

MAGNITUDE OF SEDIMENTATION IN VILLAGE TANKS

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ABSTRACT

A sedimentation study was carried out in three village tanks in the Maha Kanumulla small watershed (Anuradhapura district). The amount and rate of sedimentation were determined by using field engineering and soil surveys. The results showed that the total volume of sediment collected in these tanks ranged from 23 to 35% of the tank potential storage. The rate of sedimentation was found to be higher in recent past compared to the average rate of sedimentation during the total past life of the tank. The present rate of sediment yield is about 3200 and 6000 m³/km²/yr from Marikaragama and Paindikulama tank catchments respectively. Thus, the tank life index could be estimated at 35 years and 150 years for the respective village tanks. The information gathered from the study indicate that not only the village tank but also the tank catchment is affected by this erosion process as far as the agricultural use of land is concerned. Storage capacity of these village tanks is decreasing at the same rate that the sediment is collected, causing a gradual reduction in the cultivable extent of their command areas.

KEY WORDS: Area-capacity curve, Sedimentation, Soil erosion, Tank life index

INTRODUCTION

The problem of soil erosion that raises sedimentation has been the concern in many countries. Recent studies conducted in India in respect of 17 major reservoirs, show that sedimentation rates have increased three-fold due to large scale deforestation (Tejwani, 1979). High rate of sedimentation (about 730 m³/km²/yr) was observed for three reservoirs in Tanzania. One of the catchments studied was yielding a massive 13,500 m³/km²/yr (Rapp, 1976).

A preliminary observation (P.B.Dharmasena, Unpubl.) at Paindikulama indicates that during maha season (1989/90), soils were lost from 0.5 ha of cultivated field at the rate of 19,000 m³/km². This is a higher value compared to the values reported above. However, due to the fact that larger drainage basins have larger proportions of the flat areas suitable for depositing, erosion rates expressed per unit area are generally higher for small basins and decrease as the catchment becomes bigger (Morgan, 1986). Thus, the sediment yield of village tank catchment cannot be correctly estimated by extrapolating the observations from field plots.

Soil erosion resulting from clearing of forest in village tank catchments and farming without conserving soil are major concerns in the agricultural development in the dry zone of Sri Lanka (Brohier, 1975). The erosion hazard is considerable in the Alfisols (Panabokke, 1975) which cover the largest part of the dry zone. This is on account of the low water stability of the soil aggregates, easy slaking of the soil macro-aggregates following sudden wetting, rainfall intensities often exceeding the infiltration rates of the soils and the undulating nature of the catenary landscape systems.

The erosion results in degradation of farm land as the fertile top soil with plant nutrients is gradually removed. In this process, the upland becomes less productive or perhaps unproductive (Tennekoon, 1980), and the tanks below are filled with sediment (Kunkle and Dye, 1981) leading to a gradual change on the entire tank village farming system in relation to its hydrology.

Sedimentation of village tanks leads to several problems such as reduction of the tank storage capacity, reduction of sub-surface flow into the tank, blocking of the sluices and channels with sediment and filling the dead storage with silt, resulting in non-availability of water in the tank during the dry season for domestic and other uses. In recent tank rehabilitation programmes, the tank bunds have been raised to compensate the loss of storage capacity from sedimentation. However, this is not very successful because on the one hand there is high evaporation losses due to a larger surface area, and on the other hand, some of the paddy lands under the upper tanks in a cascade are submerged.

Due to lack of knowledge on the magnitude and the rate of sedimentation in village tanks, above consequences have not been identified as a result of mismanagement of tank catchments. Thus, authorities are not convinced to take necessary steps for the protection of village tanks from sedimentation. The objective of this study therefore, was to quantify the lost volume of tank storage due to sedimentation and to estimate the present silting rate in village tanks which would indicate the decreasing rate of tank storage potential.

METHODOLOGY

Definition of tank life index

The tank storage potential decreases as the eroded material is sedimented in the tank bed. The rate of filling the tank storage with sediment and the storage capacity of tank will determine the time taken to fill the entire tank with sediment. Thus, an index would be useful to understand to what extent the problem is serious.

The proposed tank life index can be defined as time, in number of years, required to fill the present storage volume of a tank with the present rate of sedimentation.

