New Countryside (2023) Volume 2 Issue 1, *18 pages*.
https://doi.org/10.55121/nc.v1i2.33

ResearchArticle

Estimating Total Factor Productivity Growth in the Sri Lankan Coconut Sector

S. M. M. Samarakoon [1*], H. L. J. Weerahewa [2], L. H. P. Gunaratne [2]

[*1.] *Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka. E-mail: smmsamarakoon@gmail.com*

[2] *Department of Agriculture Economics and Business Management, Faculty of Agriculture, University of Peradeniya,Sri Lanka. E-mail:jeevikaw@gmail.com; lhpguna2010@gmail.com*

ABSTRACT

The stagnant nature of Sri Lankan national coconut production over many decades has been an issue in fulfilling the ever-increasing demand for domestic coconut consumption and industry. Thus, this study aims to address the question of the driving forces of total coconut production growth. This study identifies the sources of Sri Lankan coconut sector growth from 1985 to 2019 by calculating the Total Factor Productivity (TFP) growth by administering a log-transformed Cobb – Douglas production function and decomposed the results using a data set sourced from various government publications. According to the findings of the study, the average TFP growth of the coconut sector in Sri Lanka for the period 1985-to 2019 has been -1.1%, whereas it was -0.1% and -1.9% during the two sub-periods; 1985-2000 Sub-period I, 2001-2019 Sub-period II, respectively. Therefore, it is evident that the negative growth of the TFP is mostly driven by the high negative growth in the post-2000 period. These findings will help to formulate future growth policies in the coconut sector of Sri Lanka.

Keywords: Sources of growth; Total factor productivity; Cobb-Douglas production function; Coconut cultivation; Drought effects.

1. Introduction

Coconut (Cocos nucifera L.) has existed from time immemorial[1] and is now a crop that is cultivated by the people of Sri Lanka for its diverse uses. Coconut is closely intertwined with the Sri Lankan lifestyle as a versatile livelihood crop and is recognized as the "Tree of Life" as every part of it can be put to some use. The coconut is the traditional and most widely cultivated plantation crop in Sri Lanka, covering an area of 443,538 Ha, coming second only to the staple crop rice (1,140,000 Ha), and accounting for nearly 20% of the total agricultural lands in the country[2]. The sector directly employs around 135,000 people in production and industry and provides a livelihood for over 700,000 people[3]. The coconut industry's

ARTICLE INFO
Received: June 21, 2022 | Accepted: November 30, 2022 | Available online: July 5, 2023

CITATION
S. M. M. Samarakoon, H. L. J. Weerahewa, L. H. P. Gunaratne. Estimating Total Factor Productivity Growth in the Sri Lankan Coconut Sector. New Countryside 2023; 2(1): 10-26 pages.

contribution to the GDP and export earnings in 2019 was 0.7% and 5.1%, respectively[4]. The national coconut production is around 2,500-3,000 million nuts per annum, of which domestic consumption accounts for 70% (1,750-2,000 million nuts/year) at the rate of 116 nuts/capita. The rest of the production is used as raw material for a vast number of coconut kernel-based industries that manufacture a variety of products for both domestic and export markets[5].

However, the increasing cost of production and lower revenues in the monoculture coconut plantations pose a significant challenge in running the plantations at a good profit level. Therefore, the coconut sector faces difficulties in competing with other agricultural and non-agricultural sectors that use the land to raise more profitable crops, as a heavy demand exists for coconut land for non-agricultural business ventures. As a result, inviting new investments and keeping the investments is a challenge, as is justifying the use of resources to sustain existing coconut farms while the average nut production from the 1980s to the present remains unchanged (i.e., around 2,700 million nuts). Given the stagnant state of the coconut sector, this study estimates the driving forces of total coconut production growth and the sources of Sri Lankan coconut sector growth from 1985 to 2019 by calculating the Total Factor Productivity Growth (TFPG) by administering a log-transformed Cobb – Douglas production function.

2. Review of Literature

2.1 Theoretical framework - Productivity growth

Productivity measures are often used to assess a country's economic performance. Long-term economic growth is generally dependent on three factors: growth in the size of the labor force, growth in the amount of physical capital (e.g., tools, machines, and computers) available to workers, and growth in output due to factors of production. Productivity is a measure of how well an economy produces goods and services with a given number of workers and amount of physical capital. Productivity growth is often of particular concern to policymakers because it is a vital determinant of long-term economic growth and drives increases in income for businesses and individuals. The concept of productivity growth has gained importance for sustaining output growth over the long run because input growth alone is insufficient to generate output growth because of diminishing returns to input use[6]. Productivity growth in agriculture, where land is also an important input, both necessary and sufficient conditions are required for the development of the sector and the economy. It is a necessary condition in the sense that it enables agriculture to avoid the trap of Ricardo’s law of diminishing returns to which the sector is more prone. On the other hand, it is a sufficient condition because it increases production at a reduced unit cost or price in real terms[7].

2.2 Agriculture productivity growth

The productivity growth in agriculture, which has been yielded from different development strategies implemented, has captured the interest of economists for a long time[8]. As agriculture develops, it releases resources to other sectors of the economy. This has been the basis of successful industrialization in developed economies such as the United States, Japan, or countries in the European Union. Thus, agricultural development becomes an important precondition of structural transformation towards industrial development, as it precedes and promotes industrialization[8].

The extensive discussions, deliberations, and policy recommendations related to the effects of development strategies have emphasized the importance of analyzing and quantifying both the short-term and long-term implications of the strategies discussed above. Therefore, scholars have attempted to examine the effects of different development strategies in terms of productivity growth using various analytical techniques.

2.3 Measuring productivity growth

There are two types of productivity measures, which are often used to assess a country's economic performance. A partial productivity measure relates output to a single input; examples include labor productivity (output/hour worked), capital productivity (output/unit of capital), and energy productivity (output/joule of energy used). On the supply side, the growth of an economy, an industry, or a firm is determined by the rate of expansion of its productive resources and by improvements in their efficiency; that is, by total factor productivity (TFP) growth[9]. In studies of long-term growth, many analysts focus on TFP as the pre-eminent measure of productivity. TFP growth is commonly associated with innovation and technological change, the long-run drivers of per-capita income growth. Murray, A.[10] explains that TFP relates an index of output to a composite index of all inputs.

Partial productivity measures have their own set of strengths and weaknesses. Such measures are of theoretical interest because of their close relationship to factor prices. From a practical perspective, a partial productivity measure may be more informative than TFP for certain analytical purposes because partial measures allow an analyst to focus attention on the efficiency of the use of specific resources that are of special interest in a particular context[10].

2.4 Growth accounting

Solow, R. M.[11] introduced a growth accounting framework, and later, Denison, E.[12,13] further developed the framework. The TFP can be measured as a residual factor. In this approach, assess the factors contributed to growth in the output that is not calculated in the factors of production. This approach measure the technological changes mainly the rate of change of TFP indices[14]. The TFP index is measured as the ratio of the index of net output and the index of total factor inputs. The index of total factor inputs is derived as a weighted average of labor inputs, capital inputs, and land inputs with relative income shares of the three factors as respective weights.

