ECONOMICS OF LAND DEGRADATION INITIATIVE

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Implemented by: giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

POLICY BRIEF

The economics of soil organic carbon

Multi-benefits from sustainable land management for smallholders in Western Kenya

Evidence from Western Kenya shows that implementing Sustainable Land Management (SLM) practices:

- **leads to economic benefits for farmers:** SLM farmers had higher income than farmers practicing business as usual stemming from higher yields and diversification of products. Farmers therefore have a strong economic rationale to participate in a voluntary carbon credit scheme piloted in Western Kenya even without being directly remunerated through the scheme.
- **is carbon effective:** Assessed SLM farm plots store comparatively more carbon in topsoil than control farms. This points to including below-ground carbon in carbon projects. Additionally, the actual carbon sequestration rate in the study area is higher than the rate that was used to certify the project. Thus, within carbon certification schemes there is likely more carbon sequestered than is remunerated.
- **enhances soil biodiversity:** SLM farmers also had more soil microbial communities compared to the farmers practicing business as usual.

1. Introduction

The farming system of Western Kenia is characterized by small-scale subsistence agriculture, with low inputs, low yields, and rapid loss of soil fertility. This leads to soil degradation which makes soils less productive, as well as reduced food and income security. Healthy and productive soils are not only relevant for food production, but also for carbon sequestration: Soils are the largest carbon reservoir of the terrestrial carbon cycle and store more carbon than all terrestrial vegetation and the atmosphere together. Soil organic carbon (SOC) sequestration can contribute to climate change mitigation, by taking atmospheric CO_{2e} and converting it into soil carbon.

According to the International Panel on Climate Change (IPCC), carbon sequestration in agriculture contributes approximately a quarter of the annual mitigation options[1] in the Agriculture, Forestry and Other Land Use (AFOLU) sector. Thereby, carbon sequestration in agriculturally used land by soil carbon management has twice the mitigation potential of agroforestry systems (IPCC, 2022). Sustainable Land Management

1 at a carbon price of < USD 100 t CO_2

(SLM) in the last years has gained attention because of its potential to contribute to climate change mitigation and adaptation by SOC sequestration.

Extension services to increase implementation rates of SLM among smallholder farmers though often lack financing. **To enable long-term financing for extension services, a new and innovative approach comprises the use of the revenues of agricultural carbon credits to support SLM**. This policy brief is based on the results of the Economics of Land Degradation (ELD) study on the economics of soil organic carbon in Western Kenya assesses this possibility. The study analyses **how sustainable practices are impacting the economic performance of smallholder farmers**, and **what the carbon sequestration potential of SLM practices, namely CA and ISFM, is**. It also aims to conclude **how extension services for SLM practices impact their implementation**. Results can be used for the development of carbon projects in agriculture such as the Western Kenya Soil Carbon Project (WKCP) and for policy recommendations on the promotion of SLM practices.

Box 1

What is Sustainable Land Management?

SLM is defined as “the use of land resources – including soils, water, vegetation, and animals – to produce goods and provide services to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions” (**WOCAT**).There are different types and a large variety of SLM practices.

This study focuses on the following two practices and compares them with conventional farming:

- **Conservation Agriculture (CA)** is based on minimal soil disturbance. Main CA principles are no or minimum tillage and permanent soil cover (mulch, crop residues) combined with increased crop diversity and crop rotation.
- **Integrated Soil Fertility Management (ISFM)** involves the combination of nutrients from organic and inorganic sources alongside improved germplasm, while addressing local constraints such as soil water availability and acidity/alkalinity that impede expected nutrient use efficiencies. ISFM thus promotes measures such as liming of acidic soils, demand-oriented fertilization, and applying compost and farmyard manure.