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Site selection

Three village tanks were selected from the Maha Kanumulla tank cascade which is in one of small watersheds situated within the main watershed of Nāchchaduwa major tank (Fig. 1). Of the three tanks, Paindikulama and Siwalagala are uppermost tanks in drainage valleys and Marikaragama tank is a second in a chain of tanks. Due to the presence of a tank above Marikaragama, the effective catchment area has been reduced to 70.4 ha which is half of the total extent. Basic tank data of the three tanks studied are given in Table 1.

Table 1. Basic tank data (as in 1990)

Description	Paindikulama	Siwalagala	Marikaragama
Catchment area (ha)	123.0	62.0	70.4
Tank area (ha)	16.3	15.0	23.0
Full supply level (m)	3.4	2.7	3.2
Capacity (ha. m)	25.8	19.9	35.3
Command area (ha)	53.8	27.0	27.3
Capacity/catchment (m)	0.24	0.32	0.50

Volume of sediment

The total volume of sediment deposited in each of the three village tanks was determined separately by using a sediment depth survey. Surveys were carried out at Paindikulama in 1987, and Siwalagala and Marikaragama in 1990. The sediment depth survey was carried out in 20m x 20m grid size by augering up to the original soil surface. Initially, textural analysis was carried out for different depths in a few locations of each tank to obtain the sand/(silt + clay) ratio. On the assumption that the sediment contains relatively higher percentage of silt and clay than the original layer in most of the time, a sudden contrasting increase in the value of sand/(silt + clay) ratio was considered as the boundary between the sediment layer and the original soil layer (S.Somasiri, Personal Communication). This difference could be recognized through estimation of texture by feeling the soil between the thumb and fingers. However, this needs experience gained from comparing texture determined by feel and by mechanical analysis. Sediment depth contour maps were prepared for each tank while area - sediment depth curves were developed by plotting sediment depth against the area covered by the depth contour. The total volume of sediment was obtained by computing the area below the curve.

