doi:10.25081/jpc.2025.v53.i2.10001
Journal of Plantation Crops, 2025, 53 (2): 43-49

# Growth, instability, and decomposition of coconut production in Gujarat: a comprehensive analysis of trends and dynamics

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*(Manuscript received: 22.01.2026, Revised: 29.03.2026, Accepted: 23.01 2026)*

## Abstract

Coconut (*Cocos nucifera*), often referred to as the "*Kalpavriksha*" is an economically vital crop. India, particularly its southern states, is a major producer of coconut, contributing significantly to GDP and supports around 12 million livelihoods Gujarat, a non-traditional coconut-growing state, has witnessed a rise in coconut cultivation, especially in coastal districts like Kutch, Junagadh, Porbandhar, and Navasari. This study analyzed the growth, instability, and decomposition of coconut cultivation in Gujarat over the period 2000-2020, using secondary data.The statistical tools employed such as, Compound Annual Growth Rate (CAGR) was used to evaluate growth trends in area, production, and yield. Instability was assessed using Coefficient of Variation (CV) and Cuddy-Della Valle Index (CDVI), while decomposition analysis quantified the contributions of area, yield, and their interaction to production changes.The results reveal significant variability in growth in area and production across most districts, with Gujarat's coconut area with a CAGR of 4.10 percent (2000-2020) and production 5.80percent. However, yield growth showed a decline of -0.87percentin Period II (2010-2020). Instability analysis revealed varying degrees of volatility, with Surat and Valsad showing the highest instability in area and production (CV of 30.05% and 46.68%, respectively), while Kutch displayed relatively stable growth. Decomposition analysis revealed that area expansion contributed significantly to production increases (41.54% in Period I, 127.96% in Period II), while yield effects were less consistent (-20.51% in Period II). This emphasizes the need for targeted interventions to enhance yield through better farming practices and climate-resilient varieties, alongside continued support for area expansion.

***Keywords:*** Coconut, Gujarat, Growth Analysis, Instability, Decomposition, Yield, Area Effect.

## Introduction

Coconut (*Cocos nucifera* L.), often hailed as the "Tree of Heaven" or *Kalpavriksha*, is one of the most versatile and economically significant crops cultivated in tropical and subtropical regions globally. The coconut palm is cultivated throughout the year for decoration as well as for its culinary and non-culinary uses. Virtually every part of the coconut palm has significant economic value and plays animportant role in the Indian GDP and provides food security, livelihood for about 12 million people in India (Vinodhini & Deshmukh 2017) Coconut is grown in more than 93 countries throughout the tropics and subtropics, with an annual production of around 65674 million nuts obtained from an area of 12.257 million hectares.The coconut productivity is 5,440 nuts per hectare (CDB.2021). About 74.47 per cent of the global production of coconut comes from three countries, viz., the Philippines, Indonesia and India. India stood first among the leading producing countries, accounting for 31.10 per cent (20.736 million nuts) of the total world production of coconut in 2021 followed by the Philippines (22.07 percent) and Indonesia (21.29 percent).

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**Table1.** Percent share of area and production of major coconut growing districts in Gujarat (2023-24)

| Districts | Area (ha) | Percent share | Production (000 Nuts) | Percent share |
|---|---|---|---|---|
| Gir Somnath | 10800 | 39.42 | 106812 | 40.24 |
| Junagadh | 6000 | 21.9 | 59880 | 22.56 |
| Bhavnagar | 3612 | 13.18 | 35723 | 13.46 |
| Valsad | 3360 | 12.26 | 28056 | 10.57 |
| Kutch | 1050 | 3.83 | 13377 | 5.04 |
| Porbandhar | 710 | 2.59 | 6269 | 2.36 |
| Navsari | 599 | 2.19 | 5062 | 1.91 |
| Devabhumi Dwaraka | 370 | 1.35 | 3115 | 1.17 |
| Surat | 243 | 0.89 | 1946 | 0.73 |
| Vadodara | 158 | 0.58 | 1308 | 0.49 |
| Others | 498 | 1.82 | 3916 | 1.48 |
| Total | 27400 | 100 | 265464 | 100 |

