Land use effects sediment dynamics in the headwaters of a tropical montane forest in Western Kenya

Jaqueline Stenfert Kroese[1,2], Suzanne Jacobs[2,4], Lutz Breuer[3,4], John Quinton[1] and Mariana Rufino[1]

[1] Lancaster Environment Centre, Lancaster University, Lancaster, United Kingdom (J.Stenfertkroese@lancaster.ac.uk)

[2] Centre for International Forestry Research (CIFOR), Nairobi, Kenya

[3] Institute for Landscape Ecology and Resources Management (ILR), Justus Liebig University, Giessen, Germany

[4] Centre for International Development and Environmental Research (ZEU), Justus Liebig University, Giessen, Germany

1 Introduction

East African streams are often characterized by high suspended sediment concentrations. This is a major threat to communities using the water resources in their daily lives and to the wider economy. Land use changes and conversion natural vegetation to croplands is a major contributor to water resource degradation through suspended sediments. However, the availability of sediment yield data is severely limited.

- Within Kenya, there are only a few studies about the **effect of land use changes on suspended sediments** at catchment-scale.
- In addition, there is **lack of empirical evidence** on **annual suspended sediment yields** of headwater catchments of Lake Victoria.

The Mau Forest Complex is the largest remaining montane forest block in Kenya. However, over the last few decades, one quarter of the indigenous montane forest has been lost mainly due to the conversion to smallholder and commercial agriculture. The monitored streams are tributaries of the Sondu River that drains into the highly turbid Lake Victoria.

The **aim of this study** is to analyse sediment dynamics under three dominant land uses: smallholder agriculture (SHA), tea and tree plantation (TTP) and natural forest (NF) in the headwaters of the Sondu River Basin.

2 Study area

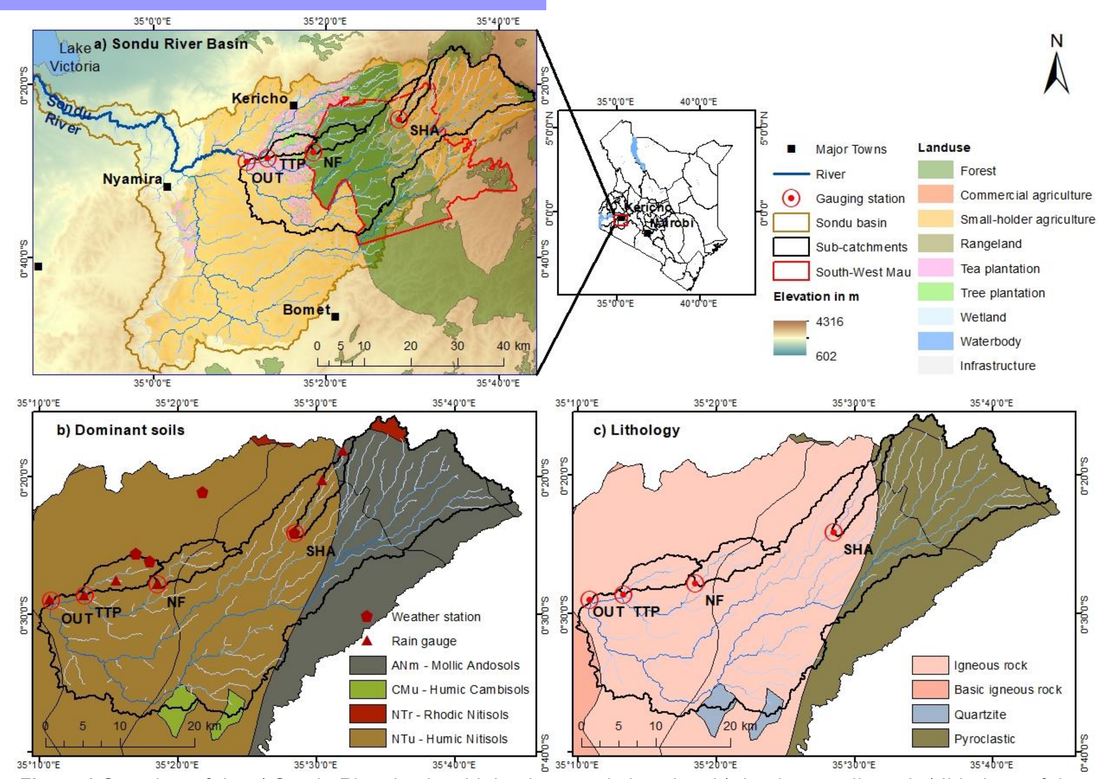

Figure 1 Overview of the a) Sondu River basin with land use and elevation, b) dominant soils and c) lithology of the three catchments: tea/ tree plantation (TTP), natural forest (NF) and the smallholder agriculture (SHA) within the main catchment (OUT)