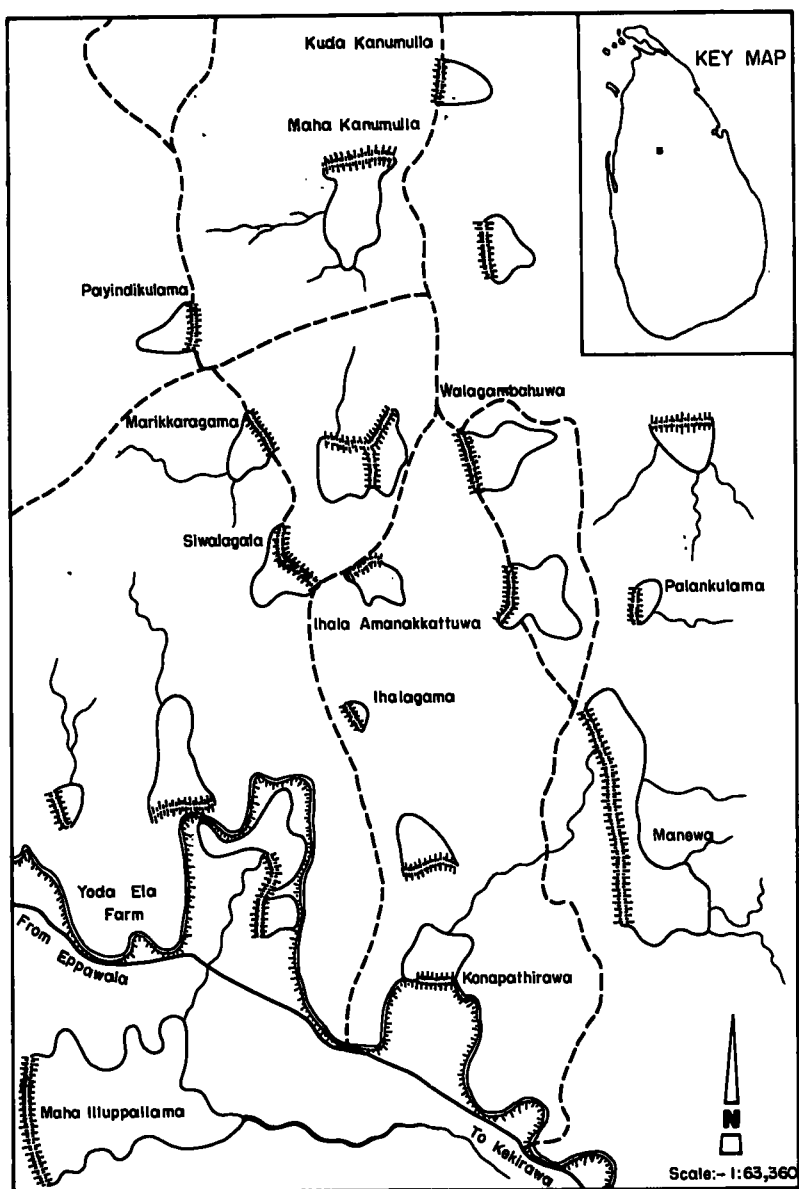


FIG. 1 : LOCATION MAP OF STUDY SITES

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Rate of sedimentation

Tank bed level surveys carried out some years ago (Paindikulama - 1984), Marikaragama - 1986) were repeated in 1990 (Fig. 2) to determine the possible reduction in the storage capacities which may be attributed to sedimentation. During the concerned period, both these tanks have not undergone any rehabilitation works which would have affected the results. These tank bed level surveys were also carried out in 20m x 20m grid size.

RESULTS AND DISCUSSION

Analysis of particle size distribution showed that there is a clear margin between sediment deposit and the underlain original soil (Tables 2, 3 and 4). Generally, a sand deposit was found at the soil boundary in central area of the tank bed that might be due to the bed load deposit prior to the construction of the tank. Sediment layer of the periphery of the tank bed could be traced by feeling the high content of fine sand in the sample.

Sediment - depth contour maps were prepared for all three tanks (Fig. 3, 4 and 5). Area - sediment depth curves were developed (Fig. 6) by using the above sediment contour maps. An example for cross sectional view of the tanks giving current surface relief and the original surface relief is shown in Fig.7. Results indicate that most of the sediment have been deposited closer to the tank bund and thinned out towards the tank periphery following the tank bed geometry.

Tank sedimentation data calculated by using area - sediment depth curves are reported in Table 5. The Paindikulama tank recorded the highest percentage of sediments (35%) and Marikaragama the lowest (23%) among the three tanks investigated. It indicates that even if the rainfall is not a limiting factor, as a consequence of sedimentation, the irrigable extent would be reduced according to the magnitude of sedimentation.

Rate of sedimentation

Paindikulama

Area - capacity curves developed for Paindikulama in 1984 and 1990 show a distinct reduction in the tank bed areas and the storage capacity at any elevation. This means that the sedimentation occurs everywhere in the tank bed. However, sediment distribution during last 6 years also follows the same pattern as in the past. It is not evenly distributed. The depth of sediment is deeper in the centre and gradually thinned up radially towards the periphery (Fig. 3, 4 and 5). The average rate of sediment yield from Paindikulama catchment during the period from 1984 to 1990 was $6000 \text{ m}^3/\text{km}^2/\text{yr}$. The depth of sediment varies from 0 to 15 cm/yr

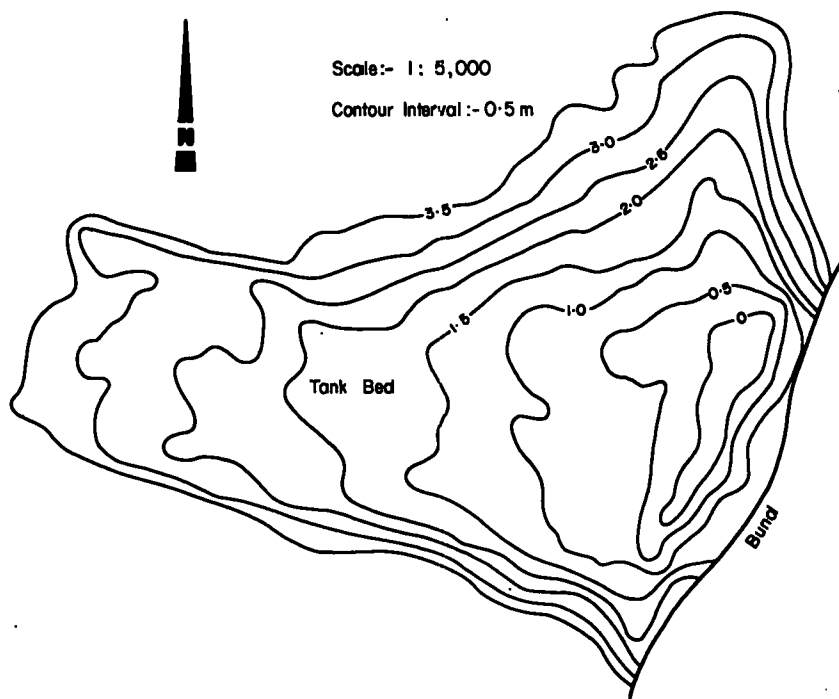


FIG. 2: TANK BED CONTOUR MAP OF PAINDIKULAMA.

