german
cooperation
DEUTSCHE ZUSAMMENARBEIT

Co-funded by
the European Union

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Economic benefits through agroecological soil practices: Evidence by ProSoil

As a federally owned enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices

Bonn and Eschborn, Germany
Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66
I www.giz.de

Programme / project description

Global Programme Soil Protection and Rehabilitation for Food Security

www.giz.de/en/worldwide/32181.html

Authors

Matti Cartsburg, HFFA Research GmbH, Berlin

Juliane Kaufmann, HFFA Research GmbH, Berlin

Alica Nagel, HFFA Research GmbH, Berlin

Responsible / Editor

Responsible: Dr Anneke Trux

Editors: Andrea Bender, Tim Eckey, Levke Sörensen, Linos Xanthopoulos

Design / layout

FLMH | Labor für Politik und Kommunikation

On behalf of

Federal Ministry for Economic Cooperation and Development (BMZ)

This publication was produced with the financial support of the European Union and the Federal Ministry for Economic Cooperation and Development (BMZ). Its contents are the sole responsibility of GIZ and do not necessarily reflect the views of the European Union and the Ministry for Economic Cooperation and Development (BMZ).

Bonn, February 2024

Content

Abbreviations and Acronyms 4

Glossary 5

1. Analysing economic evidence on agroecology: An overview of the Global Programme ProSoil 6

2. Economic viability of agroecological practices for smallholder farmers 8

   2.1 Soil and water conservation pays off in ProSoil areas 8

   2.2 Integrated soil fertility management measures resulting in high returns in ProSoil areas 9

   2.3 Sustainable land management proves profitable in most ProSoil areas 10

3. Broader economic andsocial benefits of agroecological practives: Food security, climate resilience and societal health 12

4. Further evidence and lessons from non-ProSoil analyses 16

5. Take-aways for different target groups 19

   5.1 Recommendations for policymakers 19

   5.2 Recommendations for donors 20

   5.3 Recommendations for practitioners in development cooperation 20

Exploring ProSoil economic evidence through individual factsheets 21

Bibliography 57

Abbreviations and Acronyms

BAU	Business-as-Usual (Scenario)
BCR	Benefit-Cost Ratio
BNF	Biological Nitrogen Fixation
CBA	Cost-Benefit-Analysis
COI	Cost of Illness
DNG	Discounted Net Gains
DTR	Discounted Time of Return
DVRPU	Dry Valley Rehabilitation and Productive Use
EBITDA	Earnings before interest, taxes, depreciation, and amortization
ECA	Economics of Climate Adaptation framework
ELD	Economics of Land Degradation Initiative
ETB	Ethiopian Birr
ESS	Ecosystem Services
FAO	Food and Agriculture Organisation of the United Nations
FCFA	Franc de la Communauté Financière d'Afrique
FP	Farmer Practices
IAT	Integrated Assessment Tool
IISD	International Institute for Sustainability Development
INR	Indian Rupee
IRR	Internal Rate of Return
ISDD	International Institute for Sustainability Development
KSh	Kenyan Shilling
LSRP	Lowlands Soil Rehabilitation Project
LULC	Land use/Land cover
NDVI	Normalised Difference Vegetation Index
NPV	Net Present Value
ROI	Return on Investment
SIRR	Social Internal Rate of Return
SLM	Sustainable Land Management
SNPV	Social Net Present Value
SOC	Soil Organic Carbon
SWC	Soil and Water Conservation
UNU-EHS	United Nations University - Institute for Environment and Human Security
USD	US Dollar
WTP	Willingness to Pay

Glossary

Agroecology is a systemic approach from agricultural production to consumption, which incorporates ecological, socio-cultural, technological, economic and political dimensions. It emerged as a science and now includes agricultural practices and a social movement (cited from GIZ 2023).

Assumptions are reasonable beliefs or presuppositions made by researchers during their research about certain aspects of their study. These presuppositions serve as foundational elements for the research process, helping to shape the research questions, design, methodology, and the interpretation of results. They are necessary for progressing in the research process when certain aspects cannot be directly observed or measured.

The **Benefit-Cost Ratio (BCR)** compares the benefits of a project or investment to its costs. Calculated by dividing the present value of the expected benefits by the present value of the expected costs, a BCR with a value greater than 1 indicates that the benefits of the project outweigh the costs while a BCR less than 1 indicates that the costs are greater than the benefits.

Cost-Benefit Analysis (CBA) is a technique used to evaluate the feasibility of a project or policy by comparing the costs and benefits associated with it. CBA involves identifying all the costs and benefits of a project, quantifying them in monetary terms, and comparing the net benefits to determine whether the project is worth pursuing.

Discounted Net Gains (DNG) are a financial metric used to evaluate the net benefits of a project or intervention by considering the costs and benefits of both the intervention scenario and the counterfactual scenario. It is calculated by subtracting the net present value (NPV) of the counterfactual scenario from the NPV of the intervention scenario. A positive DNG indicates that the intervention is expected to generate net gains, whereas a negative DNG indicates that the intervention is not expected to be beneficial.

The **Discounted Time of Return (DTR)** refers to the number of years required for the cumulative discounted annual savings to offset the investment or the additional cost of investment.

The **Internal Rate of Return (IRR)** is used to measure the profitability of an investment. It is the discount rate at which the net present value (NPV) of the investment equals zero. A higher IRR indicates a more profitable investment.

Net Present Value (NPV) determines the value of an investment or project, measuring the difference between the present value of the expected cash inflows and the present value of the expected cash outflows, discounted at a specified rate. A positive NPV indicates that the investment is expected to generate value, while a negative NPV indicates that the investment is not worthwhile.

Partial Cost Accounting is a method used to assess the costs associated with a specific aspect or component of a project or activity. It involves identifying and analysing the costs that are directly related to that particular component, excluding other indirect or overhead costs. By focusing on the specific costs, partial cost accounting provides a more detailed understanding of the cost structure and allows for a more accurate evaluation of the financial feasibility of that specific component.

Return on Investment (ROI) is used to evaluate the profitability of an investment. It measures the ratio of the net profit to the initial investment. ROI is expressed as a per centage and is calculated by dividing the net profit by the initial investment and multiplying by 100. A higher ROI indicates a more profitable investment.

1. Analysing economic evidence on agroecology: An overview of the Global Programme ProSoil

Working towards sustainable soil protection and rehabilitation, the Global Programme Soil Protection and Soil Rehabilitation for Food Security (ProSoil) aims to promote sustainable land use in selected partner countries, including Benin, Burkina Faso, Ethiopia, India, Kenya, Madagascar, and Tunisia. The programme comprises several different areas of action, with correlated aims. By implementing agroecological and climate-intelligent soil protection and rehabilitation measures involving the affected smallholder farmers, the goal is to enhance food security, anchor soil protection and rehabilitation at the political, institutional, and societal level.

As a global programme it also aims to transfer knowledge and to exchange lessons learned and innovations in soil protection.

Commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) and co-funded by the European Union (EU) and the Bill & Melinda Gates Foundation, ProSoil activities have taken place since 2014, resulting in a range of evidence as to their effectivity. Since June 2021, the EU has additionally co-funded the part of ProSoil known as ProSilience, which aims to enhance the agroecological transition of agri-food systems in four of these partner countries.

This compilation of economic evidence looks at the studies and reports about ProSoil activities that were carried out between 2014 to 2023, many in partnership with the Economics of Land Degradation (ELD) Initiative **(www.eld-initiative.org)**. They were analysed in terms of their economic, social, environmental and benefits as the compilation sought to answer two key questions:

I. Are agroecological practices economically viable for smallholder farmers?

II. What are the wider economic and social benefits of agroecological practices?

The studies under review provide a comprehensive analysis of the economic impacts of agroecological measures on approximately 5,000 rural households. Located within the regional scope encompassing the ProSoil partner countries, they also include smallholder farming systems in Niger as part of the AGRICA[1] initiative.

The following measures representing a wide range of applications in agroecology, mainly at the field and landscape level, were examined in the studies reviewed[2]:

- **Soil and water conservation (SWC)** measures such as water-spreading weirs, dams and dry-stone measures, stone bunds, vegetative stripes, embankments, and other earthworks, as well as cover crops, mulching, residue management, improved or zero tillage, zaï and, half-moons.
- **Integrated soil fertility management,** including the application of manure, organic fertiliser and biochar.
- **Sustainable land management** practices such as organic farming, agroforestry, intercropping, mixed cropping, crop rotation, improved varieties and fertilising plants.

The studies employed a wide range and combinations of methods to assess the economic and monetary values associated with agroecological measures. These included the assessment of the real production data of individual households in the form of contribution margin calculations and cost-benefit analyses, model calculations of fictitious data, as well as the valuation of ecosystem services using the experimental choice method and willingness to pay. As many of these studies examined agroecological practices implemented in combination, an independent assessment of each individual measure was not always possible.

Despite the analytical challenges that arise from differences in methodology, a review of the studies can provide insights into the effectivity of the various agroecological measures. Considering these in context with the results of further programmes not affiliated with ProSoil can further guide future choices for implementing agroecological measures based on the region-specific benefits.

[1] The AGRICA project, implemented by the Potsdam Institute for Climate Impact Research (PIK) in cooperation with the GIZ GmbH on behalf of the BMZ, provides comprehensive climate risk analyses to inform science-based adaptation planning in the agricultural sector of selected countries in sub-Saharan Africa.

[2] The classification of agroecological practices investigated in the studies was made by the authors and is largely based on the classification already made by the studies themselves. Where no classification was made, the authors made it themselves.

2. Economic viability of agroecological practices for smallholder farmers

2.1 Soil and water conservation pays off in ProSoil areas

The review of the reports on agroecological measures at the farm level has shown that they make sense not only from an environmental perspective but also from an economic point of view. Altough results are dependent on preconditions and context-specific assumptions, improvements have been shown in all the projects analysed[3]. **Soil and water conservation (SWC)** measures as seen in the form of building smaller structures in the fields to stop water and soil erosion or at landscape level, for example, are popular and often implemented agroecological practices. Individual studies reveal that such SWC has nearly always paid off financially for the farmers.

The Dry Valley Rehabilitation and Productive Use approach (DVRPU) in the **Ethiopian lowlands** exhibited this; here, the use of water-spreading weirs in combination with hand dug wells led to increases in net benefits from crop and livestock production for the farmers. These study results from the Afar Region have shown that such investments in water and soil conservation pay off in the arid and pastoral context. For the **Ethiopian**

[3] It is important to acknowledge that the assumptions and data used in the analysed studies (e.g. discount rates) vary between projects, highlighting the need for careful consideration of the study context before comparing or utilising the presented numbers.

highlands, the ELD initiative calculated that agricultural yields would decrease by five per cent over the next 30 years with no change in land management but increase by ten per cent with soil and water management conservation methods applied.

In the Ethiopian lowlands, large scale soil and water conservation measures like water-spreading weirs prevent soil erosion and increase net benefits for crop and livestock producers.

On apricot and olive farms in **Tunisia**, soil and water conservation in the form of earthworks, embankments and groynes have led not only to an expansion of the production area but also to a 50 per cent increase in yields. From an economic perspective, the measures have paid off extraordinarily, with a return on investment of almost 700 per cent[4].

The Ethiopian and Tunisian findings are supported by results from Burkina Faso and India. In **Burkina Faso**, the production of sorghum, millet and corn supported with half-moon structures, the zaï method of digging small planting pits common in the western Sahel, or living as well as stony hedges have shown high profitability. They have achieved economic returns of up to 35 per cent over a period of ten years – mainly induced by large yield increases. In **India**, watershed development (e.g., drainage) has also been able to increase incomes and achieve positive BCRs as it improved farmers' access to water and thus helped them to expand their economic activities, such as diversifying their crop production.

Large-scale soil and water conservation measures often not only increase productivity but can also increase the area under cultivation.

Taken as a whole, these region-specific solutions to soil and water conservation reveal themselves to be highly beneficial to a variety of agricultural production systems.

2.2 Integrated soil fertility management measures resulting in high returns in ProSoil areas

Integrated soil fertility management (ISFM) often combines different measures in its aim to strengthen soil fertility. Applying any type of fertilising biomass resulted in very large financial benefits in all studies examined; it is always accompanied by very large yield increases at manageable costs. In **Ethiopia**, for example, the use of compost and lime, resulted in a yield increase of 70 per cent and an increase in gross margins of 85 per cent. In **India**, too, study results in ProSoil's intervention areas have shown that manure application in cereal-based cropping systems provided significant financial benefits for the farmers. At the same time, the return on labour input and labour-use efficiency decreased in this scenario, a result which must be taken into account when evaluating alternatives, especially if viable off-farm employment opportunities exist.

Two further CBAs on business models for the production and use of biochar and biofertiliser in India showed that both practices are highly profitable generating profit after two to three years. Insights from **Kenya** comparing different agroecological practices within the framework of different studies revealed that the application of manure and cover crops contributed by far to the highest yield increases and highest profitability compared to soil and water conservation, agroforestry and other sustainable land management practices. Depending on the context of the assessment, the use of manure reaches the

[4] Two factors account for the enormous productivity of the measures: An increase in yield and an expansion of the production area.

break-even point after just one to four years with benefits approximately twice as high as the costs. These experiences from ProSoil intervention areas suggest that there is a slight trade-off to be made in terms of the labour intensity but ultimately, the measures prove to be profitable in terms of crop yield and revenues.

