Ref. Ares(2023)8911951 - 31/12/2023

CANALLS

AGROECOLOGICAL PRACTICES FOR SUSTAINABLE TRANSITION

D2.2 Holistic Agroecology Assessment Framework - Initial version

PROJECT ACRONYM: CANALLS
PROGRAMME: HORIZON Europe
Grant Agreement: No 101083653
TYPE OF ACTION: HORIZON-RIA
START DATE: 1 January 2023
DURATION: 48 months

Funded by the European Union

Document Information

Issued by:	UCB
Issue date:	30/12/2023
Due date:	31/12/2023
Work package leader:	CIRAD
Dissemination level:	Public

Document History

Version	Date	Modifications made by
1.0	30/09/2023	Desk study update by UCB
1.1	30/10/2023	Internal peer review
1.2	30/11/2023	Review by the Task 2.2 lead
2.0	10/12/2023	1st quality review by Diego Cerrudo and Udaya Sekhar Nagothu
2.1	24/12/2023	2nd quality review by Tim Ndah and Isaac Balume
2.2	31/12/2023	Review by WP2 lead
2.3	31/12/2023	Submission of final report

Authors

First Name	Last Name	Beneficiary
Janvier	**Mulumuna wa Lola**	**Catholic University of Bukavu (UCB)**
Damas	**Birindwa**	**UCB**
Espoir	**Bisimwa**	**UCB**
Wivine	**Munyahali**	**UCB**

In case you want any additional information, or you want to consult with the authors of this document, please send your inquiries to: mulumuna.walola@ucbukavu.ac.cd; birindwa.rutega@ucbukavu.ac.cd; ebisimwa@yahoo.com; wivine.munyahali@ucbukavu.ac.cd

Quality Reviewers

First Name	Last Name	Beneficiary
Diego	Cerrudo	CIRAD
Udaya Sekhar	Nagothu	NIBIO
Tim	Ndah	UHOH
Isaac	Balume	ETHz

Executive Summary

Assessing the conditions and performance of agroecological transitions in different contexts is the key to support the transitions of current agricultural and food systems to more sustainable systems. Similar to the study and implementation of complex adaptive systems, agroecology needs framework tools for determining boundary conditions, entry points, and anchor points in which to assess and design (or redesign) sustainable food systems. The indicators to measure sustainability performance of agricultural and food systems are believed to be beyond classic parameters such as yield/ha, $/farm, food diversity and consumption, etc. at household/farm or landscape level. Other indicators include important sustainable parameters like Kcal/person, nitrogen leaching/ha, number of healthy people, etc. Tools that have been designed around the world to assess transitions to agroecology like TEEBAgrFood, FootPrint, IFAD-AE, GTAE-GUIDE, SOCLA, LUME, SAFA, FarmDesign, MESMIS, BOOST-AE, ACT, ESSIMAGE among others are available. However, these tools have limited scope of application, with indicators in many cases that do not fully capture all dimensions of agroecology.

Based on the 10 Elements of agroecology, FAO has designed a Tool for agroecology Performance Evaluation (TAPE) to produce globally comparable data. This tool has been applied to establish an agricultural sustainability baseline for project design, monitoring and evaluation, and to diagnose and compare the performance of different agricultural systems over time at the farm/household and landscape level.

To select a holistic agroecology assessment framework (HAAF) for the diagnosis of the production systems and provide evidence on the multidimensional performance of the agroecological practices across 8 agroecological living labs (ALLS) in Burundi, Cameroon, Democratic Republic of Congo (DR Congo) and Rwanda, CANALLS project does not need a new tool, which has never been tested. The application of the TAPE, a tool that is suitable for the assessment of different agroecological zones and forest transition phases in the Sub-Saharan Africa (SSA) region will avoid the duplication of efforts in terms of time and costs. However, TAPE is not a readymade approach or set of tools that can be used in every situation.

Although, the utilisation of TAPE has raised some concerns regarding the selection of minor indicators, the advantage of this tool is that it can still be improved by external actors and users' inputs. Additionally, there are important ideas to be gleaned from TAPE as authors who underlined the strengths and weaknesses of the tool have also provided suggestions for its improvement.

The more TAPE is adaptable to local conditions, the more the tool is specific to the context of the assessment and the less it is possible to compare results with other contexts. Because of that, a complementary tool called Knowledge – Attitudes – Practices (KAP) can easily be designed for the CANALLS project. This approach will bring to TAPE flexibility for unclear situation to describe in communities.

Key words: Agroecology, transition, assessment, tool, TAPE, CANALLS, living labs.

Table of Contents

List of Tables

List of Figures

Table 1. Terms and Definitions

Abbreviation	Definition
AFS	Agricultural and food systems
ALL	Agroecology living lab
AE	Agroecology
CAET	Characterization of agroecology transition
CANALLs	Driving agroecological transitions in the humid tropics of Central and Eastern Africa through traNsdisciplinary Agroecology Living Labs
DR Congo	Democratic Republic of the Congo
FAO	Food and agriculture organization
GHG	greenhouse gases
NGO	Non-governmental organization
SDGs	Sustainable Development Goals
SSA	Sub Saharan Africa
TAPE	Tool for agroecology performance and evaluation

1. Introduction

1.1 Background

There is consensus that the current global food system is not delivering good nutrition for all and is causing environmental degradation and loss of biodiversity, such that a profound transformation is needed to meet the challenges of persistent malnutrition and rural poverty, aggravated by the growing consequences of climate change (Wezel *et al*, 2020).

Despite the fact that sub-Saharan Africa is relatively well endowed with natural resources, the incidence of hunger and poverty is greater than in other developing regions, while the population growth rate is higher and the number of poor is increasing. African farming systems are facing a range of challenges due to climate change, land and water resource degradation, biodiversity loss, etc. Yet, the economic and institutional policies do not create the necessary incentives for agricultural production. In order to restore the environment and satisfy the food and economic requirements of a growing population, there is an urgent need for different ways of producing (Dixon *et al.,* 2001).

To transform current agricultural and food systems into more sustainable systems that address these issues, one possible solution is the adoption of agroecological practices that need to be applied across food systems and crop value chains. However, to meet this, a transition phase is prerequisite to shift from the current agricultural practices toward agroecological production systems.

Agroecosystems are inherently complex systems. Multiple components are in constant interaction resulting in emergent phenomena at different scales in time and space. Moreover, farmers manage their farms to satisfy a multiple individual and societal demands such as food and nutritional security, income generation, risk management, the preservation of cultural values and environmental stewardship, among many others (Mottet *et al.,* 2020**;** Lopez-Ridaura, 2022**)**.

So far, agroecological approaches have gained prominence in scientific, agricultural and political discourse suggesting pathways to follow (FAO, 2019).

Agroecology (AE) is arguably the only concept that is globally defined as being a holistic transformative approach to food systems, and there is mounting evidence of its potential to address several food systems challenges simultaneously (HLPE, 2019; Mottet *et al*., 2020; Bezner Kerr *et al*., 2023). AE involves the application of integrated ecological, economic and social principles to the transition of smallholder farming systems, towards greater resilience *(*HLPE*, 2019).* It also seeks to reconnect producers and consumers through a circular and solidarity economy that prioritizes local markets and supports local economic development by creating virtuous cycles. This involves adapting 13 generic agroecological principles (recycling; input reduction; soil health; animal health; biodiversity; synergy; economic diversification; co-creation of knowledge; social values and diets; fairness; connectivity; land and natural resource governance; participation) to local circumstances (*FAO, 2021*). These principles are well connected to the 10 AE elements of FAO (Bicksler *et al*., 2023).

To facilitate the transition from conventional farming to agroecological farming, adequate concepts, methods and tools to measure and assess impact and productivity of agroecological farming systems are needed, which consider their multi-functionality and other specific characteristics (Wiget *et al*, 2020).

To assess performance of the complex and multifunctional nature of agroecosystems several efforts have been directed towards the development of methods and tools to capture such complexity, while providing elements for improvement in the design of sustainable agroecosystems. Hence, different actors along the agricultural research and development continuum have developed diverse agroecosystem analysis methods and tools. These go from highly elaborated mathematical models to truly hands-on practical guidelines (FAO, 2019; Levard, 2023).

Although these methods and tools show increasing evidence on the impacts of AE, results remain fragmented because of heterogeneous methods used and data collected, as well as differing scales, locations and timeframes and knowledge gaps (Mottet *et al.,* 2020).

To fill the gaps, the specialized agency of the United Nations that leads international efforts to defeat hunger, food and agriculture organisation (FAO) has designed TAPE, a Tool for agroecology Performance Evaluation to produce globally comparable data. TAPE is based on the 10 Elements of the AE and was developed with the main goal to produce global and harmonized evidence on the multi-dimensional performance of agroecological systems (FAO, 2019). It determines when a practice, project, investment, or policy can be considered truly agroecological. The tool factors all significant human and environmental health, social and economic criteria, (such as profitability, ecosystem services, carbon and GHG footprints, biodiversity, social inclusion, etc.) into a set of tractable performance metrics that facilitate the evaluation of agroecological approaches. As TAPE ensures the measurement of the multiple economic, environmental, and social values created by agriculture or food systems, CANALLS project needs TAPE to assess the agroecological indicators at farm/household and landscape levels as part of its mission to produce globally comparable data to be collected across the 8 selected agroecological living labs (ALLS) in Burundi, Cameroon, DR Congo and Rwanda**.**

In this context, TAPE is the framework capable to assess the status of agroecological transition of local farms and to identify its correlation with farms' quantitative performance across the economic, social, and environmental dimensions of sustainability. Its application can support the co-creation and sharing of knowledge among producers, foster the adoption of more sustainable production practices and inspire the formulation of public policies that support agroecological transitions.

In light of the above, we argue that: 1) TAPE will contribute to assess the sustainability of our agricultural and food systems in a multidimensional manner and in the variety of contexts of Burundi, Cameroon, DR Congo and Rwanda; 2) its' application will support the transition toward sustainable food systems, as the tool can be used from project monitoring to regional assessments or comparative analysis, and in different geographical contexts.
However, given the context-specific nature of agricultural and food systems (AFS) and the varying needs of actors, many authors believe there will ever be a perfect tool or framework for assessing agroecology that can meet every objective in all possible contexts (Geck et al., 2023). In view of this situation and to fill the possible deficit in indicators selection, this document provides elements for TAPE improvement in designing sustainable agroecosystems in the CANALLS project mandate areas.

1.2 Objectives

The objectives of this document are (i) to provide a comprehensive review of main existing AE assessment frameworks; (ii) to analyze the suitability of TAPE for AE assessment of ALLs in CANALLS project and; (iii) decide if the highlighted indicators in TAPE cover all the important aspect of the project, if not (iv) propose and design a knowledge, aptitudes and practices (KAP) model as a complementary tool for more flexibility of TAPE.
This document is organized as follows: (1) literature review of tools on agroecology assessment, (2) TAPE description and the rationale behind its selection as a tool to be used in CANALLS project, and (3) conclusions.

2. Existing frameworks and tools

2.1 Introduction

To evaluate sustainability in agro-ecosystems at local and higher levels, sets of agri-environmental indicators have been selected and included in the various tools that have been designed (Van Cauwenbergh *et al.,* 2007).

However, in the process of selecting a tool for sustainability evaluation of AE systems, adequate number and pertinence of indicators are required. Indicators should be able to define and monitor AE as a key part of the global response to deforestation, water scarcities, biodiversity loss, soil depletion and greenhouse gas emissions and has the potential to alleviate poverty, reduce hunger and malnutrition and decrease inequalities. Hence, the general approach to selecting tools to evaluate the level of integration of the AE concept in farms/ households consists of identifying a framework *centered on human dignity*. It is a question of finding a tool that best highlights the possibility of sustainably leading a healthy and productive life at the expense of the natural, human, and financial resources available in a peaceful and just environment. For this, priority is given to tools that clearly describe natural, social, political, spiritual, human, and social capital of communities. It must also explain the structures and systems, both formal (institutions, legislation, power structure, etc.) and informal and traditional (value systems, beliefs, religions, etc.), specifying as much as possible how they sustainably promote access to the assets and how do these assets also influence their evolution. The selected tool must also highlight the potential shocks capable of disrupting access and enjoyment of resources by humans and the trends in their occurrence to allow the formulation of means of mitigation and adaptation drawn from both formal and informal knowledge and practices. Thus, it will be a question of promoting the tool that clearly clarifies the networks of learning and exchange of experiences both horizontally and vertically at the community level regarding sustainable and efficient use of available resources.

