

RAINFALL EROSIVITY AND POTENTIAL EROSION IN THE CENTRAL DRY ZONE

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ABSTRACT

In planning of a sound land and water management system for an area, assessment of rainfall erosivity and potential soil erosion is a prerequisite. A study was carried out using rainfall data and land characteristics to estimate the erosion risk in the central dry zone of Sri Lanka. Six locations were selected to represent the study region. Detailed analysis of rainfall data at Maha Illuppallama was carried out and results were examined with respect to other locations too. Results indicated that 70% of yala rainfall and 50-55% of maha rainfall are erosive. However, 55-65% of annual erosive rains occur during the maha monsoon. Erosion risk is high in low elevated areas. However, spatial variation of potential erosion is not only due to erosivity but also due to slope changes. The months, March and September would be vulnerable for high erosion risk as arable lands are bare because of clearing for seasonal cultivation in these two months.

KEY WORDS: Rainfall erosivity, Rhodustalf, Soil erosion

INTRODUCTION

Need for estimating possible erosion levels in agricultural development schemes has been more pressing at present because a considerable portion of arable land goes out of production annually in the world due to erosion.

The factors which influence the rate of soil erosion are mainly rainfall, runoff, wind, soil, slope, plant cover and presence or absence of conservation measures. Morgan (1986) groups all these factors into three categories: energy, resistance and protection. The energy group is termed as erosivity. Knowledge of erosivity and potential erosion in an area is a useful information for planning agricultural production and watershed management programmes. It gives an indication of erosion risk, and spatial and temporal variations of the erosion severity.

The rainfall erosivity can be assessed through its kinetic energy and momentum. Many researchers attempted to relate the kinetic energy to the rainfall intensity; thus, intensity was considered the most suitable variable for evaluating erosivity of rainfall (Wischmeier and Smith, 1958; Hudson, 1965; Carter *et al.*, 1974; Zanchi and Torri, 1980).

Different erosivity indices based on intensity have been used during the last five decades to represent erosive power of rainfall. Wischmeier and Smith (1958) introduced the index EI_{30} , and for tropical climate it was later replaced by $KE > 25$ (Hudson, 1965). As tropical rainstorms are short duration and of varying intensities a new index referred to as Rl_e has been recently proposed to avoid difficulties in computation (Dharmasena, 1992a). The index (Rl_e) can be obtained by summing up all multiplications of rainfall increments and correspondent intensity values in a rainstorm [$Rl_e = \text{Sum. } (R_i \times I_i)$, where R_i is amount and I_i is intensity in i^{th} increment of rainfall].

The intensity governs the percent runoff of a rainfall which subsequently determines, the magnitude of erosion, and intensity has a major role in rainsplash process. Therefore, it is important to study the inter-variation as well as intra- variation of the rainfall intensity. In many countries sufficient rainfall records from autographic gauges are not available to calculate erosivity in a region. In such cases, attempts are made, for the recording stations where erosivity can be determined, to find a more widely available rainfall parameter which significantly correlates with erosivity and from which erosivity values may be predicted using a regression equation (Roose, 1975; Ateshian, 1974; Morgan, 1974). It should be emphasized that although this approach is universally valid, the equations developed for a particular region cannot simply be generalized (Morgan, 1986). Thus, it is necessary to develop such equation for the area concerned in order to study the rainfall erosivity in detail.

Soil erosion has been estimated from plot measurements at Maha Illuppallama, under various conditions. Krishnarajah (Unpublished data, 1984) reported that in cotton cultivated plots without any conservation measures, the annual soil loss was 22.2 t/ha. Even in a sorghum/pigeonpea inter-cropped plots soil was lost at the rate of 21.3 t/ha. Dharmasena (1992b) reported that soil erosion in a maha season can be as high as 54 t/ha from chena lands in the rhodustalf region. Wickramasinghe and Premalal (1988) observed that the annual erosivity in the dry zone region is higher than that in the up country mainly due to high percentage of erosive rainfall which occur in the low country dry zone. However, no attempts had been made to estimate the potential soil loss in these studies.

