

Faculty of bioengineers

Use of the Tool for Agroecology Performance Evaluation (TAPE) to assess farms of the KEA program in Arusha rural district, Tanzania

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1 Introduction

Being a farmer means spending your life finding solutions. Being a farmer means spending your life finding solutions because in agriculture, new problems arise every day. Agriculture is about producing animal and plant products. It's about managing living beings wisely to try to exert some relative control over them, even though the very nature of these living beings is to be unpredictable. They are unpredictable and, moreover, impacted by elements that are difficult to control such as the environment and weather. Saying this, the complexity of this magnificent profession/lifestyle becomes evident. It's easy to understand that farmers spend their time facing challenges. How to approach the profession of farming to navigate this complexity as peacefully as possible?

In the rural region of Arusha, agriculture is not just a job but a way of life that dictates the rhythm of households. This small-scale family farming is particularly vulnerable to these fundamental agricultural problems. The risks that affect agriculture hit these systems, which are already precarious, even harder. In case of setbacks, beyond a decrease in income, many families, who rely primarily on agriculture for their food, quickly face food insecurity.

Finding sustainable solutions is as complex as the causes that lead to these situations. The development of traditional agriculture in these regions focuses on finding sustainable solutions for secure production. The organization of traditional agricultural systems is based on this quest for stability in service of production. However, these systems sometimes have their limits, and the impacts of climatic hazards or crop/animal diseases are felt harshly, especially given the lack of state-level solidarity systems.

It is with the aim of helping to build even more resilient agricultural systems in the face of the increasingly frequent and impactful challenges of agriculture that the Kilimo Endelevu Arusha (KEA) program works. This program is based on the concept of agroecology, which embraces this logic of sustainability, working towards long-term stability.

It is in this context that this study is conducted, assessing the agroecological level of KEA program farmers.

2 Context

2.1 Kilimo Endelevu Arusha

This MSc thesis is part of the "Kilimo Endelevu Arusha" (KEA) project, which translates to "Sustainable Agriculture Arusha" in English. KEA is a program jointly conducted by "Iles-de-paix" (IDP), Cari, Recoda, and the MVIWAARUSHA. IDP, Cari, and RECODA are Belgian, French, and Tanzanian agriculture-focused NGOs, while MVIWAARUSHA is a peasant organization from the Arusha region. They initiated this program together in 2022 with more than 600 farmers. It is a five year program that will end in 2026. The aim of the program is to build stronger resilience for each farm facing economic and agronomic inherent difficulties as well as new challenges raised by an evolving context of demographic transition and climate change.

In each of the ten villages, groups of farmers are created and organize meetings every week. Those meetings are the opportunity for farmers and NGO's member to share on agronomic issues. The program is based on a spreading dynamic, group members are following specific training and share their experience with the other members of the group at the meeting. This organization allows a deeper and more qualitative learning of techniques for the ones directly involve in the formation while reaching as many as possible by the spreading dynamic. This is following the RIPAT (Rural Initiative for Participatory Agricultural Transformation (RIPAT)) methodology ("RIPAT Website," n.d.).

2.2 The study area

The households participating in the Kilimo Endelevu Arusha program are located in the Arusha region, one of the 26 regions of Tanzania mainland, the continental state of the United Republic of Tanzania. This region is at the extreme north of Tanzania mainland and share a border with Kenya.



Figure 1: A view from Mont Meru (all pictures by Louis Baret)

The study site is located at 3 degrees south latitude and 36 degrees east longitude. All the farms studied are in a radius of 35 kilometers from the city of Arusha, the third biggest city of Tanzania with an estimate population of 500.000 people (“Wikipedia” 2023). Arusha is located on the southern hills of Mount Meru; a 4566 meters high solitaire summit western 50 kilometers from Kilimanjaro. The locations of the 200 farms from this study are pinned on the map (Figure 2).

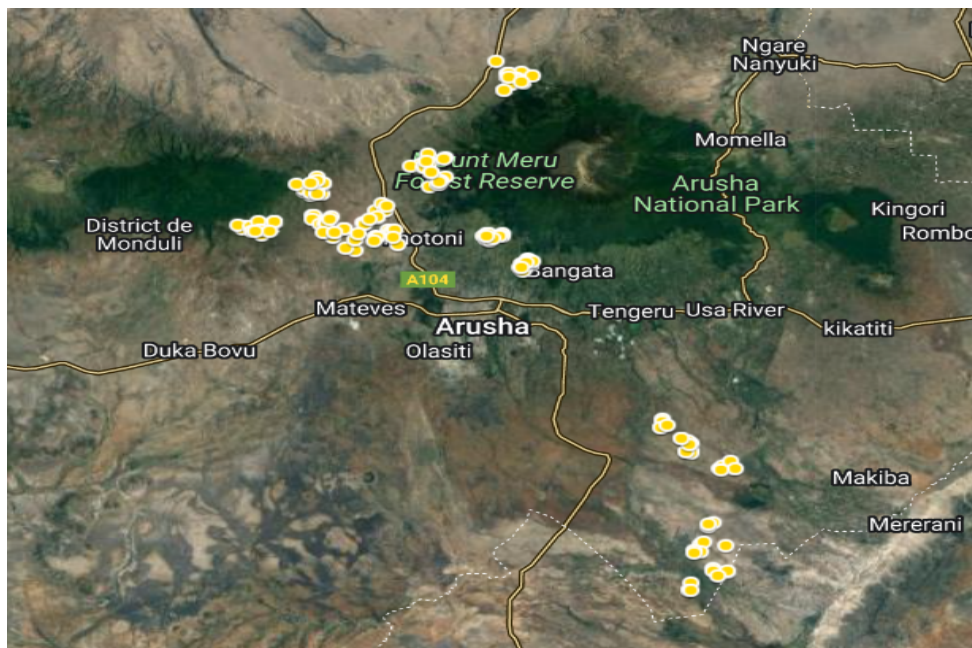


Figure 2 : Position of the surveyed farms

2.3 Climate

The average temperature in Arusha is 20 degrees Celsius. The climate is temperate with a dry season in winter and mild summers. The average temperature does not exceed 22°C during the hottest months. These characteristics correspond to a Cwb climate, subtropical highland climate, according to the Köppen-Geiger classification. There are two rainy seasons: the short rainy season from November to December and the long rainy season from March to May (“Climate-Data.Org,” n.d.)

The climate in the Arusha region is influenced by its topography. Higher altitude areas have a colder and wetter climate, while the lower region south of Arusha has a warmer and drier climate, characteristic of this latitude when the climate is not influenced by specific topographical features.

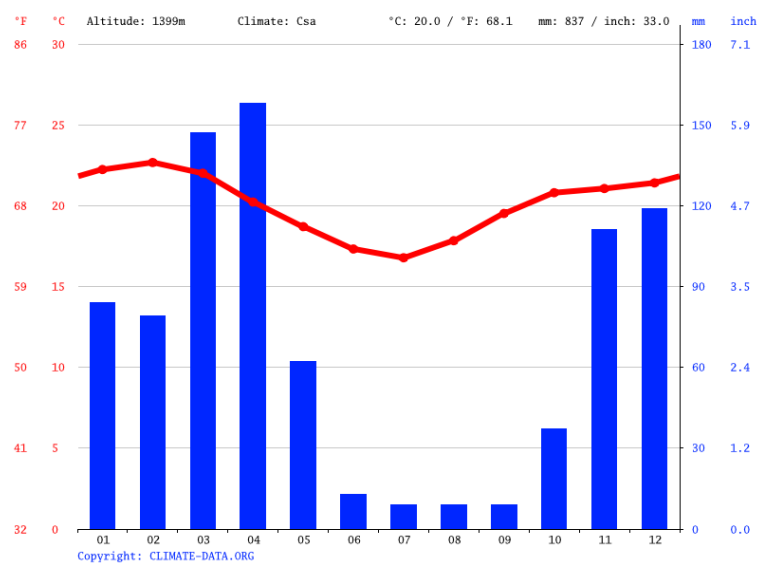


Figure 3 : Climate of Arusha (“Climate-Data.Org,” n.d.)

2.4 Description of agro-ecological zones

The altitude of the study area is not homogeneous, ranging from 940 meters for the lowest village to 1830 meters for the highest village. The altitude difference, along with the impact of Mount Meru, explains the presence of three distinct agro-ecological zones. Agro-ecological zones (AEZs) are geographical areas exhibiting similar climatic conditions that determine their ability to support rainfed agriculture (Sebastian 2014).

The three agro-ecological zones are the Lowland, Midland, and Highland. They are distinguished by their environment and their agricultural practices. From a climatic perspective, it is the level of annual precipitation that characterizes them the most. Annual main rainfall is 400-900 mm in the lowlands, 1000-1200 mm in the midlands, and 1200-2000 mm in the highlands (“Climate-Data.Org,” n.d.).

In the lowlands, demographic pressure is lower than in the other two agro-ecological zones because the climatic conditions are less ideal for agriculture. The landscape is flat, with villages spaced 2-3 kilometers apart. Agriculture is extensive, livestock plays a significant role in the systems, and herds graze freely. The main crop is maize. Cultivating a wide range of plant species as in the other agro-ecological zones is more complicated in the lowlands, as crops must be adapted to lower precipitation levels. In some farms, tractors are used for specific tasks such as plowing or grinding maize grains after harvest (Sembosi 2019).



Figure 4 : Interview by an enumerator in the lowland area.

The highlands are more suitable for agriculture, with higher demographic pressure and intensive farming practices. This system is described as a home garden area, where each household cultivates its well-defined plot. Beyond the main crops, maize and beans, many other species are cultivated, such as coffee, bananas, and a wide variety of vegetables. The highland terrain is steep, with fields often having significant slopes, requiring careful water runoff management. All agricultural work is done by hand. Parts of the slopes are served by irrigation channels. Livestock farming is not the main activity, and livestock are kept in enclosures (Sembosi 2019).



Figure 5 : Landscape of the highlands

The midlands are an intermediate territory between the lowland and highland systems. The rainfall regime allows for the cultivation of a wide range of species, similar to the highlands.

However, bananas and coffee are less cultivated than in the highlands. Some plots are flat, allowing farms to mechanize agricultural tasks, primarily plowing. Livestock farming is carried out both in free and enclosed grazing. Agricultural systems are not homogeneous within the midlands; however, they are closer to the systems found in the highlands than those in the lowlands.



Figure 6 : Landscape of the midlands

3 Methods

3.1 Aim and rationale of the thesis

The aim of this study is to assess how the farms in the Kilimo Endelevu Arusha program align with the agroecological approach to agriculture. The responses from structured interviews based on the TAPE tool are used to understand this alignment.

The idea behind the construction of this study is not to conduct an in-depth analysis of each element from STEP 1 of TAPE, but rather to delve deeper into certain aspects of the data that raise questions or hold greater importance in relation to the study's objectives. This approach avoids burdening the discussion with a detailed analysis of each element and instead focuses on key aspects that warrant further examination. It enables us to develop detailed analyses of points that deserve particular attention. That is made possible thanks to the adaptability of TAPE described in 3.5.

A first example of this approach is the construction of point 5.5. This section examines the scores of the elements based on different farming systems. Agricultural systems that integrate more diverse activities have a higher CAET. To understand why these systems have a higher CAET, we chose to focus on the recycling element by examining the questions that contribute to this score. This deeper analysis helps clarify the question raised during the discovery of the scores of the different systems: Why do systems that integrate more activities have better CAET? However, such a precise analysis cannot be conducted for each element, as it would risk diminishing the quality of the analysis in favor of the quantity of information.

3.2 Tool for agroecological performance evaluation – TAPE

The Kilimo Endelevu Arusha initiator wanted to find a relevant way to objectively evaluate the program. As it is not something on a progressive path clearly identifiable, the program is not constructed on a goal reaching pattern, it is complex to evaluate. It touches matters that are not immediately tangible, such as the impact on diversity, social aspects and well-being.

KEA aims to strengthen the resilience of the populations in the Arusha region by supporting sustainable, localized food systems and promoting agroecology (“TOR AFD Evaluation : Kilimo Endelevu Arusha: Program for Sustainable Land Management and Agroecological Transition in the Arusha Region of Tanzania” 2024). Starting from this idea, finding a way to evaluate the level of agroecology is an interesting angle to evaluate the evolution of farms through the five years of the program.

The FAO has developed recently a tool that has the goal of evaluating “the level of agroecology” named TAPE, Tool for agroecology performance evaluation (Mottet et al. 2020). The FAO starts to build this project after realizing the growing interest for agroecology all over the world.

They built TAPE based on the observation that there are many surveys that assess agroecology but these are often linked to a specific context, created by a team of scientists for a country, a given region, that fits a specific reality. FAO's aim was to create a survey that can be used in any situation, regardless of the context. The tool is simple enough to use in a limited amount of time and with limited resources. The data collection for the tool is done using a survey that is individually addressed to farmers. This survey consists of four steps.

STEP0 is a description of the systems and the context. The objective of this step is to describe the systems to understand the specific context of each farm. This step is not related to agroecology concepts; it aims to lay the groundwork for analysis.

To assess agroecology, the tool is based on the 10 elements of agroecology. These elements are the result of a global reflection led by FAO, politically validated by UN members. These 10 elements are: diversity, synergy, efficiency, recycling, resilience, culture and food traditions, co-creation and sharing of knowledge, human and social values, circular and solidarity economy and responsible governance. Since agroecology is a concept that combines purely technical, agronomic dimensions, to social aspects, this characteristic is reflected in the choice of the 10 elements.

The elements Diversity, Synergies, Efficiency, and Recycling show the actual implementation of agroecological practices in the field of surveyed farms. The elements Culture and Food Traditions, Co-creation and Sharing of Knowledge, Human and Social Values characterize the social aspects of agroecology. Finally, the elements Circular and Solidarity Economy and Responsible Governance characterize the enabling environment for agroecology.

The level evaluation of those 10 elements is the goal of STEP1.

The 10 elements are used as criteria to define semi-quantitative indices that take the form of descriptive scales with scores from 0 to 4 (a modified Likert-type scale). For example, for the element of "Diversity", the relevant indices are (i) Diversity of crops, (ii) Diversity of animals, (iii) Diversity of trees, and (iv) Diversity of activities, products and services. The score of the first index for this element ranges for 0 to 4, depending on how diversified crop production is. The scores of the four indices are summed (for example $2+3+3+4=12$) and the totals are standardized on a scale from 0 to 100 percent ($12/16 = 75$ percent) to obtain the general score for the element "Diversity" (see Survey guidebook in Annex 1).

The score from each of the 10 elements are aggregated to create a global index called the characterization of agroecological transition (CAET).

It is important to keep in mind that CAET is an unstandardized additive model. This type of model can be affected by high values in certain elements, which can have a significant impact on the overall CAET value, as it is created by simply adding up all the elements.

In addition to the evaluation of the elements that constitute the agroecology assessment in STEP1, TAPE aims to provide evidence of the performance of more agroecological systems in areas that are not part of the agroecological concept but are linked to societal well-being, such as health and economic dimensions.

To evaluate those aspect, FAO create the STEP2. This step consists of assessing the performance of systems (e.g. farms, households, territories) on the key dimensions considered relevant to sustainable food and agriculture and to achieve the Sustainable Development Goals (SDGs). The five key dimensions chosen to capture those aspects of performance are; Environment & climate change, Health & nutrition, Society & culture, Economy and Governance. Those key dimensions are assessed using question belonging to 10 core criteria of performance; secure land tenure (or mobility for pastoralists), productivity (and stability over time), income (and stability over time), added value, exposure to pesticides, dietary diversity, women's empowerment, youth employment, agricultural biodiversity and soil health. In contrast to STEP1, the data collected by STEP2 are very direct and related to concrete values such as soil structure or income.

The idea behind creating this second step, which focuses on farm performance beyond the intrinsic aspects of agroecology addressed in the first step, is to, after analyzing the step itself in order to better understand the realities in which the farms we are studying operate, perform a cross-analysis between step 1 and step 2. This will allow us to evaluate whether or not agroecology has a positive impact on these performance elements. The FAO's aim is to provide evidence of the positive impact that agroecology can have beyond purely environmental aspects (Bicksler et al. 2021)

This study is an analysis of the first snapshot in a series of three TAPE surveys that will be conduct through the program. In addition to the one conducted in 2022, another will take place in September 2024 and the final one in 2026. Thanks to these three surveys, an analysis of the evolution of the farms over the five years of the program will be possible.

3.3 Previous usages of TAPE

TAPE was applied in different African contexts ((Muluken Gezahegn Wordofa et al. 2024; Darmaun et al. 2023; Dario Lucantoni et al. 2023). Results were classically presented as an assessment of the agroecological potential. Considering the exploratory status of the data used in the present thesis, it is difficult to proceed with relevant comparisons with previous studies.

Our objective is to use TAPE for making sense of the diversity of agricultural practices in Arusha region. In this respect, another challenge is to discuss the relevance of the standardized TAPE approach in a specific context (small farms, mountainous conditions, low share of market oriented productions, ...). As mentioned by Geck et al. (Muluken Gezahegn Wordofa et al. 2024; Darmaun et al. 2023; Lucantoni et al. 2023) : “most of the tools for assessing the degree of agroecological integration used standardized indicators, despite agroecology emphasizing context-specificity. Methodologically, this study is inspired by the use of TAPE in Lesotho (D. Lucantoni et al. 2022)

3.4 Data collection

The data collection was carried out by ten enumerators who were trained for three days using the video training provided by the FAO. These three days of training included a Q&A session

with the creators of the FAO tool conducted remotely, as well as a pilot interview in a farm with all the enumerators.



Figure 7 : Enumerators participating at the pilot interview

The interviews themselves were conducted in the ten villages over ten days, with each enumerator meeting two farmers per day. The responses were collected using tablets with the Kobo Toolbox tool. After each day of interviews, the enumerators discussed the problems encountered and the methods of conducting the interviews among themselves and with the workers from RECODA and Île de Paix, with the aim of collecting data in the most consistent and rigorous manner possible.

Enumerators got a booklet with Guidelines on how to collect data, how to transform units of measurements, Swahili translations and explanations of abstract concepts. This booklet was complemented by photographs of different animal breeds and their names, and different types of pesticide and their toxicity. (See Annex 2).

3.5 Adaptability of TAPE

TAPE is designed as a data collection tool structured around questions that address a set of specific criteria. This method of gathering information creates a tool that can describe a wide range of systems while ensuring the potential for comparison through a strict and rigorous framework. This feature of the tool is illustrated by the decision to use closed multiple-choice

questions, where the different answers reflect the correspondence of reality to the statements in the questions.

When it comes to the data analysis phase, the tool does not impose a specific methodology. It is the objectives of the study in which the data collection is embedded that shape the analysis. Whether it is the importance given to deepening certain parts of the data analysis or the connections between the steps that can be highlighted, the combination of a rigorous questionnaire that allows the collection of homogeneous data with the freedom of analytical approaches to meet the specific needs of each study situation is one of the points that makes the TAPE tool relevant.

3.6 Selection of typology for evaluation

Throughout the analysis, the data will be examined based on the characteristics of the farms. The three main angles for creating categories are the production systems, the agro-environmental zones, and the quartiles of their CAET scores.

Table 1 shows the proportion of farms according to their system type and agroecological zone.

Table 1: Typology of farms in the survey

Farmers proportion per system type and agro-zone (%)					
	Diversified	Mixed farming	Tree mixed farming	Trees and livestock farming	Total
Low land	0.5	15.1	2.5	1.5	19.6
Mid land	8.0	37.7	12.1	1.0	58.8
High land	3.5	15.1	3.0	0.0	21.6
total	12.0	67.9	17.6	2.5	100.0

3.6.1 The typology of production systems

The production systems describe the main activities of the farms. The productive systems are differentiated by the integration of crops, livestock, and tree wood production and classified into categories determined by the members of Ile de Paix and described in Table 2. A large majority of farms are mixed farming (67.9%) (Table 1), the rest is divided between Tree and Livestock farming and Diversified farming. Five farms are Tree mixed farming.

Table 2 : Structure of the production systems

Production system			
Name Production system	Crops	Livestock	Trees
Monoculture	1 crop		
Diversified	>1 crop		
Mixed farming	X	X	
Tree mixed farming	X	X	X
Trees and livestock farming		X	X
Livestock farming		X	



Figure 8: A system comprising trees

3.6.2 The agro-ecological typology

A significant part of the analysis will differentiate the results according to the agro-ecological zone in which the households are located. This categorization axis was chosen because the differences in agricultural practices between the various agro-ecological zones are considerable. From intensive agriculture primarily based on the production of diverse crops on

sloped plots in the highlands to extensive agriculture on flat lands with a higher proportion of livestock in the lowlands.

The majority of households in our sample are from the midlands, with 117 households spread across six villages. There are 39 households in the lowlands spread across two villages, and 43 households from two villages are perched on the slopes of Mount Meru, in the highlands (Table 3).

Table 3 : Sample distribution: number of households per village by agro-environmental zone

Village	n
Low land	
Bwawani	19
Marurani	20
total	39
Mid land	
Ekenywa	20
Imbibia	19
Loskito	19
Olchorovus	21
Oldonyowas	19
Orkokola	19
total	117
High land	
Oldonyosapuk	20
Shiboro	23
total	43
total	199

The average altitudes of the midland and highland villages are very close and both are relatively high, at 1736 meters and 1758 meters (Table 4), respectively. The difference in classification of these villages between these two agro-ecological zones, despite their comparable altitudes, is explained by their proximity to the summit of Mount Meru. Mount Meru impacts the climate in its vicinity by concentrating clouds during certain periods and creating a shadow zone at certain times of the day. The average altitude of the lowland farms is much lower than that of the other two agro-environmental zones, at 965 meters. The satellite view in the Figure 9 allows visualization of the environmental differences in the location of the villages.

