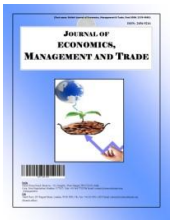

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Growth, Instability and Decomposition Analysis of Coconut in India and Tamil Nadu, Western Tamil Nadu, India: A Time Series Comparative Approach

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Authors' contributions

This work was carried out in collaboration among all authors. Author KK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KM managed the analyses of the study. Author KA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was undertaken to know the growth rate, instability, and contribution of area and yield on the production of coconut. The study was based on the secondary data for the period of 19 years (2001 – 2019) for India as well as Tamil Nadu. India is the leading producer of coconut globally 21.38 billion nuts and in the country, Tamil Nadu has the major share in area and production with 5.31 billion nuts. The pace of agricultural development of the country can be estimated through compound annual growth rate, instability is measured using Coppocks instability index and contribution of area and yield on production is studied using decomposition analysis. Results revealed that coconut growth is found to be positive in India as well as in Tamil Nadu, the production of coconut in the country is significantly positive (0.74 percent), but in the state, it is in

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decline trend (2.48 percent). The trend of productivity seems positive and similar at both the country and state level. Instability index is higher in terms of area (12.71 percent) than production (2.86 percent) and productivity (2.89 percent). Area effect was most responsible (138.2 percent and 98.3 percent) for the production of coconut than yield effect in both the country as well as the state.

Keywords: Area; interaction; instability; production; productivity.

1. INTRODUCTION

Agriculture has been the backbone of the Indian economy since immemorial. India has 2.40 percent of the global area, which supports 16.00 percent of the world's human population and 17.00 percent of cattle population (Food and Agriculture Organization [1]). Coconut (*Cocos nucifera*) provides food security and livelihood in large size of the population in the world particularly in Asia-Pacific countries. As a versatile nature of the crop and the multifaceted uses of its products, coconut is eulogized as Kalpavriksha (Tree of Heaven). Coconut is grown in more than 25 countries throughout the tropics and subtropics, with an annual production of around 67 billion nuts from an area of 11.906 million ha and the average productivity of the crop is 5638 nuts per ha (Coconut Development Board [2]). In India, 15 million people are directly and indirectly dependent on the coconut sector in areas of cultivation, processing, and trading activities. With an annual production of around 21,384 million nuts, coconut contribution to the nation's GDP is about 34,100 crores rupees (Press Information Bureau, 2019 [3]). India with the rich biodiversity of coconut is the largest producer with a 33.02 percent share or 22167 million nuts of the world's largest production of 67128 million nuts (Coconut Development Board). There has been a drastic increase in area, production, and productivity of coconut during the last 19 years is shown in Chart 1, but there was a steep reduction in production and productivity last year (2018-19) due to cyclone attacks in the coastal region and some major pest and diseases.

In state wise, Tamil Nadu stands second in production with 24.84 percent (5.31 billion nuts) and third in the area, of about 4.37 lakh hectares (CDB, 2019). The details are given in the Chart 2. Jaganath [4] in his study concluded that the yield effect was most responsible for production of cotton in all districts of Amravati division as a whole. During overall period, the area effect was most responsible for increasing soybean production in Amravati division i.e. 46.98 per cent with positive yield and interaction effect i.e. 1.91 and 51.41 per cent respectively.

Neethu [5] analyzed the "area, production, and productivity of cassava, using semi-log function revealed that there was a significant decline in an area with a compound annual growth rate of 1.37%, the non-significant decline in production by -0.02% and a significant increase in productivity by 1.30%. Cuddy-Della Valle index provides the best estimates and instability was found to be more in productivity (4.04%)". Kalpana [6] studied the time series data on area, production and productivity of jute in India and concluded that jute production in the country was growing with a compound growth rate of 1.30 percent per annum. Nisha et al. [7] in their study indicated that all the selected three aspects (i.e. area, production, and yield) have shown positive growth rates in Haryana while in case of India, positive growth rates were observed for only area and production except in Period- IV (1996-97 to 2005-06).

Coconut Production in India has jumped from 12678.4 million nuts in 2000-01 to 21384.33 in 2018-19, similarly in Tamil Nadu the production increases from 3192 million nuts in 2000-01 to 5311 million nuts in 2018-19. With the tremendous efforts of stakeholders, as well as the steps taken by Central government through Coconut Development Board, the area, production and productivity of coconut was increased. Coconut industry is highly competitive because countries like Indonesia and Philippines were marketing many coconut based products, but due to higher local demand, India is still in nascent stage in coconut processing. This leads to less remunerative price to the coconut farmers. Hence this study focus on analyzing the trend and growth variability of area, production, and yield of coconut in India, Tamil Nadu as well as Western Tamil Nadu. Also the paper focuses on the effect of area and yield of coconut on the production of coconut.

