

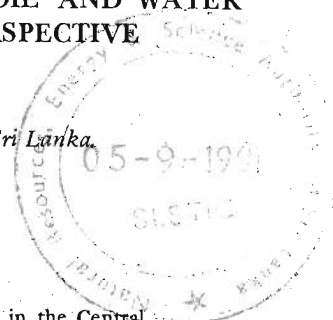
A MAN'S ROLE IN THE DEGRADATION OF SOIL AND WATER RESOURCES IN SRI LANKA: A HISTORICAL PERSPECTIVE

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Abstract: The upper catchment areas of the major rivers situated in the Central Highlands of Sri Lanka had been stripped of the natural vegetation to make way for the plantation agriculture during the British period. Large areas of forest on steep slopes were cleared within a period of less than 100 years and the consequences of these actions were immediately visible in the form of accelerated soil erosion, siltation of low lying areas, frequent flooding, drying out of streams, etc. Even after Independence, land clearing continued unabated. Today only small patches of forest are left, even those are not in the critical areas. Most of the tea plantations have lost the fertile upper soil layer due to erosion. Adoption of proper conservation strategies in the upper catchment areas to protect soil and water resources from further destruction is of paramount importance now more than ever before.

“ He treats his mother, the earth, and his brother, the sky, as things to be bought, plundered, sold like sheep or bright beads. His appetite will devour the earth and leave behind only a desert ”

Great Red Indian Chief Seattle, 1854.

1. Introduction

Sri Lanka can be sub-divided into two broad topographical regions, namely, the Central Highlands and the surrounding plains. Although the unit, Central Highlands, covers only a small percentage of the total land area of the Island (area above 300m < 17 percent), its importance in terms of the Island's climate and hydrology is considerable. There is a close association between the distribution of rainfall and elevation; the west facing slopes of the Central Highlands receive the highest amounts of rainfall in Sri Lanka from the south-west monsoon (mid-May-September).

The Upper catchments of all the major rivers of Sri Lanka are situated in the Central Highlands. These catchments were once covered with dense tropical forests but today the plantation crops, tea in particular, have replaced them to a large extent leaving only small patches of forest. Tea has been planted well above the 1524m limit set by the British Colonial Administration in 1873, as can be seen in the Nuwara Eliya district where most of the land between 1524m and 1830m is under tea plantations. There are also about 3238ha of tea above 1830m.

In 1956, the forest cover of the whole Island stood at 44 per cent and this has been reduced to a mere 24 per cent by 1981. Deforestation has taken place in all parts of the Island but the situation in the upper catchment areas seems to have reached a critical point (Figure 1). The forest cover in the upcountry districts today stand at about 16 per cent of the total area.

