

RESEARCH

Tank Sedimentation, Soil Erosion Simulations and Conservation Interventions of the Sub-catchments in Palugaswewa Tank Cascade System, Sri Lanka

P. Kowshayini¹, H.B. Nayakekorala^{1*} and S. Pathmarajah²

¹Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, 20400 Sri Lanka

²Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka

ARTICLE INFO

Article history:

Received: 15 September 2022

Revised version received: 31 January 2023

Accepted: 13 September 2023

Available online: 01 October 2023

Keywords:

Lignocellulosic biomass

Plant extracts

Parthenium hysterophorus

Zone of inhibition

Citation:

Kowshayini, P. Nayakekorala' H.B. and Pathmarajah, S. (2023). Tank sedimentation, soil erosion simulations and conservation interventions of the sub-catchments in palugaswewa tank cascade system, Sri Lanka. *Tropical Agricultural Research*, 34(4): 304-315.

DOI:

<https://doi.org/10.4038/tar.v34i4.8671>

Kowshayini, P. 

<https://orcid.org/0009-0006-0760-356X>



ABSTRACT

Tank Cascade Systems (TCS) in the dry zone of Sri Lanka is threatened by soil erosion and high levels of sedimentation. Despite these challenges, the nation lacks studies exploring spatial soil loss variations within TCS contexts. Consequently, this research aimed to assess the sedimentation levels of five tanks and to analyze the spatial distribution of potential soil erosion rates across six selected sub-catchments within the Palugaswewa TCS. By utilizing sediment depth contour maps, the current sedimentation volume for each tank was computed. The study employed the revised universal soil loss equation (RUSLE) and geographic information system techniques to evaluate the potential average annual soil erosion rate, considering both existing land use scenarios and conservation interventions. The potential annual sediment yield was calculated using the sediment delivery ratio and potential average annual soil erosion rate. At present, 40 to 50 % of the tank storage capacity has been filled with sediments under existing land use. The potential average annual erosion rates of the sub-catchments of Palugaswewa TCS ranged from 19 t/ha/yr to 44 t/ha/yr. Notably, Sri Lanka's acceptable erosion rate stands below 12 t/ha/yr, rendering the erosion rates within Palugaswewa TCS unsuitable and destructive to sustained land productivity. The sediment delivery ratio varied from 0.18 to 0.9. This study suggests that adapting appropriate conservation measures such as cover cropping and soil contour bunding reduces the potential average annual erosion rate by 8.9 t/ha/yr to 14.5 t/ha/yr in the Palugaswewa sub-catchments.

*Corresponding author- hbnkorala@gmail.com

INTRODUCTION

Tank chains or tank cascades are one of the traditional land and water management systems developed based on catchment ecosystems. Tank Cascade System (TCS) in Sri Lanka has evolved throughout two millennia to cater to the socioeconomic and cultural needs of the people adapting to the soil, geology, geography and climate of the area (Bandara *et al.*, 2010; Geekiyanage and Pushpakumara, 2013). Considering this uniqueness, TCS is recognized as a globally important agricultural heritage system by FAO in 2018.

Several issues severely threaten the sustainability of TCS, including intense rainfall resulting from climate change, population pressure, deforestation, expansion of arable lands, change of traditional land use system and negligence of the maintenance of micro-ecological components of the system (Panabokke *et al.*, 2002; Dharmasena, 2010; Abdulkareem *et al.*, 2019; Senanayake *et al.*, 2020). In the system, soil degradation can be intensified as it is expected that the predicted climate change can increase the risk of soil erosion (Lal, 2005). Erosion rates rising above natural levels reflect the impact of increased population, rapid development and human modifications (Chakrapani, 2009). Induced soil erosion threatens the TCSs by causing a high level of sedimentation, reducing the tank storage capacity of irrigation tanks (Senanayake *et al.*, 2020), and affecting the ecological balance and the ecosystem services of the TCS.

At present, the government has embarked on a heavy program for rehabilitating the TCS. The rehabilitation activities, including the raising of spillways and de-silting of tank beds to address the sedimentation issue, had seriously disrupted the hydrological balance in the TCSs (Panabokke *et al.*, 2002). Dharmasena (2009) reported that rehabilitation of small tanks should aim not only at increasing water content but also at protecting the tank ecosystem. Whole aspects of socioeconomic development and environmental sustainability collapse if any disruption is caused to the watershed (Bewket and Teferi, 2009). The traditional

tank village system was sustained over two millennia by not only the structural maintenance but also by the maintenance of ecological components, including macro land uses such as forest, paddy land, settlement area, chena lands, tank bed and micro land uses such as interceptor, tree belts, grass filter, soil ridge, water hole, forest tank etc. (Dharmasena, 2004).