3 Temporal variation of TSS

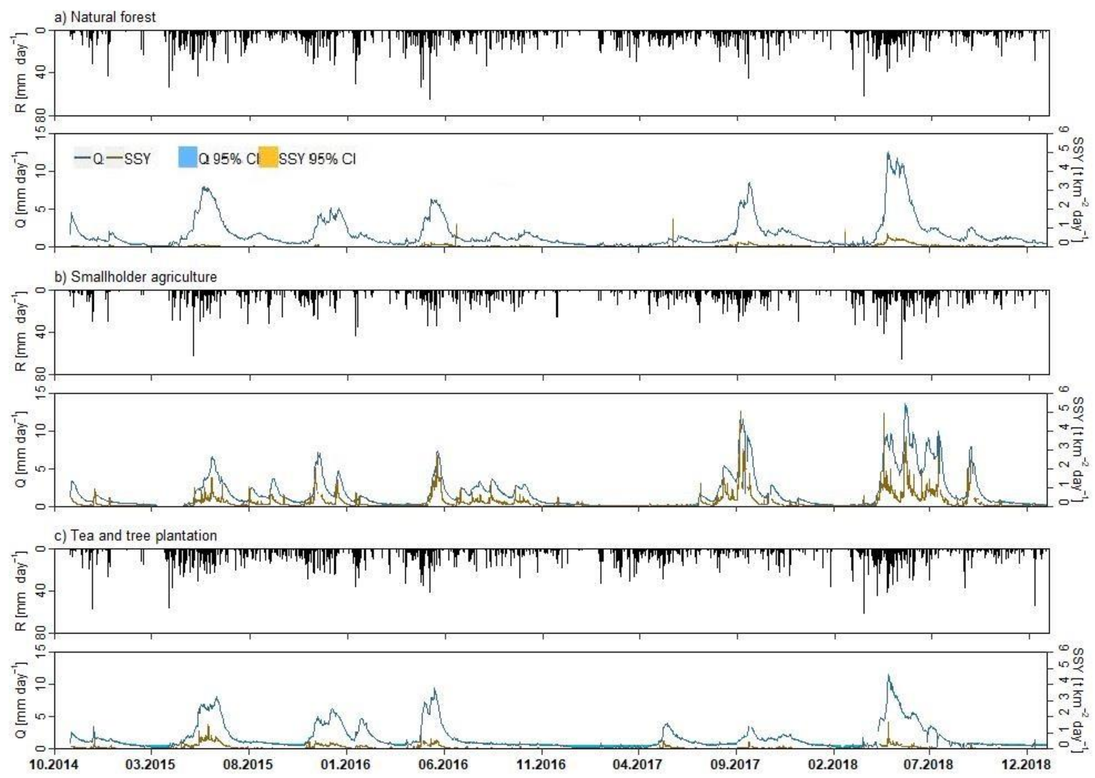

Figure 2 Accumulated rainfall (R) [mm day^{-1}], specific discharge (Q) [mm day^{-1}] and suspended sediment yield (SSY) [t km^{-2} day^{-1}] time series of the a) natural forest, b) smallholder agriculture and c) tea/ tree plantation catchment in the South West Mau, Kenya between 10.2014 and 12.2018

Each of the three catchments (27-35 km^2) are equipped with an automated measurement network monitoring hydrological and sedimentological data (Figure 1). Continious turbidity (spectro::lyser sensor) and water level (VEGAPULS WL61) measurements are taken at 10 minute intervals. Three weather stations are installed in each catchment with an additional six tipping bucket rain gauges distributed in the catchments. A site-specific turbidity-sediment rating curve was established to relate turbidity to suspended sediment concentration [mg L^{-1}].

Suspended sediment yield reflects the seasonality in specific discharge and rainfall (Figure 2). Seasonal SSY is significantly higher in the smallholder agriculture than the natural forest and the tea/ tree plantation during the long rains and moderate rains ($p<0.001$). SSY of the long rains is significantly higher compared to the other four existing seasons within the natural forest and the smallholder agriculture (Figure 3).

