

IMPACT OF LAND-USE PRACTICES ON ENVIRONMENTAL CONDITIONS OF THE HILL COUNTRY OF SRI LANKA

ANOJA WICKRAMASINGHE

Introduction

Exploitation of self-supporting forest ecosystems in favour of agriculture, establishing settlements and expanding them over wide areas was widespread particularly during the last century. The adverse effects caused by replacing the natural systems with man-made agricultural systems is often identified and realized only after a period of mismanagement. Possibilities for the depletion of the resource base by over-exploitation often varies among the agro-ecological systems but is greater in areas where the condition of land itself, particularly the morphological condition, becomes vulnerable under intensive cultivation. The repercussion of undesirable farming is well noted in the hilly areas. In many countries where the mountainous terrain is under cropland, a high rate of soil degradation is recorded under heavy rainfall conditions.

In the hill-country of Sri Lanka the environmental repercussion has accumulated over the last century or so. It was primarily associated with the clearance of forest for coffee cultivation followed by the establishment of tea cultivation. With the introduction of coffee as a plantation crop in Sri Lanka in 1830 or so, the unique floristic wealth of the hill-country has been converted to commercial crop-based monoculture. Until then, man's utilization of natural forests was restricted to some isolated patches of settlements and 'CHENAS' of shifting cultivation. Their cultivation practices often enable the systems to be re-established, to a great extent, through fallowing.

The well-marked transition in the form of land use and crop cover types has been made to reach the economic goals of agriculture. In exploiting the natural systems and replacing the floristic wealth of the hill-country with domesticated crop systems, no attempts have been made to understand the importance of maintaining land resources in order to safeguard the long-term sustainability of crop production. As it was revealed by Lowrance and others (1984), agricultural sustainability can be accomplished through agro-ecosystem management incorporating ecological, social and economic goals into the design of sustainable agro-ecosystems for a specific portion of the landscape.

However, in Sri Lanka, neither the land use systems nor the cultivation practices are identified and planned by considering the desirability of the adopted system towards environmental resources. In most cases, great prospects offered by the environment are exploited, overlooking the need for adopting desirable management practices. After utilizing the land for several decades it is difficult to simplify the situation and compare it with the natural systems. This is due to the complexity of agro-ecological systems which are controlled by natural conditions and socio-economic forces. On the other hand, the management of an agro-ecosystem to meet

both socio-economic needs and the environmental requirements is an immensely difficult task. Such management objectives require a knowledge on crop parameters and management and their interaction on the environmental aspects like soil, water and climatic conditions. In this context, although a number of studies have been conducted in visualizing ecosystem function, studies conducted by applying the ecological principles and concepts to agro-ecosystems are very few. With regard to the situation in agro-ecosystems, as has been pointed out by Rambo(1983), for the better understanding of the human interactions it is necessary to draw attention to the social aspects too. Acquisition of information covering all the relevant aspects needs a series of regional studies. The identification of the current situation, the foreseen problems and measures to prevent environmental repercussion could be attempted through examining the present condition of land resources of the agro-ecological systems under concern.

Changes in the pattern of land use in the Hill-Country

Deforestation of land in the hill-country has occurred with the introduction of plantation crops during the period of colonial administration. Deforestation for Chena cultivation, fuel and expansion of settlements is very much less in comparison with the high rates of deforestation noted in the establishment of plantation crops. Therefore, plantation agriculture is the turning point in the conversion of natural forests to the monocultural practices.

The rate of deforestation is remarkable from the time of the establishment and expansion of coffee plantations in 1830s till their decline in 1880s, recording an increase of over 12 times from 1,600 hectares in 1836 to 20,000 hectares in 1889. However, with the decline of coffee in 1880s the land never reverted back to forests. Instead, it was replaced with tea, and the far more rapid expansion of the tea industry resulted in a further high rate of deforestation in the hill-country. During the century or so between 1873 and 1990 the extent of land area under tea increased from 100 hectares to 240,870 hectares. The establishment of rubber plantations also took place almost parallel to tea cultivation, but they were positioned at a lower elevation in the wet zone. The area under rubber was 428 hectares in 1898, but due to rapid expansion of the area under rubber, the extent of forested area brought under rubber cultivation rose to almost 263,964 ha in 1946. As this process continued, by the year 1926, the plantation sector was capable of alienating almost 917,386 hectares accounting for almost 14 percent of the land area of Sri Lanka.

In addition to these changes in the evolution of agricultural land use in the hill-country, the expansion of settlements, the cultivation of vegetables, mainly the European varieties in the Welimada and Nuwara- Eliya plateaus, since 1840 to cater to the British, and the cultivation of tobacco in the mid 20th century, particularly in the dry and intermediate zones of the hill-country were also noted. As land scarcity arose, the Chena cultivation which operated on a shift basis diminished gradually. Nevertheless, owing to the unique nature of the hill-country, climatically as well as

physiographically and also the nature of soil conditions there exists a large number of farming practices varying from one geographical area to another. The evolution of land use is an indication of the changing attitudes of the people who live on the land and the nature of interaction between their needs and the environment which sustains them.

The present land use practices vary in nature and they are largely influenced by the nature of management. In conducting this study, which was aimed at examining the ecological impact of the farming systems, the Maha Oya catchment was found to be suitable, because it consists of a number of land use systems widely occurring in the hill-country.

The Location and the Physiographic Environment of the Maha Oya Catchment

The land area of the central highland above 900 metres covers only about 04 percent of the total land area of 65,415 square kilo metres of Sri Lanka. Its importance as a nation's treasure is great because it causes all major rivers in Sri Lanka to drain radially. Its physiographic differences offer a tremendous range of environmental diversities. This is further attributed to both its macro-climatic and micro-climatic differences. However, after a number of decades of continuous cultivation, the extent to which man has made use of such a unique area meaningfully, without destroying its natural wealth needs to be examined with supportive evidence.

