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Research Application Summary

Soil and water conservation practices and soil erosion intensity in the Lake Kivu Basin, Democratic Republic of Congo

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Abstract

This study was carried out with the following objectives (i) to identify existing soil and water conservation practices, and (ii) develop a soil erosion hazard model for the Lake Kivu basin. The identification of existing soil and water conservation practices was done through cross-sectional household survey, key-informants interviews and focus group discussions. Soil erosion hazard map was developed using the calibrated RUSLE model. The model was calibrated using runoff plot experimental data. The major soil and water conservation practices in the Lake Kivu included: mulch under banana, agroforestry, contour bunds, *Tithonia* and *Tripsacum* under annuals. Soil loss is moderate with severe to extreme levels observed around the highland slopes and in the southern part of the City of Bukavu. There is need to intensify sustainable soil and water conservation practices to further reduce soil loss in the area.

Key words: Conservation practices, DR Congo, land degradation, Lake Kivu Basin

Résumé

La présente étude a été conduite pour (i) identifier les pratiques de conservation du sol et de l'eau, et (ii) développer un modèle de risque d'érosion des sols pour le bassin du lac Kivu. L'identification des pratiques de conservation du sol et de l'eau a été faite à travers une enquête auprès des ménages, des entretiens avec des personnes ressources clés et des discussions de groupe. Une carte de risque d'érosion des sols a été développée en utilisant le modèle RUSLE. Ce modèle a été calibré en utilisant des données expérimentales de tracé d'écoulement. Les principales pratiques de conservation du sol et de l'eau dans le bassin du lac Kivu étaient: le paillis sous les bananaraies, l'agroforesterie, les digues de contour, *Tithonia* et *Tripsacum* sous les plantes annuelles. La perte de sol était modérée avec des niveaux sévères aux niveaux extrêmes observés autour des pentes des hautes terres et au sud de la ville de Bukavu. Il est donc nécessaire d'intensifier les pratiques

durables de conservation des sols et de l'eau pour réduire davantage la perte de sol dans la région.

Mots clés: Pratiques de conservation, RDC, dégradation des terres, bassin du lac Kivu

Background

Soil erosion is one of the key land degradation processes observed in the Lake Kivu basin. This region is covered by mountainous terrain with steep slopes that are continuously cultivated yet with a high rainfall regime (Majaliwa *et al*., 2009). Owing to soil loss from the Kivu mountain region, pollution loading into Lake Kivu has been observed. The Lake has also reportedly high concentrations of CH_4 and CO_2 which can lead to increased instability of the Lake (Cohen *et al*., 1993; 1996). Lake Kivu is critical for the survival of millions of people around the basin and beyond (Alin *et al*., 2002). The lake and the entire basin is a biodiversity hotspot area and a crtical component in the supply of protein and income for surrounding communities (Halbwachs *et al*., 2002). Despite the assertion that soil erosion is a major cause of land degradation in Kivu mountain region, limited studies have been conducted in the region to determine its magnitude and evaluate practices the communities use for its control. This constituted the focus of the current study.

Literature review

Soil loss studies in the eastern and southern Africa is limited to that which is mainly focused on scale, land use types, as well as onsite and offsite impacts which is limited in scope and regional scale. This pattern is attributed to a lack of technical expertise, equipment and resources (Morgan, 1986; Duma and Monde, 2000). Much of the literature in Africa is from eastern and western Africa notably in the studies of Majaliwa (1998), Rose and Dala (1988), Lufafa *et al*. (2003), Magunda and Majaliwa (2002).

Soil loss studies in eastern DRC focused on the gullies of the Bukavu region (Moyersons *et al*., 2004) with no traceable studies on soil erosion control. Azanga (2013) attempted some work on soil erosion measurement using catchment outlet without plot measurements. Despite the lack of extensive studies, it is apparent that soil erosion by water remains one of the major environmental problems in Eastern DRC (Majaliwa, 2012). A better understanding of soil erosion processes, factors governing them, and its relationship with on site and off site degradative processes is key to its control and sustainability of both land and water resources (Majaliwa, 2004). The aim of this study was therefore to identify existing soil and water conservation practices and develop a soil erosion hazard model for the Lake Kivu basin.

