Working Paper

Monitoring landscape restoration efforts and associated livelihood benefits for smallholder farmers in the Upper Tana Basin of Kenya

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List of Abbreviations

BACI	Before-After-Control-Impact
CGIAR	Consultative Group of International Agricultural Research
GPS	Global Positioning System
SLM	Sustainable Land Management
TNC	The Nature Conservancy
WLE	Water Land and Ecosystems

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Executive Summary

The Upper Tana Basin is an area that is very prone to soil erosion. In this study, we worked closely with 10 farmers in the Upper Tana Basin who were implementing a range of different land management options, specifically soil water conservation with terraces and forage grass strips. We installed and monitored erosion and runoff detectors in the farming landscapes to quantify how much soil was running off the surface. We compared how different land management practices if used in combination reduce soil erosion and result in livelihood benefits. The control areas that did not have SLM options showed substantial differences when compared to the areas with SLM within the different micro-watersheds over time and space. The farms without SLM produced less food but consumed most of their food produce and barely had any surplus to sell. For all micro-watersheds, SLM consistently consumed less food than the food produce they sold. This aspect has implications on the livelihood options of farmers. The interventions with SLM offered viable livelihood options for farmers while at the same time meeting their food security and nutritional needs compared to those without SLM that lacked the purchasing power due to lower market sales of their produce.

Introduction

The Upper Tana River Basin covers approximately 17,000 km^2 and is home to 5.3 million people (TNC, 2015). The basin covers Mount Kenya and the Aberdare highlands with elevations ranging from 4,500 m at Mount Kenya to about 400 m above sea level in the east of the catchment (Dijkshoorn et al., 2011). There are two rainy seasons and rainfall is relatively high with average annual rainfall of about 2,000 mm at higher altitudes (Hunink et al., 2013). This area provides water that is critical to the Kenyan economy. It fuels one of Kenya's most important agricultural areas, provides half of the country's hydropower output, supplies 95% of Nairobi's water and is home to national parks and reserves, which are important areas of biodiversity.

One of the major challenges in the Upper Tana is that upstream human activities are causing increased sedimentation in the basin's rivers, reducing the capacity of reservoirs and increasing the costs for water treatment. To address this, the Upper Tana-Nairobi Water Fund was created to help protect and restore the quality and supply of water in one of Kenya's most productive and economically important regions (TNC, 2015). Spearheaded by The Nature Conservancy (TNC), the Water Fund established a revolving fund, where a public-private partnership of donors and major water consumers 'at the tap' contribute to the endowment, which generates funds to support land conservation measures upstream (TNC, 2015). Water funds are founded on the principle that it is cheaper to prevent water problems at the source than it is to address them further downstream (TNC, 2015). Whilst the Water Fund is aimed at providing benefits to downstream users, ensuring that land users benefit from land conservation measures upstream is important to the long-term viability of the fund. CGIAR Researchers through the Research Program on Water, Land and Ecosystems (WLE) worked to better understand the benefits of land conservation measures on multi-use agricultural lands. The Upper Tana-Nairobi Water Fund activities are currently focused in three priority sub-watersheds (Figure 1). Rivers from these sub-watersheds are critical to Nairobi's water supply and Kenya's power supply. This work focused on all the three sub-watersheds: Thika-Chania, Maragua and Sagana-Gura. Complementary surveys were conducted to gain a broad understanding of the context within which farmers live in this agroecosystem but more importantly to assess how restoration efforts translate to livelihood benefits for smallholder farmers.