The calculation of the growth accounting in the research is easy because it does not require detailed econometric analysis and the requirement of data are minimum. According to Saikia, D.[7] growth accounting is a separation of change in production on changes in the quantities of factors of production from residual influences which can be defined as technological progress. If the production function is neoclassical, the Solow residual can accurately measure the TFP growth. Then growth rate of inputs is measured accurately. However, the Kendrick index and the Solow index suffer from some limitations. The Kendrick index is based on a linear production function – very criticized, as it assumes an infinite elasticity of substitution and, because of that, it uses an arithmetic weighted procedure of the factor. Solow model is one of the unique theories that explain the long-term national economic growth. The model is based on three major assumptions. First, the two factors of production (capital and efficient labor) possess perpetual returns to scale. Secondly; it assumes that other inputs apart from capital, labor and knowledge are not significant. And finally, the portion of the production invested or saved is constant and equivalent to savings in a closed economy.

2.5 Estimating TFP growth

The significant role of the output growth of the agricultural sector in the growth of the nation cannot be underrated. The output will increase due to an (i) increase in the factor inputs and (ii) efficient utilization of inputs in production. Studies on selected crops and the agricultural sector as a whole that explored the causes of the sluggishness of the sector have invariably concluded that the agricultural scenario in most developing countries has been characterized by a long-run incapability to deliver to the needs of the economy. Several factors stemming from the socio-politico-economic and ecological-environmental were cited as the forces that led to the stagnation in agriculture. In light of this discussion, several studies have been undertaken in both theoretical and empirical literature to identify the productivity growth of the economies. Some studies have focused on a single country, while others have concentrated on a selected group of countries. Most of these studies used only the primal approach to calculate aggregate TFP growth, but some studies used both primal and dual approaches. However, in the Sri Lankan context, studies that focus exclusively on the productivity performance of the economy and productivity performances of specific sub-sectors are relatively very few.

2.6 TFP growth approaches in Sri Lanka

Previous studies on calculating TFP growth for Sri Lanka alone are scarce. Generally, Sri Lanka is included in studies that conduct a regional and country-comparative analysis of the sources of growth. For example, in a study of the measurement and consistency of growth accounting for 84 countries over the period 1960 – 2000,[15] included Sri Lanka. They have found that both capital accumulation and efficiency gains are central to the growth process in countries in general. In a study of cross-country analysis for identifying patterns of economic growth for 80 developed and developing countries, Liman, Y.R and Miller, S.M.[16] examined Sri Lanka as well. They decompose output growth into factor accumulation, TFP growth, and production efficiency improvement, and find that factor accumulation growth, especially capital accumulation, is much more important than either improved quality of factors or TFP growth in explaining output growth.

Fernandez, E, Erik, E.L, Davies, M and Kock, U.[17] calculated TFP growth for Sri Lanka using the primal growth accounting framework, and find TFP growth for 1978-2004 to be 1.1 % and projected TFP growth for 2005-2009 to be 1.9 %. In their study, the share of capital in total income and the depreciation rate of the capital stock are assumed to be 0.4 and 8%, respectively. Duma, N.[18] used the primal approach to investigate the main sources of growth in Sri Lanka between 1980 to 2006 and find that the labor to be the most productive factor input in the 1980s, contributing the most to the real output growth of the sample period. But, over time, TFP growth has taken it over from labor and becomes the most important source of growth.

Gamage, G.G and Kankanamge, A.[19] examined the factors affecting TFP growth using aggregate annual data from 1977 – 2007. In the first stage of the study, they computed TFP growth for Sri Lanka in a standard growth accounting framework, and in the second stage, they developed Ordinary Least Square (OLS) and Generalized Least Square (GLS) models to test the effect of Foreign Direct Investment (FDI), openness and Information and Communication Technology (ICT) investment on TFP growth. In all estimated models, FDI has a significant and positive effect on TFP growth.

Kumari, R. D. and Tang, S. H.[20] conducted a study to identify how much economic growth is driven by improvement in TFP in Sri Lanka in comparison to other Asian economies. Their study has calculated aggregate TFP growth for Sri Lanka by using both primal and dual growth accounting frameworks covering the period 1980-2016. According to their estimates, TFP growth accounts for 45% of the total output growth for the whole period. The annual average TFP growth rates under the primal and dual approaches are 2.3 % and 3.6 %, respectively, and they have shown that the two growth drivers in Sri Lanka have been capital accumulation and productivity growth.

2.7 TFP growth in specific sub-sectors in Sri Lanka

Athukorala, P. and Jayasuriya, S.[21] conducted a simple growth accounting procedure to decompose manufacturing output growth into the relative contributions of factor accumulation and TFP growth in Sri Lanka while assessing the effect of trade policy reforms and industrial adjustment during the period 1966 – 1993. According to their estimates, there were adverse productivity implications of the increased restrictiveness in the trade regime between 1966 and 1974. Out of total output growth between these two years, almost 30% came from TFP growth.

Navaratne, D. and Jayawardane, A.[22] estimated the TFP growth of the Sri Lanka building construction industry from 1995 to 2001 using the Tornqvist Index. The study results indicated that TFP growth had a positive trend from 1995 to 1997 and recorded the maximum TFP growth in 1997. Since the year 2000, TFPG in the building construction industry has been revolving around zero. The study also concluded that there has to be a significant improvement in national data collection to have more reliable indicators of TFP growth trends in the building industry and the overall construction industry. Swarnathilake, C, Weerahewa, J and Bandara, Y. M.[23], estimated the food manufacturing industry growth from 1978 -2014 by adopting the Cobb – Douglas production function framework and found that the growth is -0.61%.

Abeysekara, M.G.D and Prasada, D.[24], empirically estimated the TFP growth of coconut plantations in Sri Lanka by adopting a cost function approach. They have further identified the sources of productivity growth in the coconut sector by decomposing the measured growth in TFP into technological change and returns to scale. The study used cost of production data over the period 1961-2016 and specified a stochastic generalized translog cost function. Parameters were estimated using the Seemingly Unrelated Regression (SUR) method. According to the results, TFP growth was found to be 0.083% per annum. Further, they have estimated that technological change and the scale of economies contributed to 78% and 22% of the TFP growth, respectively. Thus, research and transfer of technology may be the reasons for low TFP growth.

Accordingly, studies that focus exclusively on the productivity performance of the specific sub-sectors, especially agriculture in Sri Lanka, are relatively few. In the context of coconut plantations, a single study has exclusively focused on the productivity performance of the coconut sector. However, this study was limited to the coconut plantation sector, which accounts for nearly 20% of the total land holdings rather than the national average. Also, it is noteworthy that most of these studies have employed growth accounting and index number approaches, and the emphasis on the frontier approach is minimal. Therefore, this study aims to bridge this gap by estimating the TFP growth in the coconut sector at the national level by adopting the Cobb – Douglas production function framework and reviewing the policy measures adopted over time to improve productivity in the coconut industry.

3. Methodology

3.1 Theoretical framework

The coconut sector has been subjected to much research, but investigations into the growth of the coconut sector are scarce in Sri Lanka. The significance of coconut and coconut-based value-added products is experiencing a growing demand across the world market. Examining the present status of the domestic coconut industry and adopting policy measures for the improvement of the sector is crucial. The domestic coconut sector is characterized by low productivity and low returns, which then reduces the reinvestment capacity of the sector. This has been reflected in the performance of the coconut sector over the past few decades. Given the country's low coconut productivity, domestic coconut production from the existing coconut area could be increased by improving production efficiency rather than expanding the area. Since the improvement of TFP in the coconut sector is directly related to production efficiency, estimating the growth in TFP is important. It is also whether productivity growth has occurred over time and, if so, what are the sources behind this growth.

