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EFFECT OF COMMUNAL USE OF DRY ZONE FOREST LAND ON SOIL EROSION

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ABSTRACT

A broad spectrum of successions in natural vegetation from abandoned chena lands to primary forest is found in the dry zone with a wide diversity in plant composition. Man's interference with the natural vegetation here usually results in the complete removal of forest for cultivation. Also, most of the remaining forest lands have been exploited by selective felling. A study was carried out to understand the soil erosion and surface hydrology in three different vegetation types formed as a result of human activities. The types of vegetation considered are selectively logged forest, scrub vegetation and chena lands under cultivation.

The study was conducted during the period November 1988 to May 1990 at Paindikulama in Anuradhapura District. Plant composition was surveyed in selectively logged forest and scrub lands. Runoff plots of 22 m x 4 m were constructed in lands under each vegetation type. Two plots were used for each treatment, and runoff and soil loss were measured.

The survey indicated that 49 plant species are found in the study site. Although about 45% of these are available in community forests, almost all tree species have been used by villagers for various purposes. Consequently, some tree species have not survived and have been replaced by others. However, soil loss measurements show that the protection given by the canopy of forests used by the community and scrub vegetation is adequate to prevent serious soil erosion. Relatively high runoff (40%) and soil loss (12 t/ha) values were observed from cultivated chena lands. It can thus be concluded that communal use of forest land by selective logging has no serious effect on soil erosion.

INTRODUCTION

Dry zone settlers lived in harmony with forest eco-systems before the introduction of colonization schemes. The traditional villager had ample opportunities to use the forest while at the same time being the dominant contributor to its sustainability. In colonization schemes, large tracts of forest lands were cleared and the use of heavy machinery caused permanent destruction to the land resource. As a result, the forest environment in these areas has disappeared due to a lack of planning. Farmer (1957), one of the early researchers who realized the misconception of land use planning in colonization, has very correctly stated his views as follows:

> Ideally, at any rate, each colony needs village forest, to use the terminology of the mapping-out proposals of the Land Commission; the function of this forest is to provide timber for fencing, building, firewood, and so on, much as in the medieval European Village. The Wet Zone Low Country immigrant is, of course, unlikely to have had this amenity in his old home, neither is the Kandyan if he has come from an estate-girt village; but the Dry Zone peasant is used to a forest on his door step. A number of proposals have from time to time been made for the allocation of forest to the Ceylon colonies; and there are a number of colonies (notably Iranamadu colonies, Kagama Old, and Ridibendi Ela) where there are definite reservations for colonists' use. But elsewhere there is no specific provision, and colonists are wont to help themselves from jungle or from conservational reservations, not a very satisfactory state of affairs. The problem of village forest is, in fact one which needs attention.

The importance of such a statement is that as early as the 1950's, it was realized that communal use of dry zone forest land cannot be ignored in planning. The consequence of neglecting this would be the complete destruction of the forest resource.

Destruction of the dense forest in the dry zone has occurred, not only due to the creation of irrigation schemes and associated settlements, but also due to extensive clearing of land for chena cultivation. Approximately 26 percent of the Anuradhaprua district is under forest cover. However, this percentage is as low as 13 percent in some areas where a large extent of land has been opened up for chena cultivation and it is as high as 47 percent in areas with low pressure on the use of the land (Table 1)

Table 1. Summary of some land uses in Anuradhapura District.

Land use	Horowpothana Division	Thirappane Division	Anuradhapura District
Total extent (ha)	85,500	31,600	717,900
Dense forest	40%	7%	17%
Open forest	7%	6%	9%
Scrub land	15%	18%	14%
Chena	19%	36%	26%

Source : Survey Department of Sri Lanka, 1991.