Table 4 Agro-ecological repartition of the farms

Farms in their environment			
Agro-zone	Mean Altitude	# Village	# Farm
Low land	965	2	39
Mid land	1736	6	117
High land	1758	2	43
Total	1486	10	199



Figure 9 : Map of the area

3.6.3 The CAET typology

The analysis will also focus on the characteristics of the farms according to their CAET level. To do this, the evaluated systems are divided into quartiles. Each quartile is associated with a letter of the alphabet from A to D. The construction of this typology will be further developed in section 5.8.

RESULTS

4 Description of systems

4.1 Size of productive systems and land use

The studied farms are small in terms of area, with 38 % of them covering an area of 0 to 0.5 hectares, while only 12. % covers more than 2 hectares (Figure 11). The area under agricultural production averaged to 1.12 hectares and the median value of the distribution is 0.8 hectares. The largest farm extends over 6.5 hectares, and the smallest covers 0.1 hectare. However, it is worth noting that 87.6% of the farms are less than one hectare, indicating that the farms are mostly small and of comparable size.



Figure 10 :Woman working in a small farm

The small size of the farms studied is related to a specific context. Proximity to Arusha and a favorable agricultural environment in the midlands and highlands have increased the population density to 62,71 hab/km² (“Citypopulation.De” 2024) . Most farms do not use mechanical tools, and some are situated on steep terrain, which makes it challenging to cultivate large areas.

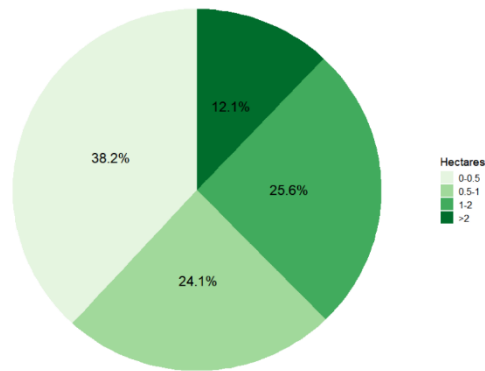


Figure 11 : Percentage of farms per size

Size of farm is dependent on the farm structure (described in 4.1). The average area of farms that include livestock and/or forest product exploitation is larger and above 1 hectare. Farms that only practice crop cultivation are smaller, with an average of 0.63 hectares. This can be put into perspective with the location of "Diversified" farms in the agro-ecological environment, where 96 % of them are in the midlands and highlands, areas with higher population density Table 5.

Table 5 : Average total area per type of production system

Average total area (ha) per type of production system	
	Area (ha)
Diversified	0.63
Trees and livestock farming	1.14
Mixed farming	1.11
Tree mixed farming	1.43

"Diversified" farms in the "Highland" agro-ecological zone have an average area of 0.34 hectares. There are seven of these farms in our sample. "Mixed farming" farms in the "Lowland" agro-ecological zone have an average area of 1.4 hectares. There are 30 of these farms in our sample. These average values highlight the difference in agricultural area between the extensive agricultural systems with livestock in the lowlands and the intensive crop farming systems in the highlands.

4.2 Diversity of crops

The farms in this study include, on average, more than three species of crops and just under three species of animals (Table 6). The difference between the different agro-zones for those values is not particularly marked. However, it should be noted that farms in the Highlands grow, on average, one more plant species than those in the Lowlands, and conversely, farms in

the Lowlands raise, on average, one more animal species than those in the Highlands. This highlights the tendency of highland farms to focus more on crop cultivation while lowland farms tend to prioritize livestock raising.

Table 6 : Acreage, number of crops and livestock according to the agroecological zone

Surface, crops and livestock			
agro_zone	Total Area	# Crops	# Animals
High land	1.0	3.8	2.1
Low land	1.5	2.9	2.6
Mid land	1.1	3.5	3.0
Total	1.1	3.4	2.7

4.3 Household composition

The households in this study have an average size of 6.4 people, including 2.5 children, one man, one woman, and one young person (aged 15 to 34) of each sex (Table 7). This is a relatively small household size considering that the total fertility rate for women aged 15 to 49 in Tanzania is 4.8 in 2022, according to the Demographic and Health Survey (“Tanzania Demographic and Health Survey (TDHS)” 2023).

Almost all adults in the household work on the farm, with 83 % of men and 93 % of women involved. A large proportion of those aged 15 to 34 also work on the farm, with 65 % of young women and 72 % of young men engaged in farming. Nearly one in five children, 18 %, work on the farm. These values do not vary significantly depending on the agro-ecological zone.

In the studied region, agriculture is the main activity not just for one person per household, but for a large proportion of the household. It is worth noting that among those aged 15 to 34, a higher proportion of men work on the family farm, whereas this trend reverses among adults, with a higher proportion of women working on the farm. This could be explained by the fact that women tend to leave their household between the ages of 15 and 34 to join their husband’s household, while men tend to stay in their original household.

Table 7 : Composition of households

Household composition											
agro_zone	Household					Total	Percentage of farmer				
	Men	Women	Young men	Young female	Children		Men %	Women %	Young men %	Young female %	Children %
Low land	0.9	0.9	1.0	0.9	2.5	6.3	91.2	88.9	78.2	69.4	15.7
Mid land	0.9	1.0	1.1	1.0	2.6	6.6	81.6	93.4	69.4	62.1	17.3
High land	0.9	1.0	1.2	0.8	2.2	6.0	79.7	93.9	72.5	72.2	22.0
Total	0.9	1.0	1.1	0.9	2.5	6.4	83.1	92.7	71.7	65.4	17.9



Figure 12: Homes in a midland landscape

4.4 Destination of agricultural production

"What is the main intended destination of the agricultural production?" The analysis of the responses given by the farmers in our sample to this question is the focus of this section.

Knowing whether households practice agriculture for their own consumption or to sell their production provides valuable insight into the different realities of each farm. The destination of a farm's production is a central aspect in the overall management and strategy of the farm.

Through this question, it appears that the farms participating in this survey are mostly very small-scale family farms. Three-fifths of the farms primarily produce for their own consumption, and one-fifth produce exclusively for their own consumption (Table 8).

Table 8 : Proportions of the different types of usage

Destination	Percentage
Mostly self-consumption and a small part of sale	44
Equally sale and self-consumption	19
Self-consumption	19
Mostly sale and a small part of self-consumption	18
Sale	0

Is the destination of production influenced by the agricultural system or the agro-ecological zone in which the farm is? It is difficult to identify a clear trend from the results disaggregated by agricultural system (Table 9) ?

However, it is notable that farms with a "tree mixed farming" system are, proportionally, more likely to sale their production. Sixty percent of them chose the first two options (mostly sale, equally sale/self-consumption). The other three systems include a higher proportion of farms (60 to 70 %) where the destination of their production is “mostly for self-consumption” and “self-consumption only”.

Table 9 : Destination of production per agricultural system

Farmers proportion per system type and production destinations				
	Mostly sale and a small part of self-consumption	Equally sale and self-consumption	Mostly self-consumption and a small part of sale	Self-consumption
Diversified	20.8%	16.7%	33.3%	29.2%
Mixed farming	16.3%	14.8%	50.4%	18.5%
Tree mixed farming	22.9%	37.1%	31.4%	8.6%
Trees and livestock farming	20.0%	20.0%	20.0%	40.0%

Among the different agro-ecological zones (Table 10), it is in the highlands that agricultural production is most frequently sold, with 58 % of respondents from this region choosing one of

the first two options in response to the question asked. In the midlands, 21 % of farms do not sell any part of their production, and 50 % do not sell or sell very little of what they produce.

Several hypotheses could explain this difference in responses across the different zones. The higher population density in the highlands could be a catalyst for a more dynamic market. The greater diversity of production in the highlands (3.3.1) could also explain the tendency of farms in this zone to sell a portion of their production.

Table 10 : Destination of production by agroecological zone

Farmers proportion per agro-ecological zone and production destinations				
	Mostly sale and a small part of self-consumption	Equally sale and self-consumption	Mostly self-consumption and a small part of sale	Self-consumption
High land	34.9%	23.3%	32.6%	9.3%
Low land	15.4%	25.6%	38.5%	20.5%
Mid land	12.8%	15.4%	50.4%	21.4%

Figure 13 represents the quantity of maize produced annually by the interviewed farms according to the destination of their production. The median production of farms that sell the most to those that do not sell at all is 540, 440, 200, and 70 kilograms per year, respectively. For each response, in the same order, the proportion of farms that do not produce any maize is 16%, 21%, 36%, and 47%.

Farms that produce more maize tend to sell more of their production. It seems logical that producing a large quantity of a given product, such as maize, would enable the farms that produce it to sell it.

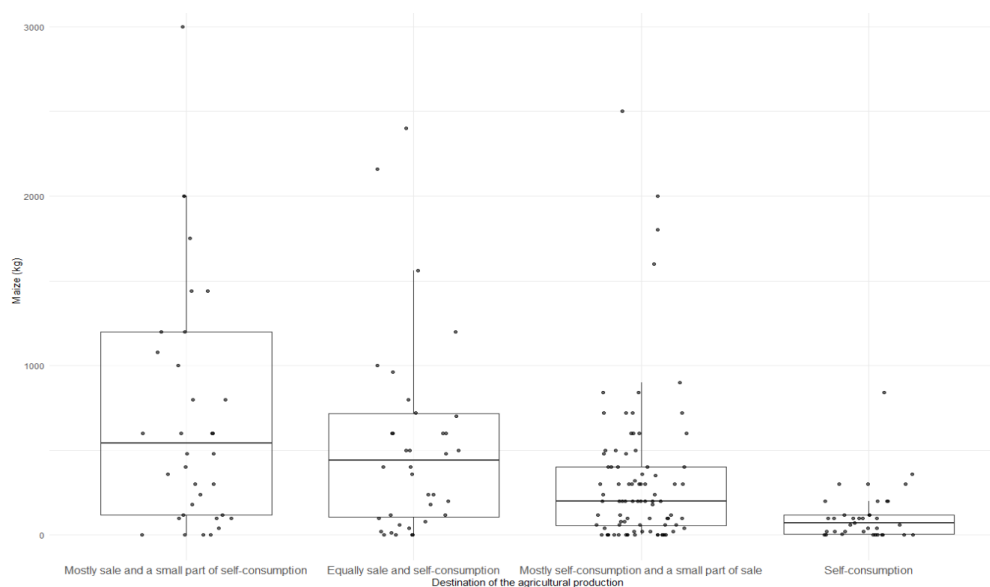


Figure 13 : Maize production per destination of the food production

5 Characterization of the agroecological level (STEP1)

5.1 Context of the use of CAET score in this study

By calling this step “characterization of the agroecological transition,” the FAO's rationale is to describe the path of farms in their transition towards more agroecological farming practices. The farms are characterized on a scale that describes their transition level according to their CAET score. This implies that the studied farms are in this process of change.

Throughout the program, the rationale of the KEA promoters is to engage with farmers around the notion of agroecology, aiming to convince them of the relevance of adopting these principles. This project is its first phase. The notion of agroecological transition will take shape during the analysis of the mid-term and end-of-term surveys, and the cross-analysis of all surveys. At the time of conducting the first survey, the households in this study are not in an agroecological transition dynamic, as most farmers are even not familiar with the concept itself. In this study, the analysis will therefore be conducted as a description of the initial level of an agroecological transition (the baseline of the process) rather than a description of the outcome of transition.

TAPE's Step 1 uses the 10 elements of agroecology to assess the level of transition of the production systems evaluated: the 10 elements are disaggregated into 36 indices with descriptive scales with 5 level of transition (scores from 0 to 4). The final scores are then converted into a percentage of transition for each element. The CAET aggregated score (the level of agroecological transition) is the average score across all the 10 elements. In Annex 1 can be find the whole survey with the questions who compose the elements and the levels of answer for each of those question.

The average CAET aggregated score for the farms in this study is 38, which corresponds to a low score. The FAO considers that a score below 50 indicates that the farm is considered non-agroecological.

5.2 Overview of the scores of the different elements

Figure 14 and Figure 15 represent the results of the elements of the CAET, the first in the form of a boxplot and the second in the form of a radar chart.

The boxplot is composed of 12 scores because the element resilience has three ways of building it, for the rest of this study, only the “new” way will be kept. This boxplot allows to visualize the median values and to get an idea of the distribution of each element thanks to the presence of the boundaries between quartiles 1 and 2 and between quartiles 3 and 4.

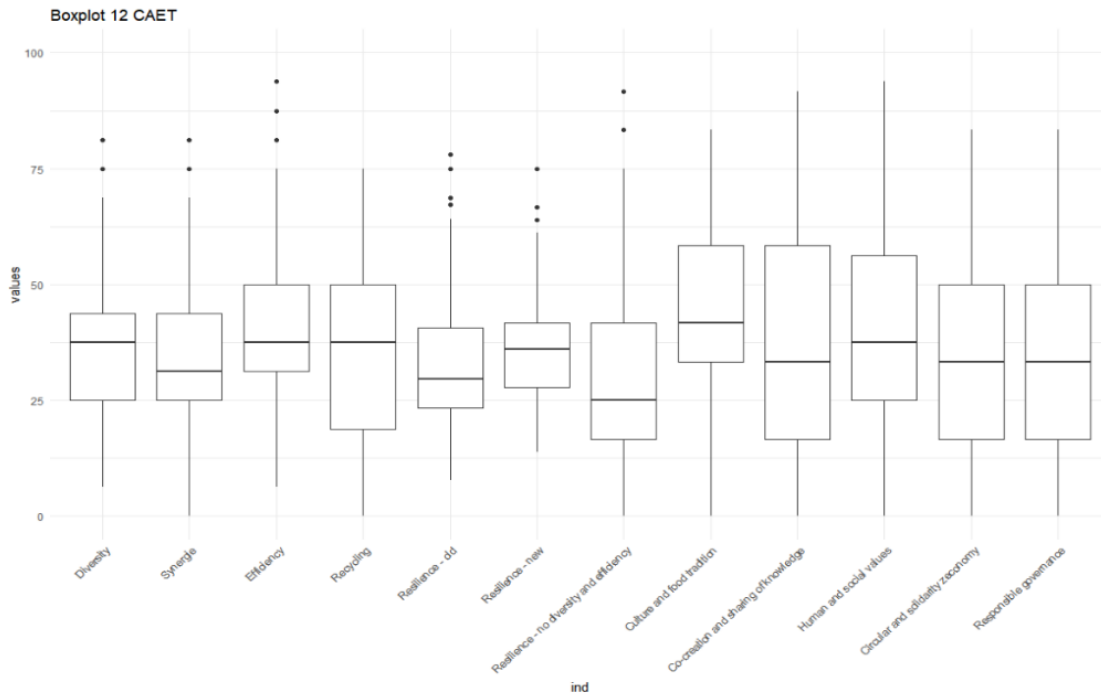


Figure 14 : Boxplots of the elements of CAET

The radar chart represents the averages of the different elements in a very visual way. The creation of a polygon with the different scores helps to understand the absolute values of the scores and to get an idea of the balance that lies between the score of the different elements.

The 12 elements have low scores and the differences between the scores are not significant. The difference between the lowest score, *Responsible Governance*, and the highest score, *Culture and Food Tradition*, is only 10 points.

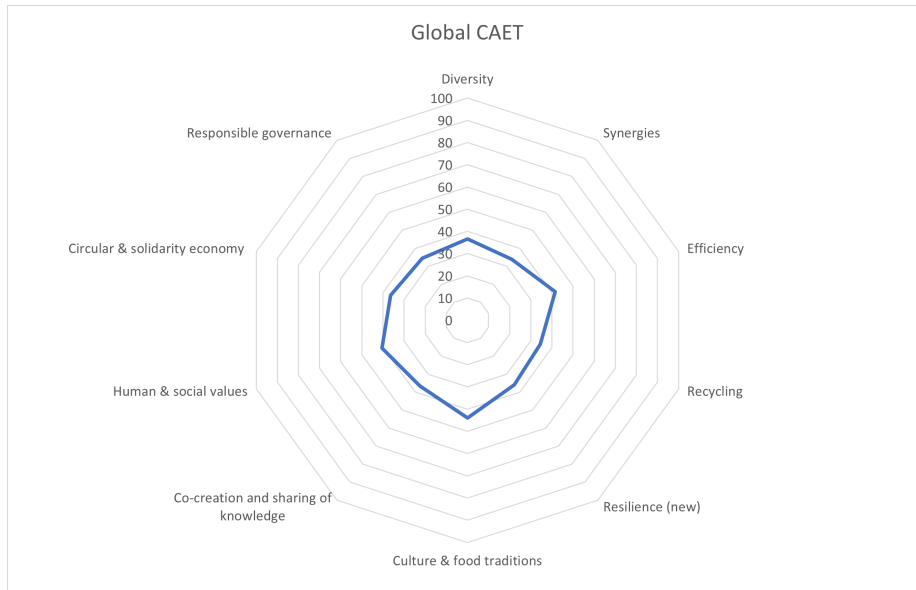


Figure 15 : Radar chart of the elements of CAET

Table 11 : Statistics of the CAET

	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture & food tradition	Co-creation & sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET total score
Mean	37	34	42	35	36	44	36	41	36	34	38
Median	38	31	38	38	36	42	33	38	33	33	35
Max	81	81	94	75	75	83	92	94	83	83	72
Min	6	0	6	0	14	0	0	0	0	0	15
SD	13	14	16	17	11	16	22	19	22	20	12

5.3 Dynamic Relationship between Element Scores and CAET Scores

Understanding the relationship between the scores of farm elements and the global CAET score allows for a better grasp of the role each element plays in the overall agroecological relationships. The graphs in this section display, for each element, a point for each farm in the study, with the CAET value on the x-axis and the specific element score on the y-axis. A regression line is drawn for each scatterplot, and the regression characteristics, R^2 and slope, are summarized in Table 12. It should be noted that the details of all the questions making up the elements are provided in the Annex 1.

The highest R^2 are on elements related to the social dimension and the lower R^2 are on elements related to the agricultural dimension.

The slope is a proxy of the accordance of the different elements with the global CAET. The highest slope is observed for elements related to knowledge and social values. Conversely, the agroecological practices implemented in the field correspond to a weak slope.

Table 12 : R square and coefficient of correlation for the link between elements of the CAET and the global CAET

R-squared and Coefficient Values for Each Variable		
Variable	R_squared	Coefficient
Diversity	0.154	0.424
Synergies	0.406	0.754
Efficiency	0.192	0.598
Recycling	0.541	1.062
Resilience (new)	0.548	0.663
Culture & food traditions	0.520	0.966
Co-creation and sharing of knowledge	0.520	1.364
Human & social values	0.600	1.208
Circular & solidarity economy	0.720	1.597
Responsible governance	0.640	1.367

5.3.1 Elements characterizing the agroecological practices implemented in the field

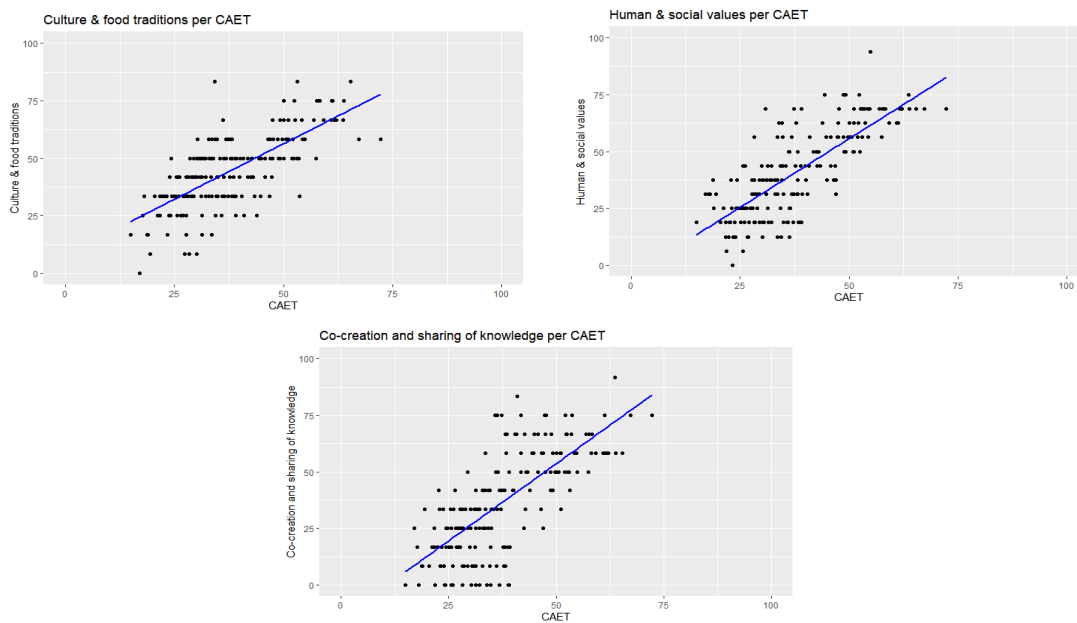


Figure 16 : Distribution of different elements of CAET (culture and food, human and social value, co-creation and sharing of knowledge) according to global CAET

The elements of **diversity** and **efficiency** have low R^2 values (Figure 17), indicating that there is no clear linear relationship between these two elements and the CAET. However, when looking at the regressions that can be made, it appears that the slopes of these regressions are quite low. There is no apparent connection between these elements, fundamental to

agroecology as they are directly related to the practical aspects of agriculture, and the overall relationship built on all the elements. This is both surprising and interesting to observe!