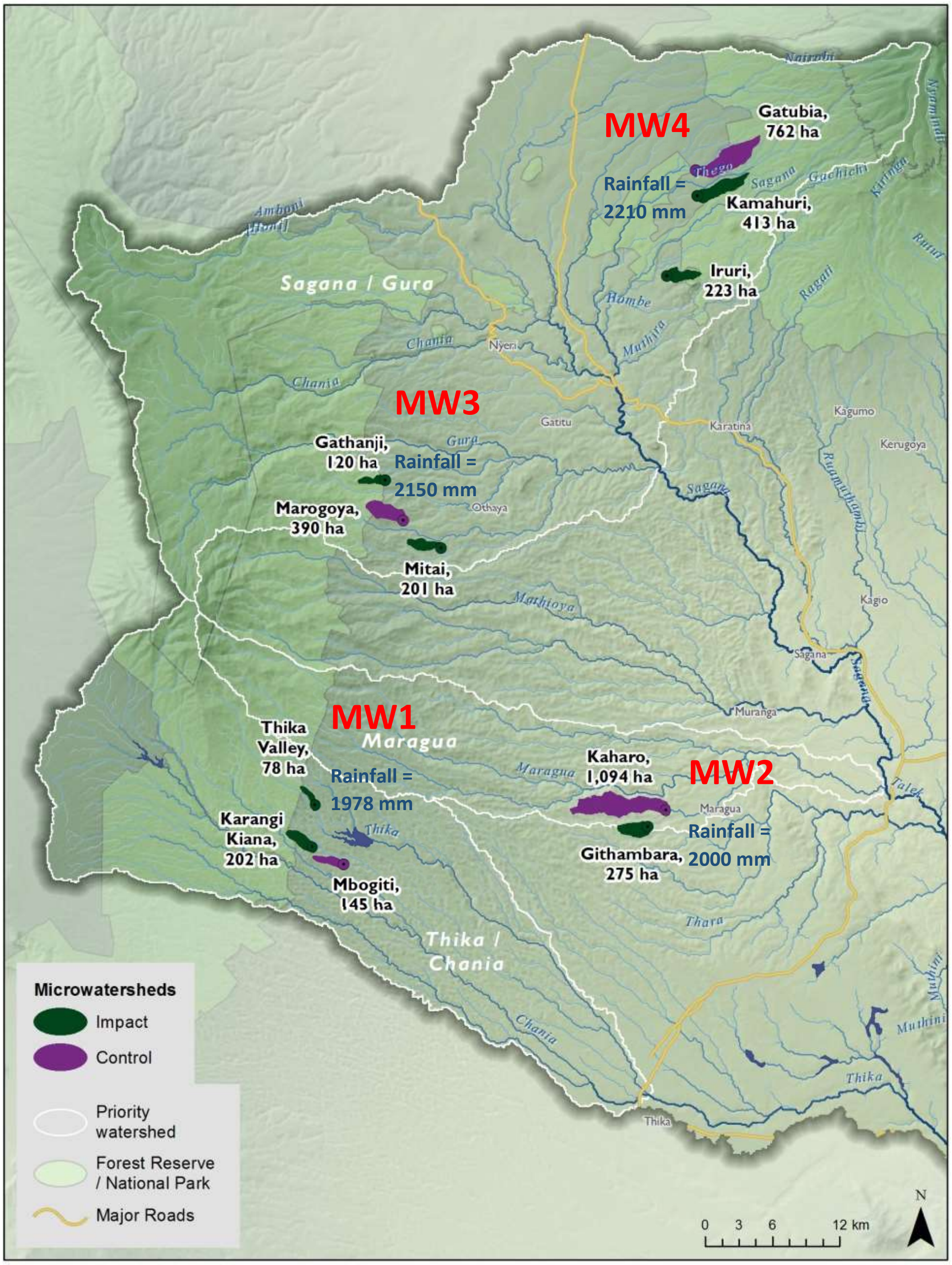

Figure 1. A map of the Upper Tana in Kenya showing the location of the three priority sub-watersheds (Thika-Chania, Maragua, Sagana-Gura). Also shown are the location of four micro-watersheds (MW1, MW2, MW3, and MW4) in each cluster and type (control or impact) of each micro-watershed with annual average rainfall amounts for 2016-2018.

