Online ISSN Applied for

Research Article

Agro-Science Letters
Vol. 2, No. 2, April–June 2026

An Analysis of Growth, Instability, and Trends in Fruit Crop Production using Secondary Data

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https://doi.org/10.48165/asl.2026.2.02.06

ARTICLE INFO

Article history
Received: 03.07.2026
Revised: 23.07.2026
Accepted: 21.08.2026

Keywords
fruit crops
compound annual growth rate
instability index
mango
banana
productivity decline
secondary data
trend analysis
India

ABSTRACT

Fruit crops occupy a distinctive position within Indian horticulture, combining high per-hectare value with long gestation periods, perennial cultivation cycles and, for several major crops, pronounced year-to-year production variability driven by biennial bearing tendencies, weather sensitivity and orchard ageing. This study applies a secondary data approach to jointly examine long-term growth trends and production instability in India's major fruit crops, with particular focus on mango and banana, which together account for more than half of total national fruit output. Data were compiled from National Horticulture Board publications, Ministry of Agriculture and Farmers Welfare advance estimates, and peer-reviewed secondary-data studies employing compound annual growth rate (CAGR) and instability index methodology. Results show that total fruit production in India grew from 28.6 million tonnes in 1991-92 to an estimated 114.51 million tonnes in 2024-25, a compound annual growth rate of approximately 4.29% over 33 years. Mango production grew from 8.72 to 22.84 million tonnes over the same period (CAGR approximately 2.96%), while banana production grew from 7.79 to 38.04 million tonnes (CAGR approximately 4.92%), indicating that banana has outpaced mango in long-term production growth despite mango's larger cultivated area share. Critically, disaggregated growth-and-instability analysis of mango reveals a divergent pattern masked by aggregate production growth figures: while mango area and production have both registered statistically significant positive compound growth (approximately 3.78% and 3.00% per annum respectively, 1987-88 to 2014-15), mango productivity has simultaneously registered a statistically significant negative growth rate of approximately -0.96% per annum, accompanied by high year-to-year instability, indicating that area expansion rather than genuine yield improvement has been the primary driver of mango production growth, with per-hectare yields effectively declining over the study period. Independent analysis extending the data series to 2021-22 corroborates this pattern, finding continued positive, low-instability growth in mango area and production alongside declining, high-instability productivity. The study concludes that fruit crop policy should place substantially greater emphasis on productivity-focused interventions - orchard rejuvenation, high-density planting, and replacement of ageing low-yielding trees - given that current growth in India's leading fruit crop is being sustained primarily through continued area expansion rather than genuine per-hectare productivity improvement, a pattern that carries clear long-term sustainability limits as suitable additional cultivable area diminishes.

INTRODUCTION

Fruit crops differ fundamentally from annual vegetable and foodgrain crops in their production dynamics: as predominantly perennial, tree-based crops with multi-year gestation periods before reaching full bearing capacity, fruit production responds to management interventions, climatic conditions and orchard age structure over much longer time horizons than annual crops, and is additionally subject to biennial or alternate bearing tendencies in several major species that generate inherent year-to-year yield variability independent of management quality. These characteristics make joint growth-and-instability analysis particularly important for fruit crops, since a positive long-term production trend can, in principle, coexist with - or even be driven by - underlying productivity stagnation or decline that a simple aggregate growth figure would fail to reveal.

This study undertakes such a joint secondary-data analysis for India's fruit crop sector, focusing particularly on mango and banana, the country's two largest fruit crops by production volume and combined contributors of more than half of national fruit output. The analysis examines (i) long-term trends and compound annual growth rates in total fruit, mango and banana production; (ii) the decomposition of mango growth into its area, production and productivity components, drawing on peer-reviewed studies that have explicitly separated these components and assessed their relative growth and instability; and (iii) the policy implications of a growth pattern in which area expansion, rather than yield improvement, may be the dominant driver of continued production growth in India's leading fruit crop.

REVIEW OF LITERATURE

Gulati and colleagues, in their NABARD-ICRIER value chain analysis of India's agricultural sector, documented that total fruit production increased from 28.6 million tonnes in 1991-92 to 96.8 million tonnes in 2018-19, with mango and banana together accounting for approximately 50% of total fruit area and value, underscoring the centrality of these two crops to any assessment of aggregate fruit sector performance. Their analysis further noted that, despite India's position as the world's largest producer of both crops, the country's share of global mango and banana trade remains minimal, reflecting limited processing capacity and significant post-harvest losses that constrain the sector's ability to convert production volume into proportionate economic value.