The explanation might lie in the fact that these elements address aspects that have been embedded in the functioning of agricultural systems for a long time. The decisions of farmers affecting these elements are highly dependent on factors such as climate, workforce, soil, market and are not explicitly oriented toward the principles of agroecology which are at the core of TAPE assessment.

The scores of these elements are not correlated with the aspects assessed by the other elements, which are more loosely connected to agricultural practices and thus more sensible to external drivers towards agroecological principles.

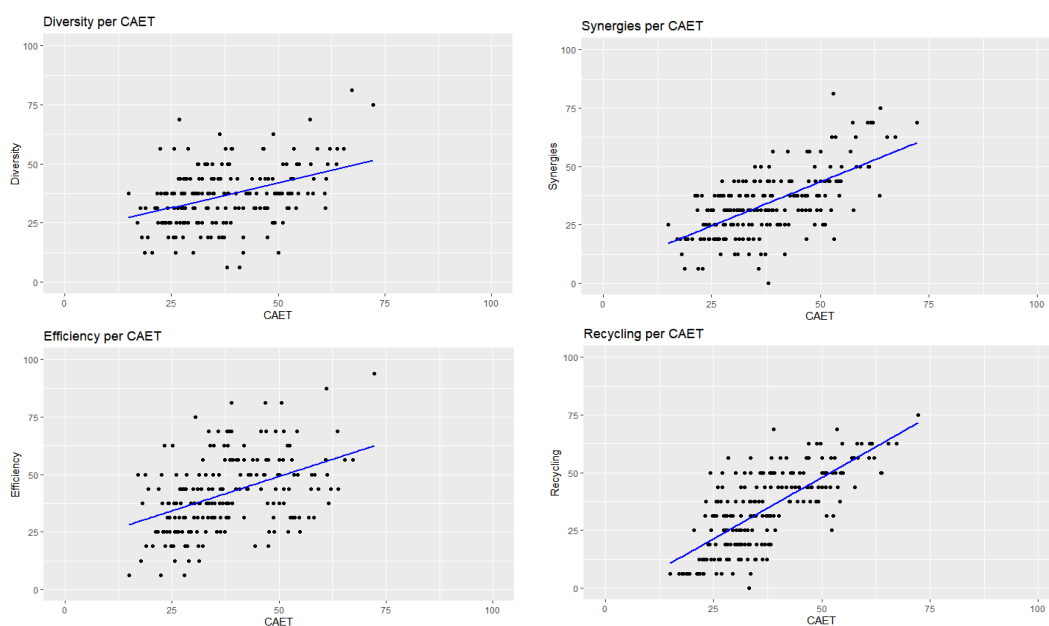


Figure 17 : Distribution of different elements of CAET (diversity, synergies, efficiency, recycling) according to global CAET

The elements of **recycling** and **synergy** have higher R^2 values (Figure 17), at 0.541 and 0.406 respectively, indicating that the regression is more representative than for the two previously discussed elements, though still not perfect. The slope values are 1.062 and 0.754. There is a correlation between the relationship of the element scores and the CAET for synergy, and this correlation is almost perfect for recycling.

This can likely be explained by the fact that for these elements, although they are also deeply embedded in the core of agricultural practices, a high score in these practices is more specifically related to an agroecologically thoughtful approach to farming. This includes, for example, the implementation of using farm-saved seeds or practicing agroforestry.

5.3.2 Element of resilience

Resilience holds particular importance due to its fundamental connection with the concept of agroecology. One of the goals of agroecology is to create greater resilience—economic resilience for households, resilience against climate uncertainties, and resilience within agricultural systems. Resilience has a unique place because of its dual role as both an element that builds agroecology and as an end goal of the agroecology concept itself.

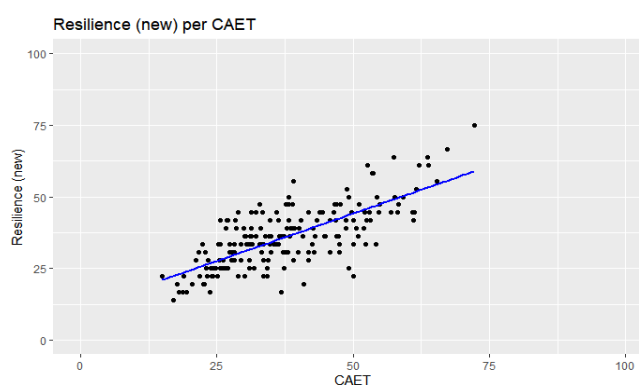


Figure 18 : Distribution of the element Resilience according to global CAET

Regarding the analysis of the relationship between the resilience score and the CAET score, the R^2 is 0.548, and the slope is 0.663. There is a connection between resilience and the agroecology characterization score, though this connection is not absolute.

It is important to remember that this element is constructed from questions related to income stability, debt levels, the extent of community support in ensuring financial resilience for farms, and the level of diversity (the final question is the average score for the element of diversity already assessed).

Considering the first component of the element (financial stability of the household), it will be revealed later in this study that the financial situation of the household is not particularly related to its level of agroecology (Figure 34), which may explain the tenuous link between the resilience element and the CAET.

5.3.3 Elements characterizing the social aspects of agroecology

The three elements characterizing Social aspects of agroecology (Figure 19) have R^2 values close to 0.5, indicating a relationship, imperfect but existing, between the CAET of farms and their scores in these three elements. This relationship is marked by a notable correlation, with slope values of 0.966, 1.364, and 1.208 for the elements "**Culture and Food Tradition**," "**Co-creation and Sharing of Knowledge**" and "**Human and Social Values**" respectively.

This common relationship highlights the importance of social aspects in creating more agroecological systems. It is not surprising to find this correspondence, as the scores for these

elements are highly indicative of the agroecological mindset present within farms and, more broadly, in the communities.

The slope of the regression for the elements "Co-creation and Sharing of Knowledge" and "Human and Social Values" is greater than 1. This indicates a positive relationship. This aspect will be revisited in Section 5.7.

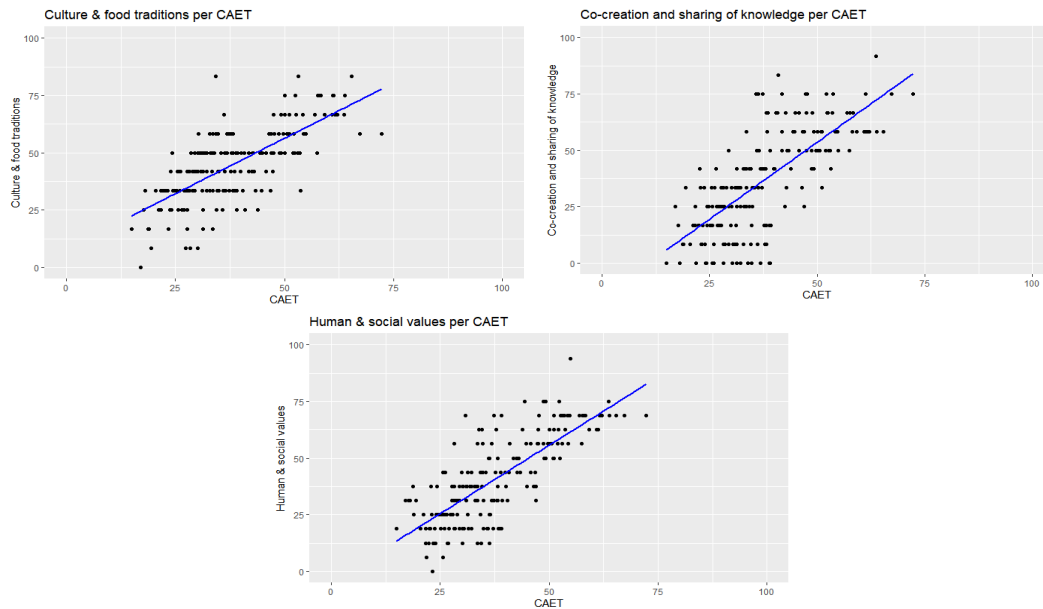


Figure 19 : Distribution of different elements of CAET (knowledge, human and social values, culture and food tradition) according to global CAET

5.3.4 Elements characterizing the enabling environment for agroecology

The elements "**Responsible Governance**" and "**Circular and Solidarity Economy**" highlight the impact of societal factors on farms' ability to implement agroecological practices. A clear and strong relationship exists between CAET and the scores for these elements, with R^2 values of 0.720 and 0.640, and slopes of 1.597 and 1.367, respectively.

Unsurprisingly, a supportive environment for agroecology is crucial and strongly linked to good results in this area. Farms with high CAET scores are characterized by very high scores in these domains.

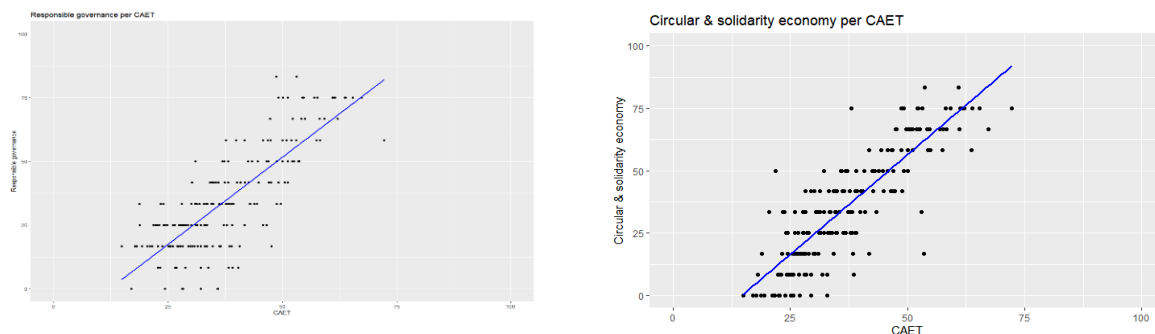


Figure 20 : Distribution of different elements of CAET (responsible governance and circular and solidarity economy) according to global CAET

5.4 Characterization of the Agroecological Level in the three agro-ecological Zones

The difference in the overall score between the different agro-ecological zones is not significant, with 34 for the lowlands, 38 for the midlands and 37 for the highlands.

However, certain elements stand out. The score for the "efficiency" element is particularly high in the Lowland and Midland agro-ecological zone (45) compared to the other elements and the general score. In the highlands, it is much lower (30).

The score for this element is constructed based on indices related to the use of external products in agricultural practices, in general, in soil fertility management and in pest and disease management. The score for each index is higher when fewer external products are used. The last index is related to the households' ability to meet their needs for cash and food.

This difference in efficiency scores between the agroecological zones may be explained by the more intensive nature of agriculture in the Highlands. Crops are grown on smaller areas with a greater diversity of crops (Table 6). This leads farmers in this region to use more external inputs.

The level of the "diversity" element is higher in the highlands and the midlands, which is related to the fact that crops are more diversified in these two agro-ecological zones, respectively 3.9 and 3.5 vs. 2.9.

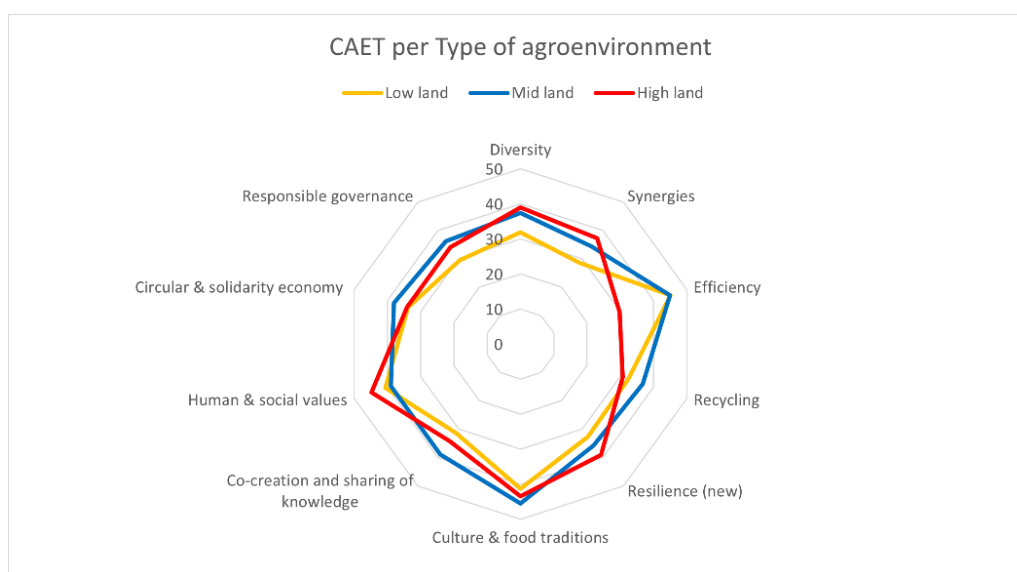


Figure 21: Radar chart of the CAET components according to the type of agroenvironment

Table 13 : Statistics of the CAET components according to the type of agroenvironment

	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture & food traditions	Co-creation & sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET total score
Low land	29	34	45	32	33	41	31	41	34	29	34
Mid land	37	34	45	37	36	45	39	39	38	36	38
High land	39	37	30	31	39	43	34	45	34	34	37

5.5 Characterization of the Agroecological Level in the four types of farming systems

There are notable differences in CAET scores between farming systems. It is observed that more diversified systems have higher scores. The two systems that integrate both crop cultivation and livestock farming have higher scores (Mixed farming, 39 and Tree mixed farming, 37), whereas systems that only incorporate one of these aspects of agriculture have lower CAET scores (Trees and livestock farming, 33 and Diversified, 29).

The reason for this difference is likely found in the construction scheme of the tool. Many indices have scores directly linked to the criteria used in the typology of farming system under study (see Annex 1).

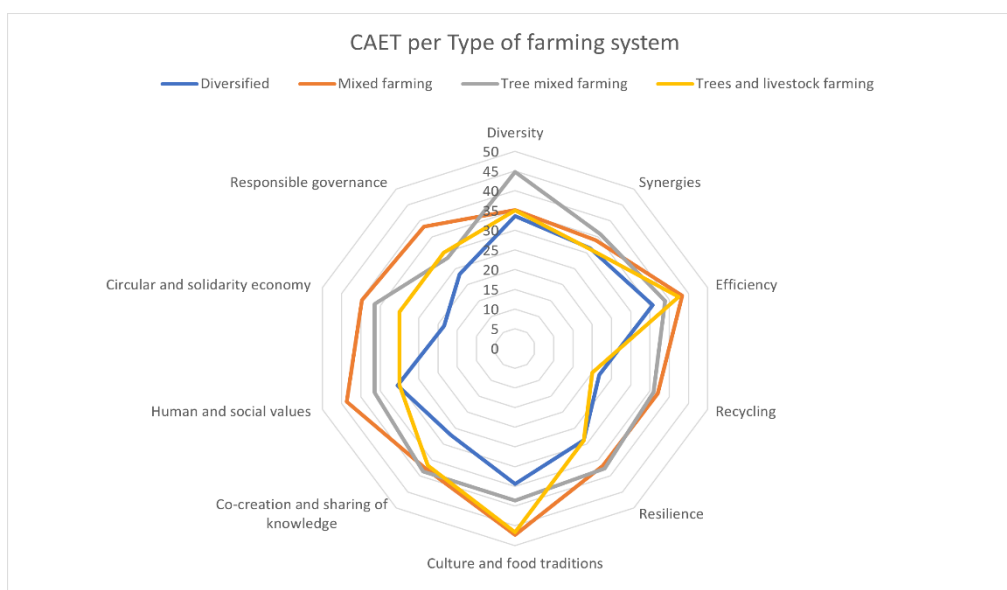


Figure 22 : Radar chart of the CAET components according to farming systems

Table 14 : Statistics of CAET elements according to types of farming systems.

	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture & food tradition	Co-creation & sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET total score
Diversified	34	32	36	22	29	34	27	30	18	23	29
Mixed farming	35	34	43	37	37	47	38	44	40	38	39
Tree mixed far	45	36	39	36	38	39	39	36	36	28	37
Trees and lives	35	31	43	20	29	47	37	30	30	30	33

An example to understand this aspect is the construction of the "recycling" element. The figure below shows the average scores for the four questions composing the "recycling" element, broken down by farming system types. For the question "recycling of biomass and nutrients" (whose response levels are described in the Table 15), the three agricultural systems that involve livestock in their practices have significantly higher scores. The responses to the question are formulated in such a way that farms engaged in livestock farming are more likely to respond with a higher score because they naturally have more easily recyclable residues, such as manure.

Table 15 : Score of the element Recycling according to the system type.

Mean score for indices of the element recycling per system type			
Recycled Biomass	Water Usage	Seeds & Breeds	Renewable Energy
Diversified			
1.50	0.46	0.88	0.67
Mixed farming			
2.92	0.45	1.71	0.84
Tree mixed farming			
2.80	0.40	1.80	0.74
Trees and livestock farming			
2.40	0.00	0.80	0.00

RECYCLING OF BIOMASS AND NUTRIENTS

0 – Residues and by-products are not recycled (e.g. left for decomposition or burnt). Large amounts of waste are discharged or burnt.

1 - A small part of the residues and by-products is recycled (e.g. crop residues as animal feed, use of manure as fertilizer, production of compost from manure and household waste, green manure). Waste is discharged or burnt.

2 - More than half of the residues and by-products is recycled. Some waste is discharged or burnt.

3 - Most of the residues and by-products are recycled. Only a little waste is discharged or burnt.

4 - All of the residues and by-products are recycled. No waste is discharged or burnt.

The TAPE tool gives higher scores to systems that are more diversified and self-sufficient. This explains the very low scores achieved by "diversified" farms that do not include livestock. This link between the type of farming and the scores on the elements that form the CAET should be kept in mind when analyzing STEP 1.

The question raised by this observation is: "Does the construction of a more agroecological farm, for farms that only practice crop cultivation, necessarily involve the integration of livestock?"

Based on the analysis of responses to the TAPE tool, if a farm moves towards diversifying its practices by integrating livestock, it will see its CAET score increase. However, this is not the only axis of change on which farms can rely.

In practice, this evolution is feasible in some situations but less realistic in others as the reasons why farmers do not practice livestock farming are multiple. Some of these reasons are practical: the terrain does not allow for livestock farming, the farm size is too small. Other reasons are cultural: livestock farming is not in the customs of the tribe. For example, the Chagga are primarily cultivators, while the Maasai are generally nomadic pastoralists.

Exchanges between livestock farmers and crop farmers are a way to evolve systems towards a more agroecological logic. They materialize, for example, through straw-manure exchanges, which allow for the transfer of materials to form a loop of organic matter transfer between animals and plants, bypassing the scale of the farm. An issue in this case is the capture of this interaction in a farm by farm assessment process.

5.6 Characterization of the Agroecological Level by CAET quartiles

To better understand the typology of farms that are more or less agroecological, it is useful to analyze the sample by separating it into different categories according to the levels of CAET.

The usual practice is to categorize by using fixed scores (<50, 50-60, 60-70,...) (Muluken G. Wordofa et al. 2024).

One issue with our sample is that, due to the low CAET values of the farms studied, the distribution in these different fixed categories will be very heterogeneous, with a large majority of farms falling into a single lower category. From a statistical point of view, it is problematic to make comparisons between categories when they are represented by very different numbers of farms and the two most agroecological categories contain very few farms Table 16.

Table 16 : Number of farms in the different fixed categories of CAET.

CAET categories	#
Non agroecological < 50	164
Inceptient transition 50 - 60	25
In transition to agroecology 60 - 70	9
Agroecological > 70	1

To circumvent this issue, another method of categorization will be used: separating the sample into quartiles based on their CAET scores. By doing this, the sample is divided into four blocks, each represented by the same number of farms, while differentiating the sample based on their CAET levels. The four quartiles are named A, B, C, and D.

The two quartiles adjacent to the median (CAET 34.86) are the narrowest in terms of CAET scores; 50% of the farms are situated between CAET scores of 28.15 and 46.73. The narrowest quartile is the second one, with 25% of the farms concentrated between an CAET score of 28.15 and the median. Generally, a large proportion of CAET scores are close to each other and near the mean, while the data points farthest from the median are rare but have extreme values.