This study employs production function analysis among the different approaches used to estimate the TFP growth with the intention of comparing and contrasting with the other production functions. An advantage of using the stochastic frontier model is that it can help understand the causes of productivity changes over time.

Productivity measures the relationship between outputs (total product) and input factors of production (primarily labor and capital). It equals output divided by input.

$$TFP = \frac{Total\ Product}{Weighted\ Average\ of\ Inputs} \quad (1)$$

The most widely used production function is the Cobb-Douglas function which is as follows:

$$Q = A * K^{\alpha} * L^{\beta} \quad (2)$$

Where Q is the total product, K is capital, α is the output elasticity of capital, L is labor, and β is the output elasticity of labor. Q is the total product, and the product of Kα and Lβ is the weighted average of inputs. If we rearrange the Cobb-Douglas function, we get the following formula for TFP:

$$TFP = A = \frac{Total\ Product}{Weighted\ Average\ of\ Inputs} = \frac{Q}{K^{\alpha} * L^{\beta}} \quad (3)$$

TFP represents the increase in total production, which is over the increase that results from the increase in inputs. It results from intangible factors such as technological change, education, research and development, synergies, etc. It is more useful to look at productivity increase over a period instead of the absolute value of TFP. The following growth accounting equation gives us the relationship between growth in total product, growth in labor and capital, and growth in TFP:

$$\frac{\Delta Q}{Q} = \alpha * \frac{\Delta K}{K} + \beta * \frac{\Delta L}{L} + \frac{\Delta A}{A} \quad (4)$$

3.2 Estimating TFP growth in the Sri Lankan coconut sector

Analytical framework

The economic theory of production has provided the analytical framework for most empirical research on productivity. TFP is one of the measures used in economics theories to measure the portion of output not explained by the number of inputs used in production. Further, it is determined by how efficiently and intensely the inputs are utilized in production[25]. Authors in many studies emphasize all the residual factors after accounting for input growth are called as the index of ignorance[26]. Aragon, C.T, Carambas, N, Andres, R., Roxas, K and Fernandez, D.[27] determined the TFP growth in the Philippine coconut sector using the stochastic production frontier method, and Abeysekara, M.G.D and Prasada, D.[24], estimated the TFP growth in the Sri Lankan coconut sector by employing a cost function approach.

This study adopts the following model for our analysis in the context of the widely used Cobb-Douglas production technology framework:

$$Y = f(A, F, L, R, D, T) \quad (5)$$

Where; Y = Output (independent variable), A= cultivated land extent in hectares, F = fertilizer usage; L = labor usage; R = Rainfall; D = Temperature proxies by number of drought months and T = Time (to capture the technological change). Accordingly, the output (Q) in the entire coconut sector in Sri Lanka is expressed as a function of fertilizer usage (F), labor (L), annual rainfall(R), number of drought months (D), and time (T). Output (Y) is expressed in terms of the number of coconut nuts harvested in the country/ year. Cultivated land extent (A) in hectares, fertilizer usage (F) is used as the amount of fertilizer used (in mt) in coconut cultivation and "L" defines as the number of labors engages in the coconut sector. Annual average rainfall (R) is expressed in millimeters (mm). The number of dry months/ year is used as a proxy for the temperature (The rainfall less than the 100 mm/month is considered as a dry month). Time (T) is used to capture the technological change over the study period. The study considered all the mature plantations of smallholders and estates for the output model. Although rainfall and drought have some kind of inverse relationship, according to the literature, there is a mixed impact of both variables on coconut production.

According to past studies, the responsiveness of coconut production to fertilizer and rainfall has proven the presence of lag effects. Therefore, appropriate lag variables were used in the model where it is necessary to represent the characteristic nature of the coconut sector.

The above equation (5) can be log-transformed as below and thereby minimize the problem of heteroscedasticity.

$$\Delta lnY_T = a + \propto (\Delta lnF_{T-2}) + \beta(\Delta lnL_T) + \gamma(\Delta lnR_{T-1}) + \lambda(\Delta lnD_T) + \theta(\Delta lnA_T) + \varepsilon_{i,T} \tag{6}$$

Where;

α= Output elasticity with respect to fertilizer

β= Output elasticity with respect to labor

γ = Output elasticity with respect to annual rainfall

λ = Output elasticity with respect to number of dry months

θ = Output elasticity with respect to area cultivated

a = Intercept

T = Study time period;

$\varepsilon_{i,T}$ = The residual term which is the TFP growth capturing technological progress, and

Δ = Proportionate rate of change.

In the Divisia Index framework, the above equation (6) can be written as below to identify TFP growth as the difference between output growth and input growth, while in the transformation, intercept ‘ a ’ is dropped as it has no part to play in the model below.

$$\Delta \ln TFP_T = \Delta lnY_T - [\alpha(\Delta lnF_{T-2}) + \beta(\Delta lnL_T) + \gamma(\Delta lnR_{T-1}) + \lambda(\Delta lnD_T) + \theta(\Delta lnA_T)] \tag{7}$$

Where;

$\Delta \ln Y_T$ = Growth rate of output

$\alpha (\Delta \ln F_T)$ = Contribution of fertilizer

$\beta (\Delta \ln L_T)$ = Contribution of labor

$\gamma (\Delta \ln R_T)$ = Contribution of rainfall

$\lambda (\Delta \ln D_T)$ = Contribution of number of dry months

$\theta (\Delta \ln A_T)$ = Contribution of area cultivated

$\Delta \ln TFP_{i,T}$ = TFP growth rate

Table 1: Descriptive statistics of the data

Variable	Obs.	Mean	Std. Dev.	Min	Max
Annual national coconut production (mn nuts)	35	2,648.94	289.11	1,937	3,096
Total coconut land (ha)	35	406,116.1	25,345.13	394,836	466,00
Annual fertilizer usage (mt)	35	35,443.31	10,192.08	5,456	56,927
Annual labor usage (total number of employees)	35	145,074.9	24,063.46	105,500	187,000
Annual rainfall (mm)	35	1,843.05	259.39	1,363.33	2,288.5
Annual drought month (per month<100 mm)	35	2.91	1.153	0.79	6.33

Source: CDA, CCB, and CRI various issues

The above model was employed to empirically estimate the TFP growth of the coconut industry in Sri Lanka. Annual national data from 1985 to 2019 was used for the analysis (Table 1). The Sri Lankan economy fully opened in 1977/78 and it transformed around 1985. Therefore, this study considered the 1985 to 2019 period and split it into two; 1985-2000 and 2001-2019. This study aims to bridge the gap by estimating the TFP growth in the coconut sector at the national level by adopting the Cobb-Douglas production function framework and reviewing the policy measures adopted over time to improve productivity in the coconut industry.

