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Analyses of socio-economic and environmental effects of agroecological practices

A methodological guidance

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As at March 2025, Bonn

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Abbreviations

BAU	Business-As-Usual
BCR	Benefit Cost Ratio
CBA	Cost-Benefit-Analysis
CBR	Cost Benefit Ratio
CEA	Cost-Effectiveness-Analysis
GDP	Gross Domestic Product
GEM	General Equilibrium Model
HS	Harmonised System
ISFM	Integrated Soil Fertility Management
IRR	Internal Rate of Return
LCA	Life Cycle Assessment
MCA	Multicriteria assessment
NDVI	Normalized Difference Vegetation Index
NPV	Net Present Value
PEM	Partial Equilibrium Model
SITC	Standard International Trade Classification
SOC	Soil Organic Carbon
TAPE	Tool for Agroecology Performance Evaluation
TCA	True Cost Accounting
TEV	Total Economic Valuation

Glossary

Carbon leakage	Emissions reductions, i.e. via climate policies, in a region or country can be outperformed by an increase of emissions in another country as a direct consequence of the actions taken in the country that reduces emissions.
Contingent valuation	The non-market-based economic valuation approach is used to provide an estimate of the economic value of non-traded goods, such as environmental effects, for which there is no direct market information. It estimates willingness to pay based on stated preferences of beneficiaries of agroecological measures.
Contribution margin	The contribution margin is the selling price per unit minus the variable cost per unit. It is the amount of profit left after subtracting (only!) variable costs from the revenue and with which the fixed costs can be covered.
DALYs	Disability-adjusted life years (DALYs) is a health index that enables comparison of reductions in health burdens and combines morbidity and mortality effects. One DALY represents the loss of the equivalent of one year of full health.
Discount rate	The discount rate is used to determine the present value of future benefit and cost flows. It is expressed as a percentage rate at which the value of equivalent benefits and costs decrease in the future compared to the present. The discount rate is needed to conduct a cost-benefit-analysis (CBA) and can be obtained from the (local) interest rate at which money for investing in agroecological practices can be borrowed from a lender (e.g. banks).
Ecosystem services	Ecosystem services are the benefits people derive from ecosystems and are divided into provisioning services/goods like food, wood and other raw materials, regulating services from plants, animals, fungi and micro-organisms such as pollination of crops, prevention of soil erosion and water purification, and a vast array of cultural services, like recreation and a sense of place.
Externalities	An externality is a positive or negative impact of an economic activity that affects a third party that is not directly related to that activity and therefore unpriced. Erosion and chemical runoff caused by infrastructure building is an example of a negative externality.

Market-based valuation	Methods used to value assets, goods or services on the basis of the prices at which similar items are available or traded in a free market.
Non-market valuation	Methods used to give economic value to assets, goods or services that are not traded in competitive markets such as health assets or environmental services. One purpose of these approaches can be to generate data suitable for input into cost-benefit analyses.
Opportunity costs	It is the value of what is lost when choosing between two or more options. In other words, it is the cost of any activity compared to its best alternative use. Assessing opportunity costs is important to find out the real cost of an activity.
Shadow price	A shadow price is an estimated price for something that is not normally priced or sold in the market. Because no actual price can be assigned by trading in a market, the true value is unknown and can only be estimated. The estimation is often based on an assumption of the highest price that someone is willing to pay for the good. Its accuracy may or may not reflect the actual value of the item.
Sensitivity analysis	It is an analysis of how the result of a cost-benefit-analysis such as the net-present-value is affected by changes in key variables such as the discount rate. Where the measure is shown to be sensitive to the value of a variable that is uncertain, meaning that relatively small and likely changes in a variable affect the overall result, it is advisable to ensure flexibility and might consider testing of the measure first.
Social accounting matrix	A social accounting matrix represents flows of all economic transactions and transfers that take place within an economy or between different production activities.
Willingness-to-pay	The maximum amount a consumer is prepared to spend, sacrifice or exchange in order to consume a particular good or service or to avoid something undesired, such as environmental pollution.

01. Introduction

Globally, agriculture is highly dependent on prevailing climate and weather conditions as well as natural resources such as soils. Soil is a non-renewable resource, and its unsustainable use leads to erosion, nutrient depletion and degradation. In some cases, the consequences are irreversible destruction of soil ecosystems and, in the case of agricultural ecosystems, a decline in yields as soils lose their productivity. In addition, soil degradation increases vulnerability to the impacts of climate change and contributes to further greenhouse gas emissions, e.g. through the loss of sequestered carbon and biodiversity. These interactions can have major impacts on farmers' income, people's food security and all rural livelihoods. In order to protect agricultural soils and ensure sustainable food production, as well as to contribute to climate change mitigation and biodiversity conservation, the socio-ecological transformation of agricultural and food systems is an urgent need.

As "an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems…" (*FAO, 2018*) **agroecology** is considered to have great potential for the socio-ecological transformation of agri-food systems. Agroecology can be understood as a scientific discipline, a set of farming practices and a social movement and as such extends far beyond farming practices.

The agroecological transformation of agri-food systems takes place across five interlinked levels, of which the transformation in the first two levels happens within farms, the third one includes the whole agroecosystem and levels four and five expand the scope to the entire agri-food system. The cooperation among stakeholders from politics, science, the private sector and civil society as well as an inclusive rural community are key elements.

Convincing farmers, decision makers and donors to invest in agroecology requires demonstrating short- and long-term economic returns, positive environmental and climate impacts, and the contribution to food and nutrition security. However, measurable good practices, policy guidance, and mechanisms to promote widespread implementation of agroecology on the ground are still insufficient. There is a knowledge gap regarding direct economic effects as well as social, environmental, and climate impacts of agroecological practices. Stakeholders expressed the need of scientific evidence with concrete results and data proving the potential of agroecological strategies. Agricultural, resource and environmental economics offer diverse analytical techniques and impact assessments to close this gap. The suitability of a methodology depends above all on the objective(s) and data availability. However, the challenge is to choose a methodology which, on the one hand, is practicable in a context where information and data are often limited but, on the other hand, is sophisticated enough to produce meaningful and reliable results.

01

By giving guidance on how to choose an appropriate analytical design for evidence creation, this product intends to support agricultural and rural development programmes in pushing forward the agroecological transition towards more sustainable agri-food systems.

This guidance has been prepared by HFFA Research GmbH for the Global Programme "Soil Protection and Soil Rehabilitation for Food Security" (ProSoil), which is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH commissioned by the Federal Ministry for Economic Cooperation and Development (BMZ) and co-funded by the European Union. This co-funding focuses on agroecological transition towards resilient agri-food systems and is called ProSilience.

The methodological guidance provides an overview of the state of the art in economic and environmental analysis suitable for ProSoil and broader development contexts. It explains the proposed methodologies, their key indicators and results as well as data requirements and provides information on the application context. The guidance also includes advice and tips on what to consider before beginning a study. Practical ideas on how to involve relevant stakeholders in the various steps of an analysis help tailor studies to the needs of the target group and ensure that the results are useful to the stakeholders. Using this product, colleagues in ProSoil partner countries should be able to identify their main research questions and purpose of such and analyses as well as to formulate beforehand what type of results they would like to obtain. They should have a basic understanding of existing economic and ecological analysis methodologies and know which methodology might be suitable for their specific needs. They should feel able to put an analysis out to bit and select an appropriate research partner to eventually embark on a customized study.

Chapter 2 starts with a reflection of what to consider, when preparing a socio-economic and/or environmental analysis (chapter 2.1), afterwards chapter 2.2 explains the crucial involvement of relevant stakeholders within such processes, followed by a brief explanation on how to use this guidance at hand (chapter 2.3). Chapter 3 summarises potential methodologies to assess socio-economic and environmental effects of agroecological practices.

02.
How-to-Chapter

> Be aware that the procedure described below is an ideal process. Each study takes place under different conditions and on different information bases. Accordingly, the individual steps can also vary in their sequence and application.

2.1 HOW TO SET UP SOCIO-ECONOMIC AND ENVIRONMENTAL ANALYSES?

This chapter explains the necessary steps that need to be taken before preparing a study and that eventually should lead to the selection of a suitable methodology. This process is often also referred to as the inception phase. It is one of the most critical phases of a study as it lays the foundation and significantly determines the course of the research and ultimately its success. A very important aspect is the involvement of the target group in the planning right from the beginning. In chapter 2.2 you will find some ideas on how to design the initial phase of a study with the participation of the target group. And you can find more ideas in the ELD User Guide.

The following questions are designed to guide you through the inception phase and help you select a suitable methodology:

→ *The ELD Benin study (2017) on the economics of conventional and organic cotton production serves as an example.*

1 What are the needs in the broader context that you want to focus on?

Make sure that the relevant needs and drivers (socio-economic, cultural, biophysical) are known and understood. Identify where there is further proof or evidence needed in order to come up with specific research questions afterwards. Consultations and interviews with potential stakeholders and affected people can be helpful to identify these needs.

→ *In Benin, cotton is hugely important to the national economy and the sector provides a source of income to half of its population. However, cotton is a controversial crop and difficult to grow, yields can be decimated by severe weather and the crop is vulnerable to pest attacks. In Benin, 90 % of all imported pesticides are used on cotton and there are frequent reports of health problems amongst farmers.*

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2 Who is the target group?

Once you understand the context in which you want to conduct the research, you should focus on identifying the specific target group(s) of your study. You can make use of a stakeholder map to get an overview on the groups that are either affected and/ or should be informed by your research. As the results could be interesting for various actors, it can make sense to target more than one group of interest. This is very context dependent. Depending on the target group(s) you might want to concentrate on different topics, aspects and research questions. But be aware that a one-size-fits-all solution may ultimately not be a good solution for anyone, e.g., if the results are too general. Depending on the context, an option could be to target one group and translate the results into the language of the other group, or to split the study into parts with different foci. Ideally, narrow down your target group(s) to better identify what kind of facts and figures might be useful to them.

The following non-exclusive list provides an overview of potential actors of a given target group along the different levels of intervention:

Intervention levels	Potential target groups
Field / farm	Farmers, household / family of farmers, extension service providers etc.
Landscape	Local communities, relevant land users and owners, local / regional administration and governance bodies etc.
Market	Producers, consumers, retailers, other private market actors along the supply chains etc.
Society	Politicians, tribal governments, NGOs, industrial associations, citizens etc.

02.

Potential target groups are very diverse and bring along very different interest and knowledge. For example**, at farm level**, the impact of agroecology in form of household food security, income generation or the amount of labour intensity are crucial variables for farmers' decision on whether they switch to agroecological practices or not. In addition, the effect on agroecology on the long-term preservation of ecosystem services as "auxiliary agents" for agricultural productivity can be of interest for farmers.

At landscape level, there is a higher chance of conflicting goals of different land and resource users in a specific area. Including all these diverging interests and needs while at the same time acknowledging power asymmetries between involved actors is crucial when identifying the target groups. Especially at landscape level, boundaries of ecosystems services that are influencing agroecological practices might not match administrative or jurisdictional boundaries of relevant institutions that effect land management decisions.

At market level and the level of society, target groups could be interested in the effects of labelling systems or of subsidies on agroecological products, the effects of agroecology on employment in the agroindustry, or how agroecological production patterns influence climate-resilience of food systems.

→ *The target group is Beninese political decision makers.*

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3 What is the concrete purpose of the study and how will the results be used?

→ *Given the challenges facing the cotton sector in Benin, there is a clear case for questioning „business as usual“.*

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The core of this step is to define the objective of the study. Here, it is important to keep the target group defined in the second step in mind, as this is the group you want to support, inform, or influence with the results of your study. Ask yourself the following questions to come up with a clearly defined objective:

- Which information and knowledge are most relevant to the target group and should be generated by the study?

→ *What are the consequences of government subsidies in conventional cotton production and are these subsidies being used wisely overall?*

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- What specific question(s) should the research answer?

→ *What are the costs and benefits of organic and conventional cotton production? What are the consequences of conventional cotton production in terms of damage to health and the environment, as well as the costs to the public purse?*

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- Which stakeholders need to be engaged?

→ *Conventional and organic cotton producers*

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- How will the results be used?

→ *The results of the study should serve as a basis for argumentation for political decision-makers and encourage them to invest public funds in more sustainable management methods.*

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4 What is the scope of the study?

Once you have defined your target group and the objectives of your study, you probably know where your study will be geographically located. Now it is important to define the scope of your study. This is not only about the geographical boundaries and spatial scale, but also about the intervention level and the reference area to be assessed. The four intervention levels presented on p. 9 can be helpful when clarifying the scope of the study.

→ *The study is conducted in the municipality of Banikoara in Northern Benin. The assessments and calculations are made on farm level with a reference area of one hectare.*

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5 Which indicators are appropriate for your target group?

This question refers to not only what is feasible and measurable, but especially what is *comprehensible* for the target group. For example, the profitability of an intervention over a long time which can be best expressed by a cost-benefit-analysis (CBA) in the form of the net present value (NPV) and the internal rate of return (IRR), may not be appropriate for farmers who usually calculate with revenues or margins and for shorter time horizons. The quick check in *chapter 2.3* provides information on outputs and indicators that can be helpful in addressing this question. When you think about appropriate indicators, you should also already think of how the results can be communicated to the target group after the finalization of the study (*see chapter 2.2*).

→ *The target indicators are the gross margin of conventional and organic cotton production and the costs of illness with status today. The chosen indicators have the advantage that they are basic indicators in economics and therefore probably already known to policymakers as well as to a wider audience.*

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6 What are your (possible) constraints and how can you address them?

One example is that certain data can only be obtained during the harvesting season, this might be a constraint as farmers might be busy and not available for interviews or biophysical assessments might interfere with labour to be done at field. Please ask yourself:

- What kind of data is needed?

→ *Production and budget data, i.e. costs and revenues of conventional and organic cotton production, including yields, input quantities, producer prices and health related incidences.*

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- Is this data accessible?

→ *No, it was not.*

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02.

Narrow down your study focus and research question. It is not always possible to cover all aspects. The more defined the subject of the study is, the more precise and meaningful the results will be. Combinations of agroecological practices can be assessed individually or as sets. This is dependent on your research question, the information you want to generate and ultimately data availability. Be aware that if you assess sets of practices, statements on the concrete impact of individual measures are difficult to make.

- Do you have to collect the data yourself, or can it be acquired somewhere else?

→ *The data was collected based on a survey conducted with 90 randomly sampled organic cotton producers and 190 randomly sampled conventional cotton producers.*

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- Does the data collection/interview period interfere with certain agricultural work steps to be done/elections at national level? Is it necessary to consider certain constraints from stakeholders?

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- How much time do you have for the different steps of conducting the study?

→ *The research was scheduled for 7 months.*

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- What is your budget?

→ *The estimated total working days for the study amounted to around 100 expert days.*

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- Do you need additional expertise, equipment or software?

→ *No.*

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7 How will the results be communicated and disseminated?

The communication and dissemination of such studies needs to be planned right from the beginning. How and where can the target group be reached best? It is very important to contextualize the results of a study to the needs of the target groups. This can be an additional step that needs to be considered when planning time and resources. What are good windows of opportunities and events to (further) spread the results? In this respect you should also consider what is the best timing for conducting the study. This could not only be important for using the momentum and achieving the greatest possible reach. Depending on what is assessed, the timing can also have an influence on the results.

→ *The study results were disseminated at national events in Benin to directly address the target group of policymakers. Often it makes sense to also share the results in international events and platforms such as the Transformative Partnership Platform on Agroecology (TPP), FAO's Agroecology Knowledge Hub, FAO's Family Farming Knowledge Platform, World Overview in Conservation Approaches and Technologies (WOCAT), PANORAMA Solutions, adaptationcommunity.net and the ELD website (Economics of Land Degradation).*

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8 Are there other related relevant studies which can be used as a reference or research basis, or which may be already implemented in parallel by other donors (to avoid duplication; and strengthen coordination with other donors)?

→ *E.g., Fotopoulos, C. and Pantzios, C.J. (2019): A Comparative Cost Analysis Of Organic And Conventional Cotton Production In Viotia – Greece; ECON-WOCAT dataset.*

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After you have answered the questions listed above, you should be able to select a methodology that is appropriate for your specific purpose. Chapter 2.3 will provide orientation on how the methodologies that are subject to this guidance are structured, so that your selection process is targeted.

Combination of methodologies: Depending on the research questions and the target group, it may make sense to combine two or more methodologies in one study. For example, a purely economic valuation could be combined with an environmental analysis to cover aspects that are difficult to monetise. It may also be necessary to use two methodologies to incorporate the results of one analysis into the other. One example is the economic valuation of certain ecosystem services, the results of which could then be used to implement a CBA.

02.

Get your contractor on board as soon as possible once a contract has been concluded. The earlier your research contractor is involved into the process, the better. It can make sense to adjust study designs during the inception phase. Precise and constant communication is key: The better your contractor knows, what you want to achieve and whom to reach, the better she/he can design the research according to your needs. In order to ensure the best possible quality of the study, it is also advisable to get external support or backstopping, for example, from the ProSoil steering unit or external consultants to check the quality of the of the socio-economic and/or environmental analyses.

STEPS AFTER SELECTING A METHODOLOGY:

1. Once you have selected a methodology, that fits your purpose, the next step would be to identify relevant partner institutions, research organisations or consultancies that will support the research. Check, whether they have conducted similar assessments in the past to avoid duplication and to profit from already existing research results. You can read example studies to see whether this corresponds to what you envisage. Important is not only methodological knowledge existing within the organisation, but also their local knowledge regarding the target area or the target group.

2. Formulate Terms of Reference, that are as concrete as possible and that give answers to the above listed questions. It might make sense to include an inception phase into the contract as adjustments in the study design might be needed depending on the multiple aspects that were described above and that influence the implementation of a study.

2.2 HOW TO INVOLVE RELEVANT ACTORS INTO THE ANALYSES

Participation is one of the 13 agroecological principles as defined by High Level Panel of Experts on Food Security and Nutrition of the United Nations (*see further literature on participatory research at the end of this chapter*), which means to encourage social organisation and greater participation in decision-making by food producers and consumers to support decentralised governance and local adaptive management of agricultural and food systems. Co-creation of knowledge is another of the 13 principles that asks for the horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange. Hence, the question of how to involve relevant actors into the evaluation of socio-economic and environmental effects of agroecological practices and how to disseminate results is not a minor one. Against this background, this chapter provides inspiration for participatory research approaches, with practical suggestions for uptake on how to integrate stakeholders in relevant steps of the analyses.