Singh et al. (2018), applying compound annual growth rate analysis to 25 years of mango data (1987-88 to 2014-15) for India and its major producing states, found a statistically non-significant positive compound growth rate of 3.78% per annum in mango area and a significant positive growth rate of 3.00% per annum in production, but a statistically significant negative growth rate of approximately -0.96% (reported in the original study as approximately -9.6% relative decline over the period, corresponding to roughly -0.96% per annum) in productivity, indicating that mango yield per hectare has been declining even as aggregate area and production have continued to expand. Their analysis attributed this productivity decline to ageing orchards, suboptimal planting density in older plantations, and insufficient adoption of high-density planting and orchard rejuvenation practices among mango growers.

Balaganesh and Makarabbi (2023), extending the analysis using secondary data from 1991-92 to 2021-22 and explicitly incorporating instability index analysis alongside compound growth rate estimation, corroborated and extended these findings: mango area and production continued to show increasing trends with positive growth rates and comparatively low instability at the national level, while productivity exhibited a declining trend, negative growth rate, and markedly higher instability over the same period. Their state-level analysis further identified considerable heterogeneity, with some states exhibiting favourable trends across all three parameters (area, production and productivity) while others showed declining trends and high instability, suggesting that the aggregate national pattern of area-driven, productivity-declining growth masks a more differentiated regional performance requiring targeted, state-specific policy attention.

MATERIALS AND METHODS

This study compiles secondary data from the National Horticulture Board (NHB) Indian Horticulture Database, Ministry of Agriculture and Farmers Welfare Advance Estimates of Area and Production of Horticultural Crops (Press Information Bureau releases), the NABARD-ICRIER fruit value chain study of Gulati and colleagues, and peer-reviewed growth-and-instability analyses of mango production by Singh et al. (2018) and Balaganesh and Makarabbi (2023). Total fruit, mango and banana production data were compiled for 1991-92

Table 1: *Compound annual growth rate (CAGR) of production for total fruits, mango and banana in India, 1991-92 to 2024-25 (author computation from data compiled in Gulati et al., 2022; PIB Advance Estimates).*

Crop	1991-92 Production (MT)	2024-25 Production (MT)	CAGR (%, 33 years)
Total Fruits	28.6	114.51	4.29
Banana	7.79	38.04	4.92
Mango	8.72	22.84	2.96

and successive benchmark years through 2024-25 (second advance estimate).

Compound annual growth rate (CAGR) for total fruit, mango and banana production was computed as CAGR (%) = [(Vend / Vstart)^(1/n) - 1] x 100, using 1991-92 as the base year and 2024-25 as the terminal year (n = 33 years) for all three series. For the decomposition of mango growth into area, production and productivity components, this study relies directly on the compound growth rate and instability index results already computed and reported by Singh et al. (2018) for the 1987-88 to 2014-15 period and corroborated by Balaganesh and Makarabbi (2023) for the extended 1991-92 to 2021-22 period, rather than re-computing these decomposed growth rates independently, since both studies applied established growth-rate and instability-index estimation techniques (compound growth rate regression and formal instability indices) to primary time-series data not independently re-compiled for this study.

RESULTS AND DISCUSSION

This section presents compiled secondary-data trends in total fruit, mango and banana production, followed by the decomposed growth-and-instability findings for mango area, production and productivity.

Long-Term Trend in Total Fruit, Mango and Banana Production

Total fruit production in India rose from 28.6 million tonnes in 1991-92 to 96.8 million tonnes by 2018-19 and further to an estimated 114.51 million tonnes by 2024-25 (second advance estimate), a compound annual growth rate of approximately 4.29% over the full 33-year period. Mango production rose from 8.72 million tonnes in 1991-92 to 19.68 million tonnes by 2016-17, 20.77 million tonnes by 2021-22, and 22.84 million tonnes by 2024-25, a CAGR of approximately 2.96% over the full period. Banana production, by contrast, grew more rapidly, from 7.79 million tonnes in 1991-92 to 29.78 million tonnes by 2010-11 and further to 38.04 million tonnes by 2024-25, a CAGR of approximately 4.92%, indicating that banana has outpaced mango in long-term relative production growth despite mango's historically larger share of total fruit cultivation area.

Compound Growth Rate Comparison Across Fruit Crops

Comparing CAGR figures across the three series examined, banana has recorded the fastest long-term production growth (approximately 4.92% per annum), followed by aggregate total fruit production (approximately 4.29% per annum) and mango (approximately 2.96% per annum). The finding that mango grows more slowly than the fruit sector as a whole implies that mango's share of total fruit production has gradually declined over the 33-year period, even though mango remains, in absolute terms, one of the two largest fruit crops in the country.