With this background a study was planned to understand the erosivity status and potential erosion in the central dry zone of Sri Lanka by studying the following aspects of rainfall: erosive fraction of rainfall; rainfall-erosivity relationship; temporal and spatial variation of erosivity; and potential erosion in selected locations.

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METHODOLOGY

Rainfall records at Maha Illuppallama were mainly considered for the analysis. In addition, mean monthly rainfall for the locations, Anuradhapura, Galgamuwa, Horowpothana, Maradankadawala, Polonnaruwa and Kantale was used to understand the spatial variability of erosivity. The analysis was extended to estimate potential soil loss from the rhodustalf phase in these locations.

Erosive fraction of rainfall

According to Hudson (1965) erosion is almost entirely caused by rain falling at intensities greater than 25 mm/hr. Thus, from rainfall records at Maha Illuppallama in each month from October, 1989 to December, 1990, erosive rainfall was computed by summing all rain increments that exceeded the intensity of 25 mm/hr, and percentage of total rainfall was calculated.

Rainfall-erosivity relationship

Erosivity (EI_{30}) was calculated on a daily basis using RI_e index adopting the following formula proposed by Dharmasena (1992b):

$$EI_{30} = 3 (RI_e - 1) \dots\dots (1)$$

where EI_{30} is in t.m/ha and R is daily rainfall (cm) and I_e effective intensity (cm/hr).

Daily rainfall amounts and correspondent erosivity (EI_{30}) values were used to find the nature of their correlation. Relationships were also attempted for monthly values.

Temporal and spatial variation

Monthly erosivity values were computed for all the seven locations by using the rainfall-erosivity relationship developed for Maha Illuppallama in order to understand the temporal variation of erosivity. By summing the monthly erosivity values, annual erosivity values were also obtained to enable the visualization of spatial variation of erosivity within the central dry zone.

Potential soil erosion

The maximum soil loss one would expect from a certain portion of land can be estimated by considering a situation with no conservation measures and free of any vegetative cover. The Universal Soil Loss Equation was used in the following form to estimate the potential soil loss:

$$A = R.K.(LS)_{\max} \dots\dots (2)$$

where A is annual soil loss (t/ha), R is annual erosivity (t.m/ha) and $(LS)_{\max}$ is the maximum LS factor which is anticipated for a given slope (S) and slope length (L). The surface irregularities which alter the erosion process are not considered in the $(LS)_{\max}$ factor.

RESULTS AND DISCUSSION

Erosive rains

There were 100 rainstorms which occurred during the study period from October, 1989 to December, 1990, of which 41 storms produced runoff. Although all storms did not produce runoff, as splash erosion on bare land in the rhodustalf region was also considerable (Dharmasena, 1992b), all 100 storms were considered for computing the erosive fraction of rainfall. Results show that more erosive rains occur in the months of May, September and October (Table 1). Among them, the month October had high amount and erosive fraction of rainfalls. In most of the rainfed farming areas, the land is bare, and soil is tilled in October, hence all factors are favourable by that time for high erosion risk. Though the month, September has few rainfalls, most of them were erosive and high rates of erosion occur if the land is free of vegetation. When yala (March - September) and maha (October - February) rains were considered separately, two different linear relationships were found between monthly rainfall and amount of erosive rains.

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Table 1. Monthly distribution of erosive rainfall

Year	Month	Total rainfall (mm)	Percent erosive rainfall (%)
1989	October	292	62
	November	161	41
	December	33	0
1990	January	87	18
	February	15	0
	March	63	33
	April	21	0
	May	80	96
	June	0	-
	July	0	-
	August	13	33
	September	67	69
	October	309	61
	November	129	14
	December	69	24
Total		1339	Average 47

For yala rains:

$$R_e = 0.78 R - 6.2, \quad r^2 = 0.80^{**} \dots\dots (3)$$

For maha rains:

$$R_e = 0.69 R - 33.5, \quad r^2 = 0.94^{**} \dots\dots (4)$$

where R_e is amount of erosive rains (mm) and R is monthly rainfall (mm).