**Source:** Director of Horticulture, Govt. of Gujarat

In India, coconut is cultivated majorly in 18 states and five union territories with southern states accounting for 90 per cent of country's coconut production, (CDB, 2022-23). In Gujarat, a non-traditional coconut-growing state, the crop has gained prominence in recent years, particularly in coastal districts Gir Somnath, Junagadh, Bhavnagar, Valsad after districts contributes about 87 percent of state production and area (Anonymous, 2023-24) Viz., Gir Somnath, Junagadh, Bhavnagar, Valsad. The study aims to analyze the growth, instability, and decomposition of coconut production variablesacross major districts of Gujarat. By evaluating trends in area, production, and yield, the research results identify factors influencing the performance of the coconut sector and to provide insights for enhancing its sustainability. Decomposition analysis shows that the area effect and yield effect play a crucial role in the total change of coconut production.

The present study is based on secondary data related to area, production and productivity of Coconut in the state of Gujarat. The data was collected from various secondary sources i.e. Coconut Development Board, Department of Horticulture, Government of Gujarat and Horticulture Statistics at a glance.

## Methodology

The statistical tools used were Mean, coefficient of variation (CV %), growth rate was measured using Compound Annual Growth Rate analysis (CAGR), instability was estimated using Cuddy Della Valle Instability (CDVI) and Decomposition Analysis. The time series data of area, production and yield of Coconut crop in major districts of Gujarat for 20 years (2000-01 to 2019-20) was divided into two periods: Period-I (2000-01 to 2009-10) and Period-II (2010-11 to 2019-20).

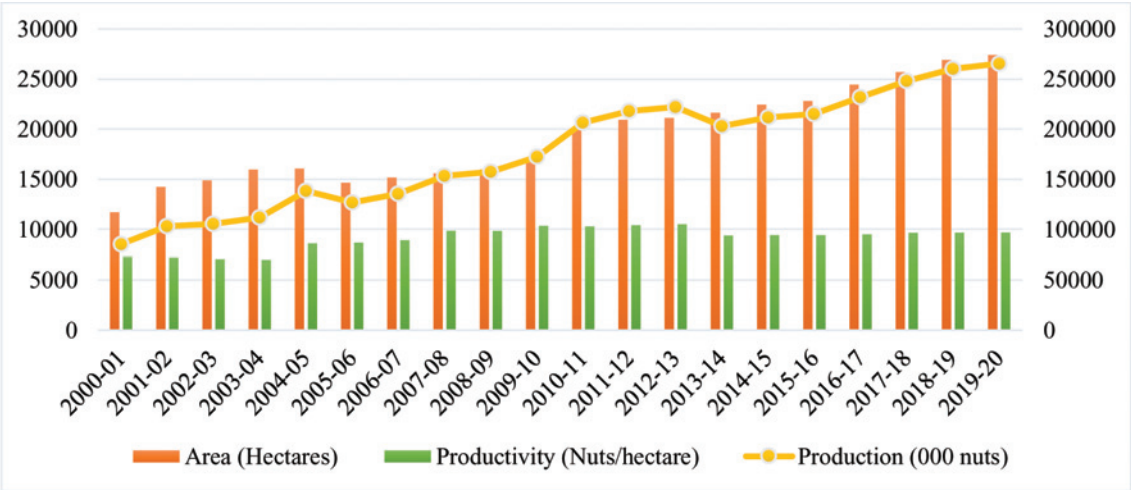


**Fig.1.** Area, production & productivity of coconut in Gujarat (2000 - 2020)

**A) Compound annual growth rate**

CAGR was estimated to study the percentage increase or decrease in the area, production and yield parameters. The following exponential type of function was used.

$Y = ab^t.e$

Where, Y = dependent variable for which growth was estimated i.e. area (ha), production (lakh Nuts) and Yield (Nuts /ha).

a = intercept or constant

b = regression/trend coefficient

t = periods in years (1, 2, 3…n)

The value of CAGR was worked out as follows:

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

The standard error of the regression coefficient (SE(b)) was computed using:

$$SE(b) = \sqrt{\frac{MSE}{\Sigma_{(t-T)}{}^2}}$$

Where

MSE = mean square error of the regression

t = time variable

T= mean of the time variable

The t-statistic used to test the significance of the growth rate was calculated as:

$$t = \frac{b}{SE(b)}$$

The calculated t-value was compared with the tabulated t-value at 1%, 5%, and 10% levels of significance. Based on this test, the growth rates were classified as significant or non-significant.