Approaches used in the study

Monitoring at sub-watershed and plot levels

As depicted in Figure 1, four clusters of micro-watersheds (MW1 through MW4) are arranged in sets within a larger sub-watershed; one or two treatments and one control, with similar soils, crops, and weather events. The treatment watershed represents an area in which conservation activities were targeted toward sediment control. The control represents an area in which conservation activities were not conducted forming a Before-After-Control-Impact (BACI) design. Runoff measurements were compared from representative sites prior to and again after conservation interventions were installed at specific areas within farmer fields which were selected for monitoring erosion, rainfall and runoff (Figures 2 and 3)

Field installations and Trainings

The farmers were trained on how to read the rain gauges, monitor runoff levels and measure the soil sediment levels in the calibrated runoff detector troughs after each rainfall event.

Figure 2: Photographic representation of the soil trough setup in the various plots: (1st LEFT) A soil trough installed in one of the plots with beans and Napier grass; (2nd LEFT); A CGIAR-WLE Scientist training farmers on how to read and record data from a calibrated runoff detector soil trough; (2nd RIGHT): CGIAR-WLE Scientist installing a rain gauge in one of the farms (RIGHT); CGIAR-WLE Senior Scientist supervising the installation of the soil troughs in designated experimental plots (Photo Credits, Fred Kizito).

Data collection

Figure 3 Photo representation of monitoring efforts at project field sites. (Left) A CGIAR-WLE research assistant reading and recording infiltration data, (2nd Left) A trough with actual runoff and soil sediment eroded after heavy rain (2nd Right and Right) A farmer emptying and registering the runoff in a trough and reading the sediment (Photo Credits, Fred Kizito).

Data collected from micro-watersheds

The various datasets collected during the erosion monitoring include;

1. GPS Co-ordinates of each plot
2. Hydraulic Conductivity (Infiltration) data
3. Rainfall data and soil moisture storage
4. Runoff and sediment data

Specific observations

i. From 2016 through 2018; the March-May rains were well distributed throughout the rain season (data not shown here) and for the October–December period, rains mostly fell in the month of November.

ii. For farmers C2, D and G (See Table 1) within the micro watersheds had no SLM practices in their farming areas and this resulted in substantial amounts of sediment filling the troughs after the rains.

Table 1: Description of the farm intervention practices and crops grown

Farm	Farmer	Micro watershed	SLM Practice	Crops grown
1	D	Kirangi Kiana (MW1)	No SLM	Maize, Beans, Cabbage
2	E	Mbogiti (MW1)	Terrace & Grass strip	Maize, Beans
3	F	Githambara (MW2)	Terrace & Grass strip	Maize, Bananas
4	G	Kahuro (MW2)	No SLM	Maize, Beans, Bananas
5	H	Gathanji (MW3)	Grass strip	Maize, Cabbages
6	I	Marogoya (MW3)	Terrace & Grass strip	Maize, Beans
7	A	Kimakia (MW4)	Terrace & Grass strip	Kale, Potatoes, Maize, Pineapples
8	B	Kimakia (MW4)	Terrace & Grass strip	Sweet Potatoes, Maize
9	C farm 1	Kimakia (MW4)	Grass strip	Kale, Potatoes
10	C farm 2	Kimakia (MW4)	No SLM	Tea & Maize

Results and Discussion

Micro-watershed level results

Results from three water quality Eureka Manta monitoring probes within the basin included measurements of temperature, salinity, electrical conductivity, total dissolved solids, pH and turbidity at hourly intervals (Results not shown). Based on the monitoring results, the turbidity and conductivity variations were in response to flushes of water from the landscape responding to rainfall events. In a couple of specific events, we noted that although there were instances of high rainfall events in some watersheds, this did not necessarily result in high turbidity and conductivity values because sustainable land management (SLM) interventions conducted upstream of the Maragua bridge resulted in lower levels of sediment and runoff. These differences often become more apparent over a longer duration as interventions are more established in the landscape. Based on transect walk observations conducted in each micro-watershed within four clusters (See Figure 1), there were visible signs of soil erosion within the landscape. Additionally, areas within the watershed had evidence of sustainable land management practices within the 10 farming areas that had a mix of various crops and SLM practices as well as areas where no SLM practices were implemented. Erosion detector monitoring troughs were installed to monitor the landscape in March- April and October-December 2016 rains at the 10 different farms, each having 3-5 plots on which the troughs were setup. In all the 10 farms, GPS locations were taken and rain gauges were installed for the farmers to read, and to aid in recording the data collected. We discuss observations from some of the monitoring data in relation to soil erosion and the associated intervention measures.

