Field experimental assessment of soil erosion processes at different scales in Gumara-Maksegnit watershed, Lake Tana Basin

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Introduction

Rainfall-driven soil erosion and consequential land degradation are among the major threats of the mountainous landscape of Lake Tana Basin. In the course of a bilaterally funded project led by the International Center for Agricultural Research in the Dry Areas (ICARDA) an integrated watershed assessment has been undertaken in Gumara-Maksegnit watershed (Figure 1) to 1) allocate the 'hot-spots' of land degradation and to 2) investigate combined bio-physical and socioeconomic measures to counteract ongoing depletion of agricultural areas and to improve rural livelihood (Ziadat and Bayu, 2015).

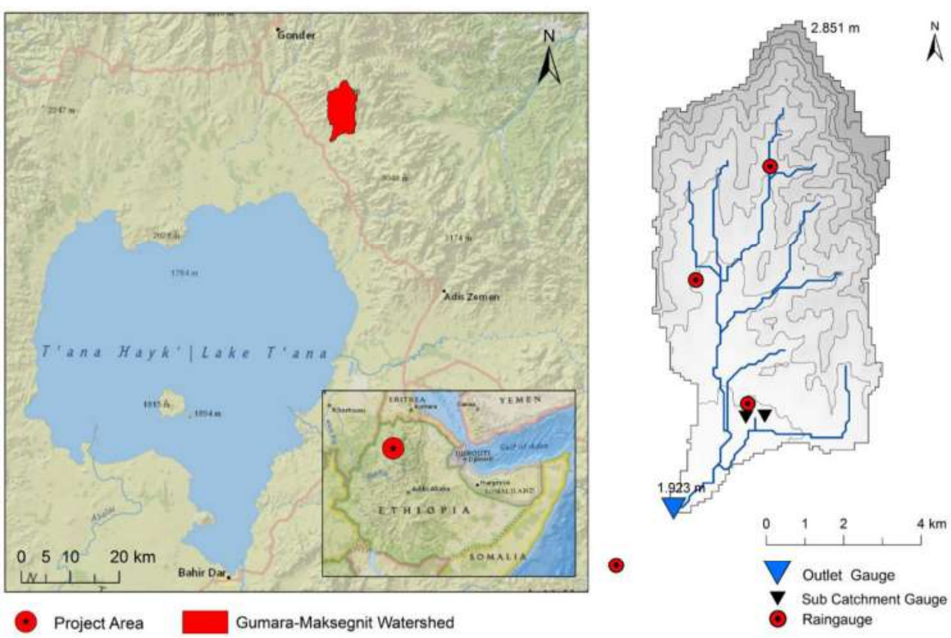

Figure 1. Location of the Gumara-Maksegnit watershed (left side) and the watershed topography, rain gauges and outlets (right side).

Watershed modeling considering Suitable Land Management (SLM) practices and Soil and Water Conservation (SWC) measures such as stone bunds (Figure 2) has been performed using the Soil and Water Assessment Tool (Neitsch et al., 2009; Addis et al., 2013). Proper simulation of SLM and SWC techniques requires detailed process understanding at different scales. For stone bund SWC assessment, two sub-catchments have been selected to compare treated and untreated landscape conditions. At the same time, plot and hill slope scale experiments were conducted to evaluate the impact of stone bunds on surface runoff and sediment yield at the field level. In the frame of the TropiLakes conference excursion, both sub-catchment monitoring and field level SWC experiments will be presented.

Figure 2. A stone bund located in the treated sub-catchment (Ayaye) of Gumara-Maksegnit watershed.