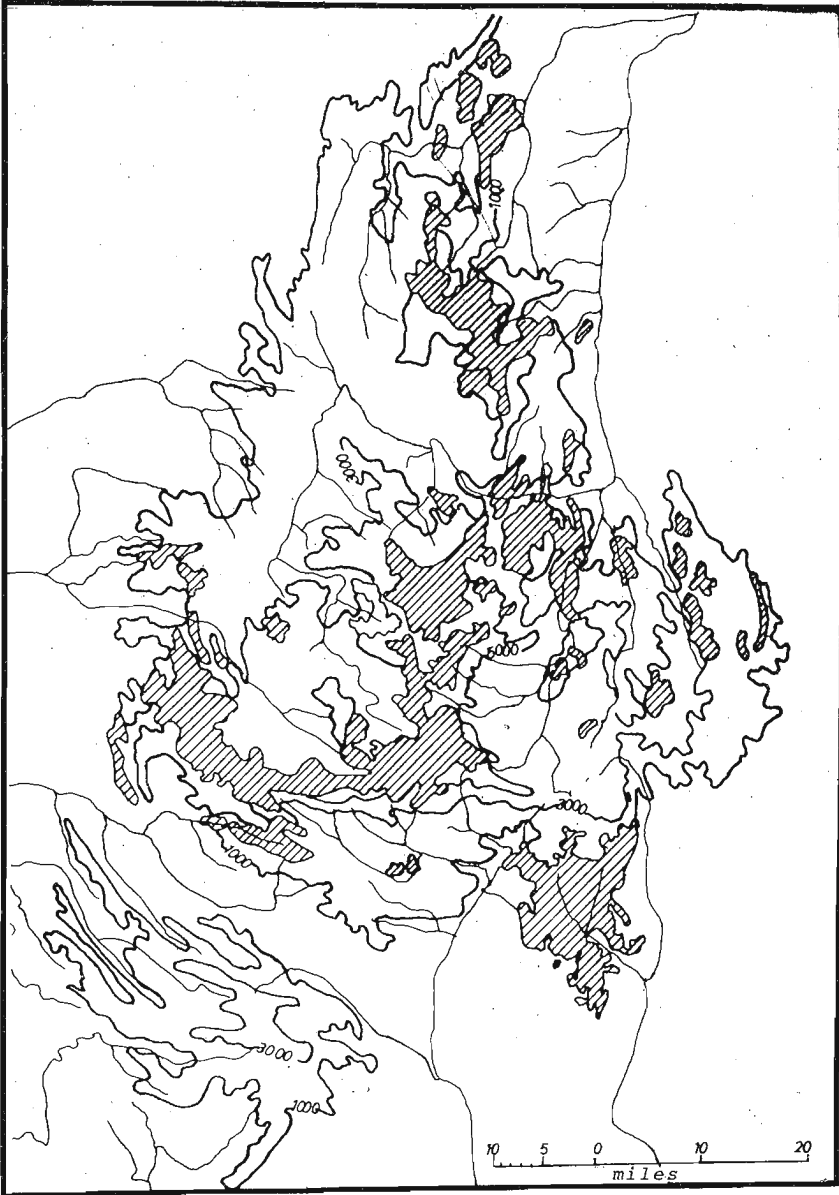


Figure 1 : Forest Cover in Upper Catchment Areas of Sri Lanka

Vegetation plays a vital role in protecting and improving soil and water resources of a region; its effect on the upper catchment areas are of great importance. Natural vegetation performs several functions vital to the protection of upland areas from accelerated erosion, such as (a) interception of rainfall, (b) increasing the infiltration capacity of the soil, (c) increasing the surface resistance to the overland flow, (d) binding of the soil together, (e) maintenance of soil fertility and moisture levels, (f) regulating the stream flow etc.

Burns³ reckons that the erosive power of the rainfall in the upcountry areas of Sri Lanka is quite high. Exposed soils are subjected to rain-splash erosion by breaking up soil aggregates. The soil particles detached from the aggregates by rain-drop impact are carried downslope by the overland flow. Removal of the vegetation cover increases the surface runoff, which attains erosive velocities on bear slopes. According to the theoretical calculations of Burns³, a rainfall of 102mm an hour and a runoff of 6m per second would have the energy of 1.91×10^9 jules per sq. km. Such a force would have an enormous destructive effect on the top soil in the absence of a vegetation cover.

Bad management of the plantations has aggravated the problem of soil erosion on slopes in the Central Highlands. The accelerated erosion can be brought under control by adopting suitable conservation strategies. The tea bushes in the well managed plantations provide complete protection to the soil from rain splash erosion by intercepting the rainfall. Soil erosion is severe in tea plantations with open spaces between tea bushes.

Deforestation in the Central Highlands and its effect on the soil and water resources cannot be understood without looking at the history of land use in this region. The transformation of the dense tropical forest, once described by Robert Knox (Knox, 1681) as impenetrable, to an almost continuous blanket of plantations took place over a relatively short period of time as will be shown later. The history of the plantation agriculture of the Island is also the history of environmental degradation in the Central Highlands. A close scrutiny of the available evidence would reveal the extent of damage caused by man due to his unhealthy attitude towards nature.

