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Assessing Total Sustainability of Coconut Plantations using Multi-Criteria Analysis

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ABSTRACT

Coconut (*Cocos nucifera* L.) is recognized as one of the major plantation crops in Sri Lanka. Sustainable coconut cultivation is a balance between economic, social and environmental priorities. Multi-Criteria Analysis (MCA) is particularly useful as a tool for sustainability assessments. The study was conducted to assess economic, social and environmental sustainability of coconut plantations in the coconut triangle to develop Total Sustainability Index (TSI) in order to rank the plantations based on their current performance levels. Fifteen mature coconut plantations which are having more than 50 ha were selected by using simple random sampling method. The primary data were collected by interviewing plantation managers through a structured questionnaire. MCA was employed to assess each plantation in terms of economic, social and environmental criteria. Narammala plantation had the highest TSI. The coconut plantations were economically viable and the results of Kruskal Wallis One-Way ANOVA test revealed that, there was a significant difference amongst the plantations in the coconut triangle ($P<0.05$). According to the results of Pairwise comparison, plantations in Puttalam district were significantly different from the plantations in Kurunegala and Gampaha districts. Total sustainability can be maintained in long term by producing coconut while protecting environment, ensuring farming is economically viable and maintaining better relationship with workers.

KEY WORDS: Coconut plantations, Multi-criteria analysis, Total sustainability

INTRODUCTION

Coconut is one of the major plantation crops in Sri Lanka. The total extent under coconut cultivation is 394,836 ha (Department of Census and Statistic Annual Report, 2002). Sri Lanka is the fourth largest coconut producing country in the world. The annual coconut production is between 2400 to 3000 nuts in million and average land productivity is around 6,625 nuts/ha/year (Central Bank Annual Report, 2011). The coconut sector plays an important role in contributing to the national economy and ensuring food and nutrition security to large fraction of the population. It contributes about 1.4% to the GDP (of 2.75% of total plantation crops) and 3.57% of foreign exchange. Also it provides a contribute 2.8% to the Gross National Product. Per capita consumption of coconut in Sri Lanka is about 115 nuts per annum (Central Bank Annual Report, 2011).

The coconut sector provides a live hood for about 5% of the total work force engaging about 500,000 people both direct and indirect employment (Liyanage, 1999). The "coconut triangle" refers to the main coconut growing areas, has 230,083ha or around 60% of the country's coconut growing lands (excluding coconut in mixed stands and home gardens), and this is almost entirely within the Kurunegala, Puttalam and Gampaha districts (Department of Census and Statistics, 2002).

Sustainable coconut cultivation is a balance between social, environmental and economic priorities. This means producing sufficient, affordable, quality foods, while protecting the environment and biodiversity and ensuring farming is economically viable and contributes to the well being of local communities while maintaining the ability to do all of this in the long term (Amudhasurabi and Vasanthakumar, 2001).

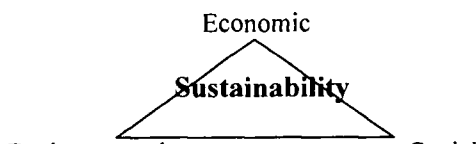


Figure 1. Sustainability triangle

Multi-Criteria Analysis (MCA) is a comprehensive and widely used tool to aid decision-making where there is a choice to be made between competing options. It is particularly useful as a tool for sustainability assessments where a complex and inter-connected range of environmental, social and economic issues must be taken into consideration and where objectives are often competing, making trade-offs unavoidable. It provides a robust and transparent decision making structure, making explicit the key considerations and the values attributed to them, and providing opportunities for stakeholder and community participation

(Massam, 1988). MCA can be applied at all levels of decision-making, from the consideration of project alternatives to broad-reaching policy decisions guiding a transition towards sustainability.

Specific objectives of the study were to assess economic, social and environmental sustainability of coconut plantations in the coconut triangle to develop Total Sustainability Index for coconut plantations in order to rank them based on their current performance levels and to identify the constrains and suggest appropriate remedial measures to increase the sustainability.

METHODOLOGY

Study Area

Study was carried out in Kurunegala, Puttalam and Gampaha districts which are representing the coconut triangle. Fifteen mature coconut plantations which are having more than 50 ha were selected by using simple random sampling method. For the better representation, five coconut plantations were selected from each district (Table 1).

Primary data were collected by interviewing plantation managers through a structured questionnaire during the January to March 2013. The questionnaire was based on costs, benefits, labor wages, welfare facilities and environmental friendly practices. Secondary data for the survey were collected from estate offices and Coconut Research Institute (CRI) in Lunuwila.