However, if few indicators are monitored, crucially important developments may escape our attention when focusing on a particular area and the system trade-offs may not be properly taken into account. Conversely, if too many indicators are considered, data collection and data processing become difficult to handle at a reasonable cost, redundancies might appear and the message expressed by the indicator set becomes difficult to understand (Van Cauwenbergh *et al.,* 2007).

This desk study aims at selecting a tool comprising a set of “essential” indicators that will be useful for the different work packages (WP1, WP2, WP3 and WP4) of the CANALLS project. Attempts are made to overcome obstacles by using an intuitive judgement of experts familiar with a particular discipline (e.g. agronomy, ecology, economy or other disciplines), which introduced some important biases due to “an overly dense indicator specification or gaps for some critical issues”.

2.2 Description of existing tools

In the absence of globally recognized definitions of agroecology, early approaches relied mainly on i) qualitative analysis and ii) the five levels of food system change and integration of agroecology. When FAO (2018) published the 10 elements of agroecology (Barrios et al., 2020) and the CFS HLPE (2019) proposed the 13 principles of agroecology, this paved the way for more systematic approaches to measuring the degree of agroecological integration in funding and project portfolios. Biovision (n.d.a) developed the Agroecology Criteria Tool (ACT), which integrates Gliessman’s (2015) five levels of food system change with FAO's (2018) elements of agroecology (adding “regulation and balance” as an 11th element). The tool provides a total of 62 criteria corresponding to the different elements of agroecology, used in assessing the degree to which each of them has been integrated. To assess to which degree agroecology is integrated into the in-country portfolio of the International Fund for Agricultural Development (IFAD), developed IFAD's Agroecology Framework. The IFAD Agroecology Framework was also inspired by FAO's 10 elements but focuses on three core elements (efficiency, recycling, and diversity). Apart from the project and portfolio levels, assessing agroecological integration at farm and household scales has received considerable attention (Geck *et al.,* 2023).
Some examples of tools are being briefly described below.

2.2.1 TEEBAgriFood

As a project, TEEBAgriFood seeks to “evaluate all significant externalities of agri-food systems, to better inform decision-makers in governments, businesses and farms.

The TEEBAgriFood valuation framework is a frame of analysis that enables us to answer the question "what should we value, and why?" The framework ensures that nothing important is missed and that the full range of impacts and dependencies (including externalities) from eco-agri-food systems can be individually examined and collectively evaluated for the application in question, be it a typology comparison, a policy evaluation, a business question or an accounting question. Using a universal framework each type of food system, production alternative, or consumer choice can be held to a common form of assessment of all significant costs and benefits, whether they be economic, social, or related to risks and uncertainty (TEEB, 2018).

The valuation framework seeks to provide both a common understanding of what an evaluation might entail, as well as a cross-cutting template for carrying out such an evaluation. For each type of food system, production alternative, or consumer choice, TEEBAgriFood offers a common form of assessment of costs and benefits by using a single universally applicable framework (TEEB, 2018).

The development of TEEBAgriFood was informed by holding up the seven indivisible principles that guide the work of the Global Alliance for the Future of Food: renewability, resilience, equity, diversity, healthfulness, inclusion, and interconnectedness.

The TEEBAgriFood valuation framework displayed as a matrix enables a structured evaluation of all material impacts and externalities along different stages of the value chain. However, the framework only provides a structure and an overview of what should be included in an analysis but does not prescribe methods for valuation. Methods of valuation will depend on the values to be assessed, availability of data, and the purpose of the analysis (Eigenraam *et al*., 2020).
Although TEEBAgriFood provides a structure and an overview of what should be included in an analysis, the framework does not prescribe methods for valuation. Methods of valuation depend on the values to be assessed, availability of data, and the purpose of the analysis (TTEB, 2018).

2.2.2 Footprint

Every year people demand more resource from nature than it can regenerate. The environmental footprint is an umbrella concept referring to environmental indicators used to quantify environmental pressures and impacts of human activities such as production or consumption. Footprint indicators are a suite of tools that are now able to capture a large variety of environmental issues, also focusing on food systems. These include the Ecological, Carbon, Water and Nitrogen Footprints (Caro *et al*., 2023).

Individuals, communities and government leaders use data from Global Footprint Network to better manage limited resources, reduce economic risk, and improve well-being.

Footprint was one of the first comprehensive attempts to measure human carrying capacity not as a speculative assessment of what the planet might be able to support, but as a description of how many planets it actually takes in any given year to support human demand on resources in that given year (Wackernagel et al., 2006). The Ecological Footprint was the only metric that compares the resource demand of individuals, governments, and businesses against Earth's capacity for biological regeneration (Wackernagel *et al*., 2006).

The ecological footprint (EF) is an area-based indicator to measure ecological safety, which quantifies the intensity of human resource use and waste discharge activity in a specified area in relation to ecological capacity to provide for human activities (Rees, 1992). To date, the EF method has been explored to produce a detailed picture of resource consumption or waste discharge via the assessment of energy footprint, carbon footprint (CF), water footprint (WF), nitrogen footprint (NF), chemical footprint and biodiversity footprint (Fang *et al*., 2013, 2015). The CF, WF and NF are the three components of EF that are used to measure ecological safety or sustainability and to determine whether human activities exceed the limits of ecological carrying capacity (ECC) at different scales (global, national, regional, organizational, industrial and household scales) (Feng and Zhao, 2020).

The Food Footprint tracks the use of productive surface areas. Typically, these areas are: cropland, grazing land, fishing grounds, built-up land, forest area, and carbon demand on land (Wackernagel *et al*., 2006). The Food Footprint can be tracked by category of products, such as bread and cereals, fruit, vegetables, fish and seafood, meat, animal-based oils and fats, etc.

2.2.3 IFAD-Agroecology framework

The IFAD Agroecology Framework was inspired by FAO's 10 Elements of Agroecology. It defines agroecology-relevant interventions through 33 activity groups operating at four levels (Figure1): (i) agroecological practices at farm level; (ii) natural resource governance, community learning and adoption of nature-based solutions to sustain and enhance ecosystem services and secure equitable access to resources for vulnerable groups at landscape level; (iii) support for value addition and innovations in connecting small-scale producers and consumers around shared values of sustainable and healthy food (market level); and (iv) instruments and services enabling agroecology and sustainable food systems (policy level) (IFAD, 2021). With this approach, three key elements needed to be present at the farm and/or the landscape level for a project to qualify as agroecological:

- increasing resource use efficiency while reducing and/or substituting external inputs;
- recycling water, nutrients, biomass and/or energy; and
- diversifying and integrating different farming sectors (various crops and/or animals) with high levels of biodiversity to facilitate efficiency and recycling, spread risks, increase resilience, and produce a greater variety of nutritious food.

IFAD's four mainstreaming priorities (gender, climate change, nutrition, and youth) and Indigenous Peoples are included in the framework as cross-cutting categories called "thematic areas" (Figure 1).

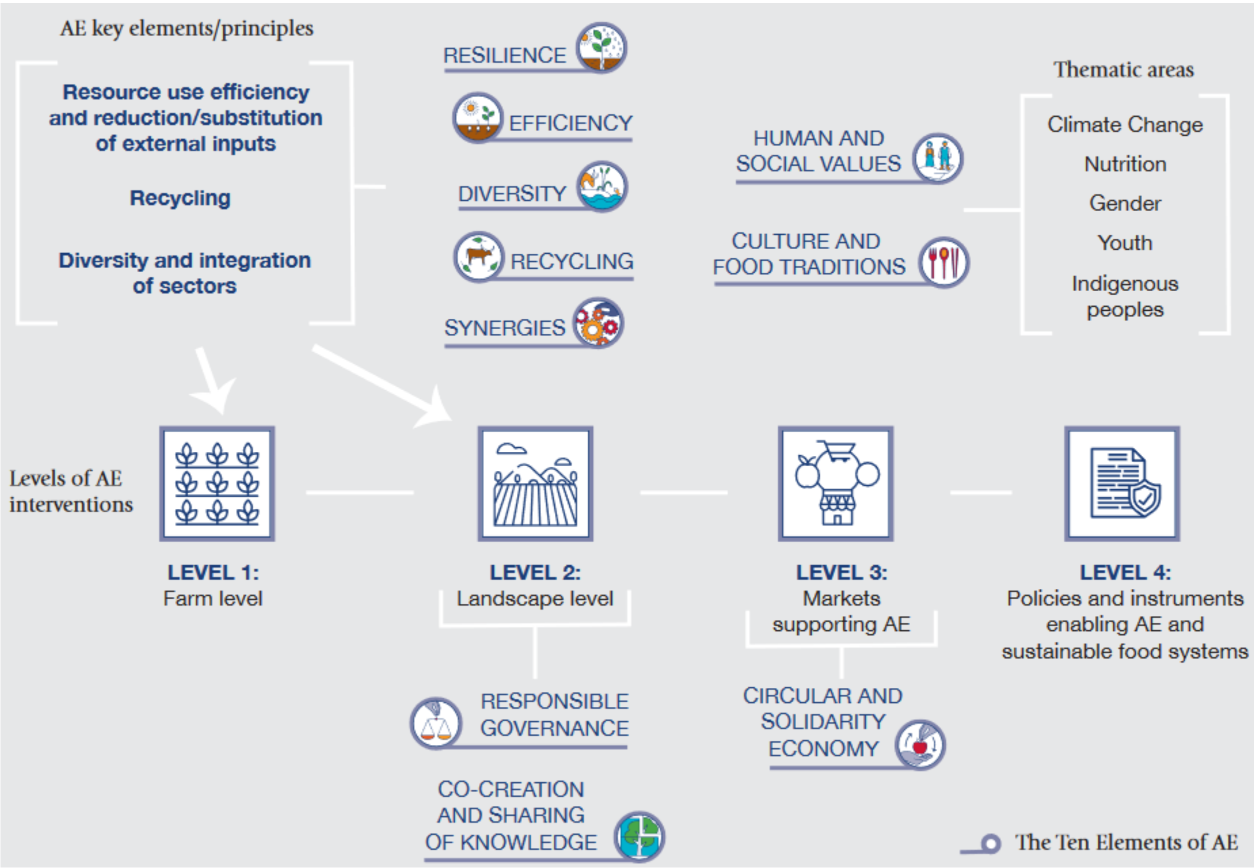

Figure 1. The IFAD Agroecology Framework and the 10 Elements of Agroecology (IFAD, 2021)

2.2.4 GTAE-GUIDE

The tool is called "*Guide pour l'évaluation de l'agroécologie" (*GTAE_guide). It features an approach and methodological tools to assess the effects of agroecological practices and systems on the agro-environmental and socio-economic performances of agriculture, and on the conditions necessary for the development of agroecology. It is devised to help development stakeholders better design their projects, programmes, and public policies, to facilitate the creation of references and support farmers so that they can better evaluate the results of their practices and thereby make informed decisions (Levard, 2023).

The GTAE guide is the result of collaboration between the GTAE "Groupe de travail sur les transitions agroécologiques" (Agrisud International, AVSF, Cari and GRET) and AgroParisTech, CIRAD, IRD and Institut Agro Montpellier. The method is based on a multitude of experiences around the world. It was developed in association with actors who accompany the agro-ecological transition in different countries and actors from the academic world, the method considers the specificities of each territory and the diversity of agricultural production systems (Levard, 2023).

This guide on the evaluation of agro-ecology has a double objective:

- Improving the support of farms in their agro-ecological transition, by providing decision support based on the results of practices
- Producing references to document the benefits of agro-ecology for farms, the economy, the climate and the environment.

It is intended for development actors in charge of designing and implementing projects, programs and public policies in favour of agroecology.

The main advantage of this tool is its adaptation to field realities and ability to fit a wide variety of situations:

- on the one hand, to assess the effects of agro-ecological practices and systems on the agri-environmental and socio-economic levels
- on the other hand, to evaluate the conditions for the development of agroecology (Levard, 2023).

While the tool contains certain elements that go beyond the farm and incorporate some aspects of agroecology on the community, landscape, or food system level, the focus of all three tools is on the farm level. The GTAE framework is arguably the most comprehensive yet highly flexible approach to assessing agroecological performance but is currently only available in French (Geck *et al*., 2023).

2.2.5 SOCLA

It's a theoretical approach developed in Latin America and identified as critical Latin American agroecological thought (Rosset *et al*., 2021). The agroecological method for participatory soil and crop health assessment was developed by the SOCLA (Sociedad Científica Latinoamericana de Agroecología). The tool describes a practical methodology to rapidly assess the soil quality and crop health of agricultural systems using simple indicators chosen, applied and interpreted jointly by farmers and researchers. Field measurements are made on agroecosystem properties that reflect soil quality and plant health. As measurements are based on the same indicators, the results are comparable and allow farmers to monitor the evolution of the same agroecosystem along a timeline, or make comparisons between farms in various transitional stages (Nicholls *et al.,* 2004).