Now the natural vegetation that protected and improved the river catchments in the Central Highlands for thousands or perhaps millions of years have almost completely gone. Reverting much of these areas back to forest is realistically not possible. Therefore, it should be a priority concern to find suitable alternative land use and conservation strategies to minimize the damage.

2. Situation Upto the British Period

Human interference with the natural environment would have been greatest in and around the major centres of population concentration, which were located in the lowlands, particularly in the Dry Zone, upto the Kandyan period. Throughout many of the major historical periods of the Island, the Central Highlands remained more or less in its natural state. The influence of the pre-historic cultures such as those of Ratnapura, Balangoda, Bellanbendipalassa, Nilgala, Kitulgala, Bandarawela etc. may not have been so critical in large scale environmental change though they may have cleared forests for agriculture or for homesteads and to chase out predatory animals. Holmes⁵, Pearson¹⁰ and Perera¹¹ postulate that the origin of grasslands in some parts of the Central Highlands may have been a result of the clearing of forests by man. A comparable phenomenon has been observed in New Guinea where the lands abandoned by a neolithic tribe after cultivation for a few seasons did not revert back to forest, but to grasslands. Perera¹¹ reckons that Bandarawellian culture of Sri Lanka bears some resemblance to the New Guinea tribe and therefore they too may have practiced some form of agriculture with the help of stone implements and fire. Rosayro⁴, however, takes a different view and claims that the grasslands are the natural vegetation in the regions where they are found and they never had woodland type vegetation. However, there is no appreciable difference in soil type of grassland areas from those of adjacent forests and it is quite possible that clearing of forest may have led to the development of grasslands.

The early Aryan settlers were concentrated mostly in the Dry Zone lowlands of Sri Lanka. Perera¹³ basing himself on the distribution of irrigation works and ancient inscriptions, concludes that these early settlements were confined to areas with Reddish Brown Earths because of their high fertility and water retention capabilities. This pattern of the distribution of settlements remained until the depopulation of the Dry Zone and the shift of the population into the Wet Zone lowlands. Development activities of King Parakramabahu I (1164–1297 A. D.) did not extend to the hill country above 457m or the Wet Zone lowlands in any major way.¹³

From about 13th century A.D., colonization of the Wet Zone lowlands and the highlands upto 762m can be seen. The Dry Zone lowlands were gradually depopulated due to the effects of a combination of environmental and sociopolitical factors.

During the Portuguese period, migration of the population into the Kandyan Kingdom occurred at a greater rate than ever before, but the majority of Kandyan villages at that time were situated below 762m above msl adjacent to the river valleys. During this period, forest clearance for homesteads and chena cultivation took place but the long recycling period of the chena lands (upto 20 years) would have helped the restoration of the forest cover. Therefore, the land use practices during this period on lower

slopes would not have caused serious environmental problems, and the upper catchment areas and the steep slopes would have been left intact.

3. British Period : Deforestation due to Plantation Agriculture

A major change in the land use in the Central Highlands occurred in the 1830's with the introduction of plantation agriculture. The 1830's saw the beginning of large scale land sales to prospective planters, the greater portion of which was in the Central Highlands. Most of these lands were covered by natural vegetation and unaffected by the activity of the Kandyan villager. The major settlements in the hill country were still confined to elevations below 920m.¹⁴

The land purchased by the European planters was soon converted into coffee plantations. The scale of deforestation during the coffee boom is given by the data published annually by the colonial administration from the 1830's till the decline of the coffee industry in the 1880's (Table 1).