The land use and land components of the TCS determine the functionality and sustainability of the system (Mahatantila *et al.*, 2008). Dynamics of land use and land cover explain the present situation of soil erosion and the vulnerability of land for future planning (Abdulkareem *et al.*, 2019). Further, land slope, soil type, and soil management influence soil erosion and these factors show a spatial distribution in the catchments. Therefore, this could lead to a spatial distribution of soil erosion in the TCS. A proper understanding of the spatial distribution of soil erosion in the catchments is essential for the control of sedimentation of the tanks in the TCS. And adopting supporting conservation practices such as terracing, contour farming, strip/ cover cropping and soil contour bunding will effectively reduce soil erosion by influencing drainage patterns, runoff concentration and runoff velocity (Renard *et al.*, 1991). There are no studies conducted on assessing the spatial soil loss in tank cascade systems in the country. Therefore, the objective of the study was to find out the total sedimentation level in selected tanks of Palugaswewa TCS and study the spatial distribution of potential soil erosion rates under various land uses in the present context and with some selected conservation methods in Palugaswewa TCS.

METHODOLOGY

The study was conducted in the Palugaswewa TCS located in the Palugaswewa divisional secretariat division in the Anuradhapura district. The study area falls under the agroecological zone of DL1b (Ministry of Agriculture and FAO, 2017). Six tanks from Palugaswewa TCS were selected for this study, namely Maha tank, Alapath tank, Yakandagas tank, David tank, Kundalugas tank

and Udakadawala tank. The sub-catchments of the Palugaswewa TCS were delineated using ArcGIS 10.8. Extents of different land use in the catchment were assessed using the land use map of the year 2018 of the Palugaswewa DS division, prepared by the Land Use Policy Planning Department, Anuradhapura. Data including a sediment depth contour map developed from a bathymetric survey using augur, tank capacity, and catchment area were obtained from the Climate Resilient Integrated Water Management Project (CRIWMP). The Sediment depths were extracted from the map, and the area covered under different depth contours of each selected tank was calculated using ArcGIS 10.8. The volume of the sediment in tanks was computed using the sediment depths and the calculated area.

The mean annual rainfall was calculated using thirty years of daily rainfall data (1988 - 2018) for six rain-gauge stations around the study area, namely Anuradhapura, Diyabeduma, Giritale, Hingurakgoda, Mahagalkadawala and Mahaillupallama. The R factor layer was calculated using the inverse distance weighted interpolation technique and a regression model proposed for the Sri Lankan conditions by Wickramasinghe and Premalal (1988) shown in Eq. 1.

$$R = \frac{972.5 + (9.95 * P)}{100} \quad \text{Eq:1}$$

where R is the annual rainfall erosivity (MJ mm ha⁻¹ h⁻¹yr⁻¹) and P is the mean annual rainfall (mm).

Palugaswewa TCS consists of Reddish Brown Earth (RBE) soils on upper land and Low Humic Glay (LHG) soils in the valley bottoms. Their soil erodibility factors were used to create K (erodibility) factor layer. Slope length and steepness were calculated using a 30 m × 30 m resolution Digital Elevation Model (DEM) downloaded from <https://dwtkns.com/srtm30m/>. The slope length factor was computed using Eq. 2, and “m” in this equation was taken as 0.2 as the slope of the sub-catchments of the study area is less than 1% (Wischmeier and Smith, 1978). The slope steepness was determined using Eq. 3, as suggested by McCool et al. (1987).

$$L = (\lambda/22.1)^m \quad \text{Eq:2}$$

where L is the slope length factor, λ is the horizontal projected slope length (m), and m is the slope length exponent.

$$S = 10.8 \sin\theta + 0.03 \text{ for slope percent} < 9\% \quad \text{Eq:3}$$

where S is the slope steepness factor and θ is the slope angle in degrees.

The C (Vegetation) factor was estimated by using the Wishmeirs graph (Roose, 1996), which explains the combined effect of mulch and canopy on soil erosion. The canopy cover was determined by looking at the Google image, and the surface cover was determined by ground observations and judgment. At present, conservation measures are used only in terraced paddy lands. The conservation interventions assumed were cover cropping for the open forest and forest plantation, and soil contour bunds for homesteads and *chena* lands. The spatial distribution of soil erosion of the sub-catchments of Palugaswewa TCS was created by multiplying all factor layers of R, K, LS, C, and P with the raster calculator using map algebra in ArcGIS 10.8.

The potential average annual sediment yield was calculated using Sediment Delivery Ratio (SDR) and Potential average annual soil erosion rate. SDR was calculated as a function of travel time (Ferro and Minacapilli, 1995).

$$SDR_i = \exp\left(-\beta \sum_i^n \frac{li}{ai si^{0.5}}\right) \quad \text{Eq:4}$$

where SDR_i is the sediment delivery ratio of a cell, β is the coefficient for the catchment, $(li/ai si^{0.5})$ is the travel time of the cell to the nearest channel(s), $(ai si^{0.5})$ is the flow velocity of the cell (m/s), li is the length of a diagonal side in the cell according to the flow direction(m), ai is the coefficient for land uses and si is the slope of the cell (degree).

The length of a diagonal cell is equal to cell size×√2 (Thuraisingham and Weerasinghe, 2009). The coefficient for each land use (Fernandez et al., 2003; Yang et al., 2012) was assigned to each land use. β is a catchment-wide constant. The β can be determined using field experiments, expert opinion, trial-and-

error and recursive methods (Thomas *et al.*, 2020). In this study, β is set to the value of 0.01 by the trial-and-error method. Eventually, the raster layer of SDR with a resolution of 30 m was generated using the conversion tool in ArcGIS 10.8. Sediment yield for the catchment was obtained using Eq.5 (Kothyari and Jain, 2000).

$$Sy = \sum_{i=0}^n SDRi \times SE \quad \text{Eq:5}$$

where Sy is the potential average annual sediment yield of a cell (t/ha/yr), SDRi is the sediment delivery ratio of a cell, the potential average annual erosion rate is produced within the cell (t/ha/yr) and n is the total number of cells over the catchment.