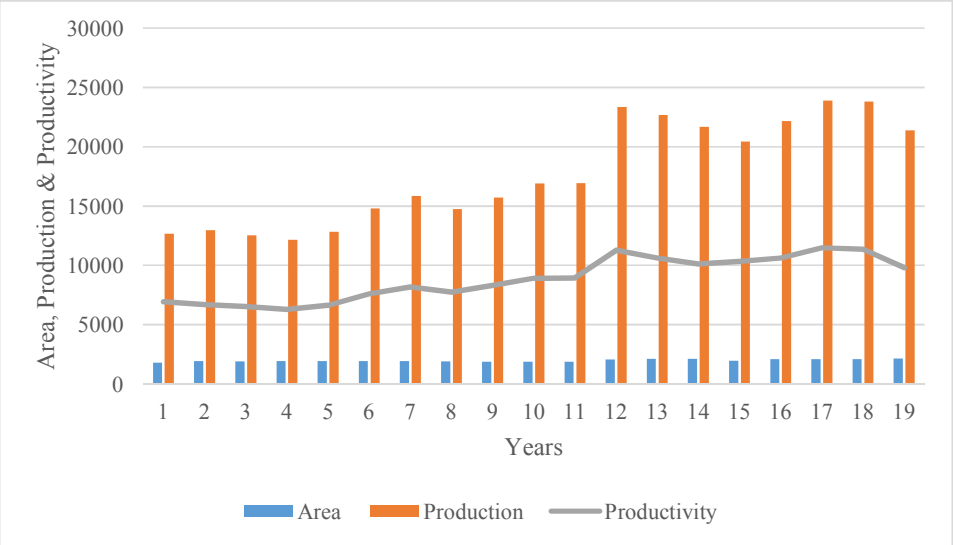

Chart 1. Area, production & productivity of coconut in India (2001 - 2019)
(Source: Coconut Development Board, 2019)

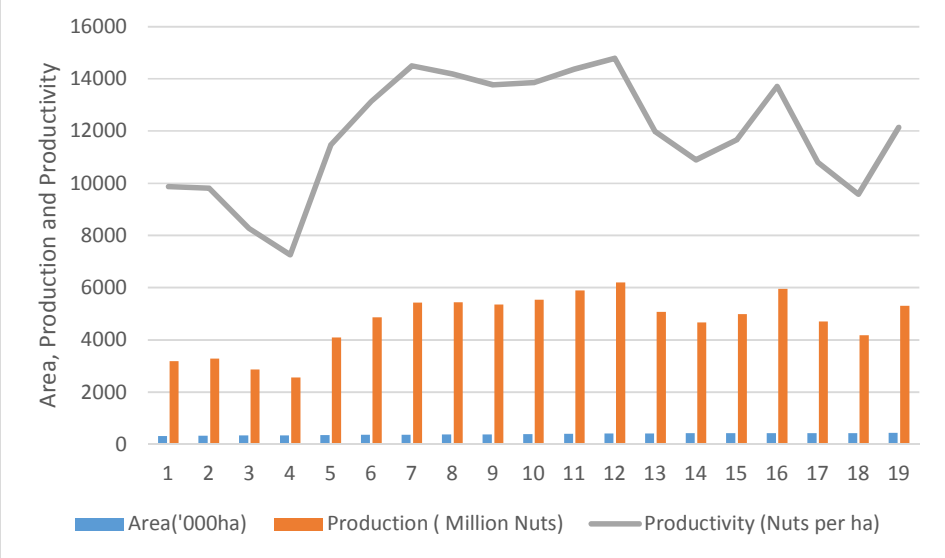

Chart 2. Area, production & productivity of coconut in Tamil Nadu (2001 - 2019)
(Source: Coconut Development Board, 2019)

2. METHODOLOGY

The data regarding the area, production, and productivity of coconut in India, Tamil Nadu and Western Tamil Nadu were collected from the Coconut Development Board for 19 years (2001-2019). The whole period of study has been divided into two periods for normalization of the study. The data collected were analyzed using compound growth rates, instability index (Coppock's Instability) and decomposition model of area, production, and productivity of coconut estimated to examine the fluctuation.