Table 1

Growth of coffee plantations

Year	Extent (ha)
1836	1,618
1845	15,364
1848	24,281
1853	52,185
1863	87,413
1879	111,290
1889	20,235

Source : Sess. Paper 18, 1951

This rapid growth of the coffee industry was greatly facilitated by the sale of Crown lands at a nominal price. The total extent of lands alienated upto 1873, the year in which the sale of lands above 1524m was banned, amounted to 372,108ha, all of which were not, however, cultivated by the new owners. Until 1873, both the colonial administration and the planters ignored the ill effects of their land use policy either due to their ignorance of the consequences or the greed for profits. The impact of the clearing of the upper catchment areas to make way to the rapidly expanding coffee plantations would have been tremendous. In the absence of a proper land use policy, the buyers were allowed to choose the land anywhere they wanted and the importance of preserving the forest on steep slopes and

watershed areas was not appreciated. However, the alarming consequences of about 40 years of indiscriminate destruction of natural forests in the Central Highlands of Sri Lanka led Sir J. D. Hooker, Director, Royal Botanical Gardens, Kew, to make representations to the Colonial Secretary on the misguided land policy of the British colonial administration in Sri Lanka. This resulted in the banning of the sale of lands above 1524m for any purpose. Subsequently a forester from the Indian Forest Service (F. D'A Vincent) was appointed to inquire into the prevalent state of the forest management in Sri Lanka and to make recommendations. According to Vincent¹⁵ at the time of the British arrival in Sri Lanka in 1796, the Island would have been extensively covered with forests. The Kandyan Kings had maintained a belt of forest, 45 – 65km wide right round the kingdom as fortification against impending threats from the European rulers occupying the coastal provinces. In 1882, not a trace of these forests could be found except in isolated patches above 1524m, and Vincent was not able to estimate the actual extent of the forest cover at that time for unavailability of accurate maps, but the Blue Book of 1881 gives the rough figures listed in Table 2.

Table 2

Forest cover in Sri Lanka in 1881	
Area	Perc. Cover
Wet Zone	71
Dry Zone	91
Whole Island	84

Source : Blue Book, 1881

These figures, although their absolute accuracy^a is doubtful, give some idea as to the extent of the forest cover towards the end of the 19th century. Yet the clearing of environmentally most sensitive areas and the lack of proper conservation practices in such lands have given rise to floods of higher frequency and greater magnitude, siltation of lowlying areas and the reduction in the volume of the dry weather flow (base flow) of many rivers originating in these areas. The situation had been further aggravated by the practice of clean weeding in plantations. During this period, forests were maintained along streams as 'stream reserves' which Vincent¹⁵ dismissed as unproductive because most of these mountain streams were rock-bottomed and erosion was confined to hillslopes which were devoid of forest cover.

After the decline of the coffee industry in the 1880's tea was introduced. The industry had a modest beginning with only 100ha in 1873 but underwent rapid expansion until a good part of the Central Highlands came under tea cultivation (Table 3). Much of the coffee plantations were conver-

ted into tea, and large areas abandoned due to low productivity did not revert back to tree vegetation. The abandoned coffee plantations were subjected to the most severe rates of soil erosion.

Table 3

Growth of tea plantations

Year	Extent (ha)
1873	101
1880	3,754
1890	89,031
1896	133,031
1900	158,638
1925	182,110
1961	257,476
1980	244,707

The rapid expansion of the tea industry resulted in a high rate of deforestation in the hill country within a short period of less than a century. The sale of Crown lands also continued till about the 1930's. By 1926, the total extent of land alienated amounted to 298,143ha (9282.5 sq.km) or 14 per cent of the total land area of the Island. From the 1930's onwards, destruction of forests continued in the Dry Zone for agricultural development.