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Table 2. Texture of sediment deposit in the tank bed soil of Paindikulama tank

Depth range (cm)	Percentage of soil particles				Sand / Silt + Clay
	Coarse sand	Fine sand	Silt	Clay	
0 - 20	12.0	0.0	6.8	81.2	0.14
20 - 40	14.0	1.0	9.0	76.0	0.18
40 - 60	15.0	2.0	5.0	78.0	0.20
60 - 80	16.0	5.0	7.0	72.0	0.27
100 - 120	42.0	4.0	5.0	49.0	0.85*
120 - 140	44.0	4.0	3.0	49.0	0.92
140 - 160	45.0	3.0	4.0	48.0	0.92

Table 3. Texture of sediment deposit in the tank bed soil of Siwalagala tank

Depth range (cm)	Percentage of soil particles				Sand / Silt + Clay
	Coarse sand	Fine sand	Silt	Clay	
0 - 20	13.6	0.0	7.6	74.8	0.17
20 - 40	13.2	0.0	7.4	81.2	0.15
40 - 60	14.8	7.2	5.6	72.4	0.28
60 - 80	25.2	12.8	1.6	60.4	0.61*
80 - 100	25.4	8.2	6.4	60.0	0.51
100 - 120	23.6	11.4	8.6	56.4	0.54

Table 4. Texture of sediment deposit in the tank bed soil of Marikaragama tank

Depth range (cm)	Percentage of soil particles				Sand / Silt + Clay
	Coarse sand	Fine sand	Silt	Clay	
0 - 40	16.0	10.8	5.2	68.0	0.37
40 - 60	22.0	8.0	4.0	66.0	0.43
60 - 80	27.0	4.0	8.0	61.0	0.45
80 - 100	16.0	10.8	5.2	68.0	0.37
100 - 120	34.0	12.8	1.2	52.0	0.88*
120 - 140	40.0	7.0	5.0	48.0	0.89
140 - 160	33.0	13.0	8.0	46.0	0.85