SOCLA has the potential as an emancipatory epistemology for England, as well as in Latin America.

2.2.6 LUME

Based on MESMIS method, Lume was developed as a contribution to cover the dearth of analytic tools for revealing the economic and ecological rationalities of family-managed agroecosystems as a superior approach to the entrepreneurial logic informing agrarian capitalism.

In the Lume method, the agroecosystem is viewed as a ‘cultivated, socially managed ecosystem:

- The agroecosystem is a social construct driven by the convergences and disputes between economic and socio-political agents in defined territorial settings. In this sense, the method dialogues with political economy.
- The agroecosystem is a material expression of the strategies adopted by families and communities to appropriate a landscape unit in order to reproduce their means and modes of life. In this sense, the method dialogues with ecological economics (Petersen *et al.,* 2020).

The method proposes analytic concepts and instruments capable of recognizing and increasing the visibility of the labour of the different people involved in the management of agroecosystems. To this end, it adopts an analytic approach consistent with feminist economics, expressing a critical view of the sexual division of labour and patriarchy, cultural and ideological elements that structure the economic relations dominant in the domestic and public spheres and mask the essential role of female farmers in generating social wealth (Petersen *et al.,* 2020).

In order to understand agroecosystems in the institutional context in which they exist, the method includes both qualitative and quantitative forms of evaluation for describing and analysing the mechanisms of economic-ecological exchange (Petersen *et al.,* 2020).

2.2.7 MESMIS

The MESMIS (Marco para la Evaluacíon de Sistemas de Manejo de recursos naturales incorporando Indicadores de Sostenibilidad) framework is consists of a participatory multi-criteria assessment and is one of the first efforts to apply systems analysis for the evaluation and design of agro-ecosystems through the use of context specific indicators (Lopez-Ridaura, 2022).

The framework relies on a systemic approach, from which seven basic attributes for sustainability are defined: productivity, stability, reliability, resilience, adaptability, equity and self-reliance (Gonzalez-Esquivel *et al*., 2021, Lopez-Ridaura, 2022).

Based on a systems approach, MESMIS provides guidelines for the derivation, quantification, and integration of locally relevant indicators. Sustainable systems properties or attributes are the basis for the selection of context specific indicators. These attributes are inherent characteristics of sustainable agricultural systems. Strategic indicators, informing these systems properties, are derived mainly through participatory approaches to reflect the objectives of farmers and other stakeholders involved on agricultural development.

The operational application of the framework has a cyclic structure and is divided into different steps: the first three steps are devoted to the characterization of the systems, the identification of critical points and the selection of specific environmental, social and economic indicators. In the last three steps, indicators are quantified and integrated for whole-systems multi-criteria assessment, and elaborate recommendation to improve their sustainability.

A great diversity of farming systems has been evaluated with MESMIS, ranging from crop and livestock-based systems, forestry, fisheries and ecotourism, and, in most cases, mixed systems where multiple components are interlinked. (Lopez-Ridaura *et al*, 2002; Gonzalez-Esquivel *et al*., 2021, Lopez-Ridaura, 2022).

2.2.8 SAFE

The framework "Sustainability Assessment of Farming and the Environment" (SAFE) is a tool content-based with principles, criterions and indicators (PC&I) framework to assessing sustainability in agricultural systems. Although content-based, SAFE differs from previous efforts in the agricultural domain by its holistic approach, covering all components of agricultural systems. In addition, several complications that may have hampered the development of content-based PC&I frameworks for agriculture are tackled in the SAFE framework: (1) problems with indicator selection, (2) scale problems for implementing such a framework and (3) lack of reference values for testing sustainability issues (Van Cauwenbergh *et al.,* 2007).

The SAFE framework references values in a structured way. Indicators and reference values are the end-products of the framework as well as the operational tools that are used for evaluating the sustainability of agro-ecosystems. Principles are related to the multiple functions of the agro-ecosystem, which go clearly beyond the production function alone. The multifunctional character of the agro-ecosystem encompasses the three pillars of sustainability: the environmental, economic and social pillars. Indicators and reference values are the end-products of the framework. They are the operational tools that are used for evaluating the sustainability of the agro-ecosystems.

The proposed analytical framework forms part of the evaluation path in agricultural sustainability. It was designed for three spatial levels: the parcel level, the farm level and a higher spatial level that can be the landscape, the region or the state (Van Cauwenbergh *et al.,* 2007). However, it is not intended to find a common solution for sustainability in agriculture as a whole, but to serve as an assessment tool for the identification, development and evaluation of locally more sustainable agricultural production systems, techniques and policies. Further details on the selection and aggregation of indicators and the practical implementation of the framework are given by Sauvenier *et al*. (2006) (Van Cauwenbergh *et al.,* 2007).

2.2.9 FarmDESIGN

The FarmDESIGN model has been developed to overcome the evaluation of i) the relations between various farm performance indicators and, ii) the consequences of adjustments in farm management. The tool was built to assess the performance of agroecosystems and design alternative, more sustainable systems. In FarmDESIGN, the main flows and stocks within farm systems are quantified and a series of economic and environmental indicators calculated. The model was designed by coupling a bio-economical farm model that evaluates the productive, economic and environmental farm performance, to a multi-objective optimization algorithm that generates a large set of Pareto-optimal alternative farm configurations (Lopez-Ridaura, 2022).

With these model generated alternative systems, it is possible to identify and quantify main trade-offs and select specific farm systems that satisfy different goals and minimize these trade-offs (Lopez-Ridaura, 2022). After design, output and end-user validation, the optimization module of the model can be used to explore the consequences of reconfiguring farming systems. The optimization aimed to maximize the operating profit and organic matter balance, and to minimize the labor requirement and soil N losses. The model outcomes showed that trade-offs existed among various objectives, and at the same time identified a collection of alternative farm configurations that performed better for all four objectives when compared to the original farm. Relatively small modifications in the farm configuration resulted in considerable improvement of farm performance (Lopez-Ridaura, 2022).

FarmDESIGN has been applied to a wide diversity of systems in most of agricultural regions of the world.

Although a predominantly research oriented use of FarmDESIGN, it has also been used for practical actions trough participatory analysis and discussion on the main results generated by the model and the practical options for transition towards more sustainable agroecosystems (Lopez-Ridaura, 2022).

2.2.10 ACT

Biovision inspired by DeLonge et al. (2016), developed the Agroecology Criteria Tool (ACT), which integrates Gliessman's (2015) five levels of food system change with FAO's (2018) elements of agroecology (adding "regulation and balance" as an 11th element). ACT enables the assessment of a project through the lens of agroecology. It visualizes the degree to which a project, program or policy is aligned with the various dimensions of agroecology. ACT methodology is based on the analytical framework by Gliessman (2016) on the 5 levels of food system change and is embedded within the 10 Elements of Agroecology by FAO (Biovision, n.d.a.). Each element of the transition includes a list of relevant topics (inclusion criteria), which were based on past work by DeLonge *et al.* (2016). The underlying interpretation of agro-ecology is a set of agricultural principles by FAO focused on optimizing biological synergies and diversity in the agro-ecosystems and reducing negative trade-offs. Those farming systems should clearly identify and target key ecological functions and aim to integrate these various elements carefully into the farming systems creating multiple levels of positive interactions and not just substituting external inputs and engaging in isolated interventions (Biovision, n.d.a.).

As limitations, ACT does not evaluate outcomes or impacts of activities. It is recommended that a mixed methods approach is utilized if such results are desired. Criteria selection is binary (yes/no) and therefore does not indicate quality or diversity of agroecological activities. This means that positive results do not exclude possibility for further development. Likewise, when comparing multiple initiatives users must rely on any notes that have been entered in the tool to distinguish the nuances of how each initiative engages with criteria. For example, an initiative that funds agroforestry tree planting will be ‘scored’ equal to an initiative that coordinates landscape integration of agroforestry projects (Biovision, n.d.a.).

2.2.11 ESSIMAGE

ESSIMAGE (Evaluation and Simulation of Agroecological Systems) is a decision support tool, which makes it possible to assess the agroecological transition process performance and to put forward possible alternatives for the improvement of the agro-environmental, social, and economic performances of a given farm.This tool has been tested as part of a CASDAR "Post-MAET Gimone" (agriculture.gouv.fr/ministere/mobilisation-collective-pour-lagroecologie) project on the subject of "Collective mobilization for agroecology" by using farm data, most of the farms having been involved in an agro-environmental measure for the progressive reduction of phytosanitary treatments since year 2008. ESSIMAGE was designed because existing tools were inappropriate for organic and agroecological systems, and did not make it possible to measure the agroecological transition performance of farms (Trabelsi *et al*., 2019). The project designed a decision support tool in order to help farms throughout the agroecological transition process, to assess the performance of this transition, and to put forward improvement scenarios. Contrary to other assessment methods, ESSIMAGE is based on both pressure and impact indicators, and takes the specificities of agricultural production systems into account. It is a flexible tool, which not only makes it possible to assess the current farm performance but also consider the future by putting forward possible alternative improvement scenarios and by simulating their consequences at a later stage. ESSIMAGE is also based on the interaction of two elements: agro-environmental, social, and economic indicators; and the GIS (Geographic Information System) software. The tool has made it possible to compare the agroecological performances of farms with an optimal situation, as well as with each other (Trabelsi *et al*., 2019).

Of the frameworks and tools described in the above section, only the IFAD Agroecology Framework directly combine measuring the degree of agroecological integration with a performance assessment (Geck et al., 2023). Gaps and limitations for the other reviewed tools best informing our decision and choice in the CANALLS project are presented below.

2.3 Limitations of the existing frameworks and tools

Many researchers have proposed methodologies to assess agroecosystem performance, but most focus on specific properties (Table 2) as the definition of an appropriate set of indicators for sustainable development appears to be a very difficult task. While the above frameworks/tools may use the same indicators, their procedure and field of application are quite different. They have a limited scope of application, with indicators that do not fully capture the different dimensions of agroecology. It also has been pointed out that even if these frameworks collect data and provide evidence on the impacts of agroecology, the data collected between frameworks are heterogeneous and difficult to compare (Wiget *et al*., 2020).
Results from these tools have been qualified as fragmented because of the heterogeneous methods and data, differing scales, and timeframes. In addition, much of the evidence lies in the literature (case studies, descriptions of communities' experiences, field observations, etc.) that are usually highly context dependent and not peer reviewed (Mottet *et al*., 2020).

Table 2. Main key attributes retained from a number of existing frameworks reviewed and the main differences between the frameworks and TAPE

FRAMEWORK	KEY ATTRIBUTES RETAINED	DIFFERENCES
MESMIS – Marco para la Evaluacíon de Sistemas de Manejo de recursos naturales incorporando Indicadores de Sostenibilidad (GIRA-UNAM)	Participatory Step-wise Hierarchical Flexible Starts with contextualization	Indicators can be quantified by different method vs protocol provided in this framework
GTAE – Groupe de Travail sur les Transitions Agroécologiques (CIRAD-IRD-AgroParistech) – Memento pour l'évaluation de l'agroécologie	Simple and reasonably time consuming Allows integration in broader systems of monitoring and evaluation Almost all criteria are common	Initial step of complete agrarian diagnostic not included in this framework Some criteria are proposed as advanced as they require more time and resources.
SOCLA – Sociedad Científica Latinoamericana de Agroecología, Method to assess sustainability and resilience in farming	Soil health assessment used as core criteria Almost all other criteria common Participatory and simple	In depth crop health assessment not included in this framework
Sustainable Intensification Assessment Framework (Michigan State University)	Not focused on particular practices Addresses different scales (field/animal, farm/household, community/territory) All 6 domains are common	Some of the criteria/indicators are included as advanced and not core in this framework
LUME - Método de Análise Econômino-Ecológica de Agroecossistemas (AS-PTA & MAELA)	Based on MESMIS method Almost all criteria/indicators are common Valuing the invisible non-monetary economy	Centrality of the principle of autonomy vs one of the aspects to assess in this framework
Measuring the impact of ZBNF, the Zero Budget Natural Farming (State Dept of Agriculture, Andhra Pradesh & Amrita Bhoomi Center)	Participatory and possible self-assessment Large number of common indicators /impacts	Method largely left to implementer to define
The Economics of Ecosystems and biodiversity - **TEEB** (ICRAF)	Separates 2 steps: description of the system and analysis of the impacts 4 dimensions of impacts are included (and this framework adds a 5th)	Economic assessment so based on 4 capitals, which is not the entry point in this framework

Sustainable Rural Livelihoods approach (CIRAD)	Includes an analysis of the context (institutions, household activities…) Could be adapted for this framework by integrating the 10 elements in the qualification of assets	Not participatory
Participatory methodologies from Malawi and Tanzania (Cornell University)	Assessing systems in transition Participatory and based on interviews	Does not prescribe indicators
SAFA - Sustainability Assessment of Food and Agriculture systems (FAO)	Includes 4 dimensions of sustainability (environment, social, economy and governance), which are 4 of the 5 dimensions on this framework Aims to be universal/global	Time consuming (21 themes and 58 sub-themes, 118 indicators); Targets enterprises (farms or companies)

As described by Geck *et al.* (2023), a suitable tool should globally provide comparable (1) measurements of the degree of AE integration (transition) at farm and household level, project and portfolio level, business and private sector level and policy level and; (2) measurements of the performance of AE.
As such, since the tool 'Footprint' covers all human demands (which span over vast arrays of activities), data availability is one of the most limiting factors for the analysis. As a result, the options are relying on weak data, leaving things out, or making assumptions, all of which limit the robustness of the results (GFN, 2020).