PARTICIPATORY RESEARCH

Understanding the diversity of the potential target groups and incorporating it into the design of the research forms the basis for producing useful research results that can lead to agroecological transformation of food systems in the long run. This understanding is expressed by the concept of research in development instead of research for development. The idea of the concept is to directly involve those agents in the research process who are needed for transformative changes. By building a coalition between farmers, scientists and other crucial stakeholders, the focus is on developing practical solutions based on scientific evidence.

Participatory action research, for example, aims to empower farmers and to democratise agricultural research through directly including farmers in the development of solutions and innovations. One example of a participatory approach for the assessment of agroecological practices is the so-called options-by-context approach, which focuses on bringing together scientific and practical knowledge to identify adequate agroecological practices as well as social innovations for famers and communities (options) for a specific location and its ecological, economic, and social characteristics (context). Participatory trials in the specific area are set up as planned comparisons. Here, farmers and the local community work in collaboration with researchers and development practitioners for testing and comparing promising options and their performance.

STAGES OF PARTICIPATION ALONG THE RESEARCH PROCESS

Stakeholders can be engaged during different phases of the research process. If possible, the whole research cycle could be constructed in an inclusive and target-group-oriented way. However, enabling participation in research is a complex and time-consuming process and the precise amount of possible participation will depend on available resources in terms of finance, time and human capacities and must be adapted to given realities of a specific research project.

02.

1. **Research design and planning**
   To ensure that the defined target indicators are meaningful for the target group, participants or representatives of that group should be engaged already at the initial stage of research, for example through consultation processes. During such consultation, the scope, location, spatial scale, as well as the strategic focus of the study can be discussed.

   For example, a research design workshop with local experts from different sectors (i.e. policy-making, international organisations, civil society and farmer representatives) could be initiated for valuing the different possibilities concerning evaluation criteria and target indicators. For planning the conduction of an analysis, the expertise of local actors could be used to identify relevant study sites and including relevant local biophysiological conditions.

2. **Data collection and implementation**
   Depending on the data needed for a given methodology, relevant information could be gathered in collaboration with the local community on the ground. Regarding the gathering of qualitative data, different methodologies could be applied, like semi-structured interviews or focus group discussions with the farming community. The principles behind such direct inclusion during data collection is to value, acknowledge and profit from local knowledge as a key source of information on land use practices and their effect on the environment and related ecosystem services.

   Regular involvement of the relevant stakeholders should be envisaged during the whole research process to ensure that the process is inclusive and clearly adapted to the needs of the target group. Sometimes and in an ideally situation, the conduction of the study goes along with capacity building measures between local actors and academic researchers on the ground. Such circular knowledge transfer ensures that, on the one hand, researchers include traditional and indigenous knowledge to widen their own research focus while, on the other hand, local knowledge systems can profit from modern forms of knowledge production and can apply them for their specific needs.

3. **Dissemination of results**
   The dissemination of relevant research results and related advice for action must already be clarified at the beginning of the research initiative. While actors in the national capitals of countries often profit from and apply digital means for communication, rural communities are often left behind regarding access to information due to the digital and literacy divide within and between countries. This makes print, comics or other forms of visual language as well as traditional means of communication (i.e. radio, theatre groups, village assemblies etc.) still very important for reaching adequate numbers of farms in certain rural areas. Also, dissemination should not be interpreted as the pure spread of information to the target group – much more, it must entail awareness raising on what the study results express in terms of concrete impact on the actors' activities as well as living and/or production conditions (short, mid, and long term).

   Consequently, apart from communicating relevant results to the specific target group and maybe other relevant stakeholders, these groups themselves should be included in the dissemination process by activating their own networks to spread information (i.e. trough training the trainer approaches) and using specific "knowledge brokers" amongst the group for targeted communication (i.e. a local famer associations, women's group representatives etc.). A specific outreach to most vulnerable and

marginalized groups that are affected by research activities and their results should be undertaken. For example, during knowledge dissemination in local communities a special focus should be given to women, extremely poor community members and other potential disadvantaged person to ensure full inclusion.

FURTHER LITERATURE ON PARTICIPATORY RESEARCH

- *Bergold (2012):* Participatory Research Methods: A Methodological Approach in Motion. In: Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, Volume 13, No. 1, Art. 30.
- *Crossland et al. (2022):* Supporting farmer innovation to restore: An illustrated five step guide to applying the Options by Context approach to land restoration. Nairobi, World Agroforestry.
- *GIZ (2022):* Transforming food systems from the bottom up. How locally developed social innovations can strengthen enabling environments for soil restoration. White Paper. Bonn, July 2022.
- *GIZ et al (2014):* Participatory economic valuation methods. Methods to incorporate stakeholder perceptions, preferences and value categories into ecosystem service valuation approaches. Method profile.
- *Gonsalves et al. (2005):* Participatory Research and Development for Sustainable Agriculture and Natural Resource Management: A Sourcebook. Volume 3: Doing Participatory Research and Development. International Potato Center-Users' Perspectives With Agricultural Research and Development, Laguna, Philippines and International Development Research Centre, Ottawa, Canada.
- *HLPE (2019):* Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by The High-Level Panel of Experts on Food Security and Nutrition. Rome, July 2019.
- *Krishnaswamy (2004):* Participatory Research: Strategies and Tools. Practitioner: Newsletter of the National Network of Forest Practitioners 22: 17–22.
- *FAO (2019):* TAPE Tool for Agroecology Performance Evaluation 2019 – Process of development and guidelines for application. Test version. Rome

02.

2.3 HOW TO USE THIS GUIDANCE TO SELECT AN APPROPRIATE METHODOLOGY

When assessing the impacts of agroecological practices, it is important to not only consider market costs and benefits, i.e. costs and benefits that can be easily quantified in monetary terms because they can be traded in markets (e.g. production costs and revenues). Even if assessments considering only market costs and benefit of agroecological practices give strong arguments, it is recommended to also assess non-market costs and benefits that are of interest for your target group i.e. those costs and benefits that are difficult to quantify in monetary terms because they are not traded on markets (e.g. human health and ecosystem services). This guidebook has gathered the most common analytical techniques and methodologies available from agricultural, resource and environmental economics that can be used to monetise or quantify the economic, social, environmental and climate effects of agroecology.

In this document, the term "methodology" is used for all the here listed analytical approaches, no matter whether they describe a fixed technique with a clear procedure and predefined indicators or rather a collection of techniques that summarise to one analytical approach. For the environmental studies the usage of these terms can therefore be misleading as the descriptions in this guidance often combine several methods and approaches for different indicators.

To be able to capture and compare information quickly within methodologies, the presentation of methodologies in *chapter 3* follows the same simple scheme. The present chapter will give you an orientation on the aspects that were used to structure and explain the methodologies.

Example scheme of methodology description

The **focus** of a methodology shows what kind of **effects can be measured**.

a. **Economic effects** refer to the financial aspects (costs and benefits) of agroecological practices. They include effects on household income and the profitability of individual measures, but also market related effects and indirect economic benefit such as the reduction of post-harvest losses from agroecological products. Effects that are referred to as social in the first place but can be monetised and therefore impact the financial situation of people, such as cost of illness, are also implied.

b. **Social effects** are understood as impacts on the social wellbeing of people and the society. They include for example effects on gender equality and the inclusion and protection of vulnerable groups, such as the prevention of child labour.

c. **Environmental effects** include all effects that agroecology has on nature and environment including land, water, soil, flora and fauna. Although the here measured effects can also have indirect impacts on the climate, like for example biodiversity loss, these analyses are not labelled with a climate focus.

d. **Climate effects** refer to the benefits of climate change mitigation and adaptation of agroecological techniques. Analyses labelled with this focus are often also relevant for measuring environmental effects. However, if they do not link directly to other than climate-related environmental effects, such as measures of carbon sequestration and reductions in atmospheric CO_2, they are defined exclusively with a climate focus.

The **intervention level** shows the level on which a methodology can be applicated.
Some methodologies are applicable for several levels.

a. **Field / farm:** Field and farm levels are the smallest units for which analyses can be conducted. The field level usually refers to one hectare, while the farm level can differ in its size and depends on the farm that is analysed. If a methodology is applicable to one of the two, then it can also be extrapolated or downgraded to the other one. This level also includes the household unit, which can sometimes be used synonymous to the farm.

b. **Landscape:** The landscape level refers to a larger but delimited area. It can be a water catchment area or a specific agroecosystem. The decisions regarding land use on this level are usually made by the (rural) community members that live in the specific location as well as by local or regional public administrations.

c. **Market:** The market level focuses on the economic side of an agroecological intervention. The research subject can be for example agricultural markets, value chains or specific value chain actors.

d. **Society:** Analyses on the societal level target the wellbeing of the society as a whole or specific communities of interest, such as the citizens of a country. Economic assessments consider the wider costs and benefits to the national economy.

02.

Information on the **complexity** of the different methods shall help the reader to estimate the necessary time and costs of an analysis as well as to select appropriate research partners. BUT be aware that the time, costs and resources also depend on other factors than the complexity of a method, e.g. data requirements.

a. **Basic complexity:** The methodologies are generally applicable for professionals working in the environmental or agricultural sector with elemental experience in economics or accounting. With prior knowledge in using and applying standard business performance instruments, these methods can immediately be applied with no or very little additional training. No or limited interdisciplinary knowledge and expertise is necessary.

b. **Intermediate complexity:** The methodologies are generally applicable for professionals working in the environmental or agricultural sector with advanced experience in economics or accounting. Some additional training is necessary to become familiar with these methods. Interdisciplinary knowledge and expertise are favourable.

c. **High complexity:** The methodologies can only be applied by well trained and experienced agricultural economists or experts familiar with the approaches and the sector. Alternatively meaningful and extensive training or the use of an external expert is necessary. Interdisciplinary knowledge and expertise are necessary.

02

Description of each methodology: The brief description of each methodology provides specific information on its application and basically discusses the procedure of quantitatively and/or qualitatively transforming input data into output information.

Input data and assumptions: An analysis stands and falls with its input data. They are the basis of each analysis. Data availability decides whether a methodology is feasible or not. Therefore, it is crucial to understand which input data is needed as well as if and how it can be made available.

Target indicators: The target indicators are the key output figures of an analysis. On the basis of their values the impacts can be measured. For evaluating whether target indicators and their values are appropriate and understandable for the target group, it is important to understand what kind of figures a methodology can produce.

Example results: Under this section real results from example studies are used to illustrate what kind of information can be generated and how results can be interpreted.

Limitations: Each methodology has strengths and weaknesses and is better or worse suited for different questions. For the correct interpretation of results, it is important to know the limitations of the applied methodology. The limitations of a methodology are those features of the design or application that affect or influence the interpretation of the results, but also limitations with regard to the object to be investigated or the significance of the results. If the limitations of a methodology are known, then the resulting information gaps can possibly be filled with the addition of other methodologies.

Further literature on methodologies: The purpose of this guidance is to give an overview on existing methods and to give guidance on *how* an appropriate methodology can be *selected*. The claim is <u>not</u> to give guidance on how to implement a specific methodology. If more detailed information on a specific methodology is necessary, these can be found in the further sources provided.

Reference studies: Methodologies are often abstract. Therefore, it can be useful to read example studies to better understand how a methodology can turn input data into output results and in which contexts other actors have applied a specific methodology. Where available, reference studies from the ProSoil partner countries were included. Where this was not possible, external example studies with reference to agroecology were carefully selected.

02.

Economic methods

Environmental methods

METHODOLOGIES[1]	FOCUS ON MEASURED EFFECTS			
3.1 Complete (total) Budgeting	✔			
3.2 Partial Budgeting	✔			
3.3 Cost-Effectiveness-Analysis (CEA)	✔			
3.4 Cost-Benefit-Analysis (CBA)	✔			
3.5 Total Economic Valuation (TEV)	✔	✔	✔	
3.6 Multiplier Analysis	✔	✔		
3.7 Single Market Models	✔			
3.8 True Cost Accounting (TCA)	✔	✔	✔	
3.9 Economic Valuation of Biodiversity	✔		✔	
3.10 Multi-Criteria-Analysis (MCA)	✔	✔	✔	✔
3.11 Adaptation Effectiveness Analysis	✔	✔	✔	✔
3.12 Life-Cycle Assessment (LCA)			✔	✔
3.13 Assesment of Biophysical Impacts			✔	✔
3.14 Water Footprint Analysis			✔	
3.15 Land Footprint Analysis	✔		✔	
3.16 Carbon Footprint Analysis				✔
3.17 Land Equivalent Ratio (LER)	✔			
3.18 Tool for Agroecology Performance Evaluation (TAPE)	✔	✔	✔	✔

[1] Many of the methods listed also partly take social aspects into account. However, social indicators are not the focus of this guide, which is why they were not considered in the clustering.

METHODOLOGY QUICK CHECK:

Once you have decided on research questions and target groups of a study, you can decide which methodology is most useful to produce answers to your questions. Moving from left

INTERVENTION LEVEL				GENERATED INFORMATION (OUTPUT, INDICATORS)
✔				Economic return on investment (or remaining net profit)
✔				Gross margin (only operational (variable) costs are considered)
✔	✔			Least-cost option of reaching an objective (cost-benefit ratio)
✔	✔			Economic profitability over time (net present value, benefit-cost-ratio)
✔	✔	✔	✔	Prices (costs) in $ of ecosystem and environmental services
		✔	✔	Sectoral linkages across value chains
		✔	✔	Ex-ante evaluation of the impacts of exogenous factors, such as policies
✔	✔	✔	✔	Natural, human and social capital
✔	✔	✔	✔	Willingness to pay and valuation of ecosystem services
✔	✔	✔	✔	Scoring of agroecological practices against indicators
✔	✔		✔	Scores for climate risk effectiveness and local feasibility
✔		✔		Environmental impact of a product, process or service
✔	✔		✔	Soil organic carbon, soil erosion, nutrient availability, land use change
✔	✔	✔	✔	Amount of water used to produce a certain good
		✔	✔	Land footprint in ha
✔	✔	✔	✔	Total amount of greenhouse gases (in kg CO_{2eq}) generated per reference unit (e.g. by a person, product, organisation, project, country)
✔	✔			Relative area needed by sole crops to produce the same yields as achieved using intercropping
✔	✔			Level of transition towards agroecology and performance indicators highlighting the contribution to reaching various SDGs

Economic

Social

Environment

Climate

Field/Farm

Landscape

Market

Society

to right through the table below enables you to proceed from the respective methodology towards the envisaged output of a study. Detailed information for each of the methodologies can then be found in *chapter 3*.

03.

Methodologies

3.1 COMPLETE (TOTAL) BUDGETING

FOCUS							
Economic effects	✔	Social effects	(✔)	Environmental effects		Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level		Market level		Societal level	
COMPLEXITY							
Basic	✔	Intermediate		High			

BRIEF DESCRIPTION OF THE METHODOLOGY

The complete or total budgeting approach is an easy-to-use economic concept of agricultural and especially farm economics. It can be used to determine the complete end-to-end cost of an agroecological practice. The specific cost of agricultural production (per field, livestock unit or farm) will be subtracted from the market revenues (again per field, livestock unit or farm), which are determined by the price and yield of the agricultural produce.
Although easy in terms of calculation, applying the full cost and revenue accounting approach requires careful planning. At least three questions need to be answered before (!) conducting the analysis:

1. What are the elements of market revenue (just the main crop or also by-products)?
2. What are the (opportunity) cost elements to be included?
3. Should cost and revenue items also include production-related taxes and subsidies / governmental payments?

According to the answers, specific data input, i.e., the monetary value of the defined revenue and cost elements, will be needed.

In contrast to the partial budgeting methodology (see next methodology), the complete budgeting includes not only the variable, but also fixed and all other costs of the farm into the calculation. It allows therefore to assess whether all costs incurred in an agroecological practice can be covered in the long run. There is no one-size-fits-all approach for conducting a complete budgeting. Data availability will always determine market revenue(s) and costs, which is why budgeting calculations may differ from each other. However, to compare several agroecological practices with each other, the use of the same revenue and cost input data is required for producing comparable target indicators.

Besides economic information, social impacts with respect to labour can be additionally drawn from the results of the calculation, if meaningful labour data in terms of working time and wages is available.

One great advantage of budgeting is that results are expressed in key economic indicators that are very common and most often known by a broad public which makes them easier to communicate than this could be the case for other analysis results.

INPUT DATA AND ASSUMPTIONS

- Variable/operational costs: e.g. inputs, seeds, water etc.
- Fixed costs/other farm costs: e.g. machinery (depreciation), land rents, hired labour
- Own costs: family labour, owned land, own capital
- *Opportunity costs*
- Market revenues:
  - Yields or production quantities
  - Producer prices for agricultural products

03.

TARGET INDICATORS

Depending on the individual assessment and the variables included, the target indicators can differ.

- Gross margin: remains after deducting operating costs from the market revenue; these operating costs may include (depending on the production system envisaged) expenditures for seeds, fertilizers and plant protection products, but also feed, water, services, etc.
- Net margin: remains when taking into consideration also other farm costs, such as depreciation, wages paid, rents, etc.
- Remaining net profit shows the remaining profit when additionally including un-paid family labour and own capital as well as own land costs into the analysis
- Economic return on investment (or labour) in %: measures the gain or loss generated on an investment relative to the amount of money (or labour) invested

Note: In other analyses the wording of the target indicators can differ, even though they mean the same thing. The other way around it is possible, that the same terms are understood and calculated differently. E.g., sometimes, the terms "benefit" and "margin" are used synonymously.

EXAMPLE RESULTS

To compare a conventional full-sun monoculture farming system with an organic agroforestry system for cacao and plantain/banana, the gross margins for each system were calculated by considering the total annual revenues and costs. Labour costs were excluded from the cost calculation, since small-holder farmers mainly use unpaid family labour. The results show that the agroforestry systems have higher revenues and twice as high gross margins compared to the full-sun monocultures due to their lower total costs ($820 versus $400). Although the full-sun monocultures had higher yields and revenues for cacao, the revenues obtained from the sales of the additional plantain/banana by-product in the agroforestry system compensated for the lower cacao revenues.