The Maha Oya Catchment selected for this study is one of the main tributaries of the Mahaweli River. The elevational difference is about 5,700 feet. Its upper tributaries drain off from about 6,900 ft. contour at the highest level and joins the Mahaweli below the 1,200 ft. contour. Its 12,928 hectares of land area consists of rugged terrain, having ridges along its periphery and deeply incised valleys with dissected terrain in the central portion (Figure 1). The Maha Oya catchment is composed of a number of mini catchments, among which the Gurulu Oya and Mul Oya cover a considerable portion of its upper catchment. With regard to slopes, the lower portion consists of slopes of 15-20 degrees and is frequently characterized with slopes of 35 degrees and above in the upper terrain.

Climatically, the area is in the intermediate zone, receiving an average of about 1,040 milimetres of rainfall per annum. Most of its rainfall is received during the northeast monsoon which occurs between October and February. In terms of soil conditions many parts consist of reddish brown latosols, exclusive of the riverine areas which consist of gley soils. The local variations in the soils are associated with the surface configuration.

The Pattern of Land Use

The Maha Oya catchment area, covers a wide spectrum of land use types prevalent in the hill-country, and the present condition is the result of interaction between the economic and demographic pressure and the resource base on which man's activities have taken place over decades. Therefore the spatial differences

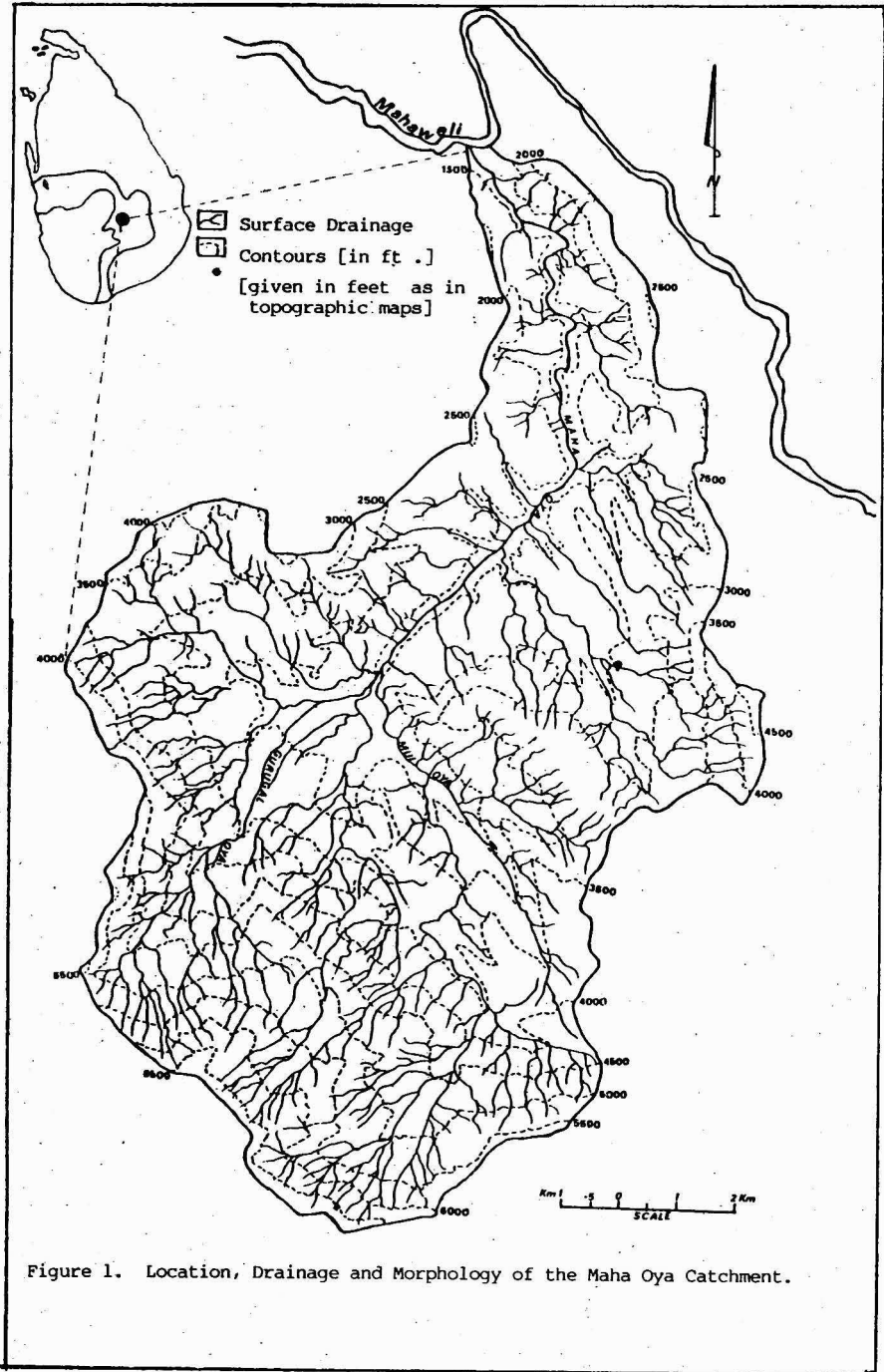


Figure 1. Location, Drainage and Morphology of the Maha Oya Catchment.

noted in its land use are not merely a result of climate, soil and morphological situation but are due to the socio-economic situation too. The consequence of this is the great diversity in the management of land resources. On this basis, the land use systems are taken as a frame to get an insight into cultivation practices and resource management.