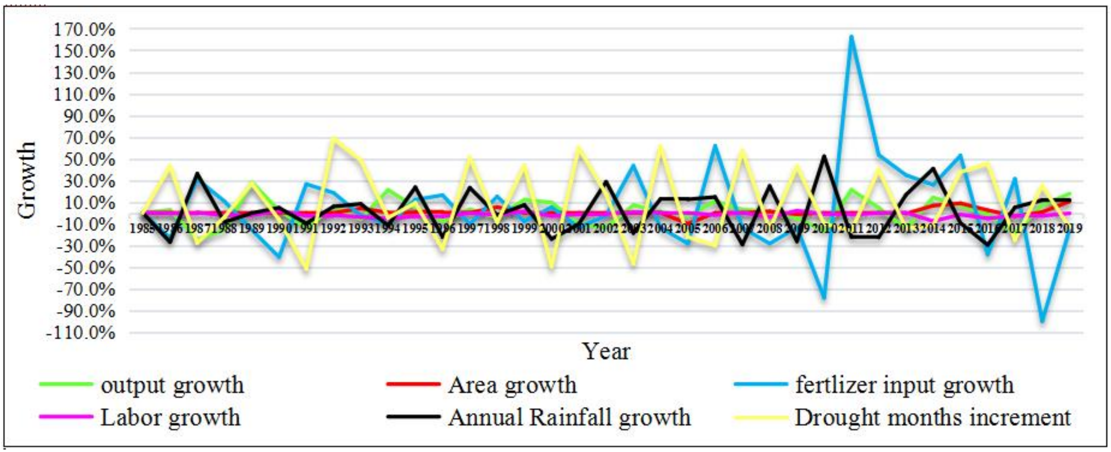

Figure.1: Productivity indicators in Sri Lanka's coconut sector (1985-2019).

Since there is a year-to-year variation in the annual growth, the period under study was divided into two sub-periods: 1985-86 to 1999- 2000, and 2000-01 to 2018-19 to reflect the changing phases of the coconut sector (Table 2). The first was the period where the plantation sector was predominant, with a high export share, soon after land reformation and trade liberalization took place. The second period is distinguished by a different political regime with a different policy setup. A new ministry was set up for the coconut industry, and many subsidy schemes were implemented, especially the coconut fertilizer subsidy. The annual growth rates of the two sub-periods and the entire period are shown in Figure. 2 and Figure. 3 for comparison purposes as well.

Table 2: Annual growth rates of output and inputs in Sri Lankan coconut sector (1985-2019)

Time Period	Output Growth	Area Growth	Fertilizer Input Growth	Labor Growth	Annual Rainfall Growth	Drought Months Increment Growth
1985-2000	1.1%	0.7%	1.5%	-1.7%	0.2%	6.6%
2001-2019	0.6%	0.8%	6.3%	-1.5%	3.3%	9.6%
1985-2019	0.8%	0.7%	4.1%	-1.6%	1.9%	8.2%

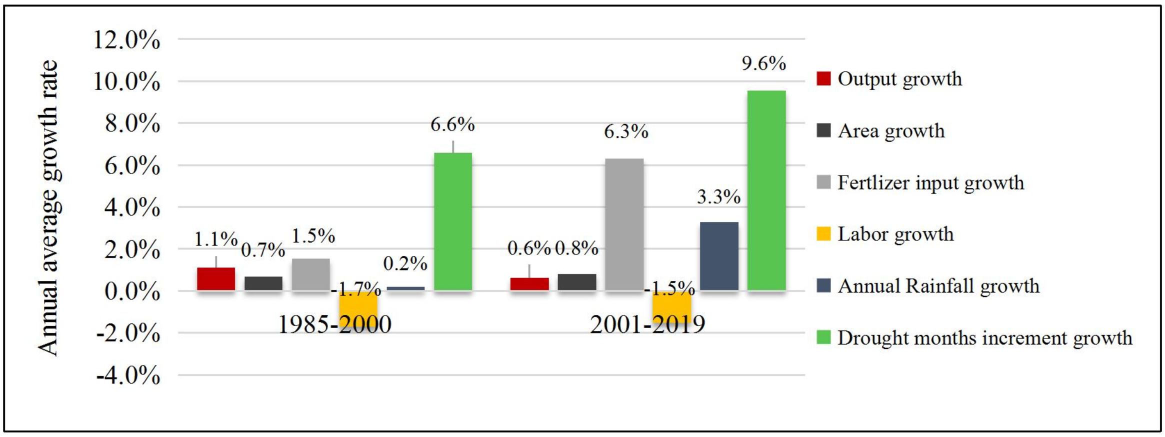

Figure. 2: Annual growth rates of output and inputs in Sri Lankan coconut sector (1985-2019).

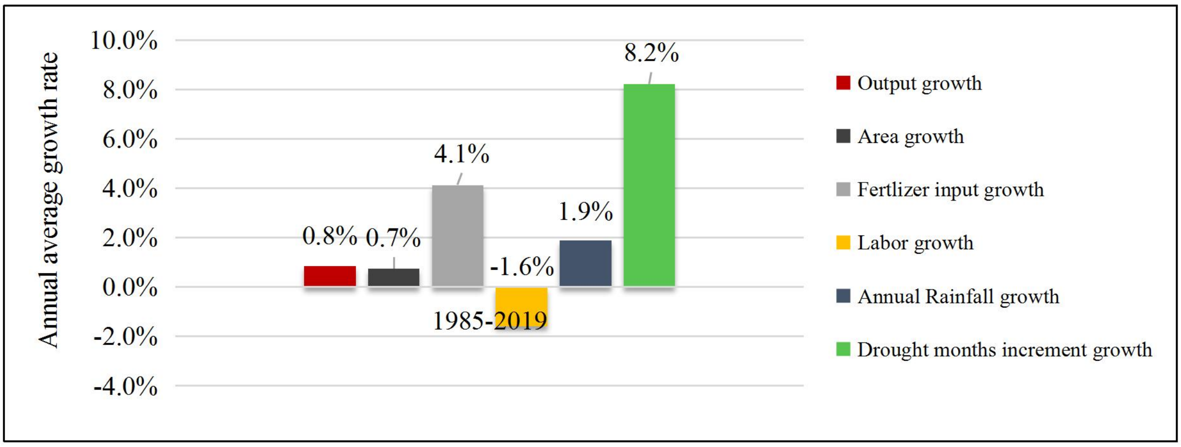

Figure 3: Annual growth rates of output and inputs in Sri Lankan coconut sector (1985-2019).

The annual average output growth is positive with a value of 1.1% and 0.6% n the two sub-periods, respectively, with a significan tdecrease. However, each input's average annu algrowth has recorded an increase during the seco ndsub-period compared to that of the first peri od.Among the inputs, the annual average growt h oflabor remains negative during both periods, whileall the other inputs exhibit positive growth . Theannual average growth of labor was -1.7 % from1985–2000, and later it recorded a value o f -1.5%,showing a slight increase. Reasons for the negativegrowth of labor may be the low persist ent laborwages and the low quality of labor; th is can bemeasured as a year of schooling as a proxy. Theannual growth of the area exhibited a marginalincrease of 0.7% to 0.8% durin g the twosub-periods considered. The annua l growth offertilizer input has recorded a drastic increase from1.5% to 6.3% during the two periods , respectively.Many fertilizer subsidy scheme s for coconutcultivation were introduced in 20 02, 2003, 2005,2006, 2015, and 2017. In con trast, a few in1985-2000 (CBSL, various issues) may have beenimpacted by the heavy usage. A mong the climaticinput variables, both annual ra infall and droughtmonths have recorded positiv e growth during the second half compared to the first half of the entire period.

Even though the annual average growth of rainfall has increased from 0.2% to 3.3%, the beneficial effect of the increment in rainfall has been offset by the simultaneous increment in drought months.