RESULTS AND DISCUSSION

The land uses in sub-catchments of the TCS are namely dense forest, scrub land, open forest, forest plantation, homesteads, lowland paddy, *chena* and tank. These land uses are repetitive in each sub-catchment. The spatial distribution of the macro land uses among various sub-catchments is given in Figure. 1. Table 1 shows that the land uses vary among the sub-catchments.

Dense Forest is the major land use in all the sub-catchments. In the sub-catchment of Maha tank, dense forest covers 77% of the catchment while *chena* and remaining land use cover less than 10% of land each. In the sub-catchment of Alapath tank, dense forest and scrub lands are natural landscapes and cover 49 % of the catchment. One special feature of this sub-catchment is that it has a fairly high percentage (22) of forest plantation. The rest of 29% is covered by homesteads and *chena* lands. The sub-catchment of Yakandagas tank has all the types of land uses found in the Palugaswewa TCS. The major land use types in this catchment are dense forest (48%) and *chena* land (21%). Tank, scrub, homestead and open forest have approximately 10 percent coverage each and the percentage of paddy and forest plantation is very low compared to other land use types in the sub-catchment of Yakandagas tank. The sub-catchments of David tank and Kundalugas tank have similar

land use types, dense forest, open forest and scrubland occupy throughout each catchment while the sub-catchment of David tank has 4% of forest plantation. In the sub-catchment of Udakadawala tank, dense forest and paddy are in similar percentages and both together cover 63% of the catchment. Homesteads and scrub cover similar land use approximately 14% each. And open forest and *chena* cover 10% land of the Udakadawala catchment.

Sedimentation levels of tanks

The magnitude of sedimentation in a few village tanks in the Anuradhapura district was studied by Dharmasena (1992a) who reported that 23 to 35% of the tanks' potential storage had been filled with sediments. Also observed is that half of the sediment deposited in small tanks is found within one-third of the tank bed area closer to the tank bund. The present sediment volume of each tank was calculated based on a sediment depth survey conducted in this TCS in 2018 by CRIWMP. It was observed that the sediment had spread in the whole tank bed area with varying depths. The sediment depths were higher closer to the tank bund where dead storage was found. The sediment depths varied among different tanks and the average depth varied from 0.64 m to 1.51 m. About 40 to 50 % of the tank storage capacity has been filled with sediments in the studied tanks (Table 2). The duration taken to the accumulation of this sediment volume is unknown as the present sediment volume of each tank was calculated based on a sediment depth survey conducted in 2018 by CRIWMP in this TCS.

Minor tanks or ponds for storing water on the surface of the ground were constructed by local people at geographically suitable locations with their indigenous skills during ancient times. Farmers were compelled to repair and maintain their systems by law and convention until the 1970s (Dharmasena, 2004). Key Informant Interviews (KII) conducted with old experienced farmers in the present study revealed that, in earlier days, village people got together yearly and removed sediment from tanks according to the extent of cultivation land owned under

each tank. Manpower and sometimes their cattle are also involved in this process. But after the 1970s, farmers became dependent

on the Department of Agrarian Development for even minor repairs and maintenance work (Dharmasena, 2004).

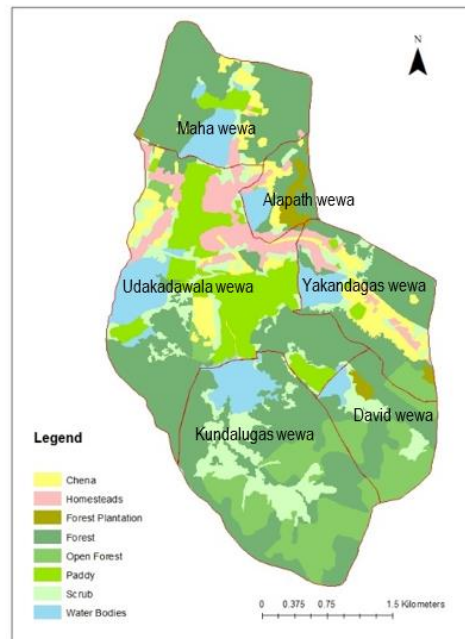


Figure 1: Land use map of the year 2018 of sub-catchments of Palugaswewa TCS
Source - Land Use Policy Planning Department, Anuradhapura

Table 1: Percentage of land use of sub-catchments of Palugaswewa TCS

Name of the sub-catchment	Alapath tank	David tank	Yakanda gas tank	Kundalu gas tank	Udakada wala tank	Maha tank
Catchment area (ha)	56.5	133.2	172.8	365.3	462.6	184.9
Land uses in sub-catchments (%)						
Scrub	5	13	10	19	13	5
Dense forest	44	42	48	49	33	77
Paddy	-	-	3	-	30	6
Open forest	-	41	8	32	2	-
Forest Plantation	22	4	1	-	-	-
Homestead	12	-	9	-	14	3
Chena	17	-	21	-	8	9
Total highly erosive land use (%)	51	45	39	32	24	12