**B) Instability analyses**

Instability in area, production, productivity of Coconut was examined by using two different measures of instability such as Coefficient of Variation and Cuddy-Della Valle Index. A low value of this index indicates low instability in area, production, productivity and vice-versa. Coefficient of Variation (CV) is the simplest measure of instability. CV can be calculated as follows:

$$CV = (\text{StandardDeviation} / \text{Mean}) * 100$$

The Cuddy-Della Valle Index is as follow:

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

Where, CV is the Coefficient of Variation in per cent, $R^2$ is the coefficient of determination from a time trend regression adjusted for its degrees of freedom.

The ranges of CDVI are given as follows

- Low instability = 0 to 15
- Medium instability = 15 to 30
- High instability = 30 and above

**C) Decomposition analysis**

Decomposition analysis estimated the effect of area and yield on production using decomposition analysis (Narmadha *et.al.,* 2022). To estimate the contribution of area, production and interaction of the two in total production, decomposition analysis has been done as given below:

$P_0 = A_0 * Y_0 \text{ and } P_n = A_n * Y_n$……..(eqn. 1)

Whereas, $A_0$ and $A_n$ represent the area, and $Y_0$ and $Y_n$ represent the yield in the base year and nth year, respectively

$P_n - P_0 = \Delta P, A_n - A_0 = \Delta A$ and
$Y_n - Y_0 = \Delta Y$…….(eqn.2)

Upon simplification of equations (1) and (2), it could be written:

$P_0 + \Delta P_n = (A_0 + \Delta A_n)(Y_0 + \Delta Y_n)$
$\Delta P_n = (A_0 + \Delta A_n)(Y_0 + \Delta Y_n) - P_0$

Substituting P0 from (1) rearranging the terms gives:

$\Delta P_n = (A_0 \Delta Y_n) + (Y_0 \Delta A_n) + (\Delta A_n \Delta Y_n)$

Production change = area effect + yield effect +interaction effect

Thus, the total change in production can be decomposed into three components viz., area effect, yield effect and the interaction effect due to change in yield and area from the base period.

**Results and Discussion**

**Compound annual growth rates (CAGR) of Area, production, and yield**

The Table 2 presents the compound annual growth rates (CAGR) of area, production, and yield of coconut across major districts in Gujarat. The growth rates of coconut cultivation in the state show significant variation across districts and time periods, reflecting different regional challenges and opportunities in coconut farming.

In terms of area, Kutch recorded the highest growth rate in both periods, with a 1 percent significant, 11.43% growth in Period I and 2.32% growth in Period II. This trend highlights Kutch's consistent expansion in coconut cultivation, likely driven by favourable climatic conditions and successful agricultural practices (Lathika and Kumar, 2005). Meanwhile, Valasad and Navasari showed a negative growth rate in Period I (-3.47% and 3.90%, respectively), but both districts saw an improvement in Period II, with growth rates of 1.84% and 5.46%, respectively, reflecting the positive impact of government schemes and increased adoption of coconut farming. Surat displayed a significant growth rate of 11.97% in Period I but a decline to 3.30% in Period II. Similarly, both Bhavnagar and Porbandar exhibited fluctuating trends, with high growth rates

in Period I followed by declines in Period II. This decrease is attributed to challenges like urban expansion and labor shortages (Elias, 2015) and other socio-economic changes in these regions.

**Table 2. Growth rate (%) of area, production and yield of coconut for major districts in Gujarat**

| Districts | Area (000 ha) | | | Production (lakh nuts) | | | Yield (nuts ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled |
| Valasad | -3.47$^{NS}$ | 1.84* | -0.24$^{NS}$ | 5.27$^{NS}$ | -0.48 $^{NS}$ | 1.38 $^{NS}$ | 9.05** | -2.28** | 1.62*** |
| Bhavanagar | 3.97* | -0.51* | 0.99* | 8.60* | -0.96 $^{NS}$ | 2.59* | 4.45* | -0.46** | 1.58* |
| Porbandhar | 3.15* | 0.76* | 2.45* | 13.07** | 1.37* | 3.42* | 9.61 $^{NS}$ | 0.61* | 0.94* |
| Kutch | 11.43* | 2.32* | 5.50* | 11.77* | 9.45* | 8.71* | 0.31 $^{NS}$ | 6.97* | 3.04* |
| Surat | 11.97* | 3.30** | -1.15$^{NS}$ | -20.06* | 3.65** | -3.17 $^{NS}$ | -9.20** | 0.34 $^{NS}$ | -2.04*** |
| Navasari | 3.90* | 5.46* | 5.15* | 3.60*** | 4.61** | 6.59 $^{NS}$ | -0.29$^{NS}$ | -0.80 $^{NS}$ | 1.37*** |
| Junagadh | 4.00* | -9.36* | 1.39$^{NS}$ | 7.33** | -10.68* | 3.73** | 3.20 $^{NS}$ | -1.46** | 2.31* |
| Gujarat | 2.44** | 3.65* | 4.10* | 7.34* | 2.74* | 5.80* | 4.78* | -0.87** | 1.63* |