LIMITATIONS

Total budgeting provides farmers and decision-makers with information on which intervention that gives the best financial return at present time. It does not include, for example, soil fertility indicators or an evaluation of the investment over time. Indeed, possible yield increases induced by higher soil fertility would not be detected with this methodology. One solution is to combine economic budgeting with another environmental assessment, such as the assessment of soil quality indicators.

FURTHER LITERATURE ON THE METHODOLOGY

- *My Agriculture Information Bank (2017)*: Farm Budgeting: Partial Budgeting And Complete Budgeting.
- *Sri Krishna Sudheer (2013)*: Economics of organic versus chemical farming for three crops in Andhra Pradesh, India. Journal of Organic Systems, 8 (2), p. 39-45.
- *Nemes (2009)*: Comparative analysis of organic and non-organic farming systems: A critical assessment of farm profitability, FAO.

REFERENCE PROJECTS AND STUDIES

- *Armengot et al. (2016)*: Cacao agroforestry systems have higher return on labour compared to full-sun monocultures. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2016, 36 (4), p. 10.
- *Sri Krishna Sudheer (2013)*: Economics of organic versus chemical farming for three crops in Andhra Pradesh, India. Journal of Organic Systems, 8 (2).
- *Agronomes et vétérinaires sans frontières (2020)*: Guide d'Analyse Technico-Economique Participative, Haïti (Projet de renforcement de l'entreprenariat rural et des filières de valorisation des produits agricoles.).
- *FiBL (2019)*: SysCom Program (2007-2019) – A Comprehensive Report. What is the contribution of organic agriculture to sustainable development? A synthesis of twelve years (2007–2019) of the "long-term farming systems comparisons in the tropics (SysCom)"; p. 16-17.

03.

3.2 PARTIAL BUDGETING

FOCUS							
Economic effects	✔	Social effects		Environmental effects		Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level		Market level		Societal level	
COMPLEXITY							
Basic	✔	Intermediate		High			

BRIEF DESCRIPTION OF THE METHODOLOGY

Like complete budgeting, partial budgeting is a common economic approach in agricultural economics. It is characterised by the fact that it separates the total costs into fixed and variable costs. In contrast to the complete costing methodology, only parts of the costs are considered. Depending on the concrete implementation, these are usually the variable costs. As for the complete budgeting the specific (variable) costs of agricultural production (per field, livestock unit or farm) are subtracted from the market revenues (again per field, livestock unit or farm), which are determined by the price and yield of the agricultural produce. Although easy in terms of calculation, applying the partial cost accounting approach requires proper planning before starting the calculation:

- What are the elements of market revenue (just the main crop or also by-products)?
- What are the variable cost elements to be included?

With the partial cost accounting no profit or loss is determined, only the contribution margin, which is why it can also be called **contribution margin accounting** or **gross margin accounting**. The partial cost accounting is therefore more of a short-term analysis, while the approach of the full cost calculation allows to measure whether all costs incurred in an agroecological production system can be covered in the long run. The partial budgeting can be used to calculate the margins of specific aspects of a farm, such as additional cost items or revenue streams and is therefore suitable to assess changes in farm management and production. Whenever data availability allows it, a complete budgeting should be preferred over partial budgeting

INPUT DATA AND ASSUMPTIONS

- Variable costs: inputs, hired labour, health or other social costs (if applicable)
- Market revenues:
  - Yields or production quantities
  - Producer prices for agricultural products

TARGET INDICATORS

- Gross margin / contribution margin (sometimes, the terms “benefit” and “margin” are used synonymously)

LIMITATIONS

Partial budgeting has the same limitations as total budgeting: It is a purely economic methodology and therefore does not take any environmental aspects into account. To include them into a study, a combination with other environmental methodologies is required.

In comparison to total budgeting, partial budgeting has limited significance with respect to the margins of an agroecological intervention due to the exclusion of fixed costs such as (unpaid family) labour. This can lead to biases, and one must be careful with interpretation of results. For the case of organic vs. conventional farming, organic farming would always have a higher gross margin since input costs are much lower. However, organic farming often requires higher labour input than conventional farming practices, which might not be reflected in a partial budgeting.

03

EXAMPLE RESULTS

Enterprise budgets of conventional and organic cotton production in Banikoara, Bénin

Conventional production – 1ha	Revenue		Organic production – 1 ha	Revenue
Price (EUR/kg)	0.32		Price (EUR/kg)	0.45
Yield (kg/ha)	1060.00		Yield (kg/ha)	697.00
Revenue (EUR/ha)	315.00		Revenue (EUR/ha)	313.00
Input costs (EUR/ha)	**With subsidies**	**Without subsidies**	**Input costs (EUR/ha)**	**Average cost**
Cotton seeds	5.40	5.40	Cotton seeds	6.10
NPK fertilizer	52.00	78.00	NPK fertilizer	4.50
Urea	23.10	34.60	Urea	7.50
Organic manure	1.30	1.30	Organic manure	9.20
Hired labour	9.10	9.10	Hired labour	20.0
Black market pesticides	38.70	38.70	Black market pesticides	9.20
Formal market pesticides	57.00	78.10	Formal market pesticides	12.00
Total cash cost	**186.60**	**245.20**	**Total cash cost**	**68.50**
Net-benefit (EUR/ha)	**Average**	**Without subsidies**	**Net-benefit (EUR/ha)**	**Average**
Net-benefit*	**134**(106)**	**77(50)**	**Net-benefit**	**244**(190)**

Source: Westerberg, V. 2017, p. 20

**Median per hectare net-benefit provided in brackets   **Statistically significant difference in means at 95 percent level of confidence*

Note: Strictly speaking, the so called net benefit above is rather a gross margin or gross benefit since fixed costs such as machinery, tools and land rental are not included in the calculation.

FURTHER LITERATURE ON THE METHODOLOGY

- My Agriculture Information Bank (2017): Farm Budgeting: Partial Budgeting And Complete Budgeting.
- IOWA State University, Extension and Outreach (2018): Partial Budgeting: A Tool to Analyze Farm Business Changes.

REFERENCE PROJECTS AND STUDIES

- Westerberg (2017): The Economics of conventional and organic cotton production. A case study from the municipality of Banikoara, Benin. Report for the Economics of Land Degradation Initiative. (ProSoil).
- Forster et al. (2013: Yield and Economic Performance of Organic and Conventional Cotton-Based Farming Systems – Results from a Field Trial in India. PLoS ONE 8(12): e81039.Results from a Field Trial in India. PLoS ONE 8(12): e81039.

3.3 COST-EFFECTIVENESS-ANALYSIS (CEA)

FOCUS							
Economic effects	✔	Social effects		Environmental effects		Climate effects	

INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	

COMPLEXITY					
Basic	✔	Intermediate		High	

BRIEF DESCRIPTION OF THE METHODOLOGY

One way of including not only monetary values into the analysis of agroecological practices is the Cost-Effectiveness-Analysis (CEA). A CEA finds out how an objective can be achieved in the most cost-efficient way or helps identifying the lowest cost option to achieve a specific objective. While the costs of the measures need to be calculated in monetary terms, the benefit can be expressed in any other quantified measure, which can be compared with the target value.

CEA is an assessment methodology for decisions that involve selecting between alternative measures to achieve one single specific objective (e.g. restore a specific area of forest or mitigate a ton of carbon) and for which all costs can be measured in monetary terms.

The objective must be defined and measurable so that benefits can be quantified in physical units.The quantification of (monetary) costs and (non-monetary) benefits allow calculating unit costs as the ratio of total (discounted) costs to total benefit. A CEA cannot answer whether an intervention is economically feasible, but it can indicate which of the alternatives is the most cost-effective way to achieving the defined objective. A CEA can also be conducted if more than one objective exists. However, this would need an aggregation approach allowing the same quantitative expression/value for both objectives. In most cases, a weighting of objectives is necessary and leads to a so-called weighted CEA, which can also be considered a simplified MCA (see next methodology 3.4 CBA).

INPUT DATA AND ASSUMPTIONS

- Benefit: specific objective that can be quantified in physical terms (units); e.g. forest area restored (in ha), or amount of carbon mitigated (in tons)
- Costs: all costs that are related to the intervention (also see 3.4 CBA) and that are monetizable

TARGET INDICATORS

The output indicator of a CEA is the **cost-benefit-ratio (CBR)**, which indicates the costs per unit (benefit). The most cost-efficient option is the one with the lowest CBR.

EXAMPLE RESULTS

From Sapkota et al. (2019), p. 1348: "[…] When yield benefits were considered, green fodder supplement to ruminant diets was the most cost-effective mitigation measure, followed by vermicomposting and improved diet management of small ruminants. Mitigation measures such as fertigation and micro-irrigation, various methods of restoring degraded land and feed additives in livestock appear to be cost-prohibitive even when considering the yield benefits, if any."

LIMITATIONS
CEAs concentrate only on a single objective or benefit. They are often not suitable to account for the complex and multi-functional nature of agroecological systems, which always have multiple objectives. In addition, CEAs commonly omit the consideration of social aspects and many other benefits.

FURTHER LITERATURE ON THE METHODOLOGY
• *GEF LME: LEARN (2018)*: Environmental Economics for Marine Ecosystem Management Toolkit. Paris, France. • *HI-AWARE Working Paper 3 (2016)*: Assessing Costs and Benefits of Climate Change Adaptation. • *United Nations Framework Convention on Climate Change (2011)*: Assessing the costs and benefits of adaptation options. An overview of approaches. • *Asian Development Bank (2015)*: Economic analysis of climate-proofing investment projects.

REFERENCE PROJECTS AND STUDIES
• *Kronbak and Vestergaard (2013)*: Environmental cost-effectiveness analysis in intertemporal natural resource policy: Evaluation of selective fishing gear. Journal of Environmental Management, 131(), 270–279. Chapter 2. • *Sapkota et al. (2019)*: Cost-effective opportunities for climate change mitigation in Indian agriculture. In: Science of the total environment, Vol. 655, p. 1342-1354.

03

3.4 COST-BENEFIT-ANALYSIS (CBA)

FOCUS							
Economic effects	✔	Social effects	(✔)	Environmental effects	(✔)	Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	
COMPLEXITY							
Basic		Intermediate	✔	High			

BRIEF DESCRIPTION OF THE METHODOLOGY

A Cost-Benefit-Analysis (CBA) examines the expected costs and benefits of a specific intervention and allows to compare it with the costs and benefits of a business-as-usual or alternative intervention. In this way, the analysis helps to identify the intervention with the highest net economic benefits compared to a business-as-usual scenario or potential alternatives. The CBA is done by first quantifying and then monetizing all expected costs (including negative impacts) and benefits associated with a specific intervention over a certain period of time. Typically, current benefits (and costs) are valued more than benefits in the (distant) future, which is integrated into the calculation by using a *discount rate*. The discount rate facilitates comparison of all costs and benefits regardless of the point in time when they occurred. To check the robustness of the CBA results, an additional *sensitivity analysis* can be conducted. Another option is to estimate whether the omission of certain costs and benefits, that cannot be monetised, affects the decision result. The great strength of a CBA lies in its direct comparability with other CBAs.

When data availability allows, CBAs can also be used to measure gender effects; for example, how male and female headed households profit differently from agroecological interventions. Therefore, certain data must be available disaggregated by men and women.

INPUT DATA AND ASSUMPTIONS

- Costs of planning, preparing, facilitating, and implementing agroecological practices, including transition costs. e.g. production costs, *opportunity costs*, costs for technology and material, health and other social costs (if applicable and monetizable)
- Benefits of following the implementation of agroecological measures.: e.g. increased yields, additional income from diversified or extended production AND benefits from the avoided environmental or social damage costs
- Prices to calculate the costs: e.g. for products, inputs, technologies, labour etc.
- (Local) *discount rate*
- Geographical boundaries (reference area): e.g. one ha, farm, household, specific larger area (to compare different CBA results, they must refer to the same reference area)
- Time horizon depends on the lifespan of the agroecological practices and can be short-term, mid-term and long-term (e.g. infrastructure investments have rather long time horizons)

TARGET INDICATORS

The ***net present value (NPV)*** represents the discounted net benefit of an intervention. In simple terms, it is the gain in money generated by the measure until a certain point in time.

- **Positive NPV** = Economically profitable
- **Negative NPV** = Economically unprofitable

The **benefit cost ratio (BCR)** is the ratio of discounted total benefits and costs and shows the extent to which the benefits exceed costs.

- **BCR > 1** = Economically profitable
- **BCR < 1** = Economically unprofitable

An **internal rate of return (IRR)** worth x simply means that money can be borrowed at a rate x during the time horizon under consideration without losing. If the IRR exceeds the discount rate used in the CBA analysis, the intervention can be considered economically profitable.

- **IRR > discount rate** = Economically profitable
- **IRR < discount rate** = Economically unprofitable

EXAMPLE RESULTS

Sourya Das et al. (2020): A cost-benefit analysis of project and control villages in Madhya Pradesh in India has been conducted to understand the economic viability of watershed development interventions in comparison to a "Business-As-Usual (BAU)" scenario, i.e. the scenario in the control villages. For the project villages, the sum of the cost of the intervention and the cost of cultivation has been included, while the control villages only had costs of cultivation. On the benefit side, benefits from agriculture (crop and fodder) were included for project and control villages, while the extra benefits resulting from the intervention such as time saving for water collection and the benefits of reduced migration were only relevant for the project villages. The benefit-cost ratio and the NPV per household and per village were then calculated by using different discount rates of 8,5 and 3 % (see table below). The different discount rates were used for a sensitivity analysis to check the robustness of the results. It can be concluded that Partala and Dungariya show better economic viability than their respective BAU scenarios. This is true for all three discount rates (which means that the results can be considered reliable). For the case of Katangi and Paundi-Mal this is not the case. Here, the BAU villages are economically more profitable than the project village, since BCR and the NPV per household of Paundi-Mal are higher than that of Katangi for all three discount rates.

Project Village	Discount Rate	BCR	NPV	NPV/HH	Control Village	Discount Rate	BCR	NPV	NPV/HH
Partala	8%	2.2	26947031	107788	**Amdara**	8%	3.20	14738046	87207
	5%	2.2	33328669	133315		5%	3.30	18277932	108153
	3%	2.3	38609854	154439		3%	3.40	21241636	125690
Dungariya	8%	2.8	5838731	110165	**Kui-Ryt.**	8%	3.10	6849835	72871
	5%	3.0	7508712	141674		5%	3.30	8701253	92567
	3%	3.2	8918437	168272		3%	3.40	10264614	109198
Katangi	8%	2.4	13581722	75454	**PaundiMal**	8%	4.30	25200581	92649
	5%	2.5	17306448	96147		5%	4.40	31691668	116513
	3%	2.5	20452667	113626		3%	4.50	37165991	136640
Kareli	8%	2.1	14699769	116665	**Sihora**	8%	2.00	9949647	77129
	5%	2.2	18923624	150187		5%	2.09	12803213	99250
	3%	2.2	22497437	178551		3%	2.15	15224628	118020

Source: Sourya Das et al. 2020, p. 27

LIMITATIONS

The main disadvantage of a CBA is, that it is a purely monetary analysis that can only include monetizable costs and benefits. This can lead to the omission of important effects of agroecological practices as some costs and benefits (e.g. related to ecosystem services) do not have an obvious monetary value. One solution is to generate monetary estimates by using non-market valuation methods (see 3.5 Total economic valuation approach) and make them integrable into CBAs. This, however, requires additional assessments prior to a CBA. One stepwise approach to do this can be found in the ELD User Guide. Another option is to consider the non-includable effects in a descriptive and qualitative or even quantitative way.

FURTHER LITERATURE ON THE METHODOLOGY

- OECD (2018): Cost-Benefit Analysis and the Environment: Further Developments and Policy Use, OECD Publishing, Paris.
- GEF LME:LEARN (2018): Environmental Economics for Marine Ecosystem Management Toolkit. Paris, France.
- United Nations Framework Convention on Climate Change (2011): Assessing the costs and benefits of adaptation options. An overview of approaches.

REFERENCE PROJECTS AND STUDIES

- Sourya Das et al. (2020): Economic valuation of reducing land degradation through watershed development in east Madhya Pradesh (India) under risks of Climate extremes, WOTR, Pune. Economic of Land Degradation (ELD). (ProSoil)
- Westerberg et al. (2019): Reversing Land Degradation in Drylands: The Case for Farmer Managed Natural Regeneration (FMNR) in the Upper West Region of Ghana. Report for the Economics of Land Degradation Initiative in the framework of the "Reversing Land Degradation in Africa by Scaling-up Evergreen Agriculture" project.
- Traoré Sidnoma and Requier-Desjardins (2019): Neutrality gains / economic gains from sustainable land / Soil management in three provinces of Burkina Faso. Study of the Economics of Land Degradation in Burkina Faso. (ProSoil).

3.5 TOTAL ECONOMIC VALUATION (TEV)

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects	✔	Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate	✔	High	(✔)		

BRIEF DESCRIPTION OF THE METHODOLOGY

Total Economic Valuation (TEV) can help measure ecosystem services that do not have a market price but still play indirect roles in the market. They can combine non-use values (which are normally difficult to quantify) with use-values, giving a holistic societal perspective unlike than this would be possible with a purely market-based approach (see next page). Use values relate to the actual use of the good in question, including the planned or optional use. Non-use value refers to the willingness to pay for maintaining some good in existence for current or future use even though there is no actual, planned or possible use, e.g. feeling concerned about a threatened species.

Depending on the value, different valuation techniques exist that can be used to measure the components of TEV. Methods based on the estimation of the demand curve (demand-based) include revealed preference methods (which rely on actual behavior in existing markets) and stated preference methods (which estimate the value of services not usually purchased and sold in actual markets).

Market price: Prices for ecosystem services that are directly observed in markets and services that are traded directly in markets, e.g. agricultural produce, timber and fuel wood.