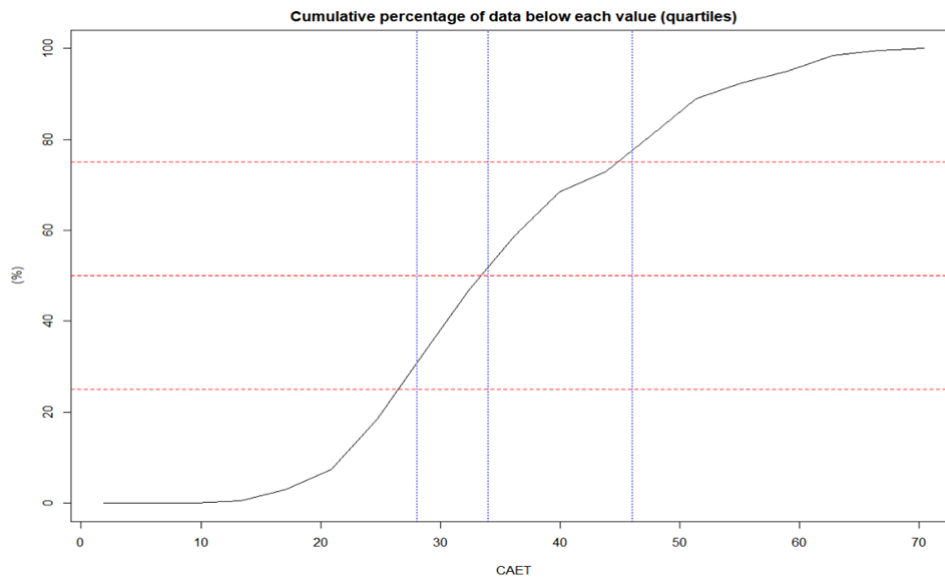


Figure 23 : Cumulated distribution according to CAET score

Understanding how the global CAET values of the different quartiles are constructed element by element is possible by observing Figure 23. This helps to identify which elements contribute to a high CAET in the upper quartiles and, on the other side, which elements are weaker in the lower quartiles.

The score of each element is higher than the score of the element in the lower CAET quartile (representatively, none of the four polygons in Figure 24 intersect). This indicates a relative consistency in the construction of the total CAET score. There isn't an element with an extremely high score that inflates the CAET of farms in a quartile while the rest of the elements are weak (or vice versa). Within the farms, the dynamics that build a CAET are general, occurring at the agronomic, social levels and influenced by the societal environment in which they operate.

The three elements with the highest scores for the first quartile (A) are efficiency, diversity, and culture and food tradition (32, 31, 30), while the three elements with the highest scores for the last quartile (D) are circular and solidarity economy, human and social values, and culture and food tradition (64, 62, 61) (see Table 1). Interestingly, there are no common elements among the three highest elements in these two extreme quartiles.

The evolution of the element score profiles between the four quartiles is not linear. The morphology of the elements in quartiles A and B is similar. The score of the elements follows the same pattern. For quartiles C and D, the difference between the scores of the different

elements is smoother compared to the first two quartiles. A trend that appears in the scores of quartile C, and is very marked in quartile D, is the relatively high level of contribution in the CAET increase of the elements Responsible governance, circular and solidarity economy, human and social values, co-creation and sharing of knowledge, and culture and food tradition. Those five elements are the three elements that characterize the social aspect of agroecology and the two elements that characterize the enabling environment for agroecology.

Meanwhile, the two highest elements of quartile A are elements characterizing the implementation in the field of agroecology, efficiency and diversity.

What differs in the way of practicing agriculture so that farms in increasing CAET categories have such different morphologies in their element scores?

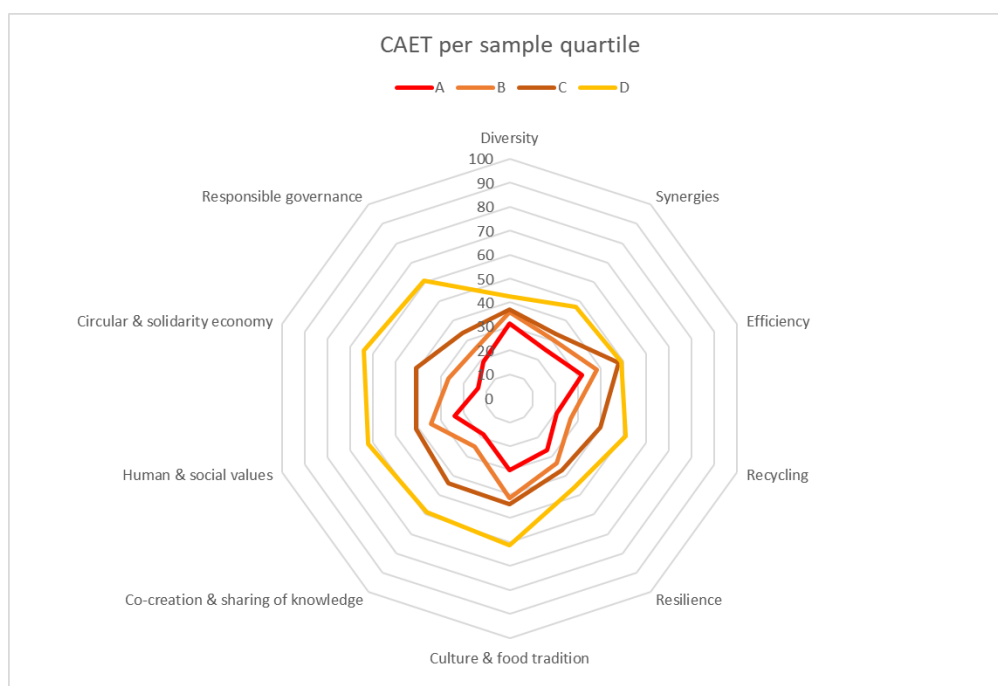


Figure 24 : Radar chart of the CAET elements according to the different CAET quartiles

Table 17 : Decomposition of CAET according to CAET categories

	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture & food tradition	Co-creation & sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET total score
A	31	25	32	21	27	30	19	24	14	19	24
B	36	30	38	27	34	41	25	35	27	25	32
C	37	33	48	40	37	44	44	41	41	34	40
D	43	47	49	51	46	61	59	62	64	60	54

5.7 The social aspects of agroecology and the enabling environment for agroecology

Why do farms with a high CAET build their CAET on particularly high scores on elements related to social and enabling environment for agroecology?

To understand why the last quartile of CAET scores is composed of such high scores for elements related to social aspects and the enabling environment for agroecology, let's take a closer look at one element of the enabling environment, the circular and solidarity economy. After examining this, we will delve into a social element, culture, and food tradition.

a. Circular and solidarity economy

For the Circular and solidarity economy element, which is the highest element of the D quartile, the medians (which are close to the averages) of the different quartiles are 12.5, 25.0, 40.7 and 66.7 (Figure 25). The differences between the quartiles go from 12.5 between quartile A and B to 25 between quartile C and D. How can we explain these particularly high scores, relative to the other quartiles, for the D quartile?

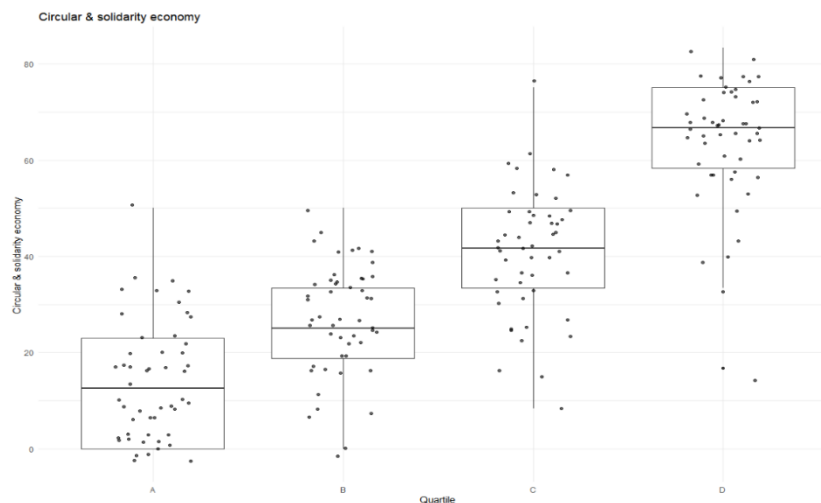


Figure 25 : Boxplot according of the Circular and solidarity economy to CAET quartile

The *Circular and solidarity economy element* assess the dynamics of the local agri-food system that surrounds each farm and the level of interaction that the farm in question has with this system. The three questions that make up this element have as their theme; "products and services marketed locally", "networks of producers, relationship with consumers and presence of intermediaries" and "local food system". Table 18 shows the Average of the responses (ranging from 0 to 4 for each of the questions) to these three questions as a function of the CAET quartiles.

The gap between the response levels of the different quartiles is rather constant for the first and third questions. The difference between the response levels between the first three quartiles and the last quartile is, on the other hand, particularly high for the question related to Networks.

Table 18 : Indices of the Circular and Solidarity economy element

Mean score for indices of the element Circular and Solidarity Economy per CAET quartile		
Products and services marketed locally	Networks of producers, relationship with consumers and presence of intermediaries	Local food system
A		
0.48	0.28	0.90
B		
0.88	0.60	1.74
C		
1.57	0.96	2.37
D		
2.44	2.56	2.68

NETWORKS OF PRODUCERS, RELATIONSHIP WITH CONSUMERS AND PRESENCE OF INTERMEDIARIES

0 - No networks of producers for marketing agricultural production exist. No relationship with consumers. Intermediaries manage the whole marketing process.

1 - Networks exist but do not work properly. Little relationship with consumers. Intermediaries manage most of the marketing process.

2 - Networks exist and are operational, but don't include women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

3 - Networks exist and are operational, including women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

4 - Well established and operational networks exist with equal women participation. Strong and stable relationship with consumers. No intermediaries.

The details of the question can be found in Table 19. The levels of response are linked to the existence of a network of producers, the proximity of producers and consumers and the involvement of women in the sales process.

Farms with a high CAET score (which are part of the D quartile) are farms that are surrounded by a particularly strong network and that maintain a close link with the consumers of their production

Table 19 : CAET quartile distribution for the network question

CAET quartile distribution for network question					
Quartile	0	1	2	3	4
A	36	14	0	0	0
B	22	27	0	1	0
C	21	15	7	6	0
D	2	9	1	35	3

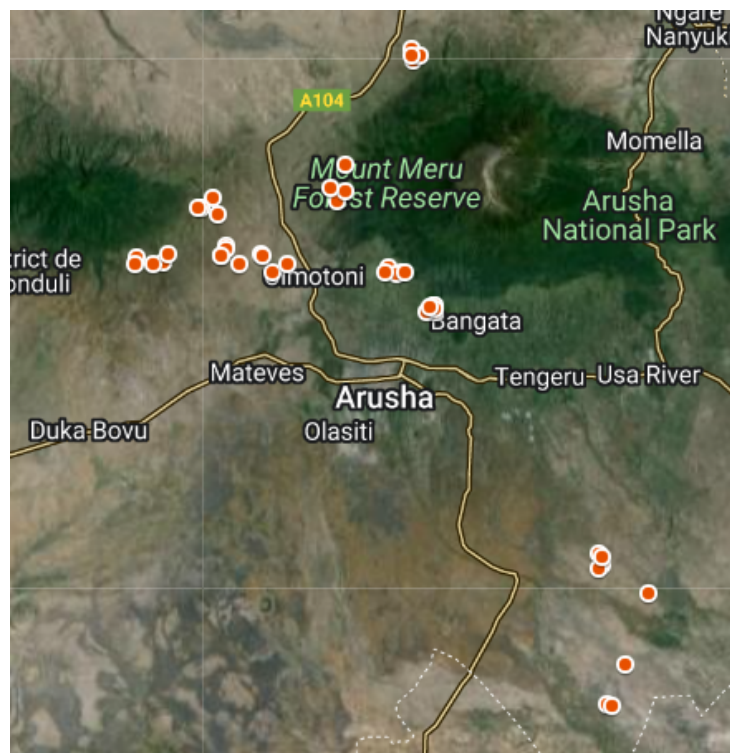


Figure 26 : Mapping of farms answering 3 or 4 at the network question.

The map in Figure 26 represents with a dot the 45 farms that answer the network question with proposals 3 and 4. They are not concentrated in a restricted location and are not particularly close to the urban centre of Arusha or a medium-sized regional locality, in comparison with the location of all the farms (Figure 2).

The ability of a farm to connect to a consumer network and to create direct links with it is therefore not linked to its location.

b. Culture and food tradition

The medians of the quartiles A, B, C, and D for the element "Culture and food tradition" are 33.3, 41.7, 41.7, and 58.3, respectively (the median values (Figure 27) are close to the average values (Table 20)). The medians of quartiles B and C are identical, with quartile A trailing by 8.4 points, while the median of quartile D is remarkably higher, surpassing by 16.6 points.

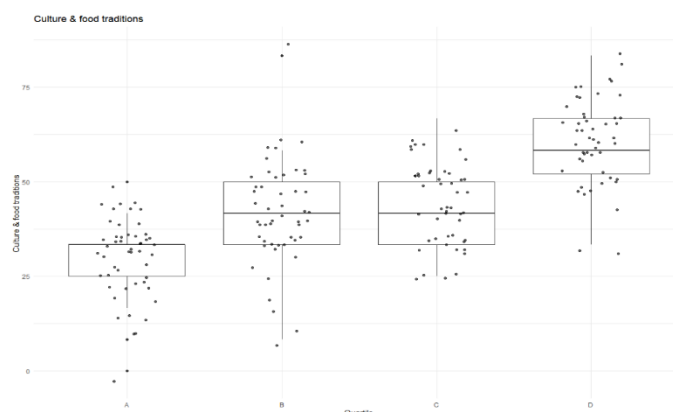


Figure 27 : Boxplot of "Culture and tradition" by CAET quartile

Table 20 : Mean score for the Culture and food elements per CAET quartile.

Mean score for indices of the element Culture and Food per CAET quartile			
	Appropriate diet and nutrition awareness	Local or traditional (peasant / indigenous) identity	Use of local varieties/breeds
A	0.46	2.16	0.98
B	0.96	2.14	1.88
C	1.12	2.39	1.78
D	1.98	3.12	2.24

The values of the averages of the answers to the questions on diet and, varieties and breeds are particularly low, ranging from 0.5 to 2 for the question on diet and from 1 to 2.25 for the question on varieties and breeds.

APPROPRIATE DIET AND NUTRITION AWARENESS

0 - Systematic insufficient food to meet nutritional needs and lack of awareness of good nutritional practices.

1 - Periodic insufficient food to meet nutritional needs and/or diet is based on a limited number of food groups. Lack of awareness of good nutritional practices.

2 - Overall food security over time, but insufficient diversity in food groups. Good nutritional practices are known but not always enforced.

3 - Food is sufficient and diverse. Good nutritional practices are known but not always enforced.

4 - Healthy, nutritious, diversified diet. Good nutritional practices are well known and enforced.

The details of the possible responses to the question regarding diet are outlined in the box above. The response levels are built according to the quantity, diversity, and nutritional aspect of the food, as well as awareness of good nutritional practices.

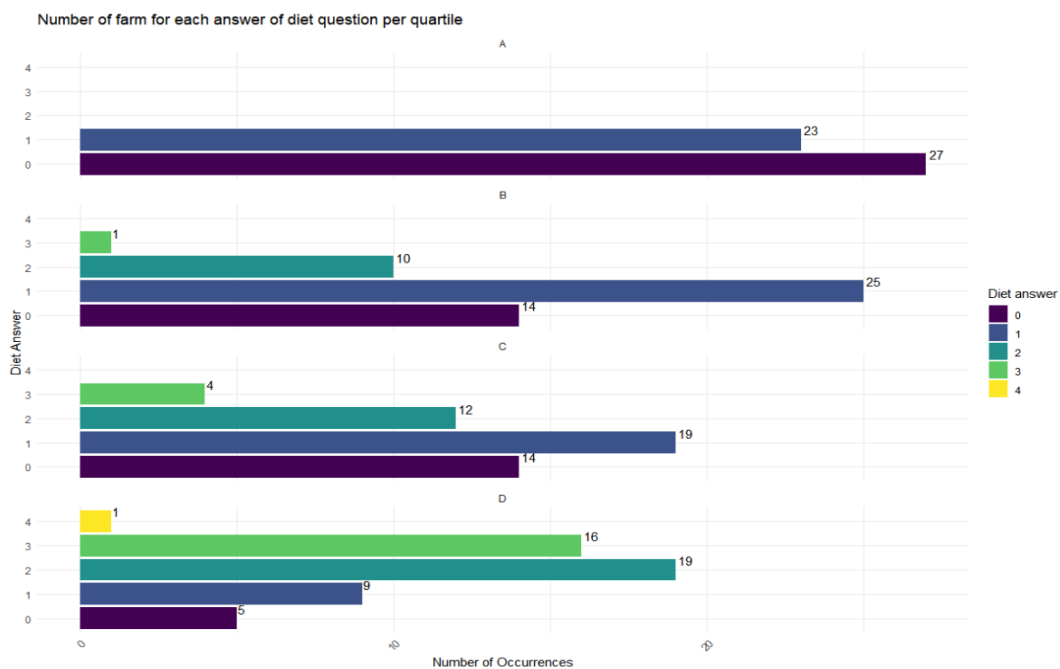


Figure 28 ; Distribution of answers to the question of diet

The lower CAET quartiles only respond with the first two options at the question on diet (Figure 28). Farms that have a low CAET score are affected by a concerning food issue, with the majority consuming systematically insufficient food quantity to meet nutritional needs.

5.8 Farm's repartition according to CAET quartiles

Table 21 classifies each of the 199 farms in our sample according to its location in one of the three agroecological zones, its type of farming system, and its level of CAET.

Table 21 ; Distribution of CAET quartile by agroecological zone and system type

Contingency Table					
Number of occurrences for each combination of system type and agro-ecological zone by quartile.					
Agro-ecological zone	System type	Quartiles			
		A	B	C	D
High land	Diversified	6	0	0	1
	Mixed farming	7	6	6	11
	Tree mixed farming	3	2	0	1
Low land	Diversified	1	0	0	0
	Mixed farming	9	7	7	7
	Tree mixed farming	1	3	1	0
	Trees and livestock farming	0	3	0	0
Mid land	Diversified	9	3	3	1
	Mixed farming	13	18	19	25
	Tree mixed farming	1	7	12	4
	Trees and livestock farming	0	1	1	0

The combination of agroecological zone and farming system that concentrates the most farms in our sample are the mixed farming farms located in the midlands. There are 75 of them, representing 38 % of the total sample (Table 1). Those farms have CAET score in each quartiles category but the proportion of those in the highest quartile (D, 33%) is higher than the proportion of those in the lowest quartile (A, 17%).

Regardless of the agroecological zone, mixed farming farms (which represent 68% of the sample) are close to be evenly distributed across the four quartiles. It should be noted that the proportion of mixed farming farms in each agrozone is higher in the last quartile than in the first for the highlands and midlands, the opposite is true for the lowlands.

The combination of agroecological zone and farming system with the highest proportion of farms in the first quartile is diversified farms in the highlands. Six out of the seven farms with those specifications are in quartile A, while the seventh is in quartile D.

When analyzing, it should be kept in mind that a large majority, 75%, of farms in quartiles C and D have a mixed farming farm system.

These observations highlight the link that can be made between the level of agroecology and the farming system. Systems integrating crop cultivation and livestock farming are rewarded with higher scores (see Section 5.4).

5.9 Diversity and Resilience

The element **Diversity** assesses the diversity of farms from an agronomic perspective through four questions. This element has a clear and understandable structure, as it is easy to grasp what a low or high score represents. The four questions that build it are very straightforward, with simple counting responses.

The first three questions assess the diversity of species and varieties of crops, livestock, and trees. The response levels range from 0 to 4, with zero representing monoculture, farms without livestock, and without tree cultivation, and 4 representing farms with a lot of diversity in each of these aspects. The fourth question addresses the diversity of farm activities.

It is important to remember the notable characteristic of elements related to field practices, including diversity. Their score is not linked to the CAET trend; farms with a high CAET score do not necessarily have a high diversity score and vice versa. This aspect is explored in section 5.3.1.

The evaluation of **Resilience** by the TAPE tool focuses on the financial aspects of variance, income stability, mechanisms to reduce vulnerability, indebtedness and the average score for the element of diversity (an important particularity to keep in mind when comparing diversity and resilience (see Annex 1). It does not capture all aspects of resilience, but it is a good parameter for understanding the general resilience level of farms.

The FAO defines resilience as "the ability to prevent disasters and crises, as well as to anticipate, absorb shocks, and adapt or restore the situation in a quick, effective, and sustainable manner." ("Résilience | Renforcement Des Capacités | Organisation Des Nations Unies Pour l'alimentation et l'agriculture," n.d.) Resilience is fundamental in building more sustainable systems.

It is often acknowledged that more diversified agricultural systems have stronger resilience. Having a greater diversity of cultivated crops allows, for example, the mitigation of the impact of an exceptional event because different crop species respond differently to such events. One may be more resistant to drought, while another may be less affected by the presence of a specific disease. A higher number of crops, therefore, reduces the risk that such events will lead to total crop failure in any given year, as there will always be other crops to rely on.

To determine if these convergences between diversity and resilience are indeed taking place in the farms studied here, the scores of these two elements will be compared.

CROPS

0 - Monoculture (or no crops cultivated).

1 - One crop covering more than 80 percent of cultivated area.

2 – Two or three crops with significant cultivated area.

3 - More than 3 crops with significant cultivated area adapted to local and changing climatic conditions.

4 - More than 3 crops of different varieties adapted to local conditions and spatially diversified farm with multi-, poly- or inter-cropping.

