in 2010-11 and common low in 2017-18 for area, production and productivity clearly indicates that the state's banana cultivation is highly sensitive to rainfall, water availability and climatic factors. This calls for stronger focus on

climate resilient varieties, better water management, and improved crop practices to stabilize yield in the coming years.

Compound annual growth rate of area, production and productivity of banana

Compound growth rates were calculated for India and Tamil Nadu to measure the yearly increase or decrease in area, production, and productivity of the banana.

Table 1, shows the compound annual growth rate in area, production and productivity of banana in India and Tamil Nadu over a period of 22 years from 2003-04 to 2024-25. An exponential trend model was used to capture the long-term growth pattern, with time taken as the independent variable.

At the national level, area and production of banana in India grew at a significant rate of 4.07 percent and 3.84 percent per annum, respectively, with p -value < 0.001 , indicating a strong and consistent expansion. The R^2 values of 0.76 for area and 0.81 for production suggest that time explained about 76 percent and 81 percent of the variation in these variables. This shows that banana cultivation in India has expanded steadily, supported by favourable policies, market demand and technology adoption. However, productivity recorded a slight decline of -0.22 percent per annum, which was not statistically significant. The low R^2 value of 0.03 (3%) indicates that independent variable i.e., time was not explaining the variations efficiently while factors other than time had a greater influence on productivity changes in India. This suggests that the increase in national production has come mainly from area expansion rather than from large yield gains.

On the contrary, in Tamil Nadu, the growth scenario of area, production and productivity of banana was different. Both area and production showed a stagnant trend with growth rates of 0.42 percent and -0.34 percent per annum, respectively, and both were non-significant. The very low R^2 values of 0.04 and 0.01 further confirm that time was not a key driver of change, accounting for only 4 percent and 1 percent of the variation in area and production respectively. However, productivity in the state declined at the rate of -0.75 percent per annum and was significant at 10 percent level. The R^2 value of 0.13 implies that only 13 percent of the variation in productivity could be attributed to time. The negative growth in productivity suggests that yield levels have faced pressure over time, possibly due to climatic stress, disease incidence, and reduced input use in some years.

Overall, the comparison shows that India as a whole has experienced steady growth in banana area and production, while Tamil Nadu has remained largely stagnant with a slight decline in productivity.

Instability in area, production and productivity of banana

In this study, Cuddy-Della Valle Index was used to measure instability in banana area, production, and productivity. CDVI is a more suitable measure when the data follows a time trend. It is preferred over simple coefficient of variation because it removes the trend effect from the data. This gives a clearer picture of year-to-year fluctuations rather than long-term growth. It helps in understanding how much these variables fluctuate and the level of risk associated with them. Table 2, presents the Instability Index, for area, production and productivity of banana in India and Tamil Nadu.

At the national level, area showed the highest variation at 24.93 percent, followed by production at 23.44 percent and productivity at 8.94 percent. The CDVI values for area, production and productivity were 12.30, 10.24 and 8.82 percent,

respectively. The relatively lower CDVI values compared to the coefficient of variation indicate that, after removing the trend effect, instability in banana area, production and productivity in India were low during the study period.

In Tamil Nadu, area was more stable with a CDVI of 13.42 percent, which is lower than the national CDVI of 12.30 percent, despite having a lower mean area of 101.58 thousand hectares as against 764.26 thousand hectares at the national level. However, production in Tamil Nadu was highly unstable with a CDVI of 25.99 percent, which is much higher than the national index of

10.24 percent. This wide fluctuation in state-level production can be attributed to frequent adverse weather conditions, variability in monsoon and incidence of pests and diseases in major banana growing areas. For productivity, Tamil Nadu recorded a higher average yield of 43.99 tons per hectare compared to the national average of 37.35 tons per hectare. But the state also experienced greater instability in yield, with a CDVI of 13.87 percent compared to 8.82 percent at the national level.