As a result of chena cultivation in the dry zone, there is a broad spectrum of successions with a wide diversity in plant composition in the natural vegetation. The scrublands are the result of abandoning chena lands after deterioration of land productivity has set in. This then begins its long recovery period from scrub to forest - if conditions favour this process. However, due to the increasing demand for arable land with a good physical base, scrub lands usually soon go back into cultivation. Typically, man's interference with the natural vegetation results in the complete removal of forest cover for cultivation. However, some of the remaining forest lands have been exploited by selective logging. As a result, the dense forest cover is reduced to open forest land resulting in changes in ecology and hydrology. In the past, this type of open forest land was purposely left by village communities to serve as a source of timber, firewood, fruits, medicine and many other needs. At present, communal use of forests has been restricted by several legislative Acts but the importance of such village forests is recognised - even by policy makers and other relevant authorities. Thus, the present study was designed with the objective of assessing the magnitude of soil erosion taking place on land subjected to use by local communities. The types of land use/ vegetation cover considered for this study were community used forest, scrub vegetation and cultivating chena lands.

METHODOLOGY

Study Site

The study was carried out at Paindikulama in Anuradhapura district. Paindikulama is a traditional village where the small tank is considered the heart of the village. Farmers practise both chena and lowland irrigated farming. Paindikulama tank is one of the eight upper-most tanks in the Maha Kanumull tank cascade which is a cluster of 18 small tanks.

Paindikulama tank has a capacity of 26 ha m spread over an area of 16 ha, which is supposed to support the cultivation of 54 ha. Thus the irrigation potential of the Paindikulama tank is 0.48 m. These data indicate clearly that farmers must seek other farming opportunities - mostly chena in the catchment of Paindikulama tank which has an extent of 123 ha. The land use summary of the Paindikulama tank catchment is given in Table 2.

Table 2. Land use summary of Paindikulama tank catchment.

Land use	Extent(ha)	Percentage
Dense forest	38.6	31.5
Open forest	18.7	15.2
Scrubland	29.0	23.6
Chena land	33.1	27.0
Highflood region	3.3	2.7
Total	122.7	100.0

The study has two main components. The first was a survey to identify plant species in open forest and scrublands. The second was to measure runoff and soil loss from open forest, scrubland and chena. The study was conducted during the period November, 1988 to May, 1990.

Plant Composition Survey

Farmers were interviewed to obtain an inventory of plant species found in the area. The uses and services of the plant species were also recorded. A field survey was carried out to prepare a list of plant species available in the Paindikulama tank catchment.

A 50 m by 50 m block of land, which had been used by villagers for various purposes other than cultivation, was demarcated and a 5 m by 5 m grid survey was carried out in the block locating all trees, including dead stumps. Girth, location, approximate age and height were recorded for each tree.

Soil Loss and Runoff Measurements

Three land use types were selected for soil loss and runoff measurements. They are: (a) open forest resulting from a reduction of canopy cover after complete or partial removal of trees by the community; (b) scrubland formed after fallowing the chena land for 8 to 10 years; and (c) chena land under cultivation during the study period. Two plots of 22 m by 4 m in size were selected from each land use type. Land slope, bulk density and infiltration rates were measured without disturbing the vegetation in the plots. Plots were constructed with cement plastered brick boundaries.

Two runoff collecting tanks were constructed for each plot such that one tenth of the excess water from the first tank would flow into the second tank. The size of the first tank was 4 m by 0.5 m by 0.5 m, and of the second, 2 m by 1 m by 0.5 m. The capacity of the runoff collecting tank system was 11 m^3, this being sufficient to measure 75 percent runoff produced from a daily rainfall of 150 mm. The design of the runoff collecting tank system is given in Figure 1.

Soil infiltration rates were measured near to the experimental plots. Standard infiltrometer rings were used and measurements were taken after saturating the soil for at least 24 hours. Crust formation or surface soil disturbance was prevented by pouring water slowly onto a piece of jute sack laid on the soil surface. Six infiltration measurements were taken from the six runoff plots representing two points for each land use type.

Bulk density measurements were taken from the area surrounding each runoff plot. Samples from the surface layer were collected using 5 cm diameter and 5 cm high sampling rings. Six samples were taken from each plot.