Although 'IFAD-AgroEcology framework' is inspired by FAO's 10 elements, the tool focuses on three core elements (efficiency, recycling, and diversity). If a project integrates these three elements at the farm or landscape level, it is considered agroecology-based. Given the increasing interest in tracking finance for agroecology and the variety of different approaches and tools used, a multi-stakeholder consortium developed a harmonized framework for tracking agroecology investments (Geck *et al.,* 2023).

FarmDESIGN model still has some limitations and shortcomings that are not only technical, but also regarding content. The most mentioned deficiencies are error messages that appear when using the model, and the limited usability of the outputs for farmers (Bao *et al.,* n.d.a.).

ACT, Agroecology Criteria Tool provides a total of 62 criteria corresponding to the different elements of agroecology to assess the degree to which each of them has been integrated. The main limitation of the tool is the fact that criteria are binary and can only be marked as absent or present.
Among the limitations of ESSIMAGE, the tool is known as exclusive of famers. Their' participation is not explicitly stated but the authors take the view that (1) farmers have to participate in innovative processes, (2) they have to be recognized as stakeholders and not only as beneficiaries, and (3) farmers have to be involved in decision making on sustainability (Wiget *et al.,* 2023).

To respond to these limitations and the need for global and harmonized evidence on the multidimensional performance of agroecology, the Food and Agriculture Organization of the United Nations (FAO) facilitated global and regional dialogues on agroecology that included civil society, practitioners, producers' organizations, researchers, and policy makers, among others (FAO, 2019).

This is why FAO has developed a globally applicable diagnostic tool for Agroecology Performance Evaluation (TAPE) for the transition to agroecology at the territorial level. Strength and innovative aspects MESMIS, GTAE, SOCLA, LUME, TEEB, ACT, SAFA, ZBNF, sustainable intensification assessment framework, sustainable rural livelihoods, participatory methodologies from Malawi and Tanzania, are already included in TAPE (FAO, 2019).

Review of already existing analytical frameworks and consultations with experts led to the definition of key attributes for TAPE to meet the given mandate. These key attributes summarized in Table 2 also meet the founding principles described in the TAPE tool.

3. Tool for Agroecology Performance Evaluation (TAPE)

3.1 Description of TAPE

TAPE is an analytical framework based on the 10 elements of agroecology created with the main goal of producing global and harmonized evidence on the multi-dimensional performance of agroecological systems. Apart from being a rapid assessment across all 10 elements of agroecology, the use of TAPE in the context of sub-Saharan Africa (SSA) conditions is justified as the tool is built to be a stepwise approach and uses simple rating scales (Lucatoni *et al.,* 2022). TAPE provides important data and key information on the overall sustainability of farms measured by different indicators of performance. It also provides insights on how the level of agroecological transition measured using the 10 elements of agroecology links with the multidimensional performance of the evaluated systems (Figure 2) (Lucatoni *et al.,* 2023).

According to Lucatoni *et al,* (2022), the framework MESMIS inspired the team that developed TAPE to take a stepwise approach for the tool. The stepwise approach adopted in TAPE is summarized in Figure 2 below. It is based on two central steps (1 and 2) that consist of assessing the level of agroecological transitions and quantifying impacts on the core criteria of performance.

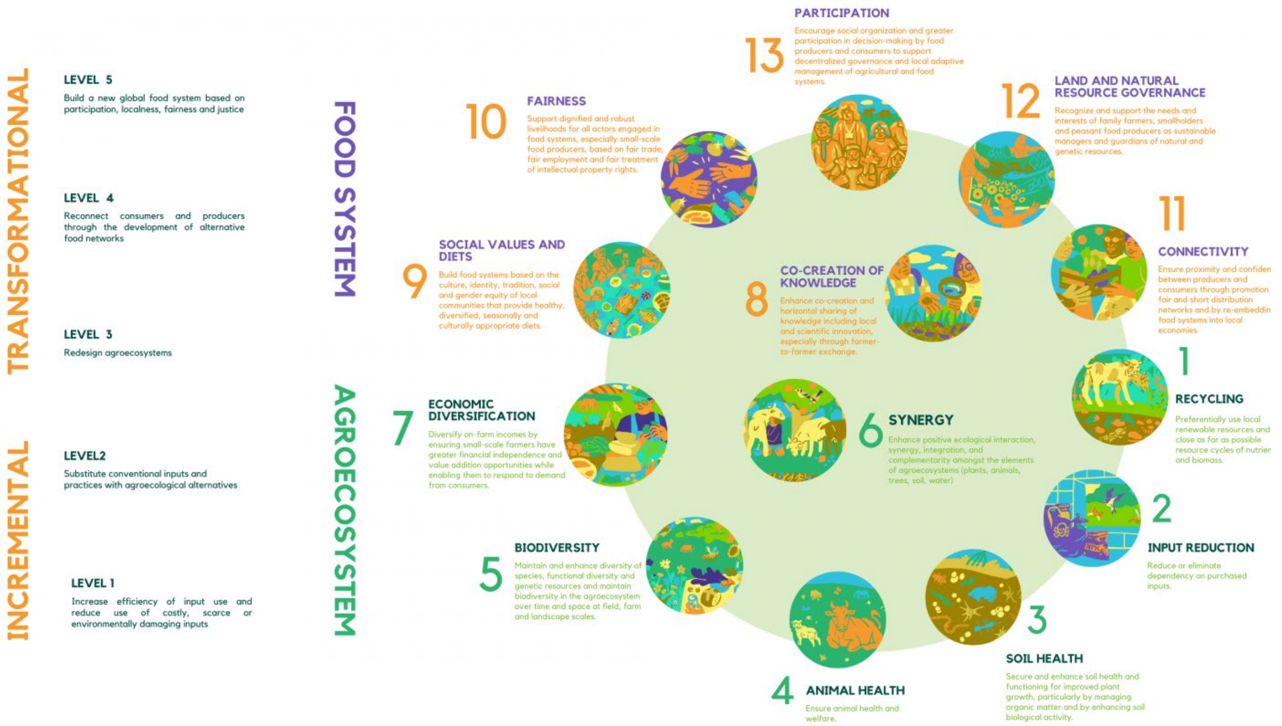

Figure 2. Agroecology transition level, element, and principal to be captured (Wezel et al., 2020)

The stepwise approach of TAPE also shows clear linkages between territorial context/attributes/enabling environments (Step 0), farm/household data collection (Steps 1 and 2), and territorial validation and discussion of evidence and linkages to enabling environment (Step 3).

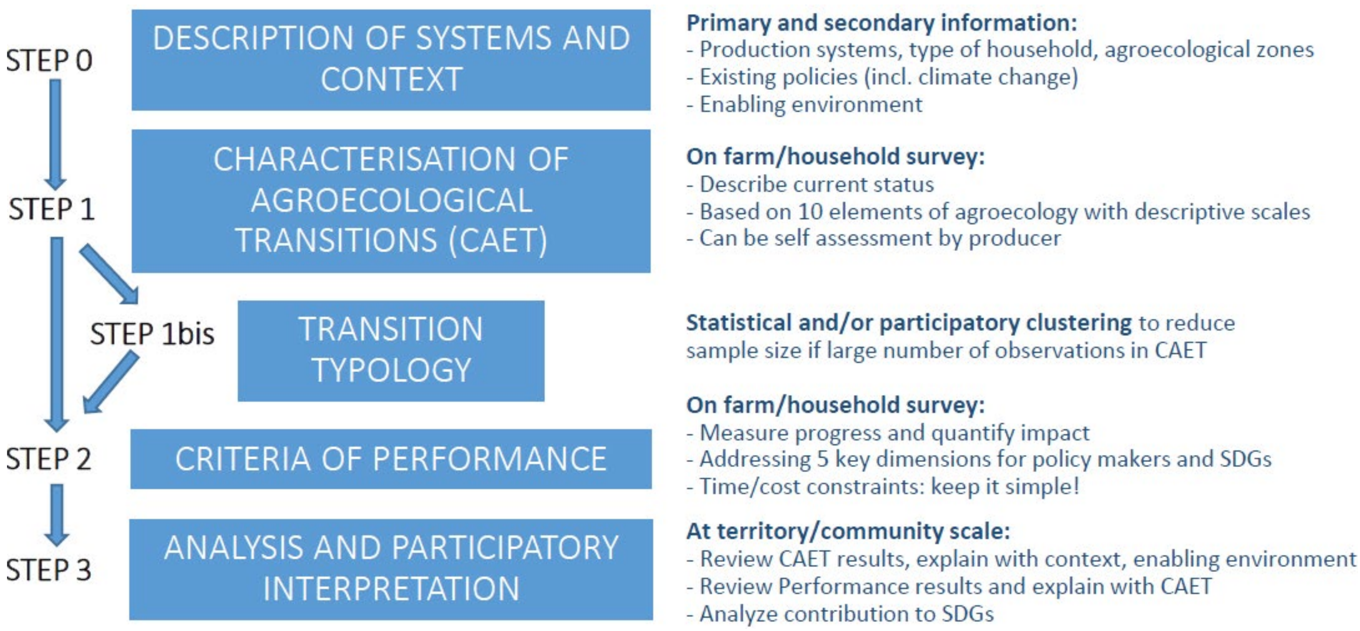

Figure 3. The stepwise approach for implementing the Tool for Agroecology Performance Evaluation (TAPE) (FAO, 2022)

General classification of productive systems and the context where they operate is a preamble to the characterization of agroecological transition and can be considered as a Step 0. This includes a description of the main socio-economic, environmental and demographic characteristics and contexts of the systems such as location, household size, productive assets, agroecological zone, landforms, forests, access to land, commodities produced and production systems in the region. Step 0 also includes a description of the enabling (or disabling) environment for agroecological transition, at higher scales than the system assessed (e.g. provincial or national) (FAO, 2019).

Step 0 of TAPE includes the description of systems and context conducted at the territorial (community, political unit, market unit, watershed, food shed, etc.) level. This step identifies and characterizes the production systems, types of households, agroecological zones, biophysical context features, socio-ecological context features, existing policies that enable or disable agroecology, and any form of enabling environment at a given point in time. Step 0 can be conducted as a desk review, but is increasingly being conducted as a participatory process in order to enhance relevance, credibility and legitimacy while documenting policy needs to elicit change. Pilot studies are now incorporating a holistic visualization during the participatory development of visual narratives using the 10 Elements of agroecology to model the territorial agrifood system as a baseline for a territorial understanding of change. However, this step has not been widely conducted in a participatory manner, a key need for future users of TAPE to incorporate. This preliminary step includes a description of the main socio-economic and demographic characteristics of the agricultural and food systems and an analysis of the enabling environment in terms of relevant policy, market, technology, socio-cultural and/or historical drivers (FAO, 2019).

The next 2 steps are conducted at the farm or household level from samples and inference spaces determined during Step 0 to collect quantifiable data on the performance of agroecology (FAO, 2019; FAO, 2022; Mottet *et al.,* 2020).