These relationships were used to estimate the amount of erosive rainfall that would occur in an average year in 3 selected locations: Maha Illuppallama, Horowpothana and Kantale (Table 2). Results clearly indicate that yala rains are more erosive than maha rains. However, total erosive rainfall is higher in maha rains than in yala rains, as total amount of maha monsoonal rainfall is higher compared to that of yala rainfall. Although the rainfall amount varies among locations, percent erosive rainfall does not differ much.

Table 2. Erosive rainfall in yala and maha in the central dry zone

Location	Yala rains (March - September)			Maha rains (October - February)		
	Mean rainfall (mm)	Erosive rainfall (mm)	Percent erosive rainfall	Mean rainfall (mm)	Erosive rainfall (mm)	Percent erosive rainfall
Maha Illuppallama	511	354	69	875	436	50
Horowpothana	543	380	70	1099	590	54
Kantale	547	382	70	1215	671	55

Rainfall-erosivity relationship

The index El_{30} was considered as the erosivity of rainfall and the following two linear relationships were found for daily and monthly erosivity values to rainfalls.

$$(Ev)_d = 1.33 R_d - 0.7 \quad r^2 = 0.73^{**} \quad \text{..... (5)}$$

$$(Ev)_m = 1.14 R_m - 3.4 \quad r^2 = 0.84^{**} \quad \text{..... (6)}$$

where, $(Ev)_d$ is daily erosivity index, $(Ev)_m$ is monthly erosivity index, R_d is daily rainfall (cm) and R_m is monthly rainfall (cm).

Mean monthly erosivity values $(Ev)_m$ were calculated from mean monthly rainfall using equation 6 for seven locations in the central dry zone. By summing the monthly erosivity values, annual erosivity values were calculated for all seven locations (Table 3) and related to mean annual rainfall values. The relationship found between mean annual rainfall and annual erosivity is given below:

$$(Ev)_a = 1.16 R_a - 42.4 \quad \text{..... (7)}$$

where, R_a is mean annual rainfall in cm and $(Ev)_a$ is mean annual El_{30} in t.m/ha.

Temporal and spatial variation

Among the locations examined, Maha Illuppallama reports the lowest erosivity (Table 3). High erosivity values are found for Polonnaruwa and Kantale. The annual erosivity in Kantale area is 40% higher than that at Maha Illuppallama. This indicates that relatively high erosion risk can be expected from low elevated areas.

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Table 3. Mean annual erosivity in selected locations

Location	Elevation (m)	Mean annual	
		Rainfall (cm)	Erosivity (EI_{30}) (t.m/ha)
Anuradhapura	91	145	126
Gaigamuwa	91	145	126
Horowpothana	64	164	148
Kantale	76	176	162
Maha Illuppallama	138	139	116
Maradankadawala	134	148	129
Polonnaruwa	61	170	155

Temporal variation of erosivity in locations, Kantale, Horowpothana and Maha Illuppallama is shown in Fig. 1. The erosivity in maha season is relatively high at Kantale and Horowpothana compared to that at Maha Illuppallama. There is a risk of erosion in the month of August when the land is bare before cultivation in Kantale and Horowpothana areas. However, in all three locations land must have a protection by September onwards. In rainfed upland farming when both factors i.e. rainfall erosivity and ground cover, are considered together it can be stated that the months March and September would bear the high erosion risk in the central dry zone. Even though months October, November, December, January and April record high erosivity in most of the cases, the cultivated land has some kind of protection by the vegetative cover. These observations stress the importance of a mulch cover at the onset of seasonal rains until the crop develops an adequate ground cover.