All six plots were located within an extent of about one hectare in the Paindikulama catchment. It was found difficult to select the six plots on land with the same slope, so direct measurements of soil loss could not be compared. If slopes are lower than 20%, the slope factor does not have a significant effect on runoff (Dharmasena, 1992). The Universal Soil Loss Equation (USLE) was used to find the Erosion coefficient (Ec) values which are independent of erosivity, erodibility, and land slope and slope length (Dharmasena ,1994a). These values were used to estimate annual soil loss from the three different land uses. Rainfall runoff relationships were developed using monthly totals, and used subsequently to estimate annual runoff amounts.

RESULTS AND DISCUSSION

Community Used Forest

From the interviews with villagers, an inventory was prepared and 76 tree species were listed. Of these, 49 species could be identified from the field survey carried out in the Paindikulama tank catchment. The 10 most dominant species were: Kunumella *(Diospyros ovalifolia)*, Vevarana *(Alseodaphne semecarpifolia)*, Satinwood *(Chloroxylon swietenia)*, Path-kokatiya *(Garcinia morella)*, Ulkenda *(Polyalthia persicifolia)*, Gulupeththa *(Cryptocarya wightiana)*, Weera *(Nerium odorum)*, Boradamana *(Grewia polygama)*, Kirikoon *(Walsura piscidia)*, and Galseru *(Tricalysia erythrospora)*. Most of the tree species found in the community used forest do have the ability of regrowth if not removed completely.

A detailed survey was carried in a block of 50 m by 50 m closer to the sites of the runoff plots. 120 trees were found in this block giving a tree density of 4.8 trees /100 m^2. The dead stumps of another 20 trees were also found inside the block. High and medium strata were distinct in the canopy architecture and they contributed much to the above plant density. This value is similar to that observed in mature homegardens under major irrigation schemes but lower than other homegardens where introduced medium canopy species are dominant (Dharmasena, 1994b). Figure 2 shows the spatial distribution of trees indicating the degree of man's interference in the village forest. Most of the trees were found as regrowth, and open areas caused by dead trees were found to be regenerating with the same tree species.

The interviews revealed that the village community uses the adjoining open forest land for five main purposes. They are; a) firewood (dara) collected from dead branches and stumps, b) fencing posts (katta) and sticks (ini) from live trees, c) medicinal parts such as bark, leaves, roots, flowers, nuts etc. of various herbs, d) house construction materials such as round poles, planks, wood sticks etc. and e) timber for furniture and various other purposes. The number of species identified for these main uses are shown in Table 3.