Box 2

The Western Kenya Soil Carbon Project (WKCP)

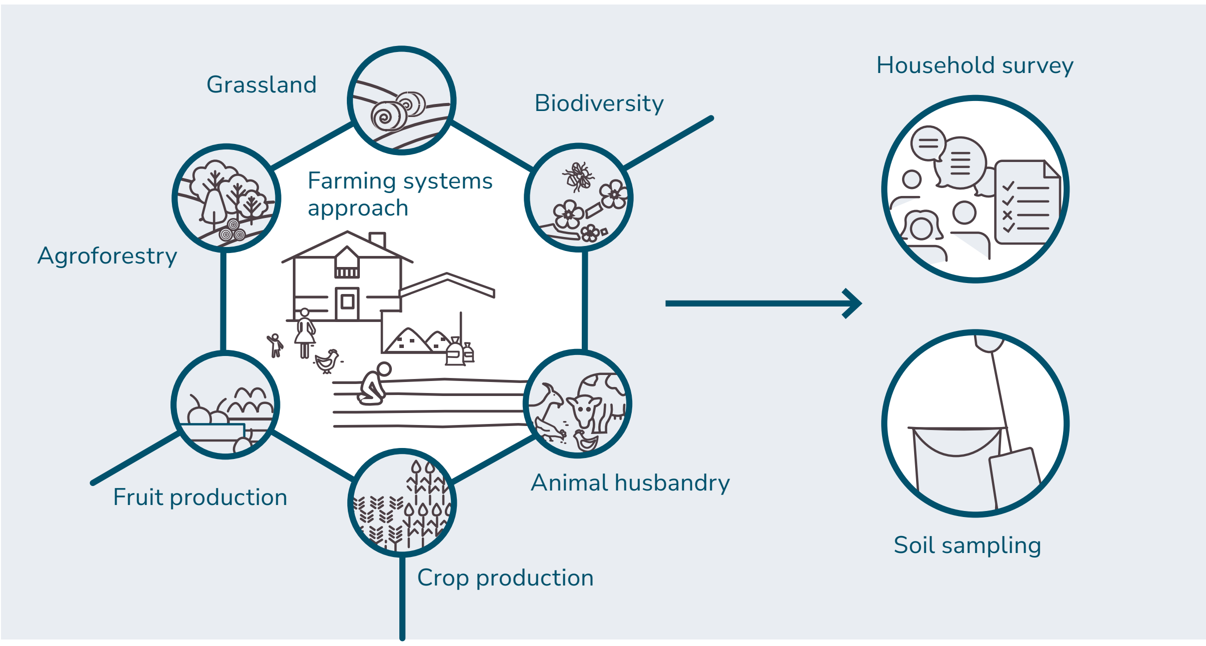
GIZs Sector *Project Soil Protection, Combating Desertification, Sustainable Land Management (SV BoDeN+)* builds on the work of GIZs Global Programme *Soil Protection and Rehabilitation ProSoil Kenya* by piloting a voluntary carbon project on the areas where SLM practices have been implemented by small-scale farmers. Within the frame of the WKCP, a climate certification scheme for soil conservation measures in connection with the VCM is developed. The project measures the climate impacts of SLM according to the Verified Carbon Standard on 32,000 ha of smallholder farms in Western Kenya. The local coordination and not-for-profit entity "Soil-Carbon Certification Services" (SCCS) coordinates the certification of the climate effectiveness of these soil conservation measures. In the WKCP, 60% of the carbon sequestered is based on agroforestry and 40% on SLM practices. By participating in the project, the farmer families get access to bi-annual extension services on SLM practices for the next 20 years at no cost.

SCCS manages the MRV system and ensures financing, adoption, and quality of climate resilient SLM through its local extension provider ***Welthungerhilfe***. In return for the carbon sequestration, the farmer families get access to bi-annual extension services on SLM practices for the next 20 years at no cost. They are financed from the revenues of the carbon credits. About 45.000 farmer families (each with Ø 5 members per household) are participating in the carbon project and profit from these services.

2. Methodology

The study applies the 6+1 step approach advocated by the Economics of Land Degradation (ELD) Initiative to assess the economics of land management (ELD 2015). It considers the economic performance and carbon content of the whole farm, including all farm components such as crop production, grass land as well as animal husbandry to avoid unequal allocation of biomass within a farm and thus distorting SOC results.

FIGURE 1 Approach assessing economic performance and carbon content of the whole farm



Household surveys to assess socio-economic parameters were combined with soil samples to measures SOC and bulk density on 64 small-scale farms in Siaya county located in Western Kenya. The sample was composed of 22 farmers practicing CA, 21 farmers practicing ISFM (all part of ***GIZs ProSoil Kenya***) and 21 conventional farmers as control group. The samples were selected by a stratification based on the farming practices applied, a minimal size of two hectares land cultivated as well as gender and age considerations. The relatively small sample size is countered by relatively homogenous results and a high saturation of the data.

