

RESEARCH ARTICLE

Financial and Economic Sustainability and Risk Resiliency of Coconut-Based Agroforestry Systems in Sri Lanka

S. M. M. Samarakoon^{1*}, H. L. J. Weerahewa², D. K. N. G. Pushparkumara² and L. H. P. Gunaratne²

¹Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka

² Faculty of Agriculture, University of Peradeniya, Sri Lanka

*Corresponding Author : S. M. M. Samarakoon, Email: smmsamarakoon@gmail.com

ABSTRACT

Coconut plantations in Sri Lanka are predominantly maintained as mono-crops and receive relatively low returns than other intensified land-use systems. However, it was evident that over 20% of coconut plantations in the country could be used more productively and profitably by incorporating Coconut Based Agroforestry Systems (CBAS). Therefore, the objective of the present study was to assess the financial and economic viability and risk resiliency of CBAS compared to coconut mono-cropping. The cost-benefit analysis was carried out to determine the financial and economic viability, and a sensitivity analysis was conducted to assess the resilience to perceived risk. Data recorded by Kurunegala Plantations Limited from 88 coconut plantations representing 15 intercropping systems from 2007 to 2019 were used for the analysis. Results of the financial analysis of selected estates revealed that almost all the intercrops except groundnut and betel were financially viable. Accordingly, the highest Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratio (BCR) were observed in the CBAS, including rambutan and pineapple, indicating that they are the most financially viable CBAS. According to the sensitivity analysis, almost all the perennial crop-based agroforestry systems were financially viable except for guava and pepper in the presence of the three worst scenarios tested, namely; reduction of output price by 10%, removal of fertilizer subsidy, and increase of wage rate by 15%. Notably, all the CBAS were economically viable. These results provides the information for growers and policymakers in selecting risk resilience agroforestry systems under coconut.

Keywords: Coconut based agroforestry systems, cost-benefit analysis, intercropping, perennial crops, risk resiliency

1. INTRODUCTION

Coconut (*Cocos nucifera* L.) is a traditional and the most widespread plantation crop in Sri Lanka, covering an area of 440,536 ha (CBSL, 2019) or nearly 20% of agricultural lands in the country (DCS, 2014). It plays a significant role in the national economy by contributing about 0.7 % to the Gross Domestic Production, 2.8% to the agricultural earnings, and 5.1% to total export earnings, respectively, in 2019 (CBSL, 2019). Coconut is primarily a smallholder crop, and about 85% of holdings in the country have an average holding size of less than 8 ha. The balance is over 8 ha, categorized as estates (DCS, 2014). In Sri Lanka, most of the coconut lands are maintained as monoculture and thus, receive relatively low returns than intensified land-use systems (Peiris et al., 2003a). Therefore, to improve the productivity of the existing coconut lands, the shift from coconut monoculture to Coconut Based Agroforestry Systems (CBAS) has been recognized as one of the national priorities for developing the coconut industry since the early 1990s (Liyanage, 1994). Moreover, using criteria such as rainfall regimes and soil type, Ranatunga et al. (1988) proposed that approximately 110,000 ha of coconut lands are agronomically suitable for establishing CBAS in the country. However, despite the government efforts to provide subsidies, low-interest loans, and extension support to popularize CBAS over the past two decades, the adoption rate of CBAS in the agronomically potential area is limited to 25% (Fernando et al., 2000). Even within the large-scale growers, slow progress has been observed in adopting CBAS. Among the adopters of CBAS, most growers are limited to semi-perennial crops such as banana, pineapple, and betel. The lifetime of these semi-perennials is approximately five years; having completed the harvest, they remove

the intercrops. Hence, diversified lands again become a mono-crop of coconut. Besides, landowners are reluctant to invest in CBAS due to high labor requirements and labor costs, increasing input costs, and fluctuating output prices of products of CBAS. Fernando et al. (2000) stated that risk associated with yield and price outcomes of intercrops appears to be the crucial factors constraining the adoption of CBAS by farmers, thus emphasizing the need for exploring the influence of the above less-frequently addressed aspects on the adoption of CBAS in Sri Lanka. However, despite these limitations, it has been identified that the estate sector has more potential for the establishment of CBAS as the estate sector has organized management practices with high technical expertise. The large-scale CBAS may be described best as an entrepreneur who provides the risk capital and makes all decisions regarding the scale of operation, cropping patterns, and manages the enterprise as a commercially oriented farm unit (Ranatunga et al., 1988), and large-scale coconut growers can also diversify in many different activities of which CBAS has many advantages (Idirisingshe, 2011; Pushpakumara et al., 2011). Furthermore, it is also well accepted that crop diversification is identified as one of the most commonly used risk management strategies in agricultural systems of the world.

Therefore, this paper investigates the financial sustainability and economic viability of CBAS for short-term and long-term coconut land allocation in large-scale coconut plantations. The specific objectives of this paper are to assess the financial and economic viability of 15 CBASs and to identify the risk resilience nature of selected CBAS in the presence of perceived risks.

2. METHODOLOGY

This study used a grower-centered financial and economic costs-benefits and risk analysis of 15 CBAS, but the Coconut Research Institute recommended 26 CBAS systems for the entire Island. However, for the analysis, we considered 15 CBAS systems suggested to the estates in the Kurunegala and Gampaha districts with suitable Agro-Ecological Zones. The activity budgeting method was employed to develop cost and benefit cash flows. Both economic and financial analysis were carried out to determine the financial and economic viability of the selected class. In addition, a sensitivity analysis was conducted to assess the risk resiliency of different systems.

In financial analysis, the analysis is done from benefits accruing to individual participants or beneficiaries of a project or firms and corporations involved that would be interested in profitability in undertaking a proposed enterprise (European Commission, 2008). The financial analysis looks at the economic returns to an individual, a private firm, or a profit-oriented government corporation. It uses market prices of goods and services. In contrast, an economic analysis that measures the benefits and costs to the country does not use market prices because they are distorted. Instead, the economic analysis uses shadow prices, which reflect the opportunity cost of goods and services or willingness to pay. In addition, the economic analysis makes adjustments to transfer payments involved in the project accounts, such as interest payments, taxes, or subsidies. However, in financial analysis, the entities do not add to the country's existing resources and merely represent the transfer of resources. Therefore, transfer payments, such as taxes, subsidies, and interest payments, are considered (Amarasinghe, 2015).