2.1 Compound Growth Rate Analysis

Growth rate are worked out to examine the tendency of variables to increase, decrease, or remain stagnant over the period. Lathika [8] used CAGR to estimate the area, production and productivity of various crops in India. It also indicates the magnitude of the rate of change in the variable under consideration per unit of time.

The rate of change of "Yt" per unit of time expressed as a function of the magnitude of "Yt" itself is usually termed as the compound growth rate (CAGR) which can be expressed mathematically as:

$$Y = ab^t e$$

In Logarithm, it becomes log y = log a = t log b + error, it can be written as Ln (Y) = $Ln(b_o)+b_1t$.

Where t is the time variable, Y variable for which growth is calculated and b1 is regression coefficient of t on Y.

The above expression is multiplied by 100 to give the compound growth rate of "Y" in percentage term. There are many alternative forms of growth function viz., linear, exponential, modified exponential, Cobb-Douglas, etc. which have been developed and used by the researcher. The mathematical form of log-linear function (also known as an exponential function) is as follows:

$$CAGR(\%) = (Antilog\ b_1\text{-}1) \times 100$$

2.2 Instability Analysis in Area, Production and Productivity

Instability means deviation from the "trend". In agriculture instability is an inherent characteristic due to weather conditions, seasonal variation in area, yield, and production of crops from year to year. Instability analysis can be studied using three measures of instability such as Coefficient of Variation, Cuddy-Della Valle index, and Coppock's index. Kamalkar [9] analyzed the instability using Coppock's index. Hence, in this study, Instability has been studied using Coppock's index:

$$m = \frac{\varepsilon log P_{t+1} - log P_t}{n}$$

$$V\ Log = \left(\frac{\left(\varepsilon log P_{t+1} - log P_t - m\right)^2}{m}\right.$$

$$Coppocks\ Index = (Antilog)\sqrt{(V \log -1)} \times 100$$

Where,

X_t = Area / Production / Yield

t = Number of years

m = Mean of the difference between the logs of X_{t+1}, X_t

Log V = Logarithmic variation of the series

Coppock's instability index is a close approximation of the average year to-year percentage variation adjusted for trend and the advantage is that it measures the instability in relation to the trend in prices. A higher numerical value for the index represents greater instability.

2.3 Decomposition Analysis

Jamal [10] estimated the effect of area and yield on production using decomposition analysis. To estimate the contribution of area, production and interaction of the two in total production, decomposition analysis has been done as given below:

$$P = A0\ (Yn - Y0) + Y0(An - A0) + \Delta A \Delta Y$$

$$I = \left[\frac{Y \Delta A}{P}\right]\left[\frac{A \Delta Y}{P}\right]\left[\frac{\Delta A \Delta Y}{P}\right]$$

Where,

P = Change in Production
A0 = Area in the base year
An = Area in the current year
Y0 = Yield in the base year
Yn = Yield in the current year
ΔA = Change in Area (An-A0)
ΔY = Change in Yield (Yn-Y0)

3. RESULTS AND DISCUSSION

3.1 Estimation of Growth in Area, Production and Productivity

The compound growth rate equation was fitted to assess the growth in the area, production, and productivity of coconut in India, Tamil Nadu, and Western Tamil Nadu. Data pertaining to the area, production and productivity were collected for a period of 19 years (2001 -2019) and divided into two sub-periods, sub-period 1 (2001 -2010) and sub-period 2 (2011-2019). The data has been analyzed using linear compound annual growth rate formula and the results are given in Table 1.

The total area under coconut cultivation in India during the year 2001 was 18.24 lakh hectare and increased to 21.79 lakh hectare in 2018-19. The growth of the area in India during the first decade was slowly increasing with 0.10 percent and in the second decade, there was a steep increase (0.87 percent). Production was higher (3.51 percent) during the first sub-period and it got diminished in the second decade to 1.88 percent. In terms of productivity growth was higher, i.e., 3.41 percent during sub-period one and decreased to 1 percent during second sub-

period. Due to adoption of Laying out of Demonstration Plot scheme by Coconut Development Board, farmers started cultivating coconuts, hence the area increased at faster pace in the second period.

