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Authors: Illukpitiya, Prabodh, Shanmugaratnam, Nadarajah, and Kjosavik, Darley Jose

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Prabodh Illukpitiya, Nadarajah Shanmugaratnam, and Darley Jose Kjosavik

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An Evaluation of Land Management Activities

The mountain ecosystems of Sri Lanka are now in crisis, with rapid degradation of the productive resource base and the environment. There are unmistakable symptoms of unsustainability in current production practices and patterns of resource use in tea agroecosystems. The present study was undertaken with the overall objective of examining the sustainability of resource use, with special reference to the land management practices on tea plantations on the Uva highlands of Sri Lanka. Eight different tea plantation units were randomly selected for detailed study, representing a total area of 4548 ha. The information related to the management of the plantations was mainly collected from plantation records.

The findings of the study confirmed that the ecological capital of the plantations is in a critical state. Private management companies have been exercising a strategy aimed at short-term profits by extracting higher yields with the aid of inorganic fertilizers and other agrochemicals. Hence activities such as replanting, infilling and bush management have been neglected. Shortage of skilled labor is a major threat to the future of the tea estates. An inter-estate analysis of the quality of the management of tea plantations indicated that most of the tea estates had become marginal. Long-term management plans need to be formulated and implemented in order to make the tea plantations ecologically and economically sustainable.

Keywords: *Tea production; agroecosystem management; sustainable resource use; ecological capital; labor shortage; Sri Lanka.*

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Introduction

Tea, scientifically known as *Camellia sinensis*, was introduced to Sri Lanka in 1867. Soon large areas of thick jungle were cleared and brought under cultivation. This changed the landscape in the central mountain region of the country. In conventional business terms, the transformation of natural forests into plantations was highly successful. The tea industry has been playing a significant role in Sri Lanka's economy (Sivapalan 1993). In 1998, tea accounted for 16.4% of total exports and 7% of total employment. Today tea is grown at high, medium and low elevations on plantations as well as on smallholdings in Sri Lanka. Private plantation companies manage 430 estates, which together occupy 99,000 ha. The state's Janatha Estate Development Board (JEDB) manages hundreds of estates totaling 96,000 ha at different elevations. About 88,000 ha of tea is under 206,000 smallholdings (ADB 1999).

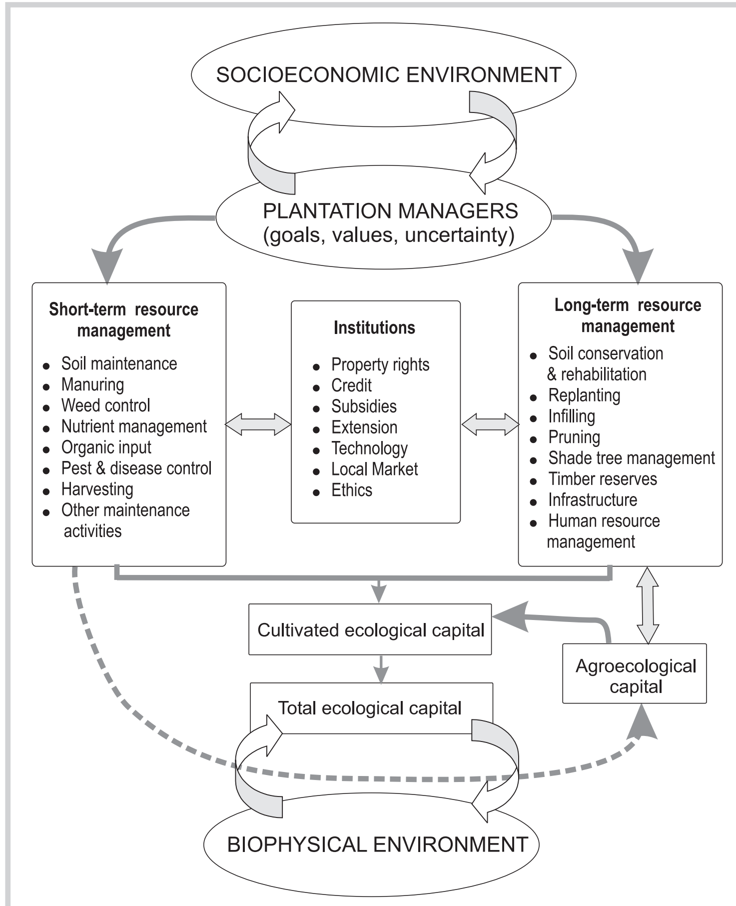
Today, Sri Lanka's hill country has large areas of poorly managed tea plantations. The deterioration of ecological capital, declining or stagnant productivity, obsolescent processing machinery, rising production costs, and loss of competitiveness on the world market for tea have been the main trends in Sri Lanka's tea plantation sector in the post-nationalization era since 1975 (Shanmugaratnam 1997). Though the government embarked on a major program of privatization of the tea plantations in 1992, under pressure from the World Bank and other international financial institutions, there appears to have been very little change in material conditions within tea agroecosystems. Alternative resource management strategies are therefore imperative for perennial agroecosystems such as tea plantations, especially on the deforested hills, to ensure the sustainability of the mountain environment. The present study was thus undertaken with the objective of critically evaluating the current pattern of land management on tea plantations in the Uva highlands of Sri Lanka.

