# Study on structural break analysis in Indian coconut (*Cocos nucifera*) production

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### Abstract

Coconut (*Cocos Nucifera.L*) is distributed across the tropical belt in Asia, East Africa, and America. The CGR and structural break analysis were employed to examine the growth rates and multiple break period respectively. The results show the structural break year of area, production and productivity for major states in India was found after 1996, 2005 and 2011 which showed the impact of WTO, NHM and establishment. Based on structural break, growth rate of area, production and yield of coconut was estimated using compound growth rate. Coconut production and productivity increased at a rapid rate in Karnataka, Tamil Nadu, and Andhra Pradesh. It suggests that these states, which are India's top producers of coconuts, have a bright future in the industry. Kerala's negative growth rate shows that other crops in the state are only little expanding their production areas relative to coconuts. Though the Coconut Development Board established a Technology Mission on Coconut, yield of coconut has not significantly increased. Therefore, it is suggested that improved coconut cultivation technology should be used.

**Key words:** Coconut, Growth rate, Structural break and TMoC

Coconut (Cocos Nucifera.L) is distributed across the tropical belt in Asia, East Africa, and America. The top coconut producers, accounted to 79% of the global production. Indonesia, India, and the Philippines being main producers. Indonesia, the Philippines, India, Brazil, Sri Lanka, Thailand, Vietnam, Malaysia, Papua New Guinea, and Tanzania are other countries producing coconut (Elias, 2015). Among these nations, Indian coconut production has shown an upward trend over time, as seen by an increase in coconut area from 1.82 to 2.15 million ha, production of 12.67 to 22.96 billion nuts, with average productivity of 6,951 to 10,668 nuts/ha between 2000-01 and 2020-21. (CDB, 2022).

In India, Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh, account for around 89% of the total coconut area and 90% of total production, (Jayasekhar and Jacob, 2021). The Indian government recognised the value of coconuts and established the Coconut Development Board (CDB) (Narmadha *et al.*, 2022). Since 2001, CDB has been carrying out a technology mission on coconuts to enhance value- addition through processing (Lathika and Kumar, 2005). Hence, critical analysis of structural break and trend in Indian coconut production is needed.

## MATERIALS AND METHODS

The study is based on annual time series data covering the period of 30 years, viz 1990-91 to 2020-21. The secondary data on area, production and productivity of coconut for four major coconut-growing states Kerala, Karnataka, Tamil Nadu, and Andhra Pradesh, and India, were collected from CDB and Directorate of Economics and Statistic, Ministry of Agriculture, Government of India. The Compound growth rates (CGR) is computed by applying the formula: $Y_t = ab^t$

In the log form, it is written as: $\text{Log } Y_t = \text{Log } a + t \log b$

where, $Y_t$ = area/production/productivity in year 't', t = time element which takes the value 1, 2, 3, ....... N, a = intercept and b = regression coefficient.

The value of b is computed by using OLS method. Further, value of CGR was worked out as follows: CGR (r) = (antilog b - 1) x 100

Udhayakumar *et al.* (2021) used Student't test to check the significance of the CGR.

The instability index is a simple analytical tool for determining the variation or instability in any time series data (Narmadha and Kandeepan, 2017). It was estimated using Coppock's instability index (Coppock, 1962). The estimable form is given below:

$$V \log = \sum [\log (X_{t+1} / X_t) - m]^2 / n$$

The instability index = Antilog $(\sqrt{V \log} - 1)$ x 100

where,

Xt = area/production/productivity in the year 't',

t = number of years.

M= mean of difference between Logs of Xt+1, Xt.

Log V = logarithmic variance of the series.

An unanticipated shift in time series data causes a structural break. During the shift, the values of linear regression model's parameters do not remain constant and this could be due to external influences, major

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policy changes, or a variety of other factors. If breaks are not identified, a continuous analysis taking entire period may lead to forecast errors and may make the proposed model questionable. In this regard, break in the Clemente– Montañes–Reyes test (1998) was employed which estimates two endogenous structural breaks in the data series by using stata software. Based on identified structural break, CGR was computed (Anbukkani *et al.*, 2017) and Narmadha and Karunakaran, 2022).