Description of the study

This study was conducted in three territories; Bunyakiri, Katana, Kabare and the City of Bukavu in the Lake Kivu Basin. Annual rainfall varies between 1134 mm and 1689 mm with an average of 1411 mm. The rainfall is bimodal with a dry season from June and July. The soil comprises of clay and rich volcanic soil, which is easily eroded. The geological composition is of Precambrian metamorphoses sediments (metamorphic rocks) and Preterozoic platform sediments. Verhaeghe (1964) described metamorphic limestone and numerous travertines along Lake Kivu and Lake Edward. Carbonates for the production of cement are also found north and north-west of Lake Kivu (Majaliwa *et al.*, 2012). A cross-section household survey involving 200 respondents and 10 key informants were was conducted to identify existing soil and water conservation practices in this part of the basin. Soil erosion hazard was generated using the Revised Universal Soil Loss Equation (RUSLE). It estimates annual erosion (tonnes/acre/year) resulting from interill/sheet and rill erosion attributed to rainfall and associated runoff on determined a landscape profile, using the following equation:

$$A = R * K * LS * C * P \quad \text{..........} \quad (1)$$

Where:

A = annual soil loss from sheet and rill erosion in tons/acre
R = rainfall erosivity factor
K = soil erodibility factor
LS = slope length and steepness factor
C = cover and management factor
P = support practice factor

Since there is no erosivity equation for eastern part of DRC two equations, that of Moore (1978) and Bols (1978) for East Africa and Indonesia, respectively, were adopted. An average of the two erosivity values was used for rainfall data of Bukavu and Kavumu. The Moore (1978) equation is given by the expression (2) below:

R = 0.029 (3.96P+3122)-26.......... 2

P being the annual rainfall amount (mm)

Bols (1978) recommended the use of Equation (3) below:

R = 2.5*P2/[100(0.078P + 0.78)].......... 3

Where R = rainfall erosivity (J m-2); and P = annual rainfall (mm).

The erodibility factor was determined using the nomograph. The slope length and steepness factor were generated from the segment map resulting from the SRTM Digital Elevation Model. Filtering operation (Dfdx and Dfdy) was performed to generate slope map. The slope map was then calculated from two gradient maps using equation (3)

Slope (%) = (hyp(Dx,Dy)/pixel size) * 100.......... 4

Since the RUSLE requires slope values in degrees, a slope map in degree was generated through map calculation operation with the expression;

Slope (deg) = raddeg (atan (Slope/100)).. 5

From literature it has been noted that the predictive capacity of RUSLE at slopes above 21% is poor (EI – Swaify *et al*., 1982). For slopes up to 21%, the original USLE formula for estimating slope length and slope steepness was used as follows:

LS<21 = (L/72.6)* (65.41sin(S) + sin (S) + 0.065) 6

Where,

LS = Slope length and slope steepness factor. L = Slope length (m), S = Slope steepness (radians)

While for slope steepness of 21% or more, the Gaudasasmita equation was used:
LS = (L/22.1)^0.7* (6.432*sin(S^0.79)*cos(S))...7

Where, L is the slope length (m), LS = Slope length and slope steepness factor. S = Slope steepness (radians). Through map calculation the slope length and slope steepness maps were combined by an "if" function to generate the LS factor map.

LS factor = f (slope<21, SL<21, SL<21).. 8

The land use map (2015) was used to generate a C-factor map using Morgan (1995) C-values. (Table 1).

Only potential soil loss was estimated, thus P-factor was assumed to be equivalent to 1. The soil erosion hazard map was then reclassified after calibration using soil loss measured in Lwiro (Adidja, 2014) and then reclassified using the classes in Table 2 (FAO, 1990).

Table 1. Derived C factor for land use types in the study area

Land use	C factor
Woodlot	0.001
Annual crops	0.7
Banana	0.05
Banana + Coffee	0.05
Coffee	0.07
Range	0.1
Forest	0.001
Swamp	0.001
Built up area	1.0

Results

The commonly used practices in the region include mulch under banana; agroforestry, contour bunds, *Tithonia* and *Tripsacum laxum* under annual crops (Fig. 1). The use of these practices is however not wide spread.

The soil loss and soil erosion hazard map for the three territories and the Bukavu City is shown in Figure 2. Soil loss varied from low to high (Fig. 3). The soil loss in the study area is moderate (20-50 t/ha/yr). It is highest around the chains of mountains cutting across the three territories and the southern part of the Bukavu City.