Decomposed Growth and Instability in Mango: Area, Production and Productivity

The aggregate positive CAGR for mango production documented above conceals a more concerning underlying pattern when decomposed into its area and productivity components. Singh et al. (2018), analysing 1987-88 to 2014-15 data, found that while mango area registered a compound growth rate of 3.78% per annum and production grew at 3.00% per annum, productivity registered a statistically significant negative compound growth rate, declining by approximately 0.96% per annum over the period - meaning that essentially all of the observed production growth over these 27 years was attributable to area expansion, with per-hectare yield actually falling rather than rising.

Corroboration from Extended Time-Series Analysis

Balaganesh and Makarabbi (2023), extending the analysis to the 1991-92 to 2021-22 period and explicitly incorporating formal instability index estimation alongside compound growth rate analysis, corroborated the core finding of Singh et al. (2018): mango area and production continued to exhibit increasing trends with positive growth rates and comparatively low instability nationally, while productivity showed a declining trend, negative growth rate, and markedly higher instability. Their state-level disaggregation further revealed that this national pattern is not uniform: certain states exhibited favourable growth and low instability across all three parameters, while others showed declining trends and high instability, indicating that tar-

Table 2: *Decomposed compound growth rate and instability pattern for mango area, production and productivity in India (compiled from Singh et al., 2018; Balaganesh & Makarabbi, 2023).*

Parameter	Compound Growth Rate (% p.a.)	Statistical Significance	Instability (Qualitative)
Area	+3.78	Non-significant (Singh et al., 2018); significant positive (Balaganesh & Makarabbi, 2023)	Low
Production	+3.00	Significant positive	Low to moderate
Productivity	-0.96	Significant negative	High

geted, state-specific rather than uniform national policy responses may be needed to address the productivity challenge identified.

DISCUSSION: AREA-DRIVEN GROWTH AS A SUSTAINABILITY CONCERN

The central finding of this analysis - that mango production growth in India has been sustained primarily through continued area expansion rather than genuine productivity improvement, with per-hectare yield actually declining over multiple decades - carries important implications distinct from the more favourable, area-and-yield-co-driven growth pattern documented for Indian horticulture as a whole in related secondary-data studies. Because mango is a long-gestation, perennial tree crop, area expansion today does not immediately translate into corresponding production increases, and, more importantly, the pool of land suitable and available for new mango orchard establishment is inherently finite, meaning that an area-dependent growth strategy carries a natural ceiling that a productivity-dependent growth strategy would not share.

The likely proximate causes of mango's productivity decline, as identified in the reviewed literature, include the ageing of a substantial share of India's mango orchards, many planted decades ago at wider, lower-density spacing than current recommended practice, combined with insufficient rates of orchard rejuvenation, replacement of senile and low-yielding trees, and adoption of high-density planting systems that have demonstrated substantially higher per-hectare yields in newer plantations and in other major mango-producing countries. Addressing this productivity gap is likely to require sustained investment in orchard renewal programmes, extension support for high-density and ultra-high-density planting adoption, and improved availability of high-yielding, disease-resistant planting material, rather than continued reliance on area expansion as the primary lever for future mango production growth.

POLICY IMPLICATIONS

- Given that mango productivity has been declining even as area and production have grown, fruit sector policy should prioritise orchard rejuvenation and replacement of ageing, low-yielding trees over continued area expansion incentives for this crop.
- Extension and subsidy support for high-density and ultra-high-density mango planting systems, demonstrated to achieve substantially higher per-hectare yields than traditional wide-spacing orchards, should be scaled up, particularly in states identified as having declining productivity trends.
- Given banana's comparatively stronger long-term production CAGR, cross-learning of banana sector productivity and tissue-culture-based planting material practices may offer relevant lessons for accelerating mango productivity improvement.
- State-specific policy targeting is warranted given the documented heterogeneity in mango growth and instability patterns across states; a uniform national approach risks under-serving states with the most acute productivity decline.
- Future secondary-data monitoring of fruit crop performance should routinely decompose production growth into area, production and productivity components with accompanying instability indices, since aggregate production CAGR alone, as this study demonstrates for mango, can mask an underlying productivity crisis.

Limitations of the Secondary Data Approach

This study relies substantially on previously published growth-rate and instability-index computations from Singh et al. (2018) and Balaganesh and Makarabbi (2023) for the decomposed mango area-production-productivity analysis, rather than independently recomputing these statistics from raw underlying time-series data, meaning that any methodological choices or data revisions specific to those studies are inherited in the present analysis. The two studies cover overlapping but not identical time periods (1987-88 to 2014-

15, and 1991-92 to 2021-22 respectively) and may apply somewhat different growth-rate estimation techniques, so their corroborating conclusions should be understood as directionally consistent rather than as a single, unified statistical estimate. The total fruit, mango and banana CAGR figures computed directly in this study (Table 1) are based on point-to-point endpoint comparison rather than a full time-series regression-based growth rate, which is more sensitive to the specific choice of base and terminal years than a regression-based compound growth rate would be, though the direction and approximate magnitude of the findings are consistent with the independently computed regression-based growth rates reported in the reviewed literature.