3.3 TFP growth in coconut sector

Table 3 summarizes the OLS estimates of the Cobb-Douglas production frontier model for the coconut sub-sector using the stochastic production frontier analysis. Durbin-Watson test values, in general, show no auto-correlation issues, while the ADF test shows the data set has stationary properties. According to Table 3, the output elasticities concerning inputs were significant at the 5% and 10% levels, except for the area cultivated.

When considering the output elasticities concerning inputs over the study perio(1985-2019), rainfall has the highest positive significant output elasticity, which is 0.3684. Similarly, the number of dry months also has an output elasticity value of 0.0884, which is significant at a 5% significant level. Therefore, it is evident that the climatic variables significantly affect the output produced in the coconut sector. However, it is noteworthy that the output elasticity for fertilizer is 0.2532, which is positive and significant at a 5% significant level only during 1985-2000. But it was not significant from 2001 to 2019 and overall period. This may be a reason for the overuse of subsidized fertilizer during the post-2000 period. Moreover, the output elasticity for the area cultivated is not significant in all three situations, and it has a negative value. In the production function, the negative value of land implies the characteristic nature of land use by monoculture coconut plantations, utilizing only 25 % of the land under cultivation[28].Aragon, C.T, Carambas, N, Andres, R., Roxas, K and Fernandez, D.[27] have estimated a Cobb-Douglas production frontier function of coconut farmers in Davao City, Philippines, between 2003 and 2007, and have obtained negative elasticity values for land and labor, which are not significant.

Table 3: Econometric estimations of output elasticities in coconut cultivation in Sri Lanka: 1985-2019

Study period	Output elasticity with respect To Land (A)	Output elasticity with respect to Labor (L)	Output elasticity with respect to rainfall (R)	Output elasticity with respect to dry months (D)	Output elasticity with respect to fertilizer (F)	Adjusted R^2	D-W Statistics
Sub period I (1985-2000)	-1.0333 (0.501)	-1.1590* (0.095)	0.0027 (0.992)	0.0903 (0.191)	0.2532* (0.082)	0.7762	1.9473
Sub period II (2001-2019)	0.1336 (0.673)	-0.2744 (0.203)	0.3667*** (0.002)	0.0133 (0.782)	-0.0426 (0.212)	0.6236	1.9587
Whole period 1985-2019	-0.2132 (0.502)	-0.4140*** (0.002)	0.3684*** (0.001)	0.0884** (0.037)	-0.0044 (0.904)	0.6178	2.0963

Note: ** and *significant at 5% and 10% levels, respectively. p values are given in the parenthesis

The estimated parameters of the production function were then used to calculate the TFP growth in the coconut sector as given in Equations 7. This analysis revealed that the rate of growth of TFP in the Sri Lankan coconut sector from 1985−to 2019 was -1.1% (Table 4). The reasons for the diminishing growth of the coconut sector may be the reason of lack of research and development; poor infrastructure; and problems with technology transfer resulting from inputs used in stage III of production and the technological frontier has not expanded.

This study's results are consistent with Sri Lanka's food manufacturing industry –0.61%[23] and inconsistent with the rate of growth of TFP recorded for coconut in Kerala at 0.051%, a study conducted for the period 1980–81 to 2004–05[29], for coconut in the Philippines at 1.52%[30], and the most recent study conducted by[30] for the Sri Lankan coconut plantation sector, indicating that large-scale plantations have positive TFP growth of 0.083%. Smallholders are more responsible for the negative TFP growth. Therefore, technology transfer towards smallholders is very important. However, it is important to note that the latter study has employed annual time series data of the Sri Lankan coconut estates, which are managed under company management and account for around one-fifth of the total coconut land area in the country, for their estimations. In contrast, this study employed annual time series data for the whole domestic coconut industry.

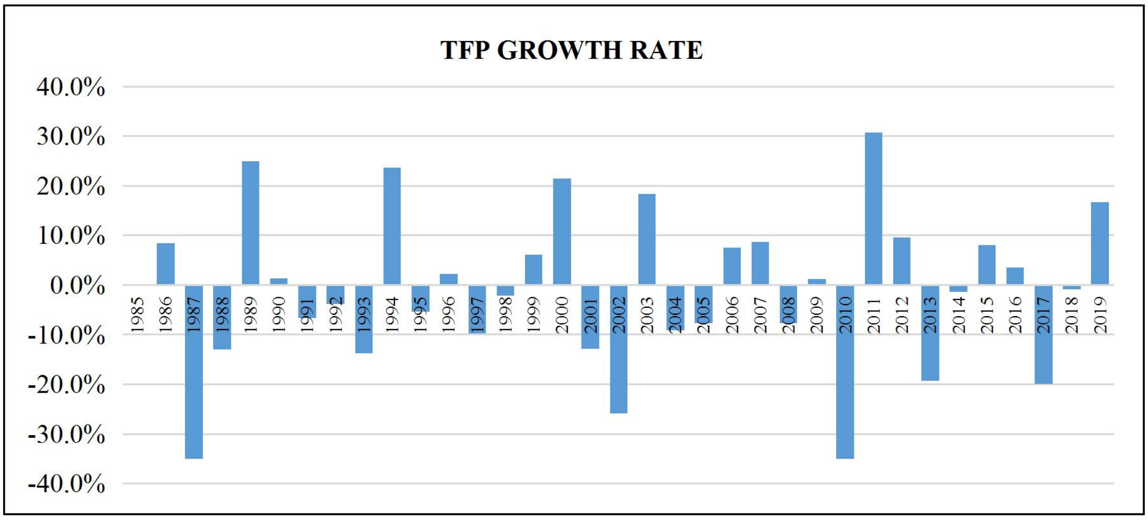

Figure 4: TFP growth in the coconut sector in Sri Lanka (1985-2019).

The trends in relation to the TFP growth for the domestic coconut sector have produced mixed results over the considered period (Figure. 4). According to the estimates, the highest positive value of TFP growth rates has been achieved in 1989,1994,1999,2006, 2011,2014, and 2019, whereas the highest negative value of TFP growth rates has been recorded for the years 1987,1988,1991, 2002, 2010, 2013 and 2017. However, this inconsistency in TFP growth trends is not uncommon in recent empirical studies. Abeysekara, M.G.D, Prasada, D.V.P and Pathiraja, P.M.E.K.[30], studying the TFP growth in coconut crop in Kerala, find that TFP growth has shown mixed results over the two policy reform periods, 1980–1994 and 1995-2004, and TFP growth is seen to have slightly increased over time. Similarly,Abeysekara, M.G.D, Prasada, D.V.P and Pathiraja, P.M.E.K.[30], studying the TFP growth Sri Lankan coconut sector, find that; TFP growth has shown mixed results over the three policy reform periods, 1961-1982,1983-2002, and 2004-2017, and TFP growth is seen to have marginal fluctuations over time.

According to the study results, there was very low (negative) TFP growth for some of the years while there is positive growth for several years. However, in particular, there was a negative growth in TFP at the first sub-period. Then it has further decreased slightly during the second sub-period resulting in an overall negative TFP growth in the entire period considered as shown in Figure. 2. The reason for causing lower TFP growth in the Sri Lankan coconut sector seems to be the high contribution to gross output by inputs, including the climatic variables and fertilizer. Although this phenomenon is not much prominent during the 1985–2000 sub-period, it has recorded a noticeable improvement during the post-2000 sub-period with further increase input growth resulting in a negative TFP growth. It is also noticeable that the fertilizer input growth rate increased from 1.5% to 6.3 % over the two sub-periods.

