UNIVERSITY OF HOHENHEIM

Modelling catchment–scale erosion mitigation potential of legume–led crop rotations under varying slope lengths

Eric Koomson[1*], Tarirai Muoni[2], Carsten Marohn[1], Alan Duncan[3], Ingrid Öborn[4], Georg Cadisch[1]

1. University of Hohenheim, Institute of Agricultural Sciences in the Tropics (Hans – Ruthenberg – Institute), (490e)
2. Swedish University of Agricultural Sciences, Crop Production Ecology, Almas Allé 8, 750 07 Uppsala Sweden
3. International Livestock Research Institute (ILRI), 30709 Naivasha Road, Nairobi – Kenya
4. International Centre for Research in Agroforestry (ICRAF), Nairobi – Kenya

www.foodsecurity.de

Introduction

The highland regions of western Kenya constitute a major hot–spot for water–driven soil erosion due to erosive rainfall, intensive land cultivation, and steep topography. In the smallholder-dominated Rongo sub–county land tenure is traditionally organised in strips in slope direction and predominant maize plots are ploughed downhill. Slope length and degree have a pronounced influence on water erosion, equating them to energy factors that maximize surface run-off. The question arises, how can legume rotation systems be placed in strategic landscape positions to minimise effects of slope length on soil degradation and nutrient loss emanating from soil loss?

Aim

To improve knowledge of the impact of slope length under typical maize–beans intercropping systems on sustainability of the production base (soil fertility) and environment (runoff, erosion).

Objectives

- To assess the impact of different slope lengths on run-off and soil loss in the field.
- To represent run-off and soil loss in baseline simulations of a dynamic model.
- To test a range of scenario adaptations to erosion mitigation under different slope lengths using landscape-scale model (LUCIA) for impacts on soil fertility.

Materials and methods

Erosion–different slope lengths

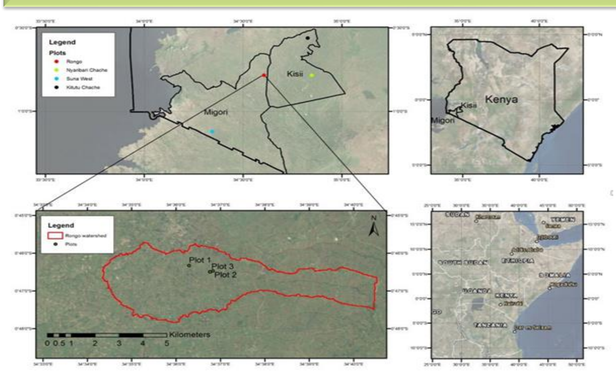


Figure 1. Map showing study site and plots

Experimental design

- RCBD–3 farms (F1, F2 & F3)
- Treatment (Slope length, SL)
  SL1=20, SL2=60, SL3=84m, 2 rep per SL
- Parameters evaluated: Runoff, soil loss
- Maize (*Zea mays*) – Common beans (*Phaseolus vulgaris*) intercrop

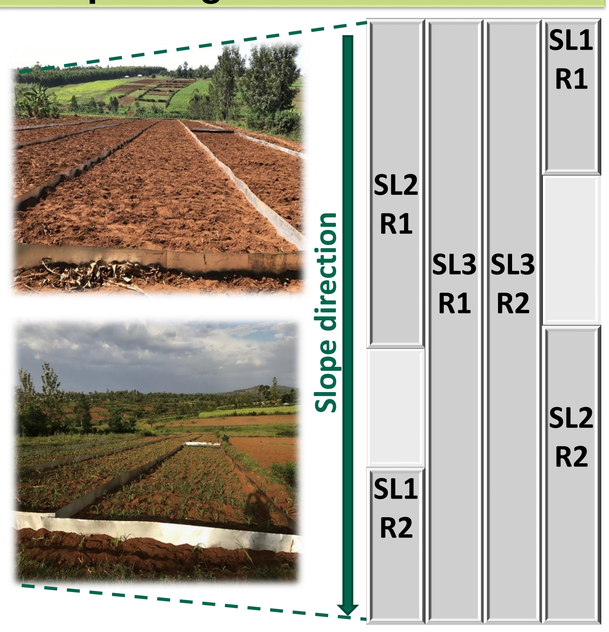


Figure 2. Layout of erosion bounded plots

Modelling

LUCIA model

- Process-based dynamic model
- Simulates landscape-scale effects of changes in environmental conditions

Parameterization/calibration

- Maps: soil, land-use, slope, DEM
- Field data: run-off, soil loss, soil C, N, texture, % gravel; agronomic e.g. yield, biomass, soil cover
- Weather: rainfall, air temperature
- Management: planting date, plant density.