Replacement cost: Cost of replacing an ecosystem service with a human-made service, e.g. water storage and filtration by wetlands replaced by reservation and filtration plant or the amount of fertilizer needed to replenish the equivalent amount of nutrient loss saved from the agricultural fields.

Damage cost avoided: Damage avoided due to ecosystem service, e.g. river flow control by wetlands.

Opportunity cost: The next highest valued usage of the resources used to produce an ecosystem service; e.g. the opportunity cost of ecosystem services from a natural ecosystem might be the value of agricultural output if the land is converted to agricultural instead of conserved in a natural state.

Hedonic pricing: Influence of environmental characteristics on prices of marketed goods, e.g. soil condition for agricultural fields.

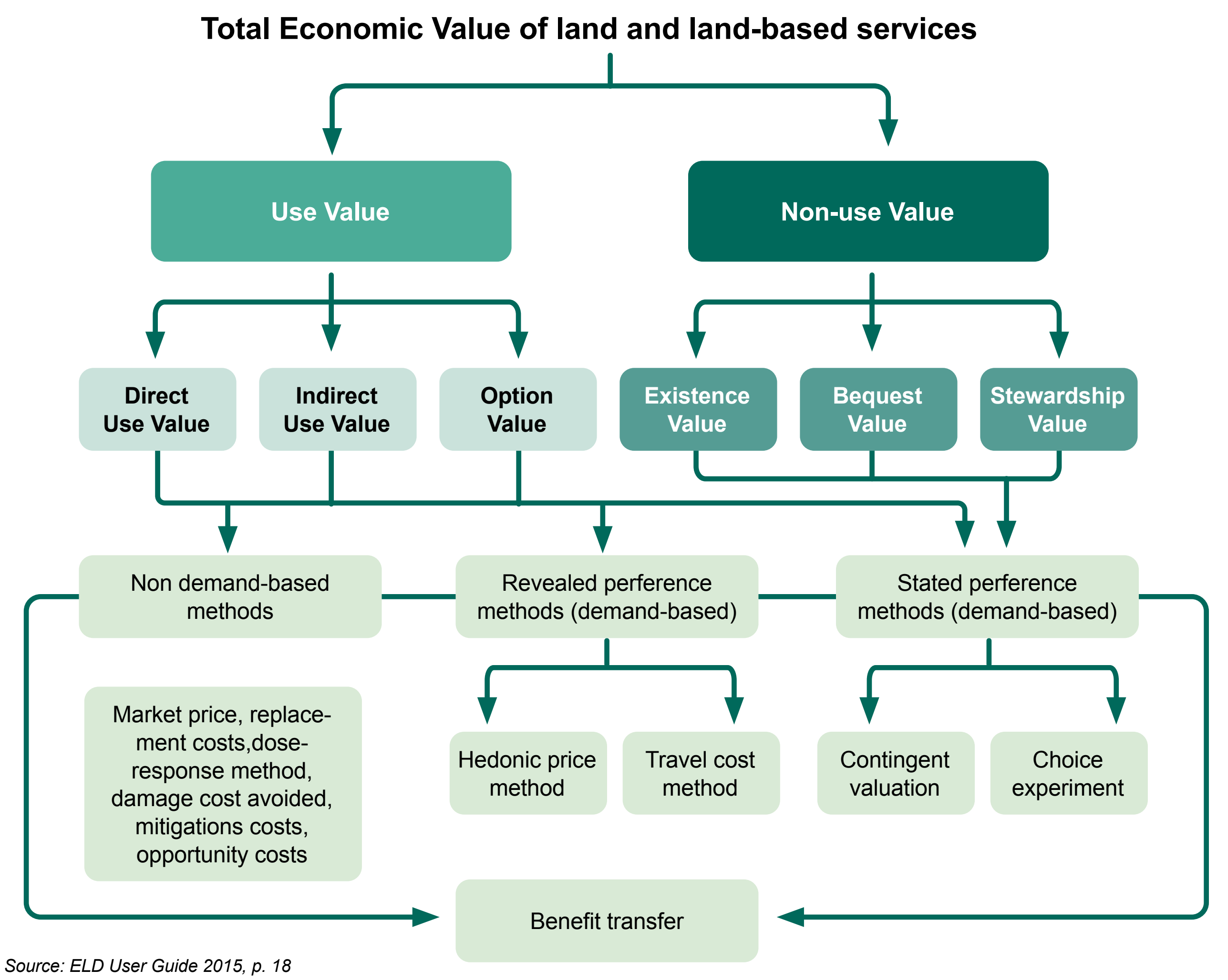
Travel cost: Demand for ecosystem recreation sites using data on travel costs and visit rates, e.g. recreational use of ecosystems.

Contingent valuation: People's willingness to pay for an ecosystem service through surveys, e.g. flood risk attenuation.

Choice experiment: People's trade-offs between ecosystem services and other goods to elicit willingness to pay, e.g. flood risk attenuation.

Note: The monetised values can either be considered as a stand-alone analysis or be entered into a CBA to produce information on the long-term profitability of an agroecological practice.

BRIEF DESCRIPTION OF THE METHODOLOGY – CONTINUED



Source: ELD User Guide 2015, p. 18

03.

3.5 TOTAL ECONOMIC VALUATION (TEV) – CONTINUED

INPUT DATA AND ASSUMPTIONS
The input data needed varies. However, data about the status quo and the improvement or the deterioration of an ecosystem service will always be necessary to have information of the impact of the agroecological practice. This data can be generated with the help of environmental assessments prior to the TEV.
TARGET INDICATORS
• Monetary values and prices of ecosystem services
EXAMPLE RESULTS
From *Sourya Das et al. (2020)*: The watershed development intervention in India improved several provisioning ecosystem services such as the groundwater recharge and the flow in water streams, which ultimately led to the improvement of the water availability for household purposes. To determine the economic value for the provisioning of water for household usage the "market price" and "damage costs avoided" method was applied. By identifying the time (with the help of surveys) that could be saved with the improved water access and by assigning a price to this time, the monetary value of the ecosystem service was calculated.
LIMITATIONS
The valuation of ecosystem services is complex. One limitation refers to the interdependency of ecosystem services. The economic value of an ecosystem service may depend on its relationship with other services, and therefore an assessment of the value of one service may not easily consider how other services are being affected. In addition, double counting can be a problem. Some ecosystem services are not complementary and the provision of one can be precluded by others (trade-offs). To prevent double counting, the full range of complementary and competitive services must be distinguished before any aggregation of values is completed. One must be aware that valuation techniques for environmental goods and services are imperfect and shadow prices can only be estimates. Values for environmental goods and services are, therefore, uncertain and can change very rapidly.
FURTHER LITERATURE ON METHODOLOGY
• *GEF LME:LEARN (2018)*: Environmental Economics for Marine Ecosystem Management Toolkit. Paris, France. • *OECD (2006)*: Cost-Benefit Analysis and the Environment: Recent Developments. • *ELD Initiative (2015)*: ELD Initiative User Guide: A 6+1 step approach to assess the economics of land management. GIZ: Bonn, Germany.
REFERENCE PROJECTS AND STUDIES
• Traoré Sidnoma et Requier-Desjardins (2019) : Neutrality gains / economic gains from sustainable land / Soil management in three provinces of Burkina Faso. Study of the Economics of Land Degradation in Burkina Faso. (internal ProSoil document).

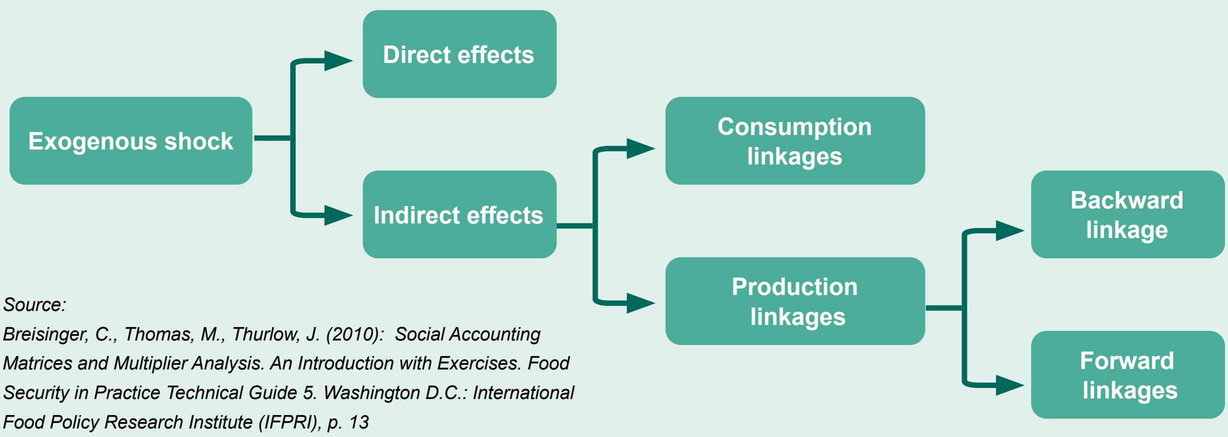
03.

3.6 MULTIPLIER ANALYSIS

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects		Climate effects	
INTERVENTION AREA							
Field/Farm level		Landscape level		Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate	✔	High			
BRIEF DESCRIPTION OF THE METHODOLOGY							

Often, an economic impact analysis is conducted at sector level, i.e. the primary agricultural market. But changes (also often referred to as external shocks) in the agricultural market usually impact other parts of the economy because sectors upstream (i.e. input industry) and downstream (i.e. processing, trading and retailing) are closely interlinked with the primary sector. Upstream linkages are also often referred to as backward linkages, while downstream linkages are referred to as forward linkages. Additionally, these linkages can be further differentiated into demand and supply side linkages. Hence, impacts on a sector always have direct and indirect effects along the whole supply chain. These effects can stretch from stage to stage across the whole economy, i.e. from agriculture to food processing to transporting to supermarkets and eventually to the final consumer. Now, multipliers capture the transmission of a sectoral change across the economy. These impacts can be quantified, for example via effects on the gross domestic product (GDP), household income or the labour market. Adding up all those effects across all backward and forward linkages leads to the multiplier effect of the sectoral change. The so-called Multiplier Analyses can be used for the assessment of such effects.

This method is only applicable if multipliers are available. Determining the multiplier values itself is highly complex and data demanding. Basically, it can be distinguished between two different multiplier approaches, which differ in complexity and data demand as well as explanatory power. Input-output multipliers only consider effects of production linkages. Consumption linkages, i.e. changes in income, on the other hand are not included. Multipliers based on a [Social Accountability Matrix (SAM)](#) include both production and consumption linkages. Using input-output multipliers is less data demanding and a more pragmatic approach while using multipliers based on the construction of a Social Accountability Matrix is much more complex and data driven. Hence, using multiplier analysis and choosing the right method strongly depends on the availability of multipliers.



Source:
Breisinger, C., Thomas, M., Thurlow, J. (2010): Social Accounting Matrices and Multiplier Analysis. An Introduction with Exercises. Food Security in Practice Technical Guide 5. Washington D.C.: International Food Policy Research Institute (IFPRI), p. 13

03

INPUT DATA AND ASSUMPTIONS
• Objectives
TARGET INDICATORS
• Economy-wide or sectoral GDP • Changes in income • Changes in employment
EXAMPLE RESULTS
From *Noleppa and Cartsburg (2021)*, p. 152: "[…] Using once more sophisticated multiplier analysis also allows to calculate the overall labour effect and leads to the conclusion that more than 870 000 jobs in storing, processing, packaging, internationally trading and retailing along the value chains would additionally suffer from income losses or unemployment in the EU in total by 2040 if plant breeding progress in the next two decades stopped."
LIMITATIONS
Determining multiplier values is complex and time consuming. Therefore, resorting to existing multipliers will often be the option of choice. However, data is not always easily accessible and can reduce the applicability of this method. Additionally, multiplier analyses are useful for determining effects of quantity-based shocks and are less applicable for price shocks or determining price effects.
FURTHER LITERATURE ON THE METHODOLOGY
• *Breisingner and Thomas (2010)*: Food security in practice: social accounting matrices and multiplier analysis: an introduction with exercises. Washington, DC: IFPRI. • *Bwanakare (2017* : Non-extensive entropy econometrics for low frequency series. Chapter 5: A SAM and multiplier analysis: economic linkages and multiplier effects. Berlin: De Gruyter.
REFERENCE PROJECTS AND STUDIES
• *Fuentes-Saguar et al. (2017)*: The role of bioeconomy sectors and natural resources in EU economies: a social accounting matrix-based analysis approach. In: Sustainability (9): 2383. • *Cingiz et al. (2021)*: A cross-country measurement of the EU bioeconomy: an input-output approach. In: Sustainability (13): 3003. • *Noleppa and Cartsburg (2021)*: The socio-economic and environmental values of plant breeding in the EU and for selected EU member states. Berlin: HFFA Research GmbH.

03.

3.7 SINGLE MARKET MODELS

FOCUS							
Economic effects	✔	Social effects		Environmental effects		Climate effects	
INTERVENTION AREA							
Field/Farm level		Landscape level		Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

Market models are used to represent economic processes that are based on microeconomic theory. These models are often used to investigate the economic effects of policy instruments, such as trade or tax policies and are widely used in agricultural economics.

Market models allow for an ex-ante evaluation of the impacts of exogenous influencing factors, such as policy adjustments or trade changes and support decision-making processes. One can distinguish between two different types of market or equilibrium models, which differ in their coverage of markets, called general or partial equilibrium models. General equilibrium models (GEM) include the whole economy, while partial equilibrium models (PEM) focus on only one part of the economy, i.e. agriculture, while ignoring inter-actions with other sectors and markets. While GEM are demanding in terms of know-how, resources and data availability, PEM work with less data and are easier to conceptualize, program, calibrate, and finally implement.

PEM are very useful for policy decisions that focus on a certain part or sector of the economy. A simple version of a PEM is a comparative static model which displays only the initial situation and the final equilibrium achieved in the sector or economy after the implementation of a so-called shock. Shocks are exogenous influencing factors impacting supply and/or demand of a product, such as yield reductions by pests and diseases or decreasing input costs due to the application of agroecological practices. PEM can, depending on their complexity, range from single-market-single-country models to multi-market-multi-country models. The most pragmatic approach is the single-market PEM, which only focusses on one product, i.e. wheat, and the impact of a certain exogenous shock on the wheat market in only one or more countries. PEM can be built using standard spreadsheet technologies, such as MS Excel and do not need special programming software.

INPUT DATA AND ASSUMPTIONS

- Supply and demand quantities
- Prices
- Elasticity values

TARGET INDICATORS

- Supply and demand
- Trade
- Market prices
- State budget
- Welfare (producer and consumer surplus)

EXAMPLE RESULTS

From OECD/FAO (2022), p. 155: "[…] The global area harvested to cereals is expected to grow by 19 Mha (3%) by 2031. It will expand mainly in Asian countries by about 9 Mha, notably in India and Kazakhstan. Globally, wheat and maize areas are projected to increase by 3% and 5%, while other coarse grains and rice areas are expected to increase by 2% and 1%. Decreasing harvested areas of rice in China, Viet Nam and Brazil will be offset by gains in India and African countries. With land expansion limited by restricted land availability as compared to the previous decade, the result of constraints placed on converting forest or pasture into arable land, as well as ongoing urbanization, increased global production is expected to be largely driven by intensification. Growth in yields, due to improving technology and cultivation practices in middle-income countries in particular, is expected to sustain future cereals production. Globally, yields are expected to grow between around 6% for wheat, 7% for other coarse grains, 8% for maize, and 12% for rice."

LIMITATIONS

As the name already highlights, single market models focus only on one market and make it possible to assess how certain impacts or shocks may impact this specific market. However, this is quite a simplification as such a modelling approach ignores interactions with other markets such as substitution effects with other products. Additionally, single market models are by its nature partial equilibrium models. This means, this kind of model only looks at one product in one sector (i.e. the wheat market) but ignores all other parts of the economy. Possible interactions between the market for wheat and other sectors of the economy are therefore also excluded of the analysis. Hence, single market models are cost-effective and useful tools to model certain changes on a market, especially when these changes are quite specific to this market. However, the results of such a modelling exercise can not include the complexities of market and sectoral interactions as they would appear in real life.

FURTHER LITERATURE ON METHODOLOGY

- *Jechlitschka et al. (2007)*: Microeconomics using Excel. Milton Park: Routledge.
- *OECD/FAO (2015)*: The Aglink-Cosimo model: A partial equilibrium model of world agricultural markets. Paris: OECD Publishing.
- *Lüttringhaus and Cartsburg (2018)*: Modelling agricultural markets with the HFFA-Model. HFFA Research Paper 02/2018. Berlin: HFFA Research GmbH.

REFERENCE PROJECTS AND STUDIES

- *OECD/FAO (2022* : OECD-FAO Agricultural Outlook 2022-2031. Paris: OECD Publishing.
- *Jansson and Wilhelmsson (2022)*: Impacts on agricultural markets of a large production loss in Ukraine. Lund: AgriFood Economics Centre.
- *Nelson et al. (2014)*: Climate change effects on agriculture: economic responses to biophysical shocks. In: Proceedings of the National Academy of Sciences of the United States of America (111): 3274–3279.