In Tamil Nadu, growth in the area was recorded as 2.26 percent during the first sub-period and declined to 0.74 percent during the second sub-period. Proper awareness about the schemes were not implemented in Tamil Nadu, hence the growth in area was very less compared to India as a whole. A similar trend was recorded in the production of coconut, which was higher during the first sub-period, i.e., 8.87 percent and the growth of coconut production was suddenly reduced to 2.48 percent during the second sub-period. The growth in productivity of coconut in Tamil Nadu was also higher, i.e., 6.46 percent during the first period and again a steady decline to 3.46 percent per annum during the second sub-period. Due to sudden pest and disease incidence, natural calamities like cyclone the production and productivity curve in Tamil Nadu shows negative growth (2.47 percent) in second period.

In Western Tamil Nadu, the compound growth in the area of coconut cultivation was recorded positive, i.e., 2.89 percent in the first decade and got cut to 1.81 percent during the second period of the study. Similarly, the growth in the production of coconut was peak in sub-period one and recorded a negative growth during sub-period 2. On the other hand, the productivity of coconut followed a similar trend and recorded positive (4.81 percent) in sub-period one and found negative (6.89 percent) in sub-period 2.The pattern of Tamil Nadu followed in Western Tamil Nadu region also. Production and Productivity during the second period shows negative growth was mainly due to sudden pests and disease incidence.

Overall the growth of the area was recorded positive in India, Tamil Nadu, and Western Tamil Nadu. Western Tamil Nadu recorded higher growth in the area followed by Tamil Nadu and India. Production growth in the country was higher in India and in the Western region recorded positive, whereas it was recorded negative growth. In terms of production, India's annual production grows at 4.23 percent per annum, Western Tamil Nadu growth pace was found at 3.38 percent and in Tamil Nadu, it decreases at 3.20 percent. The productivity of coconut in India also grows at 3.46 percent compared to 1.10 percent in Tamil Nadu and it was recorded as negative in Western Tamil Nadu.

3.2 Instability Analysis of Coconut in India, Tamil Nadu and Western Tamil Nadu

The following Table 2 shows the Coppock's instability index of India, Tamil Nadu, and Western Tamil Nadu.

Table 1. Growth rate of area, production and of productivity of coconut in India, Tamil Nadu & Western Tamil Nadu

Period	Area			Production			Productivity		
	India	TN	WTN	India	TN	WTN	India	TN	WTN
Sub-period - I	0.10	2.26	2.89	3.51	8.87	8.87	3.41	6.46	4.81
Sub-period - II	0.87	0.74	1.81	1.88	-2.48	-2.48	1.00	-3.20	-6.89
Overall period	0.74	1.73	2.70	4.23	-3.20	3.38	3.46	1.10	-.057

(Source: CDB, 2019)

Table 2. Instability analysis of area, production and of productivity of coconut in India, Tamil Nadu & Western Tamil Nadu

Period	Area			Production			Productivity		
	India	TN	WTN	India	TN	WTN	India	TN	WTN
Sub -period - I	0.83	0.38	2.89	2.56	7.29	8.87	2.57	7.42	4.81
Sub -period - II	1.90	0.31	1.81	4.87	5.73	-2.48	4.28	6.67	-6.89
Overall period	12.71	8.83	2.70	3.86	6.95	3.38	2.89	4.82	-.057

The instability in the area under coconut cultivation in India was lower (0.83 percent) in the first decade than the second decade (1.90 percent), and in Tamil Nadu, it was recorded that sub-period 1 was instability 0.31 percent than sub-period 1. In Western Tamil Nadu, the variability was higher in sub-period 1 (2.89 percent) than sub-period 2 (1.81 percent).

In India, the production instability index was recorded higher during sub-period 2 (4.87 percent) than the sub-period 1 (2.56 percent). But in Tamil Nadu & Western Tamil Nadu, the instability index was higher 7.29 & 8.87 percent respectively in sub-period 1, whereas in sub-period two, it was found 5.73 percent in Tamil Nadu, but the variability was negative in sub-period 2. Instability index on productivity was higher (428 percent) in the second decade in India, and in Tamil Nadu and Western Tamil Nadu, it was higher during sub-period 1. In Western Tamil Nadu, the variability was negative (6.89 percent) in sub-period 2, whereas it was found positive in Tamil Nadu.