The increase in rainfall and increment of dry months have considerably increased from 0.2% to 3.3% and 6.6 % to 9.6%, respectively, partly explaining the negative TFP growth in the post-2000 period. The growth of area cultivated and the labor usage remains comparatively unchanged during the two sub-periods while the growth of output has declined from 1.1% to 0.6%. As shown in Figure. 3, the average TFP growth of the Sri Lankan coconut sector for the entire period (1985–2019) has been −1.1 percent. A closer look at the two sub-periods reveals that this negative TFP growth recorded for the entire period has been due to the very low TFP growth (−1.9%) achieved in the post- 2000 period compared to the low TFP growth of -0.1% achieved in the pre-2000 period. However, according to Abeysekara, M.G.D, Prasada, D.V.P and Pathiraja, P.M.E.K.[30], large-scale coconut plantations have shown positive TFP growth. The analysis of the returns to scale for the period of 1985-2019 can be done based on the estimates of the stochastic frontier production function in Table 4 determining the scale benefit of coconut production has been done by summarizing the input coefficients other than the land factor. The sum of the coefficients is 0.0428, which, implies that the coconut production system in Sri Lanka operates at decreasing returns to scale.

Although inputs have increased considerably, TFP growth in the post-2000 period has recorded a significant decline compared with the pre-2000 subperiod. The changes in TFP growth in the coconut sector during the study period can be attributed to some of the policies and programs implemented. This section summarizes the main policies and programs that successive governments implemented to promote the growth of the coconut sector during the period under consideration. Even though it is difficult to precisely align the effects and implications of these development strategies to the productivity growth trends over individual years, these strategies have had a notable impact on productivity measures, possibly with lagged effects on the domestic coconut sector. There were different programs to improve the sector's productivity by increasing the use of fertilizer and improving the quality of planting materials. There may be some economic justification for a subsidy to attract non-users, but the optimal subsidy is unlikely to be as high as the present 50% level. In any case, if the failure is in the understanding of (especially small) farmers as to the optimal dosage, a better instrument (from both an efficiency and a distributional viewpoint) is to expand extension services, especially to small farmers, to provide them with information on optimal fertilizer dosages.

Table 4: Summary of econometric estimations and input/output growth rates of coconut cultivation in Sri Lanka

Study Period	Land		Labor		Rainfall		Dry months		Fertilizer		Output growth	TFP growth
	Elasticity	G/R	Elasticity	G/R	Elasticity	G/R	Elasticity	G/R	Elasticity	G/R		
Sub period I (1985-2000)	-1.0333 (0.501)	0.7%	-1.1590* (0.095)	-1.7%	0.0027 (0.992)	0.2%	0.0903 (0.191)	6.6%	0.2532* (0.082)	1.5%	0.6%	-0.1%
Sub period II (2001-2019)	0.1336 (0.673)	0.8%	-0.2744 (0.203)	-1.5%	0.3667*** ** (0.002)	3.3%	0.0133 (0.782)	9.6%	-0.0426 (0.212)	6.3%	1.1%	-1.9%
1985-2019	-0.2132 (0.502)	0.7%	-0.4140* (0.002)	-1.6%	0.3684*** (0.001)	1.9%	0.0884** (0.037)	8.2%	-0.0044 (0.904)	4.1%	0.8%	-1.1%

Note: ** and *significant at 5% and 10% levels, respectively. p values are given in the parenthesis

The fertilizer subsidy scheme for coconut in Sri Lanka was introduced in 1956. Under this scheme, coconut fertilizer was made available at a 50% subsidy rate. This specific fertilizer subsidy was then abolished, and it was made a general fertilizer subsidy for all crops in 1976. The coconut producers were further assisted by a special credit scheme for coconut fertilizer which came into effect in April 1979, giving credit at a low-interest rate (9%), with repayment over 5 years, inclusive of a grace period of 2 years. This has been discontinued since 1988. The subsidy rate for NPK mixtures has increased to 75% during 1979-83. Fixed fertilizer prices had been maintained during 1983-87. The price level for a 50-kg bag was set at LKR 350 in 1994, LKR 600 in 1996, LKR 350 in 1997-2002, LKR 800 in 2003, and again LKR 350 in 2005. In 2015 the successive government changed the fertilizer subsidy into a cash transfer system, which was a failure. Subsequently, in 2017, the government decided to provide a 50-kg bag of fertilizer at LKR 500 to farmers with less than five acres and at LKR 1,500 to tea, coconut, rubber and other crop growers.

These policy measures are reflected by the substantial increase in the fertilizer input growth rate during the sub-period 2001-2019. The provision of fertilizer subsidies was expanded in 2006, which yielded both favorable and unfavorable results. Later, smallholders who own less than 5 acres of tea, rubber, or coconut land were also provided with a 50 kg bag of urea at a subsidized rate of LKR 1,200[31]. Although there have been so many subsidy schemes given to increase the usage of fertilizer. However, according to table 4, the output elasticity of fertilizer is positive and significant only in the 1985 to 2000 period. There may be a reason for the overuse of fertilizer. In contrast, the output elasticity of drought is positive. There may be a reason why, without rainfall, pollination of the coconut flowers is enhanced. This is consistent with the finding that rainfall washed off the fallen and reduced pollination[32].

In 2011, the "*Kapruka Purawara*" program was implemented to enhance coconut production by up to 3,650 mn nuts by 2016. Under this program, around 4 mn coconut plants were distributed in 2011. Another 6 mn plants were distributed in 2012[33]. In 2017, subsidy programs for soil conservation, organic fertilizer, dolomite application promotion, and drip irrigation systems were initiated by the CCB to increase coconut production in the short term[34]. However, amidst these subsidy schemes for expanding the coconut land extent, the growth of cultivated land area under coconut remains unchanged (i.e. 0.7% and 0.8% during the two sub-periods, respectively). In contrast, the growth of output declines from 1.1 % to 0.6%, suggesting the importance of revisiting the effectiveness of these development programs.

Increased public sector research investment is one of the most important policy measures that can be implemented to boost the productivity of the coconut sector. Technical change, achieved through research in agriculture, is the most critical variable in increasing productivity in agriculture.Arndt, T.M. and Ruttan, V.W.[35] reported that returns to investment in agricultural research have been two to three times higher than those of many other social investments. Although large-scale coconut plantations have accounted for 20% of the total area, if the research in the coconut industry is to be carried out by the organized plantation sector, the direction of research would be biased towards large plantations rather than small and subsistence farms.

The Coconut Research Institute (CRI) has developed hybrids for the wet-zone areas of the island. Although the high yields from the new varieties are consistent with the land-saving objective. The inputs and sophisticated management required for hybrids are biased more towards organized plantations than small and subsistence farms. The plantation sector bias by the CRI in generating technology can be attributed to historical factors and the greater demand by estates for research outputs. The colonial rulers established the research institute for the coconut industry to cater to the requirements of the plantation (export) sector, in which they had a main interest. Even after Independence, CRI has continued to fulfill the objectives set by the colonial rulers with less attention devoted to the requirements of small farmers. The majority of potential beneficiaries of the technology in the coconut growing industry are small subsistence farmers who tend to be less educated, less politically articulate, and less organized as a pressure group. They are in a poorer position to create an effective demand for appropriate technology.