03

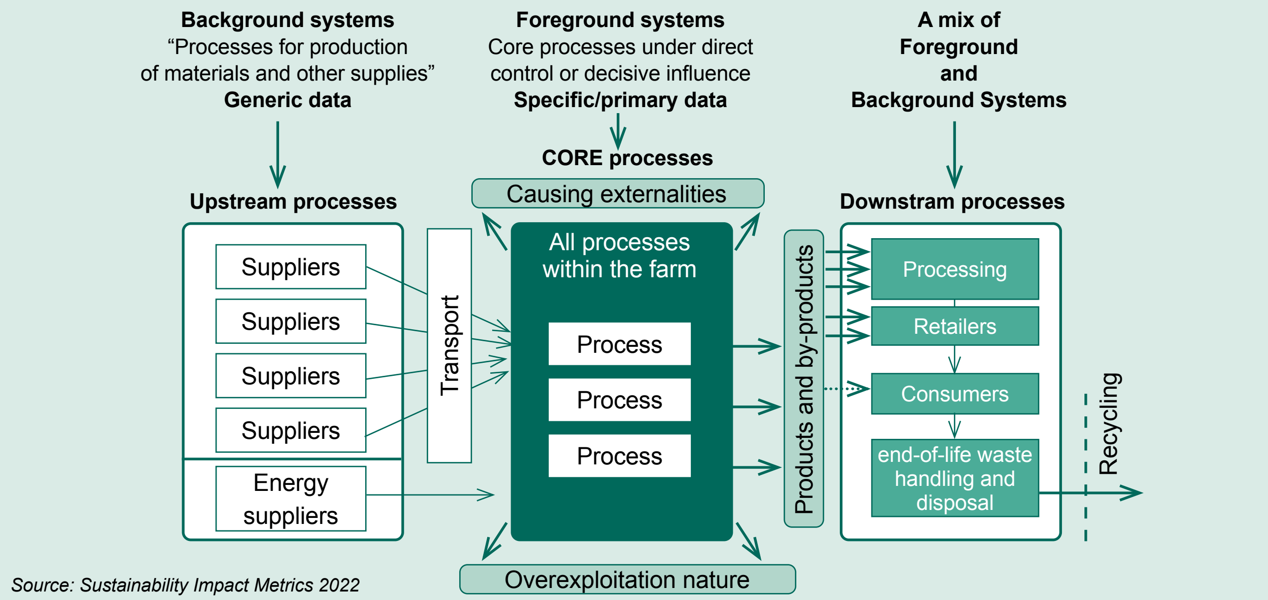
3.8 TRUE COST ACCOUNTING (TCA)

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects	✔	Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

True Cost Accounting (TCA) aims at evaluating the externalities of a defined eco-agri-food system that goes beyond the traditional measurement of economic key performance indicators. TCA uses systemic approaches to evaluate all visible and invisible, direct, and indirect impacts of the eco-agri-food system. The TCA methodology conceptualises external impacts according to four capitals. These capitals are Natural, Social, Human and Produced Capital. The focus of the TCA methodology lies in the first three capitals since they contain the externalities of an agri-food product. Produced capital (main production cost) is widely covered in current accounting standards and to a large extent already reflected in the price of a food product, quantified in monetary units.
TCA is an approach rather than a standardized methodology. Therefore, no single blueprint for a TCA application can be derived. Depending on the individual situation, the scope and the system boundaries of the study, as well as the processes that are included and those which are excluded, differ. TCA compiles the results from different assessments on different sub-topics using different methods.

TCA is similar to the calculation structure in Life Cycle Assessments (LCA). There is a foreground system (the farm under study), and there are the background processes in the supply chain (supply of diesel, electricity, fertilizers, pesticides, cattle food, etc.). While the background system, i.e. all materials that are supplied to a farm are calculated with LCA, the foreground issues related to the three capitals need to be addressed in individual TCA assessments (see other environmental methodologies 3.9-3.15). One major difference between the LCA and the TCA approach is, that the reference point in a LCA is "untouched nature", while for TCA it is a "conventional farm". So, in contrast to LCA, farmers can make positive contributions to the steady state, for example by keeping biodiversity and soil organic carbon at high level. In a LCA, any activity of mankind is degrading nature. Where possible, the impact indicators, like soil erosion or greenhouse gas emissions, are monetised with the help of a monetization factor. These factors can be found for example in the Eco-cost Value database or in the TCA Handbook.



Source: Sustainability Impact Metrics 2022

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INPUT DATA AND ASSUMPTIONS

The elements included into a TCA differ according to the intervention to be evaluated and could include marketed as well as non-marketed (intangible) elements:

- Economic inputs and outputs (e.g. yields, income, production costs, intermediate inputs)
- Ecosystem services
  - provisioning services (e.g. habitat or energy provision)
  - cultural services (e.g. cultural heritage)
  - regulating services (e.g. soil fertility enhancement, soil formation, nutrient cycling)
- Residual flows (e.g. water pollution)

TARGET INDICATORS

- Natural capital indicators (e.g. greenhouse gas emissions, soil erosion, water pollution)
- Human capital indicators (e.g. labour conditions, human health, living wage)
- Social capital indicators (e.g. human rights, gender pay gap, share of women, child labour)

The expression of these indicators can be done in monetary, quantitative, or qualitative terms; or scores or as a mixture of it.

EXAMPLE RESULTS

From *True Cost Initiative (2022)*: The average true cost of a material or product can be estimated by assessing the true cost of all tiers of all the supply chains. For the case of an apple pie, the true costs were aggregated in two steps: first, the sum of true cost per tier was formed (e.g. tier 3: apple growers, tier 2: transportation, tier 1: puree makers) and second, the true costs of all tiers are added up. In some instances, it might not be feasible for a company to assess all its suppliers. In this case representative samples should be taken. For more details on this example, see *TCA Handbook, p. 46.*

LIMITATIONS

TCA is a very sophisticated methodology as it has the claim to include all externalities of an intervention. Since it is still a rather new approach, there are not many references and example studies available, and limitations are therefore not yet fully assessed. In the past, TCA has been particularly used to determine the true costs of food products.

FURTHER LITERATURE ON THE METHODOLOGY

- *True Cost Initiative (2022)*: TCA Handbook – Practical True Cost Accounting guidelines for the food and farming sector on impact measurement, valuation and reporting.
- *Soil & More Impacts and TMG Thinktank for Sustainability (2020)*: True Cost Accounting: Inventory Report. Global Alliance for the Future of Food.
- *TEEB (2018)*: TEEB for Agriculture & Food: Scientific and Economic Foundations. Geneva: UN Environment.
- *Sandhu et al. (2021)*: True Cost Accounting of Food Using Farm Level Metrics: A New Framework. In: Sustainability.
- *Sustainability Impact Metrics (2022)*: True Cost Accounting. The Delft University of Technology.

REFERENCE PROJECTS AND STUDIES

- *Raynaud et al. (2016)*: Improving Business Decision Making: Valuing the Hidden Costs of Production in the Palm Oil Sector. A study for The Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEB AgriFood) Program.
- *CONABIO (2017)*: Ecosystems and agro-biodiversity across small and large-scale maize production systems, feeder study to the “TEEB for Agriculture and Food”. Ecuador, Mexico and United States.
- *Bergman et al (2016)*: The True Price of Tea from Kenya Joint report by IDH and True Price.
- *Global Alliance for the Future of Food (2021)*: True value: Revealing the positive impacts of food systems transformation.

3.9 ECONOMIC VALUATION OF BIODIVERSITY

FOCUS							
Economic effects	✔	Social effects		Environmental effects	✔	Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

Economic valuation of biodiversity is subject to a lively debate in the academic arena and its importance in valuing ecosystem services has been widely acknowledged. Multiple different valuation approaches are available. Assessing the economic value of biodiversity is useful to understand how changes in biodiversity affect humans and their (economic) well-being. Economic valuation of biodiversity can be divided into direct economic value of biodiversity and indirect economic value of biodiversity. The direct economic value approach asks how biodiversity affects or impacts people's utility directly, i.e. a person is happier when the number of birds in the local forest increases. Hence, assessing the direct economic value is often based on individual preferences such as the willingness to pay for certain things. These evaluations are based on revealed preference methods and stated preference methods. For more information on these methods, please see also *chapter 3.5* on the Total Economic Valuation approach. Here, methodologies overlap with these of biodiversity valuation as biodiversity and ecosystem functioning are closely intertwined.

Indirect economic value of biodiversity on the other hand can be analysed by understanding biodiversity as an input into a process that generates a valuable economic output. Thus, changes in biodiversity (i.e. reduction of wild pollinators) impact the economic output (i.e. agricultural production) of a certain process (i.e. plant production based on pollination). In this approach it is rather the ecosystem service that is used as an input in the value generating process. Hence, it is highly important to understand the link between biodiversity, the functioning of a certain ecosystem and the ecosystem services it eventually provides. These interconnections are complex and ecosystem specific. The complexity increases even further when considering, that biodiversity and its resulting ecosystem service (i.e. pollination) can have multiple economic values resulting in trade-offs (i.e. agricultural output and carbon storage).

To sum up, three approaches for valuation of biodiversity can be distinguished: (1) revealed preferences methods, and (2) stated preferences methods are used to assess people's willingness to pay, (3) production function methods are applied to view biodiversity or rather the ecosystem services it provides as an input for the production of a good or service.

Once these methods have been applied, ecosystem services can also be quantified in the form of environmental assets that comprise of water, soil, species, natural resources etc. Calculating environmental assets is important as many of the components are public goods and therefore are often not part of a market valuation process. As a consequence, environmental assets are often not fully considered in policy or private decision-making. Once environmental assets are quantified it becomes easier to compare its present and discounted future value to other options such as converting a certain ecosystem into farmland. Such a comparison can then, for example, be executed via a cost-benefit-analysis as described in the corresponding chapter 3.4.

INPUT DATA AND ASSUMPTIONS

- Clarity on the objective of the research, i.e. what ecosystem service shall be valued and awareness that different ecosystem service from the same ecosystem may come with trade-offs
- It provides detailed knowledge of the interlinkage between biodiversity, ecosystem functioning and ecosystem services
- Detailed data on the composition of the ecosystem
- Data about the status quo and the improvement or the deterioration of an ecosystem service

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TARGET INDICATORS

- Willingness to pay
- Value of ecosystem services

EXAMPLE RESULTS

Hernandez et al (2022), adapted from p. 4: “The cost of ecosystem service degradation due to a business-as-usual agave-mezcal production in Mexico over the 2003–2019 period was estimated at US$ 19 million on average across the three analysed districts. This corresponds to the revenue that the districts in the study area lost over this period due to land degradation. The analysis showed that the cumulative losses from 2019 projected to 2030 could reach up to US$ 163 million, with an annual average of US$ 14 million. This is the cost of inaction if production practices continue to follow the current trend. With the transformation of production and making use of good agricultural practices, ecological restoration, and conservation, agave-mezcal production generates net profits, with projected cumulative profits over the same period (2019–2030) of US$ 85 million and net income of US$ 7 million per year. This sustainability scenario offers a vision of the economic potential of agave, whose growth relies on the ability to regenerate natural capital – represented by the land’s ecosystem services – and the capacity to significantly improve the socioeconomic situation of the traditional, artisan producers of agave-mezcal.”

LIMITATIONS

The methods used in direct valuation are based on people’s preferences, hence different kinds of biases can emerge. For example, the willingness to pay for the preservation of elephants might be higher than that for spiders, as elephants are likely to be more popular. Additionally, some questions regarding biodiversity require prior (expert) knowledge which might not be readily available for individuals being questioned. Hence their preferences and willingness to pay might reflect that. And lastly, direct valuation requires comprehensive experience in stated and revealed preferences methods to create meaningful results. Indirect valuation methods, on the other hand, are very data demanding and profound knowledge of the interconnections between biodiversity, ecosystem functioning and ecosystem services is necessary to correctly value biodiversity as an input in production processes.

Additionally, it is important to keep in mind the valuation of biodiversity is still a relatively young research area. A lot of research is being conducted, however, results might still be subject to uncertainties and should be used and interpreted with care.

FURTHER LITERATURE ON METHODOLOGY

- Tinch et al. (2019): Economic valuation of ecosystem goods and services: a review for decision makers. In: Journal of Environmental Economics and Policy, Vol. 8, p. 359-378.
- Hanley et al. (2019): The economic value of biodiversity. In: Annual Review of Resource Economics, Vol. 11, p. 355-375.
- World Bank (2019): Natural asset and biodiversity valuation in cities. Technical Paper.
- Badura et al. (2017): Valuation for natural capital and ecosystem accounting. Synthesis report for the European Commission. Centre for Social and Economic Research on the Global Environment, University of East Anglia.
- Hanley and Roberts (2019): The economic benefits of invasive species management, In: People and Nature, 1:124–137.

REFERENCE PROJECTS AND STUDIES

- Berghöfer et al. (2021) : Africa’s protected natural assets: The importance of conservation areas for prosperous and resilient societies in Africa. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Helmholtz Centre for Environmental Research (UFZ). Bonn/Eschborn and Leipzig, Germany.

03.

3.10 MULTI-CRITERIA-ANALYSIS (MCA)

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects	✔	Climate effects	✔
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic	✔	Intermediate		High			

BRIEF DESCRIPTION OF THE METHODOLOGY

Multi-Criteria-Analysis (MCA) integrates various assessment criteria (financial and non-financial, monetised or expressed in other quantitative and qualitative terms) in one common framework to arrive at scoring and relative ranking of the agroecological practices. MCA can be used to establish preferences between alternative practices. Unlike in a CBA or CEA, criteria do not need to be quantified or even monetised. MCA provides a systematic methodology for comparing the criteria, some of which may be expressed in monetary terms and some of which are expressed in other units. The set of criteria include all important categories of negative and positive effects resulting from the assessed measures. In a MCA it is possible to include criteria that are difficult to quantify and can perhaps only be assessed in qualitative terms such as many social indicators.

The MCA is displayed as a matrix with the alternative measures listed in the columns and the criteria listed in the rows. For the assessment, each criterion will be assigned with scores for each alternative. To enable the direct comparison of different criteria, a standardised interval scale of scores must be chosen. Data on impacts can be collected from surveys, existing data, experts, or stakeholders. MCA also applies weighting of criteria to quantify the relative importance of each criterion in the decision process. Weights can be derived from existing information or from stakeholders by asking them to state their preferences for the various criteria. By combining the standardised scores and weights of the criteria, the alternative options can be ranked through a weighted summation of criteria scores for each alternative.

A key strength of MCA is that it is not necessary to quantify all impacts in monetary terms. This means that complex and time-consuming valuation of all impacts can be avoided, and that qualitative criteria can be included in the decision framework. Even if ranking result of a MCA do not provide information on the economic feasibility of interventions, a MCA can give economically valuable insights as the results of *CBA*, *CEA* or other economic indicators (e.g. generated with the *Total economic valuation approach)*) can be integrated. Like for the economic aspects, also results from other conducted analyses, can be integrated into the MCA.

	Criterion 1	Criterion 2
Criterion weighting	Weighting	Weighting
Agroeclogical practice 1	Score	Score
Agroeclogical practice 2	Score	Score
…		

Source: Own illustration.

INPUT DATA AND ASSUMPTIONS

- Objectives
- Criteria or indicators to judge the measures against the (non-measurable) objectives
- Interval scale and scores that measure the impact of an option against the criteria
- Weights attributed to the criteria

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TARGET INDICATORS

The indicators of an MCA are also called criteria and are entered in the top row of a MCA matrix. The here displayed criteria are only examples. They finally depend on the effects that are measured. However, the unit in which the indicators are measured is always expressed in scores between a prior defined scale, e.g. 1–10. The average scores across all criteria per agroecological practice are then used to identify the best possible option and to compare practices. If indicators differ in importance, they can be weighted prior to the assessment.

- Economic indicators: e.g. yield, economic return on investment, long-term profitability
- Social indicators: e.g. nutritional quality of food, human health, labour creation, intensity and difficulty of the work
- Environmental indicators: e.g. pollution, erosion, soil fertility, preservation of water, preservation of energy
- Climate indicators: e.g. mitigation effect, adaptation impact

EXAMPLE RESULTS

From *PIK (2021)*: Climate Risk Analysis for Identifying and Weighting Adaptation Strategies in Burkina Faso's Agricultural Sector (AGRICA), Chapter 8+9:

The potential of integrated soil fertility management (ISFM) and irrigation in Burkina Faso has been assessed with respect to different indicators on a scale from "high positive potential" to "high negative potential" (see table below). The MCAs are based on prior conducted qualitative assessments based on literature and surveys. The comparison of MCAs shows great upscaling potential for both ISFM and irrigation. The ISFM strategy holds various socio-economic co-benefits including increased agricultural-production, food security and restoration of degraded land and biodiversity, while irrigation has a high potential for maladaptive outcomes as irrigation is expensive and energy intense, which might cause conflicts and lead to higher CO_2 emissions from agriculture.

MCA for ISFM in Burkina Faso							
Risk mitigation	Risk-gradient	Cost-effectiveness	Upscaling	Potential Co-benefits	Potential maladaptive outcomes	Barriers to implementation	Institutional support requirements
High	Risk-independent	High	High	High	Low	Medium	Medium to low
MCA for irrigation in Burkina Faso							
Risk mitigation	Risk-gradient	Cost-effectiveness	Upscaling	Potential Co-benefits	Potential maladaptive outcomes	Barriers to implementation	Institutional support requirements
Medium to high	Risk-independent	Medium	High	High	High	Medium to high	High

Source: Röhrig, et al. 2021, p. 98 + 110

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3.10 MULTI-CRITERIA-ANALYSIS (MCA) – CONTINUED

LIMITATIONS

The greatest shortcomings of the MCA become apparent when an option scores better on one criterion but worse on another in the matrix. This is a matter of trade-offs that are central to decisions involving multidimensional aspects. Weighting or ranking is used to overcome these difficulties. But it comes with its own methodological difficulties and runs the risk of being subjective. The comparison of MCAs conducted by different researchers is rather difficult as scores and scales can be interpreted differently. MCA is also weak in intertemporal comparisons. It does not have an analytical technique like discounting to compare impacts (benefits and costs) that occur in different years.

FURTHER LITERATURE ON METHODOLOGY

- *GEF LME:LEARN (2018)*: Environmental Economics for Marine Ecosystem Management Toolkit. Paris, France.
- *United Nations Framework Convention on Climate Change (2011)*: Assessing the costs and benefits of adaptation options. An overview of approaches.

REFERENCE PROJECTS AND STUDIES

- *Sourya Das et al. (2020)*: Economic valuation of reducing land degradation through watershed development in east Madhya Pradesh under risks of Climate extremes, WOTR, Pune. Economic of Land Degradation (ELD). (ProSoil).
- *Röhrig, F. et al. (2021)*: Climate Risk Analysis for Identifying and Weighing Adaptation Strategies for the Agricultural Sector in Burkina Faso. A report prepared by the Potsdam Institute for Climate Impact Research (PIK) in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal for Economic Cooperation and Development (BMZ).