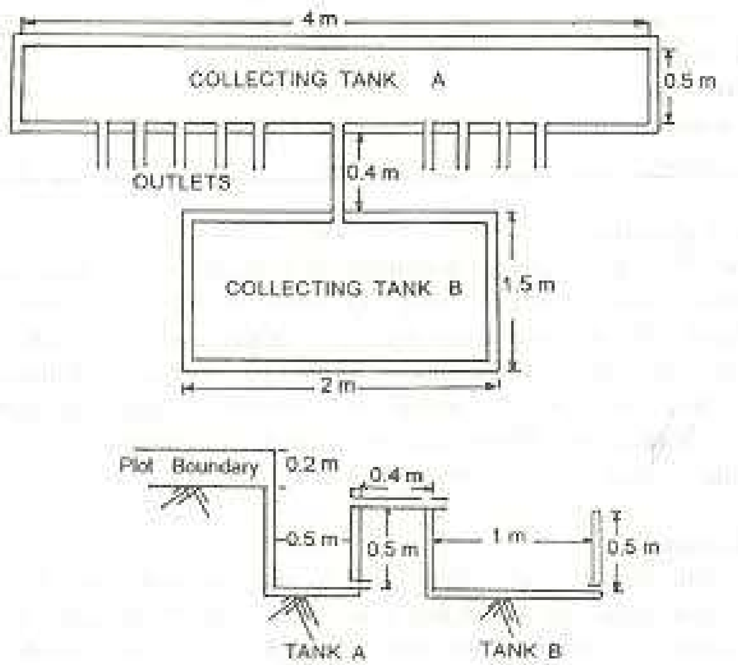

Figure 1 - Runoff collecting tank system

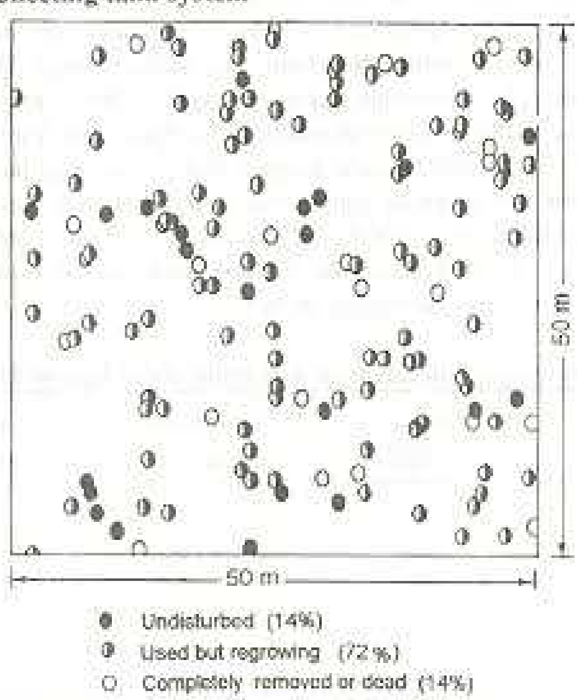

Figure 2 - Distribution of trees in a community used forest

Table 3. Purposes served by tree species in the community used forest

Purpose	Tree species No.	%
Firewood	30	61
Fencing	26	53
Medicine	23	47
House construction	22	45
Timber	15	31

Scrub Vegetation

A total of 27 plant species was found in scrublands. Of these, some species are common to both scrub and forest. Dominant species in the scrub vegetation were Veverana *(Alseodaphne semecarpifolia)*, Kaduru *(Cerbera manghas)*, Hinguru *(Acacia columnaris)*, Karapincha *(Murraya koenigii)*, Kuratiya *(Memecylon rostratum)*, Ulkenda *(Polyalthia persicifolia)*, Meegon karapincha *(clausena indica)*, Kudumirisa *(Thalassia hemprichii)*, Karamba *(Carissa spinarum)* and Podisinghomaran *(Eupatorium odoratum)*.

Soil Erosion

In the study site, the open forest used by the community was found on the upper slopes, and chena and scrublands were found in the lower parts of the catena. The bulk density of surface soil was low (1.15 g/cm^3) in the forest, moderate (1.23 g/cm^3) in scrubland and high (1.3 g/cm^3) and variable (1.21 to 1.39 g/cm^3) in the chena land. Even though the same soil (Rhodustalf) was found under the three types of vegetation, the basic infiltration rates observed were different. Under forest cover, the infiltration rate ranged form 42 to 47 mm/hr showing a considerable capacity to absorb the intensive rains which find their way down through the different canopy strata of the forest. In a previous study, Somapala (1984) observed that the basic infiltration rate ranged from 18 to 58 mm/hr in the forest and from 13 to 40 mm/hr in cultivated areas. These observations suggest that forest lands have undisturbed soil whereas the upper soil layer of chena and scrublands may have been compacted resulting in low infiltration. This is well explained by the bulk density values of the upper soil layers. Table 4 shows land slope, bulk density and infiltration rates observed for the three land uses under study.

Table 4. Land slope, bulk density and infiltration data in the study site.

Land use	Slope (%)	Bulk density (g/cm^3)	Infiltration (mm/hr)
Open forest	13	1.13	42
	19	1.16	47
Scrub	8	1.21	29
	5	1.25	28
Chena	9	1.21	25
	5	1.39	26

Soil loss and runoff measurements were taken during the period November, 1988 to May, 1990. Data were recorded for 37 storms. The total rainfall of these storms was 1127 mm. Soil loss measurements showed that for cultivated chena, 12.5 mt/ha of soil was lost from 5 percent slope and 23 mt/ha of soil from 10 percent slope. The study period covered two Maha and two Yala seasons, but the first Maha season was incomplete as measurements were started late in November. Since all rainfall was not considered in the study, the reported values cannot be used to calculate average annual soil loss for these land uses. Soil erosion from forest lands was found to be negligible, and the scrubland which was covered with regrowth of natural vegetation has kept the erosion to a minimum. Table 5 is the summary of soil loss data observed in the study.

