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Indicators of Ecological Capital Management in Up–country Tea Plantations of Sri Lanka

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ABSTRACT. *Tea [Camellia sinensis (L.) O. Kuntz.] plays an important role in the Sri Lankan economy as a foreign exchange earner and a source of employment. However, the sector has been facing various problems over the last three decades, particularly stagnation and low productivity. This problem was a result of inadequate attention given to ecological capital management in the past. The objective of this study is to identify and establish indicators of ecological capital management and to find out the relationship between these indicators and productivity in the up-country tea plantations. Four plantation companies from the Nuwara Eliya district and 21 estates with 87 divisions from these four companies were selected randomly for this study. Each division was taken as a sampling unit. Factor analysis showed that quality of ecological capital, labour use management, human resource availability and soil erosion intensity are the four main indicators (factors) of ecological capital management. The results of the multiple regression analysis between productivity (yield ha^{-1}) and the above indicators showed that productivity is dependent on these 4 indicators ($P<0.01$). Improvement in each of these aspects of ecological capital management was found to increase productivity independently.*

INTRODUCTION

Tea [*Camellia sinensis* (L.) O. Kuntz.] plays an important role in the economy of Sri Lanka. It occupies a significant position in Sri Lanka's agriculture in terms of land utilization. Tea covers 20 % of the total agricultural land area in the country while employing about 10 % of the national workforce. It also accounts for 2.1 % of the GDP (Ministry of Plantation Industry, 1996). However, since the end of 1970, the dominance of tea sector in the economy has been declining due to various reasons such as

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low productivity, increasing cost of production and heavy competition in the world market (Knutsen, 1987; PMEA, 1995). Among these, the major factor contributing to the present crisis is low productivity. It is a result of mainly inadequate attention given to ecological capital management during the last three decades (Bandara, 1995; Vijesandiran, 1997). Therefore, the economic viability of the tea plantations depends mainly on raising productivity (World Bank, 1994). The major concerning aspect of raising productivity is the management of ecological capital (Shanmugaratnam, 1995), which refers to the existing capital stock within an ecosystem, produced and modified by human intervention through investment in the natural ecosystem. Thus, ecological capital is an essential element of sustainability. In order to improve ecological capital management, first, we need to identify the indicators of ecological capital management and, then understand the nature of relationship between ecological capital management and productivity of tea.

The objective of this study was to identify and establish indicators of ecological capital management and to find out the relationship between these indicators and productivity. This study concentrates only on up–country tea plantations in the Nuwara Eliya district. The reason for this choice is the very low productivity of tea prevailing in this area (Vijesandiran, 1997) and out of 137 up–country tea plantations, 131 are in the Nuwara Eliya district.

METHODOLOGY OF STUDY

Data collection

In the Nuwara Eliya district, all 131 estates are managed by 14 private companies. Of these 14 companies, four were selected randomly (Table 1). From these selected companies, 21 estates were selected randomly based on probability proportional to number of estates per company.

Information was collected from each division of the selected estates separately because there is high variability between divisions within the estate. The data were collected from primary sources using a pre–tested questionnaire.

For this study the following variables were thought relevant in the assessment of ecological capital of tea plantations: proportion of high yielding variety (HYV), plant density (PDN), shade availability (SHA), replanting rate (RPL), vacancy rate (VCR), in–filling rate (IFI), soil fertility input (SFI), erosion control (ERC), weed control (WDC), bush management

(PRU), plucking labour (PUL), shade management labour (SHL), green manure supply labour (GML), soil management labour (SML), soil erosion (SEI), pest and disease control (PDC), human resources availability (HRA) and wind breaks (WB). In addition to these variables, yield ha^{-1} (YD) was also recorded to study the dependency of productivity on ecological capital management (ECM).

Table 1. Selected Companies and the Composition of Sample.

Regional Plantation Companies	No. of Estates Selected	No. of Divisions Selected
Bogawantalawa	06	20
Talawakelle	05	22
Kotagaia	06	21
Agrapathana	04	24
Total	21	87

Statistical analysis

This study is aimed at developing indicators of ecological capital management taking into account ecological aspects of the tea plantations. Factor Analysis (FA) was used to find out indicators (indices) from the above 18 variables *i.e.* all above listed variables except yield ha^{-1}. The principle behind FA is identifying underlying common factors from a large number of original variables. These factors are generated by grouping related variables so that each factor represents a specific aspect of variability. Thus, each factor is an indicator of one aspect of the variability (George, 1989). PROC FACTOR of SAS (SAS, 1993) was used to analyze the data. Multiple regression was performed to evaluate the role of each indicator on productivity.

RESULTS AND DISCUSSION

Eigen values represent the amount of variability explained by each factor. From the factor analysis, seven factors (indicators) were identified based on the criteria that Eigen values of a factor is greater than 1. The Eigen values and the percentage variability explained by each factor are listed in Table 2.

Table 2. Eigen values and percent of variance explained.

Factor (Indicator)	Eigen value	% of variance explained	Cumulative % of variance explained
1	6.5897	28.65	28.65
2	2.6744	11.63	40.28
3	1.9969	8.68	48.96
4	1.5525	6.75	55.71
5	1.2523	5.44	61.16
6	1.1896	5.17	66.33
7	1.0183	4.43	70.76

Seven factors explained more then 70.76 % of the observed variability. However, the variability explained by the last three were low compared to the first four (Eigen values are close to 1). Contributing variables to each factor were identified based on factor loadings (Table 3). Since the factor loadings for the last three factors were small (< 0.5) and the Eigen values of last three factors were closer to 1, four main indicators for ecological capital management were identified.

