EVALUATION OF SOIL CONSERVATION MEASURES: A case study in Mbinga District, Ruvuma Region, Tanzania

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ABSTRACT

A study to evaluate soil conservation measures was carried out at two villages, namely Tukuzi and Mahenge, in Mbinga District, Ruvuma Region, Tanzania. It was found that the ngoro farming system was effective in controlling soil erosion by water in both steep and gentle slopes. Some of the sediments collected from ngoro had high plant nutrient concentrations of available phosphorus (P), total nitrogen (N), organic carbon (OC) and exchangeable bases, possibly due to the availability of more nutrients resulting from the decomposition of grass bundles buried in the soil. In terms of preventing soil erosion from land, ngoro (of any size) and bench terraces were similarly effective. Overall contour ditches were as effective when compared with either ridges or flat cultivation. Therefore on steep slopes, ngoro should be combined with contour ditches to effectively control soil and plant nutrient losses.

INTRODUCTION

There are many areas in Tanzania which have been seriously affected by different forms of degradation including sheet and gully erosion. Some of the factors influencing soil degradation include overgrazing, cultivation on sloping lands, use of unsuitable tillage practices and invasion on marginal lands arising from population pressure.

Soil erosion by water is one of the most important forms of land degradation in Tanzania as it reduces agricultural productivity of soils through the removal of fertile top soil horizons in which crops obtain their nutrients (Per Assmo and Erickson, 1994). It is also a primary source of sediment that pollutes streams and fills reservoirs. Eroded sediment can carry organic matter and plant nutrients, particularly phosphate and nitrogen, to waterways, and contribute to eutrophication of lakes and streams. Adsorbed pesticides are also carried with eroded sediments, adversely affecting surface water quality.

Erosion is influenced by rainfall characteristics (intensity, amount, duration and distribution over the area) and the catchment characteristics (topography), vegetation, infiltration rate, soil storage capacity, the drainage pattern, size and shape and geology of the catchment). The rainfall characteristics mainly affect splash erosion due to the impact of raindrops on the soil surface, whereas, catchment characteristics influence erosion by surface runoff (rill and interill erosion).

The objective of this paper is, therefore, to evaluate both the ngoro system and the conventional The Matengo pits (ngoro) are noted to be very effective in preventing/controlling erosion on cultivated mountain sides. However, nobody has attempted to quantify their effectiveness.in conservation measures in order to compare their effectiveness in controlling erosion.

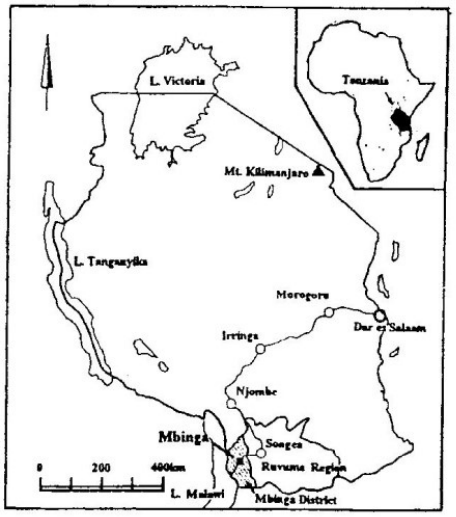

Fig. 1 Location of the study area.

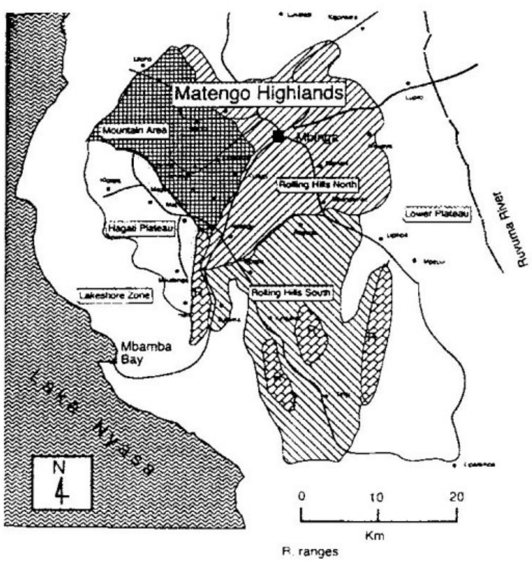

Fig. 2 Agro-ecological zones of Mbinga District.

MATERIALS AND METHODS

The conventional methods include cultural/biological and physical measures. The cultural practices include contour farming, early planting, tillage practices, ridging, mulching, and applying organic fertilizers. Biological measures include crop rotation, mixed cropping, grass strips, strip cropping and trash lines. The cultural/biological measures are related to crop and soil management (Hudson, 1981). The physical measures involve the use of terraces, cut-off drains and artificial waterways.