Table 2: Total volume of sediment in selected tanks of Palugaswewa TCS

Name of the tank	Sediment spread area (ha)	Average depth of sediment (m)	Sediment volume (ha.m)	Tank capacity (ha.m)	Loss of tank storage due to sedimentation (%)
Maha tank	20.3	0.93	18.9	48.1	39
Alapath tank	9.1	1.04	9.5	18.5	51
Yakandagas tank	11.2	1.51	16.9	42.6	40
Kundalugas tank	23.4	0.98	22.9	43.2	53
Udakadawala tank	47.9	0.64	30.6	77.1	40

According to the PRA report of CRIWMP, the number of families in the village increased three times by 2018 compared to the 1970s. This led to encroachments into the state forest and reduced the forest areas from 50% to 20% within the catchments. Also, new arable land areas as field blocks had been developed on the sides and at the bottom of the old existing paddy fields, called “akkara vela”. All these aspects contributed to the increase of erosive lands in the catchments.

According to the KII, the traditional *chena* cultivation was carried out before the start of the *maha* season in forest areas in the catchments avoiding dense forest areas and shrub jungles, and the yield from *chena* cultivation was mainly meant for household consumption. The village forests are protected by the forest ordinance of Sri Lanka. After 1981, the Forest Department did not permit *chena* cultivation using the forest. At present, the lands used for *chena* cultivation are cultivated throughout the year in the catchments. The traditional *chena* practices have now been modernized by many new practices such as using chemicals and machinery.

From KII, it was found that the *Tectona grandis* (Teak) was planted in 1970 after removing native trees such as *Manilkara hexandra* (Palu) and *Drypetes sepiaria* (Weera) in the forests of the catchments. Teak plantations create high erosion rates because of the lack of understory and the large size of leaves (Calder, 2001). And negligence of maintenance of micro-ecological components such as tree belts, grass filters, soil ridges, water holes and forest tanks that trap sediments were also some of the reasons for the increased sediment levels in tanks.

Soil erosion of sub-catchments

The drainage area of sub-catchments of Palugaswewa TCS varies only from 0.5 km² to 5 km². Due to the small nature of the Palugaswewa TCS, no variability of the rainfall among the different sub-catchments is expected in this study. Therefore, the R factor of the sub-catchments of Palugaswewa TCS is almost similar throughout the map

which is 168 MJ mm ha⁻¹ h⁻¹yr⁻¹. K factor reflects the soil's vulnerability to erosion. Palugaswewa TCS consists of Reddish-Brown Earths soils (RBE) on upper land and Low Humic Glay soils (LHG) in the valley bottoms. Both the soil has the K factor of 0.27 t h MJ⁻¹ mm⁻¹. Therefore, K takes the same value throughout the sub-catchments of Palugaswewa TCS. The study area consists of a nearly level and gently undulating land slope with a mean LS value of 3.8 and with a range of 0 to 10. The support or conservation practice represented by the P factor adopted is only terracing paddy fields at present. Therefore, land use or vegetation (C) is the most important factor which varied between 0.03 to 0.65 influencing soil erosion in this study (Figure 1). This is supported by Roose (1996) as when other factors are similar and if vegetation covers on a plot falls from 100% to 0%, erosion goes from 1 to over 1000 tons.

The experimental cascade system, sub-catchments and land uses are given in Figure 1. The soil erosion rates under the sub-catchments are given in Table 3. The data show a very high potential for soil erosion under the present land management system in the cascade. The potential erosion rates varied between 18.8 to 44.3 t/ha/yr (Table 3). According to Dharmasena (1992b), the soil erosion rate in the lower slope regions containing RBE soil in Anuradhapura district was 27 t/ha/yr. Further, Dharmasena (2003) describes that during the last five decades, the extent of the forest has drastically declined from half to less than a quarter due to colonization, rice land development under major irrigation schemes and the opening of new lands for *chena* cultivation in the dry and intermediate zones gives the clear historical evidence of soil erosion and the soil erosion rate in a *maha* season could be as high as 54 t/ha/yr from *chena* lands in the regions of RBE soil. Less than 12 t/ha/yr of soil erosion hazard can be allowed for agriculture. However, crop cultivation with the range of soil erosion from 12 t/ha/yr to 60 t/ha/yr should be managed to avoid the degradation of lands (Senanayake, 2013). Potential Total Annual Soil Loss (PTASL) is a function of the potential average annual erosion rate and the extent of the land use. An increase in the land extent increases the PTASL under any land

use. Udakadawala tank generates the highest and Alapath tank generates the lowest PTASL

as these catchments have the highest and lowest catchment areas, respectively.