Limitations of the study

A generalization of the study results is constrained by the small sample size. The results are further limited to the agroecological zone of the study area. They cannot be transferred to other agroecological zones and farming systems, due to their potential differences in productivity and opportunities to diversify production. Also, they may indicate different adaptation in SLM practices. Differing natural conditions such as basic soil parameters also significantly influence SOC sequestration potential.

3. Results

3.1 Impacts of SLM on SOC

Carbon sequestration rate

Compared to the control group, a carbon storage in the topsoil (0–30 cm) of CA farmers was calculated to be 13.86 t CO_{2e}/ha. Carbon storage was comparably lower for ISFM farmers, which stored 2.35 t CO_{2e}/ha more than control group farmers. This translates into an annual sequestration rate of 3.38 t CO_{2e}/ha/yr for CA farmers and only 0.44 t CO_{2e}/ha/yr for ISFM farmers. The overall average is around 1.9 t CO_{2e}/ha/yr.

TABLE 1 SOC sequestration in the topsoil

	Unit	CA	ISFM	CTRL
Sample size (number of HH with samples)	HH	21	21	20
Average year of SLM practice	years	4.10	5.29	1.00
SOC content	**g/kg/yr**	**13.28**	**12.49**	**12.05**
SOC in %	%	1.33%	1.25%	1,20%
SOC stock	t/ha/yr	54.61	51.47	50.83
CO_{2e} stock[2]	**t/ha/yr**	**200.41**	**188.89**	**186.54**
Difference of CO_{2e} stock in topsoil (0–30 cm)	**t/ha/yr**	**13.86**	**2.35**	
CO_{2e} sequestered per year since start of SLM	t/ha/year	3.38	0.44	

2 CO_{2e} stock is calculated by multiplying the SOC stock with the conversion factor of 3.67

The higher carbon sequestration at CA farms is because the CA farmers produce more biomass with the cultivation of cover crops than ISFM farmer provide by applying farmyard manure.

These number though cannot be generalized over larger areas, as the annual sequestration rate of carbon in agriculture soil may differ depending on the natural conditions, on the basic soil parameters and on the opportunities to implement SLM in a specific farming system.

SOC sequestration potential

The CO_{2e} stock of the topsoil differs between 218 t/ha of the upper quartile[3] to 180 t/ha of the mean value to 142 t/ha of the lower quartile[4]. This shows that the farmers with lower carbon stocks have a higher potential to increase their stock.

The total weighted increase of CO_{2e} in the topsoil within a period of 10–20 years is estimated at 37.75 t/ha. The increase of the farmers in the upper quartile within this period is 16.4 t/ha and the increase of the lower quartile is 21.4 t/ha.

This estimation is calculated based on the following assumptions:

1. 50 % of farmers increase their SOC stock by app. 15 % compared to the measured carbon stock in 2022 within the next 10–20 years.
2. 50 % of farmers are the farmers with the highest potential: Based on the carbon stock in 2022, they are estimated to increase their carbon stocks by 30 % within the next 10–20 years.
3. The farmers will introduce SLM with an emphasis on increasing biomass using cover crops, compost and manure. No-till practice is implemented wherever machinery and technology are available.
4. All farmers will extend the implementation of the SLM practices on their farmland to all cultivated land.
5. The adoption rate of SLM practices will be promoted by extension services and through provision of key inputs such as seeds for cover crops and new technologies.