Data Analysis

MCA was used as a mathematical tool to develop a Total Sustainability Index in order to rank the selected plantations according to their current performance levels by considering economic, social and environmental criteria. Depending on the plantation managers' perception weightages were assigned to those three criteria. Calculated Benefit Cost Ratio (BCR) was used to represent economic status of the coconut plantations. Collected primary data were used to analyze the social satisfaction levels to represent social responsibility status of the plantations. Five point likert scale was used to measure adoption of environmental friendly practices. Depending on the developed Total Sustainability Index; the selected plantations were ranked and checked whether there is a significant difference between the plantations in the coconut triangle by using Kruskal Wallis One-Way ANOVA test. Pairwise comparison was also performed.

Including all the selected plantations in the coconut triangle, Table 2 was prepared. Following equation was used to find the Total Sustainability Index for each plantation separately.

Table 2. Development of the Total Sustainability Index (TSI) using MCA

Plantation	W_{ENV}	W_{SOC}	W_{ECO}
A	ENV_A	SOC_A	ECO_A

$$TSI = (W_{ENV} \times ENV_A) + (W_{SOC} \times SOC_A) + (W_{ECO} \times ECO_A)$$

Where,

W_{ENV}	=	Weightage for Environmental criteria
W_{SOC}	=	Weightage for Social criteria
W_{ECO}	=	Weightage for Economic criteria
ENV_A	=	Environmental status of the plantation A
SOC_A	=	Social status of the plantation A
ECO_A	=	Economic status of the plantation A
TSI	=	Total Sustainability Index

RESULTS

Descriptive Statistics of the Sample

According to the information gathered from the sample during the study, graphical and tabular analyses were conducted to generate a picture regarding the current situation about the coconut plantations in the coconut triangle. The results revealed that, Narammala coconut plantation had the highest Total Sustainability Index out of the fifteen plantations. Thammanna coconut plantation had the lowest Total Sustainability Index (Figure 2). According to the results of Kruskal Wallis One-Way ANOVA test, there was a significant difference between the coconut plantations in the coconut triangle (Table 3).

Table 3. Results of the Kruskal Wallis One-Way ANOVA test

District	Sample size	Median	Avg rank
Kurunegala	5	1.957	11
Puttalam	5	0.916	3
Gampaha	5	1.941	10

Avg = Average, P = 0.009 (adjusted for ties)
To be significant p value<0.05

Based on the results, there was a significant difference between the plantations in Kurunegala and Puttalam districts. The plantations in Puttalam district were significantly different from plantations in Gampaha district. However, there was no significant difference between the plantations in Kurunegala and Gampaha districts (Table 4).

Table 1. Details of the Coconut Plantations

District	Plantation	Extent (ha)	Average cost /ha (Rs.)	Average benefit/ha (Rs.)	Benefit Cost Ratio	Average yield/ha (nuts)	No. of bearing palms /ha
Kurunegala	Kurunegala	442.50	35223.35	126017.96	3.58	4952	94
	Dambadeniya	294.13	33675.28	91554.67	2.72	5100	103
	Narammala	394.25	29293.31	133305.27	4.55	6088	93
	Bopitita	57.47	84042.11	146212.23	1.74	6960	93
	Mahayaya (CCB)	121.41	78496.87	297383.31	3.79	7619	114
Puttalam	Thambapanni	280.09	10813.61	14716.87	1.36	629	18
	Thammanna	101.61	53688.15	72271.88	1.35	3132	68
	St.John B	101.21	16987.13	25596.72	1.50	991	45
	Kasamadu	151.82	16322.59	23095.28	1.41	949	26
	Seenasole	103.63	55016.32	74580.62	1.36	3197	68
Gampaha	Attanagalla	411.46	33708.59	122123.83	3.62	5082	104
	Mahayaya	338.34	23456.09	85910.95	3.66	3799	64
	Dansalwatta	61.47	21419.11	78703.48	3.67	3742	66
	Nugedola	85.08	18730.60	41005.29	2.19	1705	37
	Hakbewa	59.97	19622.52	38345.71	1.95	1626	34