In order to estimate annual soil loss values, the modified Universal Soil Loss Equation (USLE) was used as described by Dharmasena (1994b).

$$A = R.K.(LS)_{max}.Ec,$$

where, A is soil loss (metric tonnes per hectare), K is erodability, $(LS)_{max}$ is the maximum slope-length factor, and Ec is the erosion coefficient

Table 5. Soil loss data from different land uses.

Land slope	Slope (%)	Soil loss (t/ha)
Open forest	13	0.03
	19	0.02
Scrub land	8	0.05
	5	0.52
Chena	9	22.99
	5	12.54

From the equation, it was found that Ec values for open forest, scrubland and chena were 0.0004, 0.005 and 0.237 respectively. Rainfall analysis indicated that the average annual erosivity at Maha Illuppallama is 125 mt.m/ha. Erodibility of Rhodustalf is 0.55. For an average terrain condition, the $(LS)_{max}$ is close to 0.744. Using this information, the annual soil loss values for forest, scrub and chena lands could be estimated as 0.02, 0.26 and 12.1 t/ha respectively. The permissible annual soil loss rate for Alfisols in the dry zone has been taken as 3 t/ha (Dharmasena, 1992). Results indicate that neither community used forest nor scrub vegetation exceeds this threshold limit. However, the chena land, which is in a crisis condition, needs much more attention regarding the control of soil erosion.

Runoff

During the study period, runoff measurements were made for the same 37 storms which were considered for soil loss measurements. A summary of runoff data is given in Table 6.

Table 6. Runoff from different land uses. Total rainfall: 1127 mm.

Land use	Slope (%)	Runoff mm	Runoff %
Open forest	13	10	1
	19	10	1
Scrub land	8	16	1
	5	23	2
Chena	9	204	18
	5	508	45

Runoff data observed on a daily basis were used to develop monthly rainfall-runoff relations for three different land uses.

Open forest $Ro = 0.01\ Rf - 0.2,\ r^2 = 0.72^{**}$

Scrub land $Ro = 0.02\ Rf - 0.5,\ r^2 = 0.81^{**}$

Chena $Ro = 0.54\ Rf - 17,\ r^2 = 0.87^{**}$

where, Ro is monthly runoff (mm), Rf is monthly rainfall (mm) and ** denotes significance at 1 % probability level.

On the basis of these relationships, monthly runoff values were estimated using the monthly mean rainfall data of Maha Illuppallama in order to obtain the annual runoff amounts and their distributions (Table 7).

Table 7. Seasonal and annual runoff values estimated from rainfall

Season	Yala Feb. - June	Maha Sept. - Jan.	Annual
Mean rainfall (mm)	434	882	1380
Runoff			
Open forest	4 mm (1%)	8 mm (1%)	12 mm (1%)
Scrub land	7 mm (2%)	16 mm (2%)	23 mm (2%)
Chena	159 mm (37%)	391 mm (44%)	552 mm (40%)

Percent runoff values are in parenthesis.

Results clearly indicate that even during the minor rainy season (Yala), chena lands yield a runoff which is more than one third of total rainfall. Runoff generation in both open forest and scrubland is negligible, and as a result, rainfall contributes much more to the replenishment of soil moisture and ground water.

CONCLUSION

Based on the results of this study, it can be concluded that use of forest land by the community for various purposes without complete removal of cover does not make significant changes to soil loss and runoff. However, chena cultivation, where farmers clear the forest, leads to very high erosion and an increase in surface runoff.

Because of the regrowth ability of trees, most of the uses do not result in permanent destruction to the forest except when trees are felled for timber. The main uses of village forest are for firewood, fencing materials medicine, house construction materials and timber. It is noteworthy that all tree species serve one or more purposes to the associated community. It is concluded that such village forests must be reserved for the community and it should be the responsibility of the villagers to maintain the value and ecological sustainability of their forest.

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