The application of compost and manure led to significant yield i ncreases and high financial benefits in many ProSoil partner countries but was often accompanied by increased labour input.

2.3 Sustainable land management proves profitable in most ProSoil areas

Agroecological management practices, also referred to here as **sustainable land management**, have likewise proven to be very profitable in most cases despite the additional labour input. The net benefit of organic cotton production in **Benin** is on average three times higher than the average net benefit of conventional cotton production, mainly owing to the lower input costs in organic farming and higher market prices for organic cotton. When the cost of illness caused by using plant protection products is also included in the calculation, the net benefit of conventional cotton farmers would be reduced by a further 23 per cent. In **Kenya**, organic farming has also been assessed as profitable, though not to the same extent as other management measures, such as intercropping, mixed cropping and crop rotation, which always scored very highly in profitability.

Organic cotton production in Benin, despite the higher labour input, results in higher net financial benefits than conventional practices due to higher market prices and lower health costs.

Agroforestry interventions in Kenya have shown mixed results, with multiple benefits alongside comparably high investment costs. Though this may be dependent upon factors such as the farming systems used or the types of fruit trees, in some cases it is not financially profitable for the farmers. One study of small-scale farmers in **Western Kenya** found that agroforestry can achieve higher yields, yet from a purely economic perspective, the costs were not recouped over the period of the study. This may be a consequence of the length of time necessary for fruit trees to mature and produce.

The impacts of agroforestry are very context specific. Although it usually leads to yield increases and system diversification, agroforestry is not always financially viable for smallholder farmers due to the high initial investment and the need for the trees to reach a certain size first.

For the establishment of agroforestry systems on medium-scale commercial farms on the other hand, agroforestry in **Kenya** proved to be highly profitable with IRRs of up to 63 per cent. One reason could be that the initial investment costs decline with the size of the farm due to economies of scale, making agroforestry more profitable as the area grows. Another assessment of **Kenya** concluded that agroforestry shows the highest benefits when implemented together with cover crops. In combination with other practices, however, agroforestry showed fewer positive results, suggesting that the success of agroforestry, more than any other measure, is highly context dependent.

An assessment of the profitability of several different

integrated soil fertility management, soil and water conservation and sustainable land management interventions on farms in **Benin** confirmed their economic viability and positive net margins. The comparison of long- and short-term users revealed that agroecological practices need some time to fully develop their potential and benefits. If fire prevention measures were taken in **Madagascar** over 15 years and sustainable land management practices were adopted instead, the additional yield per hectare of land would increase by 126 per cent compared to if nothing was done.

Whether agroecological practices are financially viable for smallholder farmers is closely linked to the context. The majority of agroecological interventions can be considered profitable or highly profitable with some measures falling short only in a few cases or countries. However, results differ considerably depending on the research questions, measures analysed and countries or even regions within a country. Choosing and adapting the appropriate agroecological measure to match the specific context is therefore crucial to achieving a financial benefit.

Embracing agroecological practices not only empowers smallholder farmers economically by reducing production costs and increasing yields, it also fosters community knowledge exchange and social cohesion. By shifting towards agroecology, the way for more equitable and resilient agri-food systems, addressing global food challenges and striving towards food security for all can be paved.

3. Broader economic andsocial benefits of agroecological practives: Food security, climate resilience and societal health

Among the studies examined, only a few explicitly looked at specific ecosystem services other than food production. Those that did, such as in Burkina Faso and Benin, revealed that certain conclusions regarding the societal relevance of agroecology can also be derived from the results at farm level. Water-spreading weirs in **Ethiopia**, large water dams in **Tunisia** or watershed developments in **India** have positive effects on production while bringing other co-benefits. They increase, for example, the drought and flood resilience and generally improve groundwater recharge and water access by reducing the time required for water collection, which is particularly beneficial for women. In **Benin**, the application of a wide range of agroecological practices like mulching, cover crops, biochar and manure improved the economic situation of women, which in turn led to more spending on education and savings.

In addition to improved agricultural irrigation and general water supply, watershed development makes communities more resilient to floods and droughts.

Though most studies did not explicitly examine the contribution of agroecological practices to **food security**, it can be deduced from the farm level results that agroecology increases overall agricultural production.

By preventing soil erosion and increasing soil fertility, agroecological practices help to increase yields and expand cultivated areas, leading to an increase in local food production.

By preventing soil erosion and ensuring long-term soil fertility, agroecological practices in almost all cases contributed to yield increases and often led to an expansion of arable land, which presumably also led to an increase in the overall quantity of production itself. A study from **Burkina Faso** calculated that the productivity gain in the intervention area could generate an annual food surplus of over 11,017 tonnes of cereals per year, which could meet the annual nutritional needs of about 58,000 people. A larger supply of food on the market usually leads to lower food price volatility, which in turn benefits the rest of the population, as food is available not only in larger quantities but also at more stable prices. One study from **Benin** even showed that agroecological practices significantly improved the dietary diversity of households and contributed to stable food provisions and nutritional intake.

An adequate and, above all, balanced diet can contribute to a healthier population, but **public health** is affected by agricultural practices on more than just a nutritional level. A study into organic and conventional cotton farming in **Benin** clearly showed the disastrous health and economic consequences associated with the use of pesticides in conventional farming and the substantial costs that not only individual farmers but also society as a whole can avoid through organic farming methods.

Organic agriculture can reduce public health costs due to lower pesticide exposure.

Further study results suggest that certain agroecological practices can improve climate change resilience and enhance ecosystem services and biodiversity. With respect to **climate change mitigation**, an assessment of agricultural fire prevention measures in **Madagascar** found that the total losses from soil organic carbon (SOC) due to agricultural fires would be nearly EUR 1.3 billion over a 16-year period. A study from **Kenya** calculated the economic benefits to society from carbon sequestration resulting from the adoption of agroforestry and concluded that it amounts to USD 700 per year and hectare. In the same study, the societal benefits from increasing **biodiversity** after implementing agroforestry were calculated to be worth USD 170 per hectare while the reduction in air pollution was USD 670 per hectare, based on a fixed price of USD 7 per kg pollutants removed. Results from a monitoring of SPR soil protection and rehabilitation interventions conducted in ProSoil partner countries have shown that the majority are also effective in terms of climate adaptation. They generally show greater effectiveness against drought than against heat stress, as many interventions focus on water management and water harvesting techniques such as irrigation, dams, dikes, and water distribution weirs. Agroforestry stands out as a universally effective intervention against both drought and heat with high social acceptability. Given the difficulties women and disadvantaged groups face in accessing land and other resources, however, it is critical to address these issues. While there is generally a high level of social acceptance among smallholders, the results of this analysis also point to challenges related to investment and maintenance costs, limited access to finance, and the importance of knowledge and training, especially for smallholders.

Agroforestry can improve climate resilience, is effective against both drought and heat and can increase carbon sequestration and reduce air pollution.

The limits of evidence: Considering the challenges of this analysis

Conducting economic analyses in the context of smallholder farms comes with a unique set of challenges. The cost structures of smallholder farms can differ significantly from those of larger farms. Sometimes, subsistence farming, which is difficult to express in monetary terms, must be taken into account. As such, the studies have been examined through the lens of these often context-specific challenges:

Differences in data base, assumptions, and currencies make comparing monetary valuation of agroecological practices difficult:

The **monetary valuation of agroecological practices is strongly dependent on the available data and assumptions made for the assessment**. CBA results are strongly influenced by macroeconomic indicators such as the discount rate. Though conducted in similar regions and under similar conditions, the studies often used different macroeconomic indicators. While in some studies the discount rates were as low as 3.5 per cent, in other projects 15 per cent was used, making comparison of results difficult. Most studies used surveys or interviews as a basis for calculations, neglecting to consider that there are strong regional differences and that the average values used do not necessarily express the reality of all smallholder farmers. Comparing results of different cost-benefit analyses across countries is likewise challenging when currencies and time horizon differ. Conducting cost-benefit analyses in currencies with high rates of variability can also introduce uncertainty and affect the robustness of the results as exchange rate fluctuation can impact the calculated costs and benefits, potentially leading to different monetary values.

Balancing financial profitability and socio-economic outcomes looks beyond economic returns (IRR) in smallholder farm investments:

When considering an investment in a smallholder farm within a developing country, **emphasis should be placed on achieving higher net benefits and generating sustainable positive economic outcomes rather than solely pursuing the highest possible IRR.** In the context of smallholder farming in developing countries, the economic benefit alone is often not decisive, but must be in line with the improvement of livelihoods and food security. While the IRR is a valuable tool for evaluating the investment's financial performance, it may not fully encompass the long-term socio-economic impacts for both the smallholder farmers and their broader community.

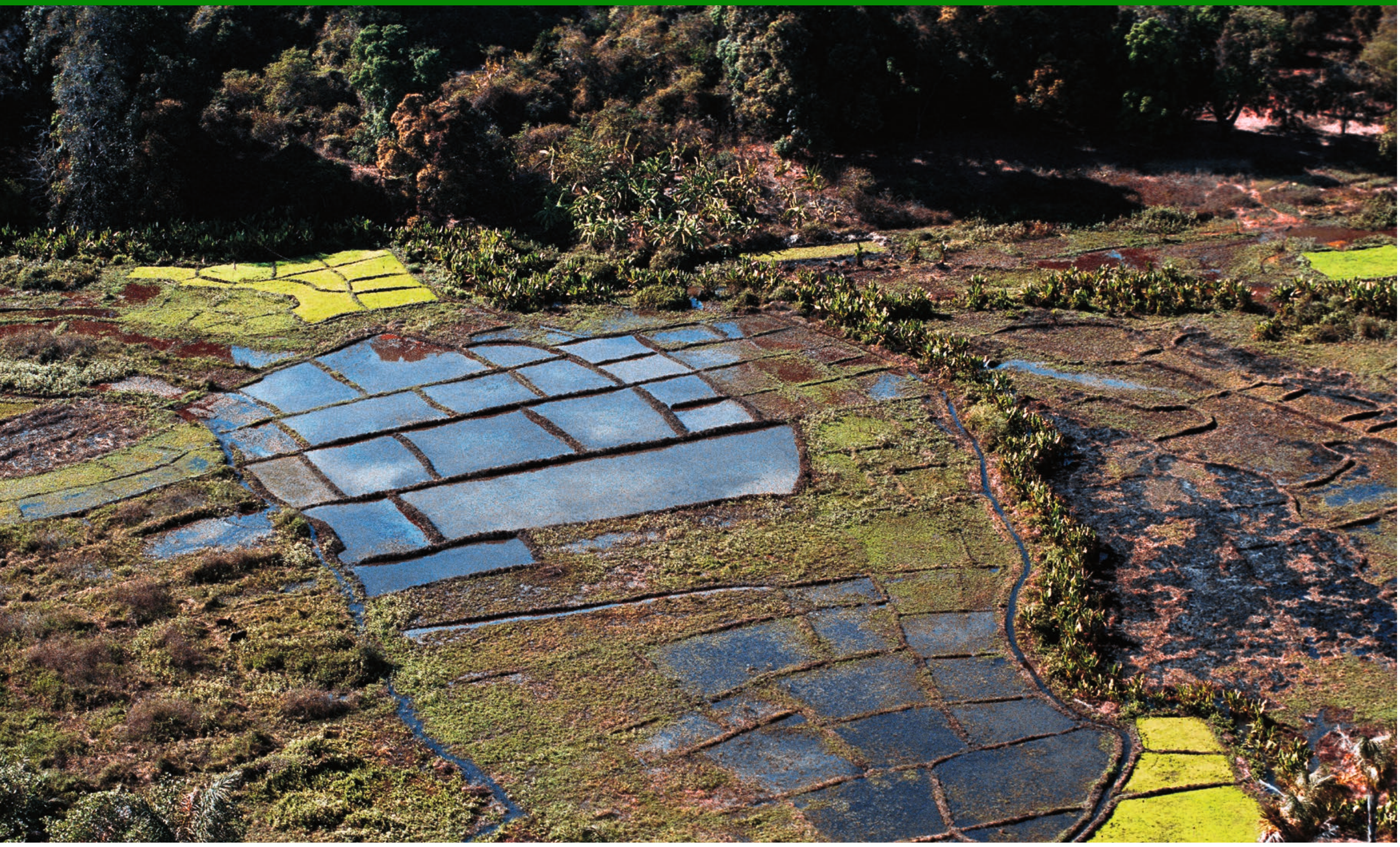
The increased labour input and associated costs in agroecology has been underestimated:

Agroecological practices often go hand in hand with a higher labour input. Often perceived as beneficial to society as increased employment opportunities can contribute to overall economic development, this increase in labour may pose challenges for individual smallholder farmers, who need to find the labour available and have the financial means to pay for additional workers. Though some economic analyses already include labour as a monetary factor, this factor is often undervalued, as wages in the countries studied are often very low. There is also a possibility of declining labour use efficiency. Even if the new practice appears financially viable, uncertainties arise as family labour, commonly predominant in smallholder farms, is difficult to monetise. Opportunity costs – the availability of viable off-farm employment options for family members – should thus be considered along with the non-remunerated family labour in cost assessments. Failing to account for the contribution of family members who work on the farm without receiving direct monetary compensation skew the results, as some measures that appear beneficial may fall short when family members consider investing time in external farm income opportunities.