2.1. Financial Analysis

Generally, the financial analysis assesses the economic effect, overall returns, self-financing capability, investment and debt repayment capacities, overall financial projection, and financial management of agricultural projects (Gittinger, 1994). For a new project, the main objective of the economic analysis is to demonstrate that the financial cash flows expected to be generated by attractive to the prospective investors, inducing them to contribute equity funds to the particular project rather than to employ it elsewhere. For a continuing enterprise, financial success would mean the ability to generate enough revenue to meet all its financial obligations on a timely basis and command an adequate level of working capital for continued operations. It also implies the ability to generate a reasonable rate of return on capital employed. The analyses on which such judgments can be based on Internal Rate of Return (IRR), the Net Present Value (NPV), and Benefit-Cost Ratio (B/C). NPV facilitates identifying feasible projects with the scale of operation, IRR guide to ranking the projects and B/C ratio provides the idea of the resource use efficiency (Gittinger, 1994). These three indicators provide a comprehensive analysis of the coconut-based agroforestry systems (CBAS).

The NPV of a project is the sum of the discounted net flows of a project. The NPV is a very concise performance indicator of an investment project. It represents the present amount of net benefits flow generated by the investment expressed in one single value, which was calculated by using the equation (1) as follows:

$$NPV = \sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t} \quad (1)$$

Bt is the benefit in the year, Ct is the cost in the year, and i is the discount rate, n is the number of years, and t= 1, 2..., n. Therefore, a positive NPV, (NPV>0), means that the project generates net benefit, and it is generally desirable either in financial terms or in economic terms.

The IRR is an indicator of the relative efficiency of an investment. The formal selection criterion for the IRR is to accept all independent projects having an internal rate of return equal to or greater than the opportunity cost of capital as given in equation (2).

$$\sum_{t=1}^n \frac{B_t - C_t}{(1+i)^t} \quad (2)$$

The Benefit-Cost Ratio (BCR) is the present value of project benefits divided by the current value of project costs, as shown in equation (3).

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}} \quad (3)$$

2.2. Financial Sustainability

One of the most critical issues to be checked is the financial sustainability of the investment, which implies that, for each year, the cumulated sum of the inflows must be higher than the outflows of that year. Therefore, the resources must be organized to satisfy this condition (European Commission, 2008). Therefore, the total Gross Margin (TGM), returns to variable cost, returns to

labor, and returns to chemical fertilizer were calculated and used to assess the financial sustainability of the production systems.

Annual Total Gross Margin (TGM) estimates the sum of annual net cash flows in the CBAS (Fernando et al., 2000). The yearly gross output of each crop was multiplied by the price to define annual gross income and deducted from the variable cost to determine the annual gross margin.

2.3. Assessment of Resilience to Possible Risk Components

To assess the risk resilience, a sensitivity analysis was carried out. The three most crucial variables of coconut plantations, namely, labor wages, fertilizer subsidy, and output prices were used in the risk assessment. The current fertilizer subsidy is 48% of the cost of fertilizer which is more critical for plantation crops (Ministry of Finance, 2019). Hence, it is possible to consider the worst-case scenario of removing fertilizer subsidy. From 2007 to 2018 (The Kurunegala Plantations Limited [KPL] was taken over by the government in 2005 and started the diversification of which records are available from 2007), the average nominal wage increase of the coconut sector was approximately 15%. Hence, it is possible to consider a worse scenario on the labor wages annual increment of 15%. According to the information during the same period, nominal output prices of the above crops varied approximately by 10%. Therefore, it is also possible to consider a worse scenario on the decrease in output prices by 10%. The Financial Discount Rate (FDR) is the opportunity cost of capital. Opportunity cost means that one will sacrifice a return for another project when using

money in one project. There are several methods to calculate FDR. In this study, the actual (weighted average) cost of capital, which was 9% (CBSL, 2019), was used as the financial discount rate for the analysis. This analysis used 0.4 ha as a land unit which is equal to one acre.

2.4. Economic Analysis

The economic analysis helps to design and select projects that contribute to the well-being of a country. An enterprise is interested in financial profit and the stability of that profit. At the same time, society or government is concerned with much broader objectives such as food security, rural employment, poverty alleviation, and resulting net benefits to society as a whole (Amarasinghe, 2015). In this study, a benefit-cost analysis was undertaken to measure the Economic Internal Rate of Return (EIRR), Economic Net Present Value (ENPV), and Economic Benefit-Cost ratio (EBC).

Economical prices are usually derived by adjusting financial or market prices. Thus, a sound financial analysis provides the basis for a credible economic analysis. However, several adjustments may have to be made to convert the financial costs and benefits. In this sense, data generated for financial analysis were used as a primary source for determining economic prices. Therefore, all the costs and benefits of the research have been valued in monetary terms by converting the financial values using the Border Price Equivalent Value (BPEV) and standard conversion factors (SCF) appropriately. The detailed procedure for generating the economical prices is given in Table 2. The economical cost of the land was calculated based on the leased rental used by the company for

leasing out the land; KPL has leased out the land for out-growers at LKR. 6000/- per annum with an annual growth rate of 0.2, and considered a 9% interest rate as the opportunity cost of capital. Accordingly, the economic price of the land was calculated by using equation (4) as follows:

$$V = R / (i - g) \quad (4)$$

Where;

- V = The imputed value of a parcel of land
- R = Annual rent or income from the land
- i = Interest rate or opportunity cost of capital
- g = Expected real growth rate of the rental price of land

The financial analysis assesses the financial viability of the CBAS in terms of overall financial projection and financial management of the considered agroforestry system. Financial and economic indicators are calculated for 15 CBAS consisting of annual, semi-perennial, perennial crops, and coconut mono-crop cultivation. Coconut is a perennial crop, and the CBAS observed in the field included annual, semi perennial, and perennial crops. The costs and benefits of such crops occur at different times. Therefore, NPV, IRR, and BCR were employed to compare the net worth of the monocrop and integrated system over the entire production period. In contrast, TGM was used to measure financial sustainability.