Cultivation of rubber commenced at the end of the 19th century, and it also underwent a rapid expansion. In 1898, there were only 433ha under rubber, but in less than ten years, it reached 60,704ha. In 1920, there were 186,157ha under rubber which reached a figure of 267,059ha in 1946. The rubber plantations were distributed in the Wet Zone at lower elevations than tea, yet one cannot ignore the bad effect this would have had on an already strained environment. The rubber plantations were also clean weeded until 1925 contributing to severe soil erosion.²¹

4. Situation After Independence

Even after independence in 1948, the destruction of the forest cover in the upper catchment areas continued as shown by the figures listed in Table 4. The head waters of the Mahaweli Ganga which drains most of the hill country rises at Nuwara Eliya at an elevation of 1200 – 2000m where about 74 per cent of the slopes has gradients of 21 – 40 per cent. Most of these slopes are prone to accelerated erosion when the vegetation cover is remo-

ved. The forest cover in this region has decreased from 19,000ha in 1956 to 10,100ha in 1980 (Table 4). During this period, the forest cover of the whole Island decreased from about 44 per cent down to 24 per cent. TAMS²⁵ estimated that 38.7 per cent of the upper Mahaweli catchment was affected by erosion and a 15 per cent of that requires immediate attention. The natural forest cover in most major river catchments of Sri Lanka has been depleted far below the generally accepted limit of 25 per cent in the upper catchment areas.²³ In many areas, forests have been cut well above the 1524m limit set by the British Colonial Administration.

Table 4

Land use in the upper Mahaweli basin between
1956 and 1980

Land Use	Extent (ha)	
	1956	1980
Towns	1,000	4,000
Intensive Agriculture	97,522	62,999
Forests	19,000	10,000

Source : TAMS (1980)

Soil conservation practices are confined mostly to the 'erodable areas' declared by the Soil Conservation Act No. 25 of 1951, which are situated in the Mahaweli catchment above Minipe and in the Kelani catchment above Kitulgala.²⁵ According to Perera,¹³ the upper Mahaweli catchment has less than 8 per cent of Forest Reserves. During the early seventies, the grasslands in the Horton Plains were cultivated with potato as a part of the Government's food drive. These grasslands in the Horton Plains performed a very useful function in absorbing rain water and releasing later to feed the streams originating there.

5. Chena Cultivation in the Hill Country

The impact of chena cultivation and firing of grasslands, too, would have been extensive in the hill country of Sri Lanka, particularly during and after the British period. Before the advent of plantation agriculture, Kandyan villagers practiced chena cultivation which demanded less labour and attention than the cultivation of paddy. Vincent¹⁵ reported that the major coffee plantations were situated at elevations between 900m and 1524m, and the chena cultivator was active in areas below 900m. The effect of chena cultivation on soil erosion is not well understood and is a matter for controversy. When the population was small, the fallow period of chena lands was adequate for the land to regain its forest cover even to a limited

extent and restore the fertility of the soil. Szechowicz²⁴ believes that under the primitive methods of chena cultivation, there is no threat of accelerated soil erosion, except during a short period of time just after the clearing of land. This danger disappears when the crops planted are old enough to provide cover. With the introduction of plantation agriculture and restrictions to chena cultivation, the peasant farmer had to use the same plot of land over and over again without adequate protective measures contributing to soil degradation.

Another contributory factor could be the damage caused to the patana grasslands, most of which are situated in regions with elevations above 450m (dry patana between 450 and 1524m and wet patana above 1524m). These grasslands have been subjected to annual firing preventing woodland species taking over. This would also contribute to soil erosion and the loss of plant nutrients. As Rosayro⁴ pointed out, the soils of the patana grasslands are severely degraded. According to the 1961 forest inventory² there were 363,667ha of various types of grasslands in Sri Lanka.