Step 1 creates a Characterization of Agroecological Transition (CAET) which is based on the 10 Elements of agroecology employing descriptive scales. For each element, 3–4 indices are utilized to characterize the particular farm/household's position along an agroecological transition scale (of 0–100, where 0 is the least agroecological level and 100 is the most advanced one) to create a sustainability baseline of that particular farm/household. For instance, for the element of Diversity, 4 indices are used based on a modified Likert-type scale that can be aggregated to characterize the farm's transition (based on a scale of 0–100) for that element. This is repeated for each of the 10 Elements, and scores can be plotted on a radar-type diagram to give an overall diagnostic of the transition to agroecology for the given farm in time and place. It is important to note that the indices, although focusing on a particular element are interlinked and interdependent, and aligned with the 10 Elements as well as with the 13 principles of agroecology. This can be seen in the previous example of Diversity, where there are plant and animal diversity assessments, but diversity is also linked to other productive activities (i.e., touching on Circular and Solidarity Economy and Resilience). This step is simple enough to be conducted by producers and their organizations but has also been successfully implemented by enumerators, extension agents, NGO workers, and project managers. The use of overall diagnostic performance via a radar diagram based on the 10 Elements serves as an important entry point for future discussions on enabling factor presence, needs, and entry points to increase sustainability (see Step 3 below) (FAO, 2019; FAO, 2022; Mottet *et al.,* 2020).

Step1 bis is optional, can be used when a large number of cases are assessed using the CAET within a relatively homogeneous territory or spatial scale and are shown to be fairly homogeneous in their variances. It may be desirable (or necessary in some cases) to draw upon a subsample of systems (or case studies) before proceeding with the performance criteria (Step 2) (FAO, 2019; FAO, 2022; Mottet *et al.,* 2020).

Step 2 is conducted to measure progress and quantify impact of agroecology through a selected list of core criteria of performance once Step 1 is completed. This step addresses 5 core dimensions that are of importance to policy makers and to the SDGs (governance, economy, health and nutrition, society and culture, and environment), which also have clear linkages to the principles and the 10 Elements of agroecology. Step 2 utilizes 10 existing criteria based on existing methodologies that create quantitative data. This step has a farm walk component, a gender disaggregated component, and is designed to easily collect data. Both Step 1 and Step 2 are carried out via a KoBo Toolbox survey. The two steps are linked together, with Step 1 providing a diagnostic or characterization of the level of agroecological transition while Step 2 quantifies the multi-dimensional performance for that particular farm or household at a particular point in time (FAO, 2019; FAO, 2022; Mottet *et al.,* 2020).

Step 3, the Analysis and Participatory Interpretation step, is conducted at the territorial level and is designed to allow the community/territory to review the Step 1 and 2 results on the impact and performance of agroecology. It explains the results based on the context and enabling/disabling environment from Step 0, explores the linkages between Step 1 and the performances of Step 2, and discusses what enabling factors need to be strengthened and disabling factors need to be removed or overcome to advance particular needs and desires (FAO, 2019; FAO, 2022; Mottet *et al.,* 2020).

Apart from its direct task of assessing the performance of agroecology, TAPE is also about helping farmers and being useful to them by providing valuable information which is able to contribute to their development.

3.2 Rational for TAPE selection

There's still a shortage of frameworks that allow for measuring agroecology on a landscape or food system scale although at the farm/household level, a considerable number of tools. The later tools allow for farm-level holistic performance assessment of different approaches to enhancing the sustainability of agriculture. Their performance assessment frameworks on both landscape and territorial food system level remain limited and rare. In addition, the key values and principles of agroecology built from a transdisciplinary science is not always well integrated into performance assessment frameworks (Geck *et al*., 2023). Furthermore, most of the tools for assessing the degree of agroecological integration used standardized indicators while agroecology emphasizing on specific context. Based on these observations, a call for continued development of landscape and food systems scale assessment approaches and research on how best to balance the need for globally comparable approaches with assessing agroecology in a locally relevant manner (Geck *et al*., 2023). However, considering the growing demand for evidence on the AE performance across its different dimensions of sustainability and its potential to contribute to the achievement of the SDGs can globally be achieved through the use of TAPE methodology (FAO, 2019). The alignment of our team for TAPE relies on the necessity coming from the fact that with this tool, there is a certain harmonization of definitions, a simplification of the procedure and hypotheses concerning the data to be collected in the living labs.

In the following paragraphs, we present the main reasons we think TAPE is a suitable tool to capture economic, environmental and social impacts of agriculture and food systems; assess the status of agroecological transition of local farms and to identify its correlation with farms' quantitative performance across the economic, social, and environmental dimensions of sustainability.

3.2.1 How TAPE was developed

AE evaluation using TAPE includes several steps (Step 0 – Step 1 – Step 2 – Step 3). It is based on 10 elements of agroecology (as defined by FAO) and encompasses a description of agricultural systems and geographical context, the characterization of agroecological transitions (CAET), and the criteria of performance with concrete measures of progress such as productivity, income, and dietary diversity. The whole process is based on self-assessment and surveys conducted at both individual farm and the community levels (Lucatoni *et al*., 2023).

TAPE has been developed with the goal of fulfilling this knowledge gap through the creation of global and harmonized evidence on the multidimensional performance of agroecological systems. During the development of TAPE, 12 assessment frameworks were reviewed by the authors (Table 3). Among them we find tools like MESMIS, GTAE, SOCLA, LUME, TEEB, ACT, SAFA, ZBNF, sustainable intensification assessment framework, sustainable rural livelihoods, participatory methodologies from Malawi and Tanzania, etc. (FAO, 2019).

Table 3. Assessment frameworks reviewed during the development of TAPE

Reference	Description
López-Ridaura et al. (2002)	MESMIS, a highly participatory and flexible framework for sustainability assessments of small farmer natural resource management systems, guides indicator selection rather than prescribing specific indicators.
Levard et al. (2019)	The *Mémento pour l'évaluation de l'agroécologie* of the French GTAE proposes a very comprehensive approach to evaluating the effects of agroecology on different sustainability dimensions.
Nicholls et al. (2004)	The agroecological method for participatory soil and crop health assessment was developed by the SOCLA.
Musumba et al. (2017a, 2017b)	The sustainable intensification assessment framework provides researchers with indicators to assess the performance of agricultural innovations in five sustainability domains (productivity, economic, environment, human condition, and social).
Petersen et al. (2020)	Lume: A method for the economic-ecological analysis of agroecosystems, a highly participatory approach for analyzing the interaction of different economic and ecological aspects relevant to agroecological transitions
La Via Campesina	An unpublished and unspecific method to assess the impacts of ZBNF in India was used by La Via Campesina.
TEEB (2018)	The TEEB for Agriculture and Food framework which is highly systemic and inspired by true cost accounting yet does not provide specific methods or indicators for assessments.
Sourisseau (2014)	The sustainable rural livelihood approach as discussed by Sourisseau (2014)
Bezner Kerr et al. (2019a, 2019b)	A qualitative approach for assessing the performance of agroecology in the context of East Africa
FAO (2014)	SAFA sustainability assessment of food and agriculture systems, a globally applicable set of 118 indicators designed to assess private enterprises (including farms) in four dimensions (environment, social, economy, and governance)
Hammond et al. (2017)	RHoMIS, a standardized household survey, which collects data on over 40 indicators across sustainability domains, focusing on production, market access, food security and nutrition, poverty alleviation and climate change mitigation.
Zahm et al. (2008)	The IDEA method for assessing farm sustainability which consists of 41 indicators across three dimensions or "scales" (agroecological, socio-territorial, and economic) and is designed for self-assessment by both farmers and policymakers

The 10 Elements of AE serve as the foundation for the normative and operational aspects of the Scaling Up Agroecology Initiative, which include various tools, knowledge pieces, projects, policy initiatives, and sharing platforms. Nowhere is this foundation of the 10 Elements clearer than in the TAPE, a tool for assessing the multidimensional performance of agroecology (Lucatoni *et al.*, 2022). TAPE relies upon the 10 Elements to characterize the level of agroecological transition of production systems in agriculture (Moet *et al.*, 2020).

3.2.2 Committee on World Food Security (CFS) endorsement

The Committee on World Food Security (CFS) is a United Nations' foremost inclusive international and intergovernmental platform for all stakeholders to work together to ensure food security and nutrition for all. Using a multi-stakeholder, inclusive approach, CFS develops and endorses policy recommendations and guidance on a wide range of food security and nutrition topics. Hence, TAPE was endorsed by the CFS to encourage the adoption of agroecology and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition, as well as by important authors and academics. This tool can be used to evaluate farming systems and projects to bring an agroecological focus to diverse activities across the dimensions of sustainability (Lucatoni *et al.*, 2023; Moet *et al.*, 2020).

3.2.3 Application fields

TAPE was designed to be applied in all regions of the world and all types of agroecosystems. It is currently being used in different geographic regions, territories, and production systems to validate its methodology and to populate the global database on the multi-dimensional impact of agroecology (Mottet et *al.*, 2020). So far, TAPE has been successfully applied on more than 5000 farms across 40 countries, with a strong focus on sub-Saharan Africa (Mottet et *al.*, 2020). Through a standardized survey filled during farm visits, TAPE has provided a characterization of the level of agro-ecological transition of local farms and an assessment of their performance across the economic, environmental, and social dimensions of sustainability (Wiget *et al.*, 2023).

In terms of agricultural practices, CANALLS project target countries are mainly composed of small producers with many in the process of transition to biological certified agriculture which makes them more receptive to deeper transformation.

For example, “Louvain Développement” has applied TAPE in South Kivu province in the DR Congo to assess the agroecological transition in this region. The tool was judged practical, clear, and relevant for many indicators, except for those requiring more explanation and contextualization.

3.2.4 Approach, data collection and presentation

TAPE uses a stepwise approach at the smallholder level and collects information that provides useful results at the larger scale. This tool is a rapid assessment across the agroecology elements using simple rating scales. It is designed to easily collect and analyse both quantitative and qualitative data.

The presentation of the results is meant to inform all interested stakeholders on the performance of agroecology and, support the transition of different types of agricultural systems towards more sustainable production. Additionally, it encourages the formulation of adequate programs and policies that enable different processes of transition taking into consideration agroecological practices and principles. Such evidence is particularly needed in the context of the project where agroecology is considered as a science, a practice and a social movement that has been less promoted in various regions (Mottet *et al.*, 2020; Lucatoni *et al.*, 2023).

3.2.5 Monitoring and evaluation of project

TAPE is being used to inform project design, monitoring and evaluation. The tool is used for monitoring to inform the current status of agroecological transitions in the target area and to identify the relationships between the level of agroecological transition of local farm types and their quantitative performance across the economic, social, and environmental dimensions of sustainability.

For instance, the Characterization of the Agroecological Transition (CAET), reveals if the level of transition towards agroecology is whether limited or high, and calculate the number of farms that can be considered as agroecological in a landscape (FAO, 2019).

Results from TAPE are also used to tailor activities to different farm types needs in order to successfully transition to agroecological systems fulfilling project objectives and addressing communities' needs.

3.2.6 Generation of governments' potential support of agroecology

So far, there is no certification label for agroecology showing gaps of knowledge that are require in formulation of regulations surrounding products from agroecological practices. Therefore, there is a need for public institutions to recognize AE, as well as foster knowledge and awareness about it. In that way, consumers will be aware of what they buy is local, fresh, seasonal, and produced in an environmentally and socially responsible way.

In this context, acknowledging and supporting TAPE would be something that the government could do, not just for the agricultural sector alone, but more importantly for its producers. TAPE, in particular during the second step, requires making very detailed economic assessment of farms' inputs, costs, productivity, and profits. It gives a clear idea of how sustainable the farm business is. TAPE also helps to observe how efficient a producer is, based on all these criteria thus raising awareness about the strengths and weaknesses of their production system. It could be like an audit tool for farms' businesses which, on one hand, monitors them and, on the other, helps to identify points to improve. On the political level, all this can be very useful as it can help guide political decisions and identify how legal frameworks could accelerate and help the transition to agroecology.

3.2.7 Co-creation

In TAPE, end-users were able to select or add indicators they considered essential for the assessment. Between 2019 and 2022, TAPE was refined through feedbacks received by several end-user groups including farmers, technical institutions, non-governmental organizations, and research institutions.

Adapting to local conditions allows a method to be tailored to the needs of end-users and to produce context-specific knowledge. This makes assessments more legitimate and useful. Producing context-specific knowledge that meets end-users' needs is key for steering and managing agroecological transitions (Darmaun *et al.,* 2023).