The Land Use Systems which Occurred in 1956

The evolution of land use systems often occurs both in space and time. The resource conditions on which man has established his arable crops and the socio-cultural aspects dealing with his decisions are difficult to reformulate. In this context, aerial photographs could be used as a store of information, particularly in identifying the spatial disparities in land use. The aerial photographs taken in 1956 were used as a basic source and a starting point in this study. The area coverage of the land use types in 1956, is given in Table 1. The major types of land use in 1956 were as follows:

- i. Forest land: including both low productive wet zone forests and low productive intermediate zone forests;
- ii. Patana grasslands;
- iii. Tea plantation;
- iv. Shifting cultivation;
- v. Homesteads;
- vi. Systems of dry cropping: mainly based on the cultivation of vegetables and cereals;
- vii. Coconut cultivation;
- viii. Paddy cultivation.

Table 1 : The area coverage of the Land Use Types in 1956

Land Use Type	Area (ha)	Percentage
Non-Productive Wet-zone forests	960	07
Non-Productive Intermediate Zone forests	256	02
Patana Grasslands	1408	11
Chena-Land	384	03
Paddy Cultivation	1280	10
Tea Cultivation	4672	36
Dry-Lands Cultivation	2112	16
Coconut Cultivation	448	04
Settlements and Homesteads	1408	11
TOTAL	12928	100

As noted in the spatial pattern of land use in 1956 (Figure 2), the area under forest cover was almost a fraction of the catchment. It was restricted to the highest elevational drainage divide of the south and southwest. Although these are remnants of wet zone forests, in terms of floristic wealth and productivity, they are not comparable to the forests prevalent in the interior of the wet zone.

Another feature of the land use was the existence of Patana grass. The isolated patches of Patana Grasslands were often interspersed by the croplands and settlements. Almost 40 percent of the catchment area had been completely converted to tea by 1956; this was the major land use system noted mostly above the 3,500 ft. contour line in the upper part of the catchment. To a lesser extent, it occurred below this elevation along the eastern and western boundaries of the upper and middle sections of the watershed.

Among other land use types, dryland farming was widespread mainly in the lower part of the catchment, while the traditional system of paddy cultivation was confined to the valleys, and lower slopes where it had been cultivated on terraced fields. The chena system based on shifting cultivation existed in 1956. The isolated patches of shifting cultivation are an indication of the conversion of forest land to food production, where land was available and population pressure was less. But, as noted in Figure 2, even in 1956, the chenas were strictly limited to a few blocks, and possibilities of moving into virgin or already fallowed areas were not apparent.