* High value is on the original soil surface

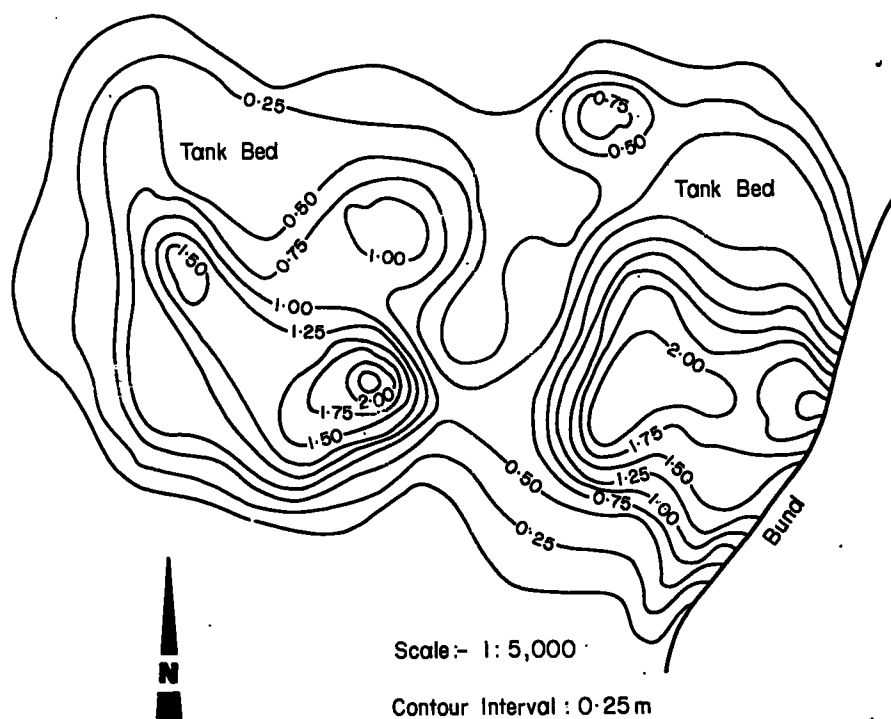


Fig. 3. Sediment depth contour map for Siwalagala tank

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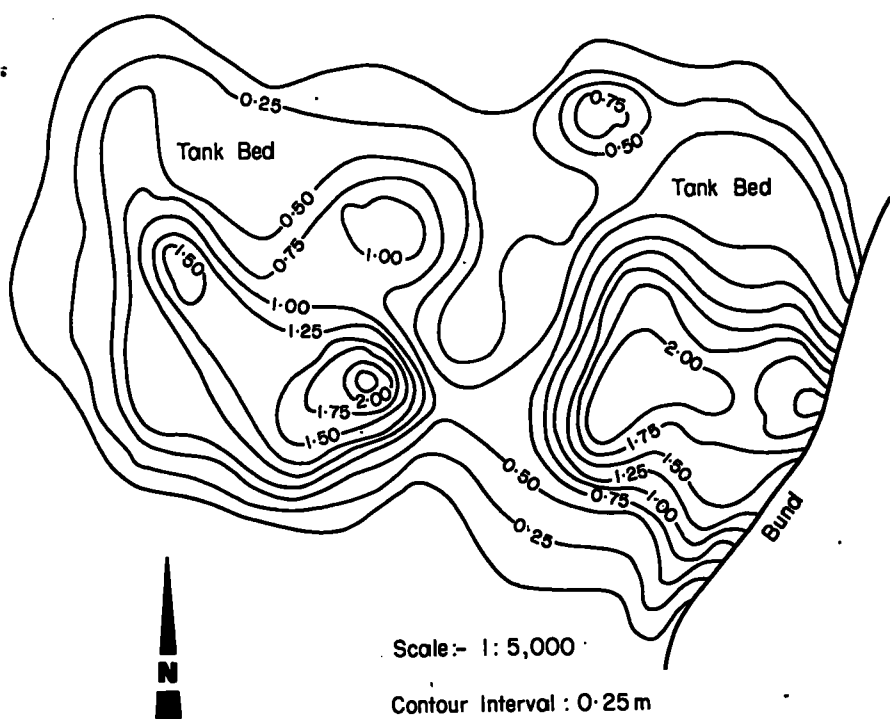


FIG. 4 : SEDIMENT DEPTH CONTOUR MAP FOR PAINDIKULAMA TANK.