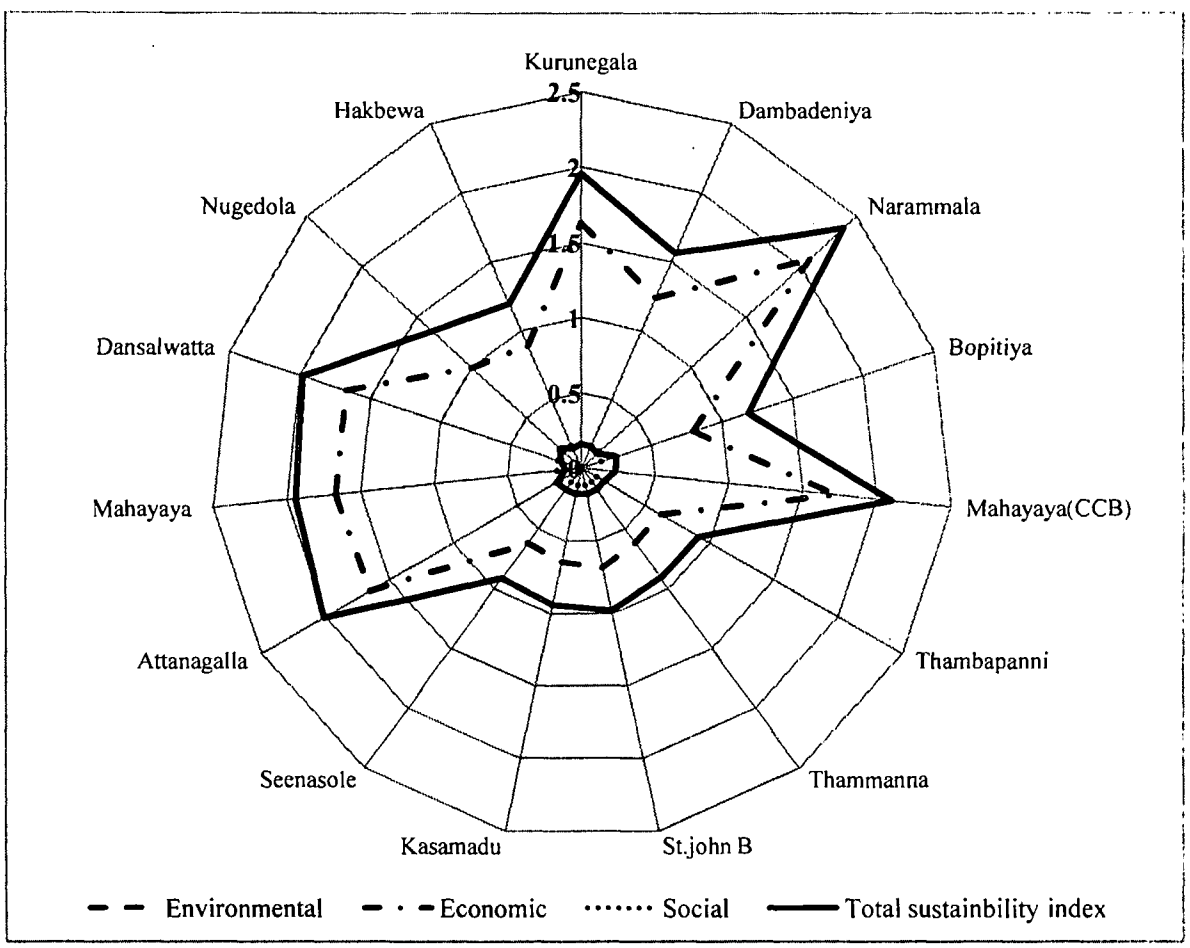


Figure 2. Outcome of MCA

Table 4. Results of the Pairwise comparison

Pairwise comparison	Rank different
Rk-Rp	8
Rk-Rg	1
Rp-Rg	7

Note: Rk-Average rank of Kurunegala, Rp-Average rank of Puttalam, Rg-Average rank of Gampaha
CD_{KW} = 5.543717
To be significant the Rank different> CD_{KW}

DISCUSSION

Coconut cultivation is highly sustainable due to its great ecological tolerance and benefits. Increase in coconut yield as well as productivity of land require the adoption of proper management practices. Achieving this task on large holdings would require skilled and professional on plantation management. The results revealed that, Puttalam district plantations were significantly different from the plantations in Kurunegala and Gampaha districts. There were several factors behind this observation. Economical sustainability has become more important to the plantations' owners due to the scarcity of physical and financial resources, increasing cost of external inputs and fluctuation of price of coconut. By using the costs and benefits identified during the study; BCR was calculated for Kurunegala, Puttalam and Gampaha districts separately. Results revealed that, all the plantations were economically viable. However, lowest BCR reported in Puttalam district. It was 1.396 (Figure 3).