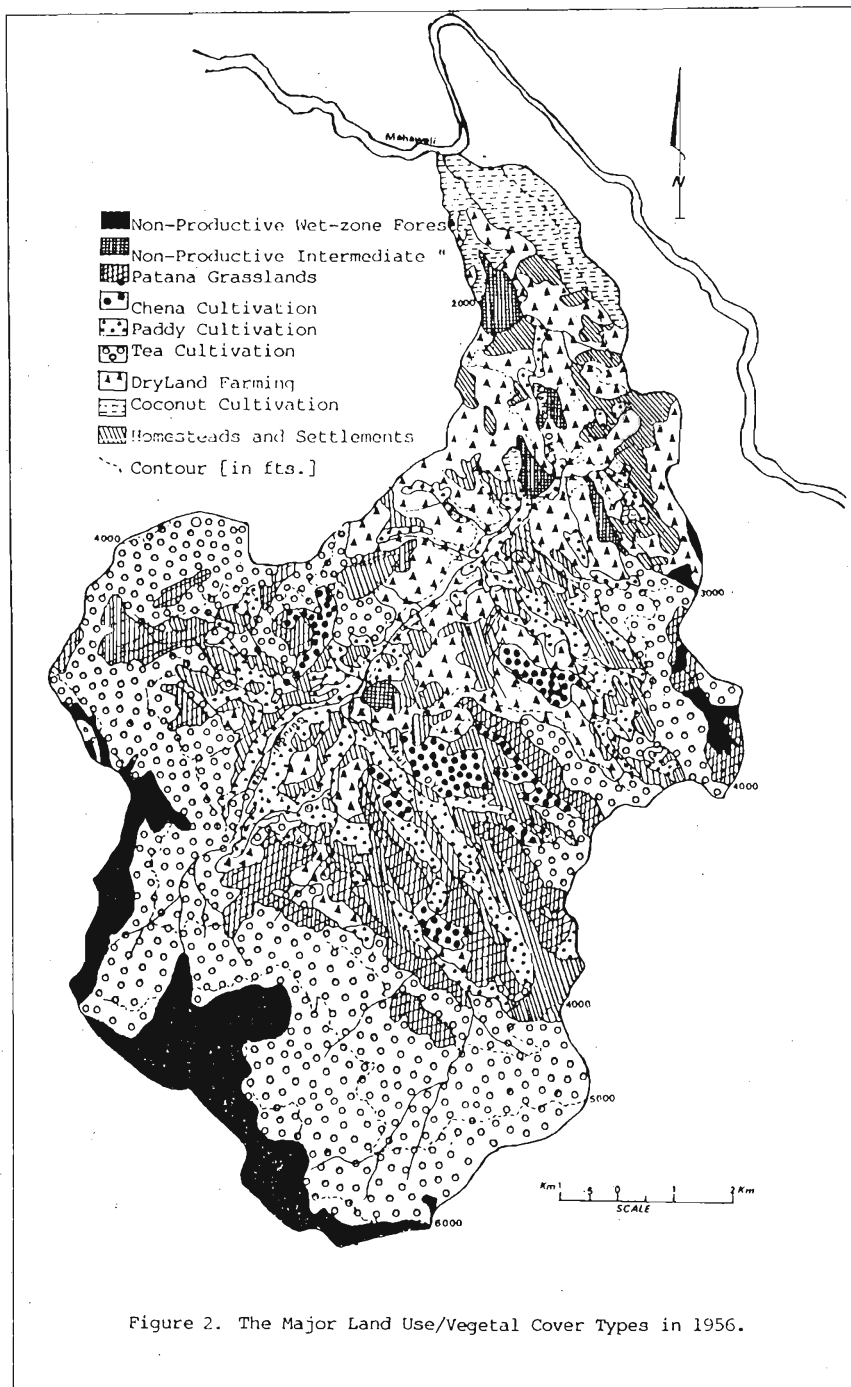


Figure 2. The Major Land Use/Vegetal Cover Types in 1956.

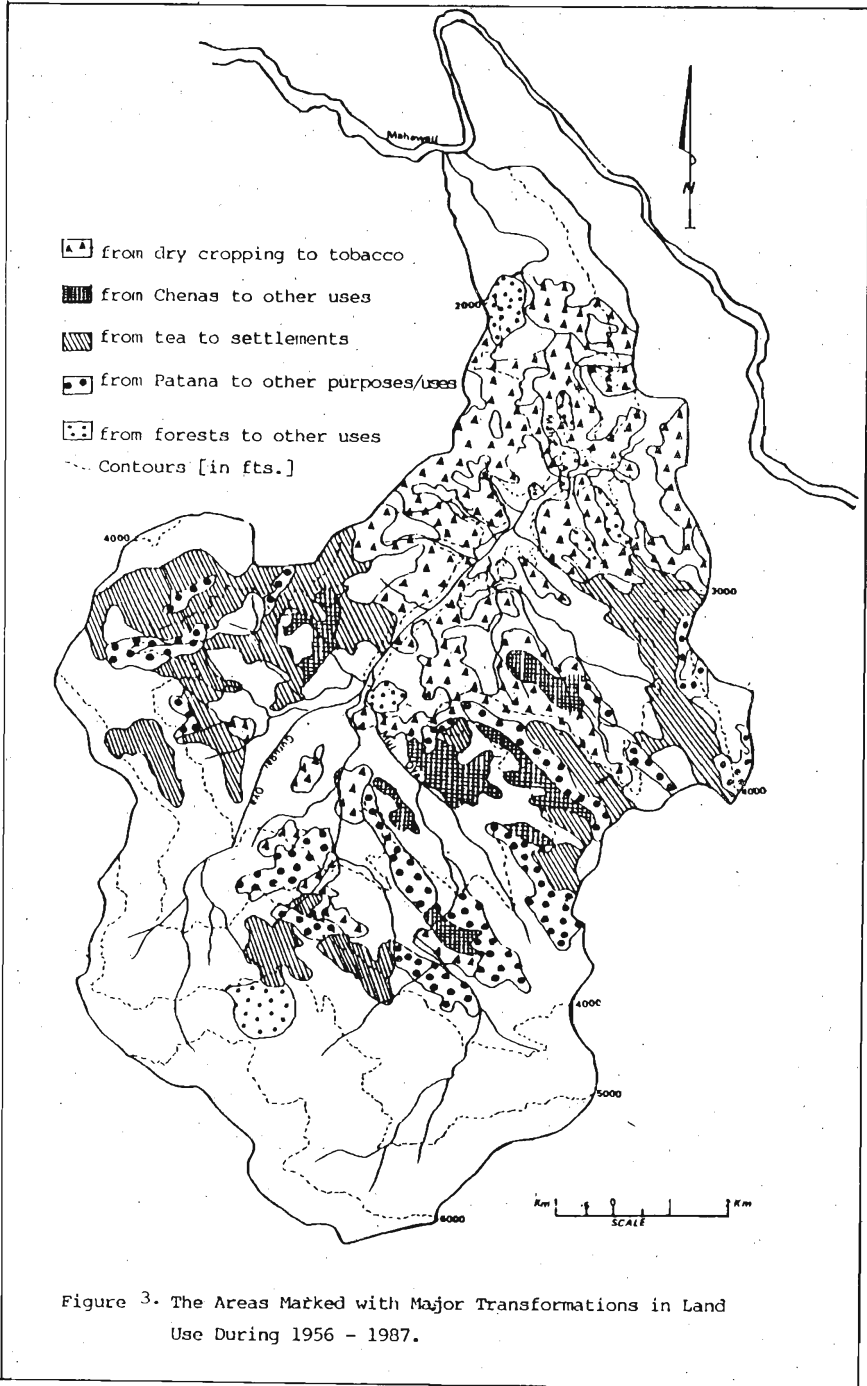


Figure 3. The Areas Marked with Major Transformations in Land Use During 1956 - 1987.

In the mountainous terrain, prior to the alienation of land for the cultivation of tea, chena cultivation may have been widespread in the 19th century.

Settlements and the homesteads were less scattered, and were mostly confined to the lower valleys where most of the paddy farming prevailed. Confining the settlements to lowlying valleys and lower slopes is an indication of the influence of paddy cultivation on the livelihood of the peasants.

During the last three decades two forms of changes have taken place in the agricultural land use and farming. The first change had taken place spatially, from 1956 to 1987, mainly in the physical form of land use. As shown in Figure 3, this includes:

- i. Complete disappearance of 'Chenas' which were converted to tobacco and vegetable cultivation;
- ii. Reduction of the land area which was under the low productive intermediate zone forests;
- iii. Expansion of village settlements;
- iv. Acquisition of marginal tea lands for the expansion of settlements;
- v. Conversion of Patana Grasslands for the purpose of agriculture;
- vi. Replacement of dry crop farming with tobacco and vegetable cultivation.