Coppock's Instability Index shows that the instability in the overall period 2001-2019 was higher in India and Tamil Nadu 12.71 percent and 8.83 percent, respectively. Meanwhile, in Western Tamil Nadu, the production instability was found to be higher 6.95 percent. There seemed a positive trend in the area during the period 2011-2019 in Tamil Nadu and Western Tamil Nadu, where the instability was low among the period with 0.31 & 1.81 percent respectively. In India, the production instability during the overall period was 3.86 percent and Tamil Nadu recorded the instability of 6.95 percent. In terms of productivity instability, it was highly volatile during 2011-2019 for India (4.28 percent) and 2001-2010 for Tamil Nadu (7.42 percent). Overall the yield uncertainty was recorded as 2.89 percent for India and 4.82 percent for Tamil Nadu. But in Western Tamil Nadu, there was recorded negative instability (0.057 percent). The instability in production and productivity was mainly due to climate change, natural disasters, and sudden outbreak of pest and disease incidence in the state as well as the country.

3.3 Decomposition of Production Variability in Coconut

Decomposition analysis was used to study the contribution of area, productivity, and their interaction effects on the variability of production. The decomposition of production variability into its different components was done for the two sub-periods for coconut production, and the results are shown in Table 3.

During sub-period 1, the area effect of India was mostly, (i.e., 188.4 percent responsible) for the production variability, and in the second period, it gets reduced to 89.1 percent of production. But in the case of productivity, sub-period 2 was most responsible, i.e., 26.8 percent variability in production than sub-period 1 (6.8 percent). The interaction effect of both area and productivity on production was 13.3 percent in India during sub-period 1 and 7.5 percent during sub-period 2.Similarly, in Tamil Nadu, the area effect in the sub-period 1 was highly positive on the yield to 354.7 percent, and it got declined in the sub-period 2. Whereas the productivity effect on production during the sub-period 1 & 2 was positive with 6.5 and 3.7 percent. The interaction effect in Tamil Nadu on production was highly positive in the sub-period 1 and it was negative.

Area and productivity effect on the production of coconut in Western Tamil Nadu follows a similar pattern of Tamil Nadu. During the sub-period one, the area effect and productivity effect on coconut production was 13 percent and 6.5 percent during sub-period 1and it seemed a negative effect during sub-period 2 with 477.6 on area effect. The productivity effect was positive in sub-period 2. The interaction effect on the production of coconut was positive 4.4 percent during sub-period one and it was negative in sub-period 2.

Table 3. Decomposition of production variability in coconut

Period	Area effect (%)			Productivity effect (%)			Interaction effect (%)		
	India	TN	WTN	India	TN	WTN	India	TN	WTN
Sub -period - I	188.4	354.7	13.0	6.8	6.5	3.7	7.5	84.4	4.4
Sub -period – II	89.1	-237.0	-477.6	26.8	3.6	3.5	13.3	-15.7	-76.7
Overall period	138.2	98.3	-73.1	14.6	5.0	3.5	26.9	34.6	-42.9

Overall (2001-2019) area effect was high in India with 138.2 percent and yield effect was 14.6 percent and interaction effect on production was 26.9 percent. In the Tamil Nadu area effect on production was 98.3 percent during 2001-2019 and the yield effect on production was 5 percent and the interaction effect was 34.6 percent. Whereas in Western Tamil Nadu, the area effect was negative (73.1 percent) and the yield effect was 3.5 percent. The interaction effect was also recorded negative in Western Tamil Nadu. Thus both area and productivity influence the production of coconut in the country as well as the state, whereas only productivity effect was the major reason for coconut production in Western Tamil Nadu.

4. CONCLUSION AND RECOMMENDATIONS

Coconut is a multifaceted crop with various uses and a part of daily consumption in many parts of the world with Rs.30000 crore contributions to the economy of India. The growth of the area is in a positive trend, but the production shows a declining trend over the years in the Tamil Nadu. Various reasons affect the production of coconut like climate, natural disaster, the emergence of pest and disease incidence. There is a high variability in the area of coconut cultivation in the country over the years and production variability is high in Tamil Nadu. The area effect of the yield of coconut was highly pronounced in India and Tamil Nadu. Percent contribution of interaction effect (both area and yield) is more responsible for coconut production.

Based on findings from the study, measures to be taken by the central and State governments to improve coconut production and its contribution to the nation's economy include:

1. Area effect on production of coconut is high, hence government should intervene in this regard to improve the area of coconut cultivation by adoption the Laying out of Demonstration Scheme (LoDP).
2. Introduce new varieties in coconut with high yield, drought tolerance, pests and disease resistance.
3. Formulation and adoption of Good Agricultural Practices standards for coconut cultivation by the concerned authorities which helps to improve the production and productivity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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