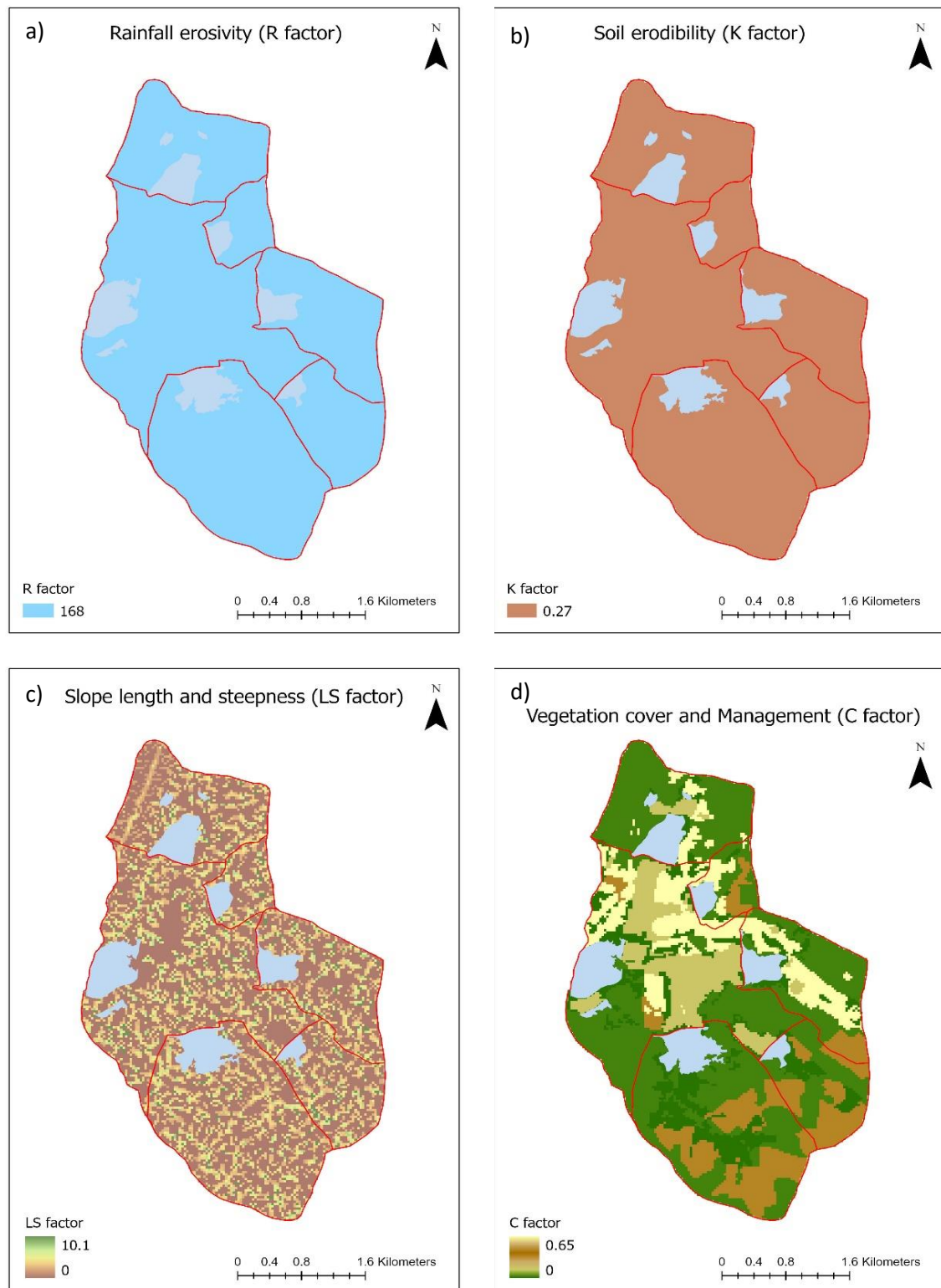


Figure 2:(a) R factor (b) K factor (c) LS factor (d) C factor maps of sub-catchments