Table 1: Compound Annual Growth Rate of area, production and productivity of banana in India and Tamil Nadu

Sr. No.	Particulars		India	Tamil Nadu
1.	Area ('000 ha)	R ²	0.76	0.04
		Coefficient	0.04	0.004
		CAGR (%)	4.07***	0.42 ^{NS}
		Standard error	0.15	0.14
		t-value	7.8813	0.8583
2.	Production ('000MT)	p-value	<0.001	0.40
		R ²	0.81	0.01
		Coefficient	0.04	-0.003
		CAGR (%)	3.84***	-0.34 ^{NS}
		Standard error	0.12	0.25
3.	Productivity (MT/ha)	t-value	9.2075	-0.3965
		p-value	<0.001	0.70
		R ²	0.03	0.13
		Coefficient	-0.002	-0.01
		CAGR (%)	-0.22 ^{NS}	-0.75*
		Standard error	0.09	0.13
		t-value	-0.7606	-1.7200

Note: ***, * indicates significant at 1 percent and 10 percent level respectively and NS indicates Not Significant

Table 2: Instability in area, production and productivity of banana in India and Tamil Nadu

Sr. No.	Particulars	Area ('000 ha)		Production ('000 MT)		Productivity (MT/ha)	
		India	Tamil Nadu	India	Tamil Nadu	India	Tamil Nadu
1.	Mean	764.26	101.58	28272.33	4519.82	37.35	43.99
2.	SD	190.50	13.88	6627.92	1179.14	3.34	6.54
3.	CV	24.93	13.66	23.44	26.09	8.94	14.86
4.	R ²	0.76	0.04	0.81	0.01	0.03	0.13
5.	CDVI	12.30	13.42	10.24	25.99	8.82	13.87

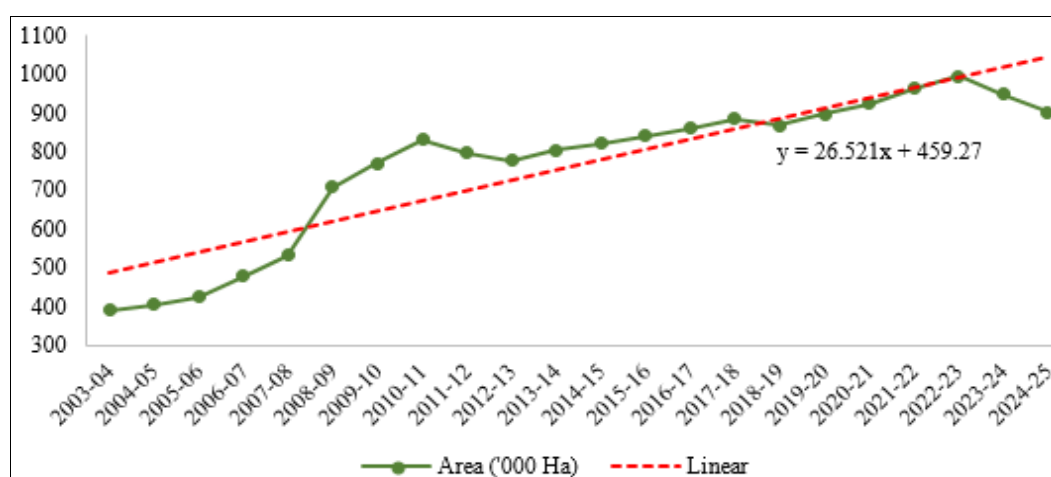


Fig 1: Trend in area of banana in India (2003-04 to 2024-25)

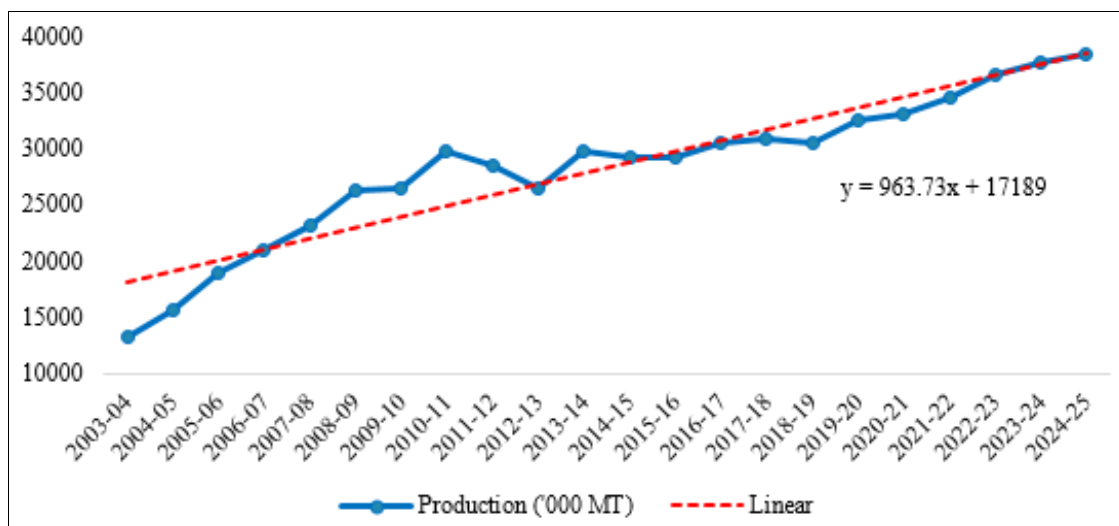


Fig 2: Trend in production of banana in India (2003-04 to 2024-25)