## RESULTS AND DISCUSSION

The major coconut-producing states in India are shown by their triennium ends in the Table 1. During TE 2020, 89 % of the area under coconut farming were Kerala (35%), Karnataka (29%), Tamil Nadu (20%), and Andhra Pradesh (5%). The Triennium Ending was calculated for four periods: TE1990-91, TE2000-01, TE2010-11, and TE2020-21 and the results demonstrate that, with the exception of Kerala, all other states exhibit an increase in area under coconut, which doubles at TE2020-21 compared to TE1990-91.

The four states with the highest coconut production during TE2020–21 was Kerala (35%), Tamil Nadu (26%), Karnataka (24%), and Andhra Pradesh (6 %). Together, they produced almost 92 % of country's coconut total production. The Triennium Ending results show that during four Triennium Endings, the production of coconuts doubled in major states. Production and productivity of coconuts have significantly increased since the establishment of CBD,

which increased productivity, area expansion, replanting and rejuvenation, processing, and value- addition, and implemented the Technology Mission on Coconut (TMoC) in 2001–2002. (Gandhimathy, 2021).

The results show a rising yield that doubles by TE 2020–21 compared to TE 1990–91. Andhra Pradesh produced the most nuts (13,003), followed by Tamil Nadu (12,510), Kerala (9,833), and Karnataka (8,776) (Table 1). As a result, India's average output of 9,888 nuts grew by a significant margin. The widespread use of high-yielding varieties as crop and farm management activities, policy support to improve irrigation facilities, market infrastructure, and thus the supply of agricultural credit, farm input subsidies, and farmers' enthusiasm for adopting high-yielding varieties were the main drivers of impressive growth in coconut in India (Abeysekara and Waidyarathne, 2020).

The change in area, production and productivity trend of coconut were analyzed using Clemente– Montañes–Reyes test method of structural break analysis for major coconut- producing states in India (Table 2). The area under major coconut growing states has found a first break year between 1996 and 1999 due to the impact of WTO implementation on 1995 and second break year found after 2001 which showed that Technology Mission on Coconut was enacted during the corresponding period. The first estimated break year of coconut production has been found to be 1999 for Kerala and India and late 2005's for Tamil Nadu, Karnataka and Andhra Pradesh which

**Table 1:** Triennium Ending (TE) of area, production and yield of major coconut producing states in India

| | States | Kerala | Karnataka | Tamil Nadu | Andhra Pradesh | India |
|---|---|---|---|---|---|---|
| Area ('000 ha) | TE 1990-91 | 840 (57.10) | 226 (15.37) | 207 (14.05) | 57 (3.90) | 1471 (100) |
| | TE 2000-01 | 968 (54.29) | 314 (17.63) | 307 (17.22) | 101 (5.66) | 1782 (100) |
| | TE 2010-11 | 784 (41.38) | 435 (22.95) | 397 (20.94) | 104 (5.49) | 1895 (100) |
| | TE 2020-21 | 759 (34.99) | 622 (28.68) | 423 (19.51) | 117 (5.39) | 2170 (100) |
| Production (million nuts) | TE 1990-91 | 4268 (46.39) | 1167 (12.68) | 2240 (24.34) | 694 (7.54) | 9200 (100) |
| | TE 2000-01 | 5758 (46.26) | 1640 (13.18) | 3180 (25.54) | 1356 (10.89) | 12448 (100) |
| | TE 2010-11 | 6091 (36.85) | 3064 (18.54) | 5974 (36.14) | 1156 (6.99) | 16530 (100) |
| | TE 2020-21 | 7504 (34.97) | 5206 (24.26) | 5623 (26.21) | 1386 (6.46) | 21458 (100) |
| Yield (Nuts/ha) | TE 1990-91 | 5086 | 5161 | 11022 | 11964 | 6252 |
| | TE 2000-01 | 5941 | 5218 | 10465 | 13522 | 6985 |
| | TE 2010-11 | 7795 | 6222 | 14678 | 10580 | 8722 |
| | TE 2020-21 | 9883 | 8776 | 12510 | 13003 | 9888 |