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3.11 ADAPTATION EFFECTIVENESS ANALYSIS

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects	✔	Climate effects	✔
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	✔
COMPLEXITY							
Basic	✔	Intermediate		High			

BRIEF DESCRIPTION OF THE METHODOLOGY

There is no standard methodology or framework for measuring the climate adaptation effectiveness of agroecological practices. Adaptation in agriculture is a complex process with interrelationships between natural resources and ecosystems, agricultural production systems, socio-economics as well as institutional and policy systems that drive adaptation processes and outcomes. The risks that arise from climate change are highly context-specific and so are the local conditions with respect to agroecological zones and socio-cultural habits.

Depending on the individual situation of the study site and purpose of the study, the indicators for assessing the adaptation effectiveness of agroecological practices can be different. In the “further literature” section you will find some ideas and approaches how to set up an evaluation framework and information on what needs to be considered when conducting adaptation effectiveness assessments. There are, however, two major aspects that are very likely relevant in any context in which agroecology is implemented to adapt to climate change risks: the effectiveness in responding to these risks and the feasibility of actually implementing agroecological practices. The feasibility is a very important aspect since, without it, any measure, no matter how effective, is useless.

Based on these assumptions, a participatory adaptation M&E approach has been developed by ProSoil. It puts an emphasis on discovering the climate risk context and evaluating the adaptation effects of agroecological and adaptation practices by drawing from the knowledge and experience of a wide range of stakeholders. However, this rather qualitative assessment can easily be combined with additional data, e.g. on adoption rates of agroecological practices to harness quantitative conclusions, such as the number of households applying adaptation effective practices etc.

The approach consists of two parts: analysis of climate adaptation effectiveness (Effectiveness Analysis) and analysis of socio-economic feasibility (Feasibility Analysis), both designed as *MCAs*. While the Effectiveness Analysis assesses the adaptation effectiveness of technologies in response to specific climate risks (which will be also analysed as part of this analysis), the Feasibility Analysis evaluates the local feasibility of technologies based on social and economic indicators such as social acceptance or cost effectiveness. While the Effectiveness Analysis is conducted by local experts and scientists in the field of adaptation in agriculture and environment etc., the Feasibility Analysis is conducted by actors implementing field activities including farmers themselves and representatives from extension services. In the analyses every technology is assigned with a score based on its relevance for climate change adaptation and how feasible its implementation is on local level. It is advisable to do the assessment and the scoring in a participatory workshop format to facilitate exchange and discussion amongst the evaluators. The framework, i.e. the target indicators to be assessed, can – and for the case of climate risks even must be – adapted to the individual and local context. A stepwise instruction on how to implement this method can be found in this *guidebook*.

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INPUT DATA AND ASSUMPTIONS

- Qualitative or quantitative data and information on the prior selected indicators

TARGET INDICATORS

- Adaptation effectiveness scores in response to selected climate risks
- Local feasibility scores with respect to socio-economic indicators, e.g. social acceptance and finance

EXAMPLE RESULTS

Technologies for soil protection and rehabilitation	Adaptation effectiveness	Local feasibility	Combined adaptation relevance
Conservation Agriculture	4.0	3.2	3.6
Agroforestry	4.6	3.7	4.2
Soil and water conservation - Physical Technologies	2.8	3.2	3.0
Soil and water conservation - Biological Technologies	3.6	3.1	3.4
Soil and water conservation - Cultural Technologies	3.2	3.2	3.2
Integrated Soil Fertility Management	3.8	3.4	3.6
Pest Management	3.2	3.4	3.3

Source: Mucee Ncurai (2022): Policy Brief. Soil Protection and Rehabilitation to Support Climate Change Adaptation in Western Kenya

LIMITATIONS

The major limitation of this methodology lies in its poor comparability with other analyses. Depending on how the scoring and weighting is conducted, scales can be interpreted differently and evaluators of one group may level themselves at a lower level of the scale, while another group of evaluators settles further up the scale and therefore ends up with an unintended higher scoring of indicators than the other group. For more limitations, please see also the limitations explained under MCA.

FURTHER LITERATURE ON METHODOLOGY

- GIZ (2022): How do soil protection and rehabilitation contribute to climate change adaptation? A participatory multi-stakeholder approach for monitoring and evaluation.
- FAO (2017): Tracking adaptation in agricultural sectors. Climate change adaptation indicators.
- UN Framework Convention on Climate Change (2019): Methods and approaches for assessing adaptation, adaptation co-benefits and resilience. Workshop report by the secretariat.
- Leiter et al. (2019): Adaptation metrics: current landscape and evolving practices, Rotterdam and Washington, DC.

REFERENCE PROJECTS AND STUDIES

- UN Framework Convention on Climate Change (2021): Assessment of agricultural adaptation measures in Africa, considering adaptation gaps and co-benefits.
- Wehinger and Lutta (2024): The economics of soil organic carbon - Multi-benefits from sustainable land management for smallholders in Western Kenya

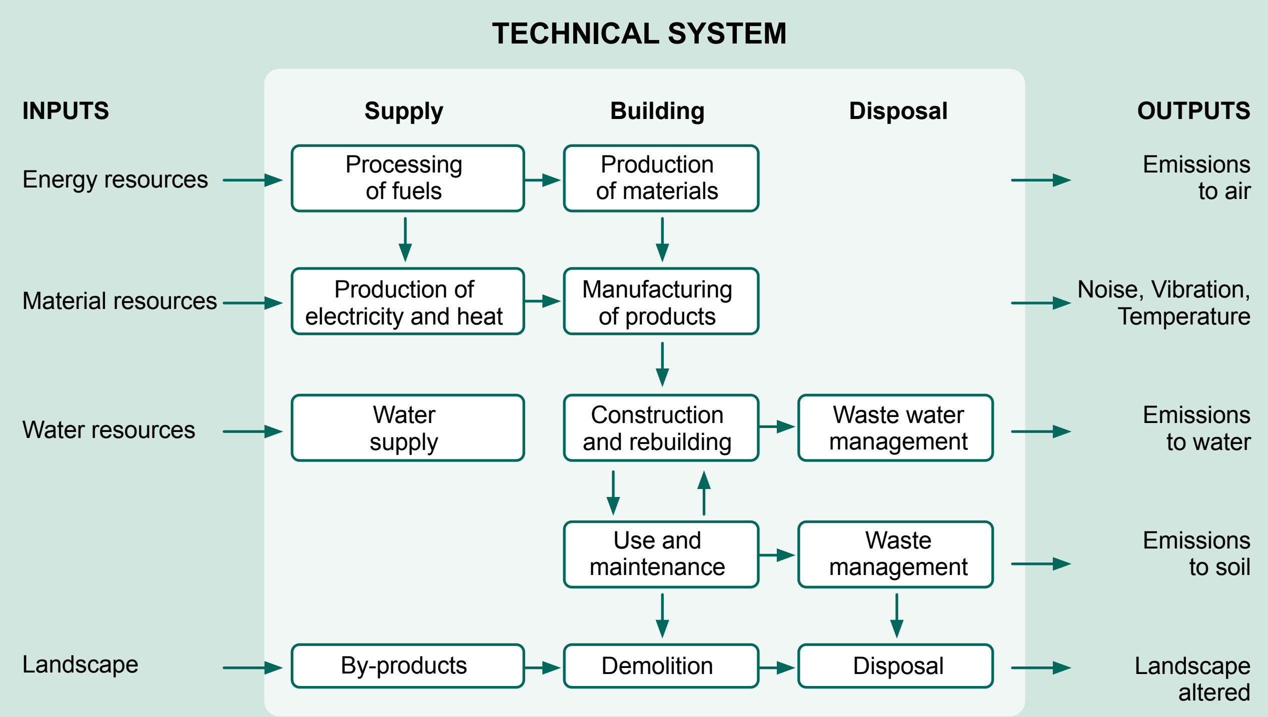
3.12 LIFE CYCLE ASSESSMENT (LCA)

FOCUS							
Economic effects		Social effects		Environmental effects	✔	Climate effects	✔
INTERVENTION AREA							
Field/Farm level	✔	Landscape level		Market level	✔	Societal level	
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

Life Cycle Assessment (LCA) is a valuable tool to estimate the total environmental impact of a product from its first stages of material acquisition, through production and use up until it reaches its end of life within the disposal system. This is sometimes also referred to as an analysis from cradle to grave or a systems approach. LCA is a widely accepted methodology and has a wide spectrum of applications in different industries. The ISO standard *14044:2006* defines the general framework for executing a LCA. Such comprehensive analysis can be utilised to compare the environmental impacts of products or processes with each other. The specialty of LCA is, that it does so by not only looking at the product in a certain state but at the whole system of industrial processes that make the functioning of that product possible. *Guinée and Heijungs (2017)* formulate the implementation of an LCA as follows: “Typically, LCA starts by defining goal and scope, then proceeds to the inventory analysis, then optionally continues to impact assessment and ends with the interpretation.” The authors emphasizes that defining goals and scope at the start is critically important and includes the following question that need to be answered:

- What is the intended application?
- What are the reasons for carrying out the study?
- Who is the intended audience?
- What are the system boundaries?
- How is the functional unit defined?



Source: Amanac, 2015

BRIEF DESCRIPTION OF THE METHODOLOGY – CONTINUED

LCA is a tool to analyse all the processes that are necessary for producing, using and disposing a product and integrates all these process steps into a system of connected processes. Thus, a LCA has the potential to display in which ways agroecological produce have advantages in terms of recycling or resource use. All these processes need to be quantified, which is also referred to as the inventory phase. This is essentially the data collection phase. Defining these processes is complex and data availability is key. The system of processes defined in the inventory phase is often visualised by using a flow diagram depicting the different process steps (see figure on p. 52). An LCA ends with the impact assessment, where the potential impacts of the defined processes are calculated and a final interpretation of the generated data is presented. However, LCA is highly iterative and refining things while going back and forth along the steps of a LCA is common.

INPUT DATA AND ASSUMPTIONS

- Input data depends on goals and scope of the LCA. Data that is relevant to describe the different process steps is necessary. This includes resource, input and energy use for production, transportation, processing, use, and waste management.

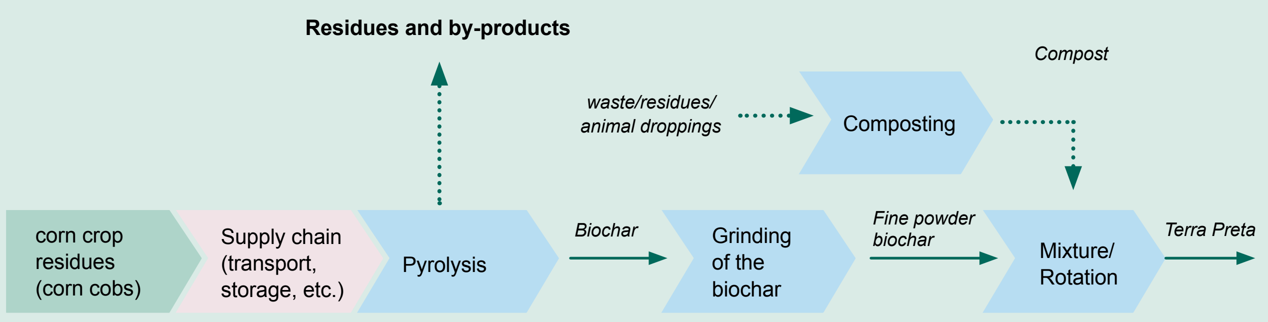
TARGET INDICATORS

- Target indicators depend on the product impact that is subject of the analysis. Examples for viable indicators are:
  - global warming potential (i.e. in kg of CO_2-equivalents)
  - eutrophication potential
  - acidification potential
  - human toxicity potential

EXAMPLE RESULTS

Life Cycle Assessment for the production of biochar and compost (i.e. terra preta) from organic residues in Benin to assess potential environmental impacts.

Analysed supply chain:

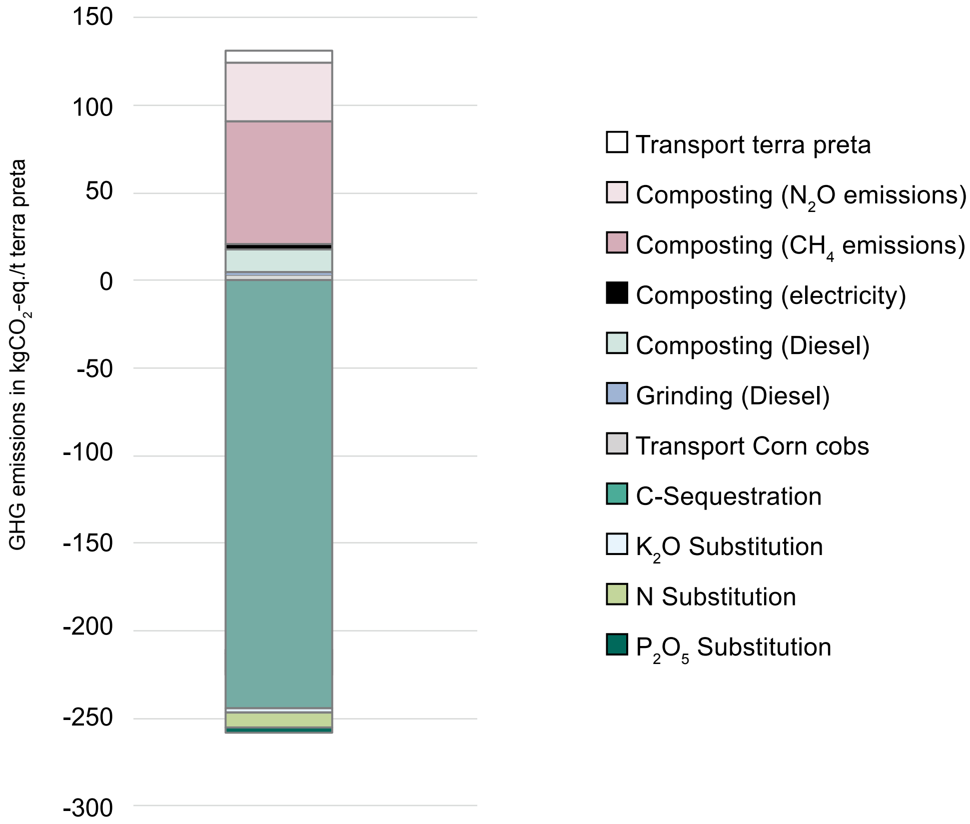


Source: DBFZ analysis conducted for ProSoil, 2023

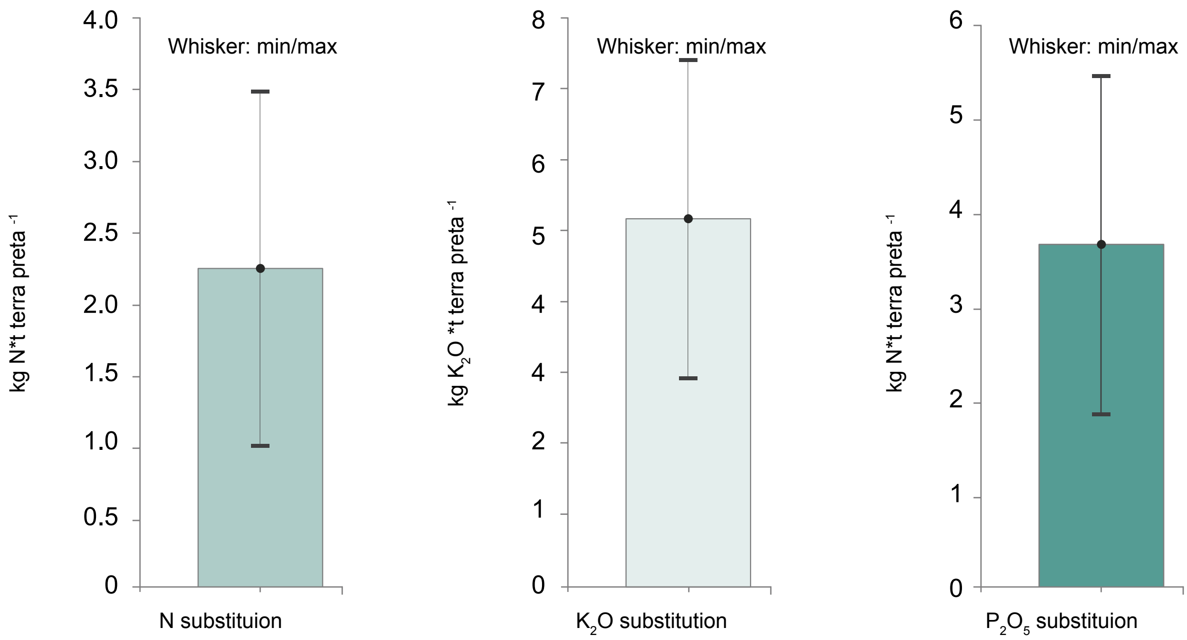
3.12 LIFE CYCLE ASSESSMENT (LCA) – CONTINUED

EXAMPLE RESULTS

The following figure shows a preliminary result for the GHG emissions per tonne of terra preta produced:



Nutrient content (per tonne):



Source: DBFZ analysis conducted for ProSoil, 2023

LIMITATIONS

Depending on the scope of an LCA, assumptions and scenarios can vary, which leads to different results and makes cross-comparison complicated. Also, depending on the data set used for a specific question, values might differ. Standard data sets for certain factors such as emissions, energy use, etc. might deviate from the technology of process that is subject of a specific LCA. Because LCAs cover the entire life of a product, a plenitude of data is necessary to reflect this life cycle. Often data gathering and its compatibility is time and resource intensive. In addition to that, present LCA frameworks do not consider social welfare or other social dimensions. Hence, when social indicators are part of an assessment, other methodologies or a combination of an LCA with other methods might become necessary.

FURTHER LITERATURE ON METHODOLOGY

- *Hauschild et al. (2018)*: Life Cycle Assessment. Theory and Practice. Springer.
- *ISO (2022)*: ISO 14044:2006 Life Cycle Assessment – Requirements and guidelines.
- *Guinée and Heijungs (2017)*: Introduction to Life Cycle Assessment. In: Sustainable Supply Chains. Eds: Bouchery et al. Springer.
- *Curran (2013)*: Life Cycle Assessment: a review of the methodology and its application in sustainability. In: Current opinion in chemical engineering, Vol. 2, p. 263-277.
- *Finkbeiner et al. (2010)*: Towards Life Cycle Sustainability Assessment. In: Sustainability, Vol. 2, 3309-3322.