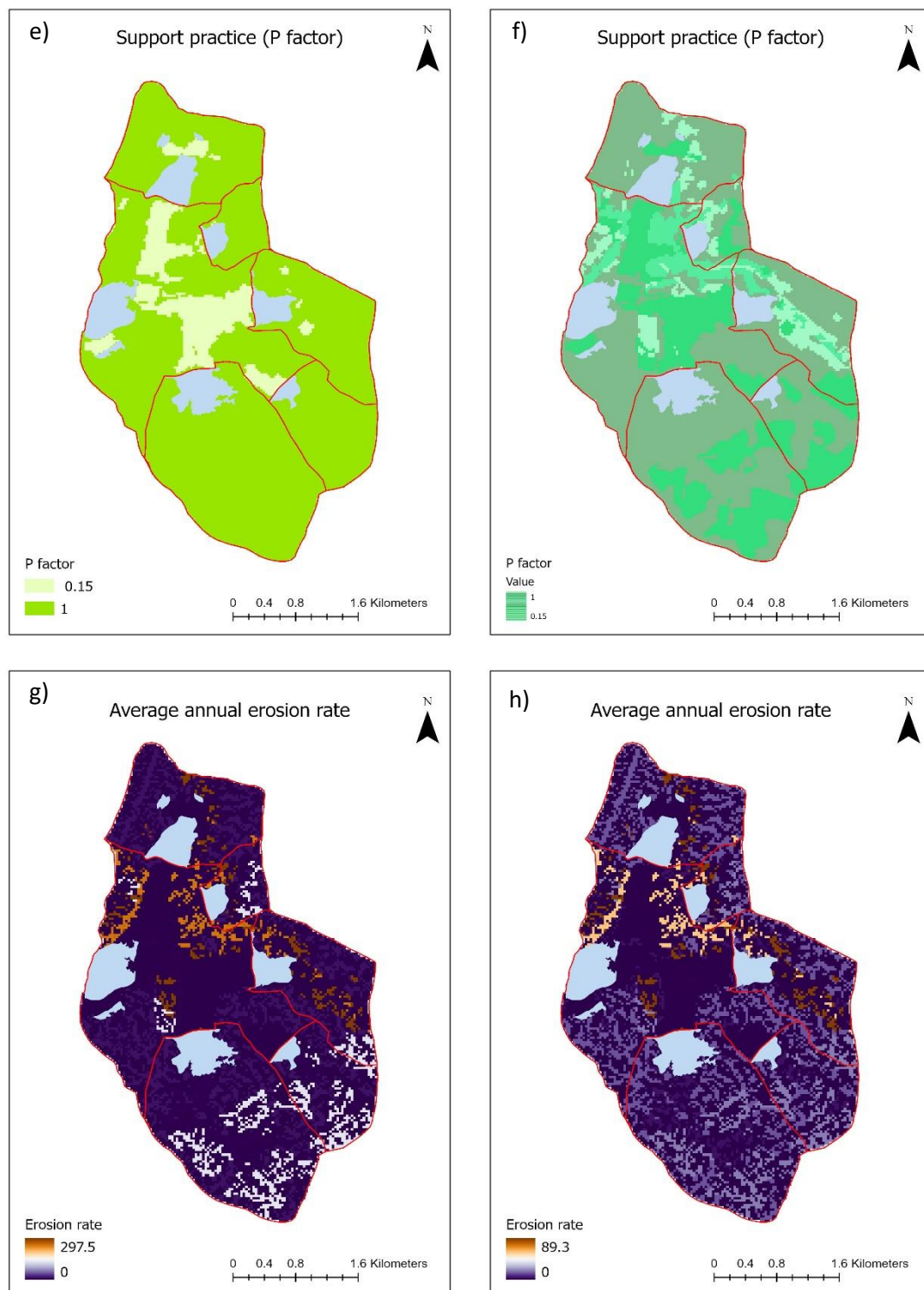


Figure 3: Maps of (e)P factor with only conservation practice in paddy (f) P factor (g) Average annual soil erosion rate with only conservation practice in paddy (h) Average soil erosion rate of sub catchments

Table 3: Soil erosion of sub-catchments in Palugaswewa TCS

Name of the sub-catchment	Alapath tank	David tank	Yakanda gas tank	Kundalu gas tank	Udakada wala tank	Maha tank
Potential average annual erosion rate (t/ha/yr)	44.3	30.0	39.9	23.1	27.4	18.8
Potential total annual soil loss (t/yr)	26,085	43,407	71,599	95,799	130,581	38,316
Potential average annual with the introduction of conservation practices (t/ha/yr)	14.5	9.6	14.5	8.9	10.5	10.7
Reduction of soil erosion after the introduction of conservation practice (%)	67.3	68.0	63.7	61.5	61.7	43.1

Table 4: Soil erosion of sub-catchments in Palugaswewa TCS

Name of the sub-catchment	Alapath tank	David tank	Yakanda gas tank	Kundalu gas tank	Udakada wala tank	Maha tank
Mean SDR	0.66	0.63	0.71	0.64	0.72	0.69
Potential rate of average annual sediment yield (t/ha/yr)	29.5	20.0	35.9	14.8	18.6	12.4
Potential annual total sediment yield (t/ha)	1,666.8	2,662.0	6,203.5	5,409.4	8,613.7	2,036.1

High erosive land use types are *chena*, homesteads, forest plantation and open forest and the least erosive land uses are scrub, forest and paddy. Some catchments, including Alapath tank, David tank, and Yakandagas tank have a high percentage of high erosive land uses. In present conditions, sub-catchment of the Maha tank has the lowest erosion as it has the lowest percentage of high erosive land uses and the highest percentage of dense forest cover. The sub-catchment of Alapath tank has the highest erosion rate as it has the highest percentage of highly erosive land uses, namely forest plantation, homestead and *chena*. Out of this, forest plantation occupies the highest percentage of land. Native trees such as Manilkara hexandra (*Palu*) and Drypetes sepiaria (*Weera*) were removed and Teak was planted in the catchment area of Alapath tank during the 1970s. Teak trees shed leaves during the dry period before the onset of rains in the *maha* season and have very low canopy cover. Teak

plantations create high erosion rates because of the lack of understory and the large size of leaves (Calder, 2001). The sub-catchment of Yakandagas tank have the second highest erosion rate. It has the third highest percentage of highly erosive lands but has the highest percentage of *chena* lands which has the highest C factor. When comparing the remaining catchments, David tank shows high erosion as it has a highly open forest. In the sub-catchment of Udakadawala tank, almost 75% of the land use includes dense forest, scrub and paddy, which are low erosive land uses. The sub-catchment of Kundalugas tank shows the lowest erosion rate next to the sub-catchment of the Maha tank and has the lowest percentage of highly erosive land uses.