Underestimating externalities creates a critical gap in agroecological assessments and decision-making:

In many of the studies analysed, both positive and negative externalities of agroecological interventions were estimated rather than calculated. While many measures are profitable from an agricultural production perspective, in terms of external effects, they were either not examined or examined separately from the production-oriented analyses. This has advantages and disadvantages. For the farmer, an assessment of the financial parameters of the agricultural production system may be essential to adopt new practices. The inclusion of external factors that are rather intangible or would first affect the farmer in the distant future may be misleading for him and his investment decision. On the other hand, the exclusion of positive and negative externalities from investment calculations can lead to an underestimation of the practices' real costs and benefits. It is not unlikely that certain practices are not financially profitable for an individual farming household in the short term but would create positive (economic) effects for society in the long term.

4. Further evidence and lessons from non-ProSoil analyses



Apart from the studies within ProSoil, other studies demonstrating the economic benefits of agroecology have been conducted. One looking at the economic impact of agroecological practices in Benin at the farm level between 1960 and 2015 and showed that the Mucuna application provided significant improvements in the economic situation of farming households (Adegbola, 2016). In another assessment, the adoption of integrated soil fertility practices led to a reduction in the seed quantities needed per hectare.

CBAs conducted in the context of AGRICA in Niger and Burkina Faso in 2021 and 2022 respectively also proved the economic profitability of select agroecological measures. The findings in Burkina Faso on the use of climate information for rainfed maize production, the adoption of integrated soil fertility management techniques for sorghum cultivation, and the switch to improved sorghum varieties indicate that all three strategies are highly beneficial and economically viable for the farmers, with switching to improved sorghum varieties offering the highest returns on investment. While both climate information for rainfed maize production and adopting integrated soil fertility management techniques for sorghum production show positive returns on investment, their NPV and IRR values are comparatively lower than those found by switching to improved sorghum varieties (Röhrig, et al., 2021). Likewise, the CBAs conducted in Niger revealed that implementing integrated soil fertility management techniques, adopting agroforestry system with millet and cowpea intercropping and producing alfalfa on irrigated fodder banks are profitable strategies. Of the three, the measure that appears to be most profitable is the improved fodder production with alfalfa (Röhrig, et al., 2022).

In the project areas of the Lowlands Soil Rehabilitation Project (LSRP), the Afar and Somali Region in Ethiopia, an impact assessment in the Economics of Climate Adaptation framework estimated the costs of damage related to climate change by 2050. It determined that in the Afar region the most cost-efficient measures were to establish improved forage storage and manage protected areas, while wetland restauration and the establishment of fodder tree and grass nurseries marked the best options for the Somali region. The establishment of communal seedbanks proved to be cost-efficient in both regions. By implementing the discussed measures over the next 31 years, the model estimated that damage costs of approximately 500 million USD could be avoided with an investment of only 10 million USD (UNU-EHS; Frankfurt School of Finance and Management, 2021).

From an investment perspective, improved sorghum varieties and Alfalfa production to improve livestock feed supply proved to be the most profitable of the various adaptation options tested for farmers in Niger and Burkina Faso.

One lower-investment measure – mulching in groundnut cultivation in Madagascar – was found to generate benefits six times higher than costs. The study conducted by the International Institute for Sustainability Development (IISD) confirmed mulching to be a quick win as it not only leads to savings in groundnut seeds and the time needed for ploughing and sowing, but also increases yield considerably.

Mulching saves time and seeds and increases yields of Malagasy groundnut farmers.

Apart from the economic benefits, a meta-analysis of more than 500 studies have shown that agroecological practices have significant benefits for biodiversity. In particular, agroforestry, organic farming and crop rotation have positive effects such as species richness and soil activity. Reduced tillage has been found to contribute strongly to increased soil microbial activity and biomass (Leippert, 2020). Agroecology has also been shown in the studies to contribute to the conservation of biodiversity and ecosystems at the landscape level beyond the farm. FAO (2023), for example, found that agroecology supports pollinators and insectivorous communities in production landscapes and promotes the movement and dispersal of species by creating friendly habitats and improving ecological connectivity.

In more than 500 studies, agroecological practices have been demonstrated to provide significant benefits for biodiversity, supporting species richness, soil activity, and conservation efforts at both farm and landscape levels.

There is likewise strong evidence and much agreement outside ProSoil that agroecological approaches also support climate change adaptation, as many principles of agroecology are directly linked to climate adaptation principles, such as harnessing synergies and systems thinking (Sinclair, 2019). The results of eight meta-analyses involving up to 40,000 comparisons and up to 3,700 experiments confirm certain agroecological practices like crop diversification and restoration activities contribute to the provision, regulation and support of ecosystem services. While there is no clear evidence of increased yields from agroforestry, the overall yield of the system is often positively influenced (Snapp, 2021), which again shows that externalities should always be taken into account in order to realistically assess the impact. Some evidence exists that agroecology also contributes to climate change mitigation by increasing the carbon content of soils and reducing emissions from chemical agricultural inputs, however, with relatively few studies in this area, there is a need for further research (Snapp, 2021).

Agroecological approaches offer substantial support for climate change adaptation, aligning with climate adaptation principles, as evidenced by meta-analyses showing the positive impact of certain practices on ecosystem services, while also showing potential for climate change mitigation, albeit requiring further research.

5. Take-aways for different target groups

5.1 Recommendations for policymakers

While several studies confirm the economic value of agroecological practices, showing that agricultural productivity can increase with the help of certain agro-ecological practices, they have also proven that yields will eventually decline if no action is taken. As a lack of financial resources or lack of access may be keeping smallholder farmers from adopting agroecological practices without the framework of a project, as many agroecological practices require initial investments for inputs, machinery or additional labour, it is crucial for policymakers to provide resources. The careful use of soil and resources and maintaining soil productivity should be considered a societal task, and priority should be given to financial support and incentives to farmers so that they may adopt and integrate agroecological practices into their farming systems. It is important, too, for farmers to recognise the necessity of preserving the productivity of soils in the long run and adapt even those measures which offer limited or no direct financial return for smallholders. In regions with high erosion rates, extensive long-term development measures may be needed before improvements can be seen so providing funds to counteract negative trends and prevent economic losses is necessary.

5.2 Recommendations for donors

The total economic value from investments into agroecological interventions depend heavily on an area's specific conditions, however, site-specific investments proved to create long-term benefits for both the environment and farmers. As considerable initial investments are required, especially for structural and input-intensive measures such as dams or tree planting, farmers may not be able to raise the necessary financial resources themselves, which is why these measures have to be initiated and supported from outside. Financial support in the form of assistance for farmers' cooperatives or as loans with special terms is particularly crucial in the early stages of implementation as regular loans are usually expensive. If payments for ecosystem services are applied in combination with other policy and informational measures, farmers may be incentivised to adopt practices that might otherwise not be economically viable for themselves but bring significant benefits to society and the environment. Donors, as the primary funding entities for research in development cooperation, should ensure that the studies they support are attuned to the specific needs and contexts of the regions where interventions are implemented.

5.3 Recommendations for practitioners in development cooperation

A few things should be considered when producing robust evidence of the positive economic and societal effects of agroecology. Since agroecology is understood as a holistic concept, it is important to evaluate the effects of agroecological practices holistically and from different perspectives (e.g., farm, landscape, market or societal perspective). While taking different approaches is useful, as is the investigation and linkage of different agroecological levels, this should be undertaken with care. To convince farmers, donors and policymakers of agroecology's advantages, it is important that the study results are reliable, have a clear reference and that measured effects can be clearly attributed to specific agroecological interventions (causality). A solid database is the best starting point for meaningful analyses, which can best be achieved by monitoring and economic evaluation on regular basis.

Considering the significant variations in preconditions, studies and their research questions must be tailored to the local context and the respective target group(s). Comparisons across different countries, even when looking at the same agroecological practices, can be difficult if the preconditions are different or the definition of certain agroecological interventions is indistinct. Mainstreaming study designs by aligning the studies' input data and assumptions can be helpful to make the monetary effects of interventions comparable. For CBAs, standardising the timeframe used for the calculations is just one example. Although the usage of the NPV is a great tool to decide which intervention is the most viable at project level, it is not useful for making comparisons across projects or even countries. For cross-project comparison, the BCR is more suitable.

In the studies examined, the results at farm level predominate. To prove the societal relevance of agroecology, more evidence is needed at the landscape and at the societal level.

Neglecting the true value of ecosystem services and disregarding the significance of externalities in agroecological assessments perpetuates a critical gap in decision-making. Comprehensive evaluation that accounts for these essential factors is imperative to fostering agriculture that is both economically and ecologically sustainable and to ensuring the long-term viability of our ecosystems.

Exploring ProSoil economic evidence through individual factsheets

As condensing complex and context specific research is a challenge, individual factsheets have been prepared for each study analysed, to complement the concise compilation of findings. These factsheets provide detailed information on the methodologies and the investigated agroecological measures and put the results into context. The agroecological practices conducted have been categorised according to their thematic focus and measured effects (economic, ecological, social, or environmental) as well as intervention areas (field/farm, landscape, market, and society), providing a better understanding of the studies' scope. Each factsheet serves as a succinct description, capturing the core elements necessary to characterise and summarise the respective study. These factsheets can be found in the Annex.

Table of contents Annex

A 1. Ethiopia 23

A1.1. Soil degradation and sustainable land management in the rainfed agricultural areas of Ethiopia: An assessment of the economic implications 23

A1.2. Integrated soil fertility management end of season evaluation: Farmer views and productivity analysis 25

A1.3. Evaluating the impact of natural resource management interventions on land, water and pastoral livelihoods in the Afar Region of Ethiopia 27

A 2. Tunisia 30

A2.1. Rainfed agriculture and ecosystem services builds resilience to climate change: A Cost-Benefit-Analysis of sustainable land management 30

A2.2. Economic evaluation of soil and water conservation management on olive and apricot tree farms in Kairouan, Tunisia 32

A 3. Benin 34

A3.1. Profitability study of sustainable land management practices, Benin 34

Comparison of economic profitability indicators for long-term, short-term and non-users of agroecological practices 37

A3.2. The economics of conventional and organic cotton production: A case study from the municipality of Banikoara, Benin 38

A4. Burkina Faso 40

A4.1. Economic gains from sustainable land management in three provinces of Burkina Faso 40

A5. Kenya 42

A5.1. Costs and benefits of sustainable soil fertility management in Western Kenya. Kenya Project Report 42

A5.2. Economics of land use management on ecosystem services: A case study of Aberdare Water Tower in Nyandarua County 45

A5.3. Cost-Benefit Analysis for climate-smart soil practices in Western Kenya 47

A6. India 50

A6.1. Economic valuation of reducing land degradation through watershed development in east Madhya Pradesh under risks of climate extremes 50

A6.2. Advancing knowledge on the costs and benefits of sustainable soil fertility management in Maharashtra and Madhya Pradesh, India 53

A7. Madagascar 55

A7.1. Support project for capacity building in the economics of sustainable land management and land degradation. Madagascar project report 55

A1. Ethiopia

A1.1. Soil degradation and sustainable land management in the rainfed agricultural areas of Ethiopia: An assessment of the economic implications[5]

KEY MESSAGE	Large-scale conservation structures can decrease soil erosion by almost 50 per cent. Economically, the best option combines conservation structures, fertilizer application and the production of fodder grass.
FOCUS	Economic and environmental effects
INTERVENTION AREA	Landscape level
METHODOLOGY	CBA, biophysical and land cover modelling
AGROECOLOGICAL PRACTICE	Soil and water conservation techniques
STUDY DESCRIPTION	**Study Aim:** To model and assess the long-term effects of sustainable land management practices and their related costs and benefits to determine the most profitable combination. A model of land cover and existing conservation structures, covering an area of 600,000 square kilometres of rain-fed cultivation **(54 per cent of Ethiopian territory)** was developed. **215,000 square kilometres were identified as cropland.** After modelling the estimated annual net soil erosion, the following four (investment) scenarios and their effects on crop production over the next 30 years, were estimated: 1. Current distribution of conservation structures and currently fertilised croplands; 2. Current distribution of conservation structures and fertilizer application on all croplands; 3. Conservation structures on all sloping cropland and currently fertilised croplands; and 4. Conservation structures on all sloping cropland and fertilizer application on all croplands. Calculation of NPV with a cost-benefit analysis (with and without fodder grass cultivation) based on: • Discount rate of 12.5 per cent • 30-year timeframe (2014 -2045) • Determined costs and benefits

[5] (Hurni, et al., 2015)

RESULTS

Before any interventions, the annual net soil erosion based on the model was estimated to be -940 million tonnes for the study area or 18 tonnes per ha, including cropland as well as conservation structures. Currently, there are soil and water conservation structures on 18 per cent of slopes steeper than 8 per cent. As 77 per cent (about 12.7 million ha) of cropland is situated on such slopes, to preserve them an additional 59 per cent of the cropland would need conservation measures. Considering only existing cropland, the annual net erosion is estimated to be -380 million tonnes (20.2 tonnes per ha) and could be reduced by 45.5 per cent to 11.8 tonnes per ha if conservation structures were implemented on all sloping croplands.