Results presented in Figure 4 show an order of magnitude of increase in runoff (40%) for areas with no SLM and the same trend was observed for sediment (20% increase) (Figure 4B) compared to Figure 4A. This underpins the importance of landscape stewardship at the farm level where SLM practices were implemented and this in turn translates to wider positive environmental benefits at the watershed level compared to areas without SLM practices.

For all the four micro-watersheds MW1-MW4, runoff levels were consistently lower (20-35%; Figure 5A) for areas with SLM compared to higher level (65-85%; Figure 5A) for the areas with no SLM within those micro-watersheds. In a similar trend, sediment levels were consistently lower (15-30%; Figure 5B) in SLM areas compared to areas with no SLM that registered higher sediment levels (70-85%; Figure 5B).

For all the four micro-watersheds MW1-MW4, infiltration levels were consistently higher (59-70%; Figure 6A) for areas with SLM compared to lower levels (30-41%; Figure 6A) for the areas with no SLM within the micro-watersheds. Likewise, soil water storage levels were consistently higher (55-70%; Figure 6B) in SLM areas compared to areas with no SLM that registered lower soil water storage (moisture) levels (30-45%; Figure 6B). Farmers within the micro-watersheds conducted structural measures (grass strips and terraces) as well as agronomic measures (mulching) that promoted soil and water conservation through reduced runoff, evaporation and erosion, these in turn increase infiltration and moisture retention within the crop root zone.

Food produced in the micro-watersheds included maize, beans, vegetables, bananas and fruits. Food production within the micro-watersheds was calculated based on Kilo Calories per Hectare per Year (Figure 7A). Similarly, detailed surveys were conducted over a 2 year duration to know what proportions of food were consumed and sold (Figure 7B and 7C). A key message from Figure 7A is that the areas that practiced SLM interventions had higher food production compared to the areas without SLM. The latitudinal comparison (with and without) effects of grass strips and terraces establishment (on the same farms) eventually increase crop yields due to reduced runoff and erosion and increased water infiltration, retention of soil moisture, and nutrients. The farms without SLM (MW1-MW4) produce less (Figure 7A); most is consumed (55-75%) (Figure 7B) hence very little is left for sale (25-45%) (Figure 7C). For all watersheds (MW1-MW4) SLM consistently consumed less (30-55%) (Figure 7B) than what they sold (45-70%) (Figure 7C). This has implications on the livelihood options for the farmers. The interventions with SLM offers viable livelihood options for farmers while at the same time meeting their food security and nutritional needs compared to those without SLM that lack the purchasing power due to lower market sales of their produce.