Experimental Sites

Data for evaluating the effectiveness of both traditional and conventional conservation measures for controlling erosion by water were collected from runoff plots established in two villages, Tukuzi and Mahenge, in Mbinga District, Ruvuma Region, Tanzania (Fig. 1 and 2).

Agro-ecological zones of Mbinga District

Mbinga District can be divided into five agro-ecological zones. These include: high altitude and low altitude mountainous areas, high plateau, rolling hills and lakeside zones. The altitude varies from 900 m along Lake Nyasa to 2000 m above mean sea level in the high altitude mountains. Mahenge is in the high plateau while Tukuzi is in the low altitude mountains.

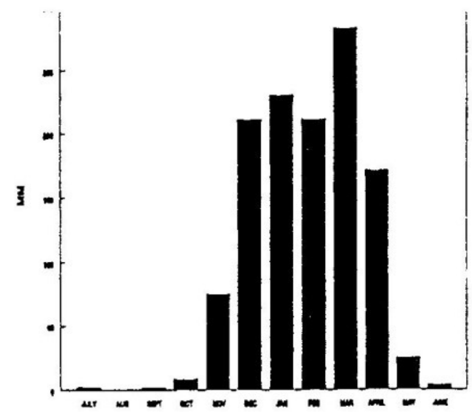

Fig. 3 Distribution of rainfall in the study area.

Climate

The climate of the Matengo highlands can be described as being temperate to cool tropical. The annual average temperature is 23 °C with a maximum of 30 °C and a minimum of 13 °C in the highlands. The rainfall pattern is unimodal with an average annual amount ranging from 900 mm to 1200 mm. The main wet season

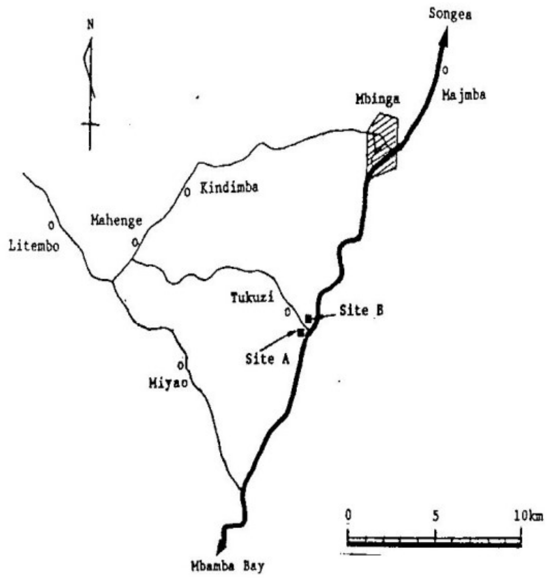

Fig. 4 Location of experimental sites at Tukuzi (sites A and B) and Mahenge villages.

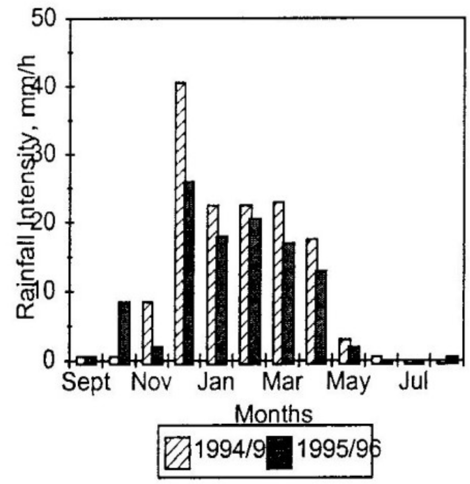

Fig. 5 Distribution of maximum intensity for 1994/95 and 1995/96 seasons at Tukuzi.

extends from December to April. The monthly distribution of rainfall is shown in Fig. 3.

Runoff plots and equipment

At Tukuzi, runoff plots (22.1 m by 5.0 m) were established at two sites with differing slopes (8.9° for site A and 20.5° for site B, Fig. 4). At the downslope end of each runoff plot, a sedimentation tank, equipped with water level recorder and V-notch weir, were installed. Three conservation measures were tested at both sites: ridges, ngoro and flat cultivation (bare plot) each of which was grown with maize except the bare plot. From these experiments runoff hydrographs (from recording water level gauges and V-notch weirs), sediment in the tanks, plant nutrients in the sediment, rainfall intensities (from recording rainfall gauge) were determined.

However, at Mahenge only sediment collected from the plots of different conservation measures (including ridges, ngoro without grass, ngoro with grass, flat cultivation, contour ditches and bench terraces) was determined.