The box above summarizes the responses to the diversity element question regarding crop diversity. Figure 29 shows the resilience scores based on the response levels to the "crops" question. The number of farms for each response level is, in ascending order, 11, 35, 110, 33, and 10. The median resilience scores in the same order are 30.55, 33.33, 33.33, 41.66, and 43.05.

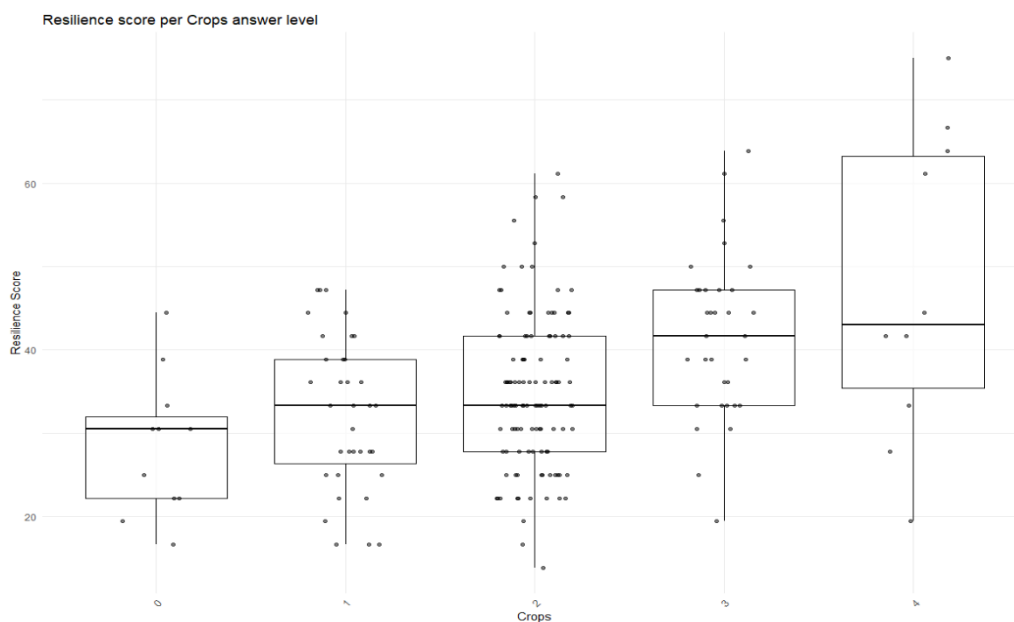


Figure 29 : Relationship between the crop score and the resilience score

The higher the response level for the "crops" question, the higher the resilience score. However, the strength of this relationship is not particularly strong. For example, the median score for level 2 crops, which represents the largest number of farms, is the same as level 1, only 2.78 points higher than level 0, and about ten points lower than the highest level.

Regarding crop diversity in the farms from this study, it appears to have only a slight impact on resilience levels. Therefore, farm resilience does not rely solely on this variable but also on other aspects of farm organization.

5.10 CAET and destination of production

Figure 30 represents the CAET scores of farms ordered according to their responses to the question about the destination of production. In this sample, the destination of farm production does not have an impact on their CAET. The medians of the four categories are not significantly different, ranging from a score of 32 to a score of 38.

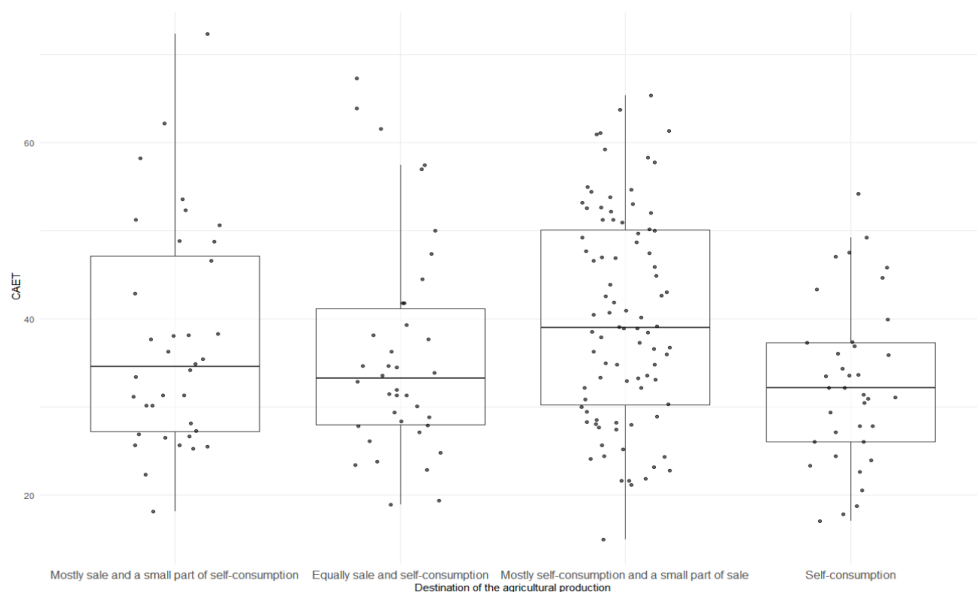


Figure 30 : Boxplot of CAET score according to the production destination

The Figure 31 presents the 10 elements that make up the CAET of the farms in the study according to the destination of their production. The overall CAET scores do not show a huge difference. The two extreme values are separated by only 7 points. These two extremes are the groups "Mostly self-consumption and a small part of sale" and "Self-consumption". Therefore, making a generalization for these two groups, which have a very similar management of their production, is not possible.

Selling part of their production seems to put farms in a comparable dynamic; the categories "Mostly sale and a small part of self-consumption" and "Equally sale and self-consumption" have very similar values, both in terms of CAET and their elements.

Households whose production is only for their own consumption have a relatively low CAET compared to other typologies. This low CAET is due to weak scores in key agroecological elements such as diversity, synergy, resilience, and co-creation of knowledge.

This observation can be analyzed in different ways. The idea here is to suggest hypotheses for reflection without taking sides.

The fact that farms that only consume what they produce have a low score can be seen as either a cause or a consequence. Because they do not engage in sales dynamics, they may not achieve a good score; or conversely, because they do not operate under optimal agroecological conditions, they may not have the opportunity to create a sales dynamic.

This raises the question of whether entering into a sales process is essential to increase their level of agroecology. Is it necessary to sell part of their production to enhance this level?

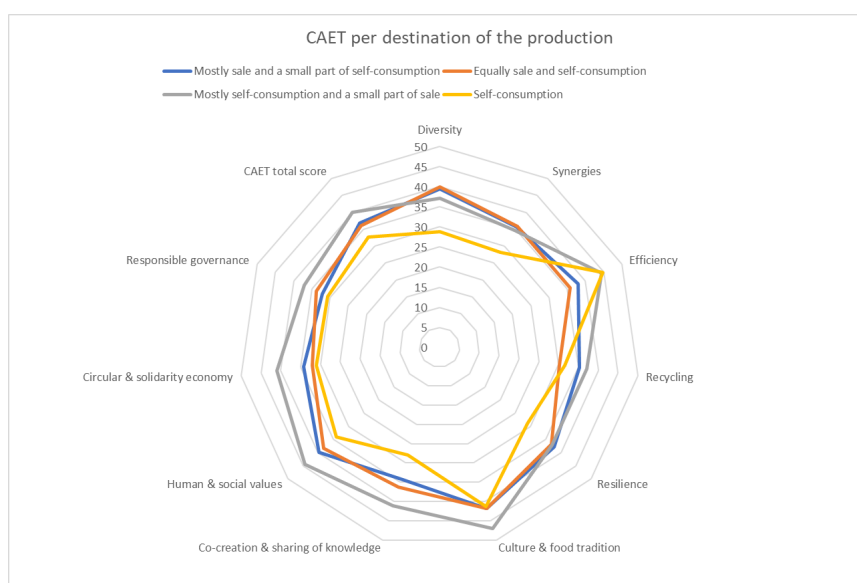


Figure 31 : Radar chart of CAET elements according to destination of production

Table 22 : Statistics of CAET elements according to destination of production

	Diversity	Synergies	Efficiency	Recycling	Resilience	Culture & food tradition	Co-creation & sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET total score
Mostly sale and a small part of self-consumption	40	36	38	35	38	42	34	40	34	32	37
Equally sale and self-consumption	40	36	36	30	37	42	36	38	32	34	36
Mostly self-consumption and a small part of sale	37	35	44	37	37	47	41	44	41	37	40
Self-consumption	29	28	45	32	29	41	28	34	31	31	33

5.11 Individual analysis

Figure 22 shows the score obtained for each dimension of the CAET for each farm. If all the dimensions of the CAET were perfectly aligned within a farm, the colours would be vertically homogeneous and would evolve from the lightest on the left to the darkest on the right in a regular manner. Overall, the logic is respected, except for the efficiency score and diversity score parameters where the farms that perform best are not those with the highest CAET.

This confirms what was previously observed and hypothesized in section 4.3.1. The elements implemented in the field are decoupled from the overall agroecological trend.

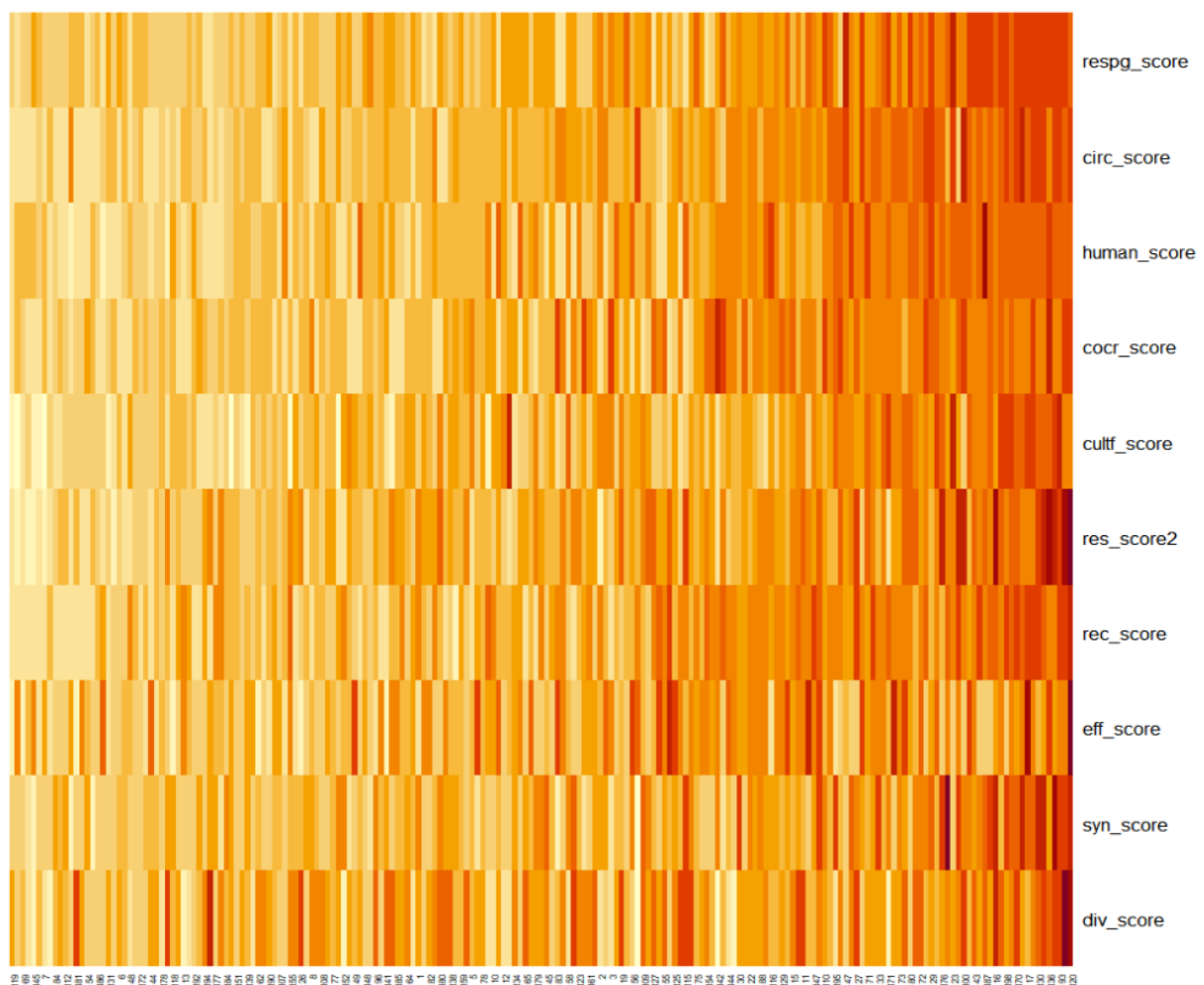


Figure 32 : Heatmap of the elements of the CAET by farm (sorted by global CAET score)

6 Multidimensional performance of agroecology

TAPE's Step 2 collects quantitative data on the core criteria of performance considered essential for the multidimensional sustainability of productive systems in agriculture and strictly linked to the achievement of the SDGs.

By analyzing the links between the variables of TAPE’s Step 1 and Step 2, we can assess the multidimensional performance of farms and the role of agroecology in achieving different dimensions of sustainability.

In the context of this study, we will focus only on the economic dimension.

6.1 Economic dimension

All responses related to economic data are answered for a period of 12 months. The currency of the monetary data is Tanzanian shilling (TSh).

Figure 33 orders the Gross Farm Revenue from agricultural activities of the 199 farms in the sample. The average Gross Farm Revenue from agricultural activities is 840 700 Tanzanian shillings.

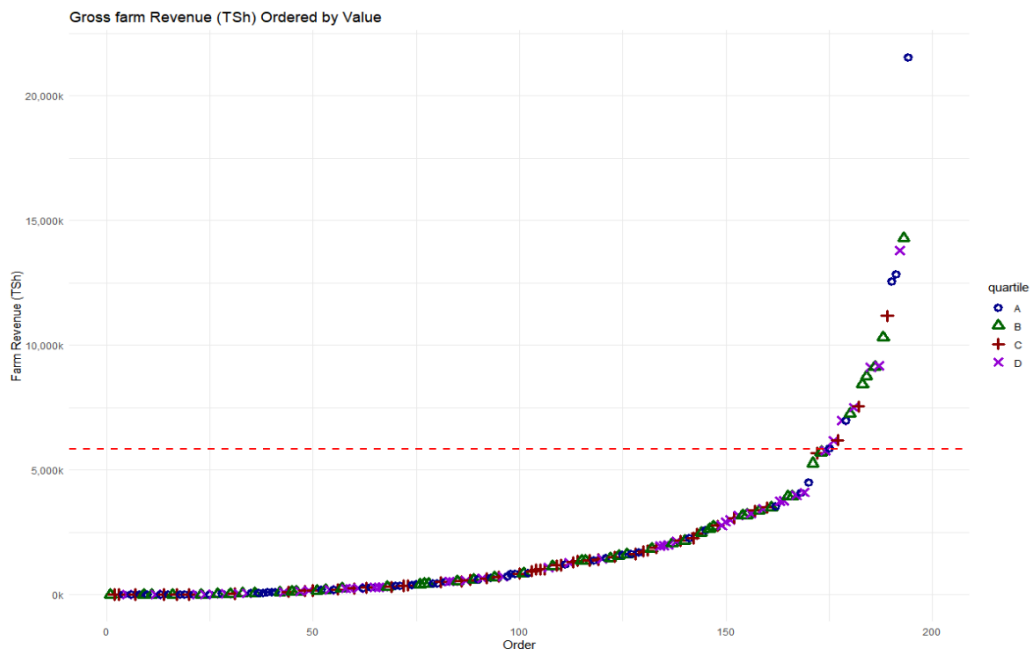


Figure 33 : Distribution of gross farm income – dotted line indicates the 90 % quantile.

The shape of the curve is exponential, but the lower part of the curve still concentrates most of the farms. Ninety percent of the farms have a farm revenue below 5 825 140 TSh.

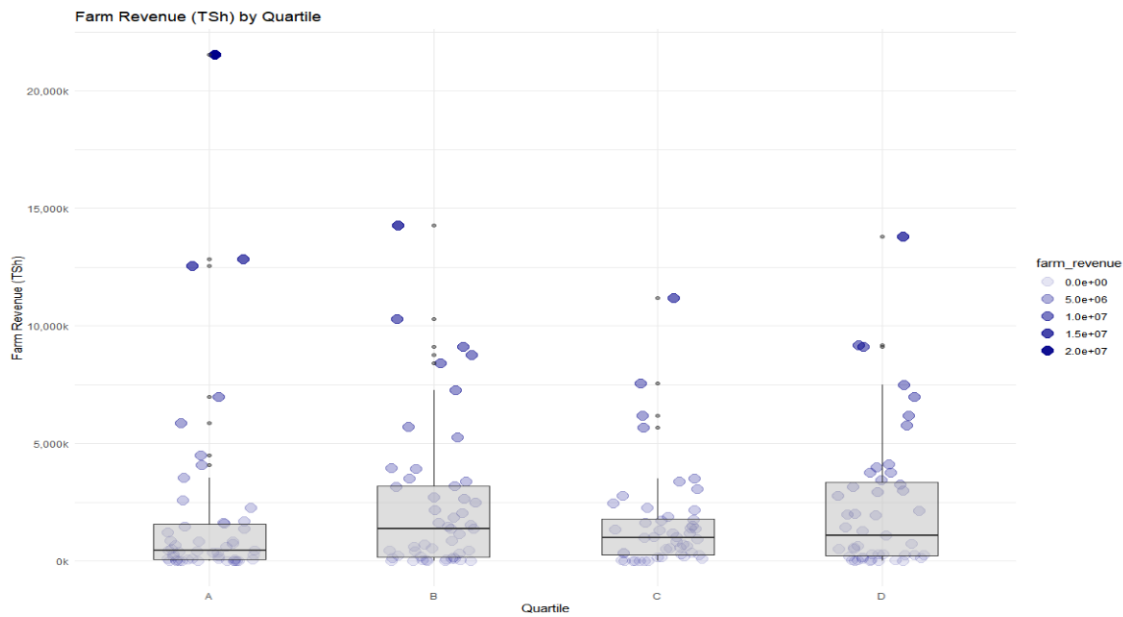


Figure 34 : Boxplot of gross income

Figure 34 presents the values of Gross Farm Revenue from agricultural activities according to the CAET score quartiles. The median farm revenue for quartiles A, B, C, and D is 435.000, 1.360.000, 1.006.250, and 1.091.000 TSh, respectively. The median of quartiles B, C, and D is more than twice as high as the median of quartile A.

A correlation between low revenue and a low CAET level is observed only in the first quartile. There is no general trend of increasing revenue across the top three quartiles. The median values are comparable, with the second quartile having a higher farm revenue value.

It is difficult to determine which of these two parameters is the cause and which is the effect. Overall, farm income does not have an impact on, nor is it impacted by, the level of agroecology measured by CAET quartile. However, it is important to note that farms with a low agroecological score (quartile A) have significantly lower incomes.

These two aspects are not directly linked, but farms with a low CAET score are penalized in their income, or vice versa. A deeper discussion on this subject will take place in section 7.1.

Table 23 : Correlation between Farm revenue and CAET elements

Correlations between Farm Revenue and CAET element											
Diversity	Synergies	Efficiency	Recycling	Resilience (new)	Culture & food traditions	Co-creation and sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET	
0.24	0.19	-0.14	0.05	0.23	0.00	0.02	0.09	0.03	-0.01	0.08	

Table 23 shows that there is no correlation between farm revenue and CAET (0.08). There are weak negative and positive correlations between farm revenue and the elements that compose the CAET.

The correlation between the CAET and the farm revenue quartile by quartile is weakly positive for the lowest and highest CAET quartiles, there is no correlation for the intermediate quartiles (Table 24).

The correlation between farm revenue and the elements of diversity and resilience is stronger for farms in the higher CAET quartiles. This observation is particularly intriguing as it suggests that the impact of integrating greater diversity and enhanced resilience on income is more pronounced in farms with higher overall agroecology scores. In other words, the more agroecological a farm is, the more its income benefits from diversifying its production.

The correlation between farm revenue and the synergy element is weaker for farms in the higher CAET quartiles. In general, the more agroecological a farm is, the less an increase in synergy contributes to higher income. This trend contrasts with what was observed regarding diversity. The added value of implementing agricultural practices that emphasize synergy is more pronounced when a farm has a lower agroecological level..

Table 24 : Correlation between Farm revenue and score by quartile category

Correlations between Farm Revenue and Scores by quartile category											
Quartile	Diversity	Synergies	Efficiency	Recycling	Resilience (new)	Culture & food traditions	Co-creation and sharing of knowledge	Human & social values	Circular & solidarity economy	Responsible governance	CAET
A	0.06	0.42	-0.22	0.15	0.20	0.21	-0.03	0.21	0.01	-0.12	0.24
B	0.25	0.07	-0.19	-0.03	0.19	-0.19	-0.12	-0.08	0.04	0.21	-0.07
C	0.27	0.16	-0.23	0.03	0.29	0.02	0.04	0.00	-0.22	-0.24	-0.01
D	0.50	0.17	-0.05	0.04	0.44	-0.23	0.31	0.33	0.19	-0.14	0.30

7 Enumerators

As explained in section 3.4, the data was collected by ten enumerators. Are the response levels given by farmers influenced by the enumerator who asked the questions?

Each day during data collection, the ten enumerators interviewed farmers from 20 farms across two villages. Therefore, it is possible to compare the results between enumerators since the sample that each enumerator interviewed is homogeneous in terms of both number and location.