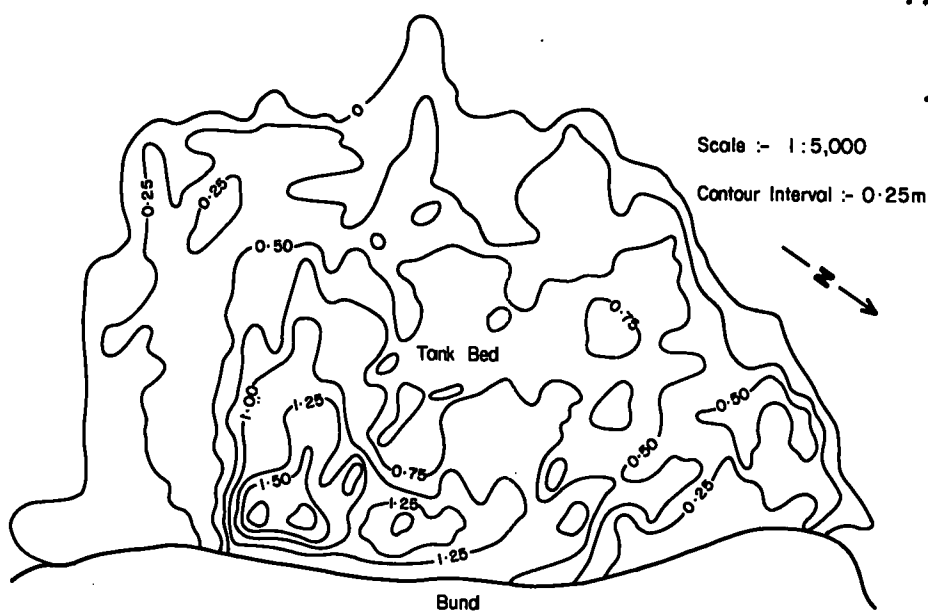


FIG. 5 : SEDIMENT DEPTH CONTOUR MAP FOR MARIKARAGAMA TANK

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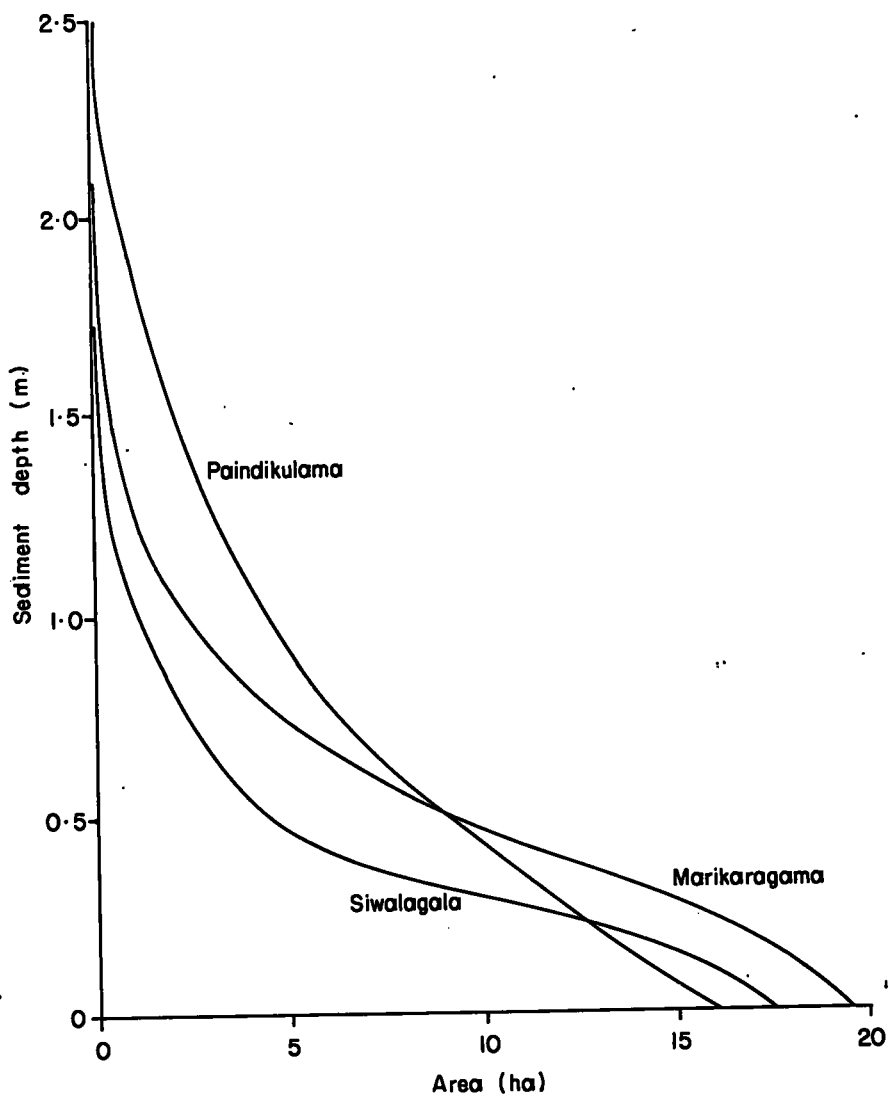


FIG. 6 : SEDIMENT DEPTH AREA CURVES FOR 3 VILLAGE TANKS.