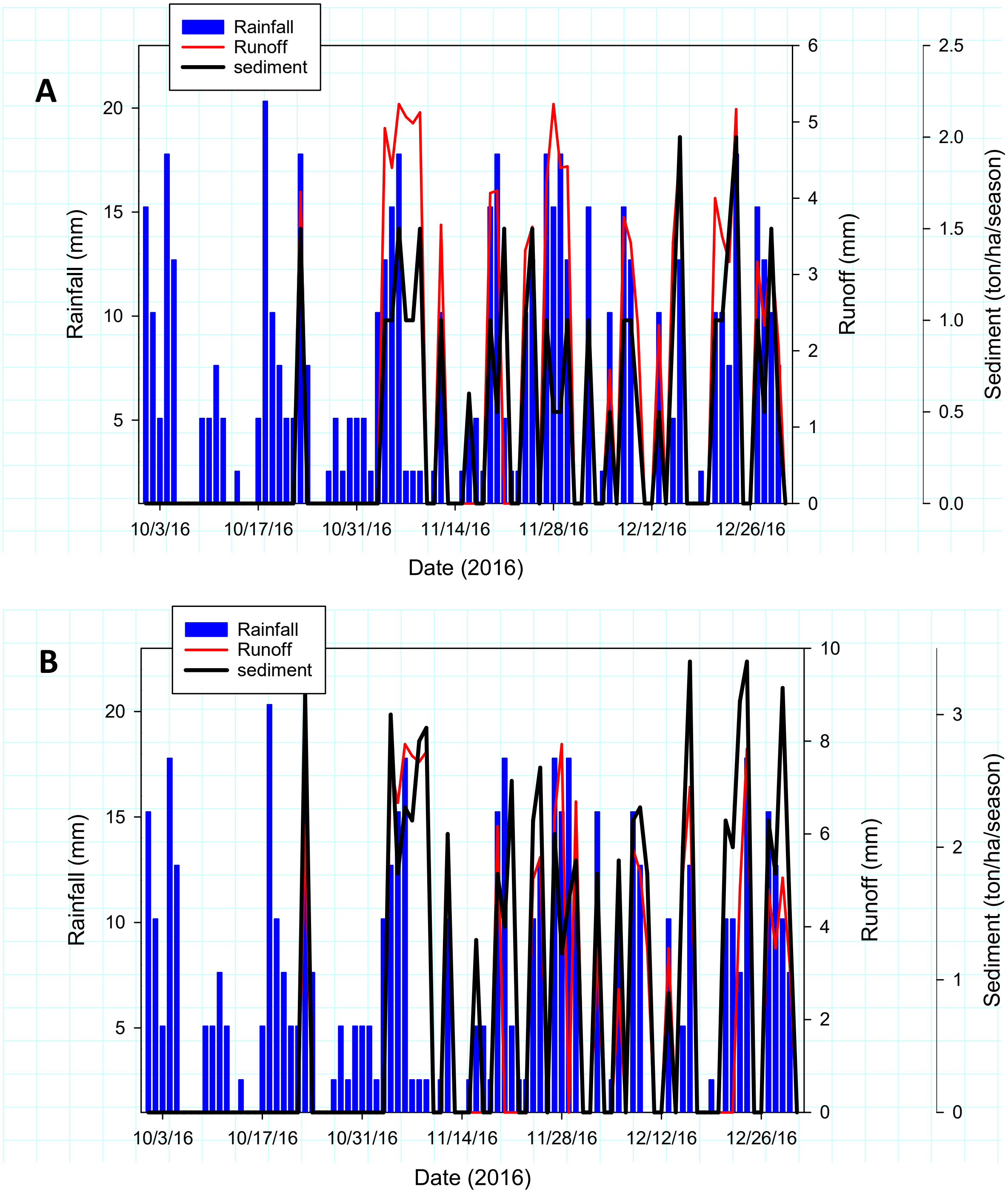

Figure 4. Variation of runoff and sediment deposition with rainfall for sub-areas in farmers' fields with SLM (A) and without SML (B). The SLM practice had a combination of grass strips and terraces