Conceptual framework and management of tea agroecosystems

Although "ecosystem" is a well-established concept (Tansley 1935), the idea of an "agroecosystem" is more recent. Agroecosystems can be considered as ecological systems modified by human beings to produce food, fiber or other agricultural products (Conway 1985, 1987). Major studies on agroecosystems have been concerned with flows and cycles of energy and materials (Frissel 1978; Loucks 1977; Lowrance et al 1984). The sustainability of an agroecosystem would require explicit consideration of all environmental relationships (Carr and Williams 1991). It is also important to bear in mind that farmers are not likely to adopt practices that may be environmentally friendly or helpful in regenerating the natural resource base, but are not economically feasible (Pezzey 1989; Barbier 1989).

Cultivation of tea on plantations has numerous dimensions, representing a social institution as well as an agricultural system (Rote 1986). The tea agroecosystem interacts with the socioeconomic environment through the application of purchased inputs, labor relations, sale of outputs, and other transactions. Its interactions with the biophysical environment are manifested in different ways, depending on crop production practices. Agronomic practices that disregard longer-term negative effects on the resource base contribute to

FIGURE 1 Conceptual framework for the management of tea agroecosystems. (Adapted from Shanmugaratnam 1995)



degradation in a cumulative fashion through soil erosion, pollution and build-up of pathogens (Figure 1). Agroecosystem management decisions are best applicable under local conditions, though decisions taken by policy makers and events at the national and global levels often tend to override local management decisions.

A tea plantation represents a stock of cultivated ecological capital developed by human agents with the aim of extracting value for use in direct consumption or exchange. A basic requirement for the sustainability of these systems is that the rate of appropriation of use values should not exceed the rate of their natural regeneration (Shanmugaratnam 1995). On-site resource management on tea plantations is determined by managers under various institutional and resource conditions. On-site management decisions involve short as well as long-term considerations.

Short-term management decisions are concerned with routine activities such as land and crop management practices. Unlike annual cropping systems, perennial systems such as tea plantations require long-term investment in activities such as infilling, replanting and maintenance of soil capital. Long-term investment decisions are often affected by political and economic factors at various levels. For instance, fear of nationalization may induce plantation owners to discount long-term investment as risky and opt for short-term profit maximization strategies. Such decisions promote asset depletion, as in the case of company-owned tea plantations in Sri Lanka after independence. Further, the combination of a downward trend in prices, rising production costs, and higher opportunity costs of capital may discourage long-term investment.

Methodology: primary data sources in the plantation sector

Information regarding management of tea plantations was collected from estate records (PMR 1993–1998). Estate managers in Sri Lanka have a reputation for maintaining reliable records on different activities on their plantations. These records include data on technical aspects as well as labor. For example, a soil investigation book consists of data related to soil organic carbon measurements and soil acidity (pH) in different tea fields on the estate. Soil samples are randomly taken from fields and sent to the Tea Research Institute of Sri Lanka (TRI) for analysis. TRI offers soil testing services to estates, charging a small fee for each soil sample. Hence, a record features reliable information on average annual organic carbon and the pH status of tea soils in each field.

Soil bulk density is measured using soil augers. Three sites from each estate and adjacent forests are randomly chosen and soil samples are obtained using manually operated soil augers. The volume of the soil sample is calculated using the formula $\pi r^2 h$ (where π = 3.14, r = radius and h = height of soil sample). The weight of the soil samples is also measured.