2.5. Data

The database with unit cost tables was prepared by collecting data from 88 estates belonging to KPL. The estates are situated in all three climatic zones (the Wet, Intermediate and Dry). Since the coconut has been grown in three climatic zones in Sri Lanka, the analysis used 15 CBAS representing three climatic zones of the country. Data recorded by the KPL from 2007 to 2019 for 15 CBAS were used for the study. Details of economic lifespan and other agronomic aspects of the 15 CBAS selected for the analysis are presented in Table 1 and mono-cropped coconut plantations. The prepared unit cost tables were verified with some parallel data collected by the Coconut Research Institute, Department of Export Agriculture, and Department of Agriculture. The calculations of the annual gross margin for each crop are based on January 2019 factor and product prices. The crop budget for 15 CBAS was prepared to examine the financial viability under the possible three major risk components.

The economical prices of outputs were calculated according to border equivalent price value. The economic value of labor was obtained by converting the market value of work into the shadow wage rate. The other relevant economic prices (i.e., price of materials and machinery) were obtained by multiplying financial costs using an appropriate standard conversion factor. Finally, the monetary worth of the land was calculated based on leased rental used by the company for leasing out the land.

Inorganic fertilizer is the only imported input used in these cropping systems. Therefore, CIF fertilizer prices were obtained from fertilizer companies in dollar terms and converted into local

currency using the exchange rate. Then relevant costs such as bagging and transportation were added to get the import parity price at the farm gate. A summary of the financial and economical prices used for the analysis is shown in Table 2.

Table 1 : Details on crops, their economic lifespan, and other agronomic aspects used for the analysis.

Crop	Suitable climatic Zone	Economic lifetime (years)	Unit price (LKR/kg)	Average labor requirement (md/0.4 ha /yr)	Average fertilizer requirement (kg/0.4 ha/yr)	Variety of crop	Spacing (meters)	Plants/0.4 ha as a monocrop	Plants/0.4 ha under coconut
Annual Crops									
Ginger	IZ, WZ	1	190	105	450	Local, Chinese	0.3*0.3	30,000	20,000
Ground Nut	DZ	1	125	75	340	MI-1	0.4*0.4	50,000	35,000
Semi Perennial Crops									
Banana	All Three	5	40	57	375	Local varieties	2.4*2.4	675	250
Betel	IZ	5	1.5/leaf	167	621	Local varieties	0.4*0.3	2,000	1,000
Papaw	DZ, IZ	5	30	59	294	Rather, Red Lady	3*3	450	300
Pineapple	WZ, IZ	5	115	49	739	Mauritius	0.6*0.4 Single raw	6,000	4000
Perennial Crops									
Cinnamon	WZ, IZ	20	2200	30	115	Local	0.9*1.2	3,600	1,024
Cocoa	WZ, IZ	20	400	12	150	NA 32 Millawana	2.4*3	445	200
Dragon Fruit	IZ, DZ	20	310	63	630	Red	3.6*3.6	300 Posts	150 Posts
Mango	DZ, IZ	20	200	34	65	TOMEJC	7.2*7.2 (Monocrop) 8*16 (Intercrop)	75	30
Guava	DZ, IZ	20	80	56	625	Horana	3.6*3.6 (Monocrop) 3.6* (Intercrop)	300	150
Pepper	WZ, IZ	20	650	65	338	Panyur	2.4 * 2.4	688	350
Cashew	DZ, IZ	20	300	14	56	WUSS	6*6 (Monocrop) 8*16(Intercrop)	80	30
<i>Rambutan</i> (<i>Nephelium lappaceum</i>)	WZ	20	2.5/fruit	27	79	Malwana special	10*10(Monocrop) 8*16(Monocrop)	40	30
<i>Durian</i> (<i>Durio</i>)	WZ	20	150/fruit	15	114	Golden pillow	10*10(Monocrop) 8*16(Monocrop)	40	30

Note: Wet Zone (WZ), Intermediate Zone (IZ), and Dry Zone (DZ) Fertilizer requirements and spacing of crops are based on respective institutional recommendation

Table 2 : Financial and economical prices used in the analysis.

Description (Input/ Output)	Financial Price (LKR)	Economic Price (LKR)
Output prices (LKR/Kg) FOB prices of outputs were converted into economic prices at the farm gate		
Banana	40.00	58.00
Betel	187.00	301.00
Cashew	300.00	228.00
Cinnamon	2,200.00	1468.00
Cocoa	400.00	293.00
Dragon fruit	310.00	217.00
<i>Durian</i>	150.00	153.00
Ginger	190.00	189.00
Groundnut	125.00	204.00
Guava	80.00	148.00
Papaw	30.00	40.00
Pepper	650.00	675.00
Pineapple	115.00	156.00
<i>Rambutan</i>	75.00	107.00
TOMJC mango	200.00	185.00
Price of materials (LKR/Kg) Financial price of materials (Plants, fertilizer, chemical, tools and equipment) were multiplied by 0.92 to get the economic price (Calapur irrigation project ADB, 2013)		
Banana	25,000.00	23,000.00
Betel	64,000.00	58,880.00
Cashew	6,600.00	6,072.00
Cinnamon	34,582.00	31,815.00
Cocoa	5,900.00	6,007.60
Dragon fruit	280,000.00	274,988.00
<i>Durian</i>	6,300.00	5,796.00
Ginger	99,550.00	91,586.00
Ground nut	5,760.00	5,299.00
Guava	25,125.00	28,635.00
Papaw	25,800.00	23,736.00
Pepper	19,016.00	17,495.00
Pineapple	331,500.00	327,943.20
<i>Rambutan</i>	6,400.00	5,888.00
TOMJC mango	21,000.00	19,320.00