The second form of change has taken place technologically in the form of crop management and modernization. As this study is mostly concerned with changes in the physical form of land use or farming, and their impact on ecological resources, less attention is given to examine the changes in crop management such as application of fertilizers, pesticides and herbicides.

However, both these forms of changes are equally important in determining the quality of environmental resources and the sustainability of agriculture. The environmental changes brought about by the evolution of land use are most important in determining the soil productivity. For example, extensive deforestation in any area results in a decrease in soil productivity, water resources, soil nutrient pool and soil moisture retainability. At the same time extensive deforestation increases soil moisture evaporation, soil denudation, and leaching of soil nutrients. Therefore, if preventive measures are not taken at the stage of establishing farming systems, and if desirable measures are not adopted at the management level, the condition of land resources is liable to deteriorate.

Impact of Land Use Practices on Environmental Conditions

The management of ecological resources in the process of crop production have some consequences upon the environmental quality. The degree of ecological hazards is not equal, but constraints are more serious in areas characterized with slopes of high gradient and by a high intensity of rainfall. Even in the dry zone areas of Sri Lanka, where presumably the erosional effects should be less, due to its undulating terrain condition, soil degradation is found to be considerable due to the nature of farming practices (Wickremasinghe 1987). The situation in the hill-country is specific due to its physical set up (Wickramasinghe, 1986, 1989). It is also commonly noted in a number of other studies i.e. Lal (1985), Rapp (1972), and Virgo *et al.*, (1978). Among the major problems, soil erosion, reduction of water resources and soil nutrient condition are the most outstanding.

Land Use and Soil Erosion

Accelerated soil erosion on croplands is a symptom of ecological imbalance and it often varies from one farming system to another with regard to the characteristics of farming practices and the land on which a particular system is operated. As it is noted by Vaillaume (1982), soil erosion is a multi-faceted and complex process that is affected by a multitude of interacting environmental parameters.

According to Kadomura and Yamamoto (1979), the rate of soil erosion in the world is estimated to be about $10 - 15 \text{ m}^3 \text{ km}^{-2} \text{ year}^{-1}$ with rates increasing to $150 - 500 \text{ m}^3 \text{ km}^{-2} \text{ year}^{-1}$ in the mountainous regions. But according to Fournier's (1962) estimation, the potential denudation rate of the subhumid and semiarid regions of Africa should be about $1,450 \text{ m}^3 \text{ km}^{-2} \text{ year}^{-1}$. The potential denudation rate for Africa as a whole is estimated to be $510 \text{ m}^3 \text{ km}^{-2} \text{ year}^{-1}$ (Lal, 1985). However, what is apparent in the available literature is the extremely high differences in the rates of erosion. Many of the differences in this aspect may be due to the complexities which have arisen when generalizing the phenomena. For instance, estimates of denudation rates made by Fournier (1962) and by Strakhov (1967) differ by several orders of magnitude. It is therefore difficult to estimate the terrestrial erosion and generalize the rates due to the complexity of the process itself, which varies spatially in relation to the biotic and physical conditions and their interactions. For practical purposes, it is therefore important to examine this factor with a data base using ecological zones, physiographic regions or farming systems as a frame for investigation.

A common fact which is accepted by the researchers is the increasing severity of soil erosion whenever the natural vegetation is reduced or removed for other purposes. According to the study of Roos (1970), in the humid regions of the Ivory Coast, the surface runoff under forest cover was only 1.5 percent of the 1,750 mm of annual rain fall, while interflow formed a major component of the water balance and amounted to 500 - 600 mm per year. Deforestation increased the surface runoff by 50 times, whereas the increase in sediment yield was thousand times compared to the forested situation. Such a great increase in the sediment yield may be due to

the sudden exposure of the land surface which was formerly protected by the vegetal cover.

The erosional rates recorded in this study show a great variation among farming systems, but it is important to bear in mind that much of the deforestation for cultivation had taken place almost a century ago, and therefore, in most of the systems, the magnitude of materials ready to be removed by the surface runoff was mainly made available by man himself when preparing the land for sowing or planting by tilling or turning the soil prior to the on-set of rainfall. For the purpose of measuring the rate of annual soil erosion two sites were located covering 25 square metres in each of the land use systems. The sediment yield of the sample area was allowed to be moved into a metal gutter and then funneled into a barrel. The average-dry weight of the collected sediments of each of the systems was taken for comparative purposes. Whenever possible the measurements were taken from sites located on slopes ranging between 25 and 35 degrees.

Soil erosion was extremely high in tobacco cultivation with an average of $1,302 \text{ m}^3 \text{ km}^{-2} \text{ year}^{-1}$. The main reason for such a high rate is its undesirable farming practices, e.g. complete clearance of fields and turning of soil before the on-set of rain and the cultivation of tobacco as a monocrop. With the on-set of rainfall the exposed soil moves down without any hindrance. During this period both splash erosion and sheet erosion take place. Consequently, most of the nutrients are either eroded away or leached.