An estate's yield book consists of tea yields from each field on the estate. The book provides data for each month on both green leaf yield and final yield after processing. There are also records in the form of charts on plucking, manuring, weeding, infilling, labor, timber and fuelwood. Details of the amount plucked by field during each plucking interval are given in the plucking chart. The manuring chart records the amount of inorganic fertilizers (N, P, K) and dolomite applied in each field. The weeding chart shows the amount of weedicides applied. The infilling chart contains information related to infilling activities performed on each field. The population chart shows all data related to the labor force on the estate. The ratio of labor to land was calculated by dividing the total number of the labor force employed for field activities in each plantation by the total area of the plantation.

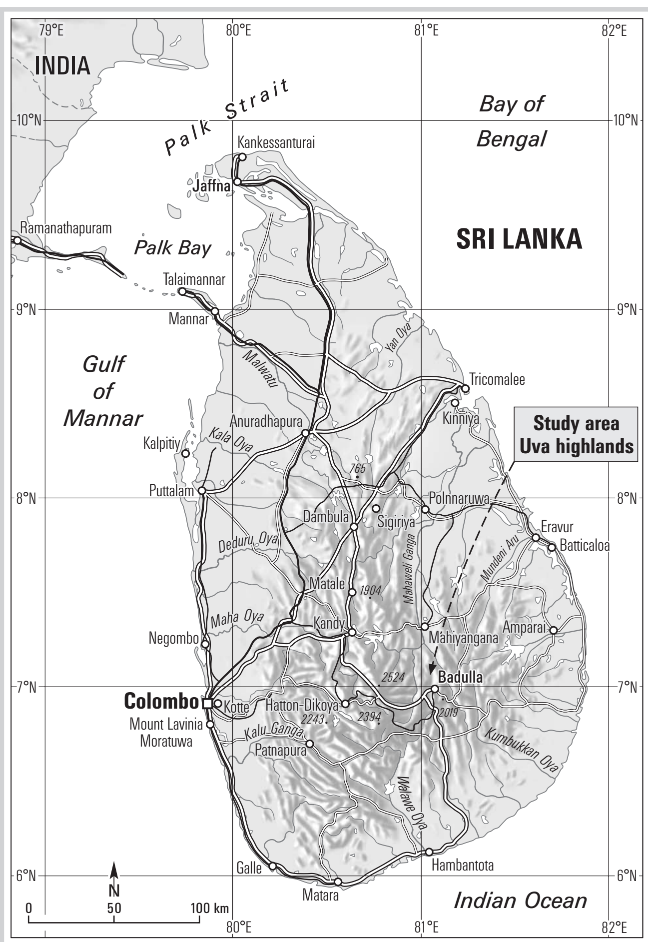
For the present study, 8 different plantation units at different altitudes were selected from the Central

TABLE 1 Information on the tea estates sampled for this study.

Estate	Elevation (m)	Total divisions	Vegetatively propagated fields	Seedling fields	Total no of fields
Welimada Group (We)	1200	4	20	22	44
Udaweriya (Ud)	1707–2133	6	1	43	44
Glenanore (Gl)	1372–1432	4	7	24	31
Chelsea (Ch)	1182–1455	2	5	20	25
Dickwella (Di)	750–1200	3	14	25	39
Aislaby (Ai)	1191–1374	4	21	37	58
Poonagalla (Po)	762–1402	7	11	43	54
Craig (Cr)	1128–1528	5	16	28	44

Hills. The details of the selected plantations are given in Table 1. All these plantations belong to the Uva highlands (Figure 2) and are currently managed by private companies. The tea plantations were randomly selected within the study area. Data were gathered from a total of 339 fields from 35 divisions in the 8 plantations. This represents a total of 4548 ha in the study area. The total land area under tea cultivation in the Uva highlands is 36,020 ha (DoS 1992). Hence the sample covered 12.62% of the area under tea in this region, which is an appropriate sample size for a field study.