6. Effect of Deforestation on Soil and Water Resources

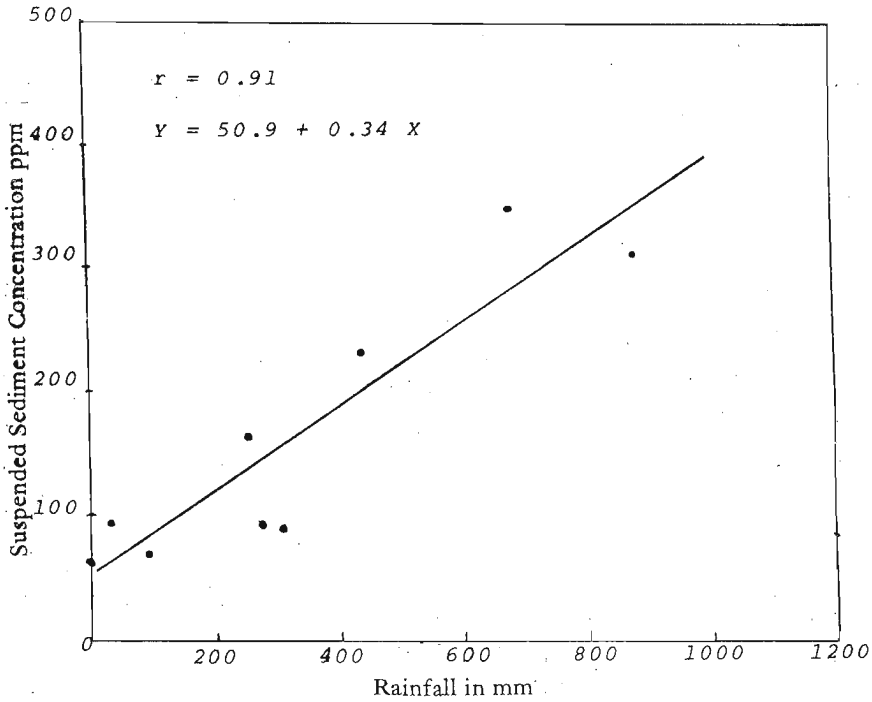
The scale of the problem of soil erosion, siltation of low-lying areas and the deterioration of water resources caused by rapid deforestation in the catchment areas with the spread of plantation agriculture in the Central Highlands of Sri Lanka may be assessed from evidence found in historical documents of the British period. The grave situation that existed in the 1870's, after nearly 40 years of coffee plantations in the hill country, is revealed by accounts of Sir J. D. Hooker, whose intervention led to the banning of the sale of lands above 1524m. But this does not seem to have improved the situation to an appreciable extent according to the Director of the Royal Botanical Gardens, Peradeniya (Thwaite), who complained in 1879 of a serious problem of erosion in upland areas and he attributed this to deforestation and to the prevalent land use practices.

The first concrete evidence of the effect of the British land policy in the Island on the rate of the soil erosion is found in the Report of the Kelani Valley Railway Commission.¹⁶ The commission recommends the extension of the railway into the Kelani valley, since the river transport of plantation produce had become difficult, if not impossible, due to the silting up of the river between the rapids above Yatiyantota and the confluence of the Sitawaka Ganga and the Kelani Ganga, decline of the dry weather flow and frequent floods in the Kelani Ganga. The commission has attributed this situation to deforestation in the upper catchment area of the Kelani Ganga. A commission was appointed again in 1904 to report on the erosion problem in the upper Kelani Ganga catchment and came to the same conclusion on the cause of soil erosion in this area. Thus, at the turn of the century, Sri Lanka was facing an ever growing problem of environmental degradation as a result of human interference in this delicately balanced environment.

In 1921, P. M. Luchington of the Indian Forestry Service, reporting on the prevailing state of the forests in Sri Lanka, identified the lack of a proper soil conservation strategy and the practice of clean weeding in tea estates as the chief contributory factors for the accelerated soil erosion in the hill country. He recommended that slopes above 60 degrees should be kept under natural vegetative cover and that forest planting should be carried out in the upper catchment areas of the Island's major rivers where the forest had been removed. This clearly shows that even after nearly a century since the beginning of plantation agriculture in the Central Highlands of Sri Lanka no adequate conservation measures had been in use despite the growing threat of soil erosion in cultivated lands and also that the colonial administration had not taken necessary steps to protect the areas most vulnerable to accelerated soil erosion.