RESULTS AND DISCUSSION

Seasonal Soil loss at Tukuzi

Table 1 shows the effects of soil conservation practices and slope on seasonal soil loss by water erosion for two maize growing seasons, i.e. 1994/95 and 1995/96. Between the two growing seasons, the seasonal loss decreased significantly in all conservation practices except for the bare plot that appear to have increased in terms of the amount of soil eroded from sight B (Table 1). The bare plot soil loss increased from 55.7 tons/ha in 1994/95 to 80.6 tons/ha in 1995/96. The decrease of soil loss between the two seasons was due to the fact that rainfall was heavier in 1994/95 than in 1995/96 season (Fig. 5). However, the increase in soil loss from the bare plot of site B between these seasons was caused possibly by the steep slope that increased the scouring of soil from bare surface and the carrying capacity of runoff (increase of velocity).

At site A, ngoro gave the least soil loss in both seasons; i.e. 2.4 tons/ha and 1.2 tons/ha for 1994/95 and 1995/96, respectively. Ridges were also very effective in minimising soil loss with 7.3 and 3.0 tons/ha for the 1994/95 and 1995/96 seasons, respectively. The bare plot was the worst in terms of soil loss in both seasons (Table 1). For site B, again ngoro was the best in terms of soil conservation followed by ridges and worst of all, the bare plot (Table 1). The results also show the effects of slope on seasonal soil loss. When site A and B are compared (Table 1), one notes that site A (slope of 8.9°) lost less soil loss than site B (slope of 20.5°) with similar soil conservation, ngoro or ridge cultivation. Inevitably, bare plots were more catastrophic in terms of soil loss from steep than from gentle slopes. These results confirm the superiority of traditional ngoro farming system in controlling soil erosion by water as perceived by farmers inMbinga.

Table 1: Effects of conservation practices and slope on seasonal soil loss for the two seasons (1994/95 and 1995/96) at Tukuzi, Mbinga District.

Si te	Slope (deg.)	Conserv ation Practice	Soil loss ton/ha 1994/95	Soil loss tons/ha 1995/96
A	8.9	Bare	39.0	38.6
		Ridge	7.3	3.0
		Ngoro	2.4	1.2
B	20.8	Bare	55.7	80.6
		Ridge	14.3	10.6
		Ngoro	5.8	1.4

Table 2: Effects of conservation practices on Seasonal soil loss at Mahenge, Mbinga District

Conservation practices	**Soil loss, tons/ha**
Ridges	15.8
Ngoro without grass	4.5
Ngoro with grass	·2.3
Flat cultivation	83.2
Contour ditches	9.5
Bench terraces	2.4

Table 2 shows the effects of conservation practices (measures) on seasonal loss of soil at Mahenge experimental site during the 1995/96 season. Bench terraces and ngoro with grass (standard ngoro) gave similar seasonal soil loss (2.4 and 2.3 tons/ha, respectively). Flat cultivation had the highest seasonal soil loss (83.2 tons/ha) followed by ridges (15.8 tons/ha). Ngoro without grass gave higher soil loss (4.5 tons/ha) than standard ngoro (2.3 tons/ha). Thus, grass has marked effect on the strength of the ngoro and minimises soil loss by water. The grass acts both as drains and as agents accelerating infiltration of water into the ground.

The results from the Mahenge plots also have shown that bench terraces would be as effective as ngoro with grass in the control of soil erosion by water. Since ngoro may require more labour [2] than most of the other systems of conservation measures in the long run [[5], terraces could be considered superior to ngoro in the Matengo highlands. Emphasis could be put on constructing bench terraces where feasible to minimise seasonal drudgery in land preparation among farmers in Mbinga.

Nutrient Loss

Table 3 shows that the sediment from the ngoro plots at both sites was richer in nutrients than from the other conservation practice (ridge) as shown by the higher values of available phosphorus (P), total nitrogen (N), organic carbon (OC) and exchangeable bases (statistical analysis was not done). This is probably due to the rapid movement of these nutrients into drains made up of the buried grass and plant residues in ngoro. The pH of the sediment was also high probably due to the high content of calcium (Ca) from the plots. These elements lost to the surface runoff decrease the productivity of farms and also pollute the surface water of streams and rivers. Also phosphorus and nitrogen contents contribute to the eutrophication of streams and lakes which affect the aquatic life.