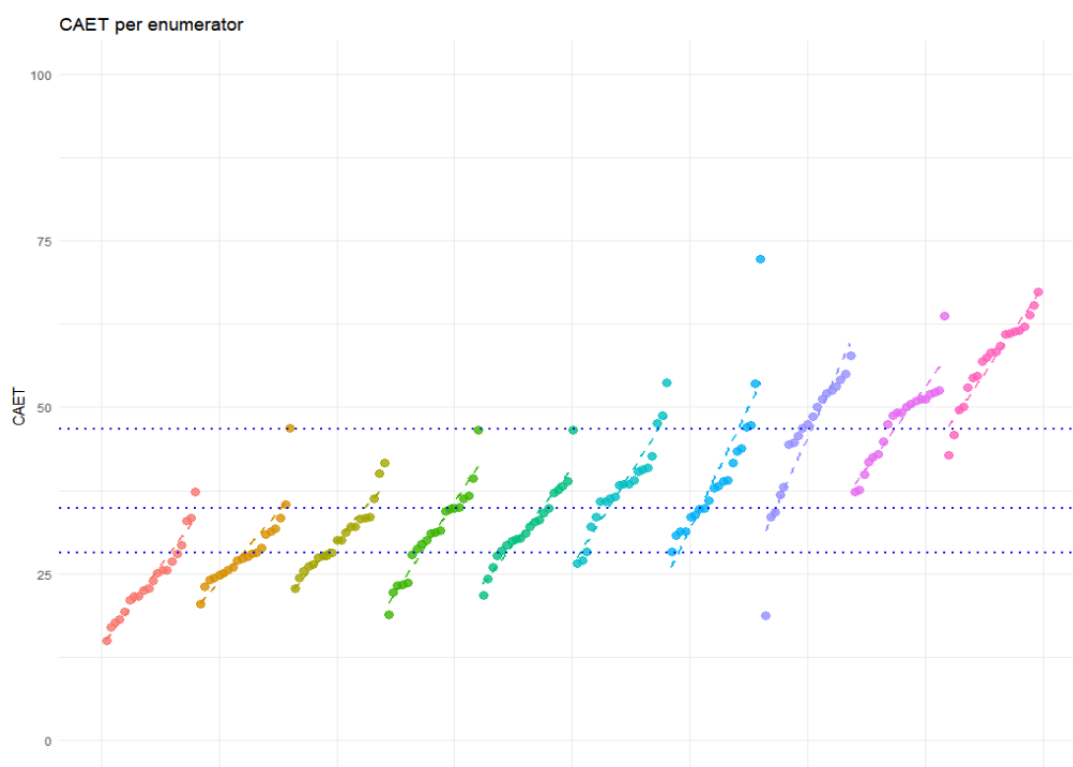


Figure 35 : CAET per enumerator (each dot is a farm, one color per enumerator)

Figure 35 shows the CAET scores of farms according to the enumerators, who are arranged in ascending order based on the average CAET of the farms they interviewed. The dotted horizontal lines represent the quartile boundaries of CAET.

It's striking how much the "enumerator" factor seems to have a significant impact on the data. The lowest CAET score evaluated by the enumerator with the highest average CAET is higher than the highest score evaluated by the enumerator with the lowest average CAET. Beyond being striking, this raises concerns about the accuracy of the collected values.

The decision was made not to modify the data by adjusting it to try to mitigate the effect of this factor using coefficients or other means, as such practices can be risky and distort reality. Knowing that it wouldn't have been just a small portion of the data that needed adjustment but the entire dataset.

7.1 The hypothetical causes

The fact that different individuals conducted interviews for the same study makes it very challenging to achieve consistency in responses. Each person is unique, with their own way of interpreting and asking questions. This complicates the goal of being able to compare responses across all interviews. What this data suggests is that the coordination efforts to harmonize the scales of different questions need to be further developed.

To understand those differences, one hypothesis is that some questions are more difficult to assess, with the appropriate level of response being more subject to the enumerator's judgment, leading to greater variance linked to the enumerator. To explore this further, it is useful to closely examine two questions from the elements that have very different approaches.

The "crops diversity" question within the *Diversity* element asks about the number of crop species, with straightforward response options ranging from 0 for monoculture to four for more than three crops (see Survey guidebook in Annex 1).

The second question assesses the level of participation of producers in the governance of land and natural resources within the *Responsible Governance* element. The structure of this question is detailed in the box below. This question addresses a more complex topic than simply counting the number of crop species. It is less straightforward for both the enumerator and the respondents to provide a clear answer to it.

PARTICIPATION OF PRODUCERS IN GOVERNANCE OF LAND AND NATURAL RESOURCES

With gender perspective

0 - Producers are completely excluded from the governance of land and natural resources. There is no gender equity in the governance of land and natural resources.

1 - Producers participate in the governance of land and natural resources but their influence on decisions is limited. Gender equity is not always respected.

2 - Mechanisms allowing producers to participate in the governance of land and natural resources exist but are not fully operational. Their influence on decisions is limited. Gender equity is not always respected.

3 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. They can influence decisions. Gender equity is not always respected.

4 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. Both women and men can influence decisions.

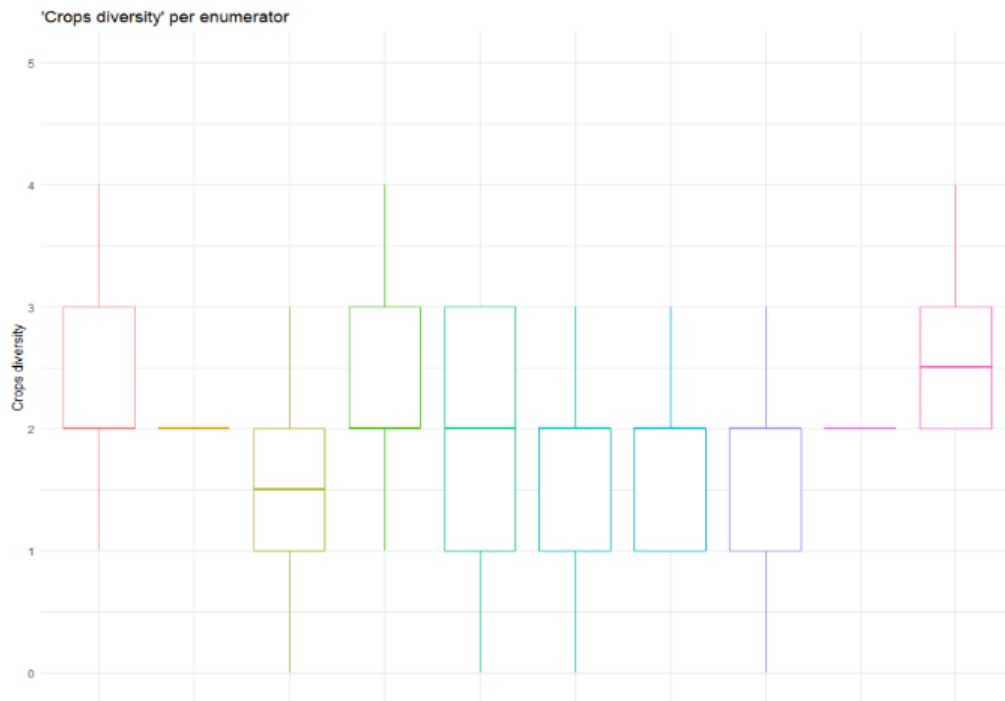


Figure 36 : Boxplot of score according to enumerator for Crop diversity element

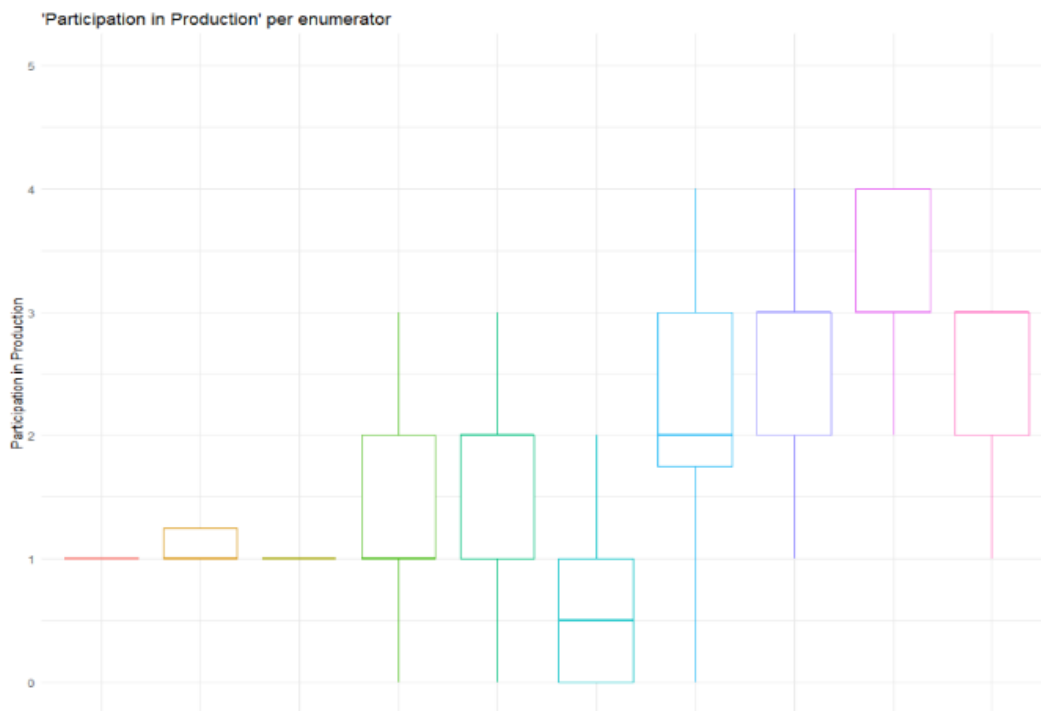


Figure 37 : Boxplot of scores according to enumerators for elements "Participation in production"

Figure 36 and Figure 37 present the boxplots of responses to these two questions based on the enumerator who asked them. The hypothesis made earlier is confirmed. While the medians of responses for each enumerator are relatively similar, around 2, for the "crop diversity" question, the medians are significantly different for the "Participation in Production" question. The differences between enumerators observed for the "Participation in Production" question correspond, in terms of ranking, to the values observed in Figure 35, which showed the CAET values by enumerator.

This indicates that it is indeed these more complex questions, which are challenging for respondents to position themselves on, that create differences between enumerators. Should the questions themselves be reconsidered, or should more emphasis be placed on these specific questions during enumerator training? These questions address important aspects of agroecology that would be unfortunate not to evaluate. The relevance of asking certain types of questions at the farmer level may also need to be reconsidered.

Table 25 : Variance of median by enumerators for the different elements of CAET Table 25 shows the variance of the medians for each element's score by enumerator, and **Erreur ! Source du renvoi introuvable.** 29 allows to visualize these variances. These values highlight which elements are subject to significant variance between enumerators. Unsurprisingly, the elements that assess field implementation have the lowest variance, while social elements and those related to the enabling environment for agroecology exhibit higher variances. Elements that deal with less tangible aspects, where it could be harder for farmers to position themselves, tend to show more variance between enumerators.

Table 25 : Variance of median by enumerators for the different elements of CAET

Variance of Medians by Inquirer Category	
Elements	Variance of Medians
Diversity	43.84
Synergies	59.57
Efficiency	79.10
Recycling	251.30
Resilience (new)	33.03
Culture & food traditions	139.66
Co-creation and sharing of knowledge	394.48
Human & social values	263.56
Circular & solidarity economy	455.44
Responsible governance	311.73

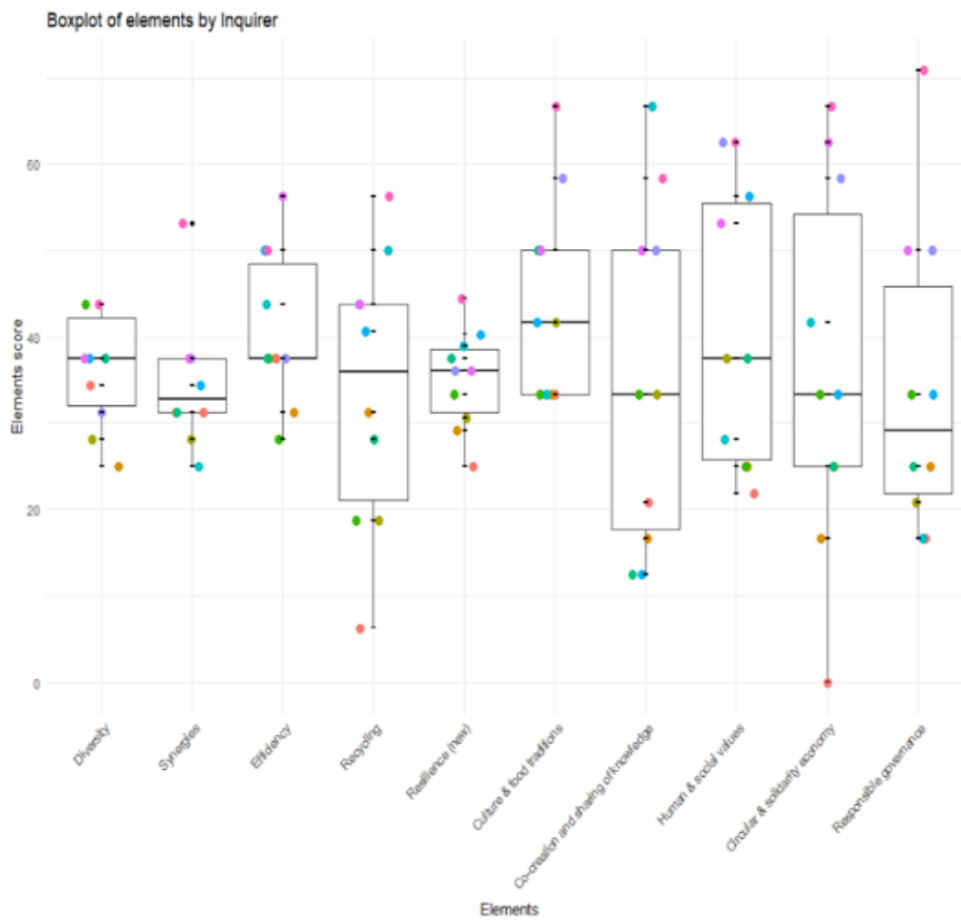


Figure 38 : Boxplot of element median according to enumerator (each color is a different enumerator)

The fact that these specific elements show higher variance is problematic because they are the ones contributing the most to the highest CAET score (see Section 5.6 and Figure 24). The analysis regarding the importance of these elements in constructing high CAET scores might be flawed in light of the findings in this section.

8 Modeling

8.1 Method

Creating models allows you to capture the mechanisms in place between different variables. The main objective is to understand what may explain CAET scores.

To improve the efficiency of the estimates, the SUREG method will be used. This method allows several regression equations to be estimated at the same time, considering the potential correlations between the residuals of these equations. By jointly analyzing the correlation of the residuals of the different regressions, the tool allows the parameters of each of them to be defined more precisely.

In this case, the equation explaining the CAET scores will be associated with two other equations: one on farm revenue and the other on the animal/income proportion divided by farm revenue.

As far as the explanatory variables are concerned, the rationale is to look at parameters that describe the farm in a simple and direct way : the number of workers on the farm and the surface area. These are agronomic parameters, all directly related to the practices of agriculture. They provide effective information on the specific dynamics of each farm. A description of each of them is given below.

8.2 Description of explanatory variables

Total Area - The size of the farm is a major characteristic of the farm. Depending on its size, farming practices from farm to farm will not be the same. A larger farm will not manage its space in the same way as a smaller farm. The size of the farm also provides information on the land wealth of a household. In the specific case of this study, farms do not have very large differences in size, which is important to keep in mind when analysing the impact of this parameter.

Number of workers in the farm - The Number of workers in the farm is a parameter that describes the structure of the farm well. A farm is above all humans who work to produce from the land. Farms that are supported by a different number of people do not have the same dynamic.

Number of crop/tree species - This parameter is the answer to the question "How many crop/tree species do you grow?". The number of crop and tree species provides information on the diversity of production on farms. This parameter influences the dynamics of a farm, possibly impacting its revenue and increasing its resilience to climatic hazards.

Livestock - The number of animals on a farm provides a very concrete understanding of how it is structured. This figure provides direct information on animal and livestock production. It also allows us to understand the size and wealth of farms, animals being a significant asset.

8.3 Description of control variables

The control variables will allow us to ensure that the variability of our explanatory variables is not hidden behind one of these variables. The choice was made to take four categorical variables as control variables.

Agroecological zone - The different agroecological zones have a significant impact on the activities of the farms they house. The specific social and environmental context of each of them dictates, in part, the conduct of the farms in this study.

Income compared to three years ago - This parameter takes the answers to the question "How do you compare your income today compared to three years ago?". The three proposals being "More income", "Same income" and "Less income". This question provides an understanding of how the financial situation of farms changes over a three-year period. This financial situation can be a cause or a consequence of a high level of agroecology and is linked to the income of the farm without being a parameter that builds it.

Destination of the production - This is the answer to the question "What is the main destination of agricultural production? The four possible answers are "Mainly sales and a small part of self-consumption", "Also of sales and self-consumption", "Mainly of self-consumption and a small part of sales" and "Self-consumption".

This question allows us to understand whether the farm studied sells its products or work only for its self-consumption. This is an aspect that structures the farm itself and the relationship between it and the community.

Enumerator - As shown in chapter 7, the answers given by respondents may vary depending on who interviewed them. To capture this factor of variation without adding too many levels to the model, three categories were created, the first of which included the four enumerators that had the four lowest CAET averages, the second included the next two and the last four that gave the highest scores.

8.4 Regression equations

The three regressions are structured as follows. The choice was made to take the logarithm of the variables to be explained and the explanatory variables in order to better represent the relationships between variables by eliminating the effect of different scales.

$$\begin{aligned} \log(CAET) = & \beta_0 + \beta_1 \log(\text{Total area}) + \beta_2 \log(\text{Number of farmer in the farm}) \\ & + \beta_3 \log(\text{Number of crop - tree species}) \\ & + \beta_4 \log(\text{Number of animals}) + \beta_5 \text{Agroecologicalzone} \\ & + \beta_6 \text{Income compare to three years ago} \\ & + \beta_7 \text{Destination of production} + \beta_8 \text{Enumerator} + \epsilon_1 \end{aligned}$$

$$\begin{aligned} \log(\text{Farm Revenue}) &= \beta_0 + \beta_1 \log(\text{Total area}) + \beta_2 \log(\text{Number of farmer in the farm}) \\ &+ \beta_3 \log(\text{Number of crop - tree species}) \\ &+ \beta_4 \log(\text{Number of animals}) + \beta_5 \text{Agroecologicalzone} \\ &+ \beta_6 \text{Income compare to three years ago} \\ &+ \beta_7 \text{Destination of production} + \beta_8 \text{Enumerator} + \epsilon_1 \end{aligned}$$

$$\begin{aligned} \log\left(\frac{\text{Animalrevenue}}{\text{Farmrevenue}}\right) &= \beta_0 + \beta_1 \log(\text{Total area}) + \beta_2 \log(\text{Number of farmer in the farm}) \\ &+ \beta_3 \log(\text{Number of crop - tree species}) \\ &+ \beta_4 \log(\text{Number of animals}) + \beta_5 \text{Agroecologicalzone} \\ &+ \beta_6 \text{Income compare to three years ago} \\ &+ \beta_7 \text{Destination of production} + \beta_8 \text{Enumerator} + \epsilon_1 \end{aligned}$$

Ci-dessous le résultat de l'utilisation du SUREG par le logiciel R.

systemfit results

method: SUR

	N	DF	SSR	detRCov	OLS-R2	McElroy-R2
system	408	366	210.277	0.023025	0.437093	0.479928

	N	DF	SSR	MSE	RMSE	R2	Adj R2
CAET	136	122	5.15961	0.042292	0.205650	0.610096	0.568549
farmRevenue	136	122	150.89398	1.236836	1.112131	0.485568	0.430751
anrevfarmrev	136	122	54.22361	0.444456	0.666675	0.190706	0.104470

The covariance matrix of the residuals used for estimation

	CAET	farmRevenue	anrevfarmrev
CAET	0.04229192	0.00302521	-0.00512065
farmRevenue	0.00302521	1.23683591	-0.06698135
anrevfarmrev	-0.00512065	-0.06698135	0.44445581

The covariance matrix of the residuals

	CAET	farmRevenue	anrevfarmrev
CAET	0.04229192	0.00302521	-0.00512065
farmRevenue	0.00302521	1.23683591	-0.06698135
anrevfarmrev	-0.00512065	-0.06698135	0.44445581

The correlations of the residuals

	CAET	farmRevenue	anrevfarmrev
CAET	1.0000000	0.0132273	-0.0373493
farmRevenue	0.0132273	1.0000000	-0.0903407
anrevfarmrev	-0.0373493	-0.0903407	1.0000000

SUR estimates for 'CAET' (equation 1)

Model Formula: log_caet_tot2 ~ log_totarea + log_num_workers + log_num_crops_c1 + log_num_animals_a1 + agro_zone + inc3 + dest + inquirer_cat