The evidence so far considered depicting a grave situation in the Central Highlands of Sri Lanka is confined to qualitative information in the form of observations by environmentalists. Therefore it is not possible to estimate the extent of damage done by the plantation agriculture on the water and soil resources of the Island in quantitative terms. Until 1930, no data is available on the sediment discharge by the major rivers originating in the Central Highlands. A continuous record of the suspended sediment discharge is available only from 1950 and even that is limited to a few rivers and data on the bedload transport and the solution load are not available at all. The suspended load has been used as a measure of the rate of soil erosion in various environments (Langbein and Schumm, 1958, Douglas, 1967, Wilson, 1973). Although this may be criticised on the ground that it represents only a part of the total load and also in certain environments the greater part of the load is derived from river bank erosion, its usefulness, at least as a rough measure of the rate of erosion, is undeniable. Therefore, the analysis of the information available on the suspended sediment load of Sri Lankan rivers would be of tremendous value in understanding the magnitude of the problem we are faced with and also to identify the causative factors. The earliest measurements of the suspended sediment discharge of a river in Sri Lanka was done by Joachim and Pandithasekera.⁶ According to these measurements, the suspended sediment load of the Mahaweli Ganga at Peradeniya was 130,000 – 820,000 tons per annum. The suspended sediment concentration as measured by Joachim and Pandithasekera⁶ is strongly correlated ($r = 0.91$) with the previous day rainfall in the catchment above Peradeniya (Figure 2). This direct and immediate catchment response to rainfall can be attributed to the erosive power of the overland flow in the absence of forest cover. The experimental plot studies of Manipura⁸ in tea estates have also demonstrated this fact. The plots covered with mulch did not produce an appreciable amount of runoff and therefore the sediment discharge was negligible, whereas the bare plots produced relatively high volumes of runoff and sediment discharge. The two variables, rate of runoff and sediment discharge on bare plots are strongly correlated with the rainfall intensity. The five-minute maximum rainfall intensity and the rates of the

runoff and sediment discharge have correlation coefficients of 0.88 and 0.86 respectively and this relationship is well illustrated by the scattergrams (Figure 3). These results demonstrate the validity of the use of suspended sediment data as a measure of the rate of erosion in the upland areas of Sri Lanka, where humid tropical conditions produce a clayey regoliths.



Data Source : Joachim, et. al. (1930)

Figure 2 : Relationship Between Previous Day Rainfall and Suspended Sediment Concentraion : Mahaweli/Peradeniya

Data on the suspended sediment discharge is available for the Mahaweli Ganga from 1950 onwards. Basing themselves on these data, NEDECO⁹ estimated the average annual suspended sediment discharge of the Mahaweli Ganga at Peradeniya to be 486,000 tons. This amounts to a loss of a soil layer of 0.2mm in thickness every year from the Mahaweli catchment above Peradeniya. An erosion rate of this magnitude not only removes the most fertile upper soil layer from slopes but also affected the reservoirs on the Mahaweli river adversely.

Abernathy²² has shown that the runoff/rainfall ratio is increasing (Table 5) in the Wet Zone catchments. This may be attributed to the decline of the absorption of rain into the soil resulting in the high volume of discharge concentrated on the rainy seasons and the drying out of the streams in the dry season. A regular stream flow should be maintained if our development efforts, particularly in the agricultural sector and power generation, are to succeed.

Table 5

Average increase of runoff/rainfall ratio
of some river catchments of Sri Lanka

River Catchment	Perc. Increase
Kelani Ganga	1.52
Nilwala Ganga	2.17
Wet Zone Catchments	1.28
Dry Zone Catchments	0.95

Source : Abernathy quoted by
Sessional Paper 1, 1986.