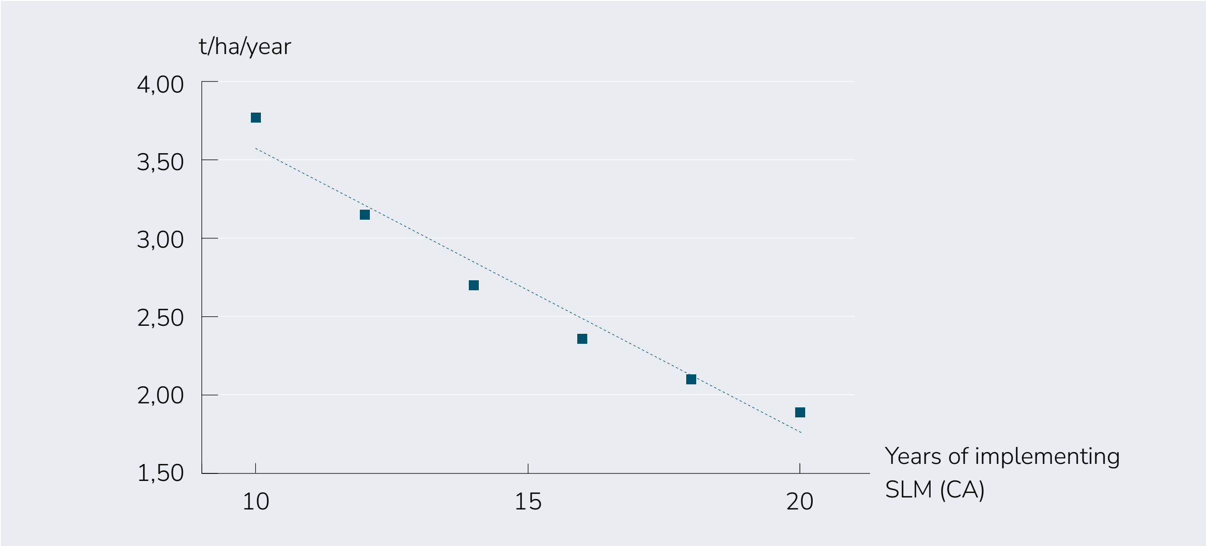
Depending on the adoption time of the SLM practices and based on the carbon sequestration rates from above, the annual sequestration rate is expected to reach in average 1.98 t/ha/year for an implementation period of 20 years. The WKCP calculated for soil carbon sequestration with a sequestration potential of 1.2 t/ha/year. The overall sequestration potential of the WKCP though is much higher, as only app. 40 % of the carbon sequestered within the project comes from SOC sequestration, and app. 60 % comes from carbon sequestered in biomass in agroforestry systems.

The study results show that the carbon sequestration rate determined based on the soil samples and the calculations is much higher than the sequestration rate used within the WKCP, as project developers usually operate with rather conservative estimates. The actual carbon sequestration within soil carbon projects in agriculture verified by certification standards therefore may be higher than the sequestration certified by the issued carbon credits.

3 The upper quartile is the central value that lies between the median and the highest number of the distributions – in this case the average of 50 % of the farms, with a value above the median (average of all values).

4 The lower quartile is the central value that lies between the median and the lowest number of the distribution – in this case the average of 50 % of farms, with a value below the median.

FIGURE 2 Annual carbon sequestration rate of CA, depending on implementing period of the SLM practices



3.2 Impacts of SLM on economic performance of farming HHs

Cost and benefits at farm level

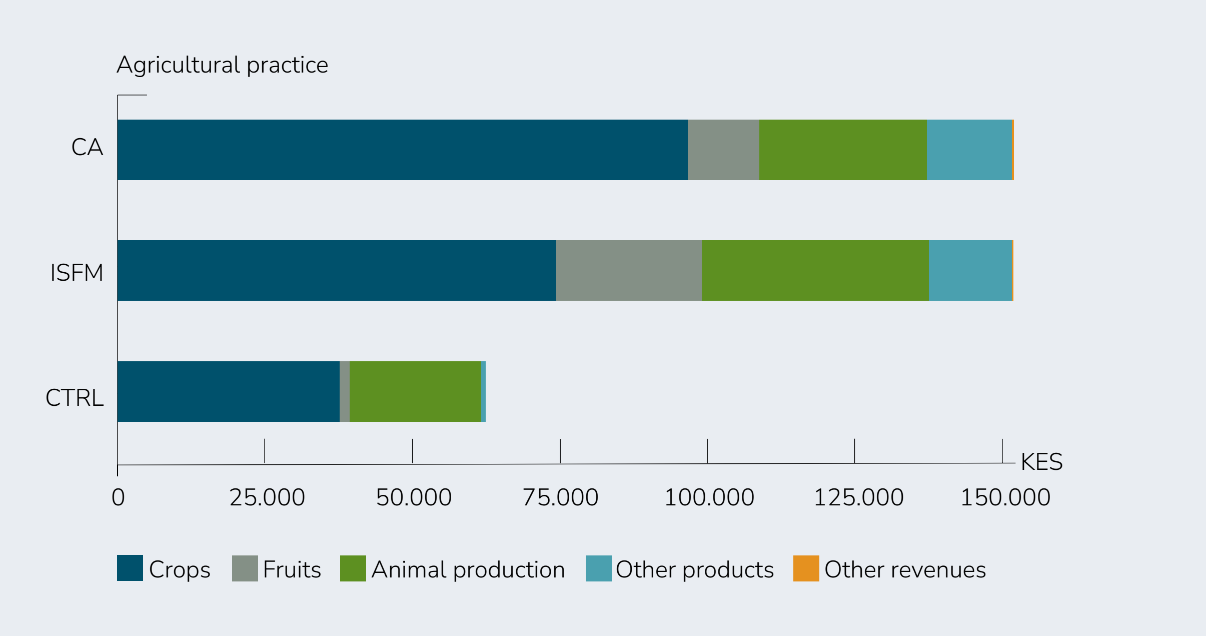
The study results show significant differences in the economic performance of CA and ISFM farmers compared to CTRL farmers. The income from farming activities of CA and ISFM famers was twice that of the CTRL group farmers: CA farmers gained 1,083 USD/HH/yr and ISFM farmers gained 1,085 USD/HH/yr, whereas CTRL farmers gained only 324 USD/HH/yr.