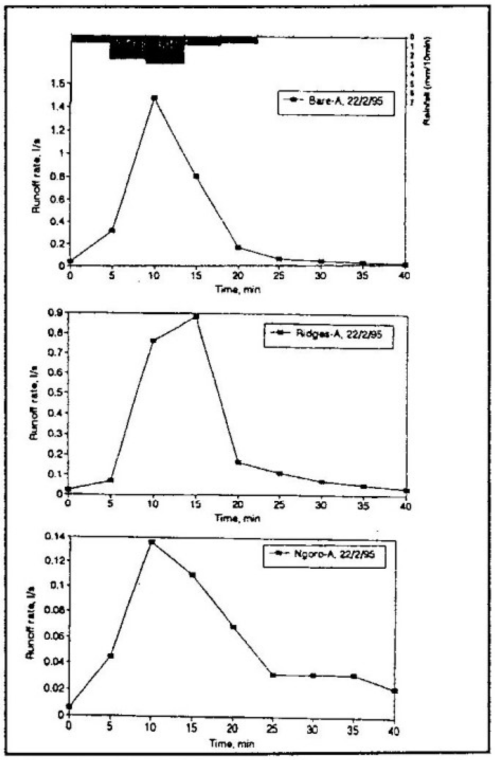

Fig. 6a Rainfall-runoff relationships at Site A.

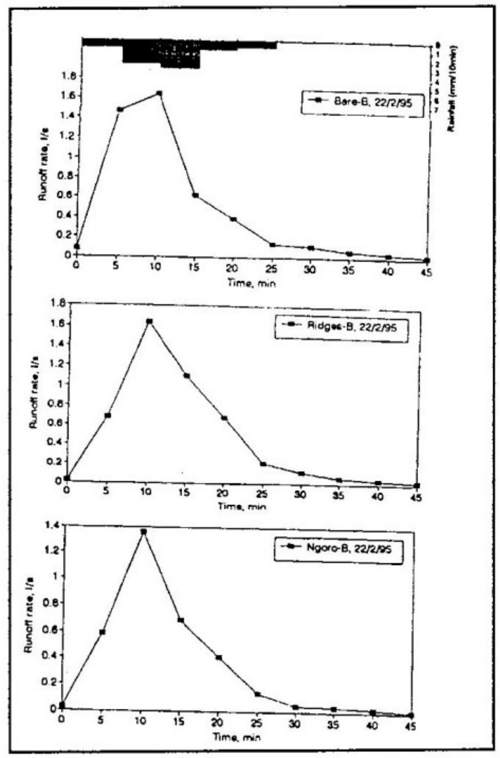

Fig. 6b Rainfall-runoff relationships at Site B.

Runoff rate

The hydrographs derived from runoff rates showed variations in magnitude caused by the effects of conservation practices and slope on runoff rate (Fig. 6a and 6b) . For the same site (site A, slope 8.9° for example) ngoro gave the lowest peak of hydrographs (0.14 l/s) followed by ridges (0.9 l/s). The bare plot, however, gave the highest peak (1.5 l/s). Regarding the effect of slope on runoff rate, the peak of hydrograph was higher on a steep slope (site B, 20.5°) than gentle slope (site A, 8.9°). The hydrographs correlated closely with the results of the soil loss from conservation practices and slope since runoff rate increases the scouring action on the soil surface (rills) and the transporting capacity of surface runoff.

CONCLUSIONS AND RECOMMENDATIONS

The ngoro farming system is an effective soil erosion control practice in both steep and gentle slopes. Some of the sediment collected from ngoro had high nutrient concentrations possibly because of the availability of more nutrients resulting from decomposition of grass bundles buried in the soil. However, more studies are required to confirm the current observations.

In terms of preventing soil erosion from the land, ngoro (of any size) and bench terraces were similarly effective. Overall contour ditches were also effective when compared with either ridges or flat cultivation. Therefore, on steep slopes ngoro should be combined with contour ditches to effectively control soil and nutrient losses.

Table 3 Chemical properties of eroded sediment at Tukuzi for site A and B

Site A

Treatment	pH H_2O	N (%)	OC %)	Available P (mg/kg)	CEC me/ 100g	Na me/100g	K me/ 100 g	Ca me/ 100 g	Mg me/ 100 g
Bare	6.3	0.32	4.0	2.28	5.4	0.009	0.04	0.53	0.13
Ridge	6.4	0.29	3.5	2.46	6.4	0.011	0.04	0.77	0.10
Ngoro	7.6	0.34	3.7	0.53	5.4	0.012	0.06	2.33	0.16

Site B

Treatment	pH H_2O	N (%)	OC (%)	Available P (mg/kg)	CEC (me/100 g)	Na (me/100 g)	K (me/100g)	Ca (me/ 100 g	Mg (me/ 100 g
Bare	5.6	0.35	3.9	2.28	5.0	0.008	0.025	1.41	0.23
Ridge	6.3	0.37	4.2	2.11	6.6	0.010	0.029	1.01	0.16
Ngoro	7.0	0.40	4.5	2.28	6.6	0.016	0.047	0.05	0.30

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