Scenario 1: BAU would lead to a decline of yields by more than 5 per cent over a period of 30 years.

Scenario 2: Current conservation structures and fertilizer application leads to an increase of production of around 3 per cent.

Scenario 3: Implements conservation measures without the application of fertilizer leads to a production similar to current values.

Scenario 4: Conservation measures and fertilizer could lead to an increase of productivity by 10 per cent

NPV statistics of the whole study area for each scenario (.1 without fodder grass .2 planting of fodder grass)

SCENARIO	1.1.	1.2	2.1	2.2	3.1	3.2	4.1	4.2
MEAN (ETB/HA)	112.744	116.522	113.589	117.356	115.300	126.678	117.311	128.689
MEAN (USD/HA)	5.754	5.947	5.798	5.990	5.885	6.466	5.988	6.568

Comparing NPVs of the conducted scenarios shows that individual adaption of management options is needed. A combination of conservation measures, fertilizer application and the cultivation of fodder grass is the most profitable in most administrative areas; in some regions, like Tigray, conservation structures have already been built or as in Amhara region, the increase in yields doesn't cover the investment costs needed to apply additional fertilizer. Areas with high erosion rates and low NPVs have the highest need for development interventions, but spatial differentiation is key to their success. For all the scenarios, the IRR was calculated and reached values over 50 per cent, with the highest rates achieved in scenario 1.1.

A1.2. Integrated soil fertility management end of season evaluation: Farmer views and productivity analysis[6]

KEY MESSAGE	Implementing integrated soil fertility management in cereal production leads to increased yields, gross margins and a positive BCR for participating households.
FOCUS	Economic effects
INTERVENTION AREA	Farm/Field level
METHODOLOGY	Participatory farmer evaluation and productivity analysis of integrated soil fertility management and conventional farming practice, benefit-cost ratio
AGROECOLOGICAL PRACTICE	Improved varieties, application of lime, manure, compost, fertilizer, and moisture harvesting, intercropping, line seeding
STUDY DESCRIPTION	**Study Aim:** To improve soil fertility and productivity by implementing different integrated soil fertility management (ISFM) measures in selected areas of the Ethiopian regions of Amhara, Oromia and Tigray. The interventions implemented were adapted to regional micro-watersheds. They included: improved varieties (wheat, maize, teff, faba bean, field pea, lupin), application of lime, manure, compost and fertilizer, moisture harvesting practices, intercropping and line seeding. **A participatory evaluation of 159 farmers was conducted**, analysing their experiences with ISFM practices they had implemented in 2016 and compared to normal farmer practices (without the implementation of integrated soil fertility management measures). In a second step, the gross margin per ha, the returns to labour per day as well as benefit-cost ratio for four major crops (maize, faba bean, teff, wheat) were calculated based on farmer-led demonstrations to analyse differences between integrated soil fertility management and normal farmer practices (FP).

RESULTS

Farmers reported increased yields along with a greater need for labour and cash after implementing Integrated soil fertility management measures. Compost played an important role in raising yields. The application of inorganic fertilizer raised concerns regarding an increasing amount needed to maintain soil fertility.

[6] (Ellis-Jones, Lichtner, Halefom, Schulz, & Deressa, 2017)

Productivity changes across crops and regions in Birr (n=159)

ITEM	ISFM	FP	INCREASE	%
Grain yield - kg	4,425	2,605	1,820	70 %
Residue yield - kg	7,716	4,702	3,015	64 %
Gross value/output	49,559	30,017	19,543	65 %
Purchased inputs	5,770	2,980	2,790	94 %
Margin over inputs	43,790	27,037	16,753	62 %
Labour and draft animal	7,812	7,640	172	2 %
Total input costs	13,582	10,620	2,962	28 %
Gross margin	**35,978**	**19,397**	**16,581**	**85 %**
Benefit-cost ratio	**3.6**	**2.8**	**0.8**	**29 %**
Labour estimate (days)	136	133	3	3 %
Returns to labour (Birr/day)	**321**	**203**	**118**	**58 %**

Besides the need to adjustments measures locally, a combination of practices is needed to increase yields.

Comparing productivity across crops and regions shows:

- a 70 per cent increase in yields compared to the current farming practices
- an increase of 64 per cent in crop residues, which is used as livestock feed
- an 85 per cent increase in gross margin.

Although the costs **for purchased inputs increased by 94 per cent**, the increased gross margin led to a **58 per cent increase in returns to labour** and a **29 per cent increase in the benefit-cost ratio.** A comparison of the four analysed crops shows increased output levels for all crops:

- wheat showed the lowest increases (54 per cent)
- maize increased by 80 per cent, resulting in increasing gross margins for all crops
- faba bean showed the biggest increase with 128 per cent.

The returns to labour increased between 46 and 87 per cent, with benefit-cost ratios increasing by up to 64 per cent. Lower but still positive effects could also be confirmed in a sensitivity analysis using higher costs for inputs or labour.

A1.3. Evaluating the impact of natural resource management interventions on land, water and pastoral livelihoods in the Afar Region of Ethiopia[7]

KEY MESSAGE	Implementing water-spreading weirs (WSWs) in conjunction with hand dug wells substantially boosts crop production by increasing the cultivation area while reducing the time spent fetching water.
FOCUS	Economic, environmental, social effects
INTERVENTION AREA	Landscape and societal level
METHODOLOGY	Documentary analysis, semi-structured interviews, observations, CBA (Benefit-Cost Ratio, DNG)
AGROECOLOGICAL PRACTICE	Watershed management - soil and water conservation through the implementation of dams and dry-stone measures.
STUDY DESCRIPTION	**Study Aim:** Water-spreading weirs were built to: • reduce run-off and erosion from sporadic flash floods, • rehabilitate degraded catchment and pasture areas in order to increase income and food security through increased yields, • produce fodder • safeguard migration routes for pastoralists. By the time of the assessment in November 2017, 34 water-spreading weirs have been built, expected to flood and rehabilitate an area of 1700 ha. Different scenarios were assumed in order to analyse effects on crop yields, livestock productivity, and improved water access for the population. A cascade of six completed weirs was used as a model for a cost-benefit analysis comparing the monetary effects of water-spreading weirs. Assuming that the cascade has a lifespan of 10 years and a total inundated area of 212 ha (35.5 ha per weir), while the discount rate is 3.5 per cent, six possible intervention scenarios were investigated:

COUNTERFACTUAL SCENARIOS		INTERVENTION SCENARIOS	
C1	Land is used for crop and livestock production	**I1**	Cascade of 6 weirs and 2 waterpoints
C2	Land is used for crop and livestock production, but affected by a major drought affecting crop and livestock benefits	**I2**	Cascade of 6 weirs only

[7] (Calow, Ludi, & Pichon, 2018)

COUNTERFACTUAL SCENARIOS		INTERVENTION SCENARIOS	
C3	Land is used for crop and livestock production, but affected by a major flood, affecting crop and livestock benefits	I3	Cascade of 6 weirs, flood damage to weir, crop and livestock benefits and 2 waterpoints
C4	Land is used for crop and livestock production and annually 5 per cent of land is lost to gully expansion	I4	Cascade of 6 weirs, flood damage to weir, crop and livestock benefits
C5	Land is used for pastoralism only	I5	Cascade of 6 weirs, drought impacting crop and livestock benefits and 2 waterpoints
C6	Land is used for pastoralism only and annually 5 per cent of land is lost to gully expansion	I6	Cascade of 6 weirs, drought impacting crop and livestock benefits

RESULTS

Assuming the volume of a weir to be 300 cubic meter, total fixed costs would add up to Ethiopian Birr (ETB) 646,560 per weir or ETB 3,879,360 for a cascade of 6 weirs. The improved access to cropland, improved pastures as well as an improved water source would directly benefit 292 households (or 2,044 people) living within approximately 1.5 km of the weirs.

Net returns would only become negative if a drought were to destroy 70 per cent of total crop yield when interventions exist. Without such measures, net returns would become negative with a 50 per cent loss.

Crop production:

	BUSINESS AS USUAL	INTERVENTION (2)
TOTAL GROSS VALUE (ETB)	233,798	1,107,771
VARIABLE COSTS (ETB)	118,578	358,137
ANNUAL NET BENEFIT (ETB)	115,219	749,634

Total variable costs for crop production without weirs is estimated at ETB 118,578 and with weirs ETB 358,137.

Annual net benefits amount to ETB 749,634 for the larger area under crops as well as the increased cultivation of high-value crops while the counterfactual scenario leads to an annual net benefit of only ETB 115,219.

RESULTS

Livestock: Baseline cultivation determines the how much livestock production improves:

- Assuming all land is under natural pasture, net livestock production is calculated to be **ETB 225,046**
- A combination of crops and natural pasture increases to **ETB 300,661**
- The intervention scenario would see benefits as high as **ETB 470,485.**

Water access: Improved health and the time saved normally spent fetching water would result in a net benefit of **ETB 2,652,423** per year, assuming that two water points are built and 100 per cent of a community switches to that improved water source using 25 litres a day of water; the initial investment costs for the implementation of a hand dug well is estimated to be **ETB 57,100.**

INTERVENTION	I1	I2	I3	I4	I5	I6
B/C RATIO	2.17	1.18	1.64	0.83	2.11	1.11

Building weirs alone is not able to generate enough revenues if no additional benefits for society (water points) are created. Although the NPV of the investment can be positive, the counterfactual scenario is economically more viable.

Discounted Net Gains (DNG) from switching from counterfactual to intervention scenarios in ETB
(DNG = NPV intervention scenario – NPV counterfactual scenario)

	L1	L2	L3	L4	L5	L6
C1	8,873,238	(1,932,433)	5,314,152	(5,491,519)	8,269,485	(2,536,186)
C2	8,987,352	(1,818,319)	5,428,266	(5,377,405)	8,383,599	(2,422,073)
C3	9,028,530	(1,777,142)	5,469,444	(5,336,227)	8,424,776	(2,380,895)
C4	9,565,350	(1,240,321)	6,006,265	(4,799,406)	8,961,597	(1,844,074)
C5	10,466,788	(338,883)	6,907,702	(3,897,969)	9,863,035	(942,636)
C6	10,822,206	16,535	7,263,120	(3,542,551)	10,218,453	(587,218)

Values in brackets are not a viable investment option.

This analysis is sensitive to assumed parameters; results may differ using different assumptions.

A2. Tunisia

A2.1. Rainfed agriculture and ecosystem services builds resilience to climate change: A Cost-Benefit-Analysis of sustainable land management[8]

KEY MESSAGE	To ensure the scaling up of SWC practices, which are highly profitable for both Tunisian strategic crops and SLM, diverse measures are necessary to ensure widespread adoption and gain efficiency. These include incentive mechanisms, land consolidation, promotion of "soft" SWC practices on farm level, reforestation, and more.
FOCUS	Economic and environmental effects
INTERVENTION AREA	Farm and landscape level
METHODOLOGY	CBA and valuation of ecosystem services (productivity change, discrete choice experiment, opportunity cost and avoided cost approach, voluntary carbon market pricing)
AGROECOLOGICAL PRACTICE	Tabias (bunds constructed around fields), terrasses and benches, individual basins, large scale water dams, rainwater harvesting technologies, and soil moisture conservation measures (e.g., plant cover and mulching)
STUDY DESCRIPTION	**Study Aim:** To create a link between agricultural practices and the ecological functions of land and ecosystems by monetizing the effects of SWC on different ecosystem services. In showing how good agricultural practices can improve ecosystem services, once improved, these could in turn contribute to the productivity and profitability of agriculture. The study follows the ELD 6+1 step approach. The assessment is based on a household survey and the production data of **397 farms** of different sizes: among them **54 per cent are solely dedicated to a single crop production** (189 olive farmers; 8 cereal farmers and 9 specialized in livestock farming). **46 per cent of the sample consists of mixed crop farming**, predominantly, olive and livestock farming and olive/cereal cultivation. The farms are located in four governorates (Béja, Siliana, Kairouan and Kasserine) in the northwest and centre-west regions of Tunisia.

8 (Hernandez, Megdiche, & Garci, 2023)

A CBA is used to compare a BAU scenario under the premise that no additional mitigation policies or measures related to SWC will be implemented beyond those already in place at the farm and landscape levels (see details above). The measures are assumed to improve ecosystem services such as agricultural productivity, soil fertility, erosion control and carbon storage etc. By improving these ecosystem services, the SLM scenario assumes among others:

- A yield increase of 25 per cent from the third year onwards;
- An increase in production volume for both olives and cereals resulting from area expansion (land consolidation measures) and yield increase;
- A reforestation of 40,000 ha;
- A price modification for olives and cereals at a premium price in recognition of fulfilling ecosystem services.

To value and monetise the ecosystem services, different evaluation methods such as productivity change method, discrete choice experiment method, opportunity cost and avoided cost approach and voluntary carbon market price approach were used.

ECONOMIC (AND ENVIRONMENTAL) RESULTS

At the farm level:

- SWC increases the yield per hectare by 88 per cent on average and by 72.9 per cent for the yield per tree.
- The combined net benefit from SWC measures for all olive producing farmers under investigation (70) is USD 75,655,216.
- The presence of dams has a significant impact on the volume of production and yield of about 94 per cent
- The combined net benefit from SWC measures for all cereal producing farmers (231) is USD 25,041,352.
- Since the installation of SWC is financed by the state, the farmers do not have additional investment costs, except additional labour costs. Hence, the total net benefit for all 397 surveyed farmers is USD 100,696,568 resulting from higher yields, higher production quantity and higher market prices for their products.

