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Assessment of soil erosion and soil conservation practices in Angereb watershed, Ethiopia: technological and land user context

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Introduction

Increased pressure on land use of the hill slopes since the 1970s has resulted in degradation in the highlands of Ethiopia where agriculture is based on small scale cereal production. A large number of studies in the highlands of Ethiopia have been carried out on the causes of environmental degradation, and technical remedial actions have been proposed (Hurni, 1984; Herwege and Lude, 1999; Weldeamlak and Sterk, 2002; Tesfay, 2003; Mitiku, et al, 2006). Soil erosion in association with inappropriate land management practices is one of the main factors causing degradation. Poor land and water management practices and lack of effective planning and implementation approaches for soil conservation are responsible for accelerating degradation on agricultural lands and siltation of lakes and reservoirs downstream. For decades, soil conservation programs in the highlands of Ethiopia were premised on the notion that farmers did not perceive erosion and had little or no interest in combating it. Most soil and water conservation planning approaches rely on empirical assessment methods by experts and hardly consider farmers' knowledge of soil erosion. Conservation programs relied on coercive approaches and performed poorly (Yohannes and Herweg, 2000). Failure to balance land management interventions with the current level of land degradation is still a growing challenge to small-holder farmers on the hillslopes to meet both immediate economic objectives and sustainable environment.

Angereb watershed has experienced visible symptoms of land degradation in the form of soil erosion and sedimentation of Angereb reservoir. Since it is located in the interface between rural and urban areas the issue of watershed management is difficult due to different community interests and diverse environmental factors. Designing an integrated development plan using adaptable approaches as part of a sustainable solution to the ever-increasing burden of reservoir sedimentation, and minimize the pollution and contamination of the water supply to ensure the sustainability of the water supply is thus became an urgent need. This paper therefore investigates the performance of earlier introduced conservation stone terraces and the soil erosion using local indicators and their cause-effect relationship from both technological and land users point of view in order to identify effective erosion control strategies for the watershed.

Materials and methods

The study area Angereb watershed is located north of Lake Tana basin, near to Gonder town. The study was conducted during July to August 2008 at Angereb watershed on 58 farm plots from three selected case-study catchments in the upper part of the watershed. Assessment of the existing stone terraces would give the opportunity to identify the limitations and provide hint for improvements of conservation measures. For this reason the layout and design characteristics of the terraces were collected for all terraces on 58 field plots. Length, width, height, spacing between terraces, and number of terraces per individual farmer plot were collected. These terrace characteristic values were compared and evaluated against the terrace implementation guideline of Hurni (1986). Individual and group field visits and farmers' discussion were carried out periodically for all field plots in order to identify and measure local erosion indicators. Farmers' awareness and knowledge of erosion indicators were evaluated.

Results and discussion

Performance of stone terraces

Storage capacity of terraces: According to farmers' response the storage area of the terraces were filled up within estimated 2-4 years after construction. Out of the surveyed fields during 2008, only 10 % has stored sediment behind the terraces. In most of the surveyed fields a clearly defined terrace storage area was not observed.

Terrace cross-section: Assessments in the riser height and top width of terraces have shown that the existing terraces will not be more effective unless immediate improvements should be taken. Due to the reason that the foot of the terrace was tilled every season, the terraces were collapsed on most of the sampled fields. The height of terraces from the ground surface exceeded more than 50 % of the height during establishment. According to the guideline (Hurni, 1986) the design height was exceeded due to tillage underneath the terrace. Existing width of terraces was about 50-70 % of the minimum design specification (i.e, 100 cm).

Terrace spacing: In principle, the spacing should decrease when slope gradient increases. However, terraces implemented by the farmers have shown increased trend of vertical interval for steeper slopes. The spacing between existing terraces was between 5 and 25 m with an average of 14 m. In addition to the damaged and instable terrace structures such wide spacing has caused greater runoff concentration that led to excessive erosion. The combined effect of unstable terrace cross section and larger spacing has reduced its effectiveness and efficiency to enhance crop production on terraced agricultural lands.