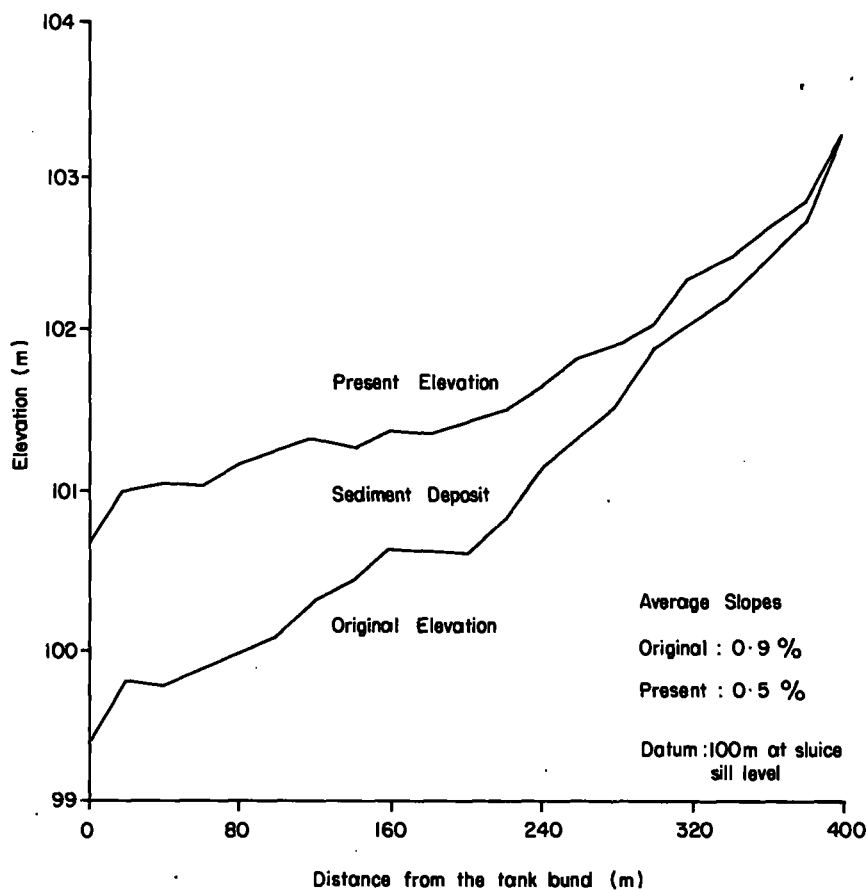


FIG. 7 : A CROSS SECTION OF SIWALAGALA TANK BED SHOWING THE SEDIMENT DEPOSIT

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Table 5. Magnitude of sediment deposits in three village tanks

Tank	Year	Catchment area (ha)	Capacity (ha.m)	Sediment volume (ha.m)	Percent silted	Silting rate (ha.m/yr)
Paindikulama	(1984)	123	30.2	9.7	24.3	-
	(1987)	123	28.0	11.9	29.8	-
	(1990)*	123	25.8	14.1	35.3	0.73
Siwalagala	(1990)	62	19.9	8.6	30.2	-
Marikaragama	(1986)*	70	36.2	9.6	21.0	-
	(1990)	70	35.3	10.5	22.9	0.23

* Calculated from area - capacity curves

or has an average value of 4.5 cm/yr. If the rate of sedimentation is not changed, it can be estimated that the total tank storage is filled with sediment during a period of 35 years. Therefore, the tank would only be 20 years which is not acceptable. According to the Paindikulama villagers, the history can go beyond 150 years, the present rate of sedimentation is 7.5 times higher than the average rate. This reveals a very high development of the erosion process in the last few years compared to the past.

Marikaragama

During a period of four years from 1986 to 1990, the tank bed area was reduced from 24.8 ha to 23.0 ha in the Marikaragama tank due to sedimentation. The consequent reduction in the storage capacity was from 36.2 ha. m to 35.3 ha. m showing a loss of about 9000 m³ of storage capacity. It indicates that the Marikaragama tank catchment yields a load of sediment at the rate of 3170 m³/km²/yr. This is a low value compared to the sediment yield of Paindikulama tank catchment. The present silting rate is about 0.5%, and if such a rate prevailed in the past it would take only 45 years to fill the existing sediment deposit. According to the villagers the Marikaragama tank is also more than 150 years old and it could be estimated that the present rate of sedimentation is at least 4 times higher than the average rate in the past.

Such estimates do not reflect the real erosion from chena as the erosion from lands other than chena do not make much contribution to the sediment yield. Chena surveys carried out during the study period showed that only 25 - 30% of the Marikaragama tank catchment was under cultivated chena conditions. However, the Marikaragama tank unlike Paindikulama is not in a very critical situation since its

tank life index is estimated to be 150 years with the present land use intensity. This could be mainly because of the fact that about one third of the Marikaragama catchment is under paddy cultivation of Ayyathayagama tank.

Observations of the study reveal that the present rate of sedimentation in village tanks cannot be overlooked as it endangers the entire farming system. The village tanks that are in the upper most location on the drainage path need immediate attention. Mismanagement of village tank catchments must be subjected to the discussion of the relevant authorities and further investigation on soil erosion and sedimentation in tank village farming environment should be one of the main focus of future research.

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