On state and societal levels:

- Through SWC implementation, soil erosion is avoided which amounts to avoided costs of USD 25,041,352 for the area under investigation (296,267 ha).
- The benefit of carbon sequestration in soil and forests amounts to USD 131,879,145 for the area under investigation.
- The total state costs to realise the SLM scenario amount to USD 32,233,643 (including costs for premium product prices, subsidies, and the implementation of SWC measures).
- The total net benefit of the costs and benefits at the farm and on state level is USD 225,383,424.

31

A2.2. Economic evaluation of soil and water conservation management on olive and apricot tree farms in Kairouan, Tunisia[9]

KEY MESSAGE	The investments into SWC measures on apricot and olive farms as well as at the landscape level are highly profitable as they increase yields and extend the cultivable area.
FOCUS	Economic effects
INTERVENTION AREA	Farm and landscape level
METHODOLOGY	CBA
AGROECOLOGICAL PRACTICE	SWC on farm level (i.e. clearing jujube trees, combination of earthworks, embankments, groynes and nitrogen fixation) and SWC measures on landscape level that are implemented upstream of a large water dam to limit siltation
STUDY DESCRIPTION	**Study Aim:** To assess the economic profitability of SWC measures at the farm and landscape levels in the governorate of Kairouan in Tunisia. Conducted in the framework of the GIZ project “Promotion of Sustainable Agriculture and Rural Development in Tunisia” (PAD), the study used three CBAs for the investments in different SWC measures on two different farms and for the investment in the improved management of a water reservoir (including a water dam) over a 10-year period. To do this, the CBAs compared agricultural production scenarios “with SWC” with production scenarios “without SWC” (= BAU scenarios). The SWC interventions are expected to increase agricultural yields and revenues, which are included in the calculation as part of the benefits. The assessment and the calculations are based on a technical survey and estimates as exact economic data was not available. A discount rate of 10 per cent is applied.

[9] (Quillérou, 2016)

RESULTS

INTERVENTION LEVEL	FARM 1 (APPROX. 15 HA)	FARM 2 (APPROX. 15 HA)	LANDSCAPE LEVEL (WATER RESERVOIR)
TYPE OF SWC PRACTICE	Clearing Jujube tree	Earthworks, embankments, groynes, nitrogen fixation	SWC measures upstream of a dam
NPV	TND 594,789 (EUR 250,564[10])	TND 567,653 (EUR 239,132)	TND 1,935,812 (EUR 815,491)
IRR	233 %	688 %	76 %

Farm 1: The gross margin for apricot production increased sharply with the clearing of jujube trees. This implementation of SWC measures increased production, which is offset by the increase in yields and the expansion of area that can be cultivated. Apricot yields could be increased by 50 per cent from 2 tonnes per hectare to 3 tonnes per hectare while olive yields also increased by 50 per cent from 1 tonnes per hectare to 1.5 tonnes per hectare. The results from the CBA show that with an IRR of 233 per cent, and a NPV of EUR 250,546 (for a 15-ha farm), **the investment is very profitable for the farmer.**

Farm 2: The gross margin of apricot and olive production increases even more intensely than on farm 1 by implementing a combination of earthworks as SWC-measures. The apricot yield increased by 52 per cent from 16.4 tonnes per hectare to 25 tonnes per hectare and the olive yield by 54 per cent from 1.3 to 2 tonnes per hectare. As on farm 1, the increase in yield and the expansion of cultivated area can compensate for the investment costs in SWC. With an IRR of 688 per cent and a NPV of EUR 239,132 (for a 15-ha farm), the **investment in earthworks is even more profitable than the investment in clearing jujube trees**, as the cost of earthwork construction is only about half that of clearing jujube trees.

The **CBA results** (see Table above) show that the investment into the construction of SWC measures upstream from a large water dam, with a water holding capacity of 377 million cubic meter and a drainage area of 1,000 hectares, is highly profitable. Even if the initial investment costs lead to a negative net benefit in the first year, from the second year onwards, the net benefit from SWC is positive and growing every year due to the increased water storing capacity and the decreasing maintenance costs of the dam. The IRR of the investment is 76 per cent and the NPV reaches a value of EUR 815,491 after ten years.

[10] The conversion into euros is based on an average exchange rate of 2.37 TND in 2016, the year the study was prepared.

A3. Benin

A3.1. Profitability study of sustainable land management practices, Benin[11]

KEY MESSAGE	Agroecological practices are economically profitable and generate positive net margins by strongly contributing to yield increases. Comparing their application over the long term these practices show they need some time to fully develop their potential, with benefits from decreasing investment costs over time. Agroecological practices likewise improve dietary diversity, climate change resilience and the social stability of communities
FOCUS	Economic, social (and environmental) effects
INTERVENTION AREA	Farm and landscape (community) level
METHODOLOGY	Survey, total budgeting
AGROECOLOGICAL PRACTICE	Biochar, animal manure, residue management, mulching, cover crops, perpendicular tillage, no tillage, stone bunds, crop rotation, mucuna, pigeon pea, agroforestry, improved varieties, improved livestock fencing
STUDY DESCRIPTION	**Study Aim:** To evaluate the economic performance of 45 agroecological practices implemented by farmers in ProSoil's intervention areas in Benin. It assesses the climate change resilience of beneficiary farmers, the social impacts of these measures, the household food diversification and the areas to which women's spending is directed. Three categories of farmers are compared: Farmers using agroecological practices for five years, farmers using the practices in the first year along with a control group of farmers not using agroecological practices. Comprised of 418 beneficiary and 210 control group farmers, the net margins of cereal, cotton and peanut production with and without agroecology were calculated and compared in production data. Surveys were used to evaluate the food diversification of beneficiary and non-beneficiary households, women's income expenditure and the resilience of farmers against climate change.

[11] (Lable Conseils, 2023)

RESULTS

Investment costs per hectare: Among the most expensive practices are the application of animal manure, stone bunds, biochar, improved fencing of livestock and perpendicular tillage. The cultivation of mucuna and pigeon pea, residue management, intercropping and no/little tillage have the lowest investment costs.

Yield increase: Crop residue management, mulching and the cultivation of pigeon pea or mucuna are the measures that generated the highest yields on the main crops for both the farmers who implement agroecology for five years and the farmers who implement agroecology for one year. In general, yields of farmers who have implemented these practices over the long term are significantly higher than of those who do not implement agroecological practices at all or only for one year.

Rentability: The profitability of agroecological practices was assessed for all main crops, and for the totality of all measures, but as they did not distinguish between individual practices, no statement can be made as to whether one practice is economically more feasible than another. The comparison of the different types of farmers (see Table 2), however, shows that amongst all main crops, **the highest profitability by far is reached by the farmers implementing agroecological practices for five years**. Farmers implementing agroecological practices for one year still generate higher returns than the farmers without agroecological practices, though these returns are rather marginal.

Dietary diversity of farming households: There is a significant difference between the dietary diversity of households applying agroecology for the fifth consecutive year and non-adopters. There is no significant difference between the dietary diversity of newly applying farmers and "older" farmers nor between the new farmers and non-adopting farmers

Climate change resilience: The Climate Change Resilience Index (CCRI) is better for farmers applying agroecology for the fifth consecutive year (0.38) than for new farmers (0.36). Both of these indices are better than the controls (0.34).

Social and environmental impact of households applying agroecology over the long term: An important social impact noted was that 86 per cent of all farmers reported they are now seen as a resource person in their community and treated with more respect. Women used their additional income mainly to meet family needs (35 per cent), to invest in farming and livestock rearing (23 per cent), to educate their children (10 per cent) and as savings (13 per cent). From an environmental perspective, 86 per cent of farmers confirmed the restoration of soil texture and colour after applying agroecological practices. Almost half of the farmers surveyed reported a decrease in soil erosion and an improvement in water conservation. More than 90 per cent of growers even reported a decrease in deforestation.

VILLAGE TYPE	MAIN CROP	REVENUE IN FCFA/HA	VARIABLE COSTS IN FCFA/HA	FIXED COSTS IN FCFA/HA	TOTAL COSTS IN FCFA/HA
5 YEARS OF IMPLEMENTING AGROECOLOGICAL PRACTICES	Cotton	589,138	87,352	104,627	191,979
	Yam	4,952,960	67,079	67,780	134,859
	Corn	553,228	93,415	90,398	183,813
	Manioc	2,235,618	98,294	83,552	181,846
1 YEAR OF IMPLEMENTING AGROECOLOGICAL PRACTICES	Peanut	96,315	67,574	9,913	77,487
	Cotton	368,900	223,248	269,020	492,267
	Yam	5,853,087	360,619	208,954	569,573
	Corn	267,200	136,872	93,518	230,390
	Manioc	1,074,684	132,912	169,470	302,382
	Soybean	392,815	117,605	109,393	226,998
NO IMPLEMENTATION OF AGROECOLOGICAL PRACTICES	Peanut	145,583	67,425	6,910	74,335
	Cotton	362,166	137,271	285,521	422,792
	Yam	4,992,105	221,791	383,361	605,152
	Corn	155,888	1,950	80,055	202,004
	Manioc	619,294	173,250	141,821	315,071
	Soybean	264,460	107,228	47,486	154,714

Comparison of economic profitability indicators for long-term, short-term and non-users of agroecological practices

VILLAGE TYPE	GROSS MARGIN IN FCFA/HA	NET MARGIN IN FCFA/HA	MEAN DAYS PER HA	RETURN ON LABOUR IN FCFA/HA	IRR
5 YEARS OF IMPLEMENTING AGROECOLOGICAL PRACTICES	501,787	397,160	196.71	2,019	0.85
	4,885,882	4,818,102	47.30	101,867	23.96
	459,813	369,416	92.16	4,008	1.18
	2,137,324	2,053,772	38.36	53,544	8.72
1 YEAR OF IMPLEMENTING AGROECOLOGICAL PRACTICES	28,742	18,829	12.63	1,491	0.20
	145,653	- 123,367	921.87	- 134	- 0.07
	5,492,468	5,283,513	34.43	153,473	8.55
	130,328	36,810	29.39	1,252	0.14
	941,771	772,302	14.02	55,073	2.40
	275,210	165,818	29.88	5,550	0.62
NO IMPLEMENTATION OF AGROECOLOGICAL PRACTICES	78,158	71,248	12.23	5,824	07.8
	224,895	- 60,626	19.02	-3,187	- 0.13
	4,770,314	4,386,953	17.74	247,291	6.96
	33,939	- 46,116	116.46	- 396	-0.13
	446,044	304,224	14.62	20,807	0.91
	157,232	109,746	37.37	2,937	0.53

A3.2. The economics of conventional and organic cotton production: A case study from the municipality of Banikoara, Benin[12]

KEY MESSAGE	The average per-hectare incomes of organic cotton farmers in Banikoara are nearly twice as high as those of conventional cotton farmers or triple when input subsidies for conventional farmers are excluded. The total economic damage from conventional cotton farming amounts to an average cost of EUR 174 per household for the entire population studied.
FOCUS	Economic and social effects
INTERVENTION AREA	Farm level
METHODOLOGY	Budgeting and prevalence-based cost of illness (COI) approach
AGROECOLOGICAL PRACTICE	Organic farming, i.e. replacement of synthetic fertilisers and chemical pesti-cides with compost, manure and bio-pesticides
STUDY DESCRIPTION	**Study Aim:** By assessing and comparing the benefits and costs of organic and conventional cotton production, this analysis sheds light not only on production costs, but also on the health costs associated with conventional cotton production. Based on a survey of **90 randomly sampled organic cotton producers and 190 randomly sampled conventional cotton producers** in September 2016 in the municipality of Banikoara in Northern Benin, researchers gathered information relating to enterprise budgets, crop yields, input quantities, costs and farm gate prices for cotton, health-related incidences following the spraying of pesticides and barriers to adoption. To calculate the economic return on investment for the organic and conventional cotton farmers, partial cost accounting was applied. The health-related costs of pesticide use were estimated using a prevalence-based COI approach that measures the costs of an illness including all medical care costs and morbidity costs for a disease within the study-year.

[12] (Westerberg, 2017)

RESULTS

Economic return: Organic cotton farmers earn incomes three times higher per hectare, as organic farmers have significantly lower input costs despite having revenues similar to conventional producers. The net benefit of organic cotton producers is EUR 244 per ha while the average net benefit of conventional cotton farmers is only EUR 77 per ha. The major reason is that conventional cotton production is highly input intensive with expenditures on pesticides representing 50 per cent of all input costs (96 EUR per hectare out of a total cost of 187 EUR per hectare). Even if conventional cotton produces about 50 per cent higher yields than organic cotton (1,060 kg/ha vs. 697 kg/ha), the higher market price for organic cotton ensures similar revenues of about EUR 315 per ha for both organic and conventional cotton production.

Including the cost of illness caused by pesticides would have reduced the net benefit for the conventional cotton farmer by 23 per cent. If government expenditure for subsidising farm inputs had also been accounted for, the true net-benefit for a conventional farmer on an average-sized farm would be reduced by 66 per cent.