3.2.8 Tool flexibility

As a test version, TAPE is built to be improved continuously. For example, TAPE was recently extended to unplanned biodiversity. Its flexibility characteristic makes it possible to integrate an important ecological aspect which was not considered until now in assessing biodiversity. Researchers have developed a new biodiversity index for TAPE which takes into account planned and unplanned biodiversity. The new biodiversity index is based on the European BioBio method, in the development of which Agroscope participated. By comparing current version of TAPE to the initial one, this tool is capturing not only the number of varieties or trees planted, but also unplanned biodiversity such as wild bees or orchids which were successfully assessed by TAPE. Unplanned biodiversity was not noted directly in the field, but was assessed indirectly through the impact different agricultural measures may have had (Gilgen *et al.,* 2023).

3.3. TAPE selected indicators

A systematic review of agricultural sustainability indicators selected in TAPE is listed below (Table 4).

Table 4. Systematic Review of Agricultural Sustainability Indicators used in TAPE

TAPE's steps	Indicators		Methodology	observation
Step0: Contextualization of the target territory	Desk review or participatory approaches to assess		Descriptive (Mottet *et al.*, 2020)	WP1 has already collected interesting data but still need to be completed (Task 2.1, Task 3.2)
Step1: Characterization of the agroecological Transition	Diversity	Crops	CAET score 0–100 (FAO, 2019 ; Mottet *et al.*, 2020) • Score > 70: advanced in the agroecological transition	Data to be collected at farm/household level
		Animal		
		Trees		
		Activities generating incomes		
	Synergies	Crop-livestock-aquaculture integration		
		Soil-plants management system		
		Integration with trees		
		Connectivity between elements of the agroecosystem and the land scape		
	Efficiency	Use of external inputs		
		Management of fertility		
		Management of pests and diseases		
		Productivity and household' needs		

TAPE's steps	Indicators		Methodology	observation
	Recycling	Recycling of biomass and nutrients	• Score 60–70: in transition to agroecology • Score 50–60: incipient agroecological transition • Score < 50 : non agroecological (Lucantoni *et al.*, 2021)	
		Water saving		
		Management of seeds and breeds		
		Renewable energy use and production		
	Resilience	Stability of income/ production and capacity to recover from perturbations		
		Existence of social mechanisms to reduce vulnerability		
		Environmental resilience and capacity		
		Average diversity		
	Culture and food traditions	Appropriate diet and nutrition awareness		
		Local or traditional identity and awareness		
		Use of local varieties/breeds and traditional (peasant & indigenous) knowledge for food preparation		
	Co-creation and sharing of knowledge	Social mechanisms for the horizontal creation and transfer of knowledge		
		Access to agoecological knowledge and interest of producers in agroecology		
		Participation of producers in network and grassroots organisations		

TAPE's steps	Indicators		Methodology	observation
	Humans and societal values	Women's empowerment		
		Youth empowerment and emigration		
		Animal welfare		
	Circular & Solidarity Economy	Networks of empowered producers, presence of intermediaries and relationship with consumers		
		Local food system		
	Responsible governance	Producers' empowerment		
		Producers' organizations and associations		
		Participation of producers in governance of land and natural resources		
Step2: Indicators of performance	Economic dimension	Gross value of the agropastoral production per hectare	Sum of the value of the agropastoral products produced within the agroecosystem	
		Gross value of the agropastoral production per person		
		Value added of the agropastoral production per hectare	Gross value of the agropastoral production - Inputs - Intermediate consumption - Depreciation (Levard *et al.*, 2019)	
		Value added of the agropastoral production per person		

TAPE's steps	Indicators		Methodology	observation
		Expenditures for farming inputs per Hectare	Sum of the expenditures for the purchase of seeds, fertilizers, and pesticides	
		Net revenue from agropastoral activities per person	Gross revenue of the agropastoral activities - Cost of all inputs (Levard *et al.*, 2019)	
		Value added on gross value of the agropastoral production (VA/GVP)	Ratio (1/1) of the GVP on VA. A proxy indicator of efficiency and resilience (Van der Ploeg *et al.*, 2019)	
		Perception of the evolution of the income	• Score > 50: Revenue is on an increasing trend; • Score 50: Revenue is the same as 3 years ago; • Score < 50: Revenue is on a decreasing trend.	
		Integrated management of pests' index	• Score 100: high implementation of	

TAPE's steps	Indicators		Methodology	observation
	Environmental dimension		practices for management of pests and low use of pesticides • Score 0: low implementation of practices for management of pests and high use of pesticides	
		Expenditure for chemical pesticides per hectare	Sum of the expenditures for chemical pesticides per hectare	
		Soil health index	• Score 5: very healthy soil; • Score 1: lowest levels of soil health (Mottet *et al.*, 2020).	To be completed after analysis of soil samples to be collected in the ALLs in WP4
		Expenditure for chemical fertilizers per hectare	Sum of the expenditures for chemical fertilizers per hectare	
		Crops diversity index		

TAPE's steps	Indicators		Methodology	observation
		Animal diversity index	Gini-Simpson index for diversity (Mottet *et al.*, 2020)	
		Presence of natural vegetation and pollinators on farm	• Score 100: high presence of natural vegetation and pollinators; • Score 0: low presence of natural vegetation and pollinators (Mottet *et al.*, 2020)	
		Dietary diversity index	• Score 100: high consumption of different food groups; • Score 0: low consumption of food groups.	
	Social dimension	Expenditures for food for self-consumption per person	Sum of the expenditures for food for self-consumption per family members living in the household	
		Youth opportunities index	• Score 100: high opportunities for	

TAPE's steps	Indicators		Methodology	observation
			working and training for youth; • Score 0: low opportunities for youth; (Mottet *et al.*, 2020).	
		Youth emigration index	• Score 100: youth want to be farmer and are not willing to emigrate; • Score 0: youth are willing to emigrate and see no future in agriculture; (Mottet *et al.*, 2020).	
		%of youth in the household employed on farm	Composition of the household	
		% of women employed on farm		
		% of family employed on farm		
Step3: Restitution of the results	Participatory analysis, validation and interpretation of the results		Meetings, workshops, reports, and/or peer-reviewed articles	

3.4 Framework for indicator selection

In this section we present first how to measure all the criteria of CAET (step 1) and agroecology performance (step 2).

3.4.1 TAPE indicators

The framework described by FAO (2019) is used for the selection of indicators (Annex 2. Questionnaires). However, due to the context in the different agroecological living labs in the CANALLS project (Burundi, Cameroon, DR Congo and Rwanda), some of these indicators or new indicators may be removed or added respectively after the application of the TAPE in the project areas for its improvement.

Step 0, is a desk review. This review may not be necessary since the enumerators are already collect by WP1. However, if we come across gaps when conducting the study interviews rapidly made by each living lab can be conducted during co-creation process WP2, task1 and WP3 networking of agroecology living labs.

Step 1 provides information about the agroecological transitions of the farms. Each of the 10 elements of agroecology is assessed by several multiple-choice questions, with the answers resulting in value scores between 0 and 4 (Table 5).

Table 5. Framework as designed in TAPE (step 1-CAET)

ELEMENT	INDEX	CODES				
		0	1	2	3	4
Diversity	Crops	Monoculture (or no crops cultivated)	One crop covering more than 80% of cultivated area	Two or three crops	More than 3 crops adapted to local and changing climatic conditions	More than 3 crops and varieties adapted to local conditions. Spatially diversified farm by multi-, poly- or inter-cropping
	Animals (including fish and insect	No animals raised	One species only	Several species, with few animals	Several species with significant number of animals	High number of species with different breeds well adapted to local and changing climatic conditions
	Trees (and other perennials)	No trees (nor other perennials)	Few trees (and/or other perennials) of one species only	Some trees (and/or other perennials) of more than one species	Significant number of trees (and/or other perennials) of different species	High number of trees (and/or other perennials) of different species integrated within the farm land
	Diversity of activities, products and services	One productive activity only (e.g. selling only one crop)	Two or three productive activities (e.g. selling 2 crops, or one crop and one type of animals)	More than 3 productive activities	More than 3 productive activities and one service (e.g. processing products on the farm, ecotourism, transport of agricultural goods, training etc.)	More than 3 productive activities, and several services
SYNERGIES	Crop-livestock aquaculture integration					
	Soil- plant system management					

ELEMENT	INDEX	CODES				
	Integration with tress (agroforestry-sylvo-pastoralism)					
	Connectivity between elements of the agroecosystem /landscape					
Etc.						

Step 2 of TAPE considers significantly more data for the sustainability assessment (Table 6). These data include information on the harvested production, including the quantities sold, donated or self-consumed, and information on all pesticides used. With these data, several indicators are calculated that cover the five sustainability dimensions governance, economy, health and nutrition, society and culture, and environment. Indicators are binary (yes, no) to allow the drawing of the spider graph.

Table 6. Structure of TAPE Step 2, main sustainability dimensions and core criteria of performance

Main dimension	Core criteria of performance
Governance	Secure land tenure
Economy	Productivity Income Value added
Health and nutrition	Exposure to pesticides Dietary diversity
Society and culture	Women's empowerment Youth employment opportunity
Environment	Agrobiodiversity Soil health

The questionnaire to be used, the calculations, and the indicators/indices of TAPE are described by Mottet *et al*. (2020) and its supplementary materials.

Step 3 is a participatory analysis of the results, where the multidimensional performances (Step 2) are reviewed in the light of the level of transition to agroecology (Step 1) and the context and enabling environment (Step 0).

Geck *et al*. (2023) propose Key requirements for assessing agroecological transitions 1) be adaptable to local conditions, 2) consider social interactions among stakeholders involved in the transitions, 3) clarify the concept of agroecology, 4) consider the temporal dynamics of the transitions to better understand barriers and levers in their development and 5) use a participatory bottom-up approach.

At this stage, any further methodology of assessment or indicator can be added to complement TAPE and provide deeper analyses on specific topics.

3.4.2 Additional indicators for more TAPE flexibility (see details in annex2)

Despite the large promise of TAPE, there are number of limitations in its current form that have been identified through the piloting process (Mottet *et al.,* 2020). Investigations about the use of TAPE tool worldwide in assessing agroecology in agricultural and food systems are being made through a series of workshops and practice, including field workshops with farmers. Desk review shows that the key lesson learnt is that TAPE is a very powerful tool considering the stepwise approach, the rapid assessment across all 10 agroecology elements, and the use of simple rating scales (Namirembe *et al*., 2022). However, TAPE cannot be used in all the contexts as a readymade tool for diverse main reasons:

(i) First, the reasons for carrying out an agroecological assessment are multiple and the tool needs tuning to those objectives (Namirembe *et al*., 2022). Given the context-specific nature of agricultural and food systems and the varying needs of actors, there will ever be a perfect tool or framework for assessing agroecology that can meet every objective in all possible contexts. As most of the other tools developed to assess the degree of agroecological integration, TAPE also uses standardized indicators, despite agroecology emphasizes context-specificity. For example, conventional productivity indicators, like yields, labour demand, cost/benefit ratio, or total income are used in TAPE, indicating the efficiency and profitability of the assessed system. However, these indicators are not able to capture the multidimensional productivity of multi-crop systems that are very common in agroecology and subsistence farming in Africa (Wiget *et al.,* 2020 Geck *et al*., 2023). This implies that there will be a GAP in picturing environmental, economic and social values using only this tool. Considering this aspect, some indicators could easily be complemented with multifunctional ones that are more adapted without changing the structure of the TAPE tool.

(ii) Second, the ethical value of co-design means that those engaged need to be served by the assessment and be involved in negotiating its design (Namirembe *et al.,* 2022). Many empirical studies have already recognized the critical role of intrinsic farmer-related factors in the transition from conventional agriculture to sustainable agriculture. Further research is still needed to define an appropriate level of farmers' involvement that would maximize the quality and applicability of the assessment tool (Liao *et al.*, 2022). Hence, it's important that CANALLS project uses the knowledge, attitude, and practice (KAP) model to examine farmers' knowledge, attitudes, and practices in the area of sustainable agriculture. The factors affecting farmers' knowledge, attitudes, and practices must also be considered (Liao *et al*., 2022).

(iii) Third, localization is necessary (Namirembe *et al*., 2022). However, the selection of indicators and attributes is part of a participatory decision but not always explicitly explained in the framework (Geck *et al.,* 2023). The same precise set of concepts, terminology, indicators, and scales in TAPE are not relevant in all contexts, and this localization can be done using the co-design process (Namirembe *et al.,* 2022). For example, the 10 Core Performance Criteria of step 2 are not intended to be exhaustive in assessing sustainability, even if it is able to generate harmonized data between countries on the multi-dimensional performance of agroecology, which is expected to positively impact all 5 key dimensions of sustainability (Wiget *et al.,* 2020; Geck *et al*., 2023).