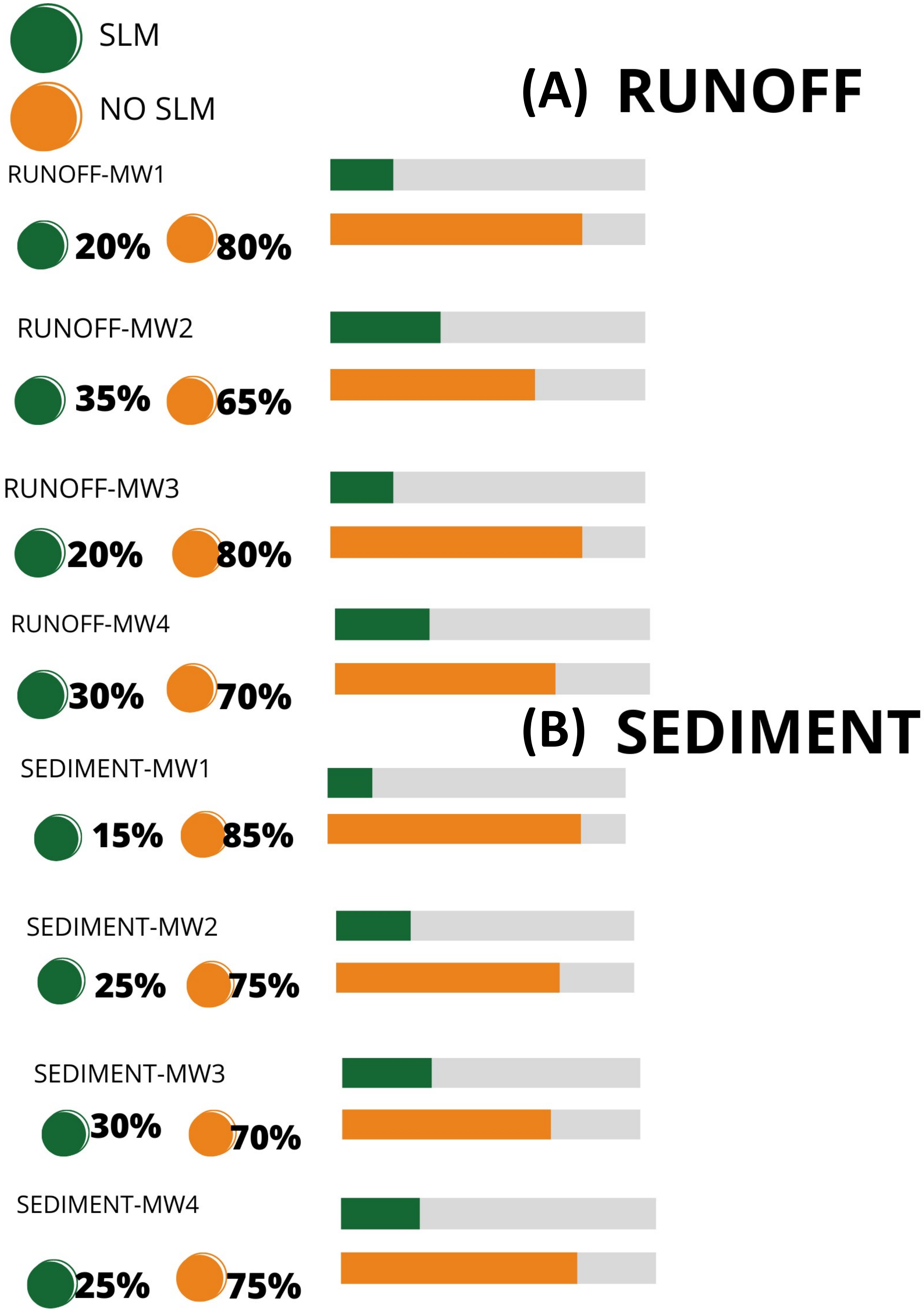

Figure 5. Variation of runoff (A) and sediment deposition (B) for the micro-watersheds 1 through micro-watersheds 4 with SLM (in Green) and without SML (in Orange). The SLM practice had a combination of grass strips, and terraces