Machinery(LKR/Tractor hour) Financial cost of machinery usage was multiplied by 0.87 to get the economic value (Jalalpur irrigation project ADB, 2013)

Banana		25,000.00	21,750.00
Betel		39,000.00	33,930.00
Dragon fruit		23,250.00	20,227.50
Ground nut		11,000.00	9,570.00
Guava		6,000.00	5,220.00
Pineapple		2,000.00	1,740.00
Labor wages (LKR/man-day)	A shadow wage rate of 0.70 was used for unskilled labor	851.00	595.00
Fertilizer cost (LKR/kg)	CIF price of fertilizer is converted into local currency and multiplied by the shadow exchange rate of 1.11 and add bagging and transport charges to get import parity price at the farm gate (ADB, 2012).	30.00	70.00

(Sources: Financial prices- Sri Lanka Customs (2019), AgriStat (2019), Economical prices- Authors' calculations)

3. RESULTS AND DISCUSSION

Financial and economic indicators were calculated for 15 CBAS consisting of annual, semi-perennial, perennial crops, and coconut mono-crop cultivation. Comparisons of different agroforestry models with coconut monoculture revealed that the estimated financial and economic indicators are higher in agroforestry models, where some models are more profitable than others. Furthermore, CBASs achieve high and early economic benefits at the farm level and increase employment opportunities.

3.1. Results of The Financial Analysis

The financial analysis assesses the economic viability of the CBAS in terms of overall financial projection and financial management of the considered agroforestry system. Coconut is a perennial crop, and the intercrops observed in the field included annual,

semi-perennial, and perennial crops. The costs and benefits of such crops occur at different times. Therefore, NPV, IRR, and BCR were employed to compare the net worth of the monocrop and integrated system over the entire production period. In contrast, TGM returns to variable cost and returns to inputs were used to measure financial sustainability. Results of the NPV, IRR, BCR, and economic sustainability indicators are shown in Table 3.

According to the Table 3, which presents the estimated financial performance indicators for the 15 CBAS, in an annual crop-based system, only ginger can be grown profitably under the considered agronomic and climatic conditions, as it has a positive NPV with a BCR above 1 (i.e., BCR=2.1). Conversely, groundnut under coconut has a negative NPV with a BCR lower than 1, indicating that this system is financially non-viable under the considered conditions because

ginger generates more income than groundnut. Pineapple generated the highest financial returns among the four crops considered in the semi-perennial crop-based systems than banana and papaya. According to the BCR, growing pineapple was the most efficient option than other semi-perennial crop-based systems.

On the other hand, the betel under coconut was not viable in the financial analysis under the company's management because betel utilized more labor than other semi-perennial crop-based

systems. Hence, growing betel in large-scale CBAS is not financially viable mainly due to the continuous requirement of caring the crop and due to sudden price fluctuations. On the other hand, under the perennial crop-based systems, rambutan generated the highest rate of return. This is due to the high-income generation ability of rambutan from 0.4 ha compared with other perennial intercrops. According to the BCR, this is the most efficient option a grower can choose.

Table 3 : Financial indicators of annual, semi perennial and perennial CBAS.

Crop	Achieving financial sustainability (years)	IRR	NPV (LKR)	BCR
Annual Crops				
Ginger	1		908,603	2.10
Groundnut	-		-52,286	0.84
Semi-Perennial Crops				
Betel	-	-26%	-76961	0.95
Papaw	2	37%	35,636	1.14
Banana	2	33%	41,911	1.13
Pineapple	2	58%	494,377	1.76
Perennial Crops				
Guava	5	15%	143,584	1.19
Cashew	4	24%	84,460	1.62
<i>Durian</i>	8	31%	237,293	2.82
Pepper	7	18%	203,242	1.36
Cocoa	5	35%	253,803	2.45
Cinnamon	6	19%	214,516	1.76
Mango	4	39%	373,858	2.29
Dragon Fruit	3	25%	787,211	1.84
<i>Rambutan</i>	6	44%	526,000	3.04

Recently introduced dragon fruit-based systems generated satisfactory financial returns. Even though mango generated a higher rate of return than cinnamon, BCR indicated that growing mango is more resource-efficient than growing cinnamon. Other perennial crops such as cocoa, pepper, durian, cashew, and guava also generated favorable financial returns.

Different CBAS also reached financial sustainability at other times. This can be attributed to the substantial reduction of the payback period in CBAS due to the generation of multiple income sources even when coconut produces zero income until its bearing stage (Peiris et al., 2003a; 2003b). Moreover, agroforestry practices ensure a proper cash flow during the pre-bearing period (Liyanage et al., 1986). For example, annual crop-based systems reached a positive gross margin within the same year of establishment, whereas semi-perennial crop-based plans got financial sustainability within two years. On the other hand, perennial crop-based systems take 4 to 8 years to reach financial sustainability. Dragon fruit-based cropping systems have the lowest TGM, thus attaining financial sustainability within the shortest period (i.e., four years). In contrast, Durian-based systems take eight years to reach financial sustainability, which is the highest among the perennial crop systems.

3.2. Total Gross Margin

Annual input and output data (cost of production and net sale average) of coconut monoculture and intercropping were used to calculate annual TGM. The length of the project period used for calculating TGM for annual and semi-perennial intercrops was one year and five years, respectively. Although we considered the lengths of the coconut-based perennial

agroforestry systems for the overall analysis as 20 years, it generates positive constant returns after 5 to 9 years. Therefore, we have included TGM only for nine years instead of 20 years to avoid repeating the exact figures up to 20 years.

Table 4 shows the annual TGM of annual and semi-perennial intercropping systems in comparison with mono-cropping coconut. Tables 5 and 6 show the yearly gross margin of perennial intercropping systems in contrast with mono-cropping coconut. In general, coconut monoculture generates negative TGM during the initial years after planting till the yield is established due to its high initial investment. However, in the analysis, an already existing mature coconut monoculture system was considered; thus, the long-term's establishment costs for mature coconut plantations can be regarded as historical costs. Besides, coconut monoculture stands considered in the analysis comprised of Sri Lanka Tall (SLT) palms. The nut yield of SLT increases progressively every year after initial bearing until a maximum is attained at about 16-18 years and is maintained after that, depending on the environmental conditions (Liyanage and Gunathilake et al., 1998). Since the average commercial age of the representative monocrop used in the analysis is 50 years, it has been assumed throughout the study that the survey sample has already achieved the maximum yield. Further, the present average production of 50 nuts/tree would be expected to continue during each year of the entire five years considered in the analysis.