The process of identifying indicators by name is based on the characteristics and attributes of the original variables contributing to each factor. Based on contributing variables to each factor, the factors were named as Quality of Ecological Capital, Labour Use Management, Human Resource

Availability and Soil Erosion Intensity. The variables PDC and WB were found not contributing to generate indicators (factor loadings < 0.5). The indicators and the original variables (factor loadings more than 0.5) contributing to each of those indicators are given in Table 4.

Table 3. Factor loadings of selected variables.

Variable	Factor 1	2	3	4	5	6	7
HYV	0.9538	0.0447	-0.0676	0.1140	0.1129	-0.0281	-0.0614
PDE	0.9645	0.0277	-0.0651	0.0709	0.0626	-0.0166	-0.0605
PUL	-0.2030	0.5807	-0.2851	-0.2815	-0.2156	0.2933	-0.0779
WB	0.2900	-0.4161	0.3398	-0.4120	-0.1750	0.1530	-0.3119
SHA	0.5642	0.4994	0.1990	0.1133	-0.0008	0.2800	0.0529
RPL	0.6962	0.0590	-0.2147	0.2388	0.1212	0.1221	-0.0138
VCR	-0.6849	0.0561	-0.1947	0.4572	0.1226	0.0428	0.2743
IFI	0.6089	-0.0483	-0.1656	-0.4147	-0.1989	0.0659	0.1347
SFI	0.8374	0.0530	-0.2087	0.0133	0.2494	-0.0612	-0.0264
GML	0.1806	-0.7670	0.2744	0.1176	-0.1167	0.2142	0.1293
SEI	-0.4802	-0.1573	-0.4275	0.5398	0.1683	0.0714	-0.0124
ERC	0.8061	0.1944	0.1256	0.0419	0.1831	-0.0549	0.0593
WDC	0.6990	-0.1825	0.0137	-0.3661	-0.2244	0.0483	-0.0489
SHL	-0.0356	0.6077	0.4217	-0.0544	0.0151	-0.3500	-0.0861
PDC	-0.2764	0.3605	0.4678	-0.2029	0.1980	-0.1739	0.0051
HRA	0.1582	0.4994	0.5703	0.2289	0.0269	0.2320	-0.0991
SML	0.1223	0.6359	0.2566	0.3862	-0.3254	0.1387	-0.0900
PRU	-0.5237	-0.0823	-0.2967	0.0749	0.4029	0.2625	-0.0232

The indicators developed by factor analysis were utilized to identify the role of ecological capital management on yield ha^{-1}. Multiple linear regression was performed in order to find out the role of each indicator on yield. Of the different transformed models of the 4 indicators and productivity tested, the best fitting model was obtained as:

$$YD = 439.9 + 71.0\ ECQ + 183.2\ LUM + 231.1\ HRA - 450.4\ SEI \quad (1)$$

$$(R = 0.72\ ;\ P < 0.01)$$

where, variable abbreviations are as shown in Table 4.

The above model shows that the highest positive influence comes from HRA followed by LUM and ECQ. The SEI was negatively related to yield. All the coefficients were significant at 10% probability level.

Table 4. Proposed indicators and the contributing original variables.

Proposed indicator		Grouped original variables
Indicator I:	Quality of Ecological Capital (ECQ)	HYV, PDN, SHA, RPL, VCR, II, SFI, ERC, WDC and PRU
Indicator II:	Labour Use Management (LUM)	PUL, SHL, GML and SML
Indicator III:	Human Resource Availability (HRA)	HRA
Indicator IV:	Soil Erosion Intensity (SEI)	SEI

Use of ecological capital management indicators in improving productivity

(1) *Human resource availability (HRA)*

The human resource availability was positively related to productivity. This indicator would influence productivity as the outcome of, (i) the high availability of human resource is an asset in fostering advancement in productivity, and (ii) out of human resources, high availability of skilled human resource could also contribute towards better ecological capital

management. Both these will promote better relationship between nature and the management of plantations. Thus, these capabilities have a positive impact on the productivity of tea lands.

(2) *Labour use management (LUM)*

The labour use management (LUM) has a positive impact on productivity. The increase in labour use with emphasis on ecological capital management would increase productivity. This could be achieved by (i) higher labour allocation towards ecological capital management, and (ii) the labour that is already in use could be promoted towards ecological capital management.

(3) *Quality of ecological capital (ECQ)*

This indicator also has a positive impact in improving overall productivity. This could be achieved by replacing old seedling tea lands with HYV. Consequence of this is that tea lands will have greater PDN while providing better coverage to the top soil, both of which lead to increasing the productivity while conserving the ecological capital.

(4) *Soil erosion intensity (SEI)*

This indicator has a negative impact on productivity. Thus, in order to increase productivity soil erosion should be kept to the minimum.

The F statistic (22.00), ($P<0.01$) and R (0.72) of the model (Equation 1) infer that the specified four ecological capital management indicators provide a sufficient explanation to the variability in the productivity of tea lands.

CONCLUSIONS

The productivity of tea in Sri Lanka is low and stagnated. A substantial part of the reduction in yield is due to lack of ecological capital management. This study revealed that there are four main indicators (aspects) which can improve ecological capital management. Improvement in each indicator independently increases productivity. However, ecological capital

management could be improved according to the priority order. This study has clearly shown that the negligence of ecological capital management will have a negative effect on productivity of tea. Sustainable management of tea plantations should involve an economically efficient enhancement of the ecological capital stock as a means to increasing productivity.

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