The magnitudinal differences existing between tea and other crops in this aspect are attributed to the nature of land use and farming practices. Much of the soil in tea plantations is exposed to rain drop action, which leads to a considerable loss of surface materials from erosion. The present condition of these degraded tea plantations is not capable of protecting the soil. The traditional practice of complete weeding in this area makes the situation worse, and it often leads to a removal of 755 m^3 of uppermost soil $\text{km}^{-2} \text{ year}^{-1}$. Moreover, as it is noted in the study of the root exposures of the tea bushes of the sample plots, almost 29 to 38 centimetres of top soil has been lost from these tea areas over the last century. This would possibly account for an average soil loss of over $1,075 \text{ m}^3$ of soil $\text{km}^{-2} \text{ year}^{-1}$. However, as it was noted earlier, the rate of erosion is attributed to the conditions of the crop cover, rainfall and the morphological condition. The tea plantations on comparable slopes in the area yield only 60 percent of the sediments which move-out from tobacco land. In comparison with tobacco, tea is capable of reducing the rate of soil erosion to a considerable level, with its root system and perennial crop cover, although 15 - 25 percent of the ground is exposed due to bad management. Nevertheless, as the situation has exhibited, the poorly managed tea in this area loses sediment at the magnitude of 15 times compared to what is noted in the homesteads and almost 20 - 22 times noted in the unproductive wet zone forests prevalent in the area. (see Table 2).

Table 2 : Effect of Land Use on Soil Erosion

Land use (crop/vegetation cover)	Annual Soil Loss (m ³ km ⁻² year ⁻¹)	Slope Angle (Degrees)
Tea	755	30 - 35
Tobacco	1302	25 - 32
Grasses	212	30
Coconut	102	13 - 13
Mixed (Homestead)	57	28 - 30
Natural Forest (a)	45	30 - 35
Natural Forest (b)	12	32 - 34

(a) = Forest located in the catchment.

(b) = Forests located outside the catchment in Hunnasgiriya Range (wet zone forest).

Grass cover on comparable slopes is advantageous in controlling soil degradation, but it is not established by man for productive purposes. Among man-made systems homesteads are the most advantageous in controlling erosional hazards. Under perennial crop cover the exposure of root collar is zero, because it is buried by the plant debris which is accumulated over a period of time.

Another fact revealed from this study is the occurrence of soil erosion at a comparatively high rate in the degraded forest land, where most of the broad canopy species have been removed for timber and exploited for fuel. The soil erosion occurs at a magnitude of 3 to 3.5 times more than that which was noted in the natural wet zone forest in the Hunnasgiriya Range.

The Soil Organic Matter

The predominant characteristics of natural ecosystems are their tendency to accumulate nutrients against the process of erosion and leaching and their tendency to persist through time. The successful manipulation of the interaction between biotic and abiotic factors often leads to the system's nutrient accumulation and persistence.

However, the magnitude of the loss of organic carbon and nitrogen from the cultivated ecosystems varies among systems. The continuous recycling of nutrients

in natural vegetation means that, small losses of soil nutrients through leaching and runoff will be easily balanced by rock weathering or by inputs of material in rainfall. But in agricultural systems, the bare surface often accelerates the loss through runoff, while tilling of the soil increases the loss through leaching. In addition, the removal of organic products for human consumption is one of the major causes for the imbalance of the nutrient conditions.

In this study, although the rate of nutrient loss is not measured, the actual magnitude of organic matter returned into the soil is measured. Among the three principal plant nutrients (N - Nitrogen, P - Phosphorus and K - Potassium), nitrogen, the most important agricultural fertilizer, is mostly derived by decomposition of organic matter returned to the soil. In this context, attempts were made to measure the organic matter returning to the soil annually, and to examine the characteristics of the soil profile of the agricultural systems. The data collected over a period of one year is given in Table 3.

Table 3 : The Magnitude of Organic Matter Returned to the Soil

Crop/vegetation cover	Organic Matter (tons ha ⁻¹ year ⁻¹)	Thickness of the Humus Layer(in cm)
Tea	2.8	05
Tobacco	3.0	04
Grasses	3.8	10
Coconut	(not measured)	21
Mixed (Homestead)	8.0	42
Natural Forest (a)	6.0	38
Natural Forest (b)	9.8	72

(a) = Forest located in the catchment.

(b) = Forest located outside the catchment in Hunnasgiriya Range.

In terms of annual organic matter accumulation, a well-marked difference is noted between the perennial systems and the seasonal cropland. Low rates are noted in tobacco, where the leaf biomass is removed, while the lowest magnitudes are noted in tea lands. According to Visser's (1960) observation the leaf fall from tea was about 03 tons per hectare per annum. The magnitude of leaf fall varies under the varying conditions of the plantations. The rate of organic matter returned to the soil from multi-structured homesteads is quite comparable to tropical rain forests, accumulating almost 08 tons ha⁻¹ year⁻¹.

The condition noted in the thickness of the soil organic layer, is more favourable in homesteads than that observed in the other cropland. This is an indication of the

desirability of mixed cropping, perennials with seasonals, to control environmental hazards and also to promote the natural fertility of the soil. Any reduction in the accumulation of plant debris which enriches the nutrient pool indicates the need for its replacement through inorganic fertilizer applications, to sustain crop production.

The Water Resource

The amount of water made available for plant growth in the rooting zone of the soil is important to the sustainability of crop production. Similarly the magnitude of water available in the form of water resources is equally important in the functioning of the hydrological cycle and also in sustaining life.

Reductions in water resources is one of the environmental constraints reported as widely occurring, due to deforestation in many part of the world. This is exemplified by the situation noted in the Maha Oya catchment, where 60 percent of the springs and water spouts had completely dried-out over the last three decades, while another 20 percent flows only during the rainy season and immediately after. This situation is a direct result of the reduction in the rates of water percolation to the soil and the increase in surface run-off. Hence a sudden increase in the discharge during the rainy season and an extremely low discharge during the drought spells are also noted in the major streams.

The other feature observed in this study is the variation in actual amount of water retention and the water-holding capacity of the soil. As shown in Table 4, these two aspects vary greatly between seasonal croplands and the systems consisting of continuous vegetal cover.