According to the Table 4, all the annual and semi-perennial intercrops, except groundnut, generated higher positive TGM than coconut monocrop under the estate management. Among the two

annual intercrops considered, ginger gives higher TGM than that of coconut monocrop. Pineapple's cropping systems have negative gross margins in the first year in the semi-perennial intercrop category. Pineapple does not generate returns in the first year but incurs high establishment costs. However, from the second year onwards, it

commences producing much higher gross margins than the monocrop system. CBAS consisting of banana, papaw, and betel generate higher positive gross margins than monocrop system in the second year ahead, more elevated than coconut monoculture.

Table 4 : Gross margins of annual and semi perennial intercrops.

Gross Margin (LKR./0.4 ha)					
System	1styear	2ndyear	3rdyear	4thyear	5thyear
Coconut Monocrop	23,137	23,137	23,137	23,137	23,137
Annual Crops					
Coconut + Groundnut	1,491	12,227	12,227	12,227	12,227
Coconut + Ginger	256,732	256,732	256,732	256,732	256,732
Semi Perennial Crops					
Coconut + Pineapple	-442,276	359,074	368,503	337,073	253,198
Coconut + Banana	-79,812	73,135	114,370	42,370	38,837
Coconut + Papaw	-42,699	51,041	83,914	41,265	42,796
Coconut + Betel	-111,745	41,440	39,542	35,283	38,687

According to Table 5 and Table 6, perennial intercrops with coconut take 3 to 5 years to produce a positive gross margin and achieve an annual TGM higher than coconut mono-cropping in varying years. However, among the perennials,

cropping systems which include dragon fruit, generate positive TGM within three years and continue to achieve the highest TGM among the perennials after five years.

Table 5 : Gross margin of perennial intercrops (LKR/0.4 ha).

Year	Coconut monocrop	Coconut+ Dragon fruit	Coconut+ Guava	Coconut+ Pepper	Coconut+ Cinnamon
1	23,137	-354,328	-92,636	-61,624	-64,854
2	23,137	-27,091	-50,714	-31,054	1,072
3	23,137	22,603	-67,203	-32,340	-1,015
4	23,137	67,489	2,883	8,127	-1,266
5	23,137	218,571	47,692	39,693	-133
6	23,137	217,869	95,692	48,686	72
7	23,137	216,869	95,692	76,033	106,489
8	23,137	217,869	95,692	102,529	105,638
9	23,137	216,869	95,692	102,529	105,638

Table 6 : Gross margin of perennial intercrops (LKR/0.4 ha).

Year	Coconut monocrop	Coconut + Rambutan	Coconut+ Durian	Coconut+ Cashew	Coconut+ Cocoa	Coconut+ Mango
1	23,137	3,895	7,150	-671	-8,072	-27,184
2	23,137	14,069	18,472	17,217	11,909	10,495
3	23,137	12,738	17,560	16,752	10,578	9,730
4	23,137	15,157	16,247	21,118	17,378	37,989
5	23,137	11,821	13,555	27,095	36,425	56,847
6	23,137	35,935	11,553	32,261	53,625	79,013
7	23,137	60,829	18,041	34,410	74,025	104,758
8	23,137	96,627	28,563	42,011	84,425	104,758
9	23,137	131,574	39,486	42,011	84,425	104,758

In summary, the annual gross margin analysis suggests that all the intercropping systems considered are superior to monocrop systems in terms of margins /unit of land. Even though net income obtained from a unit holding under coconut is the lowest among plantation crops grown in Sri Lanka (Liyanage, 1994), CBAS can provide a high and consistent income than monocropping (Liyanage et al., 1986; Ranathunge et al., 1988; Gunathilake and Liyanage, 1996;). Reducing fertilizer, weeding, and inter-cultivation costs for coconut has been identified as other secondary benefits. Furthermore, Abeygunawardena and Fernando (1992) have also shown that agroforestry can substantially raise the monetary value of the coconut lands, where mean land value has been increased (8-115%) as a result of coconut intercropping compared to coconut monocropping. Among the annual, semi-perennial, and perennial systems, ginger, pineapple, and dragon fruit are more attractive to provide positive annual gross returns during the entire planting period. Ginger generates comparatively high TGM. Thus, such a crop is much more suitable for poorly endowed farmers and smallholders concerned with sustaining a positive annual cash flow, no matter how low, rather than waiting longer to obtain higher cash flows. In pineapple, the initial investment is much higher than that of other crops in the category. The crop generates its highest TGM five years after the field establishment in dragon fruit. Thus, these crops may be suitable for better-endowed farmers as they can bear the high initial cost and be able to wait for higher returns occurring at later stages (Fernando et al., 2000).

3.3. Assessment of Resilience to Possible Risk Components-Sensitivity Analysis

Results of the sensitivity analysis against the baseline are given in Table 7 and Table 8. The sensitivity analysis for the CBAS was carried out considering seven different scenarios as follows;

- i. Scenario 1: Output price decreased by 10%
- ii. Scenario 2: Wage rate increased by 15% (LKR. 979.00 labor/day)
- iii. Scenario 3: Removal of fertilizer subsidy (LKR. 70.00/kg)
- iv. Scenario 4: Output price decreased by 10%, with the wage rate increased by 15% (LKR. 979.00)
- v. Scenario 5: Wage rate increased by 15% (LKR. 979.00) with the removal of fertilizer subsidy (LKR 70.00)
- vi. Scenario 6: Output price decreased by 10% with the removal of fertilizer subsidy. (LKR. 70.00)
- vii. Scenario 7: Output price decreased by 10%, the wage rate increased by 15% (LKR. 979.00), removal of fertilizer

Results of the sensitivity analysis showed that financial viability is different in different agroforestry systems based on various risk components. According to Table 7, in ginger crops included agroforestry systems, the three indicators considered in the sensitivity analysis IRR, NPV, and BCR exhibit a marginal decrease in all seven scenarios compared to the baseline scenario. It is important to note that the NPV reduced from LKR 908,603.00 to 838,589.00, recording a marginal decline when the fertilizer subsidy was removed (i.e., scenario 3). Moreover,

the system remains financially viable even when these risk scenarios were imposed. On the other hand, the cropping system, which includes groundnut, was not economically feasible in the baseline scenario. Thus, the situation has also worsened in the seven considered methods.