Comparison of terrace dimensions with design specifications

The implementation guideline (Hurni, 1986) provides general layout and design specifications. In the guideline, relationship of soil depth and terrace spacing for slope gradients greater than 15 % was established. Terrace spacing was determined multiplying the soil depth by 2.5. On steep slopes where the soil depth was in the range of 5 to 70 cm, the calculated spacing between terraces was found between 2 and 8 m (Fig. 2). The calculated spacing was greater than the existing spacing (5-25 m). During the field visits some farmers have discussed and indicated a critical terrace spacing not less than 5 m. However, according to the guideline 5 m terrace spacing was only applicable for all cultivated slopes with soil depth above 1 m; or for slopes less than 35 % the soil depth must be greater than 0.75 m (Fig. 2). Given the soil depth for the majority of the cultivated lands is shallow (up to 30 cm), there will be a limitation of agricultural production unless farmers agree to construct terraces with narrow spacing and/or to change their cereal crop production system.

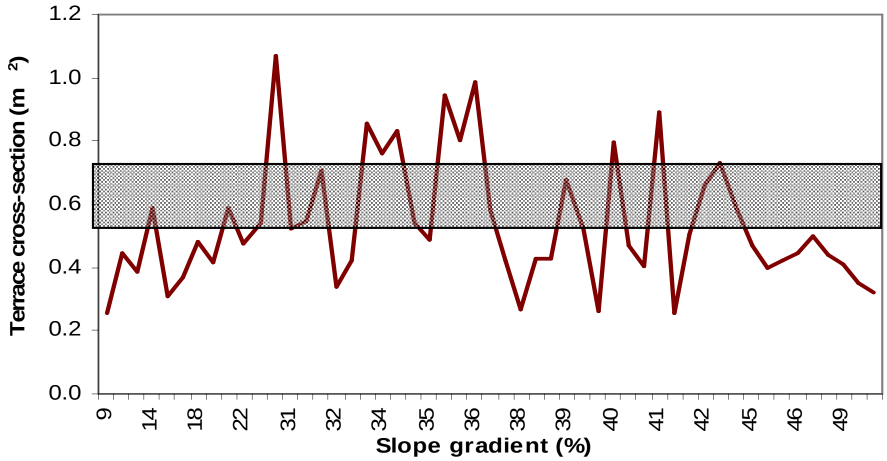

Fig. 1 Measured terrace cross-section in relation to the design specification (shaded part)

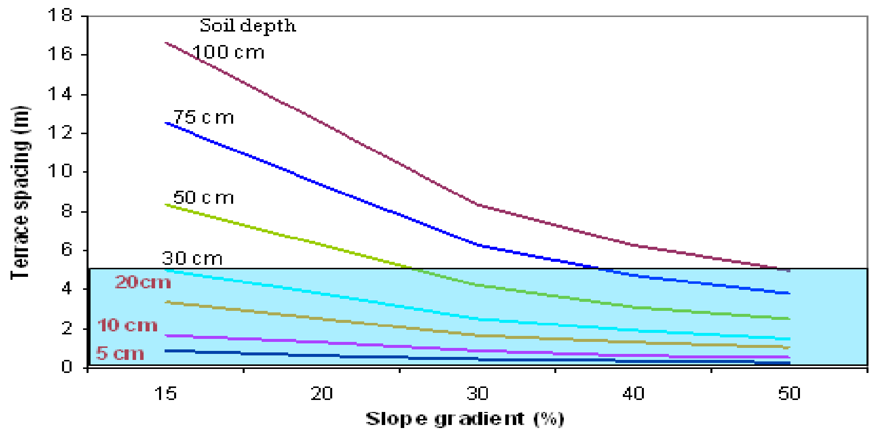

Fig. 2 Unacceptable range of terrace spacing (shaded range) from farmers' perspective