The sub-catchments of Maha tank and Kundalugas tank are under high erosion hazard class, while the sub-catchments of Udakadawala tank, David tank, Yakandagas tank and Alapath tank are categorized under

very high erosion hazard classes. This rate of erosion is not acceptable as it causes severe damage to the environment (Bergsma, 1986). Simple conservation measures such as cover cropping and soil contour bunds considered in this study are respectively biological and mechanical techniques. According to a global analysis, the effects of biological and mechanical practices in soil conservation were 88% and 86%, respectively. (Xiong *et al.*, 2018). In this study, soil erosion reduced between 62 % to 68% in all the tanks other than Maha tank after the introduction of these conservation practices. In Maha tank, soil erosion was reduced by only about 43 %, as it already had the least erosion even before applying conservation measures.

Sediment delivery in the sub-catchments

The estimated potential SDR and the potential sediment yield for the Palugaswewa TCS given in (Table 4) vary from 0.18 to 0.9 in the TCS. The minimum and the maximum drainage area of sub-catchments of Palugaswewa TCS are 0.5 km² and 5 km² as pointed out before.

The data given in Table 4 indicate that the total potential sediment yield is related to sediment yield, catchment area and the percentage of high erosive land uses such as *chena*, homesteads, open forest and forest plantations. There is a general trend of increasing total sediment yield with an increase in the catchment yield. However this trend is modified by the sediment yield and land use as seen by the data for Yakandagas tank and Maha tank (Table 4). Yakandagas tank, with 173 ha, yields 6,203 tons of sediment, while Maha tank, with 184 ha, yields only 2,036 tons. The reasons for this high difference are the differences in the sediment yield and the percent of high erosive land use extents in the two sub-catchments. In Yakandagas and Maha tank the percentages of high erosive land extent were 40 % and 17%, respectively, while annual rates of sediment yield were 35.9 and 12.4, respectively.

Dharmasena (1992a) studied the magnitude of sedimentation of the Maha Kanumulla small catchment, located close to Palugaswewa TCS, by field assessment. It

showed the total volume of sediment collected in these tanks ranged from 23 to 35% of the tank's potential storage. Further, mentioned that compared to the average sediment yield of the total past life of the tank, the recent rate of sedimentation was higher. The catchment area of Marikaragama and Paidikulama in the Maha kanumulla was 70 ha and 123 ha, respectively. During the study period, only 25 - 30% of the Marikaragama tank catchment was under *chena* cultivation, and one-third was under paddy cultivation. According to his study, the rate of sediment yield was about 3,200 m³/km²/yr and 6000 m³/km²/yr (48 t/ha/yr and 90 t/ha/yr) from Marikaragama and Paidikulama tank catchments, respectively. Values reported in this study are only estimates based on land use and they are very much lower than the values reported by Dharmasena. Very high rates of sedimentation during shorter periods can result from earth-moving activities for construction works. These are not accounted for in the estimates.

CONCLUSIONS

Half of the storage capacity of the tanks of Palugaswewa TCS has been filled with sediments. The potential average annual erosion rates of the sub-catchments of the Palugaswewa TCS vary in the range between 19 t/ha/yr to 44 t/ ha/yr where land use types such as *chena* lands, forest plantations, open forests and home gardens show high potential for soil erosion. Further, adapting simple conservation methods such as soil contour bunds and cover crops to the present land use systems can reduce the soil erosion rates of the sub-catchments of Palugaswewa TCS in the range of 43 % to 68%.

ACKNOWLEDGEMENT

This work was carried out with a grant from the International Development Research Center (IDRC), Ottawa, Canada. Their financial support is greatly appreciated.