FIGURE 2 Location of the study area (Uva highlands) in Sri Lanka. (Map by Andreas Brodbeck)



Results and discussion

Changes in soil horizon and bulk density

Due to continuous soil erosion during the last 100 years or more, soil conditions on tea plantations have changed drastically. The 'O' horizon was completely absent on all the estates studied, while a major portion of the 'A' horizon has also been lost. The best available estimates suggest that as much as 30 cm of topsoil has been lost from upland areas over the last century since tea was introduced, equivalent to an average loss of 40 t/ha/yr (Coomaraswamy et al 1999). Joachim and Pandithasekara (1930) reported an annual soil loss as high as 115 t/ha in upcountry areas of Sri Lanka. An estimation of soil losses on tea plantations in the low country, mid country and upcountry regions showed that the greatest loss was on upcountry plantations (412 t/ha/year) (El Swaify et al 1983). Given that the soil loss tolerance value of Sri Lankan soils is 9 t/ha/year, these figures are alarming.

Soil bulk density is an indicator of the degree of compaction. The mean soil bulk density at depths above 6 cm on the tea plantations studied was 1.15 g/cm^3, while the mean bulk density of the adjacent forest soil was 0.78 g/cm^3. At all locations tea soils had greater bulk density than adjacent forest soils, suggesting that tea soils are more compacted (see Coomaraswamy et al 1988 for more details on other locations).

TABLE 2 Organic carbon status of the tea soils, percentage of the number of fields and percentage of the area below the critical carbon level of 2.5%. Pool standard deviation: 0.069. (Sources: field survey conducted in 1998 and plantation management records)

Estate	Average organic carbon (%)	Standard deviation	% fields below critical level	% area below critical level
Welimada Group (We)	1.69	0.463	90.62	68.07
Udaweriya (Ud)	3.18	0.486	11.11	18.89
Glenanore (Gl)	3.74	1.236	36.08	34.05
Chelsea (Ch)	2.78	1.016	32.20	30.50
Dickwella (Di)	1.75	0.458	73.22	81.4
Aislaby (Ai)	2.01	0.431	65.51	78.33
Poonagalla (Po)	1.50	0.363	97.95	88.23
Craig (Cr)	2.52	0.555	18.18	23.09
Mean	2.16		53.10	52.82

TABLE 3 Soil acidity condition, percentage of the number of fields and percentage of the area below the critical pH level of 4.2. Pool standard deviation: 0.366. (Sources: field survey conducted in 1998 and plantation management records)

Estate	Average pH level	Standard deviation	% fields below critical pH level	% area below critical pH level
Welimada Group (We)	4.18	0.225	30.89	44.78
Udaweriya (Ud)	4.45	0.180	23.40	27.67
Glenanore (Gl)	4.55	0.403	12.90	17.15
Chelsea (Ch)	4.57	0.418	28.00	25.88
Dickwella (Di)	4.49	0.307	17.94	10.95
Aislaby (Ai)	4.56	0.444	27.58	33.86
Poonagalla (Po)	4.66	0.338	7.40	5.59
Craig (Cr)	4.48	0.470	13.63	20.07
Mean	4.51		20.21	23.24

Organic carbon of tea soils

The mean organic carbon content on tea estates in the study area was 2.16%, with a standard deviation of 0.069, as shown in Table 2. Glenanore estate had the highest organic carbon content (3.74%), followed by Udaweriya (3.18%). In terms of the percentage of organic carbon in tea soils in the study area, most plantations were in a critical condition. Many are below the critical carbon level, as indicated in Table 2. There was significant variation among tea estates in relation to organic carbon. The percentage of soil organic carbon is a major indicator of soil nutrient conditions.

Sandanam and Coomaraswamy (1982) reported 5% organic matter in Red Yellow Podzolic soils under well-managed tea plantations. The low organic matter content of soils on tea lands in the Uva basin is mainly due to excessive soil erosion and negligence in the application of organic manure over a long period of time. Low organic carbon results in low water and nutrient holding capacity, thus contributing to a decrease in yield (Stephens and Carr 1991; Tolhust 1961).

Soil acidity

Table 3 indicates soil acidity values on different plantations in the study area. The acidity of tea estates in the study area is indicated by a mean pH level of 4.51 with a standard deviation of 0.366.