REFERENCE PROJECTS AND STUDIES

- *Matuštík et al. (2020)*: Life cycle assessment of biochar-to-soil systems: A review. In: Journal of cleaner production, Vol. 259, 120998.
- *Sahoo et al. (2021)*: Life-cycle assessment and techno-economic analysis of biochar produced from forest residues using portable systems. In: The international journal of life cycle assessment, Vol. 26, p. 189-213.

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3.13 ASSESSMENT OF BIOPHYSICAL IMPACTS

FOCUS							
Economic effects		Social effects		Environmental effects	✔	Climate effects	(✔)
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	✔
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

There is no single methodology to measure the bio-physical impacts of agroecological and other agricultural practices on land, soil and natural habitats. Depending on the indicators that are going to be analysed and available research possibilities, the methods can be very different.

Soil organic carbon (SOC) is in most cases unevenly distributed over larger areas, depths, soil types and land-scapes. Applying a suitable context specific methodology is therefore crucial. There exist several methodologies to measure and assess SOC dynamics: Soil sampling with laboratory instruments is an accurate but complex and time-consuming approach to test the effects of agroeco-logical measures on soil quality. To assess changes in SOC stock over time, field measurements of a specific land plot over a longer period can be conducted. Another option is to contrast farming systems or agroecological interventions by comparing soil samples of an interven-tion with a control site. Other possibilities to capture SOC stock change than soil sampling are, for example, open-source soil and bulk density maps in combination with soil erosion models. However, these maps and models must be available in the first place and be in sufficient quality. To achieve the most accurate results, a combination of methodologies can be useful.

For larger spatial scales, geospatial technology plays an important role, too. It can give quick and accurate infor-mation on aboveground biomass. Changes in physical characteristics of an area, such as changes in land cover or land use can be detected with remote sensing satellite data from e.g. open-source programs such as [Landsat Science](). By observing the surface reflection, information on vegetation and biomass can be generated. Normalized Difference Vegetation Index (NDVI) is effective to differen-tiate savannah, dense forest, non-forest and agricultural fields and to determine evergreen forest versus seasonal forest types and to estimate various vegetation properties, including the leave area index (LAI), biomass, chlorophyll concentration in leaves, plant productivity, fractional vege-tation cover, and plant stress.

INPUT DATA AND ASSUMPTIONS

- Soil samples
- Soil model results
- Remotely sensed images / satellite images

TARGET INDICATORS

- SOC stock change (e.g. in kg/ha)
- Soil erosion (soil detachment)
- Nutrient availability to crops
- Other soil physico-chemical properties e.g.
  - Soil pH, electrical, conductivity, cation exchange capacity, total nitrogen, exchangeable potassium, calcium, magnesium
  - Soil bulk density, porosity, hydraulic conductivity and available water holding capacity
- Land use / land cover change (LULC)
- NDVI gives a quantitative estimation of vegetation growth and standing biomass. It is a simple graphical indicator that observes the surface of an area by the means of reflectance whether it contains healthy green vegetation or not.
  - NDVI values range from +1 to −1, wherein −1 is generally water bodies and +1 is generally dense green–leafy vegetation.

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EXAMPLE RESULTS

From Sourya Das et al. (2020): In a comparative analysis of watershed interventions in degraded areas the **soil organic carbon** loss has been analysed between a baseline and a status quo. The average change in soil organic carbon during 2008-2018 in project and control villages shows that "[…] soil carbon detachment is significantly reduced in project villages because of watershed development interventions. In control villages, soil carbon detachment is comparatively higher than in project villages. […] **Land-use change** in the project and control villages are somewhat similar. There is a 50% shift from uncultivable land (open scrub and barren land) to cultivable land (cropland and fallows) in both the treated and control villages. This indicates the growing need for agriculture land across villages. However, the cropping intensity in project villages Partala, Katangi and Kareli is comparatively higher than their respective control villages Amdara, Paundi Mal and Sihora."

LIMITATIONS

Accurate measurement of SOC content is costly and time-consuming, especially for soil sampling. Due to the heterogeneity of SOC distribution, the number of samples required to accurately assess SOC stocks at scales is high. Scaling up of SOC stocks from the point of sample to landscape level can be problematic and caution should be made that any calculations are based on reliable data. In addition, inadequate sampling procedures can produce a bias in data as this can be the case for soils with high rock contents. SOC content varies not only spatially but also temporally. For example, comparing samples taken in July one year with samples taken in January 5 years later is unlikely to provide accurate information on SOC dynamics.

The limitations of vegetation indices including the NDVI are also of more technical nature. All of them show atmospheric and sensor effects, and thus have a high variability and low repeatability or comparability. For example, any time there's very low vegetation cover (majority of the scene is soil), NDVI will be sensitive to that soil. This can confound measurements. On the other extreme, where there's a large amount of vegetation, NDVI tends to saturate. Indeed, in a tropical forest, NDVI will not be sensitive to small changes in the LAI because LAI is already very high.

FURTHER LITERATURE ON THE METHODOLOGY

- Lorenz and Lal (2016): Soil Organic Carbon – An Appropriate Indicator to Monitor Trends of Land and Soil Degradation within the SDG Framework? Carbon Management & Sequestration Center, School of Environment & Natural Resources, The Ohio State University, Columbus, Ohio, USA.
- Hartz (2007): Soil Testing for Nutrient Availability Procedures and Interpretation for California Vegetable Crop Production. Vegetable Research and Information Center, University of California.
- Spruce et al. (2020): Mapping Land Use Land Cover Change in the Lower Mekong Basin From 1997 to 2010. Front. Environ. Sci. 8:21.
- World Agroforestry (2020): The Land Degradation Surveillance Framework. Field Guide. ICRAF.

REFERENCE PROJECTS AND STUDIES

- FiBL (2019): SysCom Program (2007-2019) – A Comprehensive Report. What is the contribution of organic agriculture to sustainable development? A synthesis of twelve years (2007–2019) of the "long-term farming systems comparisons in the tropics (SysCom)"; p. 27.
- Musyoka et al. (2017): Effect of organic and conventional farming systems on nitrogen use efficiency of potato, maize and vegetables in the Central highlands of Kenya. European Journal of Agronomy.
- Sourya Das et al. (2020): Economic valuation of reducing land degradation through watershed development in east Madhya Pradesh (India) under risks of Climate extremes, WOTR, Pune. Economic of Land Degradation (ELD). (ProSoil).
- Musyoka et al. (2017): Effects of organic and conventional farming systems on nitrogen use efficiency of potato, maize, and vegetables in the central highlands of Kenya. In: European journal of agronomy, Vol. 86, p. 24-36.
- von Arb et al. (2020): Soil quality and phosphorus status after nine years of organic and conventional farming at two input levels in the Central Highlands of Kenya. Geoderma, 362.

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3.14 WATER FOOTPRINT ANALYSIS

FOCUS							
Economic effects		Social effects		Environmental effects	✔	Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate	✔	High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

The amount of water that is used to produce a certain good is called a water footprint. Measuring the water footprint can be done for single products, value chains, sectors of the economy of even whole countries. Usually, the water footprint is measured in m^3 per ton of production, per ha of land or even per region or country. When focusing on the agricultural sector, the water footprint essentially provides information on the amount of water, measured in m^3, necessary to produce one ton of crop, livestock product or secondary product in a specific world region.

Most often this information is given for three types of water: so-called green water, blue water and grey water. Green water refers to the volume of rainwater consumed during the production process. This is particularly relevant for agricultural products based on crops, where it refers to the total rainwater evapotranspiration (from fields and plantations) plus the water incorporated into the harvested crop. Blue water refers to the volume of surface and groundwater consumed (both evaporated or incorporated) as a result of the production of an agricultural good. The term Grey water is used to describe freshwater pollution that can be associated with the production of an agricultural product over its full value chain. It is defined as the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

Calculating water footprints is a complex and data-intensive undertaking. Further reading on methodologies and different approaches can be accessed here: Muthu (2019), Le Roux et al. (2018) and Hoekstra et al. (2011).

However, if calculating own water footprints exceeds the scope of a planned study or project, data on water footprints can be accessed in specialized databases (i.e. the Water Footprint Network), on which several assessments can be built on.

One such assessment is the analysis of water productivity. Water productivity measures the product units produced per unit of water use (i.e. m^3). Water productivity is the inverse of the water footprint data which is measured in m^3 of water used to produce one ton of an agricultural good. Therefore, water productivity is similar to land productivity (i.e. yield per hectare), but now production is not divided over the land input (i.e. hectares) but water input (i.e. m^3).

Another possible assessment based on the water footprint is the analysis of virtual water trade. Virtual water is the total volume of freshwater used to produce the products for export or import. Then, the virtual water export or import in, respectively from a particular region is the volume of virtual water associated with the export or import of agricultural goods in, respectively from the region. Estimating virtual water trade is closely linked to the assessment of virtual land trade (see 3.14 Land Footprint Analysis) as both methods are based on the assessment of internationally traded (agricultural) goods. Once the water footprint, for example in m^3 per ton, is available, this information can then be coupled with trade information across global supply chains to evaluate how virtual water is traded between regions and countries.

A third application of the water footprint is the use of this data as a baseline against which certain water saving and management techniques at different supply chain levels (i.e. on farm level or during processing) can be assessed and how these might impact the water footprint. In such a way, the water use of agroecological production patterns and technologies can be compared to other forms of agriculture production.

03

INPUT DATA AND ASSUMPTIONS

- International trade data in the form of a widely used classification system such as Standard International Trade Classification (SITC) or Harmonised System (HS) (used by UN Comtrade)
- Crop production and yield data
- Values from water footprint databases

TARGET INDICATORS

- Water footprint in m3 per reference unit (i.e. ton of product, hectare, country)

EXAMPLE RESULTS

From Nouri et al. (2019): The results show that the water footprints of all crops decrease by mulching. In addition, for most crops the water footprints further decrease when also replacing existing irrigation technology (surface or sprinkler irrigation) by drip irrigation. These results confirm that mulching and drip irrigation have positive impacts on water saving.

LIMITATIONS

Water footprints of products are useful to highlight freshwater consumption of individuals, regions or entire countries as well as the trade of virtual water embedded in products across countries. However, these metrics are highly context specific as spatial differences in water availability and use make cross-comparisons complicated. For example, comparing an imported product with a lower water footprint to the same domestically produced product with a higher water footprint does not provide information regarding the context in which these products have been produced with regards to water availability, environmental conditions (such as increasing droughts or depleting groundwater levels) and opportunity costs of water use. In addition, even a product with a high water footprint might be favourable, if such a product delivered a high revenue per drop of water in comparison to less water using but also less profitable products. Such metrics are however not displayable with the Water Footprint alone.

Ansorge at al. (2022) provide further information on limitations of the water footprint.

FURTHER LITERATURE ON THE METHODOLOGY

- Mekonnen and Hoekstra (2011a): National water footprint accounts: The green, blue and grey water footprint of production and consumption. Volume 1: Main report. Value of water research report series No. 50.
- Mekonnen and Hoekstra (2011b): The green, blue and grey water footprint of crops and derived crop products. In: Hydrology and Earth System Sciences, Vol. 15, p. 1577-1600.
- Peters and Thilmany (2022): Food systems modelling. Elsevier.
- Banerjee et al. (2021): Agroecological footprints management for sustainable food system. Singapore: Springer.

REFERENCE PROJECTS AND STUDIES

- Noleppa and Cartsburg (2015): The social, economic and environmental value of agricultural productivity in the European Union. Part II: Impacts on water trade and water use. HFFA Research Paper 01/2015. HFFA Research GmbH.
- Nouri et al. (2019): Water scarcity alleviation through water footprint reduction in agriculture: The effect of soil mulching and drip irrigation. In: Science of the total environment, Vol. 653, p. 241-252.

03.

3.15 LAND FOOTPRINT ANALYSIS

FOCUS							
Economic effects	✔	Social effects		Environmental effects	✔	Climate effects	
INTERVENTION AREA							
Field/Farm level		Landscape level		Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate		High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

A Land Footprint Analysis aims to quantify land use for food production (or any other land-based commodity), following the produced goods along the value chain and assessing the final consumption patterns of the produced food. This includes the international trade of these goods. The basic idea behind this approach is that the production of any good requires inputs, in this case: land. Thus, the inputs used for the production of a good can be considered to be a virtual part of this good. When this good is eventually traded across borders, the virtual input embedded in the product is traded likewise.

In a first step, the land use is attributed to production patterns of agricultural commodities in the countries of origin. In other words: How much of a given good is produced on how much land? This provides a first important value in the form of land embodied in each amount of a good, i.e., m^2 of land per kg of wheat. The second step then is to track the agricultural product along the local, regional or global supply chain to its final use, where the m^2 of land per kg of wheat can be attributed to a consumer's consumption pattern. This includes intermediate usages and processing.

Ultimately, this makes it possible to quantify land use from a consumer perspective, i.e., in the form of a footprint. Because international trade of the consumed goods is included in the assessment, it is possible to differentiate between a land footprint based on national production as well as so-called net virtual land trade footprints based on imported and exported goods that are not consumed in the same country as they are produced. Consequently, imports of agricultural products add land to the domestic resource while exports act to reduce it. Depending on the focus of the analysis, product flows (and embodied land use) along the supply chain can be tracked in terms of monetary values or physical quantities, such as tons of biomass moving along the value chain.

These methododologies can be utilised to either present the status quo of land footprint but also to show how certain activities such as policies, consumer behaviour or management practices such agroecological measures impact on land trade and related consumption patterns as well as land use efficiency. Having quantitative data on national land footprints as well net virtual land trade footprints makes it possible to conduct biophysical assessments. This includes carbon dioxide emissions attributed to land use and land use change such as leakage effects as a consequence of production displacements.

INPUT DATA AND ASSUMPTIONS

- International trade data in the form of a widely used classification system such as SITC or HS (used by UN Comtrade).
- Land use, crop production and yield data.
- Technical conversion factors to transform processed agricultural products back into their raw material. Available for example at USDA and Faostat.

TARGET INDICATORS

- Land footprint expressed in ha per reference unit (for example per capita or a whole country)
- Virtual net land imports and exports in ha per reference unit (for example per capita or a whole country)

03

EXAMPLE RESULTS

From *Noleppa and Cartsburg (2014)*, p. 15: "[…] the EU is currently net importing a still remarkable amount of virtual agricultural land – close to 20 million ha. The status quo, however, is the result of various developments during past years. Around the turn of the millennium, the EU has net imported almost 15 million ha, only. The acreage net occupied outside the EU's territory then doubled until the years 2006/07, obviously as the result of increasing liberalization, new and increasing demands and decreasing land productivity growth in the EU. Since then, the trend has changed again: The EU was able to lower its virtual net import of agricultural land over time by about 10 million ha. First of all, this is apparently due to good harvests, especially in grain production, rising competitiveness in meat production, but also because trading partners improved in land productivity."

LIMITATIONS

Land footprints of products are a useful tool to highlight the land that is necessary to produce a certain quantity of a product, how much land is occupied by the consumption of individuals or even entire countries and how much virtual land is embedded in the trade of products. However, these metrics are context specific as they do not provide information on the conditions under which the land was used to produce a certain amount of produce. For example, a low or high land footprint of wheat does not directly provide information whether it was produced in accordance with agroecological principles or as part of an input-intensive production process. Further, comparing an imported product with a lower land footprint to the same domestically produced product with a higher land footprint does not provide information regarding the context in which these products have been produced with regards to water availability, soil protection, input use and opportunity costs of land use.

FURTHER LITERATURE ON THE METHODOLOGY

- *Bruckner et al. (2015)*: Measuring telecouplings in the global land system: A review and comparative evaluation of land footprint accounting methods. In: Ecological Economics, Vol. 114, p. 11-21.
- *Tian and Sarkis (2022* : Embodied land resources trade in major African countries: A global trade and supply chains analysis. In: Africa and sustainable global value chains. Eds: Frei, R., Ibrahim, S., Akenroye, T., p. 79-95.
- *Banerjee et al. (2021)*: Agroecological footprints management for sustainable food system. Singapore: Springer.

REFERENCE PROJECTS AND STUDIES

- *Chen et al. (2021)*: Global environmental inequality: Evidence from embodied land and virtual water trade. In: Science of the total environment, Vol. 783, 146992.
- *Qiang et al. (2020)*: Trends in global virtual land trade in relation to agricultural products. In: Land use policy, Vol. 92, 104439.

3.16 CARBON FOOTPRINT ANALYSIS

FOCUS							
Economic effects		Social effects		Environmental effects		Climate effects	✔
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level	✔	Societal level	✔
COMPLEXITY							
Basic		Intermediate	✔	High	✔		

BRIEF DESCRIPTION OF THE METHODOLOGY

The carbon footprint is a commonly used measure to determine the total amount of greenhouse gases generated by a person, product, organisation, project or even country. It is usually expressed in carbon dioxide equivalents (CO^2e) and includes, besides carbon dioxide, other greenhouse gases such methane or nitrous oxide. The carbon footprint is considered an important metric for assessing possible strategic decisions or comparing different options in terms of their impact on the climate. It is also commonly used to measure an organisation's carbon emissions to meet regulatory requirements.

A distinction is usually made between a product carbon footprint and an organisational carbon footprint, where the product carbon footprint includes all emissions over the entire life cycle of the analysed product (typically from cradle to gate or cradle to grave). The corporate carbon footprint goes further in its required input data by assessing all economic activities of a company or organisation. This typically includes both, direct (scope 1) and indirect (scope 2 and 3) emissions. In the agricultural sector, direct greenhouse gas emissions typically arise from the use of fossil fuels for used machinery, but also from the application of fertiliser. Indirect emissions considered are usually those from the purchase of energy that is not produced but consumed by the organisation and other indirect emissions, such as those emitted by the production of used inputs.

The methodology used to determine the product carbon footprint is usually a Life Cycle Assessment (LCA) (see also Life Cycle Assessment (LCA)) that focuses specifically on greenhouse gas emissions while neglecting other parameters such as water or land use. For a corporate carbon footprint, the guidelines outlined in the Greenhouse Gas Protocol or Science Based Targets Initiative are commonly used approaches. Further guidance is provided by the ISO Standards 14064 (organizational level) and 14067 (product level) as well as by the IPCC Guidelines for National Greenhouse Gas Inventories. These resources can also be consulted to determine emission factors needed once the relevant data for the assessment has been selected.

Before the actual calculation, it is important to decide what question the assessment is trying to answer. For example, questions such as what the total carbon footprint is or where the greatest potential for reduction in the supply chain or organisation is. The next step is to define the scope and boundary by deciding which parameters will be included in the assessment and which emission factors will be used. This is followed by the data collection, which can be challenging considering the amount of data needed. Estimates are considered as a suitable alternative if a lack of information exists. To calculate the carbon footprint, the activities are multiplied by the emission factor.

INPUT DATA AND ASSUMPTIONS

- Knowledge of the supply (value) chain or organisational activities
- Yields per area unit (e.g. kg per hectare)
- Various data on the production process such as inputs, machinery, energy used
- Values from carbon footprint databases (such as the Emission Factor Database (EFDB) or the Agri-Footprint database.

TARGET INDICATORS

- Carbon footprint in kg CO_{2eq} per reference unit (i.e. ton of product, hectare, country)

EXAMPLE RESULTS

From Al-Mansour, F., and Jejcic, V. (2017): Carbon footprint of grains and fruits produced in Slovenia showed slight differences depending on the sowing method used or the type of cultivation (organic vs. conventional). Using the AgrFootprint model, the input data used are average data for fuel consumption for primary and secondary tillage, sowing, fertilisation, pesticides, harvesting, heating, cooling, additional drying and internal transport. Fertiliser application has a massive impact on the carbon footprint of a product, up to 42-76 % in this analysis. Due to lower yields in organic farming compared to conventional farming, the carbon footprint was found to be higher, while direct sowing had the lowest carbon footprint compared to sowing secondary tillage. Positive impacts can therefore be achieved by reducing energy consumption in production or by increasing productivity.

LIMITATIONS

The results of a carbon footprint analysis are dependent on data availability for the assessment. This marks a challenge in global, interlinked supply chains, where the emissions of downstream supply chains (especially scope 2 and 3) are hard to track. Besides availability of data, the right emission factors need to be used as well as the same data collection standards. It's also necessary to set the system boundaries for the assessment, which might complicate the comparison of two assessments, when different boundaries where used. Although the most relevant greenhouse gasses defined in the Kyoto protocol are usually taken into account when conducting a carbon footprint analysis, methodological differences might apply, e.g. due to a lack of data. This needs to be considered if comparisons are made, especially if it comes to comparing results from different sources.

Lastly, considering results without context might lead to wrong conclusions as considering a single factor doesn't reflect the complexity of interlinked systems. An example might here be the comparably bigger carbon footprint of organic agriculture leading to the first conclusion of choosing a conventional approach to tackle climate change. This is neglecting positive effects of organic agriculture such as on soil fertility, human health, biodiversity and water systems, that are not reflected in the analysis.

FURTHER LITERATURE ON THE METHODOLOGY

- The Greenhouse Gas Protocol (2011): Product Life Cycle Accounting and Reporting Standard. World Resource Institute. USA.
- The Greenhouse Gas Protocol (2014): GHG Protocol Agricultural Guidance Interpreting the Corporate Accounting and Reporting Standard for the agricultural sector. World Resource Institute. USA.
- European Investment Bank (2023): EIB Project Carbon Footprint Methodologies: Methodologies for the assessment of project greenhouse gas emissions and emission variations (Version 11.3). Luxembourg.
- Blonk, H., Tyszler, M., van Paassen, M., Braconi, N., Draijer, N., & van Rijn, J. (2022): Agri-footprint 6 Methodology Report: Part 1: Methodology and basic principles (Version 2). Gouda, NL.

REFERENCE PROJECTS AND STUDIES

- Al-Mansour, F., and Jejcic, V. (2017): A model calculation of the carbon footprint of agricultural products: The case of Slovenia. Energy, 136, 7–15. doi:10.1016/j.energy.2016.10.099
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3.17 LAND EQUIVALENT RATIO (LER)

FOCUS							
Economic effects	✔	Social effects		Environmental effects		Climate effects	
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	
COMPLEXITY							
Basic	✔	Intermediate		High			

BRIEF DESCRIPTION OF THE METHODOLOGY

The Land Equivalent Ratio (LER) is used to measure the yield advantage, multi cropping (MS) systems have over sole cropping systems or compare different intercropping practice with another. It is commonly defined as the relative area needed by sole crops to produce the same yields as achieved using intercropping. The methodology does not limit the number of crops considered and can also be applied to agroforestry systems or even technical uses such as agro-technological systems (e.g. farming and photovoltaic systems).

It typically considers and compares yields per crop per unit of land but can be calculated by using yield per plant as well. The LER is typically calculated by dividing the yields derived in an intercropping system by yields of sole cropping and adding them for all cultivated crops. A LER greater than 1 means, that intercropping is more efficient than sole cropping whereas a LER smaller than one indicates, that more land is required for the multi cropping system to be as productive as the sole cropping system. The LER can also be taken as an indicator for the relative yields obtained: An LER of 1.2 indicates a yield advantage of 20 % for the intercropping system.

INPUT DATA AND ASSUMPTIONS

- Yield per unit of land in monocropping systems (e.g. Kg/ha)
- Yield per unit of land in intercropping systems (e.g. Kg/ha)
- Yield per plant in monocropping systems (e.g. fruit/plant)
- Yield per plant in intercropping systems e.g. fruit/plant)

TARGET INDICATORS

- Land equivalent ratio (LER) per unit of land or per plant (e.g. per hectare of land, or tomatoes harvested.)

EXAMPLE RESULTS

An experiment by Deb and Dutta (2022) in the Indian state of Odisha has shown that multi-cropping (MC) systems outperform single-cropping (SC) systems, even when more than two crops are grown. Eight selected farms were planted with seven of the most commonly grown crops in the region in three different scenarios. Each replication of the eight farms consisted of seven SC plots and three MC plots, with row intercropping used in the first MC plots and mixed intercropping in different variations in the second and third. For the analysis, both the yield per unit area and the yield per plant were calculated, giving the same results. It was found that the yield of each of the seven crops in the MC farms was lower than in the SC farms, but when all the crops in the MC system were considered, they far outweighed the MC. While row intercropping is only marginally more productive than MC systems, mixed intercropping shows very positive yield trends.

LIMITATIONS

It might pose a challenge to analyse the exact area under cultivation, especially in indigenous farms where different types of crops are often grown at varying spacings. It is therefore difficult to determine the yield per unit area or per plant. Estimates are considered as a valid option in such advisable scenarios.

Furthermore, a limitation of the LER methodology is that it does not take time into account. As some fields may be cultivated two or even three times a year, considering the yields obtained per year may provide a more reliable indicator than just analysing one cropping season. Alternatively, the Area Time Equivalent Ratio (ATER) method can be used to include this parameter.

As the LER is a ratio, large values can be obtained from either low yields in sole cropping or from high yields in intercropping systems, it's not clear which has had the effect, or in other words, LER does not show the yields achieved per crop in the intercropping system. It could be economically more efficient to grow more of one crop, while higher yields could be achieved with a different proportion of the crop. To take these effects into account, the more complex Land Equivalent Cefficient (LEC) approach may be appropriate. It is used to calculate the proportion of the yield of a mixture component that is explained by the presence of the other components.

FURTHER LITERATURE ON THE METHODOLOGY

- *Mead, R., and Willey, R. W. (1980)*: The concept of a 'land equivalent ratio' and advantages in yields from intercropping. Experimental Agriculture, 16(3), 217–228. doi:10.1017/s0014479700010978
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- *Deb, D., and Dutta, S. (2022)*: The robustness of land equivalent ratio as a measure of yield advantage of multi-crop systems over monocultures. Experimental Results, 3. https://doi.org/10.1017/exp.2021.33
- *Adetiloye, P.O., Ezedinma, F.O., and Okigbo, B.N. (1983)*: A land equivalent coefficient (LEC) concept for the evaluation of competitive and productive interactions in simple to complex crop mixtures. Ecological Modelling, 19, 27-39.

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- *Islam M.R., Hossain M.F., Mian M.A.K., Hossain J., Alam M.A. (2016)*: Outcome of intercropping garlic with brinjal for the smallholder farmers of Bangladesh. Indian Journal of Agricultural Research. 50(2): 177-182. doi: 10.18805/ijare.v0iOF.9428.
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- *Trommsdorff, M., Kang, J., Reise, C., Schindele, S., Bopp, G., Ehmann, A., Obergfell, T. (2021)*: Combining food and energy production: Design of an agrivoltaic system applied in arable and vegetable farming in Germany. Renewable and Sustainable Energy Reviews, 140, 110694. doi:10.1016/j.rser.2020.110694

3.18 TOOL FOR AGROECOLOGY PERFORMANCE EVALUATION (TAPE)

FOCUS							
Economic effects	✔	Social effects	✔	Environmental effects	✔	Climate effects	✔
INTERVENTION AREA							
Field/Farm level	✔	Landscape level	✔	Market level		Societal level	
COMPLEXITY							
Basic	✔	Intermediate	✔	High			
BRIEF DESCRIPTION OF THE METHODOLOGY							

The TAPE methodology is a participatory framework developed by the FAO, combining various methodologies in one single approach that allows a holistic assessment on the agroecological transformation of farms and their socio-economic and environmental effects. It is not a classical methodology to assess the impacts of agroecology but goes far beyond in assessing farm performance on a multidimensional level. It can be used to assess various production systems such as crop and livestock production, forestry, fisheries and aquaculture and can be adapted to different local contexts and languages, which makes it an ideal tool for policy makers but also practitioners, scientists, producers or funding institutions, that are interested in assessing or comparing agroecological practises in a harmonious and globally consistent way.

TAPE consists of 4 steps and is implemented by using a questionnaire covering various aspects of the transition towards agroecology and farm performance. In Step 0 – Description of systems and context – basic information such as production systems, type of household, agroecological zones, existing legal and policy frameworks (incl. climate change) are collected. Step 1 – Characterization of Agroecological Transition (CAET) – is used to collect information on the current agroecological status of the farm assessed. This step is based on the ten elements of agroecology[2], covering each aspect with various questions. For example, relevant indices for the element Efficiency are (i) Use of external inputs, (ii) Management of soil fertility, (iii) Management of pests & diseases and (iv) Agricultural production and household's needs and investments. The scores of these semiquantitative indices range from 0 to 4, depending on how efficient the production is. To obtain the general score of the element, the scores of the four indices are summarized (e.g. 3+3+3+4=13) and standardised on a scale from 0 to 100 % (13/maximum score (16) = 81,3 %). This approach is used for all 10 elements.

To assess the level of agroecological transition it is advised to consider CAET values <50 % as non-agroecological systems, while farms ranging from 50 to 70 % are considered in transition whereas >70 % are advanced agroecological systems.

In case, of a large number of homogenous observations in the CAET, Step 1bis – Transition Typology – as an optional clustering to reduce the sample size can be conducted before continuing with Step 2. Here it is recommended, to form statistically sound subgroups, e.g. based on the geographic location or state of transition.

Step 2 – Criteria of Performance – covers ten core criteria relevant for achieving the Sustainable Development Goals (SDGs). These criteria are clustered in five main dimensions including Governance, Economy, Health & Nutrition, Society & Culture as well as Environment and aim to provide a systematic overview on how the assessed farm performs.

Under Step 3 - Analysis and participatory interpretation – the data collected under the previous steps is analysed, if possible, in cooperation with the community that was surveyed. Firstly, the CAET results (STEP 1) are combined with the systems data under Step 0, to measure the progress of the agroecological transformation. Secondly, the performance results collected under Step 2 are explained using the CAET results. For the assessment of this data a traffic light approach is recommended using green for desirable, yellow for acceptable and red for unsustainable performance – this interpretation should be conducted in a participatory manner to guarantee correct correlations.

Advanced Criteria covering further relevant indicators for impact analysis such as water pollution or greenhouse gas emissions can be included in the questionnaire, if necessary or helpful for the intended assessment.

[2] The ten elements of agroecology as defined by the FAO are Diversity, Synergies, Efficiency, Resilience, Recycling, Co-creation and sharing of knowledge, Human and social values, Culture and food traditions, Responsible governance, and Circular and solidarity economy.

INPUT DATA AND ASSUMPTIONS

- All necessary input data is collected via an extensive questionnaire that can be supplemented by advanced criteria if needed. The questions can be answered by the farmers through a *self-assessment* or as a guided exercise and are combined with physical inspection or the upload of pictures of the farm analysed.
- Step 0: Basic data on farm metrics such as production type, farm and household size, geolocation, crops cultivated, and animals kept.
- Step 1: Data related to the ten elements of agroecology such as soil management systems, external inputs, water and energy use, food and nutrition metrics, labour and decision-making processes.
- Step 2: Performance criteria such as land tenure, machinery used, income, food intake, soil health or pesticides used.
- Advanced criteria related to water use efficiency, greenhouse gas emissions, climate change resilience, or food security metrics can be included.

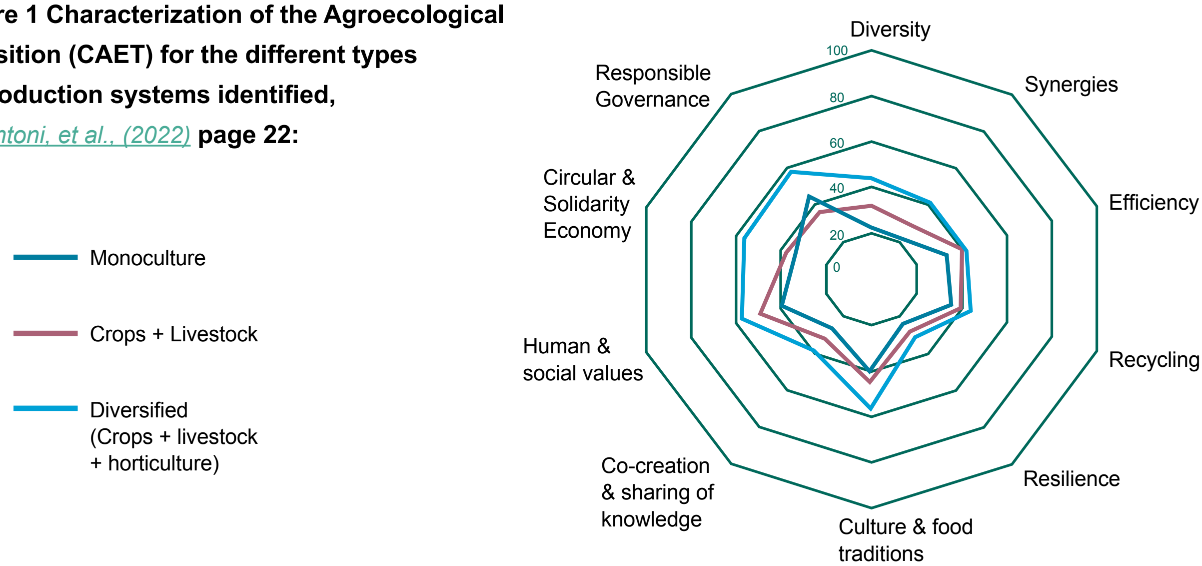
TARGET INDICATORS

- Level of transition towards agroecology and performance indicators highlighting the contribution to reaching various SDGs.

EXAMPLE RESULTS

In a project in Lesotho, the TAPE framework was used to assess 200 production systems across 4 agroecological zones, 5 districts and 19 distinct landscapes. The aim of the assessment was to gather baseline data on the sustainability of the farms participating in the project. It was found that the transition to agroecology was still in its infancy, and most farms could not be considered as agroecological as CAET results were on average 39 % and none of the elements reached above 50 %. Nevertheless, it could be shown, that farms that reached higher levels of transition towards agroecology (higher CEAT values) also reached better performance values, which means that they had a higher gross value of the production per person, used less fertilisers and had therefore slightly better soil health, showed slightly better employment opportunities for the youth, seem to spend less on food as it was assumed that they were more self-sufficient. There was no significant relationship between the governance dimension and the level of agroecological transition found. Summarising it can be concluded that farms who are further in transition towards agroecology performed slightly better in the performance indicators compared to those, who are still in the beginning of their transition although (Lucantoni, et al., (2022).

Figure 1 Characterization of the Agroecological Transition (CAET) for the different types of production systems identified, *Lucantoni, et al., (2022)* **page 22:**



03.

LIMITATIONS

The application of the TAPE methodology is rather time consuming, as it requires to answer a brought variety of questions. For production units assessed this might require additional preparation time as they need to provide relevant data on inputs, expenditures, soil quality etc... The assessment following the proposed methodology requires training as well as statistical knowledge for correct interpretation of the acquired data.

FURTHER LITERATURE ON THE METHODOLOGY

- The Agroecology Knowledge Hub hosted by the FAO provides further information on the *methodology* itself and *how to use* it.
- FAO (2019): TAPE Tool for Agroecology and *Performance Evaluation – Process of Development and guidelines for application*. Test version. Rome.
- An *Online Training* Course in Spanish provided by FAO, as well as a comprehensive *e-learning* course in English.
- Mottet et al., (2020) Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE). Front. Sustain. Food Syst. 4:579154. *doi: 10.3389/fsufs.2020.579154*.

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- *Lucantoni, et al., (2022)*: Report on the use of the Tool for Agroecology Performance Evaluation (TAPE) in Lesotho in the context of the Restoration of Landscape and Livelihoods Project (ROLL). Results and analysis. Food and Agriculture Organization of the United Nations (FAO), Rome
- Wordofa et al. (2024): Economic, environmental and social indicators of sustainability among smallholders in Ethiopia: Based on tool for agroecological performance evaluation data. Data in Brief, 52, 109988. *https://doi.org/10.1016/j.dib.2023.109988*
- *FAO (2023)*: Assessing agroecological transitions in Mali with TAPE
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