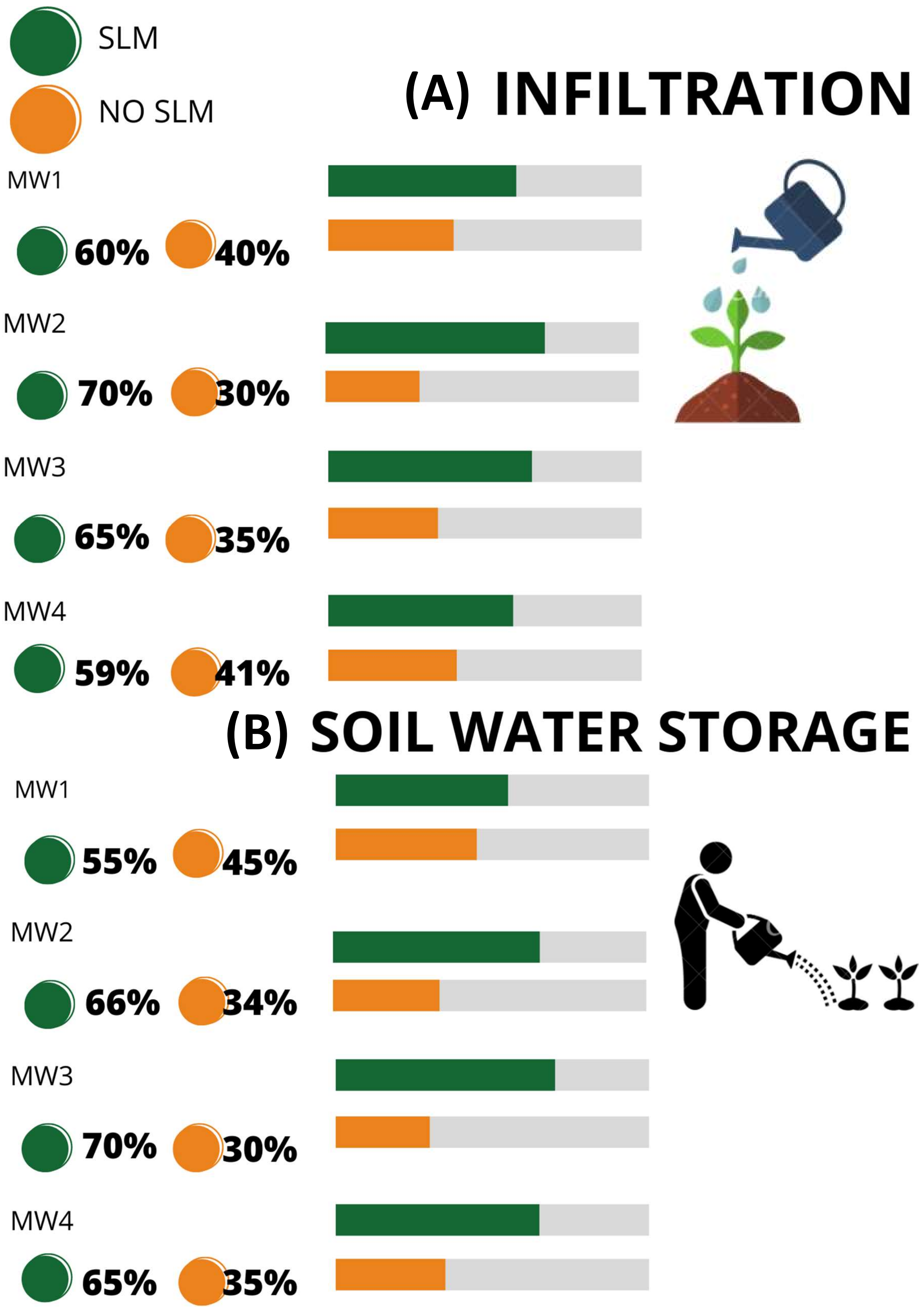

Figure 6. Variation of infiltration (A) and soil water storage (B) for the micro-watershed 1 through micro-watershed 4 with SLM (in Green) and without SML (in Orange). The SLM practice had a combination of grass strips, and terraces.