REFERENCES

- Abdulkareem, J. H., Pradhan, B., Sulaiman, W. N. A., & Jamil, N. R. (2019). Prediction of spatial soil loss impacted by long-term land-use/land-cover change in a tropical watershed. *Geoscience Frontiers*, 10(2), 389-403.
- Bandara, C. M., Yatigammana, S., & Paranavithana, G. (2010). Scientific validation of some traditional land and water management practices under Village Tank Cascade Systems. *Economic Review*, 36, 1-18.
- Bergsma, E. (1986). Aspects of mapping units in the rain erosion hazard catchment survey. Land evaluation for land use planning and conservation in sloping areas, International Institute for Land Reclamation and Improvement, publication, 40, 84-105.
- Bewket, W. and Teferi, E., 2009. Assessment of soil erosion hazard and prioritization for treatment at the watershed level: case study in the Chemoga watershed, Blue Nile basin, Ethiopia. *Land Degradation & Development*, 20(6), pp.609-622.
- Calder, I. R. (2001). Canopy processes: implications for transpiration, interception and splash induced erosion, ultimately for forest management and water resources. In *Tropical Forest canopies: ecology and management* (pp. 203-214). Springer, Dordrecht.
- Chakrapani, G. J., & Saini, R. K. (2009). Temporal and spatial variations in water discharge and sediment load in the Alaknanda and Bhagirathi Rivers in Himalaya, India. *Journal of Asian Earth Sciences*, 35(6), 545-553.
- Dharmasena, P. B. (1992a). Magnitude of sedimentation in village tanks. *Trop. Agric*, 148, 97-120.
- Dharmasena, P.B. (1992b). Rainfall erosivity and potential erosion in the central dry zone. *Trop. Agric*, 148, pp.111-120.
- Dharmasena, P.B. (2003). Soil erosion and conservation—A case study in the dry zone of Sri Lanka. *Tropical Agricultural Research and Extension*, 6(2003), pp.128-131.
- Dharmasena, P. B. (2004). Small tank heritage and current problems. Small tank settlements in Sri Lanka, 31-39.
- Dharmasena, P.B., 2009. Sustainability of small tank irrigation systems in Sri Lanka at the 21st Century, Traversing No Man's Land, Godage International Publishers (Pvt) Ltd. P 233-252
- Dharmasena, P. B. (2010, December). Essential components of traditional village tank systems. In *Proceedings of the National Conference on Cascade Irrigation Systems for Rural Sustainability*. Sri Lanka: Central Environmental Authority.
- Fernandez, C., Wu, J. Q., McCool, D. K., & Stöckle, C. O. (2003). Estimating water erosion and sediment yield with GIS, RUSLE, and SEDD. *Journal of soil and Water Conservation*, 58(3), 128-136.
- Ferro, V., & Minacapilli, M. (1995). Sediment delivery processes at basin scale. *Hydrological Sciences Journal*, 40(6), 703-717.
- Geekiyanage, N., & Pushpakumara, D. K. N. G. (2013). Ecology of ancient tank cascade systems in island Sri Lanka. *Journal of Marine and Island Cultures*, 2(2), 93-101.
- Haan, C. T., Barfield, B. J., & Hayes, J. C. (1994). *Design hydrology and sedimentology for small catchments*. Elsevier.
- Kothyari, U. C., & Jain, S. K. (2000). Sediment yield estimation using GIS. *Hydrological sciences journal*, 42(6), 833-843.
- Lal, R. (2005). Influence of soil erosion on carbon dynamics in the world. In *Soil erosion and carbon dynamics* (pp. 23-35). CRC Press.
- Mahatantila, K., Chandrajith, R., Jayasena, H. A. H., & Ranawana, K. B. (2008). Spatial and temporal changes of hydrogeochemistry in ancient tank cascade systems in Sri Lanka: evidence for a constructed wetland. *Water and Environment Journal*, 22(1), 17-24.
- McCool, D. K., Brown, L. C., Foster, G. R., Mutchler, C. K., & Meyer, L. D. (1987). Revised slope steepness factor for the Universal Soil Loss Equation. *Transactions of the ASAE*, 30(5), 1387-1396.
- Ministry of Agriculture and Food and Agriculture Organization of the United Nations, Sri Lanka. (2017). A proposal for declaration as a GIHAS the Cascade Tank-Village System (CTVS) in the dry zone of Sri Lanka [online]. [Accessed on: 4th January 2019]. Available at: <https://businessdocbox.com/74278821->

- Agriculture/A-proposal-for-declaration-as-a-giahs-the-cascaded-tank-village-system-ctvs-in-the-dry-zone-of-sri-lanka.html
- Panabokke, C. R., Sakthivadivel, R., & Weerasinghe, A. D. (2002). Evolution, present status and issues concerning small tank systems in Sri Lanka (No. H036586). Colombo: International Water Management Institute.
- Porto, P., & Walling, D. E. (2015). Use of caesium-137 measurements and long-term records of sediment load to calibrate the sediment delivery component of the SEDD model and explore scale effect: Examples from southern Italy. *Journal of Hydrologic Engineering*, 20(6), C4014005.
- Renard, K. G., Foster, R. G., Weesies, G. A., & Porter, G. A. (1991). C" RUSLE: Revised universal soil loss equation,". *Journal of soil and Water Conservation*, 46, 30-33.
- Roose, E. (1996). *Land husbandry: components and strategy* (Vol. 70). Rome: FAO.
- Senanayake, S.S., Munasinghe, M.A.K. and Wickramasinghe, W.M.A.D.B., (2013). Use of erosion hazard assessments for regional scale crop suitability mapping in the Uva Province. *Ann Sri Lanka Dep Agric*, 15, pp.127-141.
- Senanayake, S., Pradhan, B., Huete, A., & Brennan, J. (2020). Assessing soil erosion hazards using land-use change and landslide frequency ratio method: a case study of Sabaragamuwa Province, Sri Lanka. *Remote Sensing*, 12(9), 1483.
- Thomas, K., Chen, W., Lin, B. S., & Seeboonruang, U. (2020). Evaluation of the SEdiment Delivery Distributed (SEDD) Model in the Shihmen Reservoir Watershed. *Sustainability*, 12(15), 6221.
- Thuraisingham, K., & Weerasinghe, V. (2009). Soil erosion study for Bibili Oya watershed in Kelani River basin. In Sri Lanka ArcGIS user conference.
- Xiong, M., Sun, R., & Chen, L. (2018). Effects of soil conservation techniques on water erosion control: A global analysis. *Science of the Total Environment*, 645, 753-760.
- Yang, M., Li, X., Hu, Y., & He, X. (2012). Assessing effects of landscape pattern on sediment yield using sediment delivery distributed model and a landscape indicator. *Ecological Indicators*, 22, 38-52.
- Wischmeier, W. H., & Smith, D. D. (1978). Predicting rainfall erosion losses: a guide to conservation planning (No. 537). Department of Agriculture, Science and Education Administration.