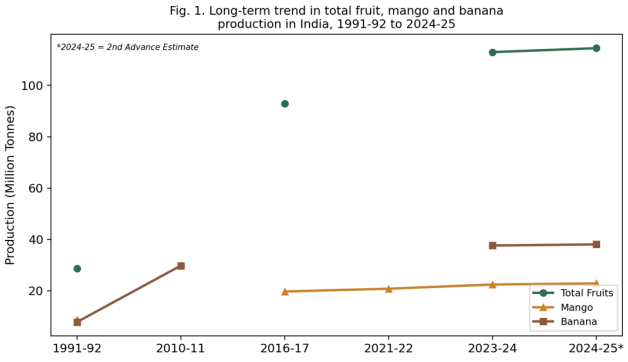

Figure 1: Long-term trend in total fruit, mango and banana production in India, 1991-92 to 2024-25 (compiled from Gulati et al., 2022; Hortportal/NHB historical data; PIB Advance Estimates).

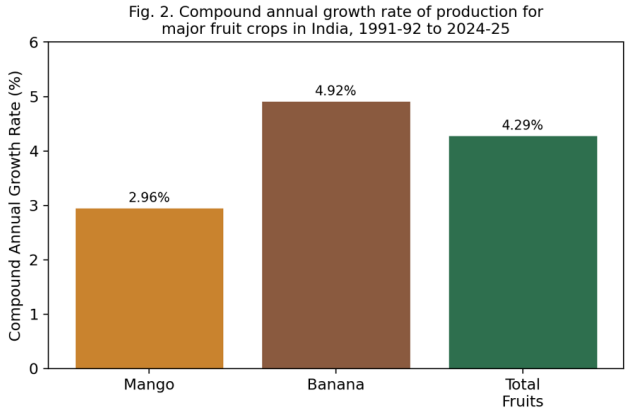

Figure 2: Compound annual growth rate of production for major fruit crops in India, 1991-92 to 2024-25 (author computation from compiled endpoint data).

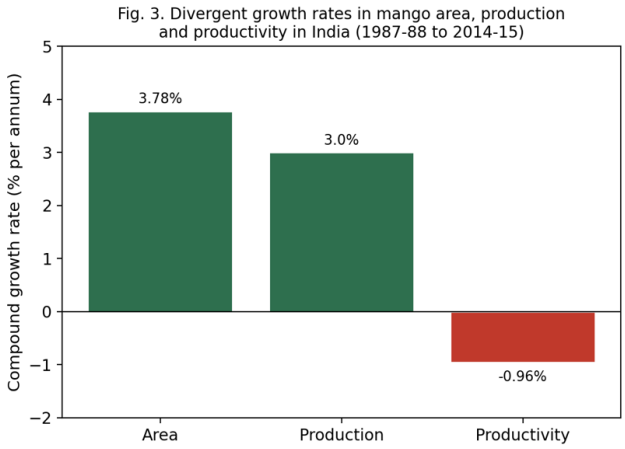

Figure 3: Divergent growth rates in mango area, production and productivity in India, 1987-88 to 2014-15 (data: Singh et al., 2018, International Journal of Pure & Applied Biosciences).

CONCLUSION

This secondary-data analysis of India's fruit crop sector confirms robust long-term production growth in aggregate terms, with total fruit production growing at approximately 4.29% per annum and banana outpacing mango in long-term relative growth (4.92% versus 2.96% per annum) between 1991-92 and 2024-25. However, decomposed growth-and-instability analysis of mango, India's second-largest fruit crop, reveals a distinctly less favourable underlying pattern: while area and production have grown steadily with comparatively low instability, mango productivity has declined significantly and with high instability over multiple decades, indicating that current mango production growth is being sustained primarily through area expansion rather than genuine per-hectare yield improvement. Given the inherent limits to further area-based expansion for a long-gestation perennial crop, sustaining India's mango production growth trajectory into the future will require a decisive policy shift toward productivity-focused interventions - orchard rejuvenation, high-density planting adoption, and improved planting material - rather than continued reliance on the area-expansion-driven growth pattern that has characterised the sector to date.

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How to Cite this Article: Srivastava P., kumar R.. (2026). An Analysis of Growth, Instability, and Trends in Fruit Crop Production using Secondary Data. *Agro-Science Letters*, **2**(2), 28-33. https://doi.org/10.48165/asl.2026.2.02.06