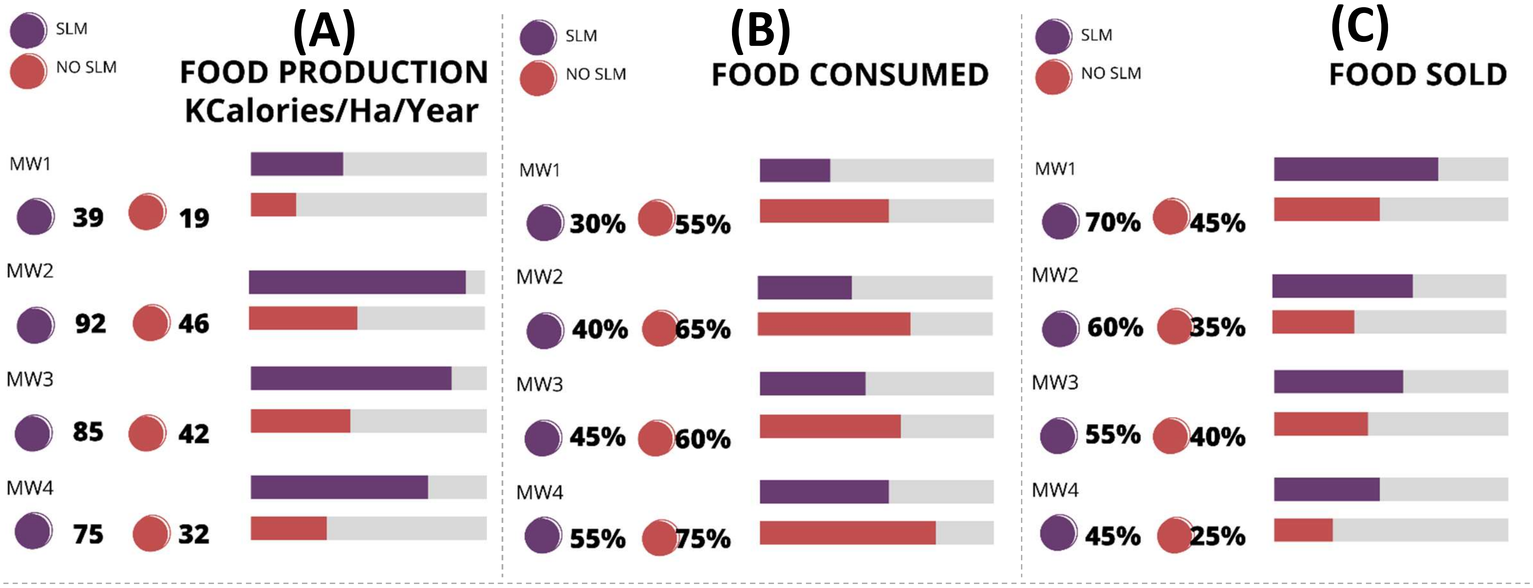

Figure 7. Food production for the micro-watersheds MW1-MW4 with SLM (in Purple) and without SML (in Red) (A). (Based on actual yield data; food production estimates based on FAO, 2003). The SLM practice had a combination of grass strips, and terraces. Food Consumed (B) and Food Sold (C) from survey results.

Policy implications for work conducted

Field measurements revealed the need to conduct dedicated monitoring studies towards quantifying the impact of farming practices on the overall environmental integrity of the watersheds in the upper Tana Basin. In order to provide sustainable intervention options for both upstream and downstream beneficiaries under these agroecosystems, focus has to look beyond environmental integrity and consider implications for livelihood needs (income and food security). The control areas that did not have SLM options showed substantial differences when compared to the areas with SLM within the different micro-watersheds over time and space. The farms without SLM produced less but consumed most of their produce and barely had any surplus to sell. For all micro-watersheds, SLM consistently consumed less than what they sold. This aspect has implications on the livelihood options for the farmers. The interventions with SLM offered viable livelihood options for farmers while at the same time meeting their food security and nutritional needs compared to those without SLM that lack the purchasing power due to lower market sales of their produce.

The results presented in this study offer valuable insights to decision making on the degree of vulnerability of portions of the Upper Tana Basin where no SLM measures are in place. This calls for re-thinking appropriate management strategies and options that will reduce sedimentation and runoff. We propose that any future interventions should allow for more holistic inclusion of social actors coupled with participatory processes that will in turn permit improvement in livelihood needs (income and food security) as environmental integrity is restored with sustainable land management options.

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