The different average farm sizes of the farm types, translate into different profits per ha: The profit per year of 1 ha of cultivated land is 1,732 USD/ha/yr for CA farmers, 1,443 USD/ha/yr for the ISFM and 555 USD/ha/yr for the CTRL farmers. The income results thus show that implementing SLM practices leads to economic benefits for farmers compared to business as usual.

FIGURE 3 Revenues and profit of the farm households from on-farm income

The revenues for CA and ISFM farmers were not only higher, but their production was also more diversified over different farming activities. Especially fruit production and other products took a larger share within ISFM and CA farms (see figure 4).

FIGURE 4 Revenues of the farms allocated according to farming activities



3.3 Impacts of SLM on biodiversity

CA and ISFM farmers had more soil microbial communities compared to the farmers practicing business as usual. The SLM practices including using organic inputs, crop diversification and rotation, and mulching and cover crop manage ment improve soil structure and soil fertility. The resulting improved growth performance of crops constitute a larger energy source for bacteria and fungi, which contributes to their increased abundance on SLM farms.

Overall, the study provides clear evidence for the benefits of implementing SLM practices in smallholder farming systems in Western Kenya. It is though difficult to demonstrate the specific impact of a single SLM practice, since the SLM practices for every farming system are highly diversified and interconnected. Nevertheless, it is obvious that SLM practices combined with diversified agricultural production increase the potential for additional income and create additional benefits for the environment.

4. Recommendations

Based on the study results, the following recommendations can be given to policymakers to foster the adoption of SLM approaches to increase carbon sequestration in soils in Kenya:

- Access to extension services on SLM significantly influences whether a farmer implements SLM practices. Therefore, access to extension services should be promoted by national policymakers. Supporting farmer groups in the procurement of inputs such as seeds for cover crops and placing an emphasis on farmer-to-farmer approaches can increase adoption rates of SLM practices.
- SLM practices should be promoted, as independent of the exact type of SLM practice, implementing SLM practices generally leads to economic benefits for farmers compared to business as usual. Farmers implementing SLM practices had higher and more diversified income than farmers practicing business as usual: While CA and ISFM farmers gained in average 1,587 USD per ha and year, farmers practicing business as usual gained 555 USD per ha and year.
- When designing carbon projects in agriculture, it is recommended to not only include agroforestry practices for carbon sequestration in biomass, but also promote carbon sequestration in soils by implementing SLM practices. They provide crucial co-benefits for the farmers participating in the carbon scheme by increased yields.
- The amount of sequestered carbon to be certified when registering a carbon project at verification bodies is mostly underestimated due to conservative sequestration estimates. It thus can be assumed that within carbon certification schemes there is more carbon sequestered than is remunerated for it.
- High carbon sequestration rates can be reached under the assumption of continuous access to extension services. Selling the carbon sequestered as carbon credits can ensure long-term financing of extension services for small-scale farmers.

Access the full report and other ELD knowledge pieces at **www.eld-initiative.org**

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The **Economics of Land Degradation (ELD)** Initiative is a global initiative at the interface of science, policy, and practice that works to make the values of land count to inform, promote, and scale land solutions for transformative change.

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