The more a TAPE is adaptable to local conditions, the more the tool is specific to the context of the assessment and the less it is possible to compare results with other contexts (Darmaun *et al*., 2023). Hence, another tool may be needed to strike the balance between global comparability and local contextual relevance. Based on these observations, we call for a development of landscape and food systems scale assessment approaches and research on how best to balance the need for globally comparable approaches with assessing agroecology in a locally relevant manner.

The new indicators will include all questions related to the Knowledge, Practices, and Attitudes within the communities. Some other questions related to land tenure, gender, etc. can be difficult to handle in particular situation. Although the socio-economic contexts of many countries differ, a method should always be adapted to a location, including within the same country sometimes. In a country like DR Congo, average income of people remains so unformal that indirect methods should always be designed for its estimation, while in other countries like in Rwanda this is easy to establish. Thus, open responses interviews should be added to establish calculation based on a consensual approach with respondents. As a consequence, a complementary tool has to be designed with all stakeholder called Knowledge – Attitudes – Practices (KAP) which will bring to TAPE flexibility in the description of unclear situation in communities.

In the spirit of the agroecology principle of co-creation of knowledge, we will invite all interested stakeholders to co-design KAP frameworks for performance assessment that best meet their needs and are well aligned with their values and priorities.

KAP is considered as a supplementary framework to TAPE for capturing in a participatory manner the local knowledge using open discussions and direct observations. The general approach is direct dialogue using guided discussions. The discussions should put the respondent at the centre of a vision of full development and considering him as a full-fledged partner in the analysis of the AE. Hence, the added value to TAPE consists in considering the common vision and collaboration in understanding of the concepts to guarantee reciprocity and respect for differences. This would ensure the formulation of orientations aimed at the transformation of unsustainable systems and structures.

4. Application of TAPE in the CANALLS project context

4.1 Methodology to implement TAPE in the ALLs

TAPE methodology, guidelines, and protocols are described comprehensively in FAO (2019) and in Mottet *et al.* (2020). The use of TAPE is considered an efficient method for evaluating farming systems and projects to bring an agroecological focus to diverse activities across the dimensions of sustainability. The steps for applying the tool are described below.

4.1.1 STEP 0

1) Objective

Stage 0 is a preliminary stage of collecting information at the living lab, district/provincial and national levels.

2) Approach

This step is a desk review (documentary review) of the administrative unit in which TAPE will be applied. Demographic characteristics of the farms, ecological, social and productive environments, and the structure of the local market are described. WP1 and WP4 have already gathered important information which will be capitalized in the description of this step.
The analysis of the favorable or unfavorable environment will include a list of public policies at local and national levels and the existence of actors that can support or hinder the agroecological transition. This analysis will also include elements of the local economy and power relations between actors that can influence opportunities for local producers. This step can include consultation with key stakeholders, in the form of a participatory workshop if GAPs are recorded. Consultation will be conducted as shown in Table 7.

Table 7. Examples of stakeholder groups that could be involved in the interview

Stakeholders' groups	Sampling (n) and specifications		Roles of the stakeholders (e.g.)
• **Farmer organizations** /cooperatives/associations	8-10	Men and women farmers (including youth), lead farmers, chairpersons, farmer promoters	• Co-testing of selected combined agroecology farming practices at ALL site.
• **Government ministries** (e.g. Ministry of Agriculture, water, or other agencies)	4-5	Experts (e.g., agriculture, water, food sectors), extension workers, policy makers/planners	• Co-creation of enabling environment for optimal functioning of ALLs
• **Research institutions** and/or innovation platforms	4-5	Researchers, scientists, innovators, consultants	• Co-design of combined agroecology farming practices/strategies
• **Academic institutions** (universities, colleges, schools)	4-5	Teachers, rectors, students,	• Co-creation of curriculum on agroecology and teaching
• **Non-government organizations** (local, international)	4-5	Development agencies (UN, regional organizations, forums)	• Co-dissemination of good agroecology farming practices
• **Value chain actors**:	4-5	Input suppliers (e.g., seeds, farm machinery)	• Co-creation of value-added market for AE products • Support to increased demand for agroecology products
	8-10	Processors, manufacturers, retailers, wholesalers, consumers	
• **Civil society**	4-5	Media (journalists, activists) or others (religious, village leaders)	• Awareness creation/raising of the society on agroecology
Total	**40-50**	**-**	-

4.1.2 STEP 1

1) Objective

This step consists of characterizing the degree of agroecological transition of agricultural production systems based on the 10 elements of agroecology (AE).

2) Approach

The characterization of agroecology transition (CAET) will be completed through the collection of information by researchers or through a self-assessment of producers.

Each AE element is described by 3 or 4 indexes, with a total number of 36 indexes in the CAET listed in TAPE. All CAET indexes contain descriptions on the agroecological practices to be considered in the assessment, including the 13 principles described by the HLPE (2019). For example, "Soil Fertility Management" index in the "Efficiency" element, it will be necessary to analyze whether producers use chemical fertilizers, at which frequency and on which crops, or they apply organic fertilizers (e.g.

compost, green manure) or agricultural practices such as crop rotation or zero tillage. The CAET indexes also provide information on the different dimensions of sustainability, including environmental (e.g. elements of synergies, efficiency, recycling).

*site description

CANALLS project is implemented in 8 ALLs in Burundi (#2), Cameroon (#1), DRC (#4) and Rwanda (#1), working alongside and enabling over 20,000 farmers and value chain actors to co-create and benefit from optimal combinations of Agroecological practices focusing on crops that are vital for subsistence and economic development (cocoa, coffee, cassava, rice, maize) (source: WP1 report).

Burundi has two living laboratories, one in Bujumbura and the other in Giheta. Agriculture and livestock farming are the main activities with the majority being small and medium-scale farming. In Bujumbura, 75% of households are directly involved in maize production, as the main focal crop while in Giheta living lab, farmers are mainly involved in coffee production.

The Ntui living lab in the Center Region of Cameroon has an estimated population of 20,000, with 46.49% being women. Most respondents (76.7%) were cocoa farmers, while food crops such as maize, cassava and yams represented 3.3%, 16.7% and 3.3%, of the respondents respectively.

In Uvira living lab in DR Congo, population estimation is 1,377,782 with around 54.5% of households focus on paddy rice production while 36.3% produce cassava. The population of Bunia is estimated at 812,090 inhabitants with agriculture being the main source of income for households within the living lab particularly for food crops, cocoa, and cocoa-based agroforestry. Kabare living labs covers an area of around 196,000 ha with about 460,000 inhabitants while in Biega ALL which was traditionally a forest landscape has drastically lost 387 ha of natural forests with their biological diversity and ecosystem services provision. Within the Biega and Kabare ALLs, coffee is among the main crops (40 % of households).

With 66,622 households in Kamonyi district, Rwanda most respondents reported using traditional and local knowledge. About, 92% of farmers in Kamonyi expressed a need for knowledge about Agroecological practices, capacity building on agroforestry practices, integrated use of chemical inputs and animal husbandry to optimise the benefits of agroecology.

*Sampling strategy

The sampling strategy for the TAPE assessment will be based on rural population data. The final sample size n (equation1) will be split into subsample-size per country. Subsamples will be calculated for each country and be proportional to the importance of farmers and mandate crop as described in WP1 report.

$$\boldsymbol{n} = \left(\frac{\boldsymbol{z^2 * p(1-p)}}{\boldsymbol{e^2}}\right) / \left\{\boldsymbol{1} + \left(\frac{\boldsymbol{z^2 * p(1-p)}}{\boldsymbol{e^2 * N}}\right)\right\},$$

Eq1. Calculation of sample size

- ***n*** *= sample size*
- ***p*** *= estimated proportion of population*
- **N = population size**
- **e = Margin of error (percentage in decimal form)**
- **z = z-score**

Thus, we propose that we use a two-stage sampling scheme to collect data from farms and households across the living labs. At the living lab level, the first stage of sampling will consist of choosing villages with identifiable geographical boundaries. The second level of sampling will consist of identifying farms within the selected villages. The sampling frame/lists for the household survey will come from the updated list of target groups of farmers produced by the existing project.

4.1.3 STEP1-bis

If a large number of cases are assessed in the same living lab, farms can be grouped along an agroecological transition gradient based on their overall score on the 10 elements. In this optional step 1-bis, several CAET results can be grouped into territorial or production typologies before moving to the performance criteria of step 2.

4.1.4 STEP 2

1) Objective

Step 2 is based on 10 core criteria of performance that aim to measure the performances of agricultural productive systems across various dimensions of sustainability (economic, environmental, social, but also, health, nutrition, and governance) linked to the achievement of multiple SDGs.

2) Approach

Data collection for step 2 should be done after step 1 (CAET). Certain parts of the survey are conducted through interviews with women in the household (women's empowerment) and certain data are collected disaggregated by sex (land tenure, dietary diversity, youth employment). Another part of the survey is conducted in the form of a transect walk over the farm and its surroundings (agrobiodiversity), which can also help inform the basic criteria and veracity of the data collected (e.g. exposure pesticides, land tenure, soil health).

4.1.5 STEP 3

1) Objective

The diagnosis based on the 10 elements of agroecology (step 1) and the analysis of the results of the basic criteria (step 2) are used to reveal the strengths and weaknesses of the systems evaluated and to explain their performance in the context of the environment of step 0.

2) Approach

Step 3 will be carried out in a participatory manner with the community in the territory identified in step 0 and in which the farm surveys were carried out in order to (1) verify the adequacy and performance of the analytical framework; (2) interpret the analysis to make it relevant to the context; and (3) design possible pathways to improve the enabling environment and support the agroecological transition, possibly using the tool to monitor progress. This step may also include the following points to contextualize the interpretation of the results:

• Review of the CAET results (step 1) and a proposal for weighting the various indexes or criteria within each element to emphasize critical aspects of the analysis to ensure contextualized relevance;

• Review of the results of the performance criteria (step 2) and a review of the thresholds applied to each of them;
• Review of the aggregation of results at the production unit level for analysis at the territorial level as well as the chosen sampling method.

4.1.6. Data collection and analysis

After identification of farmers and/or stakeholders in each of the 8 ALLs (WP3 report), data will be collected using the questionnaires described in annex 2 (https://www.fao.org/3/ca7407en/ca7407en.pdf). The following step will consist in transferring collected dataset to the FAO through the online tool KOBO (https://www.kobotoolbox.org/) for further manipulation and analysis.

4.2 Results of TAPE application in the ALLs

This section will be developed after completion of the co-creation process (Task2.1) and identification of stakeholders to be engaged within the 8 ALLs in Burundi, Cameroon, DR Congo and Rwanda (WP3).

5. Conclusions

Agroecology and systems analysis have always been associated as the core of agroecosystem, is the search for synergies through the interactions of different components to support sustainable, resilient and equitable agricultural systems. Several agroecosystem analysis methods and tools have been developed. TAPE is a tool that assesses the degree of agreement of agroecosystems to the agroecology principles and their performances. This tool aims to produce and consolidate evidence on the multidimensional performances of agroecological systems (i.e. agroecosystem informed by agroecological thinking and knowledge) and was elaborated to be globally applicable and relevant at the territorial level, thanks to collection of data at the farm/household unit.

CANALLS project intention to develop a holistic agroecology assessment framework to diagnose the production systems, provide evidence on the multidimensional performance of the agroecological practices and the impacts of the respective transition pathways that will be tested across the 8 ALLs within the implementation counties of the project can effectively use TAPE.

Not only TAPE tool will save us from not to duplicate efforts (in term of time and costs), its application in the CANALLS project will also help to the improvement of the FAO version which is still a test version. The same will be true for any other "readymade" assessment tool that involves processes, indicators, and tools that have been defined without reference to the specific context and objectives. There are important ideas to be gleaned from TAPE because authors who underlined the strengths and weaknesses of the tool have also provided suggestions for its improvement. However, TAPE is not a readymade approach or set of tools to use in every situation. The more TAPE is adaptable to local conditions, the more the tool is specific to the context of the assessment and the less it is possible to compare results with other contexts. Because of that, a complementary tool called KAP (Knowledge – Attitudes – Practices) can easily be designed for CANALLS project and be applied together with TAPE. The KAP approach will bring to TAPE flexibility to describe unclear situation in communities.

References

Anthonioz A. (2021). The suitability of the “Tool for agroecological performance evaluation (TAPE)” in a European context. MSc. Norwegian University of Life Sciences & ISARA

Bao H. et al. ((n.d.). Critical assessment of a whole-farm model using the affordance approach. MSC Thesis, Wageningen - The Netherlands (https://edepot.wur.nl/477483).