Parentheses indicates the percentage share to India
Source: Calculations are based on data from CDB, 2022

showed impact of TMoC, increased coconut production. The second break year of coconut production was found on late 2010's for all the selected sample states which shows the export promotion council was launched in 2009, hence production changed during the equivalent period. The first estimated break year of coconut yield has been found to be 1993 for Tamil Nadu and Andhra Pradesh and late 2005's for Kerala, Karnataka and India. As same as production, second break year of coconut productivity also found on late 2010's except Tamil Nadu. Because Tamil Nadu appreciated productivity improved programmes through National Horticulture Mission (NHM) on 2005. These results clearly indicate that the effects of technological and institutional change on coconut production in India are determined as the structural breaks.

**Table 2:** Structural break of major coconut producing states in India – 1990 to 2020

| States | Area | | Production | | Yield | |
|---|---|---|---|---|---|---|
| | Break 1 | Break 2 | Break 1 | Break 2 | Break 1 | Break 2 |
| **Kerala** | 1999 | 2004 | 1999 | 2012 | 2005 | 2012 |
| **Karnataka** | 1996 | 2007 | 2007 | 2011 | 2012 | 2015 |
| **Tamil Nadu** | 1997 | 2009 | 2006 | 2011 | 1993 | 2006 |
| **Andhra Pradesh** | 1999 | 2008 | 2010 | 2013 | 1993 | 2010 |
| **India** | 1996 | 2013 | 1999 | 2010 | 2007 | 2013 |

Source: Author calculation based on data from CDB, 2022

There was two break years in each category. So, three growth rates were analysed based on break years. In that, coconut area and production growth rate of India was 3.87 and 3.28% before first break year and decreased between two break years growth rate was 2.55 and 3.10% and increased after the second break year as 2.85 and 3.88% respectively. But growth rate of coconut yield increased over the period of 2.95% and slightly decreased after the second break year as 2.29% (Figure 1).

The growth rate of area, production and yield of coconut in Kerala was estimated based on break years (Figure 2). Before the first break year, there was a drastic growth in area (3.03 %), production (3.90 %) and productivity (2.79 %). But between the first and second break year, growth rate became negatively on area (2.05 %) which affected the production and yield growth rate. This was realized during 2005, ie. after implementation of NHM which depicts that area expansion in coconut cultivation is merely nominal for other crops. After the second break year 2012, again there was slight increase on growth rate of coconut production due to the export of coconut products which gain more profit.

In Karnataka, Tamil Nadu and Andhra Pradesh, growth rate showing increasing trend in coconut area, production and yield of coconut compared with first break

year to second break year (Fig. 3, 4 and 5). This may due to State Mission on Horticulture give special attention to productivity programmes on coconut production and area expansion on coconut.
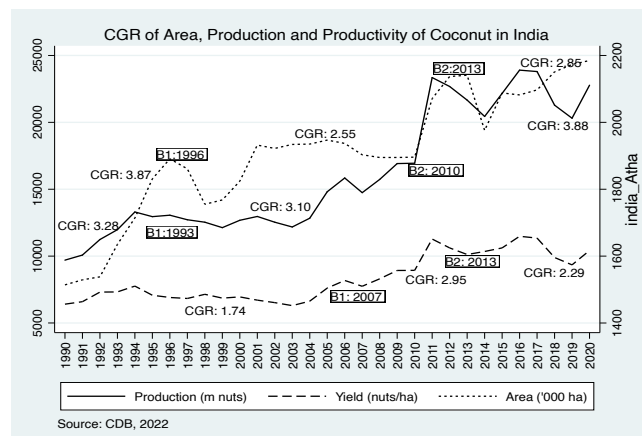