**Note: ***&** and *** denote significance at 1 per cent, 5 per cent and 10 percent levels, respectively and NS-Non significant

**Source**: Author's calculation based on data from CBD (2020).

Coconut production trends closely followed the growth in area, with Kutch maintaining high and significant at 1 percent growth (11.77% in Period I, 9.45% in Period II, and 8.71% overall). Similarly, Kutch showed impressive yield growth, particularly in Period II, with a growth rate of 6.97%, due to improved agronomic practices and favourable climate conditions. Porbandhar and Navasari exhibited positive growth in Period II for production but declines from Period I, with production growth rates of 13.07% and 1.37% in Period I, and 3.60% and 4.61% in Period II, respectively. Valasad and Bhavanagar depicting the negative growth rate of yield in period II (2.28 % and 0.46%) reflecting the decrease in production of coconuts in same period II ( 0.48 % and 0.96 %). This drop is due to erratic rainfall and pest infestations that have affected these districts' productivity (Preethi *et al.*, 2018). While Porbandhar's yield growth rate remained relatively stable, with 9.61% in Period I and 0.61% in Period II, Navasari faced negative growth in yield in Period II, with rates of -0.29% and -0.80%, respectively. Surat experienced a dramatic decline in production during Period I (-20.06%), followed by a recovery in Period II, with an increase in yield (3.65%). This volatility could be due to the long gestation period of coconut crops, where the impact of changes in cultivation practices and climate is more evident after several years.

Junagadh showed positive growth in Period I for area, production, and yield (4.00%, 7.33%, and 3.20%, respectively). However, the division of the district into Gir Somnath and Junagadh, with the major coconut cultivation blocks now in Somnath, led to a sharp decline in growth in Period II, with growth rates dropping to -9.36%, -10.68%, and -1.46%, respectively. This restructuring had a significant impact on coconut production and productivity in Junagadh.

Gujarat as a whole exhibited a steady increase in coconut cultivation, with growth rates of 2.44% in Period I, 3.65% in Period II, and a pooled growth rate of 4.10%. This overall growth can be attributed to the implementation of the Coconut Development Board's (CDB) area expansion schemes and subsidies for establishing small coconut nurseries, which have contributed to the spread of coconut farming across key districts (CDB, 2020; Kalidas et al., 2020). The positive production growth, with a significant 7.34% growth in Period I, 2.74% in Period II, and a pooled growth rate of 5.80%. However, yield growth showed a decline in Period II (-0.87%), although it remained positive over the pooled period (1.63%). This suggests that while production is increasing, yield improvements are not as consistent, highlighting the need for better productivity management.

Coconut cultivation in Gujarat is expanding however the state faces significant challenges in achieving

consistent yield growth. Kutch and Porbandhar show promising results due to favourable conditions and effective farming techniques, but districts like Surat and Junagadh demonstrate volatility. To sustain growth, there is a clear need for improved agronomic practices, better pest and disease management, and more stable climate conditions. Additionally, the promotion of climate-resilient coconut varieties for mitigating fluctuations in yield and ensuring long-term sustainability in coconut farming.

**Instability index (%) of area, production and yield**

The results in Table 3 highlights the instability in coconut area, production, and yield across different districts in Gujarat to assess the variation in growth, it is essential to examine the instability of these variables interpreting the past data. Overall, Gujarat as a state exhibited low instability from 2000-01 to 2019-20, showing no major adverse trends in area, production, and yield, indicating relatively stable coconut cultivation practices during this period.