Materials and Methods

The 54 km^2 large Gumara-Maksegnit watershed and the location of the approximately 35 ha large sub-catchments are presented in Figure 1 (right side). The two neighboring sub-catchments 'Ayaye' (treated) and 'Aba Kaloye' (untreated) characterized by comparable topography, soil and land use condition were used to verify different SWC interventions (mainly stone bunds). Both sub-catchments have been monitored since 2010 using similar techniques observing runoff and sediment concentration. At the plot level, two stone bund experiments (Figure 3; Treated plot), and two untreated control erosion plots (Figure 3; Untreated plot), as well as one hill slope level cascade plot (Figure 3; Treated plot – in down-hill cumulative setting (three plots)) were installed in 2015. To strengthen the quantitative results obtained from plot monitoring, tracer experiments were set up to monitor the different pathways of the eroded soils (Strohmeier et al., 2015). Figure 4 shows the tracer stripes installed at the cumulative hill slope plots in 2015 - this topic will be presented at the conference.

The plots are 20 m long (Figure 3) in line with the local stone bund spacing. Total runoff suspension of the plot is collected by a pipe at the outlet, routing the runoff to a sample divider and further to a collection pond. The untreated runoff plots (Figure 3) monitor the unaffected erosion response on rainfall. On the contrary, the treated plots were set up with two collection pipes – one below the stone bund collecting excess runoff over spilling or leaching through the stone bund and a second 'side-pipe', located at a 2 m side-trunk of the plot, collecting excess runoff routed along the slightly inclined bund. Thus, water and sediment retention/routing capacity of stone bunds can be assessed through balancing the different flows. Certainly, experimental interferences and accumulative hill slope processes need to be considered.

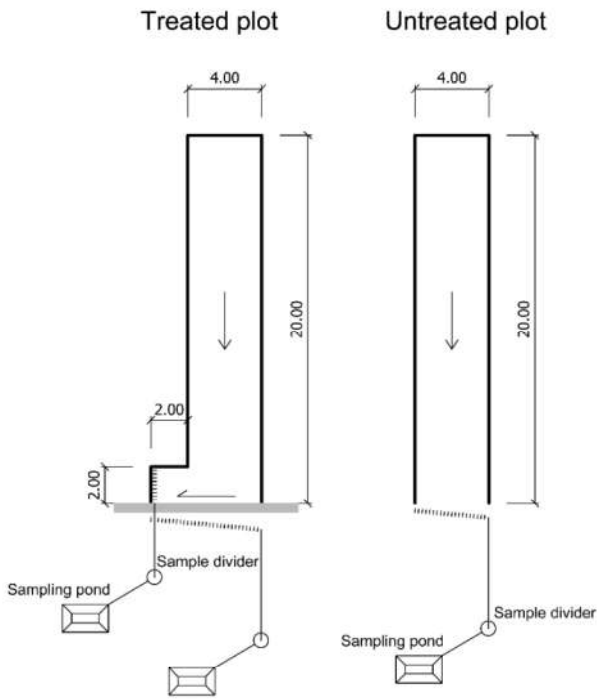

Figure 3. Sketch of treated and the untreated erosion plots (unit: meter). The cumulative hill slope plot consists of three accumulative treated plots.

Figure 4. Overview of the erosion site (top image), and the tracer experiment (colored tracer stripe (iron oxides)) carried out at the cumulative hill slope plot (bottom image).

Results and Discussion

Sub-catchment level – runoff and sediment yield at the outlets

Different seasons including wet and dry years have been observed in both sub-catchment. The corresponding data (daily runoff and sediment yield) were used for calibration and validation of the sub-watershed model (Schiffer et al., 2015) also presented at the TropiLakes conference. Figure 5 indicates runoff and sediment yield dynamics of selected events recorded in July 2012. The data shows an overall trend of stronger runoff and erosion response of the untreated sub-catchment. During the monitoring period approximately 45 % more runoff was observed at Aba Kaloye gauging station compared to Ayaye. Also the observed sediment yield at Aba Kaloye outlet seems larger (around 15 %). Considering comparable sub-catchment conditions, these values may give an idea about sub-catchment scale SWC effects.