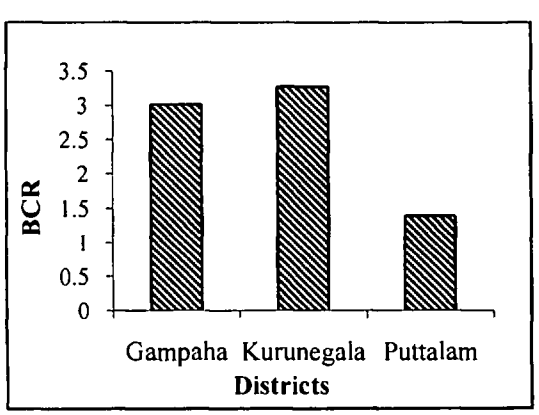
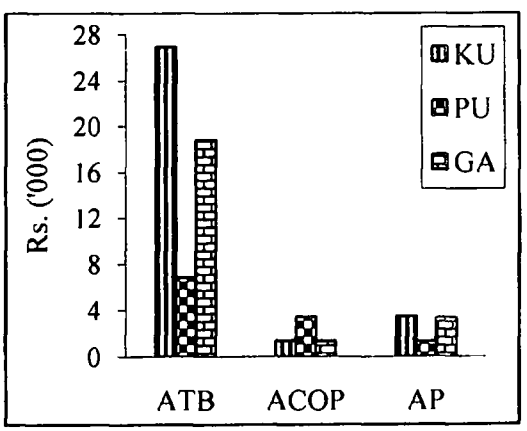


Figure 3. BCR of three districts

According to the Figure 4, Puttalam district had the highest value for average cost of production per 1000 nuts/yr. In order to get higher profits, plantations have to reduce their cost of production. Puttalam district reported the lowest value for average profit per 1000 nuts/yr. It was Rs. 1, 291.75. Also Puttalam district had the lowest value for average total benefit/ha/yr. It was reported as Rs. 6, 850.78. Generally, poor adoption of production and protection technologies, minimum use of external inputs, changes in weather patterns and low level of estate management have largely contributed to low levels of coconut productivity. Results revealed that, the lowest productivity was in Puttalam district (1,447 nuts/ha/yr). It was less than the CRI estimated average potential productivity for Puttalam district (11,410 nuts/ha/yr).



Note: KU-Kurunegala, PU-Puttalam, GA-Gampaha, ATB-Average Total Benefit/ha/yr, ACOP-Average Cost of Production/1000nuts/yr, AP-Average Profit/1000nuts/yr

Figure 4. Present situation of the coconut plantations

Number of nuts per palm is determined by the genetic capability of palms, climate, soil conditions and level of management. According to the Liyanage, (1999) estimated nuts per palm/yr was 45. However, Puttalam district reported the lowest value of 39 nuts per palm/yr. It was less than the estimated value. Depending on the density of palms; plantations must have the maximum number of healthy and productive palms. Removal of weak palms and filling vacancies must be done promptly in order to maintain a productive stand. Average number of bearing palms/ha in Puttalam district was 37 palms/ha. This was below the recommended density of 158 palms/ha by CRI.

Scarcity of the labor has become a major issue for the coconut sector. Low wage rates, high education level and poor social acceptance were the causes for labor mobility from coconut sector. Further, maintaining better relationship with labors contributed to the productivity of the plantation. Providing wages and welfare facilities were supportive actions to increase the production. In order to optimize their profits, plantations have allocated a large amount from their budget to

maintain the welfare facilities of their employees at a satisfactory level. However, it was comparatively low in Puttalam district.

Taking care of the environment is an important part of the coconut cultivation. The study was focused on how much they use environmental friendly methods to minimize the negative impacts. Puttalam district plantations were moderately used environmental friendly inputs in the production.

CONCLUSIONS

Total Sustainability Index is represented the combined effect of the economic, social and environmental sustainability of the coconut plantation. That can be used to rank the plantations according to their present Total sustainability levels. Improving the economic sustainability of the coconut plantations can be achieved by maximizing the level of revenue generated from the sales of out puts. Another option would be decrease the costs of chemicals, materials and inputs used in various production activities.

Improving the social sustainability of the coconut plantations can be achieved by increasing the wages, welfare facilities and minimizing the risks posed to workers. Improving the environmental sustainability of the coconut plantations can be achieved by optimum utilization of natural resources, reduction of toxic chemical usage in production and increasing the use of more environmental friendly inputs.

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REFERENCES

Amudhasurabi, T. and VsanthaKumar, J. (2001). Sustainable agriculture development. *Kisan World*, **28** (1), 18-19.

Central Bank Annual Report. (2011). Central Bank of Sri Lanka.

Department of Census and Statistics Annual Report. (2002). Agriculture and Environmental Statistics Division, Department of Census and Statistics, Colombo, Sri Lanka.

Liyanage, M.de S. (1999). A Guide to Scientific Cultivation and Management of Coconut. Coconut Research Institute, Lunuwila, Sri Lanka.

Massam, B. (1988). 'Multi-criteria decision-making (MCDM) Techniques in Planning', in *Progress and Planning*, Vol. 2. 2nd ed. Pergamon Press, Oxford.