When comparing the instability in coconut area, Porbandhar stands out with the lowest instability, with index of 2.57% in Period I and 0.64% in Period II. This indicates minimal fluctuations in area over time. Similarly, Bhavnagar, Navsari, and Kutch also demonstrated relatively low instability, with area variations of 6.21%, 2.14%, and 3.19% in Period I, and 2.74%, 5.79%, and 1.81% in Period II, respectively. These districts have maintained stable coconut farming practices, resulting in less fluctuation in area (Narmadha *et al.*, 2022).

**Table3. Instability index (%) of area, production and yield of coconut for major districts in Gujarat**

| Districts | Area (000 ha) | | | Production (lakh nuts) | | | Yield (nuts ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled |
| Valasad | 17.33 | 3.42 | 14.72 | 40.40 | 5.43 | 15.08 | 24.88 | 6.67 | 18.25 |
| Bhavanagar | 6.21 | 2.74 | 7.87 | 5.76 | 7.63 | 14.70 | 8.72 | 4.90 | 9.75 |
| Porbandhar | 2.57 | 0.64 | 3.74 | 20.63 | 1.06 | 6.50 | 24.80 | 0.94 | 5.37 |
| Kutch | 3.19 | 1.81 | 8.43 | 2.85 | 11.10 | 14.85 | 1.56 | 10.43 | 14.44 |
| Surat | 30.05 | 8.88 | 32.62 | 46.68 | 9.34 | 63.48 | 44.86 | 3.26 | 42.74 |
| Navasari | 2.14 | 5.79 | 7.41 | 15.04 | 12.33 | 16.40 | 17.18 | 10.99 | 15.26 |
| Junagadh | 5.05 | 23.51 | 33.86 | 20.55 | 23.01 | 43.22 | 27.35 | 4.46 | 13.70 |
| Gujarat | 6.24 | 2.24 | 6.26 | 4.89 | 5.03 | 6.39 | 4.99 | 3.50 | 8.86 |

In contrast, Surat and Valsad exhibited higher instability in area, with values of 17.33% and 30.05% in Period I, respectively, with Surat facing the most significant challenges. These high instability indices suggest that these districts may require targeted interventions, including the adoption of advanced agronomic practices, promoting climate-resilient coconut varieties, and improving market stability, to reduce the variability in cultivation.

In terms of production and yield, the instability indices were generally lower in Period II compared to Period I in districts like Porbandhar, Kutch, Surat, and Navsari. This suggests that these regions experienced fewer fluctuations in production and yield during the later period, possibly due to improved management practices, technological adoption, and relatively stable climatic conditions, which have been reported to reduce variability in agricultural output in similar growth and instability studies.

Junagadh, however, showed considerable variability in both area and production in Period II, with instability indices of 23.51% and 23.01%, respectively. Despite this, yield was relatively stable in Period II (4.46%). This fluctuation can be attributed to the division of the district into Gir Somnath and Junagadh, with major coconut cultivation blocks now located in Somnath. The structural changes within the district have contributed to these variations in coconut cultivation patterns.

Overall, the analysis indicates that coconut cultivation in Gujarat displayed greater stability in the second period (2010-2019) compared to the first period (2000-2009). The results suggest a positive trend in area, production, and yield growth across the districts, with

reduced effects from climate fluctuations and pest outbreaks during the period II. This improvement in stability likely reflects better agricultural practices, more resilient coconut varieties, and possibly the impact of government interventions aimed at improving the coconut sector in Gujarat.

**Area effect, yield effect, and interaction effect of coconut production**

Coconut production is influenced by several factors, including the area under cultivation, yield per hectare, and the interaction between these two variables. A decomposition analysis of the data from different districts in Gujarat, across two distinct periods (2000-01 to 2009-10 and 2010-11 to 2019-20), provide insights on how these factors have impacted over time. The analysis of area, production, and yield in selected districts of Gujarat explains the growth patterns, yet it remains difficult to pinpoint whether area expansion or productivity changes have had a significant impact on the overall fluctuations in coconut production. This is why a decomposition analysis is crucial, as it provides insights into the percentage contributions of area, yield, and their interactions on coconut production in the major coconut cultivated districts and Gujarat as a whole, as shown in Table 4.