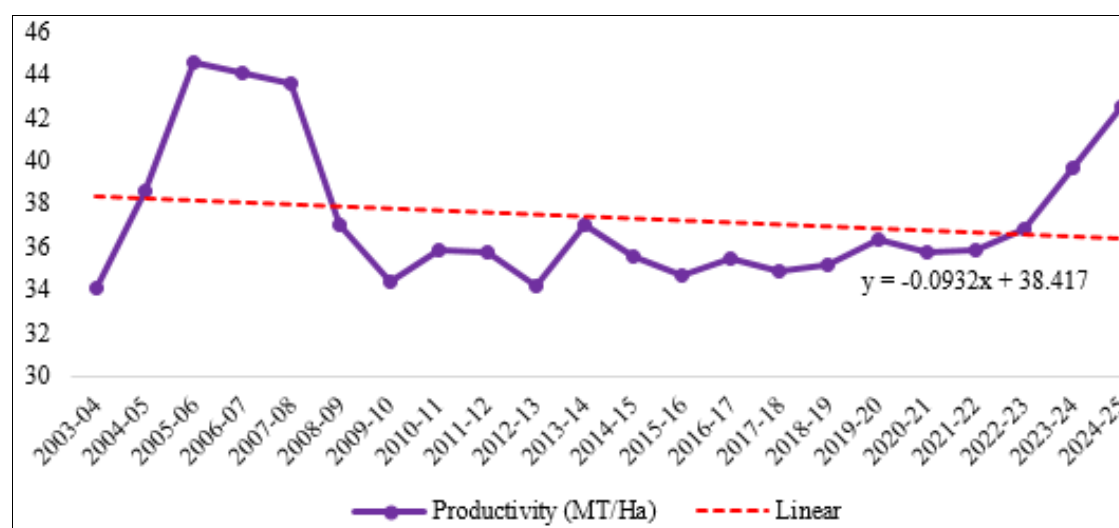


Fig 3: Trend in productivity of banana in India (2003-04 to 2024-25)

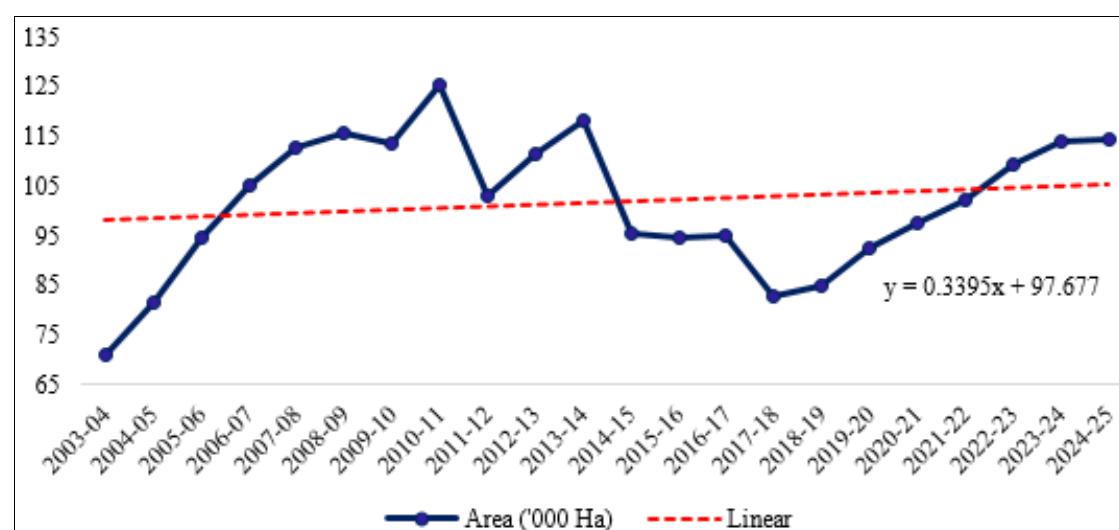


Fig 4: Trend in area of banana in Tamil Nadu (2003-04 to 2024-25)