Table 4 : The Soil Moisture Condition and the Potential Evapotranspiration at the Ground Level

Crop/vegetation type	Available water capacity(mm)	Depth of the soil layer which retains 2/3 of (AWC) (cm)	Ground level evaporation (as a % of the space)
Tea	72	40	82
Tobacco	80	50	90
Grasses	120	63	80
Coconut	200	90	71
Mixed (Homesteads)	250	80	16
Natural Forest(a)	220	76	18
Natural Forest (b)	290	110	15

(a) = Forest located in the catchment.

(b) = Forest located outside the catchment in Hunnasgiriya Range.

Among croplands, the condition of the perennial systems is advantageous in percolating a comparatively high amount of water and in having a high level of water-holding capacity. Because of the high density of crops and their canopy cover, surface run-off is less, and so, percolation of water into the soil is greater. In addition, the higher organic matter content often increases the rate of water entry into the soil as well as the amount of water that can be held. Within any system, either natural or man-made, humus builds up in the soil, largely by continuous addition of plant debris, thus decisively augmenting the field capacity of the soil. As it is quoted by Jenny (1980), it could take place at the rate of 2.20 to 2.25 percent of water for each percent of humus for the loams and sandy soils.

The shallowness of the soil is another attributory condition which leads to low level of water holding capacity and water retention. Limiting of soils to very shallow horizons or some pockets, and also the exposure of gravel and bare rocks on the surface are the characteristics noted in both tobacco and tea. In most of the high elevational cultivations, the thickness of soil is often in the range of 10 - 25 centimetres. Moreover, the depth of the A soil horizon, the layer rich in organic matter, is restricted to 03 - 08 centimetres in most areas. Quite a contradictory situation is recorded in other systems, especially in the perennial systems like homesteads and forests located on comparable slopes. As noted here, the prevalence of a perennial vegetal cover is capable of maintaining an efficient turnover of principal nutrients and developing a favourable soil column required for plant growth. It is a desirable way of maintaining the quality of the ecological resources on which crop production is to be sustained.

The Micro-Climatic Condition

Modification of the micro-climatic condition can be brought about by changes in the surface vegetal cover, which is more often a consequence of the clearing of forests for the purpose of other land uses. As stressed by Goodland and Irwin (1975), the clearing of forests, in general, often leads to an increase in the 'harshness' of the environment, both aerial and edaphic, due mainly to the misuse of the cleared land.

Comparative studies dealing with the micro-climatic condition of forests and the cleared land are limited. However, the results of the study carried out by Lawson and others (1981), in Ibadan, Nigeria, was found to be relevant in the examination of these aspects. As noted by them the forest cover was advantageous in maintaining high humidity levels and in reducing the excessive heating because it controlled both air and soil temperatures. It is also capable of minimizing the extreme seasonal variations. In this study, although continuous readings were not taken, the average temperature conditions of all crop cover types at ground level were measured. Accordingly, the average temperature conditions in December 1987 was found to vary, being 27⁰ C under tea, 28⁰ C under tobacco, 28⁰ C under grass, 26⁰ C under coconut, 24⁰ C under mixed gardens and 23⁰ C under forest cover.

Similarly, a great variation between the open vegetal cover systems and complete vegetal cover systems is noted in a comparison of the pan evaporation measured under these crop types. The rate of water loss due to evaporation on the ground surface of the homesteads and the natural forests was comparatively low, occurring within the range of 15 to 18 percent, whereas under a scattered crop cover the range of evaporation is within 71 to 90 percent of the amount noted in an open space.

Although most of the environmental aspects in this study were discussed in isolation, it is important to view each and every system as a whole. This is mainly because the land area in which a particular type of agricultural practice is operated, is characterized by a specific set of interactions determined by the condition of its vegetal cover, the organic matter input, and the removal of the production, its water resources and the soil nutrient condition. A favourable micro-climatic condition developed under a vegetal cover system is important in promoting the condition of its land resources.

Conclusion and Recommendations

The weakening of the self sustainability of farming systems is mostly due to the greater reduction in the vegetal cover of the systems which had been introduced in the past. To a great extent, the systems based on perennials which are diverse in their crop composition are in equilibrium with the soil and the environment, because the plant nutrient tied up in the vegetation are regularly available for the nutrient pool and so there exists a continuous nutrient cycle. Here, in addition to the increase in water percolation and the high soil water storage capacity, the surface run-off is also reduced effectively. The complete vegetal cover with its multi-storey structure and the leaf litter often resists the rain drop impact and helps to reduce surface run-off.

Based on the observations, it is reasonable to conclude that, although the forest clearance and its replacement with a sparse crop cover generally leads to an increased harshness of the environment, the selection of desirable strategies which are capable of protecting the land could lessen the ecological impact of farming. In this context, a great effort is needed to identify desirable farming practices to fulfil the requirements of these environments as well as those of the farmers, simultaneously.

The changes which had taken place in agricultural land use even during the last three decades have transformed the land use systems to new commercial crops, mainly tobacco, for better economic returns. The conversion of areas under dry land farming into tobacco cultivation is the major transformation in the land use which has led to a greater acceleration in the rate of erosion. It has been greatly detrimental to the associated land resources too. Having understood the detrimental effects of tobacco on the land resources and soil productivity, the Ceylon Tobacco Company, which has the monopoly over tobacco cultivation in this area, has introduced certain measures for soil conservation. These include construction of drainage, earth

bunds, stone bunds and contour terraces. Although these measures help to retain the sediment transportation by barricading the free run-off, fail to promote the build up of organic matter content in the soil.