7. Earth Slips

Another serious environmental problem that has received great deal of attention recently is the wide spread occurrence of landslides in the hill country. The first well documented occurrence was that of 1906 which, after an unusually high rainfall on 27th October, 1906, caused extreme damage to the upcountry railway line.¹⁸ The serious damage was confined to the section between Watawala and Ambewela, where 45 or so large slips occurred. Although the geological conditions and the climate are favourable for such events, such a widespread occurrence would certainly have been a direct result of human interference in an already unstable environment. Again, in 1947, earth slips were reported in many parts of the hill country causing considerable damage to property. The immediate cause of this

again was freak rainfall event, but the long term contributory factors were geological as well as man made. Gorrie²¹ puts the blame on the clearing of forests and burning of grasslands on steep slopes. This event was also preceded by a rainfall of 400 – 460mm within the Kotmale valley on a single day (14th August, 1947). The Kotmale valley, the worst affected area, had only 5262ha or 14 per cent of forest out of a total area of 46,135ha, which is grossly inadequate for the protection of the catchment; even the remaining forest areas were badly distributed and by no means cover all the ridges and hill tops.

The frequency of earth slips on steep slopes in the Central Highlands have been reported to be increasing. This has been attributed to the more recent changes in the land use in this region. Construction of reservoirs and the cultivation of tobacco and vegetable on unstable slopes have been identified as the major causes for this.

8. Conclusions

The evidence presented in the foregoing sections clearly shows that the present problem of land degradation is, to a great extent, a direct result of human activity in an unstable environment without a properly planned management strategy. It has been abundantly clear that the main characteristic of the land use policy of the British Colonial Administration in the 19th century was a sheer lack of concern for the environment. Even when the shortsightedness of these policies was highlighted by environmentalists who were well aware of the future consequences, no adequate response could be drawn from the authorities whose chief concern was to exploit the resources of the colony.

The soil conservation measures introduced by the planters in the face of falling productivity of the estates due to accelerated soil erosion would certainly have helped arrest the rate of soil degradation in certain areas. Even today well managed plantations in the hill country are free of accelerated soil erosion, but the badly managed tea estates and abandoned plantations continue to suffer from severe rates of erosion. Some of these severely degraded lands cannot be brought back to their natural state, but those lands which still have reasonable level of fertility but prone to accelerated erosion if brought under cultivation should be planted with suitable tree species. Due to a long period of cultivation and clean weeding, the majority of tea estates in the hill country has lost the most fertile top layer of soil, but now it is realistically not possible to reforest these areas due to our heavy dependence on tea for the foreign exchange.

Although the plantation agriculture was identified as the single most important factor that contributed to the degradation of soil and water resources of this region, there were other contributory factors such as chena cultivation, burning of the grasslands, alienation of remaining Crown lands

on hillslopes for village expansion schemes and upland colonization schemes etc. which played their part to further worsen the situation. Faced with an acute problem of poverty and landlessness among the hill country villagers, the Government of independent Sri Lanka was compelled to distribute a part of the remaining state lands under various resettlement schemes, and this has contributed to the decline of the forest cover in the watershed areas as shown by figures of 1956 and 1980.

The incidence of earthslips has increased from 1940 onwards and the last 10 – 15 years saw a marked increase in the incidence of such hazards in the upper catchment areas. Such hazards are catastrophic and get great deal of media coverage and public attention, particularly when populated areas are affected. Since our main source of power generation and water supply for both domestic and agricultural purposes depend on the regular and uninterrupted stream flow, the effect of deforestation in the watershed areas will be felt more acutely in the future.

To prevent frequent floods and to maintain a sufficient base flow during the dry season, it is imperative to adopt a sound watershed management strategy as emphasized by the most recent Land Commission Report.²² However, deep-rooted tree species with a high rate of transpiration under dry weather conditions may not be suitable for this purpose. Such plants could release a large quantity of water into the atmosphere through transpiration leading to a reduction in the ground water store. The actual water balance in the upper catchment areas under various types of land use should be worked out before making any judgement on the relative benefits of reforestation to conserve water resources in the region. But the available evidence so far discussed seems to indicate that the forest cover has a beneficial effect as far as the water resources are concerned. Its importance in maintaining soil fertility and slope stability is fairly well understood.

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