Assessment of local soil erosion

Farmers recognize that erosion results in yield losses but also anticipate yield increase due to introduction of conservation measures. Some farmers may have deliberately over-estimate erosion, possibly because they hoped it would enable them to participate in some subsidized conservation program. However, quantitative measurement of erosion using local indicators (Fig. 3) show that while farmers are aware of highly visible gully erosion, they are less aware of more dangerous sheet erosion, rill erosion, and tillage erosion indicating that the farmers considered the rills to be small, not large. They do not notice the long term consequences of the seasonal erosion processes. Those indicators such as gullies, land sliding, yield reduction, flooding, soil depletion, etc., were easily realized by farmers but these are costly and beyond their capacity to control. In addition to the common indicators, historical development of erosion was explained by the change in soil surface level around trees and big stones, traditional bunds left inside cultivated plots, and tillage erosion apparently observed underneath the terraces. Focusing to control the short term indicators through developing farmers' awareness is more economical and feasible than controlling long term indicators by external support (Fig. 4).

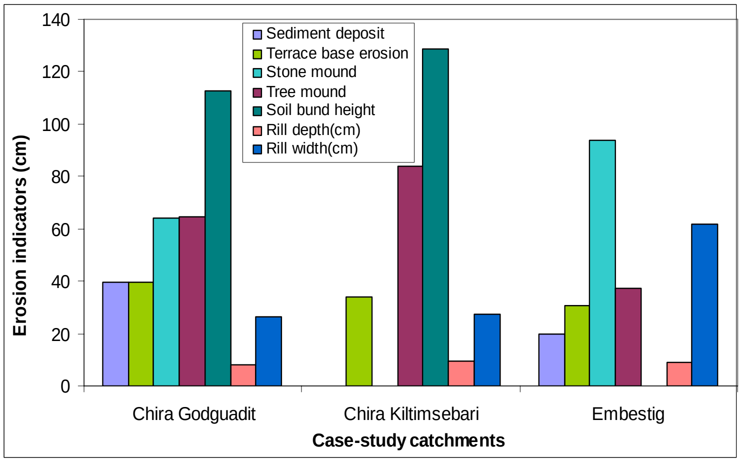

Fig. 3. Farmers assessment of erosion on field plots using local indicators

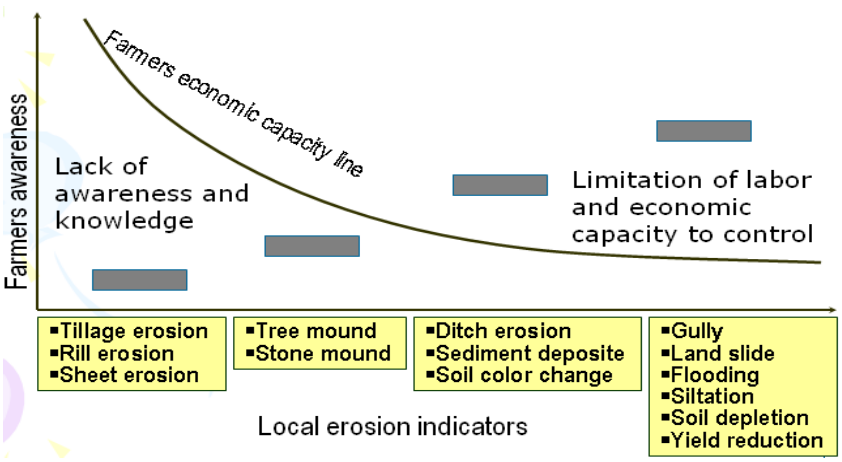

Fig. 4 Farmers awareness of erosion indicators

Conclusion

Unstable and fragmented terrace layout and wide terrace spacing were the common causes for erosion damage within the plot and adjacent fields. The low efficiency of stone terraces to control erosion brings about 10 to 46 % biomass yield reduction on top terrace area compared to bottom position. Farmers' local erosion indicators show that they do not give necessary attention to ecological sustainability. Nonetheless, further field based assessments and discussions and knowledge sharing approach with farmers will be necessary to set the design and spacing of terraces and to choose best practices for effective erosion control.

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