TABLE 4 Age distribution of vegetatively propagated (VP) tea (% area). (Sources: field survey conducted in 1998 and plantation management records)

Estate	Age (% area)					
	< 1 year	1–5 years	5–10 years	10–20 years	20–30 years	> 30 years
Welimada Group (We)	–	2.9	12.2	23.5	12.1	49.3
Udaweriya (Ud)	–	–	–	100	–	–
Glenanore (Gl)	–	5.8	–	11.6	42	40.6
Chelsea (Ch)	–	–	–	32.7	67.9	–
Dickwella (Di)	5.2	6.5	9.1	14.7	48.7	15.7
Aislaby (Ai)	4	1	1.2	–	20.5	73.1
Poonagalla (Po)	–	–	1.7	–	63.3	35
Craig (Cr)	–	–	36.9	63.3	–	–
Average	1.7	2.6	8.4	17.3	34.3	35.7

Normally tea soils are acidic in nature. For optimum production, the most suitable pH range is 4.5–5.5. Data by field indicate that a considerable amount of acreage is below the critical level. The managers of the estates studied commented that the tea soils were becoming more acidic over time. Over-fertilization of the fields with acid-forming fertilizers such as ammonium sulphate is one of the major causes of increasing acidity on tea fields. Addition of calcium carbonate is the remedial measure to maintain satisfactory pH levels. Failure to maintain satisfactory pH levels will affect the future productivity of the land.

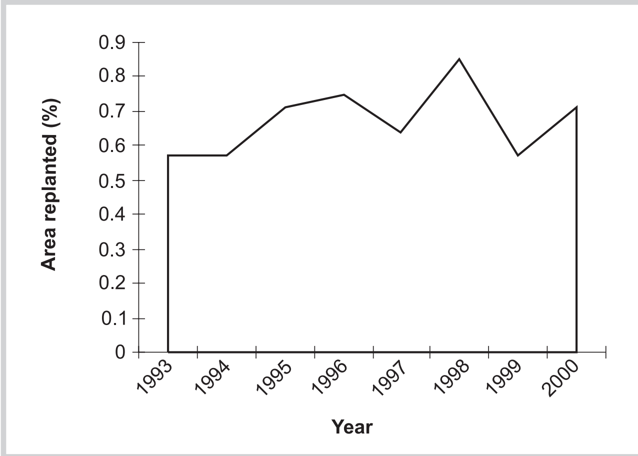
Age distribution of tea bushes

More than 90% of the seedling tea fields are older than 80 years. There are a few comparatively young seedling tea fields (Table 4). Although vegetatively propagated (VP) tea has great comparative advantages over old seedling tea (Wadasinghe 1989), less effort has been made to establish VP tea fields. Like any other plant, tea also becomes senile after a certain duration. The time period for tea to become economically unproductive depends on the genotype, the environment, and the incidence of pests and diseases. According to the estate managers, most of the pre-war seedling tea fields are more than 100 years old and hence beyond their peak cropping potential. Seedling tea fields consist of old tea varieties, and there is great genetic variation among the tea bushes on these estates.

Replanting

Replanting of old seedling tea with high-yielding clones has been practically negligible in the study sites. Figure 3 shows the average replanting of old seedling tea with VP tea since 1993. The area replanted annually was less than 1% of the area under tea cultivation in the study sites. The estimated replanting areas for the years 1999 and 2000 were 0.6% and 0.7% of the total area, respectively. At this rate of replanting it could take more than 100 years to replace the old bushes with new clones in the Uva highlands. This would mean a protracted stagnation in Sri Lanka's tea economy.

FIGURE 3 Average annual replanting rate in the tea estates of the Uva highlands.



Plant density

Maintenance of optimum plant density is necessary for both ecological and economic reasons. The recommended optimum number of tea bushes per hectare in seedling fields at higher elevations is between 9,000 and 10,000, and 12,500–13,500 for VP fields. The mean average plant densities per hectare were far below the recommended rate on all the estates studied. The mean vacancy rate on seedling and VP fields on the plantations studied was around 20% and 10%, respectively.

High vacancy rates lead to low ground cover, thereby worsening erosion and causing declining soil fertility and yield. Infilling, once a routine activity on these plantations, has been almost totally abandoned in the recent past.

Ratio of labor to land

The average ratios of labor to land on the estates studied are given in Figure 4. On all estates except Glenanore, these ratios were far below the required ratio of 3. This has placed constraints on the allocation of sufficient labor for cultivation, and is bound to have negative effects on the productivity and sustainability of the sector in the long run. The low ratios on 7 of the 8 estates indicate that the tea sector in the Uva highlands will suffer increasingly in the near future from a shortage of field and factory labor. Out-migration and absenteeism of registered resident workers, especially among the better-educated younger generation, are the major reasons for a shortage of labor. Wage levels in the upcountry rural labor markets do have a bearing on the supply of plantation labor at certain times of the year. In recent years, rural wages have shown a general tendency to rise above plantation labor wages in many areas in the upcountry, and plantation workers in these areas enter the seasonal rural labor markets (Shanmugaratnam 1997). As a result, harvesting and other field operations are adversely affected.