The analysis indicates a clear trend in production changes. The area effect has been positive in most districts throughout both periods, except for Valasad during the period I. The yield effect has also been positive in most districts, with exceptions in Valasad and Porbhandar in the second and first periods, respectively. The interaction effect is positive in all districts, although Junagadh and Bhavnagar exhibit a negative interaction effect in the second period. Valasad, Porbhandar, and Surat show negative interaction effects in the first period, with Surat also showing a negative impact over the overall period indicating that both area and production have negatively impacted the production of coconut in Gujarat.

**Table 4. Impact of area and yield on coconut production in Gujarat**

| Districts | Area effect | | | Yield effect | | | Interaction effect | | |
|---|---|---|---|---|---|---|---|---|---|
| | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled | Period I (2000-01 to 2009-10) | Period II (2010-11 to 2019-20) | Pooled |
| Valasad | -0.25 | 345.66 | 10.33 | 100.67 | -388.63 | 76.78 | -0.42 | 57.03 | 12.89 |
| Bhavanagar | 41.92 | 49.78 | 54.38 | 39.97 | 53.11 | 33.03 | 18.11 | -2.89 | 12.59 |
| Porbandhar | 101.72 | 57.40 | 84.37 | -1.35 | 39.30 | 10.57 | -0.38 | 3.30 | 5.06 |
| Kutch | 91.17 | 18.20 | 44.74 | 3.54 | 68.72 | 18.58 | 5.29 | 13.09 | 36.68 |
| Surat | 62.11 | 93.76 | 27.15 | 77.86 | 3.77 | 89.93 | -39.97 | 2.46 | -17.09 |
| Navasari | 61.71 | 76.48 | 58.36 | 28.01 | 13.82 | 17.79 | 10.28 | 9.70 | 23.84 |
| Junagadh | 46.10 | 88.12 | 46.62 | 32.96 | 20.41 | 38.50 | 20.94 | -8.53 | 14.88 |
| Gujarat | 41.54 | 127.96 | 63.49 | 41.05 | -20.51 | 15.60 | 17.41 | -7.45 | 20.90 |

The area effect, which reflects the contribution of the cultivated land to coconut production, shows a positive trend in most districts. Bhavnagar and Kutch recorded notable increases in the area effect during the pooled period, with Bhavnagar seeing a 54.38% increase and Kutch 44.74%. This suggests successful expansion of coconut cultivation in these districts, contributing positively to production. Bhavnagar's positive interaction effect (12.59%) further indicates that both area and yield improvements are working together to boost production. On the other hand, Valasad's negative interaction effect (-0.42%) suggests that the decline in area was not offset by yield increases, underscoring the importance of addressing both area and yield in coconut production strategies.

On a state level, Gujarat's area effect increased significantly from 41.54% to 127.96%, whereas the yield effect decreased from 41.05% to -20.51%, suggesting that while the area under cultivation increased, the yield did not grow at a proportional rate.These changes reflect the developmental activities that took place during the period, positively impacting area expansion. Similar findings have been reported in decomposition studies of coconut production, where expansion in cultivated area contributed more to production growth than improvements in yield, indicating that output growth

in many regions is primarily driven by area expansion rather than productivity gains (Kalidas *et al.*,2020& Narmadha *et al.,* 2022).

## Conclusion

Coconut cultivation in Gujarat reveals significant growth in both area and production, particularly in non-traditional coconut-growing districts like Kutch, Porbandhar, and Navasari. However, despite the expansion of cultivation, yield improvements remain inconsistent across districts, with fluctuations driven by factors such as climatic conditions, agronomic practices, and pest outbreaks. The decomposition analysis underscores the importance of both area expansion and yield improvement in enhancing coconut production. The findings suggest that while area expansion plays a critical role in increasing production, yield enhancement through better farming practices and pest management is essential for sustainable growth. The study highlights the need for targeted interventions to stabilize production and enhance profitability in coconut farming.Promoting climate-resilient coconut varieties along with improved agronomic practices and support for yield improvement through quality seedlings and farmer training programs

## Limitations of the Study

This study has certain limitations viz., the analysis is based entirely on secondary data obtained from sources such as the Coconut Development Board and the Department of Horticulture, Government of Gujarat. Hence, the accuracy of the results depends on the reliability and consistency of the published data. The study focuses only on quantitative indicators such as area, production, and yield, and does not incorporate qualitative factors which may also influence coconut productivity.

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