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	3.27374503	0.12693377	25.79097	< 2.22e-16 ***
log_totarea	0.02302812	0.02626238	0.87685	0.382292
log_num_workers	0.05759125	0.03755514	1.53351	0.127739
log_num_crops_c1	-0.02695886	0.06117378	-0.44069	0.660215
log_num_animals_a1	0.03228475	0.04270968	0.75591	0.451159
agro_zoneLow land	-0.04976130	0.05901483	-0.84320	0.400767
agro_zoneMid land	0.07876957	0.04773942	1.64999	0.101517
inc33	-0.02384414	0.06825402	-0.34934	0.727433

```

inc34          -0.00145377  0.06974459 -0.02084  0.983404
dest3          -0.01759266  0.05476732  0.32123  0.748589
dest4          -0.04587778  0.04824281 -0.95098  0.343497
dest5          -0.17399366  0.07590450 -2.29227  0.023604 *
inquirer_cat2  0.26488096  0.05557252  4.76640  5.2333e-06 ***
inquirer_cat3  0.51357122  0.04432480  11.58654 < 2.22e-16 ***

```

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.20565 on 122 degrees of freedom
Number of observations: 136 Degrees of Freedom: 122
SSR: 5.159615 MSE: 0.042292 Root MSE: 0.20565
Multiple R-Squared: 0.610096 Adjusted R-Squared: 0.568549

SUR estimates for 'farmRevenue' (equation 2)

Model Formula: log_farm_revenue ~ log_totarea + log_num_workers + log_num_crops_c1 + log_num_animals_a1 + agro_zone + inc3 + dest + inquirer_cat

	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	13.1729952	0.6864431	19.19022	< 2.22e-16	***
log_totarea	0.5902679	0.1420239	4.15612	6.0416e-05	***
log_num_workers	0.3165789	0.2030938	1.55878	0.1216384	
log_num_crops_c1	0.8727661	0.3308207	2.63818	0.0094213	**
log_num_animals_a1	0.1791238	0.2309690	0.77553	0.4395261	
agro_zoneLow land	-0.5666563	0.3191453	-1.77554	0.0783016	.
agro_zoneMid land	-0.5226577	0.2581692	-2.02448	0.0451046	*
inc33	0.2307383	0.3691098	0.62512	0.5330591	
inc34	-0.2619447	0.3771706	-0.69450	0.4886897	
dest3	-0.5499514	0.2961753	-1.85684	0.0657453	.
dest4	-0.1592526	0.2608915	-0.61042	0.5427210	
dest5	-1.0825289	0.4104827	-2.63721	0.0094469	**
inquirer_cat2	-0.2317198	0.3005297	-0.77104	0.4421753	
inquirer_cat3	-0.0145087	0.2397034	-0.06053	0.9518345	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.112131 on 122 degrees of freedom
Number of observations: 136 Degrees of Freedom: 122
SSR: 150.893981 MSE: 1.236836 Root MSE: 1.112131
Multiple R-Squared: 0.485568 Adjusted R-Squared: 0.430751

SUR estimates for 'anrevfarmrev' (equation 3)

Model Formula: log_anrev_farmrev ~ log_totarea + log_num_workers + log_num_crops_c1 + log_num_animals_a1 + agro_zone + inc3 + dest + inquirer_cat

	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	-0.58697285	0.41149331	-1.42645	0.156294	
log_totarea	0.04282349	0.08513724	0.50299	0.615876	
log_num_workers	0.16378193	0.12174606	1.34527	0.181032	
log_num_crops_c1	0.39303495	0.19831286	1.98189	0.049739	*
log_num_animals_a1	-0.34894656	0.13845603	-2.52027	0.013018	*
agro_zoneLow land	0.18404108	0.19131401	0.96198	0.337960	
agro_zoneMid land	-0.04363836	0.15476143	-0.28197	0.778443	
inc33	-0.00445027	0.22126557	-0.02011	0.983986	
inc34	-0.08358984	0.22609767	-0.36971	0.712242	
dest3	-0.19021907	0.17754444	-1.07139	0.286110	
dest4	-0.05732607	0.15639332	-0.36655	0.714589	
dest5	-0.12140880	0.24606683	-0.49340	0.622619	
inquirer_cat2	-0.43400585	0.18015473	-2.40907	0.017488	*
inquirer_cat3	-0.25402844	0.14369194	-1.76787	0.079583	.

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.666675 on 122 degrees of freedom
Number of observations: 136 Degrees of Freedom: 122
SSR: 54.223609 MSE: 0.444456 Root MSE: 0.666675
Multiple R-Squared: 0.190706 Adjusted R-Squared: 0.10447

8.5 Interpretation

8.5.1 CAET

The R^2 of CAET is 0.61, the model explains a significant portion of the variability of CAET. No specific explanatory variable explains the CAET score.

The level of agroecology is therefore not dependent on the production characteristics of each farm. Each farm has its own path in terms of agroecology, regardless of the size of the farm, the number of workers, the number of crop/tree species grown and the number of animals. This is very interesting information to grasp, it says a lot about the approach to agroecology of the farms in our study.

It is important to note that this study is conducted at the outset of the program, involving farmers who are not yet acquainted with the concept of agroecology. Therefore, the CAET does not assess the degree of engagement with the concept but rather provides a descriptive evaluation of the pre-existing level of agroecological practices.

When it comes to the control variables, one factor that is highly significant is the enumerator. A large part of the variability is unfortunately explained by the impact of the enumerator in the level of response to the questions. This is important to know in order to carefully analyze the data in this study. This is an important point that can be improved for future studies.

Category 5 of "destinations" has a negative impact on the CAET. This category corresponds to farms that do not sell any part of their production, that produce only for their own consumption. a non-commercial orientation does not encourage agroecological practices.

The correlations of the residuals

	CAET	farmRevenue	anrevfarmrev
CAET	1.0000000	0.0158193	-0.0448647
farmRevenue	0.0158193	1.0000000	-0.0522011
anrevfarmrev	-0.0448647	-0.0522011	1.0000000

The correlation of the residuals of CAET and the other three equations is very weakly negative, which means that the residuals that are not captured by the CAET model do not have the same dynamics as the residuals that are not captured by the other two models. The added value of using SUREG in this case is therefore not huge.

8.5.2 *Farm revenue*

The R² of 0.44 gives relative but still solid credit to this model.

Farm income is strongly correlated with the size of the farm, which makes sense.

Farm income is also correlated with the number of crop/tree species, which confirms that farms with a wider range of crop production have increased financial stability. Alternatively larger farms have more opportunity to have more crops.

It is noted that the number of animals does not influence income. This may be explained by the fact that animals are, in addition to being a productive vector, a savings reserve. Their number therefore tells us about the strength of the farm without impacting its income year-round.

As far as control variables are concerned, belonging to the Midland agroecological zone affects income negatively. Only consuming one's production, not selling it, logically also has a negative impact on income.

8.5.3 *The animal revenue / farm revenue ratio*

Through this proportion, it is possible to grasp the importance of the income from animal production. The R^2 of the model for this variable is 0.16, which means that the model explains only a small portion of the variance. The number of crop/tree species is positively significant with this proportion. Another significant factor in this model is the number of animals and this one has a negative parameter value. It's not particularly intuitive to think that the more animals there are on the farm, the less important the share of income from animals in the total income. It is still possible to find explanations. Farms with a lot of animals are the farms that produce the most in general and therefore have even greater income from other agricultural activities, thus reducing the share of livestock in income. As said above, animals are not always intended to be an object of production, they can be savings or meet other needs than to create income. At the control parameter level, only the category of enumerators that have intermediate CAET means has an impact on this proportion.

9 Discussion

9.1 Agroecology in the lives of interviewed farmers

This study is part of the Kilimo Endelevu Arusha program led by NGOs and peasant organizations with farmers from the rural Arusha region. The main goal of the program is to “improve food and farm income security of small scale farmers through sustainable land management, agroecological intensification and by creating a favorable governance context for sustainable food systems,” explains Monica Morison, who works for RECODA, in an explanatory video about the program (Iles de Paix 2022). Improving food and farm security is crucial because the situation for farmers in the region is not ideal, as explained by Sylvester Masanja, who also works for RECODA: “Food insecurity is a major concern in the Arusha Region. It is a consequence of natural resources and land degradation, low skills in family farming and inadequate government support for developing sustainable, environmentally friendly agriculture oriented at food sovereignty.”

Agroecology fits within these objectives because it embodies the philosophy of sustainable agriculture: helping farms build sustainable agricultural systems that are solid over the long term, resilient, capable of overcoming difficult years marked by plant diseases, climatic uncertainties, and income declines is the main goal of KEA.

In this broader context of the KEA program, this study aims to understand how the farms in the program align with the concept of agroecology using the TAPE tool. It examines how they stand at the beginning of a 5-year program, at a time when the farmers do not yet have an agroecological vision of their profession because they have not yet embraced the concept. In this case, the assessment of agroecological levels is purely descriptive as a baseline for further assessments.

The main lesson from the data analysis is that, according to TAPE, the farms surveyed have, on average, a low level of agroecology (see section 5.2.). The low scores for all elements indicate that the studied farms do not have an agroecological approach to agriculture at all levels. It is therefore legitimate to work on increasing this level through the program. The observation of these low agroecological levels suggests that developing a more agroecological approach could be part of the solution to the problems that farmers face. If their level of agroecology were already very high, the issues they face might not be resolvable by agroecological solutions, as there would be no room for improvement from that perspective.

Through the analysis of agroecological levels defined by TAPE, it is notable that farms with more diversified systems, such as mixed crop-livestock systems, receive better CAET scores compared to those with only cropping systems (see section 5.5). When constructing an agronomic program, the link between the agricultural system and agroecological performance should be kept in mind. The approach differs when considering the evolution of an exclusively livestock farm, an exclusively crop farm, or a mixed farm.

More broadly, the results of this study show that farms can have significant differences in many aspects, such as their environment, agricultural systems, income levels, etc. The reflection with farmers should take this into account and adapt to the specific context of each farm.

The model teaches us that production data, farm size, number of workers, number of crop/tree species and the number of animals on the farm do not positively or negatively influence the agroecological level of the farms (see section 8.5.1). This is an interesting finding; intuitively, it can be thought that these data, which are central to farm structuring, would affect the agroecological level, which is intrinsically linked to farm structure. However, this is not the case. The agroecological level of the farms in this study is built independently of these characteristics. The agroecological level appears to be the result of the farmer's willingness rather than a dynamic stemming from specific production characteristics. This discovery allows presenting the agroecological approach as accessible to all types of farms.

Within the studied farms, the level of agroecology is not directly related to income level (see section 6.1 and Table 23). However, farms with a low agroecological level tend to have the lowest incomes, on average, twice as low. This observation highlights agroecology as a means to escape financial difficulties for the poorest farms. The agroecological approach seems to act as a stabilizer of income without being a continuous booster beyond a certain level. This is a point to keep in mind when presenting agroecology to farmers. It is better not to promote agroecology as an obvious income booster to avoid creating frustration.

The use of the SUREG estimator shows that the correlation between CAET residuals and residuals of other variables, such as farm revenue and the proportion of animal revenue to farm revenue, is very low. This suggests that agroecological performance is unrelated to production performance. In the context of support programs like KEA, this indicates greater relevance for a "sprinkling" strategy, where the goal is to reach everyone equally and allow ideas to take root over time, as opposed to a "champion" strategy, where the philosophy is to first push a few very successful farmers who then serve as examples for the rest of the community. The "champion" strategy would be more relevant if CAET residuals were positively correlated with production residuals. Since being agroecological is not more financially profitable, farmers will not have the objective of becoming like the "champions" of agroecology. In this case, it is better to advocate for agroecology to a larger audience to convince them of its benefits beyond direct income aspects.

Through discussions in different villages, farmers are enthusiastic about being part of a reflective project on agricultural practices. Through these discussions, farmers also express the difficulties they face. These difficulties are often related to the core of their profession, cultivate the land, such as crop diseases affecting maize and leading to zero yields.

A positive dynamic is clearly emerging around this program because both the program technicians and the farmers are eager to work together to find solutions to problems in a constructive spirit. Farmers welcome agroecological proposals with an open mind, even though agroecology is not a conventional concept and might initially seem somewhat disconnected from concrete practices.

9.2 Reflection on the TAPE tool

The TAPE tool is well-crafted in the sense that it is built through a deep reflection on agroecology in general and on how to evaluate it. "STEP1" allows for a simple yet accurate assessment of the 10 elements that form the backbone of agroecology. The idea of having created "STEP2" to evaluate aspects that are external to agriculture but focus on the well-being

of farmers and other concepts related to sustainable development goals, for then be able to create links between "STEP1" and "STEP2," is brilliant.

When it comes time to use the tool concretely, unfortunately, difficulties arise in transitioning from theory to practice.

One difficulty is finding the response option that best corresponds to reality among the proposed answers. In "STEP1," there are questions that resonate with the reality of farms but for which it is difficult to choose the appropriate answer. An example is the questions that compose the element "Responsible governance" (see details in Survey guidebook in Annex 1). The response options for these questions attempt to capture the level of recognition of producer's rights, the level of producer's involvement in associations and in the management of natural spaces. It is not always easy for farmers to position themselves with the level of precision required by the survey with respect to these questions.

Specifically, determining where they stand between the options "Producers participate in the governance of land and natural resources but their influence on decisions is limited. Gender equity is not always respected." and "Mechanisms allowing producers to participate in the governance of land and natural resources exist but are not fully operational. Their influence on decisions is limited. Gender equity is not always respected." for the question "Participation of producers in governance of land and natural resources" is not always evident.

The large differences between responses collected by the different enumerators are a very concrete indicator of these difficulties (see section 7). When the question is unclear, the level of response is more likely to be influenced by the personal judgment of the enumerator.

Upon discovering the data, inconsistencies appear in the evaluation of "STEP 2," which is otherwise very straightforward. In very small-scale farms like those evaluated in this study, there is not always strict accounting for productive activities. The survey asks for answers to accounting questions that the farmer may not have, such as total annual production or income-related data. Data collected in these areas can therefore be unreliable.

For example, 25 out of 37 farms that respond with "Self-consumption" to the question about the destination of production answer with a positive value to the question about farm revenue. It is not possible that so many farms that do not sell their production generate revenue related to their agricultural activity. Therefore, there is an inconsistency related to the responses to this question, either at the level of the question about the destination of production, the question about farm revenue, or both. This situation is recurring in the collected data; the problem is not isolated.

Agroecology is not the simplest concept to grasp, and it is even less straightforward to evaluate. Developing a framework to assess agroecology is no small feat and inevitably encounters difficulties.

A feedback explaining the specific operational difficulties in implementing the TAPE tool for this study can be found in the Annex 2.

10 Conclusion

This study has provided a better understanding of the characteristics of a highly representative sample of farms from the Kilimo Endelevu Arusha program. More specifically, it has offered insights into their dynamics from an agroecological perspective, using the TAPE tool.

The farms participating in this study, at the beginning of the program, do not, on average, have a very high agroecological level. Despite their location within a 35-kilometer radius, they are highly heterogeneous in their structure.

The agroecological level of the farms in this study does not follow a clearly identifiable trend. A large number of parameters were tested, notably through the use of a regression model, and it was found that the agroecological level is not dependent on any of them. The farms in this study seem to build their agroecological level based on choices made by the farmers and depending on the communities around them, independently of technical data related to the farm's structure.

The advantage of TAPE is that it evaluates a very wide range of aspects, from social to purely agronomic, even assessing aspects of economic performance. This allows for a comprehensive multidimensional analysis. However, this study reveals the downside of such a broad approach; by trying to cover everything, there is a risk of losing the quality of the information. Issues related to data reliability have emerged in this study, which seem partly linked to the construction of TAPE, as revealed by the analysis of data according to the enumerators.

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Annex 1 : Survey guidebook for STEP1

STEP 1 – CHARACTERISATION OF AGROECOLOGICAL TRANSITIONS

1. DIVERSITY

CROPS

0 - Monoculture (or no crops cultivated).

1 - One crop covering more than 80 percent of cultivated area.

2 – Two or three crops with significant cultivated area.

3 - More than 3 crops with significant cultivated area adapted to local and changing climatic conditions.

4 - More than 3 crops of different varieties adapted to local conditions and spatially diversified farm with multi-, poly- or inter-cropping.

ANIMALS (INCLUDING FISH AND INSECTS)

0 - No animals raised.

1 - One species only.

2 - Two or three species, with few animals.

3 – More than three species with significant number of animals.

4 – More than three species with different breeds well adapted to local and changing climatic conditions.

TREES (AND OTHER PERENNIALS)

0 - No trees (nor other perennials).

1 - Few trees (and/or other perennials) of one species only.

2 - Some trees (and/or other perennials) of more than one species.

3 - Significant number of trees (and/or other perennials) of different species.

4 - High number of trees (and/or other perennials) of different species integrated within the farm land.

DIVERSITY OF ACTIVITIES, PRODUCTS AND SERVICES

- 0 - One productive activity only (e.g. selling one crop only).
- 1 - Two or three productive activities (e.g. selling 2 crops or one crop and one type of animals).
- 2 - More than 3 productive activities.
- 3 - More than 3 productive activities and one service (e.g. processing products on the farm, ecotourism, transport of agricultural goods, training etc.).
- 4 - More than 3 productive activities, and several services.

2. SYNERGIES

CROP-LIVESTOCK-AQUACULTURE INTEGRATION

The enumerator needs to consider the resources shared at community level. In the case of communal pastures for example, the corresponding feed inputs for animals are not considered as external. Are considered external only the feed purchased from the market.

- 0 - No integration: animals, including fish, are fed with purchased feed and their manure is not used for soil fertility; or no animal in the agroecosystem.
- 1 - Low integration: animals are mostly fed with purchased feed, their manure is used as fertilizer.
- 2 - Medium integration: animals are mostly fed with feed produced on the farm and/or grazing, their manure is used as fertilizer.
- 3 - High integration: animals are mostly fed with feed produced on the farm, crop residues and by-products and/or grazing, their manure is used as fertilizer and they provide traction.
- 4 - Complete integration: animals are exclusively fed with feed produced on the farm, crop residues and by-products and/or grazing, all their manure is recycled as fertilizer and they provide more than one service (food, products, traction, etc.).

SOIL-PLANTS SYSTEM MANAGEMENT

- 0 - Soil is bare after harvest. No intercropping. No crop rotations (or rotational grazing systems). Heavy soil disturbance (biological, chemical or mechanical).
- 1 - Less than 20 percent of the arable land is covered with residues or cover crops. More than 80 percent of the crops are produced in mono and continuous cropping (or no rotational grazing).
- 2 - 50 percent of soil is covered with residues or cover crops. Some crops are rotated or intercropped (or some rotational grazing is carried out).

3 - More than 80 percent of soil is covered with residues or cover crops. Crops are rotated regularly or intercropped (or rotational grazing is systematic). Soil disturbance is minimized.

4 - All the soil is covered with residues or cover crops. Crops are rotated regularly and intercropping is common (or rotational grazing is systematic). Little or no soil disturbance.

INTEGRATION WITH TREES (AGROFORESTRY, SILVOPASTORALISM, AGROSILVOPASTORALISM)

Consider also communal forest areas.

0 - No integration: trees (and other perennials) don't have a role for humans or in crop or animal production.

1 - Low integration: small number of trees (and other perennials) only provide one product (e.g. fruits, timber, forage, medicinal or biopesticides substances...) or service (e.g. shade for animals, increased soil fertility, water retention, barrier to soil erosion...) for humans crops and/or animals.

2 - Medium integration: significant number of trees (and other perennials) provide at least one product or service.

3 - High integration: significant number of trees (and other perennials) provide several products and services.

4 - Complete integration: many trees (and other perennials) provide several products and services.

CONNECTIVITY BETWEEN ELEMENTS OF THE AGROECOSYSTEM AND THE LANDSCAPE

Consider the surrounding areas, the semi-natural environments and the potential zones of ecological compensation

0 - No connectivity: high uniformity within and outside the agroecosystem, no semi-natural environments, no zones of ecological compensation.

1 - Low connectivity: a few isolated elements can be found in the agroecosystem, such as trees, shrubs, natural fences, a pond or a small zone of ecological compensation.

2 - Medium connectivity: several elements are adjacent to crops and/or pastures or a large zone of ecological compensation.

3 - Significant connectivity: several elements can be found in between plots of crops and/ or pastures or several zones of ecological compensation (trees, shrubs, natural vegetation, pastures, hedges, channels, etc.).

4 - High connectivity: the agroecosystem presents a mosaic and diversified landscape, many elements such as trees, shrubs, fences or ponds can be found in between each plot of cropland or pasture, or several zones of ecological compensation.

3. EFFICIENCY

USE OF EXTERNAL INPUTS

Take into account all inputs needed for production, including energy, fuel, fertilizers, seeds, young animals, straw for artificial insemination, workforce, phytosanitary substances etc.

- 0 - All inputs are purchased from the market.
- 1 - The majority of the inputs is purchased from the market.
- 2 - Some inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.
- 3 - The majority of the inputs is produced on farm/within the agroecosystem or exchanged with other members of the community.
- 4 - All inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.