The assessment, however, has neglected to note that the required labour for organic cotton farming is significantly higher than that for conventional farming. In this study, **organic farmers spend an additional 24 labour days/hectare per year**, relative to non-organic farmers. As this labour is often done by family members, no costs have been applied. If the labour costs had been calculated on the basis of a locally customary daily rate, the result might have been different.

Cost of illness: The average cost of illness (COI) from using plant protection products has been calculated at about EUR 84 per year per household affected. Overall, **70 per cent of the surveyed conventional cotton farmers experienced short term health problems** due to the use of plant protection products. One-quarter of the conventional cotton farmers have experienced long-term illnesses that are likely attributed to pesticides, **costing an average of EUR 35 per affected household per year**. In addition to private health impacts, the spraying of pesticides also inflicts external costs on neighbouring households resulting from the loss of crops and domestic animals. The total economic damage cost combining COI, crop and livestock loss amounts to an average cost of EUR 174 per household for the entire population studied.

A4. Burkina Faso

A4.1. Economic gains from sustainable land management in three provinces of Burkina Faso[13]

KEY MESSAGE	At the farm level, the implementation of zaï, half-moons, contour strips and living hedges in cereal production is highly profitable, paying off within five years. At the landscape level, the total economic value of ecosystem services that could possibly be maintained by the implemented measures is approximately USD 250 per ha/year.
FOCUS	Economic and social effects
INTERVENTION AREA	Farm and landscape level
METHODOLOGY	CBA and ecosystem valuation (producers' willingness to pay (WTP))
AGROECOLOGICAL PRACTICE	Zaï, half-moons, stony strips, grassy strips and living hedges
STUDY DESCRIPTION	**Study Aim:** To evaluate the profitability and monetary value of selected SWC measures implemented between 1988 and 2004 under the PATE-CORE project in three provinces in the central region of Burkina Faso covering an area of 44,067 ha. Based on a survey of 300 farmers, a CBA measures the profitability of SWC with respect to productivity increases. To calculate the IRR, the discounted time of return (DTR) and the NPV, the investment costs for SWC measures are compared with the revenues from production gain over a period of ten years for sorghum, millet and corn cultivation. The total economic value of selected ecosystem services possibly improved by the application of SWC measures is calculated based on the farmers' WTP[14] for these services. The evaluated ecosystem services include fodder and water gains, biodiversity enhancement, and strengthened mutual social assistance within the community. The resulting total economic value of all ecosystem service gains corresponds to the costs that can be avoided through SWC.

RESULTS

Financial profitability of SWC in cereal production: Measured over a time horizon of 10 years and at a discount rate of 10 per cent, **the interventions are profitable for the farmers**. After 10 years, the net present value for one ha of millet is FCFA 387,271, for one ha of sorghum it is FCFA 330,436 and for one ha of

[13] (Traore & Requier-Desjardins, 2019)

[14] Willingness to pay is defined as the maximum price producers are willing to pay for the improvements to be implemented (presence of services and positive impacts).

corn it is FCFA 273,280. Depending on the crop, the IRR ranges between 35 per cent (for millet) and 8 per cent (for corn) (see Figure 2). Under a global rentability perspective, any IRR higher than 6 per cent marks a profitable investment. For the investment into SWC in sorghum and millet production, the break-even point is between three to four years; in corn the break-even year is after four to five years.

CBA for the application of SWC in cereal production

DISCOUNT RATE		ECONOMIC INDICATORS		
		NPV (FCFA)	IRR	DTR (YEARS)
10 %	Sorghum	330,436	22 %	3 to 4
	Millet	387,271	35 %	3 to 4
	Corn	273,280	8 %	4 to 5

Economic value of ecosystem services that can be improved through SWC:

The total economic value for all selected ecosystem services including fodder production, water availability, biodiversity and mutual aid has been estimated to be **FCFA 162,000 per hectare and year**. This is the maximum WTP of the farmers involved. Among the individual ecosystem services, water availability has the highest value with FCFA 36,100 per hectare and year, followed by mutual aid between farmers, which is estimated to have a value of FCFA 29,700. With FCFA 16,800 per hectare and year, the increase in biodiversity has the lowest economic value. Added up over the entire lifetime of 10 years expected for SWC measures, the WTP for the quantity of water accumulated thanks to one ha with SWC is FCFA 361,500, and the willingness to pay for an intact social cohesion useful, for example, for the construction of infrastructure or mutual resource use, is FCFA 297,000.

Monetary value of ecosystem services gains per year and hectare

SERVICE	METHOD OF CALCULATION	FCFA/YEAR/HA
HARVEST GAIN	CBA on a representative sample	52,250[15]
STRAW GAIN	Experimental choice method, evaluation of producers' WTP	27,400
WATER	Experimental choice method, evaluation of producers' WTP	36,100
BIODIVERSITY	Experimental choice method, evaluation of producers' WTP	16,800
MUTUAL AID	Experimental choice method, evaluation of producers' WTP	29,700
TOTAL		**162,250**
SITUATION WITHOUT SWC	Experimental choice method, evaluation of producers' willingness to receive	**-330,300**

[15] This amount was calculated by multiplying the surplus by the average price of cereals in 2018 (250*209=52,250).

A5. Kenya

A5.1. Costs and benefits of sustainable soil fertility management in Western Kenya. Kenya Project Report[16]

KEY MESSAGE	Sustainable land management practices such as manure application, intercropping, terraces and agroforestry have led to an increase in crop productivity when implemented. Manure has the greatest positive effects while agroforestry is not a financially viable option.
FOCUS	Economic effects
INTERVENTION AREA	Farm/field level
METHODOLOGY	Surveys, consultation and interviews with experts, CBA (NPV, BCR, ROI)
AGROECOLOGICAL PRACTICE	Application of manure, intercropping, construction of physical terraces and agroforestry structures
STUDY DESCRIPTION	**Study Aim:** To assess a dataset from 2014 that included 320 farming households as well as a second survey of 60 people to fill in the gaps regarding the costs and benefits of the implementation of sustainable land management practices. Besides general data on farm size, labour use and yield/kg, more specific information like the gross and net profit as well as the costs of sustainable land management measures were gathered. Although data was gathered for the three counties Siaya, Kakamega and Bungoma, average values are considered. The conducted CBA is based on sustainable land management practices implemented in 2015, assuming their operation till 2030 using values based on farmers' estimations. Discount rates used are 3.5 per cent, 5 per cent and 10 per cent The CBA is focused on the cultivation of maize (mostly grown) as well as on the four most used sustainable land management practices - manuring (a), intercropping (b), physical terraces (c) and agroforestry (d), whereas the business-as-usual scenario (BAU) assumes no implementation of SLM measures but all other management activities continue.

[16] (Dallimer, Stringer, Osano, Njoroge, & Wen, 2016)

RESULTS

Data gathered from the first survey shows that farmers grew, on average, 2.9 crops, mostly maize (62 per cent), and had 3.6 heads of cattle. The annual household income from farming was between KSh 90,000 and KSh 1,212,000. In the three years prior to data collection, 72 per cent of farmers (229) had experienced land degradation and 63 per cent employed at least one SLM practice. Farmers were also found to be more likely to adapt sustainable land management practices if they had contact with a crop advisor or if the household was led by a woman, though this differs largely depending on the area, the practice implemented or the membership of a farmers group. Farmers who participated in the second survey grew, on average, 3.4 crops, mostly maize (85 per cent), had 3 cattle and poultry. The annual household income from farming was between KSh 2,200 to KSh 5,600,000. 59 farmers had implemented sustainable land management practices, mostly manuring and intercropping. Perceived benefits from implementing sustainable land management practices vary extremely in the regions studied, a variation which is neglected in this consideration where only average values are used; the study is therefore not representative.

SUSTAINABLE LAND MANAGEMENT PRACTICE	FULL BENEFIT EXPECTED (AFTER YEARS)	ANNUAL BENEFIT (KSH/ACRE)	ANNUAL LABOUR COST (KSH/ACRE)	DECREASE IN LABOUR HOURS (PER ACRE)	INCREASE IN YIELDS (KG/ ACRE)
A) MANURE	3	20,639	2,445	29.2	626
B) INTERCROPPING	3	9,240	2,160	8.7	46
C) PHYSICAL TERRACES	5	9,826	2,249	22.3	249
D) AGROFORESTRY	5	1,817	745	26.7	61

SUSTAINABLE LAND MANAGEMENT PRACTICE	MEASURES	R=3.5 %	R=5 %	R=10 %
A) MANURE	NPV (KSh/acre)	140,000	125,000	88,200
	BCR	2.50	2.47	2.38
	ROI period (years)	1.02	1.02	1.01
B) INTERCROPPING	NPV (KSh/acre)	46,900	42,500	31,900
	BCR	1.95	1.94	1.93
	ROI period (years)	0	0	0
C) PHYSICAL TERRACES	NPV (KSh/acre)	46,400	39,500	23,000
	BCR	2.13	2.04	1.77
	ROI period (years)	4.95	5.07	5.54
D) AGROFORESTRY	NPV (KSh/acre)	-7,470	-7,710	-8,200
	BCR	0.624	0.582	0.459
	ROI period (years)	-	-	-

Although the application of manure and intercropping positive NPVs are reached under all assumed discount rates (3.5 per cent, 5 per cent and 10 per cent) within year one, it takes longer for the implementation of physical terraces (approximately 5 years) and never turns into a profitable investment for the agroforestry scenario.

A5.2. Economics of land use management on ecosystem services: A case study of Aberdare Water Tower in Nyandarua County[17]

KEY MESSAGE	A comparison of 12 different combinations of sustainable land management practices showed that agroforestry with crop rotation and vegetative stripes had the biggest financial benefits for farmers; agroforestry and organic farming as well as mixed cropping and other practices were still profitable, though less so.
FOCUS	Economic effects
INTERVENTION AREA	Field/Farm and landscape level
METHODOLOGY	Survey, CBA (BCR, NPV ROI)
AGROECOLOGICAL PRACTICE	Terracing, agroforestry, cover crops, vegetative strips, mixed farming, mixed cropping, organic farming, and crop rotation
STUDY DESCRIPTION	**Study Aim:** A comprehensive multistage analysis of the costs and benefits associated with various sustainable land management practices. Initially, 253 farmers were surveyed to determine which alternative land management options they had adopted between 2010 and 2015. Based on their responses, the researchers created 12 categories of farmers' favourite combinations (as laid out in table below). The study further assessed land degradation patterns using the Normalized Difference Vegetation Index (NDVI) as a proxy over a 28-year period from 1990 to 2018. A cost-benefit analysis (CBA) covering a 20-year timeframe (2010-2030) to evaluate the various land management options was also undertaken. For the CBA, it was assumed that the annual production costs would increase by 8 per cent while the annual revenue is expected to increase by 5 per cent. For management options including agroforestry components, constant revenue was assumed for the first three years, 10 per cent per annum for the years four to six and then a further 5 per cent through year 20. To calculate the NPV, discounting was done using 3 per cent, 7 per cent and 15 per cent. Estimated total NPVs were obtained by adding NPVs for the 20-year period for each practice. Further, the BCR as well as the ROI were calculated.

RESULTS

Image analysis indicates a land cover change over the past 28 years. Areas under cropland increased from 1990 to 2010 but remained steady afterwards, area under grassland decreased during the same timeframe, while forests remained relatively unchanged throughout the analysed timeframe. The survey shows that most respondents own between one and two acres of land, mainly used for mixed subsistence farming, with land under crop production varying across the sampled regions. The amount of water used is shared equitably between domestic use and feeding the livestock while most of the households use tap water (55.6 per cent). Other sources include harvested rainwater (29.2 per cent), water from rivers/streams (4.4 per cent), and wells (3.6 per cent).