Potential erosion

The magnitude of soil erosion can be estimated by using erosivity values. For example, Table 4 shows the amount of soil that would be lost annually from an open field of 100 m long and on 2,4 and 6% land slopes. Here the soil is considered as well-drained Reddish Brown Earths (Rhodustalf) and its erodibility value has been reported as 0.55 (Dharmasena, 1993). Values were computed by using Universal Soil Loss Equation.

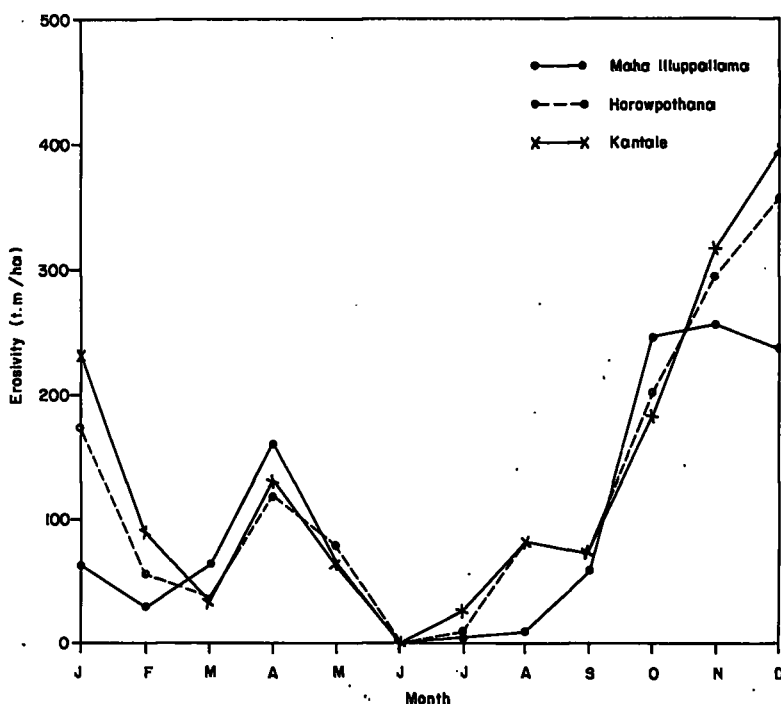


FIG. 1 : VARIATION OF MONTHLY EROSIVITY IN THREE SELECTED LOCATIONS

Table 4. Potential annual soil loss in rhodustals

Location	Potential annual soil loss (t/ha)		
	Land slope (%)		
	2	4	6
Anuradhapura	27	52	84
Galgamuwa	26	51	83
Horowpothana	31	61	99
Kantale	34	66	108
Maha Illuppallama	25	48	78
Maradankadawala	28	53	87
Polonnaruwa	33	64	104

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These values were obtained by considering a situation with no vegetative protection or supporting conservation practices. The soil erosion in reality is not always as such because other factors such as vegetation and topography can change the erosion predicted by using annual erosivity. The soil loss values given in Table 4 indicate that spatial variation of erosion within the central dry zone is not mainly due to variation of rainfall erosivity but due to variation of land slope which differs from place to place even within one micro-watershed. However, observations show that relatively lower elevated areas (Horowpothana, Kantale and Polonnaruwa) have high erosion risk in the central dry zone.

CONCLUSIONS

Even though the total amount of yala rains is relatively low, those rain storms are more intensive and erosive compared to maha rains. Erosive rain percentage is 70% and 50-55% in yala and maha rains respectively. Annual erosivity in the central dry zone ranges from 116 t.m/ha (Maha Illuppallama) to 162 t.m/ha (Kantale). A high erosion risk can be expected from lower elevated areas. Spatial variation of soil erosion in the central dry zone is not mainly due to the variation of erosivity but due to changes in topography. Undulation of the topography can make large variations in the erosion even within one micro-watershed. This calls for the need for mechanical soil conservation measures to take care of the slope effect as the most essential and initial step of soil conservation in the central dry zone. The months March and September would bear the high erosion risk; thus, use of a mulch cover at the onset of seasonal rains is also essential in cultivated lands.

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