3.4 Decomposition of coconut output growth

The estimation result of coconut output growth shows how the output changes when land, labor, rainfall, dry months, and fertilizer application change while other inputs contributing to coconut output remain constant. Such inputs include research, extension, credit, and infrastructure development. Table 3.6 shows that from 1985 to 2019, coconut output grew at a 0.8% annual rate. The weighted growth rates of input were calculated by multiplying the growth rates of land, labor, rainfall, dry months, and fertilizer by their elasticity values.

Table 5: Output growth, TFP and contribution to output growth

		CONTRIBUTION TO OUTPUT GROWTH						
Period	**Subsidy regime**	**Land**	**Labor**	**Rainfall**	**Dry Months**	**Fertilizer**	**Output Growth**	**TFP Growth**
1985-2000	few fertilizer subsidy schemes	-0.723	1.9703	0.00054	0.5959	0.3798	1.1	-0.1
	Contributions to growth	-19.19%	52.26%	0.01%	15.81%	10.07%		-2.65%
2001-2019	many fertilizer subsidy schemes	0.1069	0.4116	1.2101	0.1277	-0.2684	0.6	-1.9
	Contributions to growth	2.66%	10.23%	30.07%	3.17%	-6.67%		-47.21%
1985-2019	Overall	-0.149	0.6624	0.7000	0.7249	-0.0180	0.8	-1.1
	Contributions to growth	-4.45%	19.75%	20.87%	21.61%	-0.54%		-32.79%

The output growth is calculated as follows;

$$\text{Output growth} = TFP + \lceil (\alpha \text{ fertilizer}) + (\beta \text{ labor}) + (\gamma \text{ rain}) + (\lambda \text{ dry}) + (\theta \text{ area}) \rfloor \quad (8)$$

Where:

α, β, γ, λ and θ are elasticity values of fertilizer, labor, rainfall, dry months and area cultivated respectively.

The percentage contribution of TFP and other inputs during the three eras is shown in table 5 and figure 5 when compared with the different fertilizer subsidy regimes during the pre and post-2000 period revealed that fertilizer policy doesn't influence its output growth much from 1985-2019: from 1985 to 2000 fertilizer was contributed 10.07% to coconut output, and -6.6% from 2001 to 2019 while fertilizer contributed only – 0.54% to output growth for overall period from 1985 to 2019.

The contribution of the land to coconut output declined over the period of 1985 to 2019. The contribution of labor to the coconut output was 52% in 1985-2000 and it has come down drastically to 10.23% during 2001–2019, reflecting a sharp decline in the labor component to the coconut output growth. The contribution of rainfall was marginal (0.01%) during 1985-2000, but it has increased drastically, up to 30% during 2001-2019, and for the entire period it was 20.87%, reflecting the gravity of the moisture for the output growth in the recent past. The contribution of the dry month was 15.81% from 1985 to 2000, but it has dropped to 3.17% from 2001 to 2019. Overall TFP growth was negative from 1985 to 2000, contributing to -2.65%, and it has since dropped dramatically to -47.21% from 2001 to 2019, and it was -32.79% from 1985 to 2019 (Figure 5).

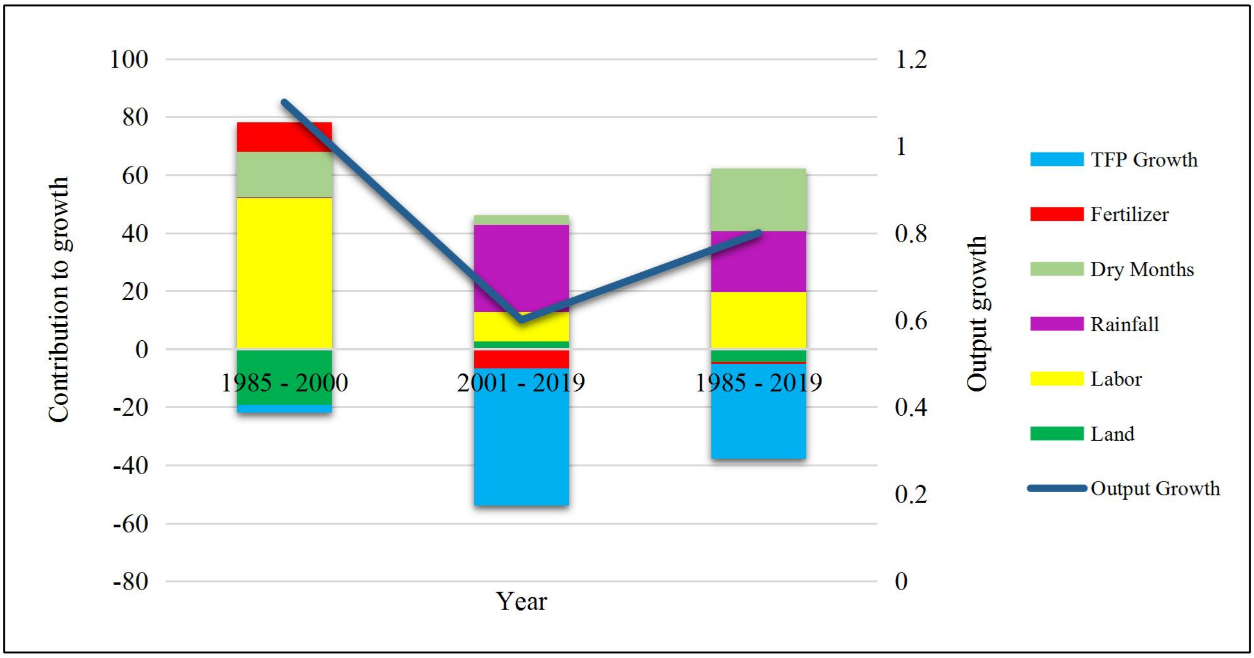

Figure 5: Contribution to output growth of coconut in Sri Lanka: 1985-2019

4. Conclusions

The productivity growth of the Sri Lankan coconut sector was estimated and reviewed during the period 1985–2019. The empirical estimates of TFP growth were calculated using a log-transformed Cobb–Douglas production function using a data set sourced from various government publications. According to the findings of the study, the average TFP growth of the coconut sector in Sri Lanka for the period 1985-to 2019 has been -1.1% whereas it was -0.1% and -1.9% during the two sub-periods; 1985-2000 Subperiod I, 2001-2019 Subperiod II respectively, demonstrated a diminishing growth rate. Therefore, it is evident that the negative growth of the TFP is mostly driven by the high negative growth in the post -2000 period. However, the overall coconut sector is characterized by low productivity growth. When decomposed the results for entire study period of 1985-2019 contribution of fertilizer for output growth was -0.54%, land -4.45%, rainfall 20.87%, Dry month 21.61% and TFP contribution to output growth was -32.79%.

Several factors have been identified as agents for overcoming the sluggishness of the coconut sector. Both institutional and technological factors work behind a thriving coconut sector. Land reform measures are one of the important institutional changes that invigorate agricultural development, which was already implanted in the coconut sector. The other institutional mechanism is related to the provision of credit. Thus, land reform measures and an institutional credit system may be reckoned as favorable factors for the growth of the coconut sector. Generally, the crucial factors that govern the growth of the agricultural sector are a vibrant market for agricultural labor and technological change.

Many research studies in the remote and recent past on the crop sector as a whole and on specific crops, in particular, concluded that the prime factor behind the diffidence of the agricultural sector was the absence of productivity growth and stagnant technology. However, the performance of the agricultural sector, especially in developing countries, often depends on environments outside the reach of policy-makers. The weather, world prices (depending on how much the world demands agricultural products and how much the rest of the world delivers), external trade barriers, terms of trade, and global market access all play a pivotal role in influencing agricultural outcomes. Consequently, the agricultural sector is arguably more susceptible and more reliant on fair global policy changes than any other sector. However,[30] found the marginal growth of the coconut plantation sector. Therefore, in this study at the national level, the coconut sector has shown negative TFP growth. There may be a reason that the majority of the smallholdings may have negatively contributed to the TFP growth.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

References

1. Salgado, M. L. M. (1955). History and development of the coconut industry of Ceylon, Part I, Coconut Research Institute, Sri Lanka, 45-46p.
2. DCS (2014). Sri Lanka Agricultural Census. Department of Census and Statistics Colombo, Sri Lanka.
3. CRI. (2020). Status of coconut sector development in Sri Lanka. (Unpublished). Coconut Research Institute, Lunuwila, Sri Lanka
4. CBSL (2019). Annual Report. Colombo: Central Bank of Ceylon.
5. CDA (2019). Sri Lanka Coconut Statistics. Coconut Development Authority, Colombo, Sri Lanka.
6. Mahadevan, R. (2003). Productivity growth in Indian agriculture: The role of globalization and economic reform. Asia-Pacific Development J. 10(2): 57-71.
7. Saikia, D. (2009). Total Factor Productivity in Indian Agriculture: Some Conceptual and Methodological Issues. MPRA Paper No. 28578. Retrieved from: https://mpra.ub.uni-muenchen.de/id/eprint/28578.
8. Ludena, C. (2010). Agricultural Productivity Growth, Efficiency Change and Technical Progress in Latin America and the Caribbean, Washington, DC: Inter-American Development Bank
9. Nishimizu, M and Page, J. M. (1989). Productivity change and growth in industry and agriculture: An international comparison. In J. G. Williamson, and V. R.
10. Murray, A. (2016). Partial versus total factor productivity measures: An assessment of their strengths and weaknesses. Int. Productivity Monitor 31(Fall): 113-126.
11. Solow, R. M. (1957). Technical Change and the Aggregate Production Function. Review of Economics and Statistics, 39, 312-320.
12. Denison, E. (1967). Why Growth Rates Differ. Washington DC: The Brookings Institution.
13. Denison, E. (1972). Some Major Issues in Productivity Analysis: an Examination of the Estimates by Jorgenson and Griliches. Survey of Current Business, 49(5), 1-27.
14. Christensen, L. R. (1975). Concepts and Measurement of Agricultural Productivity. American Journal of Agricultural Economics, 57(5), 910-915.
15. Bosworth, B. and Collins, S.M. (2003). The Empirics of Growth: An Update. Brookings Papers on Economic Activity 68. Retrieved from https://www.researchgate.net/publication/4987141_The_Empirics_of_Growth_An_Update
16. Liman, Y.R and Miller, S.M. (2004). Explaining Economic Growth: Factor Accumulation, Total Factor Productivity Growth, and Production Efficiency Improvement. The University of Connecticut.
17. Fernandez, E, Erik, E.L, Davies, M and Kock, U. (2005). Sri Lanka: Selected Issues and Statistical Appendix. International Monetary Fund. Retrieved from: https://www.imf.org/external/pubs/ft/scr/2005/cr05337.pdf.
18. Duma, N. (2007). Sri Lanka's Sources of Growth. Washington D.C. International Monetary Fund.
19. Gamage, G.G and Kankanamge, A. (2013). Factors Affecting Total Factor Productivity Growth in Sri Lanka. Modern Sri Lanka Studies, 4(1), 1-24.
20. Kumari, R. D. and Tang, S. H. (2019). Sri Lanka's Sources of Growth: The Application of Primal and Dual Total Factor Productivity Growth Accounting Approaches. 12th International Research Conference. Colombo: Central Bank of Sri Lanka.
21. Athukorala, P. and Jayasuriya, S. (2000). Trade policy reforms and industrial adjustment in Sri Lanka. World Economy, 23(3):387-404. Retrieved from: https://onlinelibrary.wiley.com/doi/pdf/10.1111/1467-9701.002718. [Accessed 15th January 2019].
22. Navaratne, D. and Jayawardane, A. (2007). Total Factor Productivity in Building Construction. Engineer, 40(1): 63-70.
23. Swarnathilake, C, Weerahewa, J and Bandara, Y. M. (2019). Productivity Growth in Food Manufacturing Industry: Empirical Evidence from Post reform Sri Lanka. Global Business Review, 1-25. DOI: 10.1177/0972150919884405.
24. Abeysekara, M.G.D and Prasada, D. (2021). Returns to Factors of Production and Total Factor Productivity in Coconut Plantations in Sri Lanka, Tropical Agricultural Research. 32(1), 58-67.
25. Comin, D. (2010). 'Total Factor Productivity'. In

S.N. Durlauf and L. Blume, Economic Growth. The New Palgrave Economics Collection. London: Palgrave Macmillan. Retrieved from: https://link.springer.com/chapter/10.1057%2F9780230280823_32.

26. Abramovitz, M. (1956). Resource and output trends in the United States since1870. In M. Abramovitz (Eds.). National Bureau of Economic Research. Inc. 1-23.Retrieved from: http://www.nber.org/chapters/c5650
27. Aragon, C.T, Carambas, N, Andres, R., Roxas, K and Fernandez, D. (2013). Total Factor Productivity Growth in the Philippine Coconut and Sugarcane Sub- sector. Republic of the Philippines: SEARCA, DA-BAR, and PhilRice.
28. Samarajeewa, S. (2000). A Production Function Approach in Coconut Cultivation. Proceedings of the 56th Annual Session, Part 1 - Abstracts (p. 276). Colombo: Sri Lanka Association for the Advancement of Science (SLASS).
29. Kottayi, S. B. (2008). Productivity Behaviour in Kerala's Agriculture. The University of Calicut.
30. Abeysekara, M.G.D, Prasada, D.V.P and Pathiraja, P.M.E.K. (2020). Equilibrium relations in the coconut sector: an analysis of fresh nut, oil, and desiccated coconut market in Sri Lanka for the period 1956-2017. Tropical Agricultural Research, 31(1), pp.1–12.DOI: http://doi.org/10.4038/tar.v31i1.8339
31. CBSL (2006). Annual Report. Central Bank of Sri Lanka, Colombo.
32. Mangika, T.P.S, Jayasinghe, U.K, Jayalath, K.V.N.N and Pathiraja, P.M.E.K. (2009). Exploring the efficiency of coconut production in Sri Lanka: Where the lazy man's crop lies? Department of Agribusiness Management, Wayamba University of Sri Lanka. pp. 43-48.
33. CBSL (2011). Annual Report. Central Bank of Sri Lanka, Colombo.
34. CBSL (2017). Annual Report. Central Bank of Sri Lanka, Colombo.
35. Arndt, T.M. and Ruttan, V.W. (1977). 'Valuing the Productivity of Agricultural Research'. In: Arndt, T.M., Dalrymple, D.G. and Ruttan, V.W. (Ed), Resource allocation and productivity in national and international agricultural research, University of Minnesota Press, Minneapolis, USA.