The cost-benefit analysis showed positive results for all assumed scenarios (NPVs are displayed in million KSh):

[17] (Gichua, et al., 2020)

	NPV IN MILLION KSH	BAU SCENARIO INTEREST RATE 7 %	BEST-CASE SCENARIO INTEREST RATE 3 %	WORST-CASE SCENARIO INTEREST RATE 15 %
AGROFORESTRY AND CROP ROTATION	NPV	1.83	2.58	1.08
	BCR	**1,74**	**1,69**	**1,84**
AGROFORESTRY AND VEGETATIVE STRIPS	NPV	1,18	1,67	0,70
	BCR	**1,72**	**1,67**	**1,82**
TERRACING AND AGROFORESTRY	NPV	0,95	1,32	0,57
	BCR	**1,58**	**1,53**	**1,67**
AGROFORESTRY AND COVER CROPS	NPV	1,01	1,43	0,59
	BCR	**1,88**	**1,83**	**1,99**
VEGETATIVE STRIPS	NPV	1,40	1,97	0,83
	BCR	**2,06**	**1,98**	**2,21**
AGROFORESTRY AND MIXED FARMING	NPV	0,61	0,84	0,38
	BCR	**1,14**	**1,37**	**1,49**
TERRACING AND OTHER PRACTICES	NPV	1,08	1,51	0,65
	BCR	**1,94**	**1,87**	**2,09**
COVER CROP AND OR-GANIC FARMING	NPV	1,05	1,47	0,62
	BCR	**2,0**	**1,92**	**2,15**
CROP ROTATION	NPV	0,55	0,76	0,34
	BCR	**1,66**	**1,59**	**1,78**
AGROFORESTRY AND ORGANIC FARMING	NPV	0,16	0,21	0,11
	BCR	**1,28**	**1,24**	**1,35**
TERRACING AND OTHER COMBINATIONS WITHOUT AGROFORESTRY	NPV	0,31	0,42	0,19
	BCR	**1,54**	**1,48**	**1,65**
MIXED CROPPING AND OTHER PRACTICES	NPV	0,09	0,10	0,07
	BCR	**1,21**	**1,16**	**1,30**

A5.3. Cost-Benefit Analysis for climate-smart soil practices in Western Kenya[18]

KEY MESSAGE	Implementing improved hybrid seeds as well as inorganic fertiliser is most cost-effective on medium-sized farms; intercropping is best suited for small-scale farms while liming is best for large-scale farms.
FOCUS	Economic, social, environmental and climate effects
INTERVENTION AREA	Field/farm level
METHODOLOGY	CBA (NPV, IRR, SNPV, SIRR), interview, workshop, focus group discussion, survey
AGROECOLOGICAL PRACTICE	Intercropping, organic manure, agroforestry, improved hybrid seeds, inorganic fertiliser and liming
STUDY DESCRIPTION	**Study Aim:** To assess which benefits and costs occur when implementing climate-smart soil practices as well as look at how social externalities associated with these can be incorporated into the benefits. After identifying five farm types, a household survey (structured questionnaire, 88 households) was conducted in 2016 that identified eight practices based on a priority ranking: • Small-scale mixed subsistence farming (intercropping, organic manure) • Medium-scale with mixed commercial dairy (agroforestry) • Medium-scale with commercial horticulture (improved tomatoes seeds, organic manure) • Medium-scale mixed with commercial cereals (improved hybrid seeds, inorganic fertiliser) • Large-scale commercial farming (liming) The cost-benefit analysis is based on average inputs and outputs for all activities affected by the climate-smart soil measures. Lifecycle periods are based on household surveys as well as data from literature, using a five-year period for the Business-as-Usual (BAU) scenario.

[18] (SK, A, CM, C, & E., 2017)

Values considered were the sum of enhanced yield and reduced labour minus implementation, maintenance and operation costs. A discount rate of 9 per cent was used for the calculation of the NPV. The cost of the BAU scenario was taken as the cost incurred by farmers to implement and maintain a farming activity per hectare before the adoption of the climate-smart soil practice, while the costs for the implemented practice includes all expenses related to the adoption, implementation, and ongoing maintenance. To assess social and environmental effects, the social net present value (SNPV) as well as social internal rate of return (SIRR) were calculated based on the sum of private NPV as well as the enhanced social benefits (increase in labour). Environmental benefits (agroforestry) were analysed assuming the average change of biodiversity after planting trees on the farm. For the other practices, there was no calculation conducted in this regard.

RESULTS

Of the 88 households interviewed, 80 were considered. Respondents were evenly distributed in the three investigated countries with the majority headed by males and having 21 years of farming experience. Based on the information gathered, the following values could be determined: To assess the environmental benefits, the average change in biodiversity after implementing trees on the farm was computed, showing a benefit of around USD 170 per ha for households that had adopted agroforestry practices. Carbon sequestration amounted to USD 700 with the reduction of air contamination of 670 per hectare per year over the entire lifecycle. The value of soil improvement was estimated at USD 13 per hectare per year. Nitrogen fixed due to the implementation of intercropping in the small-scale mixed subsistence farm typology was estimated to be about USD 81 per hectare per year, whereas in all the practices where legumes were grown, the value of nitrogen fixed was estimated to range between 11 and USD 15 per hectare per year. Social benefits (labour) were visible after implementing all eight practices.

FARM TYPOLOGY	CLIMATE-SMART SOIL PRACTICE	IMPLEMENTATION COSTS (USD/HA)	MAINTENANCE COSTS (USD/HA/YEAR)	OPERATION COSTS (USD/HA)	NPV (USD)
SMALL-SCALE MIXED SUBSISTENCE FARMING	ORGANIC MANURE	84	73	60	2,857
	INTERCROPPING	693	457	31	5,218
MEDIUM-SCALE WITH MIXED COMMERCIAL DAIRY	AGROFORESTRY	400	234	145	6,216
MEDIUM-SCALE WITH COMMERCIAL HORTICULTURE	IMPROVED TOMATO SEEDS	1,347	272	200	4,346
	ORGANIC MANURE	1,114	588	459	4,889
MEDIUM-SCALE MIXED WITH COMMERCIAL CEREALS	IMPROVED HYBRID SEEDS	1,550	510	211	6,767
	INORGANIC FERTILISER	756	455	142	6,730
LARGE-SCALE COMMERCIAL FARMING	LIMING	743	202	297	5,164

FARM TYPOLOGY	CLIMATE-SMART SOIL PRACTICE	IRR (%)	PAYBACK PERIOD (YEARS)	LIFECYCLE (YEARS)	SNPV (USD/HA/LIFECYCLE))	SIRR (%)
SMALL-SCALE MIXED SUBSISTENCE FARMING	ORGANIC MANURE	36	2	5	3,981	52
	INTERCROPPING	58	3	10	5,973	46
MEDIUM-SCALE WITH MIXED COMMERCIAL DAIRY	AGROFORESTRY	63	4	7	13,315	135
MEDIUM-SCALE WITH COMMERCIAL HORTICULTURE	IMPROVED TOMATO SEEDS	48	4	10	4,418	48
	ORGANIC MANURE	48	4	6	6,562	62
MEDIUM-SCALE MIXED WITH COMMERCIAL CEREALS	IMPROVED HYBRID SEEDS	66	3	9	6,840	67
	INORGANIC FERTILISER	70	3	15	12,126	130
LARGE-SCALE COMMERCIAL FARMING	LIMING	59	3	12	5,264	60

A6. India

A6.1. Economic valuation of reducing land degradation through watershed development in east Madhya Pradesh under risks of climate extremes[19]

KEY MESSAGE	Implementing watershed development measures helps to reduce soil erosion in upper areas, decreasing soil accumulation in lower areas with positive effects on crop production and reduced times for water fetching.
FOCUS	Economic, Social, Environmental and Climate Effects
INTERVENTION AREA	Farm/Field and landscape level
METHODOLOGY	CBA (NPV, CBR), Interview, Survey, Focus group discussion, Model, Total economic valuation (TEV)
AGROECOLOGICAL PRACTICE	Watershed development area treatment, afforestation on forest and private lands, drainage line treatment, capacity enhancement, institutional building, promotion of agriculture and livelihoods
STUDY DESCRIPTION	**Study Aim:** To assess the land degradation status in project and control villages, conduct an economic valuation using cost-benefit analysis (CBA), and analyse climate extremes in selected agroecological zones. Watershed development measures were implemented in four villages Dungairya (1a), Partala (1b), Katangi (2) and Kareli (3) between 2008-2011 as well as 2012-2017; these results were compared with those of control villages showing similar conditions. Geographical Information System and Remote Sensing technology were used to analyse biophysical data (land produc-tivity dynamics, soil erosion, soil carbon, and land use and land cover changes), assessing data from 2008 to 2018. To determine socioeconomic impacts, the economic valuation of the crop and fodder benefits (increase in yields), household water benefit (time saved for water collection) and the intrinsic value of decline in the distress migration (willingness to accept) was assessed using interviews and surveys. Based on this information, a CBA is performed over a ten-year timeline from 2008-2018 using an inter-est rate of 3, 5 and 8 per cent as well as the implementation and cultivation costs of each measure.

[19] (Das, et al., 2020)

RESULTS

Biophysical aspects: Soil detachment due to erosion usually occurs in upper catchment areas and accumulates in lower catchment areas. In the study, upper villages show decreased detachment while villages in lower catchment areas show lower accumulation. The soil carbon assessment shows the same behaviour as soil erosion, meaning soil carbon is transported from upper catchment areas to lower watershed areas.

- Upper areas: (1a) detachment reduced by 64.8 per cent (23.8 per cent in control village), (3) detachment reduced by 32.7 per cent (in control village -567.1 per cent, detachment increased)
- Lower area: (1b) accumulation reduced 53.7 per cent (55.5 per cent)
- Middle area: (2) accumulation reduced 51.2 per cent (-82.3 per cent detachment increased).

Land use/Land cover (LULC): Dungariya, cultivable land increased by 54 ha (control 36 ha); Partala shows an increase in agriculture (45.23 ha, 32 per cent) and fallow land (17 per cent) while uncultivable land is reduced by 50 per cent. In Katangi, the area under cultivation has increased by 49 per cent (74.5 ha) (115 ha in control village). In Kareli, cultivable land including fallow land increased by 19.8 ha.

Land productivity: It was found that in both years of normal and abnormal rainfall, crop production was higher in project villages than in control villages. The productivity declined in Partala (2.4 per cent, in control village 5.4 per cent), and improved in Dungariya (7 per cent vs. - 4.3 per cent in control village). In Katangi and the control village Pundai Mal, there was a decline in productivity of 8.5 per cent and 7 per cent respectively, while in Kareli and the control village, the productivity stayed stable throughout the analysed timeframe.

Economic Valuation: Based on the results from focus group discussions, the interventions implemented have contributed significantly to the conservation of soil and resulted in a reduction in soil erosion. Over time, however, the accumulation of sediment in the trenches has had a negative impact. Furthermore, an increase in groundwater table and soil moisture has been detected as a positive outcome of the interventions.

Time for water fetching: Watershed development has led to an improvement in groundwater recharge as well as the flow of streams, resulting in a significant reduction in the time required for water collection across all eight villages, including the control villages where governmental activities were implemented during the project timeframe. Specifically, residents of Dungariya saved 24 minutes per trip, while those in the other villages experienced a reduction in time of 8 to 13 minutes per trip.

Migration: A decline in seasonal migration in all villages has been observed, which can be attributed to the increase in work availability resulting from the expansion of the agricultural land under double or triple cultivation. NOTE: Migration was higher in project villages than in control villages.

Cost-Benefit Analysis

PROJECT VILLAGE	DISCOUNT RATE (%)	BCR	NPV (INR)	NPV/HH (INR)	CONTROL VILLAGE	BCR	NPV (INR)	NPV/HH (INR)
PARTALA	8	2.2	26,947,031	107,788	AMDARA	3.2	14,738,046	87,207
	5	2.2	33,328,669	133,315		3.3	18,277,932	108,153
	3	2.3	38,609,854	154,439		3.4	21,241,636	125,690
DUNGARIYA	8	2.8	5,838,731	110,165	KUI-RYT	3.1	6,849,835	72,871
	5	3	7,508,712	141,674		3.3	8,701,253	92,567
	3	3.2	8,918,437	168,272		3.4	10,264,614	109,198
KATANGI	8	2.4	13,581,722	75,454	PAUNDIMAL	4.3	25,200,581	92,649
	5	2.5	17,306,448	96,147		4.4	31,691,668	116,513
	3	2.5	20,452,667	113,626		4.5	37,165,991	136,640
KARELI	8	2.1	14,699,769	116,665	SIHORA	2.00	9,949,647	77,129
	5	2.2	18,923,624	150,187		2.09	12,803,213	99,250
	3	2.2	22,497,437	178,551		2.15	15,224,628	118,020

BCR is mostly higher in control villages except for Kareli; NPV is higher in project villages except in Katangi.

A6.2. Advancing knowledge on the costs and benefits of sustainable soil fertility management in Maharashtra and Madhya Pradesh, India[20]

KEY MESSAGE	Integrated fertility management interventions can have positive effects on ecosystem services despite fewer labour use efficiency. Shift in focus from land productivity to water productivity may be necessary to address concerns in agricultural land use.
FOCUS	Economic and environmental effects
INTERVENTION AREA	Field/Farm and Landscape level
METHODOLOGY	CBA, Integrated Assessment Tool, Stochastic Modelling
AGROECOLOGICAL PRACTICE	Soil and water conservation measures
STUDY DESCRIPTION	**Study Aim:** To investigate the effects of different cropping systems and soil fertility management practices on select ecosystem services in semi-arid regions of Maharashtra and Madhya Pradesh in India. The research is inspired by the Economics of Land Degradation Initiative approach. To evaluate the impact of various intervention strategies on crop yields and farm system performance, the study makes use of a combination of empirical data collection, expert knowledge, and crop simulation models. The impact of alternative management practices on ecosystem services is evaluated based on market and shadow prices. Comparing these values with the costs of implementing alternative management practices allows to assess the costs and benefits of different methods at both the plot and landscape level. The goal is to identify the most cost-effective and environmentally friendly methods for crop production and soil fertility management in semi-arid regions of India. A monetary value is initially determined for six ecosystem services (crop yield, by-products, water consumption, moisture storage, nitrogen leaching, and total organic carbon). Then, in a second step the authors applied an Integrated Assessment Tool (IAT) to understand the interactions between different economic and biophysical processes in smallholder farming systems. The study examined four scenarios: **1.** Existing crop-livestock mix and input level use (FP) **2.** FP + Integrated intervention: Organic manure, fertiliser, and irrigation interventions **3.** Context-specific modified crop-tree-livestock mix with the current level of input use **4.** Modified crop-tree-livestock mix + Integrated intervention (II): Suggested crop-livestock activity mix with organic manure, fertiliser, and irrigation interventions

[20] (Falk, et al., 2018)

Data from geospatial analysis, crop growth simulation models, detailed household surveys and expert knowledge was converged to assess the impact of current practices and various soil fertility enhancing interventions on crop yields and other ecosystem services (ESS). The study examined provisioning and regulating ecosystem services such as harvested yield, by-products at maturity (fodder, crop residues), water use efficiency, drainage, soil loss on a plot basis, Biological Nitrogen Fixation (BNF), potential nitrogen leached, and total organic carbon sequestration. The study analysed the trade-offs between suggested interventions and current practices on crop yields and household-level cash flows using IAT.