In the semi-perennial intercrop systems, papaya and banana showed a significant decrease in all seven scenarios when considering the IRR. The NPV in the sensitivity analysis of papaya varied from LKR 35,636.00 to LKR -67,961.00, recordings a drastic change in the system's financial viability when all three restrictions were imposed. However, according to BCR, the economic viability of the system declines marginally. Similar movement was observed in the banana-based agroforestry system's IRR,

NPV, and BCR. In contrast, NPV is reduced slightly and still financially viable in the pineapple intercropping system, even if all three risk components are considered together. However, the BCR remains more than one in all scenarios indicating that the pineapple-based systems are financially viable within the risk components.

According to Table 8, all the perennial intercrop systems except guava and pepper, and all the other models are financially viable under the three scenarios. This indicates that the bearing of risk is higher with coconut-based perennial agroforestry systems. These systems require less labor and relatively less chemical fertilizer for a unit of land area. Due to the low labor and the less amount of fertilizer requirement, high financial returns from a unit area of land.

Table 7 : Results of the sensitivity analysis against the baseline of annual and semi perennial CBAS.

Crop	Performance indicator	Baseline	OP		Fertilizer Subsidy (FS)=0	decreased	WR	OP	OP decreased
			Output price (OP)	The wage rate (WR)		by 10%	increased by 15%	decreased by 10%	increased by 15%
			decreased by 10%	increased by 15%		and WR increased by 15%	by 15%	FS=0 and FS=0	FS=0 and FS=0
based agroforestry systems									
Ginger	IRR								
	NPV	908,603	734,930	856,326	838,589	682,653	786,312	664,916	612,640
	BCR	2.10	1.89	1.97	1.93	1.78	1.83	1.74	1.64
Ground nut	IRR								
	NPV	-52,286	-79,076	- 89,590 -	105,185	-116,380	-142,489	-131,975	-169,279
	BCR	0.84	0.75	0.75	0.72	0.67	0.65	0.65	0.59
Semi perennial crops based agroforestry systems									
Papaya	IRR	37%	14%	14%	1%	-12%	-27%	-31%	
	NPV	35,636	6,386	6,864	9,939	-22,386	-38,711	-39,189	-67,961
	BCR	1.14	1.02	1.02	0.97	0.92	0.88	0.87	0.79
Banana	IRR	33%	15%	17%	-1%	-3%	-23%	-31%	
	NPV	41,911	9,257	13,698	16,433	-18,957	-44,647	-49,088	-77,302
	BCR	1.13	1.03	1.04	0.96	0.94	0.89	0.87	0.81
Pineapple	IRR	58%	48%	55%	45%	45%	42%	35%	32%
	NPV	494,377	383,555	469,218	377,953	358,396	352,794	267,131	241,972
	BCR	1.76	1.59	1.70	1.49	1.53	1.45	1.35	1.31
Betel	IRR	-26%							
	NPV	-76961	-214043	- 238155 -	170179	-375237	-331373	-307261	-468455
	BCR	0.95	0.85	0.85	0.89	0.77	0.81	0.80	0.72

Table 8 : Results of the sensitivity analysis against the baseline of perennial CBAS.

Crop	Performance indicator	Baseline	Output price (UP) decreased by 10%	The wage rate (WR) increased by 15%	Fertilizer Subsidy (FS)=0	OP		OP	
						decreased by 10% and WR increased by 15%	WR increased by 15% and FS=0	decreased by 10% and FS=0	decreased by 10%, WR increased by 15% and FS=0
Guava	IRR	15%	11%	12%	6%	8%	3%	1%	-2%
	NPV	143,584	42,671	79,285	-76,382	-21,628	-140,681	-177,295	-241,594
	BCR	1.19	1.07	1.10	0.94	0.99	0.89	0.85	0.80
Cashew	IRR	24%	21%	21%	20%	18%	17%	17%	14%
	NPV	84,460	61,693	69,108	64,993	46,341	49,641	42,226	26,874
	BCR	1.62	1.46	1.47	1.43	1.32	1.31	1.29	1.18
Durian	IRR	31%	29%	29%	26%	27%	25%	24%	23%
	NPV	237,293	199,715	223,206	201,190	185,628	187,104	163,612	149,525
	BCR	2.82	2.54	2.56	2.24	2.30	2.07	2.01	1.86
Pepper	IRR	18%	15%	15%	13%	11%	10%	9%	6%
	NPV	203,242	122,061	129,693	86,744	48,512	13,195	5,564	-67,986
	BCR	1.36	1.22	1.21	1.14	1.09	1.04	1.03	0.93
Cocoa	IRR	35%	31%	32%	28%	29%	26%	25%	23%
	NPV	253,803	210,271	238,785	200,059	195,253	185,041	156,527	141,508
	BCR	2.45	2.21	2.26	1.89	2.04	1.78	1.70	1.60
Cinnamon	IRR	19%	18%	17%	17%	15%	15%	15%	13%
	NPV	214,516	164,836	178,923	174,518	129,243	138,924	124,838	89,245
	BCR	1.76	1.59	1.58	1.55	1.42	1.41	1.41	1.27
Mango (Variety - Tom EJC)	IRR	39%	35%	35%	36%	32%	33%	33%	29%
	NPV	373,858	306,755	338,681.17	348,008	271,578	312,831	280,905	245,728
	BCR	2.29	2.06	2.05	2.10	1.84	1.90	1.89	1.71
Dragon Fruit	IRR	25%	22%	23%	20%	20%	18%	17%	15%
	NPV	787,211	610,698	717,759	557,172	541,246	487,719	380,659	311,206
	BCR	1.84	1.66	1.72	1.49	1.55	1.41	1.34	1.27
Rambutan	IRR	44%	41%	41%	41%	38%	39%	38%	35%
	NPV	526,000	446,672	499,855	500,540	420,527	474,395	421,212	395,066
	BCR	3.04	2.73	2.77	2.77	2.49	2.55	2.50	2.29