Table 2. Soil loss classes

Soil loss class	Range
Very low	0-2 t/ha/yr
Low	2-10 t/ha/yr
Moderate	10-50 t/ha/yr
High	50-90 t/ha/yr
Very high	>90 t/ha/yr

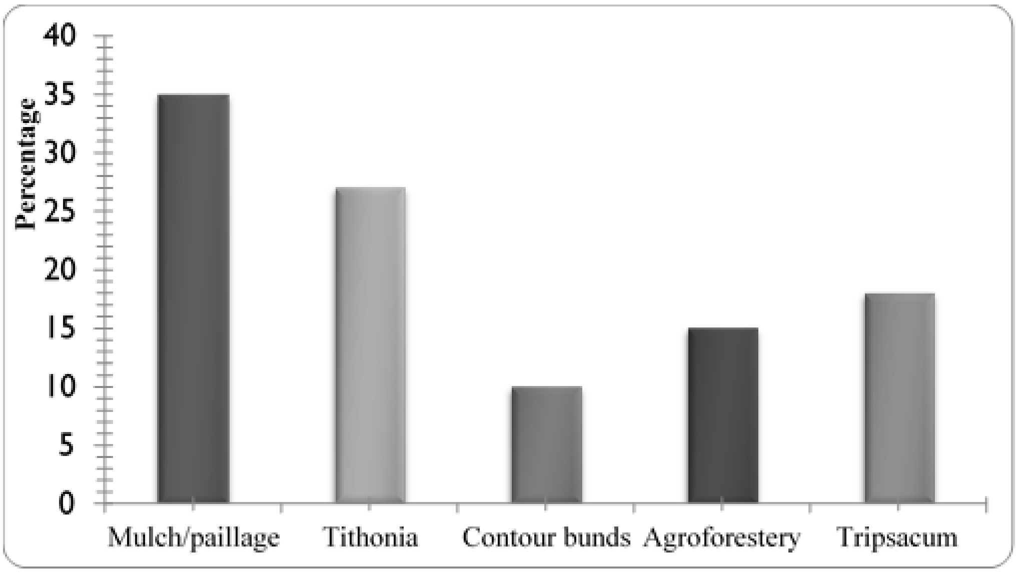

Figure 1. Existing soil and water conservation practices

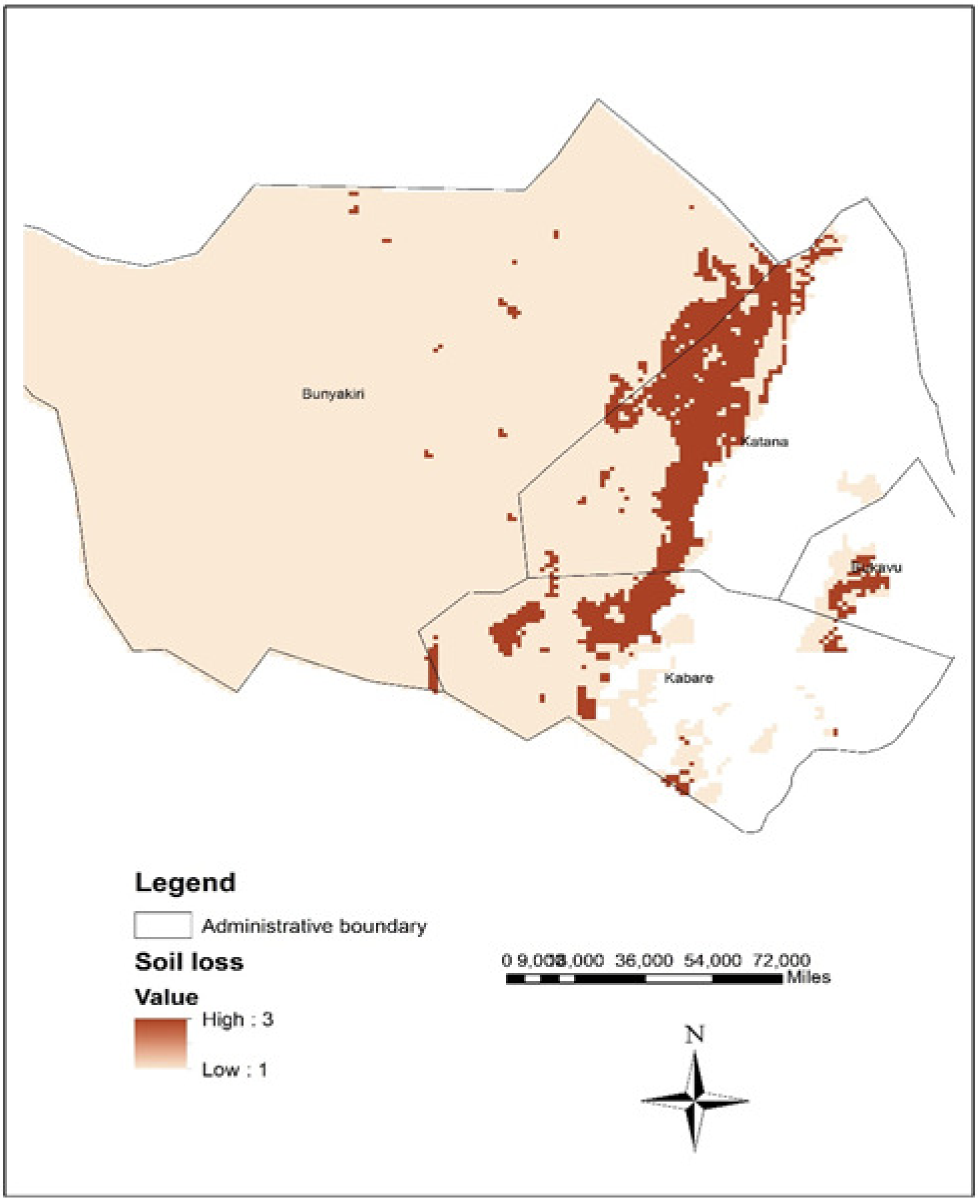

Figure 2. Soil erosion in the study area

Discussion

Soil and water conservation practices Lake Kivu basin. Communities in the Lwiro micro-catchment of Lake Kivu basin used contour bunds, mulch and *Tithonia*, *Tripsacum* and agroforestry for soil and water conservation measures. There was however a minimal number of households using one and/or a combination of these practices. This could be attributed to historical fact that the region has traditionally been fertile and was for centuries covered under dense tropical forests. As such there was no need to undertake specific

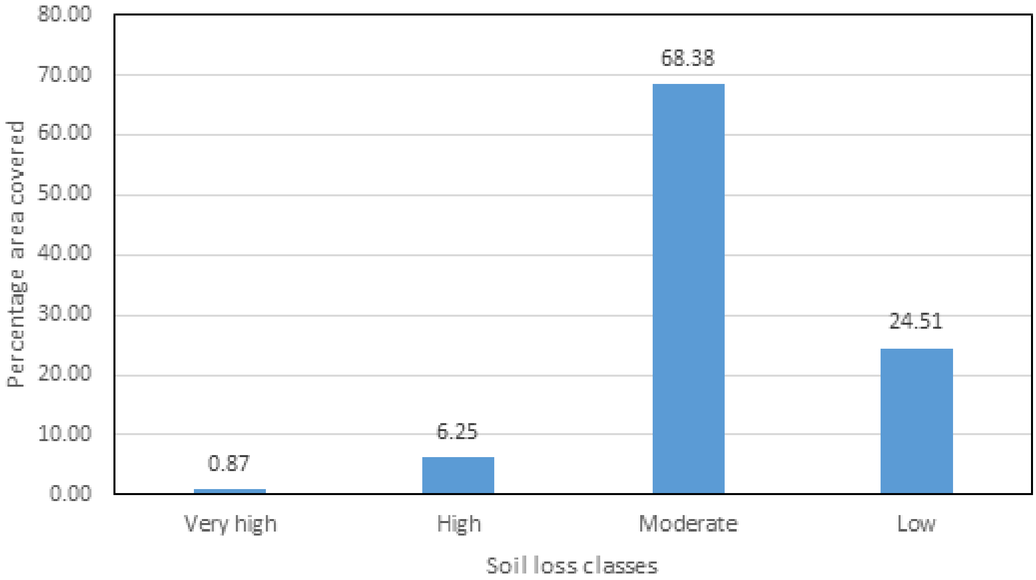

Figure 3. Soil loss classes

erosion control measures as there was barely any erosion observed. These findings corroborate those of Biragi (2011). Further, limited utilisation /adoption of soil and water conservation practices could be attributed to low farmer exposure and education. Studies have shown that farmers with high awareness invest in soil and water conservation (Gunathilaka, 1990; Amarasekara *et al*., 2008).

Soil erosion hazard in the Lake Kivu basin. Hotspot of high soil erosion is confined around the Mitumba chain stretching along the Western Rift Valley in Eastern part of DRC to the west of Lake Tanganyika. These chains of mountains are characterized by very steep and relatively bare back slopes. These arose from land use practices such tree logging for timber and charcoal and agricultural practices. These findings are in line with recent observations (Adidja, 2014; Bagalwa *et al*., 2015) around the study area and around Lake Tanganyika (Azanga *et al*., 2015).

Conclusion

This study has shown that there are a few soil and water conservation measures being used in the Lake Kivu basin. Further, limited number of households are engaged in the soil and water conservation efforts. Though soil loss and erosion is still at moderate intensity, there is potential for it to increase rapidly. As such, there is need to take strategic actions that increase the adoption and use of soil and water conservation measures in the Lake Kivu basin and particularly in the hot spot locations.

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