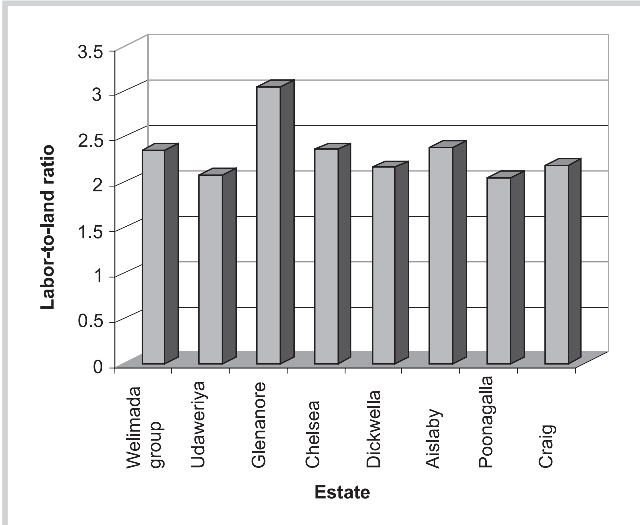
Overall assessment of the quality of field operations

The composite matrix (Table 5) provides a summary of several other indications of the levels of management on the estates studied. There is great variation in the levels of management, as illustrated by the matrix. The overall management index on most estates is in the range of 0.6–1.5. This means that not one single tea plantation can be considered as satisfactorily managed in terms of overall quality.

A case of institutional failure?

Following their nationalization in 1975, the plantations were owned and managed by the government of Sri Lanka until 1992. The government of Sri Lanka was under pressure from the World Bank and other international financial institutions to completely privatize the plantations, ie, sell all ownership rights to land and other assets. But for political reasons the government chose a rather weak form of privatization, whereby management of the plantations was contracted out to private companies (Shanmugaratnam 1997). The private sector management agent was given extensive powers of managerial discretion and operational control, but no financial exposure. The commercial risk was to be borne by the state, which was also responsible for working capital and financing of debt (Vuylsteke 1988). The contract was initially for 5 years, with provision for a maximum of 4 additional 5-year extensions subject to the management agent's performance record, with remuneration for the management agent based solely on a share of annual profits (Shanmugaratnam 1997).

FIGURE 4 Labor-to-land ratio in the tea estates of the Uva highlands.



The short initial timeframe of the contract and the terms for rewarding the management agents both served as incentives to maximize short-term gains. Therefore, it is not surprising that the plantation management made concerted efforts to maximize profits in the short run through intensive application of chemical inputs, rather than opt for infilling and replanting. The companies had no incentive to adopt soil conservation measures. Thus the new institutional arrangements were not conducive to sustainable management of the tea agroecosystem, neither in economic nor ecological terms. This is a clear case of institutional failure, the consequences of which are manifest in the degradation of the ecological capital. The findings of the present study indicate that privatization of the tea plantations as adopted in Sri Lanka has not led to management practices that ensure the sustainability of the plantations or help reverse overall environmental degradation in the Uva highlands.

In 1995, the new government embarked on a more complete privatization program, whereby controlling interest would be transferred to private companies, ie, management agents who showed at least a nominal profit were able to buy the controlling shares. In light of the findings of this study, the criterion adopted by the government is not at all helpful in identifying the plantations that have been managed with due consideration of their long-term economic viability. An estate can show a nominal profit by adopting short-term profit-making practices, even when its ecological capital stock is degrading. Moreover, an upturn in prices could easily cover up ongoing degradation of assets. It appears that

TABLE 5 Composite matrix of inter-estate resource management. Ranks were assigned based on the recommended values for each category of variables, ie: 3 = Good (ie, if recommended values are followed); 2 = Satisfactory (ie, if values are just below recommended figures); 1 = Unsatisfactory (ie, far below recommended values); 0 = Critical.

Variable		We	Ud	Gl	Ch	Di	Ai	Po	Cr
Organic carbon (oC)		0	2	2	1	0	0	0	1
Extent below critical oC		0	2	1	1	0	0	0	1
Soil acidity		0	0	2	2	1	2	2	1
Extent below critical acidity		0	1	2	1	2	1	3	2
Seedling: VP		2	0	0	1	1	1	1	1
Proportionate age of VP fields		3	0	3	3	3	2	2	3
Stand per ha:	a) Seedling	0	0	1	0	1	2	0	1
	b) VP	1	0	2	2	2	1	2	2
Vacancy rates:	a) Seedling	0	0	1	0	1	2	0	1
	b) VP	1	0	2	2	2	1	2	2
Replanting		1	0	1	1	1	1	1	1
Infilling		1	0	1	1	1	1	1	1
Land-to-labor ratio		1	1	3	1	1	1	1	1
Shade trees		2	3	0	2	2	2	2	2
Potential yield:	a) Seedling	1	1	2	2	2	2	1	2
	b) VP	2	0	3	3	1	3	2	2
Overall quality of plantation management		0.93	0.62	1.62	1.43	1.31	1.37	1.25	1.5

virtually none of the estates have been able to qualify for complete privatization, even according to the questionable criteria adopted by the present government.

Policy options and conclusion

An assessment of current resource management practices revealed that tea plantation units on the Uva highlands of Sri Lanka are not being sustainably managed. Several crucial management needs relating to ecological capital have not been adequately addressed. One of the most critical factors is the diminishing availability of organic materials for maintenance of soil quality and fertility. The depletion of soil fertility due to soil mining and soil erosion, coupled with the inadequate supply of organic matter and non-adoption of soil conservation practices, has led to the marginalization of tea lands. Acidity of soil under tea cultivation is also a critical problem.

Much of the study area consists of old seedling tea bushes, which are known as pre-war seedling tea. The annual rate of replanting is far short of what is required to clear the backlog of old tea cultivation. Infilling, once a routine activity on tea plantations, has been neglected. The current ratio of labor to land on most of the tea estates is far below the required level.

Estate managers focus on maximizing yields through agronomic practices such as high application of inorganic fertilizers, including foliar applications. Excessive use of chemical fertilizers on tea estates is widespread. This is a short-term strategy to increase yields. However, it adversely affects the status of ecological capital stock in the long run. Stone terraces and contour drains were established on tea plantations, but maintenance is not satisfactory. The situation is more critical on seedling fields than on VP tea fields. The present study shows that privatization as practiced in Sri Lanka's plantation sector has failed to allow for the adoption of better management systems with a long-term focus.

To make the tea plantations viable in the long run, management strategies have to be restructured. Soil organic carbon can be improved through the application of organic manure. Application of soil amendments such as dolomite is necessary to maintain soil acidity at a satisfactory level. Investment in replanting and infilling activities is an important strategy in the long-term management of tea plantations. Vacancy filling has to be practiced to maintain appropriate bush density and ground cover. Tea nurseries have to be established to ensure a regular supply of planting materials, meet replanting requirements and carry out infilling activities. Adequate attention needs to be given to soil conservation. Establishment and routine maintenance of soil conservation structures are important for the sustainability of tea plantations in the long run. With proper drains, terraces and the use of mulches and cover crops, soil erosion could be minimized.

An in-depth understanding of ecosystem functions and relationships is crucial to the management of ecosystems in general, and agroecosystems in particular. Essential ecological processes such as nutrient cycling must be facilitated smoothly and efficiently. Maintaining a balance between import of energies into the system and export of energies out of the system is imperative. This balance is critical in sustaining ecological capital in the long run. However, all these factors are influenced by institutional arrangements at the plantation level, which in turn have a lot to do with macro-level policies. A sustainable plantation management system must exhibit synchrony among all these elements.

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AUTHORS

Prabodh Illukpitiya
Department of Natural Resources and Environmental Management (NREM), University of Hawaii at Manoa, 1910 East–West Road, Honolulu, HI 96822, USA. prabodh@hawaii.edu

Nadarajah Shanmugaratnam and Darley Jose Kjosavik
Centre for International Environment and Development Studies, Noragric, Agricultural University of Norway, PO Box 5001, 1432 Aas, Norway. norns@noragric.nlh.no (N.S.); darley.jose@noragric.nlh.no (D.J.K.)

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