3.4. Results of The Economic Analysis

An economic benefit-cost analysis was carried out to estimate the EIRR, ENPV, and EBC to measure the economic viability of the CBAS. The estimated performance indicators are presented in Table 9 along with financial performance indicators. Notably, according to the estimated economic indicators, all the CBAS are economically viable. The highest ENPV and EBCR values are given by ginger, pineapple, and rambutan crops in the annual, semi perennial, and perennial cropping systems. Remarkably,

groundnut and betel crops that exhibit negative NPV in the financial analysis have positive ENPV. On the one hand, on a small scale, betel and groundnut crops with coconut may utilize more family labor and generate additional income. However, on the other hand, the existing betel market for export in the country is monopolistic. Thus financial prices are more distorted. Therefore, the economic indicators reveal the actual value of these systems, which hold for the society.

Table 9 : Economic and financial indicators of annual, semi perennial and perennial CBAS.

Crop	Achievement of Financial Sustainability (years)	IRR	EIRR	NPV	ENPV	BCR	EBCR
Annual Crops							
Ginger	1			908,603	943,934	2.10	2.20
Groundnut	-			-52,286	134,719	0.84	1.44
Semi-Perennial Crops							
Betel	-	-26%		-76961	966,618	0.95	1.78
Papaw	2	37%	86%	35,636	121,559	1.14	1.44
Banana	2	33%	101%	41,911	194,264	1.13	1.62
Pineapple	2	58%	111%	494,377	976,035	1.76	2.72
Perennial Crops							
Guava	5	15%	36%	143,584	954,580	1.19	2.00
Cashew	4	24%	15%	84,460	26,945	1.62	1.21
<i>Durian</i>	8	31%	30%	237,293	237,852	2.82	2.73
Pepper	7	18%	22%	148,289	274,171	1.27	1.51
Cocoa	5	35%	31%	220,066	168,842	2.26	2.16
Cinnamon	6	19%	14%	454,560	75,335	2.57	1.31
Mango	4	39%	37%	457,737	326,519	2.57	2.13
Dragon Fruit	3	25%	11%	425,101	83,063	1.34	1.09
<i>Rambutan</i>	6	44%	58%	526,000	892,321	3.04	4.81

The study revealed that the estimated financial and economic indicators are higher in agroforestry models, and some models are more profitable than others. Furthermore, CBAS achieves high and early economic benefits at the farm level and increases employment opportunities.

4. CONCLUSIONS AND POLICY IMPLICATIONS

4.1. Conclusion

This paper assesses the adaptability of 15 CBAS by using financial and economic performance indicators. Also, the risk resilience of CBAS was evaluated in the presence of three major risk components using a sensitivity analysis. Annual time series data expanded over 13 years of 88 commercially managed estates were used for the analysis. The results obtained for financial and

economic indicators concerning coconut monocropping and CBAS provide strong evidence to prove that CBAS are financially and economically advantageous vis-à-vis coconut monocropping. Among the considered 15 CBAS, except groundnut and betel, all the other CBAS are financially profitable at the current average price levels and agronomic and management practices. According to the economic analysis, all the CBAS generate economic benefits over the investment incurred.

The sensitivity analysis results to assess the risk resiliency of 15 CBAS revealed that these cropping systems respond to the risks enacted in varying degrees. Among annual crop-based systems, only ginger shows a marginal decrease in NPV and BCR in all seven scenarios compared to the baseline, thus remaining financially viable even though these risk scenarios were imposed. Pineapple is most risk resilient in the semi-perennial crop-based systems while remaining financially profitable. In the perennial crop-based systems, almost all the perennial crops were financially viable except guava and pepper under the three worst scenarios tested, namely; reduction of output price by 10%, removal of fertilizer subsidy, and increase of wage rate by 15%. Rambutan is the most risk resilience crop. This indicates that the bearing of risk is higher with perennial crop-based agroforestry systems as these systems require less labor and a relatively less amount of chemical fertilizer for a unit area of land. Therefore, these systems are suitable for medium to large-scale coconut plantations. This allows highlighting some important aspects of the domestic policy framework to encourage growing more perennial intercrops in coconut lands and thereby promoting agroforestry systems which in return brings more financial and economic benefits to the growers and environmental benefits to the system and the country. This paper contributes to the existing literature in three ways. First, this is the pioneering attempt at applying a detailed complete economic analysis for the CBAS in the plantation sector in Sri Lanka. Second, this study compares the financial analysis's estimated results, incorporating the possible risk components and underlining the implications. Third; it compared the revenue of CBAS with coconut monoculture systems of annual, semi-perennial, and perennial CBAS.