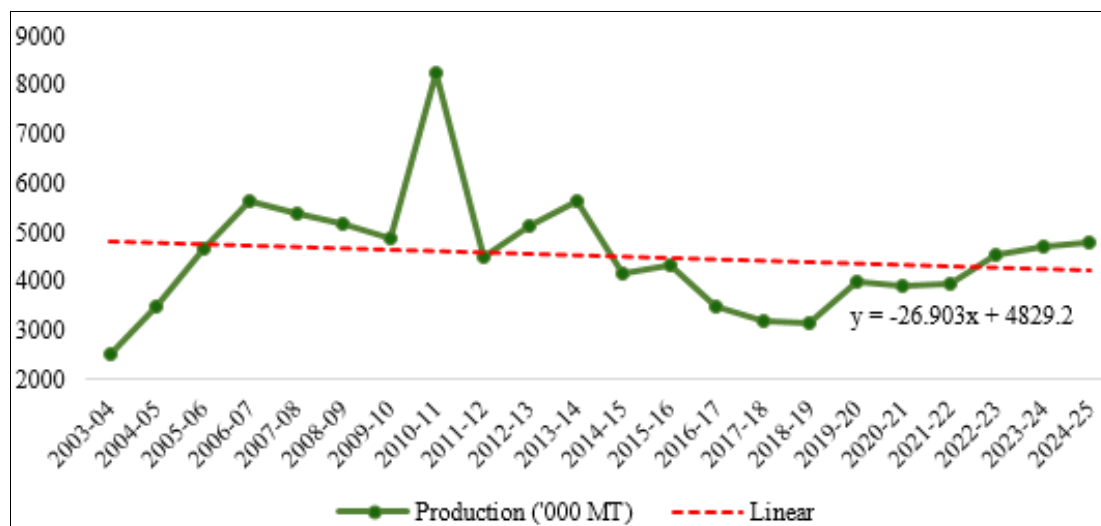


Fig 5: Trend in production of banana in Tamil Nadu (2003-04 to 2024-25)

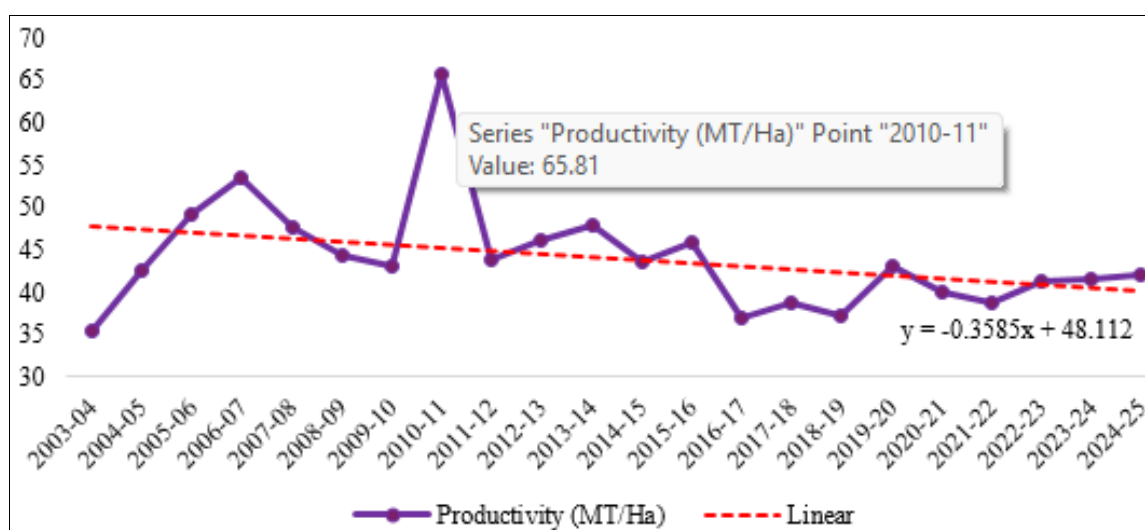


Fig 6: Trend in productivity of banana in Tamil Nadu (2003-04 to 2024-25)

Conclusion

The study concludes that banana in Tamil Nadu has not kept pace with the national growth story. While India saw steady expansion in area and production driven by demand and technology, Tamil Nadu's growth remained stagnant with fluctuating yields. The decline in productivity over time, along with high instability, shows that the state's banana sector is vulnerable to weather, disease, and inconsistent management. For sustained growth, the focus must shift from area expansion to improving yield stability through better varieties, irrigation, and climate-smart practices that suit local conditions.

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