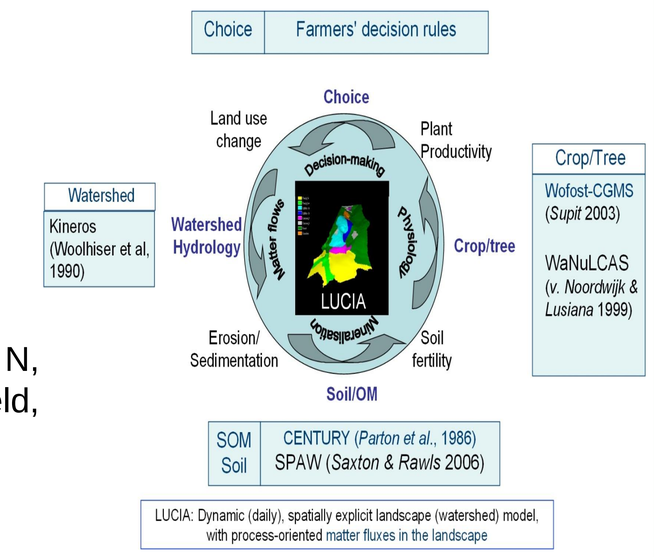


Figure 3. LUCIA model interface

Results & discussion

Field results

Table 1. Slope length impact on cumulative run-off and soil loss for the 2017 LR

Farm	Slope length (m)	Cum run-off (m^3 ha^{-1})	Cum soil loss (kg ha^{-1})
F1	20	556±0.03[a]	5027±0.14[a]
	60	476±0.03[a]	10128±0.14[a]
	84	329±0.03[b]	14218±0.14[a]
F2	20	575±0.04[a]	64±0.13[c]
	60	435±0.04[a]	210±0.13[b]
	84	283±0.04[b]	1232±0.13[a]
F3	20	652±0.05[a]	161±0.11[b]
	60	619±0.05[a]	306±0.11[b]
	84	338±0.05[b]	1599±0.11[a]

Model scenarios

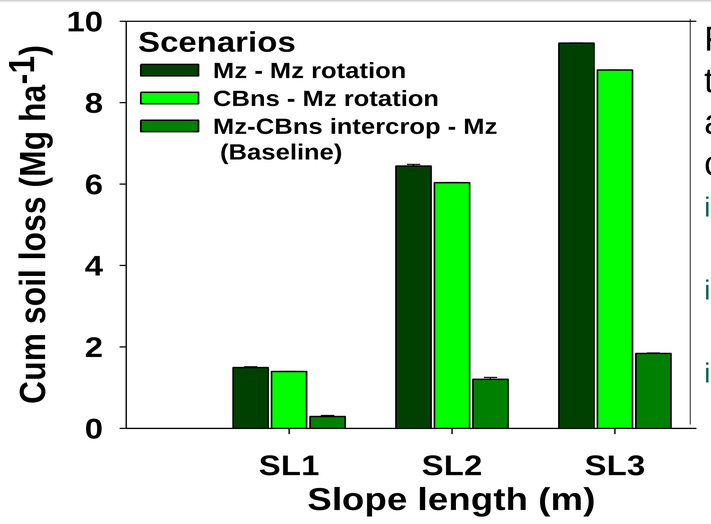
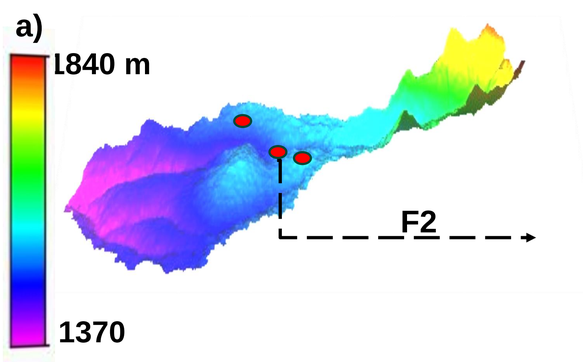


Figure 5. Scenario runs to asses the impact of slope length on annual (LR and SR) soil loss under current cropping systems:

i. Mz–Mz: sole maize rotated after sole maize.
ii. CBns–Mz: maize rotation after common beans.
iii. Mz–CBns intercrop – Mz: maize rotation after maize common beans intercropping (baseline).

Model calibration/validation



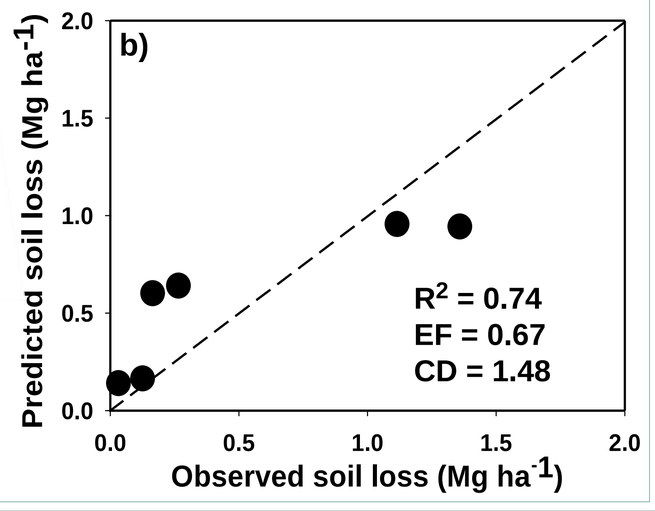


Figure 4 (a). Digital Elevation Model (DEM) map *(PCRaster map)*, (b) Observed and Predicted total soil loss for the validation period of 2017 long rain (LR).

Discussion and conclusion

- Run-off decreased with increasing slope length (SL1> SL2> SL3). The reverse was observed for soil loss (SL1< SL2< SL3).
- Slope length significantly ($p<0.05$) influenced cumulative run-off and soil loss on farms 2 and 3.
- LUCIA simulated soil loss with EF of 0.67, indicating good model performance.
- The model could not capture the trend of run-off which was opposed to soil loss and that this requires further investigation.
- Preliminary model runs showed that rotation of maize after intercropping systems reduced soil loss.
- Model runs will be extended to the watershed-level to simulate slope length impact on soil erosion and degradation.

Acknowledgment

We thank BMZ through LEGUMECHOICE Project and FSC for sponsoring this study. We also acknowledge IITA , ICRAF, KALRO and the smallholder farmers for the field support.

With financial support from the Federal Ministry for Economic Cooperation and Development

exceed EXCELLENCE CENTERS FOR EXCHANGE AND DEVELOPMENT

DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service