4.2. Policy Implications

The findings of this study offer substantial insight into the empirical assessment of financial and economic viability and resilience to the possible risk at the estate level, which is a topic full of practical consequences for policymaking. The profitability of agricultural innovation is one of the key considerations for its adaption although it is not the sole criterion. This study has concluded that the CBAS generates higher financial and economic returns than that of coconut mono-crop. Thus, the low adaptability of CBAS may lie with other factors rather than the conventionally held view of the low profitability of CBAS. Therefore, implementing appropriate strategies to realize other important factors such as supplementing the demand for the management of crops including procuring of inputs (i.e. disease-free planting materials, flowering hormones, mulching materials, etc.) and providing skilled knowledge including different agronomic practices (i.e. selection of quality planting materials, use of recommended spacing and pruning techniques, timely application of fertilizer, hormones, and irrigation, timely harvesting, pest and disease management, etc.). Moreover, this study addresses the other crucial factor which seems to minimize the adaption of CBAS, which is the perceived risk associated with output and input prices. The results of the sensitivity analysis revealed that even with the perceived risk of reducing the output price by 10 %, increasing of wage rate by 15 %, and more importantly removal of fertilizer subsidy, most of the CBAS remain financially profitable. Among the perennials, risk resiliency is higher than that of the other systems. Therefore, policy measures can be implemented to derive crop-specific incentive schemes such as the provision of high-quality planting materials and providing technical

assistance. Moreover, it is crucial to revisit the effectiveness of the existing fertilizer subsidy program which constitutes a considerable portion of the state's expenditure and to take measures to either reduce or remove the existing fertilizer subsidy scheme, as the results of this study illustrated and proved the profitability of the CBAS can be maintained even with the removal of the fertilizer subsidy. Our article, therefore, shows that identifying risk resilience intercropping systems under coconut constitutes a first step in the design of policy measures aimed at boosting sustainability at the estate level through coconut-based agroforestry systems.

Declaration of Conflict of Interests

The authors declared no potential conflicts of interest concerning the research, authorship, and publication of this article

5. REFERENCES

- Abeygunawardena.P & Fernando, M.T.N (1992). Sustainability and non-market components in coconut-based farming systems in Sri Lanka. An economic Evaluation Paper was Presented at the 2nd Asian Farming System Symposium held Colombo, Sri Lanka, 2-5 November..
- ADB (2013). Jalalpur Irrigation Project Asian Development Bank, Manila, Philippines
- ADB (2012). Additional Financing: Dry Zone Urban Water and Sanitation Project in the Democratic Socialist Republic of Sri Lanka, Manila.
- Agstat (2019). Agricultural Statistics. Volume: XVI. Socio-Economics and Planning Centre, Department of Agriculture, Peradeniya, Sri Lanka.
- Amarasinghe, N. (2015). Design, appraisal, and sustainable development projects. Books on Demand Philippines, Inc, Manila, Philippines
- CBSL (2019). Monetary Policy Review: No.05-2019. Central Bank of Sri Lanka, Colombo, Sri Lanka. 6
- DCS (2014). Sri Lanka Agricultural Census. Department of Census and Statistics, Colombo, Sri Lanka.
- European Commission, (2008). Directorate General Regional Policy Guide to Cost Benefit Analysis of Investment Projects. European Commission. Regional and Urban Policy Communication Unit, B-1049, Brussels.
- Fernando, M.T.N, Daw ME, & Edward IE (2000). Adaption of coconut-based intercropping systems in Sri Lanka: the fallacy of conventional wisdom on economic profitability. CORD 16: 1-36.
- Gittinger, J.P (1994). Economic analysis of the agricultural project. 2nd ed. Johns Hopkins University Press, Baltimore.
- Gunathilake, H.A.J & Liyanage, M.de S (1996). Terminal Report on coconut intercropping. Council for Agriculture Research Policy, Colombo, Sri Lanka.
- Idirisinghe, I.M.S.K (2011). Socio-Economics Aspects of Coconut-Based agroforestry Systems in Sri Lanka. In: Pushpakumara DKN, Gunasena HPM, Gunathilake HAJ & Singh VP (eds). Increasing Coconut Land Productivity through Agroforestry Interventions. Proceedings of a Symposium Held at the Coconut Research Institute, Lunuwila, Sri Lanka on 15th March 2011. Coconut Research Institute, Lunuwila, Sri Lanka.

- & Singh VP (eds). Increasing Coconut Land Productivity through Agroforestry Interventions. Proceedings of a Symposium Held at the Coconut Research Institute, Lunuwila, Sri Lanka on 15th March 2011. Coconut Research Institute, Lunuwila, Sri Lanka, World Agroforestry Centre, South Asia, New Delhi, India. pp. 77-86.
- Liyanage, M de S, Tejwanii, K.G & Nair, P.K.R (1986). Intercropping under coconut in Sri Lanka. *COCOS* 4: 23-34.
- Liyanage, M. de S (1994). Coconut-based agroforestry in Sri Lanka. *Peekay Tree Crop Development Foundation, Cochin* 682020. Pp. 105-122.
- Liyanage, M. de S & Gunathilake, H.A.J (1998). Agronomy and farming systems research in coconut: Sri Lanka experiences. Proceedings of the International Cashew and Coconut Conference held at Dar es Salaam: 411-417.
- Peiris, W.B.K, Fernando, M.T.N, Hitinayake, H.M.G.S.B, Dissanayake, K.B, Gunathilake, H.A.J and Subasinghe, S.D.J.N (2003a) Economic feasibility and biological productivity of coconut-based agroforestry models in Sri Lanka. *COCOS* 15: 38-52.
- Peiris, W.B.K, Fernando, M.T.N, Hitinayake, H.M.G.S.B, Dissanayake, K.B, Gunathilake, H.A.J, and Subasinghe, S.D.J.N (2003b). Social acceptability of coconut-based agroforestry models developed for smallholders in Sri Lanka. *COCOS* 15: 60-81.
- Pushpakumara, D.K.N.G, Gunasena, H.P.M and Gunathilake, H.A.J (2011). Review of coconut-based agroforestry systems in Sri Lanka. In: Pushpakumara DKN, Gunasena HPM, Gunathilake HAJ & Singh VP (eds). Increasing Coconut Land Productivity through Agroforestry Interventions. Proceedings of a Symposium Held at the Coconut Research Institute, Lunuwila, Sri Lanka on 15th March 2011. Coconut Research Institute, Lunuwila, Sri Lanka, World Agroforestry Centre, South Asia, New Delhi, India. pp. 1-28.
- Ranatunga, A.S, Liyanage, L.V.K, and Perera, R.A.J.R (1988). Coconut-based intercropping systems in the wet and wet intermediate zones. Coconut Research Institute, Sri Lanka.
- SLC (2019). Sri Lanka Customs Statistics-2019, Sri Lanka Customs, Colombo, Sri Lanka.
-