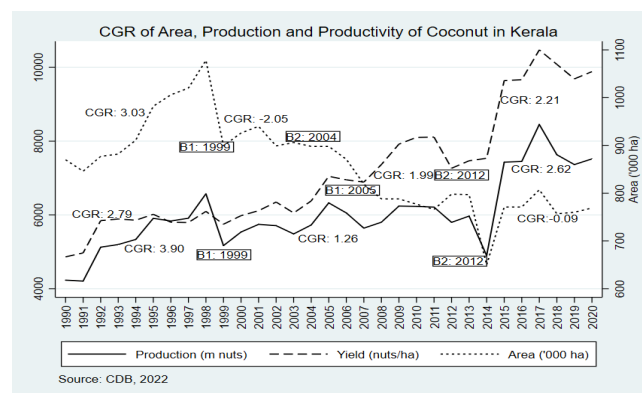**Fig 1:** CGR based on structural break for Indian coconut production



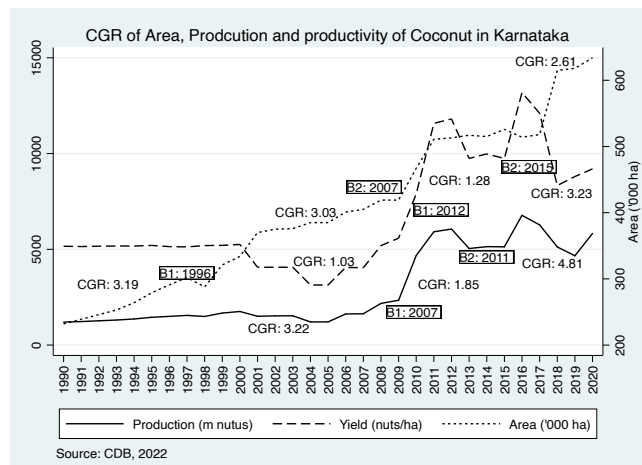**Fig 2:** CGR based on structural break for coconut production in Kerala



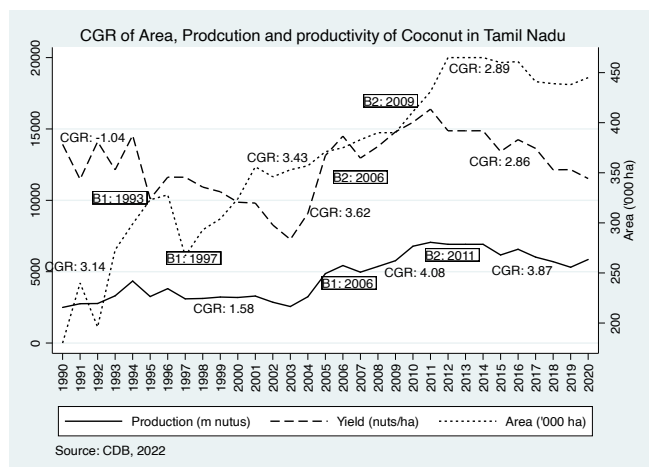**Fig. 3:** CGR based on structural break for coconut production in Karnataka

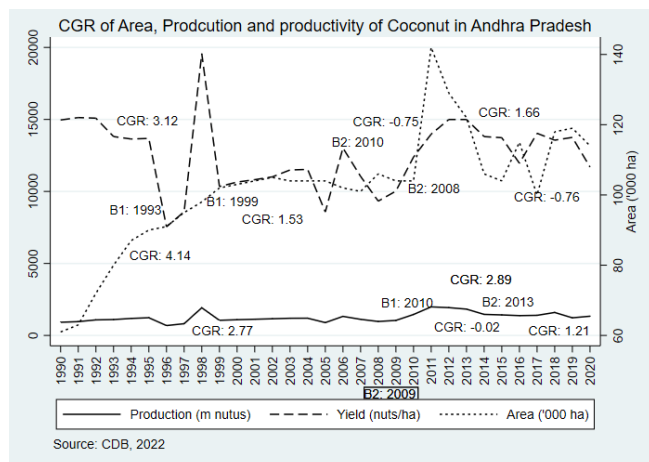**Fig 4:** CGR based on structural break for coconut production in Tamil Nadu



**Fig 5:** CGR based on structural break for coconut production in Andhra Pradesh

## CONCLUSION

Thus, it was concluded that there was structural break year in area, production and productivity for major coconut-growing states in India after 1996, 2005 and 2011 which showed the impact of WTO and NHM.

## ACKNOWLEDGEMENT

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