Assessing the impact of soil fertility interventions and current practices on crop yields and ecosystem services (ESS), these analyses included harvested yield, by-products at maturity (fodder, crop residues), water use efficiency, drainage, soil loss on a plot basis, Biological Nitrogen Fixation (BNF), potential nitrogen leached, and total organic carbon sequestration. Trade-offs between interventions and current practices were evaluated to determine their effects on crop yields and household-level cash flows.

This study found a large yield gap between potential and achieved productivity, low water and nutrient use efficiency, and widespread land degradation. Aiming to assess the impact of different intervention strategies on crop yields and farm system performance using a combination of empirical data collection, expert knowledge, and crop simulation models, the study provides globally relevant data on the economic benefits of land-based ecosystems and helps improve the efficiency of water use, soil fertility management, carbon sequestration, and increase yields.

RESULTS

The most significant impact on ecosystem services in the region is due to agricultural profit and the hidden cost of water consumption. Other indicators considered in the study, such as by-products and moisture storage, play a less important role. While these results are based on simulation models, they suggest that future assessments of ecosystem services in the context of agricultural land use in Maharashtra and India should prioritise measuring yields and water use. Increases in crop yields were also found to lead to significant losses in other ecosystem services, mainly due to differences in water consumption. The study suggests that a shift in focus from land productivity to water productivity may be necessary to address these concerns.

Integrated fertility management interventions were likewise found in the study to have positive effects on ecosystems services such as carbon build-up, nitrogen leaching, and soil moisture. By using whole-farm stochastic modelling, the study analysed trade-offs and outcomes associated with potential farm systems change in simulated farms with different cropping systems in five selected districts. The study found that fertiliser and manure interventions provided significant financial benefits in cereals-based cropping systems in high potential areas with higher rainfall and better soils, while forage intensification through integrating sorghum and integrating perennials such as mango and pomegranate can also be good for the farm's profit and carbon sequestration. However, labour-use efficiency fell in almost all scenarios due to diminishing returns to labour inputs. This tension needs to be considered when evaluating alternative systems, especially when viable off-farm employment opportunities exist.

A7. Madagascar

A7.1. Support project for capacity building in the economics of sustainable land management and land degradation. Madagascar project report[21]

KEY MESSAGE	The impact of fire on various indicators, including land use, soil carbon, and the livelihoods of rural households, is complex and significant. Effective fire management could reduce deforestation, increase soil carbon and improve the economic situation of farmers.
FOCUS	Economic, environmental and climate effects
INTERVENTION AREA	Field/farm, landscape and societal level
METHODOLOGY	Remote sensing, surveys, modelling SOC content, economic budgeting
AGROECOLOGICAL PRACTICE	Fire control measures
STUDY DESCRIPTION	**Study Aim:** Undertake a comprehensive multidisciplinary assessment of the economic costs of land degradation at the regional scale caused by fire use, the costs and benefits of possible actions and responses (including the costs of inaction). In order to assess the action against fire-induced land degradation in the Boeny region, several indicators were taken into account: • the **different forms of land use and their change** under the impact of fire and under several fire management scenarios over time, • **land productivity**, • the level of SOC for each land cover in order to highlight the losses/benefits of fire use, and • indicators on the **economic situation of local households** that are most affected by the use of fire. The analyses were conducted on the landscape and farm levels followed by modelling with and without fire control. Two scenarios were defined: • The first is the “Business as Usual” (BAU) scenario, which represents a situation where no action is taken against fire. Future land degradation trends are expected to continue. • The second is the action scenario, in which fire control measures are adopted.

[21] (Harifidy, 2020)

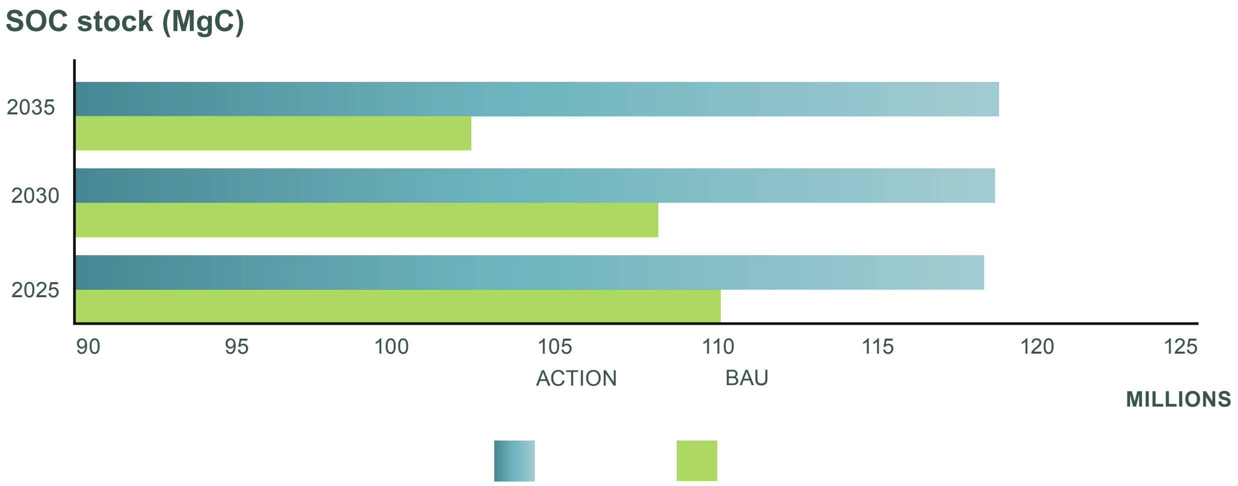
RESULTS

Land use change: Modelling indicates that a decline in fire frequency leads to increased forest coverage; models project an annual growth of 0.94 per cent, with 507,822 ha, 514,807 ha, and 517,773 ha for 2025, 2030, and 2035 respectively. Prior findings highlight land use changes predominantly affecting forests and savannahs converted to agriculture. Given fire's ties to agriculture, reduced fire incidents would drive forest expansion, curbing deforestation and the risk of agricultural fires spreading to forests. This decrease in fires would also enhance agricultural plot productivity, lowering the inclination for farmers to expand farmland and consequently reducing overall agricultural land extent.

SOC stock change: Increasing fire frequency correlates with decreased SOC content ($r2 = -0.73$, $\alpha = 0.05$). For the entire region, agricultural COS stock is 42,084,915 MgC; no fires would yield 43,528,320 MgC SOC stock. Burning thus causes a 1,443,404 MgC loss in SOC, equivalent to 5,297,295 $MgCO_2$.

Modelling action and inaction scenarios linked to COS stocks per land use shows an increase in the total SOC stock if there is a 2 per cent reduction in fires each year until 2035 (this stock corresponds to forests and agricultural areas only). The cumulative loss in SOC if no action against fire is taken is estimated at 35,177,722 MgC after 16 years. This is equivalent to 129,102,239 Mg of CO_2.

Comparison of SOC stock of action and inaction



Cost of inaction (from SOC loss): Applying a rate of EUR 10 per tonne of CO_2, the total cost of inaction would be almost EUR 1.3 billion with approximately EUR 303 million in 2025, EUR 384 million in 2030 and EUR 603 million in 2035 for the entire Boeny region.

Return on investment (ROI) for taking action[22]: The ROI is determined by dividing the cost of inaction by the cost of action. In the context of the Boeny region in 2018, the calculated cost of action stands at EUR 241,947,552[23]. The benefit derived from this action is quantified as the disparity between the cost of inaction and the cost of action. Consequently, the discounted ROI achieved over a span of 16 years of operation is measured at 1.16. An investment of EUR 308 for one hectare in 2019 would result in a cumulative return of EUR 1,643 (EUR 357 present value) in 2035.

Economic impact on household level: A reduction in fires of 2 per cent per year by implementing fire control measures would result in extra EBITDA (earnings before interest, taxes, depreciation, and amortization) of EUR 782, EUR 1,463 and EUR 2,145 per ha in 2025, 2030 and 2035 respectively, as compared with no action (BAU); these show increases of 49 per cent, 90 per cent and 126 per cent respectively compared with the BAU scenario.

[22] The type of action may vary from farmer to farmer.

[23] The investment costs for implementation depend on the type of action. For this calculation, an average cost of EUR 308 for 1 hectare of "anti-erosion conservation agriculture" was used based on ProSoil project data.

Bibliography

Adegbola, P. Y. (2016). *Document technique et d'informations 2. Analyse des travaux de recherche et d'innovations sur la gestion durable des terres au Bénin.*

Calow, R., Ludi, E., & Pichon, F. (2018). *Evaluating the impact of natural resource management interventions on land, water and pastoral livelihoods in the Afar Region of Ethiopia.*

Dallimer, M., Stringer, L. O., Osano, P., Njoroge, G., & Wen, C. (2016). *Costs and benefits of sustainable soil fertility management in Western Kenya. Kenya Project Report.* Economics of Land Degradation Initiative.

Das, S., Duraisamy, V., Yaduvanshi, A., Shinde, A., Yadav, A., Solanky, V., . . . Garg, R. (2020). *Economic Valuation of reducing land degradation through watershed development in east Madhya Pradesh under risks of climate extremes.* Pune, India: WOTR Centre for Resilience Studies, Watershed Organisation Trust (WOTR).

Ellis-Jones, J., Lichtner, A.-K., Halefom, T., Schulz, S., & Deressa, H. (2017). *Integrated Soil Fertility Management End of Season Evaluation: Farmer Views and Productivity Analysis.*

Falk, T., Murthy, D., Krishna Gumma, M., Kumar, S., Whitbread, A., Limberger, S., & Bartels, L. (2018). *Advancing knowledge on the costs and benefits of sustainable soil fertility management in Maharashtra and Madhya Pradesh / India.* Economics of Land Degradation (ELD) Study. Project Report. ICRISAT.

Gichua, M. K., Cecilia, M., King'uru, W., Meave, S., Justus, E., & Tatich, Y. (2020). *Economics of Land Use Management on Ecosystem Services: A Case Study of Aberdare Water Tower in Nyandarua County.* Economics of Land Degradation Initiative.

Hernandez, S., Megdiche, M., & Garci, G. (2023). *L'agriculture pluviale et les services écosystémiques : une question de résilience dans un contexte de changement climatique. Analyse coût-bénéfice d'une bonne gestion des terres.* ELD Tunisie.

Hurni, K., G, Z., Kassie, M. T., Kassawmar, T., Teferi, E., Moges, A., . . . Hurni, H. (2015). *Economics of Land Degradation (ELD) Ethiopia Case Study. Soil degradation and sustainable land management in the rainfed agricultural areas of Ethiopia: An Assessment of the Economic Implications.* Economics of Land Degradation (ELD) Initiative.

Lable Conseils. (2023). *Profitability study of sustainable land management practices. Interim report.*

Leippert, F. D. (2020). *The potential of agroecology to build climate-resilient livelihoods and food systems.* Rome: FAO and Biovision.

Quillérou, E. (2016). *Evaluation économique d'aménagements pour la conservation des eaux et du sol. Cas d'étude dans les exploitations d'Abricotier-Olivier du gouvernorat de Kairouan, Tunisie.* ELD Tunisie.

Röhrig, F., Gloy, N., von Loeben, S., Arumugam, P., Aschenbrenner, P., Baek, H., . . . Santo, S. (2021). *Climate Risk Analysis for Identifying and Weighing Adaptation Strategies for the Agricultural Sector in Burkina Faso.*

Röhrig, F., Gloy, N., von Loeben, S., Arumugam, P., Aschenbrenner, P., Baek, H., . . . Shukla, R. (2022). *Climate Risk Analysis for Identifying and Weighing Adaptation Strategies for the Agricultural Sector in Niger.*

SK, N., A, N., CM, M., C, M., & E., G. (2017). *Cost and Benefit Analysis for Climate-Smart Soil practices in Western Kenya. Working Paper.* International Center for Tropical Agriculture (CIAT) (CIAT Publication No. 439).

Traore, A. A., & Requier-Desjardins, M. (2019). *Neutrality gains / economic gains from sustainable land / Soil management in three provinces of Burkina Faso.* ELD Burkina Faso.

UNU-EHS; Frankfurt School of Finance and Management. (2021). *Drought Risk – Ethiopia: Executive Summary.* Bonn/Frankfurt: United Nations University / Frankfurt School of Finance & Management GmbH. 25pp.

Westerberg, V. (2017). *The economics of conventional and organic cotton production - A case study from the municipality of Banikoara, Benin.* ELD Benin.