The next major transformation, is the conversion of low productive tea land, Patana and Chenas to settlements and some other uses. It has created some adverse effects on both society and environment. The distribution of low productive land in the rugged terrain to the landless has created a number of problems, because the requisite revitalization is not within reach of the poor. However, the poor who struggle for existence throughout, cannot be expected to devote their income or time on the land for environmental benefits. The lack of technological knowhow and financial assistance also hinder the enrolment.

Under these circumstances, it is necessary to recommend the adoption of farming strategies that are practically applicable and capable of ensuring the maintenance of a continuous vegetal cover. The biological methods of erosion control in combination with a minimum tilling are much desirable to promote soil productivity in the terrain. The integration of perennial species either on contour strips or on alleys should be introduced to the area. Such types of biological methods would be beneficial in serving several purposes. They would control erosion, procure mulch, promote infiltration, water retention and nutrient cycling and also produce food, fodder, fuel, timber and shade for the community. In this respect the introduction of ecologically favourable technologies will require a collaborative effort among the farmers, policy makers, agrarian services and the enterprises engaged in production activities, such as the Ceylon Tobacco Company and such other enterprises. In addition to these, environmental awareness programmes coupled with low cost technologies must be popularized among the farmers. The sustainability of agriculture in this area depends largely on the small-scale farmers who manage almost 75 percent of the arable land. Therefore, the farmers have to play a major role in achieving the multiple objectives of agriculture.

Acknowledgement

The author wishes to extend her sincere thanks to the Natural Resources, Energy and Science Authority of Sri Lanka for the Financial Assistance provided (RG/NORAD/87/SS/08) for the carrying out of this work satisfactorily.

In addition, her thanks are also due to Mr Ranjith Wickramasinghe for attending to the preparatory work and the field work with great enthusiasm.

References

- Fournier, F. (1962). *Map of Erosion Danger in Africa South of Sahara*, EEC Commission for Technical Co-operation in Africa, Paris.
- Goodland, R.J.A. and Irwin, H.S. (1975). Amazon Jungle: Green Hell to Red Desert, *Landscape Planning*, Vol. 1, No. 2/3 pp. 123 - 254.
- Jenny, H. (1980). *The Soil Resources: Organic and Behaviour*, Ecological Studies 37, Springer - Verlag - New York, Heidelberg, Berlin.
- Kadomura, H. and Yamamoto, H. (1979). Man - Induced Erosion: the rate of erosion and an example from Okinawa Island, Southern Japan, *J. Geogr.* 87, pp. 1 - 15.
- Lal, R. (1985). 'Soil erosion and sediment transport research in tropical Africa', *Hydrological Science*, 30,2, pp. 239 - 256.
- Lawson, R., Lal, R. and Oduro-Afriyie, K. (1981). Rainfall distribution and micro-climatic changes over a cleared watershed in *Tropical Agricultural Hydrology*, Lal, R. and Russel, E.W. (eds.) (John Wiley and Sons, Chichester, New York, Brisbane, Toronto).
- Lowrance, R., Stinner, B.R., and House, G.J. (1984). *Agricultural Ecosystems Unifying Concepts*, John Wiley and Sons., New York, Chichester, Brisbane, Toronto, Singapore.
- Rambo, A.T. (1983). Human ecology research on tropical Agro-ecosystems in Southeast Asia. *Sing. J. of Trop. Geogr.* Vol. 13(1).
- Rapp, A. (1972). Conclusions from the DUSER soil erosion project in Tanzania. *Geogr. Ann.* 59A, 3-4, pp. 377 - 379.
- Roose, E. J. (1970). The relative importance of erosion and oblique and vertical drainage in the contemporary pedogenesis of a ferrallitic soil in the Mid-Ivory Coast. *Cah. ORSTOM, Pedol.* 8, pp. 469 - 482.
- Strakhov, N.M. (1967). *Principles of Lithogenesis*, Vol. 1, Oliver and Body, Edinburgh.
- Virgo, K.J. and Munro, R.N. (1978). Soil and erosion feature of the Central Plateau region of Tigrai, Ethiopia, *Geoderma*, pp. 131 - 157.
- Visser, T. (1960). Estimation of organic matter supplied by regularly plucked tea bushes. *Tea Quart.* 31, pp. 161 - 165.

- Vuillaume, G. (1982). The influence of environment parameters on natural erosion in the tropical regions of West Africa. *Stud. Rep. Hydr.* 32, pp. 225 - 251., ORSTUM, Paris.
- Wickramasinghe, A. (1986). Agro-ecological Land Potential of the Hill- country, A paper presentation at the Institute of Fundamental Studies (IFS), Kandy, Sri Lanka, October.
- Wickramasinghe, A. (1987). 'Ecological Impacts of Dry Zone Farming Systems., *Malaysian Journal of Tropical Geography*, Vol. 15, pp. 49- 57.
- Wickramasinghe, A. (1989). The environmental Deterioration in the Hill- country of Sri Lanka. *Malaysian Journal of Tropical Geography*, Vol. 19, pp 44-51.

Vol. 10 Nos 1 & 2 June and December 1987

Contents

1. Cultural Relations between Sri Lanka and North India during the Anuradhapura period
Lorna Dewaraja
21. Parent Participation in Early Childhood Care and Education (ECCE)
Swarna Wijetunga
39. Buffalo Management Under Semi - Free Grazing System : Problems and Prospects. A Case Study.
Rohana Ulluwishewa
51. Industrialisation Strategy in Sri Lanka - Recent Changes in Policy and Promotional Measures
Sriyani Dias
83. Migration to the Middle East, Social Stratification and Social Mobility: Case Studies from Sri Lanka
S.T. Hettige
121. Major Characteristics Associated with the Problem of Solid Waste Management in the City of Colombo
Jayanthi de Silva