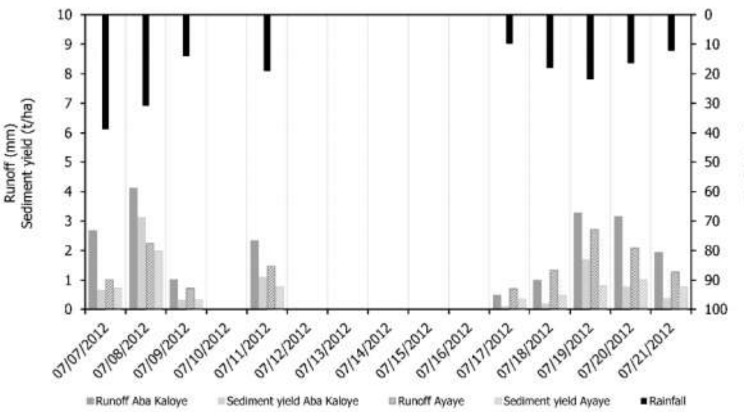

Figure 5. Runoff and sediment yield recorded at Ayaye (treated) and Aba Kaloye (untreated) sub-catchment in July 2012.

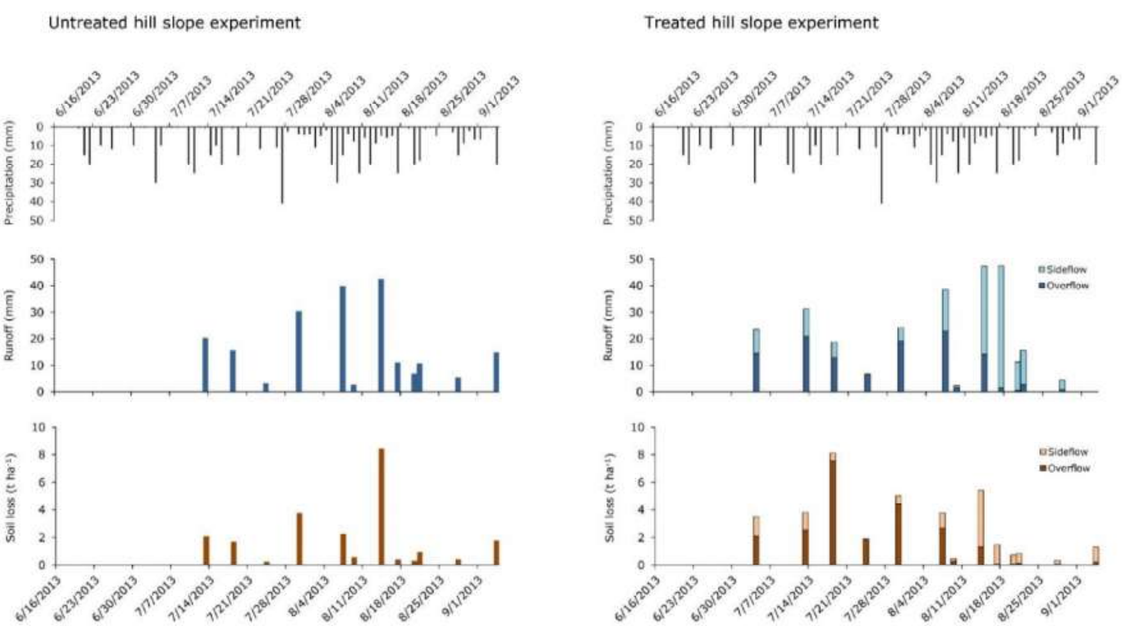

Figure 6. Rainfall, runoff and sediment yield recorded at untreated and treated erosion plots in 2013.

Field level - runoff and sediment yield from the plots

Preliminary results of 2015 field experimental campaign will be presented at the conference. However, pilot study results of at treated and untreated plots in 2013 (Rieder et al., 2014) are shown in Figure 6. Direct comparison of the side- and overflow may allow backdraws concerning plot level optimized SWC effects of stone bunds. Based on 2013 observations, down-hill directed runoff was reduced by approximately 60 %, while sediment yield was reduced by approximately 40 %.

Conclusions

The assessment of widely applied stone bund SWC intervention at sub-catchment, hill slope and plot level provide insight into scale dependent stone bund SWC effects as a required input for watershed modeling. As a future goal, advanced field experimental results of the erosion monitoring campaign conducted in 2015 will be transferred into model understandable 'language' for uptake and out scaling.

References

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