Barrios, E., Gemmill-Herren, B., Bicksler, A., Siliprandi, E., Brathwaite, R., Moller, S., Batello, C., & Tittonell, P. (2020). The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives. Ecosystems and People, 16(1), 230-247. (https://doi.org/10.1080/26395916.2020.1808705)

Bathaei A. and Štreimikien D. (2023). A Systematic Review of Agricultural Sustainability Indicators, Agriculture 2023,13, 241

Bicksler, AJ, Mottet A, Lucantoni D, Mouhamed Rassoul Sy, Edmundo Barrios (2023). The 10 Elements of Agroecology interconnected: Making them operational in FAO’s work on agroecology, Elem Sci Anth, 11: 1. DOI: https://doi.org/10.1525/elementa.2022.00041.

Biovision (n.d.a). Agroecology criteria tool: user guide. Biovision Foundation for Ecological Development & International Panel of Experts on Sustainable Food Systems. (available at https://www.agroecology-pool.org/wp-content/uploads/2021/08/ ACT_User_Guide.pdf)

Biovision (n.d.b) Agroecology criteria tool. Available at: https://www.agroecology-pool.org/methodology (accessed 16 December 2023).

Caro Dario, Fabio Sporchia, Marta Antonelli, and Alessandro Galli (2023). "Beyond the IPCC for Food: An Overarching Framework for Food Systems Sustainability Assessment" *Sustainability* 15, no. 19: 14107. https://doi.org/10.3390/su151914107

Darmaun M., Chevallier T., Hossard L., Lairez J., Copel E., Chotte JL, Lambert-Derkimba and Tourdonnet S., (2023). Multidimensional and multiscale assessment of agroecological transitions. A review. International Journal of Agricultural Sustainability Volume 21, 2023 - Issue 1 (https://doi.org/10.1080/14735903.2023.2193028)

Dixon, J., Gulliver. A. and Gibbon, D. (2001). Farming Systems and Poverty: Improving Farmers’ Livelihoods in a Changing World. Experimental Agriculture, 39, 109-110.

Eigenraam M., Jekums A., Mcleod R., Obst C., and Sharma K. (2020). Applying the TEEBAgriFood Evaluation Framework: Overarching Implementation Guidance. n.p.: Global Alliance for the Future of Food, 2020.

FAO (2018). The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems. Rome: FAO

FAO (2019). TAPE Tool for Agroecology Performance Evaluation 2019 – Process of development and guidelines for application. Test version, Rome

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 of the Committee on World Food Security, Rome.

Feng D. and Zhao G., (2020). Footprint assessments on organic farming to improve ecological safety in the water source areas of the South-to-North Water Diversion project. Journal of Cleaner Production, Volume254, 120130. https://doi.org/10.1016/j.jclepro.2020.120130

Global Footprint Network, GFN (2020). Ecological Footprint Accounting: Limitations and Criticism. Report, Global Footprint Network, 46page (https://www.footprintnetwork.org/content/uploads/2020/08/Footprint-Limitations-and-Criticism.pdf).

Gilgen A., Felder R., Baumgartner S., Herzog F., Jeanneret P., Séchaud R., Paunovic S., and Merbold L. (2023). How to Assess the Agroecological Status of Swiss Farming Systems? Application of the

Tool for Agroecology Performance Evaluation (TAPE) and Further Development. Agroscope Science | No. 172 / 2023 (evaluable at www.agroscope.ch/science: https://doi.org/10.34776/as172e)

IFAD (International Fund for Agricultural Development) (2021). Stock-take report on agroecology in IFAD operations: An integrated approach to sustainable food systems. Production, Markets and Institutions (PMI) Division (Rome: IFAD, September 2021) ((available at: https://www.ifad.org/en/).

Levard Laurent (coord.) (2023). *Guide pour l'évaluation de l'agroécologie. Méthode pour apprécier ses effets et les conditions de son développement*, Éditions du Gret/Éditions Quæ, 320 p.

Liao X., Lai Nguyen TP., sasaki N. (2022). Use of the knowledge, attitude, and practice (KAP) model to examine sustainable agriculture in Thailand. Regional Sustainability :Volume 3, Issue 1, March 2022, Pages 41-52 (https://doi.org/10.1016/j.regsus.2022.03.005).

Lopez-Ridaura S, Masera O, Astier M, (2002). Evaluating the sustainability of complex socio-environmental systems. the MESMIS framework, Ecological Indicators Volume 2, Issues 1–2, November 2002, Pages 135-148.

Lopez-Ridaura S. (2022). Agroecology and Systems Analysis for Sustainable Agriculture, Journal of Rural Problems, Volume 58 (2022) Issue 1 Pages 31-35 (https://doi.org/10.7310/arfe.58.31).

Lucatoni D, Sy MR, Goita M., Veyret-Picot M., Vicovaro M.,Brickler A., Mottet A. (2023). Evidence on the multidimensional performance of agroecology in Mali using TAPE. Agricultural Systems, Volume 204, , 103499 https://doi.org/10.1016/j.agsy.2022.103499)

Lucantoni, D., Thulo, M., Makhoebe, L.M., Mottet, A., Bicksler, A., Sy., M.R. (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

Lucantoni D., Mottet A., Bicksler A., De Rosa F., Scherf B., Scopel E., López-Ridaura S., Gemmil-Herren B., Bezner Kerr B., Sourisseau J.-M., Petersen P., Chotte J.-L., Loconto A. & Tittonell P. (2021) Évaluation des transitions vers des systèmes agricoles et alimentaires durables : un outil pour l'évaluation des performances agroécologiques (TAPE). *Agronomie et Politique Agricole Commune*, Revue AE&S 11-1

Mottet A., Bicksler A., Lucantoni D., De Rosa F., Scherf B., Scopel E., López-Ridaura S., Gemmil-Herren B., Bezner Kerr R., Sourisseau J.-M., Petersen P., Chotte J.-L., Loconto A. & Tittonell P. (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

Namirembe S., Mhango W., Njoroge R., Tchuwa F., Wellard K., and Coe R. (2022). Grounding a global tool -Principles and practice for agroecological assessments inspired by TAPE. *Elementa: Science of the Anthropocene* (2022) 10 (1): 0002 (https://doi.org/10.1525/elementa.2022.00022).

Nicholls C., Altieri M., Dezanet A. and, Feistauer D. (2004). A rapid, farmer-friendly agroecological method to estimate soil quality and crop health in vineyard systems. *Biodynamics* 2004: 33–40.

Petersen P, Marçal da Silveira L, Bianconi Fernandes G and, Gomez de Ameida S. (2020). *Lume: A Method for the Economic-Ecological Analysis of Agroecosystems*. Coventry: Centre for Agroecology, Water and Resilience (CAWR), Coventry University. Available at: https://aspta.org.br/files/2015/05/Lume-a-method-for-the-economic-ecological-analysis-of-agroecosystems.pdf

The Economics of Ecosystems and Biodiversity (TEEB) (2018). Measuring what matters in agriculture and food systems: a synthesis of the results and recommendations of TEEB for Agriculture and Food's Scientific and Economic Foundations report. Geneva : UN Environment.

Trabelsi M., Mandart E., Le Grusse P., and Bord J-P. (2019) ESSIMAGE: a tool for the assessment of the agroecological performance of agricultural production systems. Environmental Science and Pollution Research: (2019) 26:9257–9280 (https://doi.org/10.1007/s11356-019-04387-9)

Van Cauwenbergh N., Biala K., Bielders C., Brouckaert V., Franchois L., Garcia Cidad V., Hermy M., Mathijs E., Muys B., Reijnders J., Sauvenier X., Valckx J., Vanclooster M., Van der Veken B., Wauters E., Peeters A. (2007). SAFE—A hierarchical framework for assessing the sustainability of agricultural systems. Agriculture, Ecosystems and Environment 120 (2007) 229–242

Wackernagel Mathis, Kitzes Justin, Moran Dan, Goldfinger Steven and Thomas Mary (2006). The Ecological Footprint of cities and regions: comparing resource availability with resource demand. Environment & Urbanization, Vol 18(1): 103–112. doi: 10.1177/0956247806063978

Wezel A., Gemmil-Herren B., Kerr RB., Barrios E., Rodrigues Gonçalves AL., Sinclair F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems: A review. *Agronomy for Sustainable Development* 40(40). DOI: http://dx.doi.org/10.1007/s13593-020-00646-z.

Wiget, M., A. Muller, and A. Hilbeck. (2020). Main challenges and key features of indicator-based agroecological assessment frameworks in the context of international cooperation. *Ecology and Society* 25(3):25. https://doi.org/10.5751/ES-11774-250325

Annexes

Annex 1. Link to TAPE

(https://www.fao.org/3/ca7407en/ca7407en.pdf)

Annex 2. KAP model: GUIDE OF DISCUSSION

1. Step 0: System description and context
    a. Sociodemographic assessment
        i. Respondent identity
            1. Sex: M or F
            2. Education level: None, Primary school, Secondary school, or Superior level
            3. Main sector of activity: Agriculture, Livestock, Agriculture + Livestock, Salary, Other
    b. Natural resources cartography
        i. The soil, based to physical characterization:
            1. Soil color and consideration

Color	Excellent	Good	Worse	Local name
Black				
White				
Brown				
Red				
Ocher				

            2. Soil relief and consideration

Relief	Excellent	Good	Worse	Local name	Accessibility
Plaine					
Plateau					
Slope					
Valley					
Swanp					

        ii. Potable water
            1. Localization in distance from the house
            2. Number per household
            3. Availability along the year
        iii. Market
            1. Accessibility and distance
            2. Diversity and regional integration
        iv. Formal and unformal schools and practice centers
            1. Number
            2. Availability and diversity
2. Revenue evaluation – indirect methods of its evaluation in the community
    a. Main expenses at fixed cost in the household and their values.
    b. Main investment costs and their values
    c. Daily common expenses in the household
    d. What are the symbols assets of acceptable worth for a household. What are the minimum assets a normal household (not rich and not poor) should handle as criterion:
        i. Land size
        ii. Cattle number
        iii. Ship and goats number

    iv. Banana filed size
    v. Coffee or Cacao trees number
    vi. Highest level of children education accepted
    vii. Transport mean (bike, moto)
    viii. Communication mean (GSM, smartphone)
    ix. Presence or not of an income generating activity in addition to the main activity
    x. House type and or size
    xi. Other considerations:
3. Analysis of local knowledge on :
    a. External input in agriculture
        i. Pesticides
        ii. Manure
        iii. Seeds
    b. Quick soil analysis (indicators of fertility)
        i. List of indicators and their local names
        ii. Interpretation of each indicator
    c. Integrated soil management technics:
        i. Mulching
        ii. Compost
        iii. Cover plants
        iv. P release in the soil
        v. Mineral fertilizer
        vi. Legumes integration and soil rotation
        vii. Polyculture
        viii. Zero tillage
        ix. N fixation
        x. Weeding management
        xi. Pest management
        xii. Biodiversity management
        xiii. Livestock management and integration
        xiv. Other
4. Productivity and household needs
    a. livestock management
        i. Genetic diversification and maintenance
        ii. Grazing and feeding
        iii. Animal stall
        iv. Animal care and health
        v. Erosion management
        vi. Fertility management
        vii. Other
5. Recycling
    a. Field and household residues management
    b. Field burning
    c. Soil water management
        i. Mulching
        ii. Irrigation
    d. Organic material management
    e. Landraces management
6. Energy management
    a. Wood management

    b. Charco use reduction systems
    c. Smoke management
7. Systems and structure
    a. Structure contribution of the state
    b. Access to land granted to vulnerable groups
        i. Orphans
        ii. Widowed
        iii. Disables
    c. General access to production assets
        i. Land
        ii. Seeds
        iii. Loans and credits
    d. Capital and human capitals
        i. Definition of household and families
        ii. Importance of the big family
        iii. Groups and organizations
    e. Community guarantee for credit
    f. Community insurance for assets and sickness insurance
8. Food customs and traditions
    a. Local sources for energy, proteins, and fats
    b. Classify the cheapest and the most expensive sources
    c. Define accessibility per social groups
9. Co-creation and knowledge sharing
    a. Platform of knowledge sharing and management in communities
    b. Platform of horizontal intra learning
    c. Women and girls participation
    d. Network of horizontal knowledge sharing and management
10. Social considerations
    a. Women emancipation
    b. Job and task sharing per sex
    c. Women contribution to development
    d. Decision making in the household and the production processes
11. Local market and service providing
12. Governance at local and global level