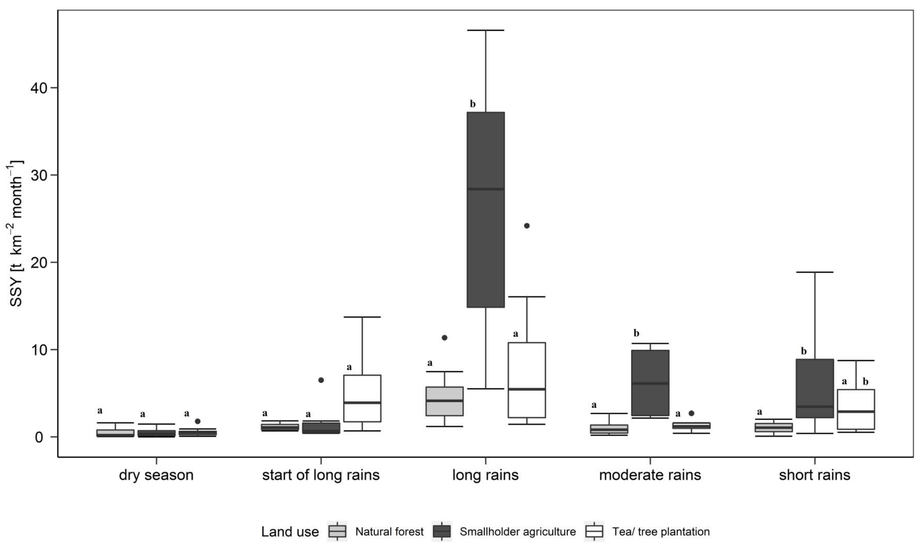

Figure 3 Seasonal monthly SSY [t km^{-2} month^{-1}] of the natural forest, smallholder agriculture and tea/ tree plantation catchment in the South-West Mau, Kenya between 10.2014 and 12.2018 (different letters above land uses in the box plot indicate a significantly different mean within each season ($p<0.05$))

4 Spatial variation of TSS

The average of total annual SSY is significantly higher in the smallholder agriculture catchment (106 t km^{-2} year^{-1}) compared to the annual yield of the tea/ tree plantation catchment (41 t km^{-2} year^{-1}) and the natural forest catchment (20 t km^{-2} year^{-1}) ($p<0.001$) (Figure 4).

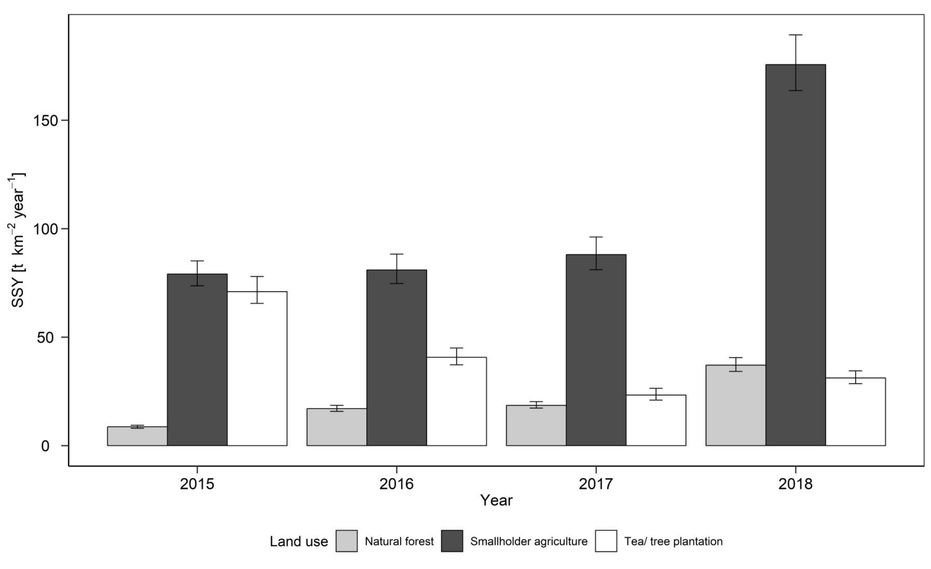

Figure 4 Annual suspended sediment yield (SSY) [t km^{-2} year^{-1}] of the natural forest, smallholder agriculture and tea/ tree plantation catchment in the South-West Mau, Kenya between 2015 and 2018 (error bar represents 95% confidence interval)

5 Conclusion and future work

- Land use effects suspended sediment yield.
- The annual suspended sediment yield in the:
  - Smallholder agriculture catchment is fivefold the natural forest catchment
  - and three times that of the tea/ tree plantation catchment
- An intact natural ecosystem such as the Mau Forest Complex protects the soil from soil erosion, traps sediment and reduces suspended sediment contribution to the stream network.
- Suspended sediment follows the seasonality in discharge and rainfall patterns.
- The long rainy season contributes the greatest proportion (45%, 51% and 65%) of total suspended sediment yield throughout the year (tea/ tree plantation, natural forest and smallholder agriculture, respectively).

Future work within the smallholder agriculture catchment:

A **sediment source fingerprinting** will point out the complexity of soil erosion with different land use, unpaved tracks, stream channel banks and gullies as potential sediment sources.

Lancaster Environment Centre | Lancaster University | Justus-Liebig-Universität Giessen | CIFOR | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH | BMZ Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung