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CANALLS
AGROECOLOGICAL PRACTICES
FOR SUSTAINABLE TRANSITION

D4.2 Economic and business viability of agroecological practices - initial version

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Executive Summary

Smallholder farmers in the Democratic Republic of the Congo (DRC), Burundi, Cameroon, and Rwanda are faced with increasing agricultural challenges, including climate change, land degradation, and food insecurity. These issues are compounded by conventional farming practices (Ntawuhiganayo et al., 2023). These conventional farming practices place an emphasis on short-term returns and external input while ignoring the important environmental and social costs of production, leading to an underestimation of the long-term viability of these practices. Agroecology offers a necessary transition by incorporating ecological principles with social equity and economic durability to construct sustainable food systems (Vikas & Ranjan, 2024). However, the comprehensive benefits of agroecology in terms of economic performance and business viability to smallholders have often been disregarded in conventional assessments (Jacobi et al., 2018; Mouratiadou et al., 2024).

Task 4.2 under the CANALLS project address the gap caused by the inherent bias of conventional assessments and create a holistic evaluation based on claim, arguments, evidence (CAE) framework (Mottet et al., 2020) to incorporate the many facets of socio-economic values from agricultural practices. The CAE framework demonstrates an ever-widening lens instead of one constrained to economic benefit, whereby multi-criteria assessments are incorporated, extended cost-benefit analysis, which includes social and environmental externalities, and participatory methods. This is intended to encompass not only the direct profit associated with crop production at the plot level, but to acknowledge the bigger picture and vital ecosystem services (e.g. enhanced soil quality, biodiversity, climate change resilience) and social benefits (e.g. greater food security and nutrition diversified livelihoods and global wellbeing) afforded by agroecology.

The approach within the context of agroecological living labs will be applied across case studies with specificity to crop-based systems (McPhee et al., 2021; Rastorgueva et al., 2025). The approach proposed is based on two interconnected pillars Viable Scaling of Agroecological Innovations for Sustainability Transitions and Multi-Actor Engagement and Scientific Support for Wider Uptake and Enabling Conditions (Jones et al., 2022; Zingwena et al., 2023). Within the CANALLS project, we will employ purposive sampling to select living labs, ensuring representation across the administrative and territorial distribution of CANALLS. Within each living lab, we will then conduct a random sampling of 30 households. To ensure gender balance and inclusivity, we will target at least 30% female participation in the sampling size (Ammari et al., 2021; Ngong et al., 2025).

ODK forms will be used for data collection that allows user-friendly data aggregation and error minimizations. The quality data will be ensured through a multi-staged process that includes tool development, enumerator training and pre-testing in four targeted living labs out of the eight. Analysis will be conducted descriptively through t-tests for dominance against other means, and advanced Tobit regression models to identify the associated factors for profitability (Perdana et al., 2021; Rubin, 2016; Voth-Gaeddert & Oerther, 2014). Finally, and importantly, there will be full cost-benefit analyses on specific agroecological value chain in target ALLs for case studies.

This study will bring much-needed, credible and quantifiable evidence about the economic viability and business potential of agroecology, which has been historically underestimated. The results from the study will be important in guiding policy at national and regional levels and can help create more enabling policy, regulatory and economic environments for agroecological transitions.

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Table 1: Terms and Definitions

Abbreviation	Definition
ALLs	Agroecological Living labs
DRC	Democratic Republic of Congo
MCA	Multi criteria assessment
CBA	Cost-Benefit-Analysis
TAPE	Tool for agroecological
PAR	Participatory rural appraisal
PLA	Participatory learning and action
B-ACT	Business Agroecological Criteria Tool
ODK	Open data kit
SWOT	Strengths, Weaknesses, Opportunities, and Threats
AEEs	Agroecological enterprises
CAE	Claims, Arguments, Evidence framework

1. Introduction

Across the Democratic Republic of Congo, Burundi, Cameroon, and Rwanda, as in many parts of sub-Saharan Africa (SSA), agricultural systems are facing immense challenges. Smallholder farmers who are the foundation of their economies and food systems, are facing compounding pressures (Amede et al., 2023). On the one hand, they have to contend with the rippling effects of climate change, increased market volatility for conventional inputs and outputs, ongoing food insecurity, as well as historic land degradation (Jones et al., 2022). On the other hand, traditional approaches that promote heavy use of external conventional or synthetic agricultural inputs often worsen these vulnerabilities and have put greater pressure on their long-term ecological sustainability, as well as the long-term economic sustainability that they aimed to achieve (Ansari et al., 2023). The burdens of the conventional external input approach with hidden costs, which include soil erosion, water pollution, and biodiversity loss issues, are seldom incorporated in the standard economic assessments whereas they should be used as a basis for evaluations of their real burden on society (Kennedy et al., 2023; Marta-Pedroso et al., 2007).

In its mark as being a resilient development path for food systems, agroecology has gained momentum as a collective response to all of these crises. It is a holistic approach that incorporates ecological principles and socio-economic conditions to develop agricultural systems that are diverse, productive, and equitable, while working with natural systems (Bellamy & Ioris, 2017; Jones et al., 2022). Agroecological practices such as intercropping, agroforestry, integrated soil fertility and pest management create non-market benefits in an inherently wide range of forms (Bakengesa et al., 2024). These benefits include the enhancement of important ecosystem services such as improved soil fertility, regulation of water, carbon sequestration and increased biodiversity, increasing the sustainability and resilience of farming systems (Robertson et al., 2014). However, the overall economic performance and business viability of these practices has not effectively been captured in classical evaluation perspectives for small farmers.

The limitations of conventional economic assessment techniques are a key barrier to farmers adopting agroecological approaches and policymakers supporting them (Mouratiadou et al., 2024). Conventional financial assessments focus on short-term monetary returns and individual productivity measures and do not appropriately represent the multi-faceted value of agroecology (Havemann et al., 2020). The long-term, non-market benefits of agroecological practices derived from improving natural capital and system resilience are significant but difficult to quantify as they contribute to less direct benefits (Boeraeve et al., 2020). The embedded inadequacy in traditional economic assessments requires a fundamental rethinking of how we evaluate agricultural systems (Mottet et al., 2020). In contrast, MCA options provide a broad approach for applying multiple economic and social indicators as forms of assessment beyond simply monetary payoffs. This framework provides an understanding of agroecological performance which is nuanced and recognizes that the value of agroecology includes not only short-term economic profitability, but also long-term economic viability for social justice and community betterment (Boeraeve et al., 2020; Ploeg et al., 2019). In that sense, there is a need to expand the traditional cost-benefit-analysis (CBA) approach to better account for externalities. By trying to quantify the costs associated with environmental deterioration contributed by conventional agriculture, and to price the unpriceable ecosystem services of agroecological practice, we can establish a clearer economic claim on probable analogies, using the example of Bakengesa et al (2024) and D'Annolfo et al (2017) for agroecology as a possibility. It might be methodologically difficult to expand the existing CBA frameworks, but it does promote an honest way to reflect systemic social benefits of agroecological practices and give better guidance to decisions.

Importantly, participatory methods are vital components for relevant evaluations because of a multitude of experiences. For smallholder farmers in Africa, agroecology depends on indigenous knowledge, innovation by farmers, and collaboration with diversified stakeholders. It is difficult to assess when farmers are not abstract principals in the evaluation; our assessments should arrive from the lived experiences of farmers, their indigenous knowledge, adaptive capacities, perceptions of benefits and challenges (Akanmu et al., 2023; Bakengesa et al., 2024). The evaluation of co-creation of knowledge and experiences allows for richer datasets and inferences and adds a new dimension of applicability for the communities to which research findings are applied (Barrios et al., 2020; Ouko et al., 2024). This evaluation of the economic performances is particularly important for the unique socio-ecological landscapes present in the DRC, Burundi, Cameroon and Rwanda, because it will highlight the sustainability of factors implemented in the experimental phase….
This task 4.2 sets out to add to this important area of knowledge by conducting a focused study of the broader economic performance and business case for agroecology by small farmers in the Democratic Republic of Congo, Burundi, Cameroon, and Rwanda, using holistic methodologies to help demonstrate the broader economic and social case for promoting agroecology at scale.

1.1 Background

The need to establish sustainable agricultural systems in Central Africa is urgent, given the set of climate challenges, increasing population, ongoing hunger and poverty, and widespread land degradation (Mapfumo et al., 2017). The traditional agricultural systems with monocropping (in most medium to large scale farmers) and sometimes high input synthetic based systems have contributed to the current agricultural challenges (Bjornlund et al., 2022). Although it has produced higher yields, the future economic sustainability of conventional agriculture practice is increasingly scrutinized as the costs of environmental externalities (e.g., soil erosion, water pollution, biodiversity) is shifted to societies, and the economic and market vulnerabilities of external reliance on inputs has become evident (Pandey & Diwan, 2018; Shah & Wu, 2019). In response to these limitations, agroecology can be a promising alternative practice that integrates economic and social principles to promote resilient, productive, and equitable food systems (Mottet et al., 2020). However, one of the biggest barriers to the uptake of agroecological alternatives and the acceptance of agroecology in policy is the inability to utilize traditional economic assessment tools (Dosso et al., 2024).

The assessment of the economic performance of agricultural practices via traditional assessments has often relied on narrow financial assessments, including yield per hectare, gross margins per hectare, and return on investment often using a short timeframe (Fiore et al., 2024). While these conventional systems of assessment are consistent with analysing short-term profitability at the farm level, they fail to capture all the benefits and costs in agroecological systems. Agroecology provides many benefits that are typically 'non-market' (Bakengesa et al., 2024). These benefits are often thought of as ecosystems services and are not routinely measured in monetary value. The advantages of agroecology can be broadly described as enhanced soil health (fertility), improved water retention, increased biodiversity to allow for pest management and pollination, climate change mitigation through carbon sequestration, and increased resilience to climate shocks (Africano, 2019; Mouratiadou et al., 2024). In contrast, the negative externalities of conventional agriculture include: the costs of environmental pollution; the public health impacts of pesticide exposure; and the impacts on rural livelihoods. These negative externalities are generally not included in normative economic calculations when examining conventional agriculture systems, distorting the true market cost over time (Mottet et al., 2020). Therefore, the understanding of approaches to agriculture requires a participatory and inclusive shift away from standard economic assessments.

Standard economic assessments have inherent limitations and should primarily engage alternative multi-criteria assessments (MCA). MCA considers agroecological systems with reference to multiple indicators, in terms of economic, and social dimensions, rather than solely on one-dimensional evaluations of financial performance. The value of agroecology systems relates to more than just short-term financial performance but incorporates long-term business viability, social equity, and social well-being. This broader consideration of agroecological performance includes particular indicators related longer-term systems performance, dietary diversity, stable livelihoods, and community participation. To illustrate this point, an agroecological farm could exhibit lower direct profits in one given year than a high-input conventional farm. However, the agroecological farm might simultaneously show substantial improvements to soil health, lessened disease pressures, and a restored sense of food security for its immediate community. Additionally, as a fundamental part of the traditional cost-benefit analyses (CBA) process, it is important to directly consider externalities. This means assigning either monetary, or qualitative value to the cost previously untracked from the impact of environmental damage from conventional agriculture, and the value of ecosystem services (Bakengesa et al., 2024). Although methodologically challenging, it is essential. In many cases, how much we can report in avoided costs of water purification, for example, due to the decreased pesticide runoff; or the reported economic value of natural pollination for increased crop yield resulting from

agroecological practice can completely change perceptions about the economic viability of agroecology and make it more likely that policy makers adopt more supportive policy initiatives to enable movement it these directions (Kremen, 2020).
Equally, the use of participatory methods should be included in evaluation frameworks. Agroecology is always built on local knowledge, innovation of farmers and involvement of communities (Vikas & Ranjan, 2024). Farmers, as the end users and leaders of agroecology and changes in their farms have the most to say about the practical limitations and their strategies for adaptation and their perceptions about changes and benefits of agroecological systems. If we only rely on an external academic evaluator to assess the benefits or impact of agroecological practices proposed by farmers or their communities, lots of important context and local, perceptions and suggestions will be missed, as there are no universal pathways for agroecological transitions. Participatory evaluations using farmer-led field demonstration, focus group discussion and farmer exchanges not only provide access to rich qualitative methods but empower local communities, enabling co-creation of knowledge and ensuring that evaluation results are useful, credible and demonstrable (O'Donovan et al., 2020; Utter et al., 2021). Participatory actions will also be key in diverse Central African situations where agroecological practices are largely applied, adapted according to how they fit with different local ecological and socio-cultural conditions.
That is why an economic case for agroecological transitions across Africa, that goes beyond analysis of resource use and short-term financial benefits, will be pivotal for formulating supportive policies, attracting investment required to support them and ultimately facilitating resilient and sustainable food systems across Africa (Bakengesa et al., 2024). The economic performance of the practices of agroecology of farmers and other value chain actors who are involved in our ALLs will be evaluated in Task 4.2 and their impact on their business viability. Data required for our assessment framework (in Task 2.2) will be gathered via quantitative periodic surveys of smallholder farmers of conventional vs agroecological practice. ETHz will lead the surveys, including group discussions, and support country project partners to undertake the surveys.
This will require the assessment of the full costs and benefits related to these practices about the direct and indirect aspects, before we can report any quantifiable evidence of the real benefits of agroecological strategies for rural communities and agroecosystems, and also enable the transfer in the applications of these innovations to other places.

1.2 Objectives

Within this research (Task 4.2), two main objectives are set to be fulfilled:

- ✓ Assessing the economic performance of the agroecological practices implemented by farmers and value chain actors in our ALLs
- ✓ Assessing the business viability of the agroecological practices implemented by farmers and value chain actors in our ALLs

2. Existing frameworks/ tools

2.1 Introduction

2.1.1 Different types of tools and frameworks FAO's Tool for agroecological evaluation (TAPE)

Current frameworks for agroecological assessment are adapting international protocols to local conditions, and more and more are adopting holistic, participatory approaches when conducting agroecological assessments. There are a number of assessments for the multi-dimensional performance of agroecological systems, with TAPE gaining traction as the most popular one. TAPE offers a standardised and flexible approach for measuring agroecological transitions at the farm/household level and aggregating the results to a community level based on the 10 Elements of Agroecology (Mottet et al., 2020; Tittonell, 2020). But it takes time and resources to collect all of the TAPE indicators, and this can be even more so the case in remote areas. Indicators are also often adapted to the different local contexts, as well as ensuring the quality of data collected in a multi-site study (Barrios et al., 2020).

2.1.2 Multi-Criteria Assessment (MCA), adapted for agroecology

The Multi-Criteria Assessment (MCA) assesses farming systems against a number of criteria based on environmental, social or economic factors. It draws on both quantitative and qualitative data in order to examine the complexities of agroecological systems (Hloušková et al., 2020). The weighting of the criteria allows stakeholders to develop their priorities in conducting comparisons between agricultural systems based on agroecology or conventional agriculture, as well as for showing the additional dimensions of agroecology that are worth considering beyond short-term yield or profit. MCA processes can assess the performance of agroecological practices in terms of their objectives, resources and values, as defined by farmers. However, the selection of the criteria and weighting are subjective, and therefore the transparency and legitimacy of participatory processes need to be demonstrated (Garfí & Ferrer-Martí, 2011).

2.1.3 Cost-benefit analysis (CBA)

Cost-benefit analysis is the most commonly used system for assessing worth. Importantly, it internalizes the externalities associated with agroecology through accounting for ecosystem services that are associated with agroecology (ex: improved soil fertility, healthy water quality, carbon sequestration), accounting for the environmental and social costs of conventional agriculture (e.g. adverse health impacts of pesticides, land degradation) (e.g., Costanza, 2006). This 'construct' demonstrates the real economic case over the long term, to support a transition to agroecological practice, particularly when one recognises the centrality of natural capital elements to smallholder producers. Quantifying the economic value of a healthy ecosystem can affect policy and investment, as evidenced by the growing number of studies being conducted in Africa (Tittonell, 2020). Nevertheless, the approach to monetise a good or service that is not exchanged in the market is empirically complicated, often involving merit-based proxy values (Jamouli & Allali, 2020).

2.1.4 Participatory rural appraisal (PRA) and Participatory learning and action (PLA)

Participatory rural appraisal (PRA) and participatory learning and action (PLA) are distinct and connected methodologies of agroecological evaluation that encourage farmers and communities to participatively collect, analyse, and interpret data derived from their own experience (Prajapati et al., 2025). Employing farmer-led experimentation and focus groups enables differentiation of economic impact assessments, perceived benefits, and user-defined obstacles; aspects of the PRA, PLA, and research field that are beyond conventional quantitative methods (Brocke et al., 2020). While PRA and PLA approaches are rooted in locally embedded knowledge, they are principally qualitative and challenge universal extrapolation; they depend on the skills of the facilitator rather than being reproducible (Chambers, 1994).

Emerging tools and approaches facilitate user-centred innovations. Researchers, farmers, and all actors co-create, test, and evaluate agroecological practices in real-world situations (Berthet et al., 2018). This involves ongoing monitoring and evaluation of socio-economic and environmental performances across a variety of crops such as cocoa, coffee, cassava, rice, and maize. Another goal is to co-design sustainable business models to improve market access for agroecological products. The following tools are in development or have undergone adaptation to support these framings.

2.1.5 Business agroecology criteria Tool (B-ACT)

Biovision, in the spirit of B-ACT, has developed a Business Agroecology Criteria Tool (B-ACT) that helps funders identify agroecological enterprises (AEEs), and assesses their positive impacts on food systems. B-ACT also links agroecology principles and financial sustainability to assist with investments in smallholders (Agroecological Mango Business Models in Kenya, 2024; Iocola et al., 2020).

2.1.6 Farm accounting software (Adapted)

Farm accounting software, when adapted to capture the specific nuances of smallholder agriculture, generate valuable data for a more comprehensive assessment of farm performance (Basir et al., 2024). By tracking inputs, diversified income and labor these tools provide foundation data that is needed to understand the socioeconomic side of different agricultural practices. The generated data will be essential for overcoming biases of conventional assessments, as highlighted in task 4.2. as well as creating a more holistic evaluation framework.

2.1.7 Digital Data Collection Tools

Digital applications including mobile phones along with remote sensing improve the quality and efficiency of data collection for performance assessment in remote locations. Mobile apps enhance data quality by minimizing human errors while capturing rich GPS coordinates and photos. The efficiency of this approach is to eliminate manual data entry errors by enabling real-time data uploads. As highlighted by Schepers and Francis (1998), this digital approach provides a faster, more accurate, and comprehensive alternative to traditional methods of data collection in assessing the economic performance.

2.2 Definition of methodology and approach

2.2.1 Challenges and limitations of the tools

Despite progress, methodological challenges remain impeded by data limitations and quality, specifically the lack of data on agroecological farms over the long-term with consistent data, which limits rigorous comparisons (Bellamy & Ioris, 2017). Systemic variation exists in the diversity of agroecological zones, farming systems and socio-economic conditions that make generalizing evaluation metrics and findings difficult (Mouratiadou et al., 2024). Quantifying and monetizing ecosystem services and social capital remains not straightforward. Transitions to agroecological production can impact how labour is demanded, often leading to more skilled labour needed at the outset; thus, evaluation of labour intensity, remuneration and what it means for well-being need to be assessed and traded off (Mouratiadou et al., 2024). Conventions of subsidies providing incentives favouring conventional inputs, or the absence of supportive policies and market access of products produced under agroecological guidelines, may distort the economic viability (Yuan et al., 2022). Less consideration is given to how short-term evaluations may be distorted or misled by looking at the changes in terms of the upfront investments involved with transitions to agroecological production or the time taken for the benefit to accrue. Frameworks like TAPE, adapted MCA and expanded CBA combined with participatory approaches and tools like B-ACT, provide a strong methodological approach to evaluating agroecology (Fiore et al., 2024). Through the continual refinement of methods, effective data collection, and context-based application, we can fully appreciate the economic performance and business viability of agroecological practices in-field and the implications for policy and investment regarding a sustainable food system.

2.2.2 SWOT analysis as an added component in CANALLS approach?

To enhance the comprehensive evaluation of agroecological practices, SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis will be strategically integrated into the methodology (Sun et al., 2019). This qualitative, yet highly insightful, tool will complement the existing quantitative and participatory methods (reviewed above), providing a structured framework for understanding the internal attributes and external factors that influence the economic performance and business viability of agroecology within the specific contexts of ALLS. FGDs will be conducted with diverse groups of farmers, including women, youth, and leaders of cooperatives, to collectively brainstorm and prioritise SWOT factors (Sahoo et al., 2018). These discussions foster richer insights and consensus-building. Preliminary SWOT matrices will be presented and validated during stakeholder workshops at the local level (e.g., in ALLs). This participatory validation ensures that the identified factors resonate with the lived experiences and expert opinions of the communities and relevant actors (Addinsall et al., 2015). SWOT analysis will provide the qualitative context necessary to fully interpret quantitative findings. For example, if a CBA shows high profitability for a specific value chain, SWOT can explain why (e.g., strong local demand, efficient farm organisation). Conversely, if profitability is low, SWOT can pinpoint the contributing internal weaknesses (e.g., poor post-harvest handling) or external threats (e.g., cheap imports).

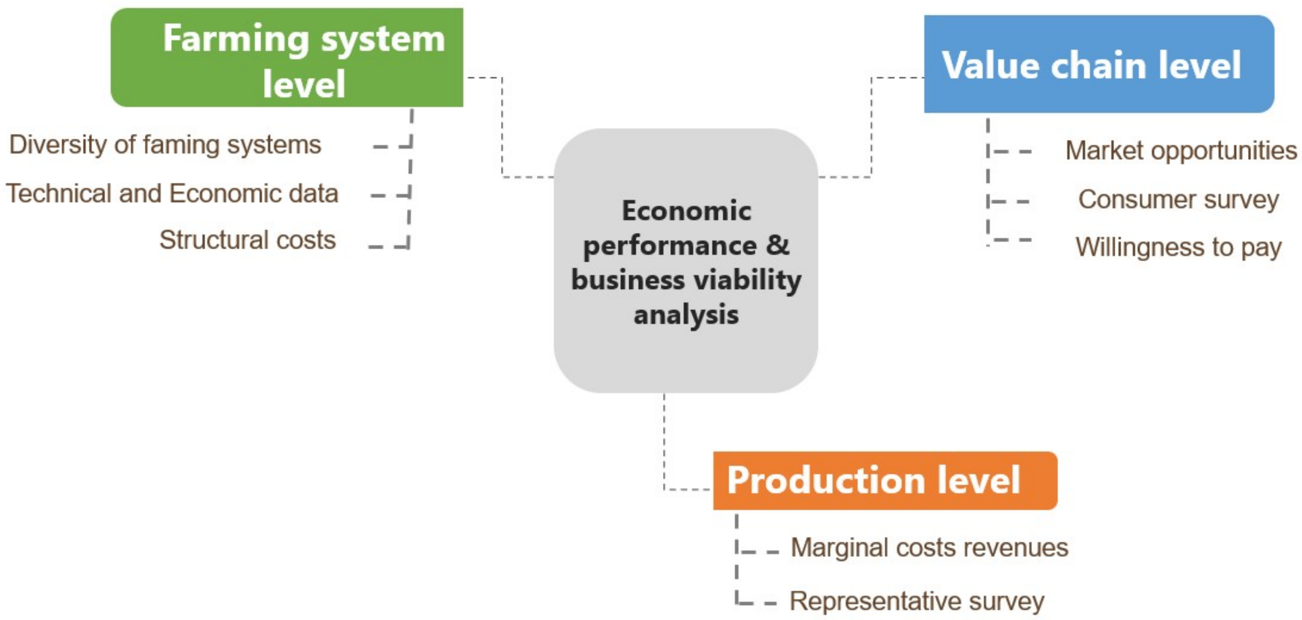

Figure 1. Component framework description of economic performance and business viability for CANALLS

3. Methodology description

3.1 Definition of methodology and approach

Our methodology to assess the economic outcome and business feasibility of agroecological practices occurring in the ALLs contexts of the Democratic Republic of Congo, Burundi, Cameroon, and Rwanda, will take a rigorous multi-step approach. This extensive sequence is expected to produce empirical evidence, reflective of the various smallholder contexts, establishing the substantive advantages to agroecological practices/strategies for rural communities and their agroecosystems. In a manner similar to Dawes & Mushongachiware (2023) and Pronti & Coccia (2020), both complex interactions and trade-offs will be considered involving human activities (economics, markets, agriculture, and policy) with natural systems (biodiversity, soils, and land). Below are step-by-step methodology and approaches:

3.1.1 Sampling strategy

The sampling strategy as presented in Fig.3 is designed to ensure representative data across ALLs while implementing tested experiments. The first strata will include the respective territorial, or district division, located in the geographic area within the administrative province of the CANALLS project. The territorial/district division will select districts reporting high rates of CANALLS activities to ensure that the study communities are linked to areas focusing on agroecological innovations and engage through demonstration experiments. The strata of the study will capture areas with a project presence and anticipated outcomes. The second strategy will include the villages within each territory whereby we will randomly select households. This will be a full hierarchy succession summary which serves as the sampling frame for random selection. A group of control treatment i.e. absence of agroecological intervention of CANALLS in the study area.

Random sample selection for 30 households or actors per ALL. In accordance with their engagement with demonstration experiments and experience or participation with certain agroecological value chains that the project promotes (Ntawuhiganayo et al., 2023), we will randomly select participants to be interviewed. The same sampling logic will apply uniformly across all strata to maintain comparability. Sampling design will also contain a gender inclusivity component -requiring at least 30% of the sample per stratum to be female. Female inclusivity is purposeful - women play an essential role in agricultural activities in Africa and experiences doing agroecological transitions meet their own challenges and contributions differently from men (Wekesah et al., 2019).

3.1.2 Data collection procedure

Data collection will be focused on efficient, accurate and real-time monitoring. Prior to fieldwork, questionnaires and matrix tools will be developed and validated. This important step will include the project experts as we will need to consider the comprehensiveness of the tools and ensure the tools capture all relevant data points. Following this there will be a comprehensive three-day training session that will be held for all enumerators. This training will review data collection processes, why each question is asked, and how to use the digital data collection tools effectively. This training will focus on ethical issues, techniques for interviews, and how to build trust with survey respondents. There will also be a one-day pre-test plan to conduct fieldwork for four selected living labs. This key step gives enumerators the opportunity to engage with the tools in a real setting, identifying ambiguity within questions, logistical issues and possible biases. The next step of desk work will take place to further refine the tools using all the comments and observations and difficulties raised by the enumerators in the pretest. Revisions and refinements of the questionnaire tools will be performed using feedback to ensure they are clear, functional, and accessible before data collection begins, while communication will also be maintained with field facilitators to prepare participants/heads of households for the arrival of the enumerators. This proactive engagement helps to build trust and manage expectations and increases the possibility of a smooth data collection process in the ALLS.

Data collection will occur through programmed ODK forms on mobile devices. The data will be uploaded directly to the data platform that has been created for this purpose and is based at ETHz's online platform. Given that the data will be collected digitally, it allows for aggregation and extraction of data in real time and decreases the possibility of enumerators error involving form completion. In addition, it will form an important basis to then communicate during daily evening meetings and brainstorming sessions throughout the data collection time, reviewing the activity and initial observations (Schneider & Deenan, 2004).

3.1.3 Data analysis and reporting

The data will be analyzed following both descriptive and inferential statistical analysis procedures. For the descriptive statistics, analysis will be started by descriptive methods where the key summary statistics are calculated (mean values, frequencies, and percentages) on all of the key variables (household demographics, income sources, input costs, yields, access to markets) (Rahman, 2015), and will be followed by assessing disparity by conducting a t-test to assess potential gender and age disparities across any of the various variables being evaluated (Dhar et al., 2014). This will help to uncover whether potential agroecological practices are differentiated by demographic groups; this is important because the experiences in agroecological practices may also vary depending on demographic group differences.

In addition to a profitability analysis (Cost-Benefit Analysis) of the agroecological practices, we will also conduct a profitability analysis specifically of the value chains that CANALLS project activities covered in the ALLs. This will expand beyond simply profit to identify any costs and benefits associated with the adoption of agroecological practices, including changes in input costs, labor requirements, yield increase, and any additional income in comparison to the control.

We will also include a Tobit regression model to help identify the factors that drive profitability in agroecological systems (Katel et al., 2020). This regression is appropriate because it allows for censored dependent variables (profitability in our case) and we will also examine the extent to which the outcome (profitability) was influenced by a number of considerations using socio-economic, demographic and agricultural variables (e.g., household size, education level, farm size, access to credit, particular agroecological practices carried out) (Karydas et al., 2023). All findings (including descriptive statistics, t-test results, Tobit regression results, and CBA results) will be presented in ways that convey the information as clearly as possible in terms of tables, graphs and pie charts that can be easy to interpret. A full report will be prepared to synthesize the findings of the data analysis.

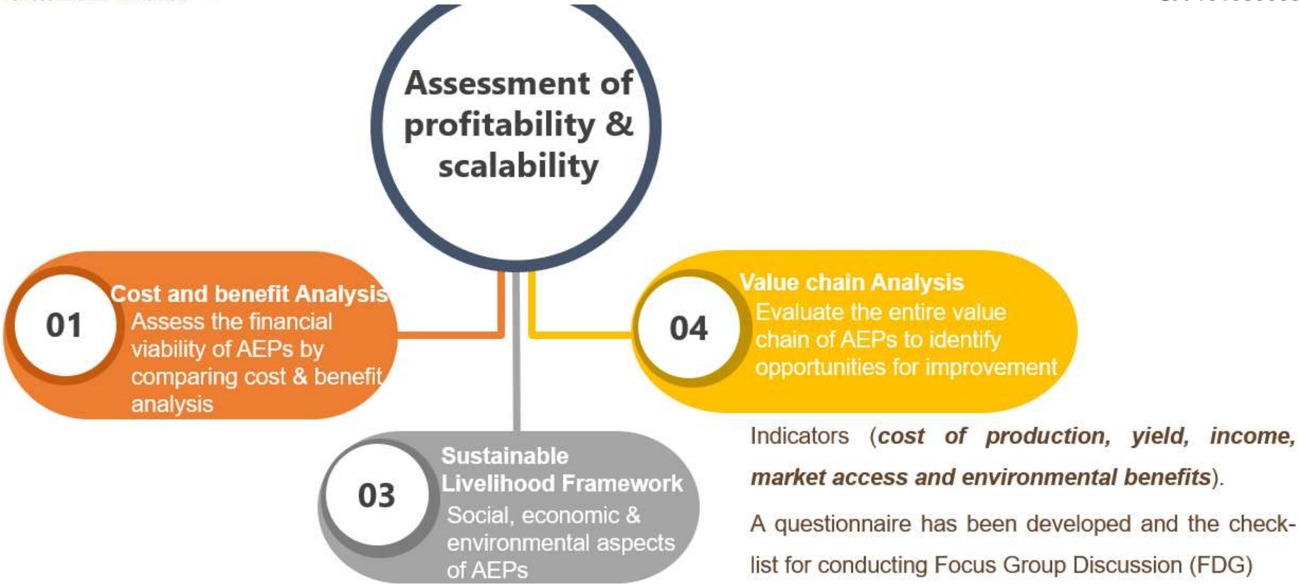

Figure 2. Tools for profitability and scalability assessment for agroecological studies

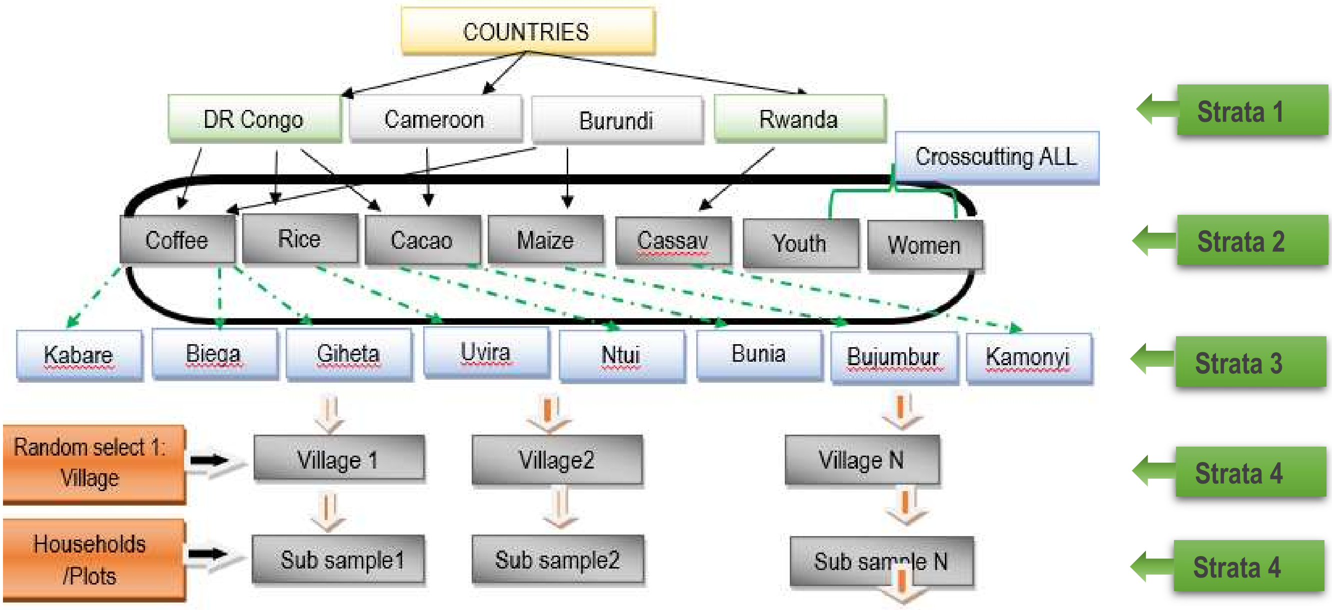

Figure 3. Household sampling strategy across countries, crop-based systems and living labs

3.2 Description of appropriate tools

3.2.1 Economic analysis: Cost-benefit analysis of agroecological practices

This section outlines the tools being used for estimation and the questionnaire we will be utilizing to assess this task. As we established above, the tools we're using for this task follow a cost-benefit analysis, along with a value chain assessment and a causal-effect estimation (Atkinson & Mourato, 2008; Dawes & Mushongachiware, 2023). To estimate the net profit earned by the producers in the Value Chain, a cost-benefit analysis via an accounting method is to be completed as described in the table below: Net Profit = Revenue – Costs

Table 2: Net Profit revenue costs estimation

Revenue	-	**Direct labour costs**	=	Net profit
		- Training and performance costs		
		- Taxes and duties		
		- Indirect labour costs		
		- Seed costs		
		- Transaction costs		
		- Production costs		
		- Advertising and marketing costs		
		- Sales costs		
		- Depreciation costs		

Transaction costs include market access fees and research costs for obtaining market information. Costs for advertising and marketing usually occur when advertising and marketing campaigns are used for their products (Sultan et al., 2021).

3.2.2 Business viability: Assessment of market access, profitability and scaling

Business viability is the systematic understanding of a business's market access, profitability and scalability potential (Natarajarathinam & Nepal, 2012). We will conduct a market study, and willingness to pay for agroecological products and services assessment. For market access we need to understand the target market and segment it, so we can then assess the distribution channels, and any barriers to entry, such as regulations or market saturation that limit access to the target customer. All of this will be done based on some headline stats like market size, growth rate, and the customer's willingness to pay so that we can point to quantified potential opportunities. Regarding the business's ability to efficiently grow without disproportionate costs, we are looking at operational capabilities of the business's activities, technology infrastructure to manage their supply chain flexibly, and fit for increased demand. Also evaluating market saturation and the incremental cost of production provides an insight into potential growth caps (Morel et al., 2017). Therefore, using the SWOT analysis, Porter's Five Forces, and scenario planning gives the business the opportunity to prioritize strategies that fit with their market, profits, and growth expectations while ensuring a strong planning interface (Helms & Nixon, 2010).

4. Conclusion and outlook

The economic assessment and business viability of agroecological methods for smallholder farmers in the humid tropics of the Central and Eastern Africa region, as carried out by the CANALLS project in the Democratic Republic of Congo, Burundi, Cameroon, and Rwanda, exemplifies the case for a shift in paradigm for agricultural development. Traditional economic assessments have always been limited by the inherently short-term focus on financial metrics and have certainly always underestimated the many benefits of agroecology. We have taken a much more comprehensive approach that employed a combination of multi-criteria assessments, cost-benefit analyses, and participatory methods to give more representative and precise accounts of how agroecological methods address the contributions to subsistence, diversification of income streams, increased resilience, and provision of ecosystem services. We aim to show direct profitability and wider societal and environmental returns, which often remain external in the current discourse, by using systematic collection of primary data through a random sampling methodology, GIS and digital apps to log and track contributions, and statistics models (e.g., Tobit regression) for analyses at the farmer and household levels in addition to detailed CBAs. Therefore, the engagement of farmers, advisors, policymakers, and academics will not only ensure that the study is scientifically robust but locally meaningful and relevant, and at the nexus of interactions between human activity and natural systems (Fiore et al., 2024). This integrated assessment is essential for developing a robust economic case for agroecology that arises above and beyond traditional accounts of development (Boeraeve et al., 2020).

Our Task 4.2 will provide compelling, quantifiable evidence showing that agroecological methods are not just environmentally, but also economically viable, and provide a business opportunity for smallholder farmers in Central Africa. We hope to counter the long-standing underestimated economic value of agroecology by accurately mapping the complexity of interactions and positive compromises of human activity and natural systems. The evidence produced as part of this study will, moving forward, be extremely valuable in informing national, regional, and international policy decisions and creating more favorable framework conditions for agroecological transitions.

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6. ANNEXES

6.1 Questionnaire tool

General objective and consent information

This study is assessing the economic performance of the agroecological practices and business viability implemented by farmers and value chain actors in our ALLs.

Would you like to participate in the interview? 1=Yes, 0= No ….

Associated characteristics of agroecological practices and business viability

To capture information related to the CANALLS outcomes, this questionnaire covers successively:

0. Introduction
1. Household sociodemographic characteristics
2. Knowledge, availability, and affordability of technologies and practices
3. Application of the different technologies and practices
4. Household income and crop utilization
5. Economic performance and business viability
6. Poverty and Household Assets
7. Access to finance and credit services
8. Social impact and behavior change

7. Section 0: Introduction

This section provides information helping to identify the geographic location of the survey. It includes information regarding the survey date, Geographical localization, GPS coordinates, name of the respondent, treatment status of the respondent, etc.

1. Survey date________________________________
2. Country______________________________ Code: 1= Cameroun, 2= Rwanda, 3=DRC,4=Burundi
3. Province ______________________________
4. Territory/Commune/district/ _________________________
5. Location of the participant: Code2: 1=Rural, 2=Urban
6. Village ______________________________
7. GPS readings of homestead: Longitude___________ Latitude____________ Altitude_____________
8. What is the main crop component: *(1) Beans, (2) Maize (3) Rice (4) coffee, (5) Potatoes, (6) Vegetable, (7) Banana, (8) Cassava,*

8. Section 1: Socio-demographic Characteristics

The household roster should include all people that "live together and eat out of the same pot". Include the following people: someone who has temporarily gone for less than six months, students studying away from home, workers who have stayed for at least a month, and someone who lives away from home but is very involved in household economic decision-making. Members who live somewhere else and only come to visit and bring money are not household members. Note years of education should be for the complete level of education. If this household is part of a polygamous family, ask only about the household members at this household.

N°	***Question***	**Response**	**Type of question**
1.01	Id of the participant		Integer
1.02	(*NAME*) IS Male or Female?		*Will automatically appear*
1.03	(*NAME*) How old is the person?		*Will automatically appear*
1.05	What is the civil status of (*NAME*)?	***Code 3***	*Select one*
1.06	Highest level of education of (*NAME*)	***Code 4***	*Select one*
1.07	The main occupation of the respondent	***Code 5***	*Select one*
1.13	What is the relation of (*NAME*) with the HH?	***Code 8***	*Select one*
1.14	How many are you in your household?		*Integer*
1.21	Type of household management	***Code 9***	*Select one*
1.22	How many people in your household contribute regularly to the household income?		*integer*
1.22.1	How many women in the household		*integer*
123	Is the respondent a firm or household		

Code 3*: 1=Single, 2=Married monogamous, 3=married polygamous, 4 =Divorced, 5 =Separated. 6=Widowed.* ***Code 4****: 1=Did not attend, 2=Primary school, 3=Secondary, 4=Tertiary, 5=Vocational, 6=Adult literacy.* ***Code 5*** *:Farming,* ***Code 6*** *: 1= Christian, 2=Muslim, 3 = Other (specify);* ***Code 7****: 0 = No, 1=Yes;* ***Code8*** *: 1= Parent, 2= Son or Daughter, 3= Spouse, 4=Other relative, 5= Neighbor or Friend, 6= Cooperative member, 7= Cooperative president, 8= Farmer promotor, 9= Other extensionist, 10= Village leader, 11= Church leader, 12= Shop owner, 13 = Lead farmer.* ***Code9:*** *1=Male-headed household; 2=Female-headed household, 3=Both (male and female)*

9. Section 2: Knowledge, availability, and affordability of agroecological technologies and practices

We are going to ask you few questions relative to knowledge, availability and affordability of technologies exposed

N°	***Question***	**Response**	**Type of question**
2.1	Have you been exposed to, participated in, or attended any CANALLS related agroecological technologies, practices, events disseminated or organized in your country	***Code 7***	*Select one*
2.1.1	Select the partner that reached the participant		*Will automatically appear per Country/Select one*
2.1.4	When have you been exposed to this agroecological technologies for the first time?		*Numeric value*
2.1.5	Select the technology or practice he/she implemented	***The list of CANALISS technologies will Be implemented***	*Will automatically appear per Country and Value Chain/ Select multiple*
2.1.6	If yes (to Q2.1) Have you ever exposed one of crop's varieties on your farm? / What is the local name of that		*Will automatically appear per Country*

	crop's, where have you find it. is it affordable in your community?		and Value Chain/ Select multiple

Code 10**: 1= Training, 2=Training through demonstration, 3=Field Day, 4=Video show, 5=Agric show, 6=Sensitization event, 7=Media event (radio and TV), 8= Input distribution, 9=SMS, 10=Interactive Voice Response (IVR),* ***Code 11: *1=Not easy, 2=average, 3=easy*

Section 3: Application for the different agroecological technologies and practices

N°	***Question***	**Response**	**Type of question**
3.1	When you were exposed to crop seeds as part of this project, did you apply them?	***Code 7***	*Select one*
3.1.1	If no (to Q3.1), what were the reasons for the non-application of the crop seeds?		*Select multiple*
3.1.2	If yes (to Q3.1), did you apply nutrient recycling (Recycling of farmyard manure and crop residues to improve soil fertility) for crop?	***Code 5***	*Appear per each value chain/Select one*
3.1.2.1	If no (to Q3.1.2), what were the reasons for the non-application of nutrient recycling for crop?		
3.1.3	Did you apply to the soil erosion control (identifying and testing biological methods adapted to local conditions)?		
3.1.3.1	If yes (to Q3.1.3), did you apply the soil erosion control entirely or partially on the farm?	***Code 13***	*Appear per each value chain/Select one*
3.1.3.2	If yes partially (to Q3.1.3), why?		*Select multiple*
3.1.4	Did you apply the agroforestry systems (implementing agroforestry practices to enhance biodiversity and soil conservation) for crop?	***Code 7***	*Appear per each value chain/Select one*
3.1.4.1	If no (to Q3.1.4), what were the reasons for no adopting an agroforestry system for crop?		*Select multiple*
3.1.5	Did you apply agro ecological practices for crop?	***Code 7***	*Select one*
3.1.5.1	If no (to Q3.1.5), what were the reasons for the non-application on crop?		*Select multiple*
3.1.5.2	Have you applied fertilizer on your crop?	***Code 7***	
3.1.5.3	If yes (to Q3.1.4.2), what type of fertilizer did you apply to this crop?		*Select multiple*
3.1.5.4	Main sources of selected fertilizers		*Select multiple*
3.1.5.5	If yes (to Q3.1.4), did you apply the fertilizer recommendations entirely or partially on the farm?	***Code 12***	*Select one*
3.1.4.5	If partially (to Q3.1.4.4), why?		*Select multiple*
3.1.5	Did you apply crop diversification for crop?	***Code 5***	*Select one*
3.1.5.1	If no (to Q3.1.5), what were the reasons for the non-application		*Select multiple*
3.1.5.2	Have you integrated trees into farming systems?	***Code7***	*Select one*
3.1.5.3	Have you applied biological control methods to manage pests sustainably	***Code7***	*Select one*
3.1.5.4	Generally, what are the key factors convincing you to adopt agroecological practices and technologies	***Code 19***	*Select multiple*

Code 12: *0 = partially, 1=entirely*
Ccode 19: 1= Cost reduction,2= Improvement of soil health, =3= Market demand.4= Technical assistance or training, 5= Others (please specify)

Section 3.2: Land access and yield measurement

Now, let us discuss the production realized during the last cropping season.

N°	Question	Response	Type of question
3.2	In total, what is the land size of your farming		Numeric
3.2.1	Unit of land area:		Numeric
3.2.2	In total, what was the land size on which you grew the crop in the last season		Numeric
3.2.3	Unit of land area:		
3.2.5	In references to (Q3.2.2), estimate the total [crop] harvested during each season		
3.2.6	Unit		
3.2.7	One [Unit] equals how many kg?		
3.2.11	What was the cropping system applied on the land during each season	***Code 14***	*Select one*
3.2.16	When decisions are made regarding getting inputs for agricultural production, who is it that normally takes the decision?	***Code 17***	*Select one*
3.2.17	When decisions are made regarding the types of crops to grow for agricultural production, who is it that normally takes the decision?	***Code 17***	*Select one*

Code 13*. 1=Increased, 2. It the same, 3. Decreased;* ***Code 14.*** *1= Intercropping, 2. Crop rotation, 3. Monocropping;* ***Code 15.*** *1 = Husband; 2= Wife; 3= Other male in the HH; 4 = Other female in the HH, 5= Any other person out of the HH; Code 16. 1= freehold, 2= leasehold, 3=communal, 4= squatter 5= other (specify);* ***Code 17.*** 1= purchase, 2= inheritance, 3= rating ,4= Gift, 5= other (specify)

(Pursue with the second crop if any in reference to question 9)

10. Section 4. Crop income and utilization

Note: Your production in the last season was [...] [Measure unit]

N°	***Question***	**Response**	**Type of question**
4.1.1	Now tell how you used your production in terms of household consumption, gift, seed, sold, etc. The sum of this decomposition should be strictly equal to the production you mentioned		
4.1.2	Use of harvested [crop]: quantity of production used for household Consumption		
4.1.3	Use of harvested [crop]: quantity of production given for free to others		
4.1.4	Use of harvested [crop]: quantity of production lost during and post-harvest		
4.1.5	Use of harvested [crop]: quantity of production used as seed		
4.1.6	Did you sell [crop] produced during the last cropping season? 1=Yes, 2=No		
4.1.7	What quantity of crops have you sell		
4.1.8	Unity of sell		*Select one*
4.1.9	At what price did you sell one [unit] of [crop production] in the last cropping season?		

4.1.10	Monetary Unit		*Select one*
4.1.11	Which market channels did you use to sell the [crop] produced during the last cropping season?	Code 20:	*Select one*
4.1.13	Who would you say decide to sell [crop] through these channels?	*Code 16.*	*Select one*
4.1.14	What is the walking distance to the nearest [crop] market in minutes?		
4.1.13	Repeat the above question for the second crop grown. Note: The production of the second crop during the last cropping season was [...] [measure unit]		

11. Section 5. Economic performance and viability

N°	*Question*	**Response**	**Type of question**
	Economic performance		*Numeric*
5.1.1	What is the total production cost per hectare for seeds?		*Numeric*
5.1.2	What is the total production cost per hectare for labour?		*Numeric*
5.1.3	What is the total production cost per hectare for inputs?		*Numeric*
5.1.4	What are other production costs?		*Numeric*
5.1.5	What is the total processing cost per hectare for inputs?		*Numeric*
5.1.6	What is the total marketing cost per hectare for inputs?		*Numeric*
5.1.7	What is the tax cost?		*Numeric*
5.1.8	What is the transportation cost for production?		*Numeric*
5.1.9	What is the packaging cost?		*Numeric*
5.1.6	Have you noticed any variation in production costs after adopting agroecological practices?	***Code 5***	*Select one*
5.1.7	What is the average selling price of your products on the market?"		*Numeric*
5.1.8	Have you noticed any variation in production costs after adopting agroecological practices?	***Code 5***	*Select one*
5.1.9	What is the average selling price of your products on the market?		*Numeric*
5.1.20	Which market channels did you use to se1.4ll the [crop] produced during the last cropping season?		*Multi select*
5.1.21	Who would you say decide to sell [crop] through these channels?		*Multi select*
5.1.22	What is the walking distance to the nearest [crop] market in minutes?		Numeric
5.1.23	Do you have access to specialized markets or premiums for agroecological products?		
5.1.24	Do you have access to markets that value agroecological products?	***Code 5***	
5.1.25	If yes, what premium do you receive for agroecological products compared to conventional products?		
5.1.27	What is the average annual income from your farm before adopting agroecological practices?		
5.1.28	What is the average annual income from your farm after adopting agroecological practices?		
5.1.29	Have your production costs changed since adopting agroecological practices?		
5.1.30	**Business Viability**		

5.1.31	How do you finance your agroecological farming activities? (Check all that apply)	**Code 21**	
5.1.32	Have you experienced any financial challenges related to agroecological farming?	***Code 5***	*Select one*
5.1.33	If yes, please describe these challenges:		
5.1.34	Do you receive any support from government or non-governmental organizations for agroecological practices?	***Code 5***	*Select one*
5.1.35	If yes, what type of support do you receive?	Code 22	*Select one*
5.1.36	Have you observed any benefits from adopting agroecological practices and what are them?	***Code 5***	*Select one*
5.1.38	Have agroecological practices affected your household's food security?	Code 13	
5.1.39	Do you participate in any farmer cooperatives or networks focused on agroecology?	***Code 5***	
5.1.40	What are your future plans regarding agroecological practices?	**Code 23**	

Code21: 1=Own savings,2=Loans from banks,3=Microfinance institutions,4=Cooperative support,5=Other (Please specify)
Code22: 1=Financial, 2=Technical training,3=Input supply,4=Market access,5=other (Please specify), **Code 23**:1=Continue and expand, 2=Continue with no change,3=Reduce, 4=Discontinue
Code 24: 1=Better market access,2=Financial assistance,3=Technical training,4=Policy support,5=Other (Please specify)

12. Section 5.1 Household off-farm income

N°	**Question**	**Response**	**Type of question**
5.3.1	Does your household have any sources of income apart from selling what you produce on the farm during the last 12 months? If yes how much is it and it source		
5.3.6	What level of off-farm income would you like to achieve in the future (next 12 months)?		
5.3.7	Unit		
5.3.8	How will you assess the change in the level of income of your household in the last 12 months?	*Code 14*	*Select one*

Code 22. *1. Work on other farms; 2. Work in local business; 3. Work in own business; 4. Remittances; 5. Work for government or public institution; 6. Rent out land to others; 7. Rent out equipment or animals to others; 8. other*

Section 6. Poverty and household assets

Productive Capital	7.1.1. Does anyone in your household currently have any [ITEM]? Yes 1

		No .... 2 >> next item
	Productive Capital	
A	Agricultural land (pieces/plots)	
B	Large livestock (oxen, cattle)	
C	Small livestock (goats, pigs, sheep)	
D	Chickens, Ducks, Turkeys, Pigeons	
E	Fishpond or fishing equipment	
F	Farm equipment (nonmechanized)	
G	Farm equipment (mechanized)	
H	Nonfarm business equipment	
I	House (and other structures)	
J	Large consumer durables (fridge, TV, sofa)	
K	Small consumer durables (radio, cookware)	
L	Cell phone	
M	Other land not used for agricultural purposes (pieces, residential or commercial land)	
N	Means of transportation (bicycle, motorcycle, car)	
S	Kindly tell us about your food and nutrition habit?	