MANAGEMENT OF SOIL FERTILITY

- 0 - Synthetic fertilisers are used regularly on all crops and/or grasslands (or no fertilizers are used for lack of access, but no other management system is used).
- 1 - Synthetic fertilizers are used regularly on most crops and some organic practices (e.g. manure or compost) are applied to some crops and/or grasslands.
- 2 - Synthetic fertilisers are used on a few specific crop only. Organic practices are applied to the other crops and/or grasslands.
- 3 - Synthetic fertilisers are only used exceptionally. A variety of organic practices are the norm.
- 4 - No synthetic fertilisers are used, soil fertility is managed only through a variety of organic practices.

MANAGEMENT OF PESTS & DISEASES

- 0 - Chemical pesticides and drugs are used regularly for pest and diseases management. No other management is used.
- 1 - Chemical pesticides and drugs are used for a specific crop/animal only. Some biological substances and organic practices are applied sporadically.
- 2 – Pests and diseases are managed through organic practices but chemical pesticides are used only in specific and very limited cases.
- 3 – No chemical pesticides and drugs are used. Biological substances are the norm.

4 - No chemical pesticides and drugs are used. Pests and diseases are managed through a variety of biological substances and prevention measures.

PRODUCTIVITY AND HOUSEHOLD'S NEEDS

Consider all types of assets, including animals, perennial trees etc.

0 - Household's needs are not met for food nor for other essentials.

1 - Production covers only household's needs for food. No surplus to generate income.

2 - Production covers household's needs for food and surplus generates cash to buy essentials but doesn't allow savings.

3 - Production covers household's needs for food and surplus generates cash to buy essentials and to have sporadic savings.

4 - All household's needs are met both for food and for cash to buy all essentials needed and to have regular savings.

4. RECYCLING

RECYCLING OF BIOMASS AND NUTRIENTS

0 – Residues and by-products are not recycled (e.g. left for decomposition or burnt). Large amounts of waste are discharged or burnt.

1 - A small part of the residues and by-products is recycled (e.g. crop residues as animal feed, use of manure as fertilizer, production of compost from manure and household waste, green manure). Waste is discharged or burnt.

2 - More than half of the residues and by-products is recycled. Some waste is discharged or burnt.

3 - Most of the residues and by-products are recycled. Only a little waste is discharged or burnt.

4 - All of the residues and by-products are recycled. No waste is discharged or burnt.

WATER SAVING

0 - No equipment nor techniques for water harvesting or saving.

1 - One type of equipment for water harvesting or saving (e.g. drip irrigation, tank).

2 - One type of equipment for water harvesting or saving and use of one practice to limit water use (e.g. timing irrigation, cover crops).

3 - One type of equipment for water harvesting or saving and various practices to limit water use.

4 - Several types of equipment for water harvesting or saving and various practices to limit water use.

MANAGEMENT OF SEEDS AND BREEDS

0 - All seeds and/or animal genetic resources (e.g. chicks, young animals, semen) are purchased from the market.

1 - More than 80 percent of seeds/animal genetic resources are purchased from the market.

2 - About half of the seeds are self-produced or exchanged, the other half is purchased from the market. About half of the breeding is done with neighbouring farms.

3 - The majority of seeds/animal genetic resources are self-produced or exchanged. Some specific seeds are purchased from the market.

4 - All seeds/animal genetic resources are self-produced, exchanged with other farmers or managed collectively, ensuring enough renewal and diversity.

RENEWABLE ENERGY USE AND PRODUCTION

0 - No renewable energy is used nor produced.

1 - The majority of the energy is purchased from the market. A small amount is self-produced (animal traction, wind, turbine, hydraulic, biogas, wood...).

2 - Half of the energy used is self-produced, the other half is purchased.

3 - Significant production of renewable energy, negligible use of fuel and other non-renewable sources

4 - All of the energy used is renewable and/or self-produced. Household is self-sufficient for energy supply, which is guaranteed at every time. Use of fossil fuel is negligible.

5. RESILIENCE

STABILITY OF INCOME/PRODUCTION AND CAPACITY TO RECOVER FROM PERTURBATIONS

0 - Income is decreasing year after year, production is highly variable despite constant level of input and there is no capacity to recover after shocks/perturbations.

1 - Income is on decreasing trend, production is variable from year to year (with constant inputs) and there is little capacity to recover after shocks/perturbations.

2 - Income is overall stable, but production is variable from year to year (with constant inputs). Income and production mostly recover after shocks/perturbations.

3 - Income is stable and production varies little from year to year (with constant inputs). Income and production mostly recover after shocks/perturbations.

4 - Income and production are stable and increasing over time. They fully and quickly recover after shocks/perturbations.

MECHANISMS TO REDUCE VULNERABILITY

With gender perspective

0 - No access to credit, no insurance, no community support mechanisms.

1 - Community is not very supportive and its capacity to help after shocks is very limited. And/or access to credit and insurance is limited.

2 - Community is supportive but its capacity to help after shocks is limited. And/or access to credit is available but hard to obtain in practice. Insurance is rare and does not allow for complete coverage from risks.

3 - Community is very supportive for both men and women but its capacity to help after shocks is limited. And/or access to credit is available and insurance covers only specific products/risks.

4 - Community is highly supportive for both men and women and can significantly help after shocks. And/or access to credit is almost systematic and insurance covers most of production.

INDEBTEDNESS

0 - Debt is higher than income.

1 - Debt is more than half of the income. Capacity to reimburse is limited.

2 - Debt is approximately half of the income.

3 - Debt is limited and capacity to reimburse is total.

4 - No debt.

DIVERSITY OF ACTIVITIES, PRODUCTS AND SERVICES

This index is the average score for the element of diversity already assessed

6. CULTURE & FOOD TRADITION

APPROPRIATE DIET AND NUTRITION AWARENESS

0 - Systematic insufficient food to meet nutritional needs and lack of awareness of good nutritional practices.

1 - Periodic insufficient food to meet nutritional needs and/or diet is based on a limited number of food groups. Lack of awareness of good nutritional practices.

2 - Overall food security over time, but insufficient diversity in food groups. Good nutritional practices are known but not always enforced.

- 3 - Food is sufficient and diverse. Good nutritional practices are known but not always enforced.
- 4 - Healthy, nutritious, diversified diet. Good nutritional practices are well known and enforced.

LOCAL OR TRADITIONAL (PEASANT / INDIGENOUS) IDENTITY AND AWARENESS

- 0 - No local or traditional (peasant / indigenous) identity felt.
- 1 - Little awareness of local or traditional identity.
- 2 - Local or traditional identity felt in part, or that concerns only part of the household.
- 3 - Good awareness of local or traditional identity and respect of traditions or rituals overall.
- 4 - Local or traditional identity strongly felt and protected, high respect for traditions and/ or rituals.

USE OF LOCAL VARIETIES/BREEDS AND TRADITIONAL (PEASANT & INDIGENOUS) KNOWLEDGE FOR FOOD PREPARATION

- 0 - No use of local varieties/breeds nor traditional knowledge for food preparation.
- 1 – A majority of exotic/introduced varieties/breeds are consumed, or there is little use of traditional knowledge and practices for food preparation.
- 2 - Both local and exotic/introduced varieties/breeds are produced and consumed. Local or traditional knowledge and practices for food preparation are identified but not always applied.
- 3 – The majority of the food consumed comes from local varieties/breeds and traditional knowledge and practices for food preparation are implemented.
- 4 – A number of local varieties/breeds are produced and consumed. Traditional knowledge and practices for food preparation are identified, applied and recognised in official frameworks and/ or specific events.

7. CO-CREATION & SHARING OF KNOWLEDGE

PLATFORMS FOR THE HORIZONTAL CREATION AND TRANSFER OF KNOWLEDGE AND GOOD PRACTICES

With gender perspective. Platforms can be formal or informal organizations, farmer field schools, regular meetings, trainings, etc.

- 0 - No platforms for co-creation and transfer of knowledge are available to producers.
- 1 - At least one platform for the co-creation and transfer of knowledge exists but does not function well and/or is not used in practices.

2 - At least one platform for the co-creation and transfer of knowledge exists and is functioning but is not used to share knowledge on agroecology specifically.

3 – One or several platforms for the co-creation and transfer of knowledge exist, are functioning and are used to share knowledge on agroecology, including women.

4 – Several well established and functioning platforms for the co-creation and transfer of knowledge are available and widespread within the community, including women.

ACCESS TO AGROECOLOGICAL KNOWLEDGE AND INTEREST OF PRODUCERS IN AGROECOLOGY

With gender perspective. Agroecological knowledge and practices may also be called in some other ways, and producers may know and apply them without knowing the word “agroecology”. Focus on the actual practices and knowledge for the evaluation, and not on the formal knowledge of “agroecology” as a science.

0 - Lack of access to agroecological knowledge: principles of agroecology are unknown to producers.

1 - Principles of agroecology are mostly unknown to producers and/or there is little trust in them.

2 - Some agroecological principles are known to producers and there is interest in spreading the innovation, facilitating knowledge sharing within and between communities and involving younger generations.

3 – Agroecology is well known and producers are willing to implement innovations, facilitating knowledge sharing within and between communities and involving younger generations, including women and younger generations.

4 - Widespread access to agroecological knowledge of both men and women: producers are well aware of the principles of agroecology and eager to apply them, facilitating knowledge sharing within and between communities and involving younger generations.

PARTICIPATION OF PRODUCERS IN NETWORKS AND GRASSROOT ORGANIZATIONS

With gender perspective.

0 - Producers are isolated, have almost no relations with their local community and do not participate in meetings and grass-root organisations.

1 - Producers have sporadic relations with their local community and rarely participate in meetings and grass-root organisations.

2 - Producers have regular relations with their local community and sometimes participate in the events of their grass-root organisations but not as much for women.

3 - Producers are well interconnected with their local community and often participate in the events of their grass-root organisations, including women.

4 - Producers (with equal participation of men and women) are highly interconnected and supportive and show a very high engagement and participation in all the events of their local community and grass-root organisations.

8. HUMAN & SOCIAL VALUES

WOMEN'S EMPOWERMENT

0 - Women do not normally have a voice in decision making, not in the household nor in the community. No organisation for women empowerment exists.

1 - Women may have a voice in their household but not in the community. And/or one form of women association exist but is not fully functional.

2 - Women can influence decision making, both at household and community level, but are not decision makers. They don't have access to resources. And/or some forms of women associations exist but are not fully functional.

3 - Women take fully part in decision making processes but still don't have full access to resources. And/or women organisations exist and are used.

4 - Women are completely empowered in terms of decision making and access to resources. And/or women organisations exist, are functional and operational.

LABOUR (PRODUCTIVE CONDITIONS, SOCIAL INEQUALITIES)

0 – Agricultural supply chains are integrated and managed by agribusiness. Social and economic distance between landowners and workers. And/or workers don't have decent working conditions, make low wages and are highly exposed to risks.

1 – Working conditions are hard, workers have average wages for the local context and may be exposed to risks.

2 - Agriculture is mostly based on family farming but producers have limited access to capital and decision-making processes. Workers have the minimum decent labour conditions.

3 - Agriculture is mostly based on family farming and producers (both men and women) have access to capital and decision-making processes. Workers have decent labour conditions.

4 - Agriculture is based on family farmers which have full access to capital and decision-making processes in gender equity. Social and economic proximity between farmers and employees.

YOUTH EMPOWERMENT AND EMIGRATION

- 0 - Young people see no future in agriculture and are eager to emigrate.
- 1 - Most young people think that agriculture is too hard and many wish to emigrate.
- 2 - Most young people do not want to emigrate, despite hard working conditions, and wish to improve their livelihoods and living conditions within their community.
- 3 - Most young people (both boys and girls) are satisfied with working conditions and do not want to emigrate.
- 4 - Young people (both boys and girls) see their future in agriculture and are eager to continue and improve the activity of their parents.

ANIMAL WELFARE [IF APPLICABLE]

- 0 - Animals suffer from hunger and thirst, stress and diseases all year long, and are slaughtered without avoiding unnecessary pain.
- 1 - Animals suffer periodically/seasonally from hunger and thirst, stress or diseases, and are slaughtered without avoiding unnecessary pain.
- 2 - Animals do not suffer from hunger or thirst, but suffer from stress, may be prone to diseases and can suffer from pain at slaughter.
- 3 - Animals do not suffer from hunger, thirst or diseases but can experience stress, especially at slaughter.
- 4 - Animals do not suffer from stress, hunger, thirst, pain, or diseases, and are slaughtered in a way to avoid unnecessary pain.

9. CIRCULAR & SOLIDARITY ECONOMY

PRODUCTS AND SERVICES MARKETED LOCALLY

- 0 - No product/service is marketed locally (or not enough surplus produced), or no local market exist.
- 1 - Local markets exist but hardly any of the products/services are marketed locally.
- 2 - Local markets exist. Some products/services are marketed locally.
- 3 - Most products/services are marketed locally.
- 4 - All products and services are marketed locally.

NETWORKS OF PRODUCERS, RELATIONSHIP WITH CONSUMERS AND PRESENCE OF INTERMEDIARIES

With gender perspective

0 - No networks of producers for marketing agricultural production exist. No relationship with consumers. Intermediaries manage the whole marketing process.

1 - Networks exist but do not work properly. Little relationship with consumers. Intermediaries manage most of the marketing process.

2 - Networks exist and are operational, but don't include women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

3 - Networks exist and are operational, including women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.

4 - Well established and operational networks exist with equal women participation. Strong and stable relationship with consumers. No intermediaries.

LOCAL FOOD SYSTEM

0 - Community is totally dependent from outside for purchasing food supply and agricultural inputs and for the marketing and processing of products.

1 - The majority of food supply and agricultural inputs are purchased from outside and products are processed and marketed outside the local community. Very few goods and services are exchanged/sold between local producers.

2 - Food supply and inputs are purchased from outside the community and/or products are processed locally. Some goods and services are exchanged/sold between local producers.

3 - Equal shares of food supply and inputs are locally available and purchased from outside the community and products are processed locally. Exchanges/trade between producers are regular.

4 - Community is almost completely self-sufficient for agricultural and food production. High level of exchange/trade of products and services between producers.

10. RESPONSIBLE GOVERNANCE

PRODUCERS' EMPOWERMENT

With gender perspective

0 - Producers' rights are not respected. They have no bargaining power and lack the means to improve their livelihoods and develop their skills.

1 - Producers' rights are recognised but not always respected. They have small bargaining power and little means to improve their livelihoods and/or to develop their skills.

2 - Producers' rights are recognised and respected for both men and women. They have small bargaining power but are not stimulated to improve their livelihoods and/or to develop their skills.

3 - Producers' rights are recognised and respected for both men and women. They have the capacity and the means to improve their livelihoods and are sometimes stimulated to develop their skills.

4 - Producers' rights are recognised and respected for both men and women. They have the capacity and the means to improve their livelihoods and to develop their skills.

PRODUCERS' ORGANIZATIONS AND ASSOCIATIONS

With gender perspective

0 - Cooperation among producers is non-transparent, corrupted or non-existent. No existing organisation or they do not to distribute profits transparently and/or equally nor do they support producers.

1 – One organisation of producers exists but its role is marginal and support to producers limited to market access.

2 - One organisation of producers exists and provides support to producers for market access and other services (e.g. information, capacity development, incentives...), but women don't have access.

3 - One organisation of producers exists and provides support to producers for market access and other services with equal access to men and women.

4 – More than one organisation exist. They provide market access and other services, with equal access to men and women.

PARTICIPATION OF PRODUCERS IN GOVERNANCE OF LAND AND NATURAL RESOURCES

With gender perspective

0 - Producers are completely excluded from the governance of land and natural resources. There is no gender equity in the governance of land and natural resources.

1 - Producers participate in the governance of land and natural resources but their influence on decisions is limited. Gender equity is not always respected.

2 - Mechanisms allowing producers to participate in the governance of land and natural resources exist but are not fully operational. Their influence on decisions is limited. Gender equity is not always respected.

3 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. They can influence decisions. Gender equity is not always respected.

4 - Mechanisms allowing producers to participate in the governance of land and natural resources exist and are fully operational. Both women and men can influence decisions.

Annex 2 : Feedbacks on surveys

SURVEY FEEDBACKS

This document is based on the feedbacks given by the enumerators during the survey conduct in november and december 2022 by IDP with 200 farmers of the Kilimo Endelevu program.

❖ IDP

➤ Organisation issue :

- Being on time to the farms, organise the timelane to knock on the door of the farmer at the time they've been inform in advance.

➤ Adaptation of the TAPE survey to the tanzanian reality

- About the quantification of vegetables : most of the farmers quantifie their production by unit, bunch, bag. The TAPE survey accept only kilos. The solution that was put in place was to convert those unit (unit, bunch, bag) into standard mass unit.

	Kilogrammes
Cucumber	
Cauliflower	
Brocoli	
Red Cabage	
Banana	
Watermelon (Small-Medium-Large)	(1-2-4)

- Problem with the calculation of the forest productive area : some of the farmers have just one or a couple of isolate fruit tree on the farm. How do we mesure those situation ?

Solution : if the number of productive trees was one or two : the area was simplified to 0 ha.

➤ Concern about the farmers who rent most or whole of the land they farm.

In a considerable amount of situations, when farmers rent most of the land they farm, the area is not the same from year to year. In our situation, the land they farm, will not be the same between the first survey, the second and the third one.

Those farmers canot put in place agricultural practices that construct themselves in the long run. For exemple agroforestry, creation of water harvesting structure, ect.

The way those farmers are “doing” agroecology have to be seen from a different angle.

In order to understand those situations and analyse their way of farming in knowledge of this particular context, it’s important to identify it.

The TAPE survey allow to identify the farmers who rent most of the area they use (by comparing the total area and the area rent). But the survey don’t catch the changement of area in the long run as it’s build as a snapshot of the last year of activity. In the Kilimo endelevu program, the goal is to analyse the evolution of farming systems on a 5 years period with the realisation of 3 surveys. To assure the consistency of the analyse, the farm where a different land is cultivate from where to year have to be identified by an additional question to the TAPE survey.

- The timing on the data collection on the year
in october/december most of the field are bare, there is no crops plant. The moment of the survey making can be changed. A concern that can be raise in this case is about the consistency of the data collect.

❖ TAPE

- Data keeping

There is some farmers that don’t keep any data on the activities of the farm (they don’t know the yield, the quantities of farm products sold,..). The chance to face a situation like that don’t depend on the region surveyed as it as been encounter in a few villages regarding the region there are located.

The solution for this issue can be to warn 1 year before the survey that a survey will be conduct.

For the Kilimo Endelevu program, it is no more a issue as the farmers who will be surveyed in two years are the same than the ones surveyed for the first round.

- Issues with TAPE

- > STEP1 > Efficiency

In some situation the farming praticies cannot be characterise by any option. For exemple on the question “Management of pest and diseases” some of the farmers don’t use any chemical pesticides and they don’t use any biological substances. As the survey is a scale between the use of chemicals and organic substance, those farmer cannot be put in any categorie of this question.

- > STEP1 > Resilience

In some situation in Tanzania, depending on the year, the region, the weather, some internal or external drivers, the farmers can face no output harvest. In those situation, they have to react and take some decision to keep their farming activity viable. This is resilience. The TAPE survey do not catch this kind of resilience.

- The accuracy of the translation from English to Kiswahili version.

> STEP2 > Agricultural biodiversity > **1** > 1 > Name of the animal species

English	Kiswahili
Cow / Bull	Bison
Bison	-

Should be

English	Kiswahili
Cow / Bull	Ng'ombe
Bison	Bison

What have been done for the 2022 IDP survey

- When the specie was cow, the enumerators clasified it as “N’gombe” in the “other” section.

- > STEP2 > Soil health > Status of residu
There is no option “no residu”. After the harvest, residu can be all eat by livestock or export to feed livestock in an other location.

- > STEP2 > Soil health > Microbiological activity

There is no option for no effervescence, a situation that can be encounter.

- Widow woman
Some of the women farmers are widow. In this case, the TAPE survey keep asking gender relatated question. The survey should not ask question gender related when the household is compose only by a woman or a man.

- The lenght of the survey

The enumerators relay that the TAPE survey can be particulary long. Some of the farmers are asking for when it will be over and wanted to switch to other activities. That can weight on the accuratie of the answers particulary for last ones that can be rush.

➤ Problems of honesty

Some of the enumerators have faced honesty problems about numbers, for example, on herd size.

➤ Certificate for enumerators

It is not related to the accuracy of the data collection but the enumerator ask if they could get a “certificate” that recognise their skills to conduct a TAPE survey as they follow the TAPE survey training and conduct a TAPE survey for 10 days.

❖ TAPE data analysis

➤ Form of data

When the time comes to analyse the data, the way the data are presented on an excel table is not always clear. Some colons are only describe by one word that cannot easily be linked to a question of the actual survey.

Some very interesting aspects of the TAPE survey are not transcribed in the excel document. For example, the type of vegetable link to the quantity produce is not present, only the information of the number of different fruit/vegetables/livestock and the total value of the production is represented. In the survey, those information are asked, it's unfortunate to lose some very usefull information between the actual survey and the presentation of the data.

Use of the Tool for Agroecology Performance Evaluation (TAPE) in Arusha district, Tanzania to assess the agroecological level of KEA program farmers

Louis Baret

SUMMARY

This study aims to assess the level of agroecology in 200 farms in the region of Arusha (Tanzania) that began a agricultural program in 2022, led by several NGOs and peasant organizations under the name Kilimo Endelevu Arusha (Sustainable Agriculture Arusha). The goal of this program is to improve food and farm income security of small scale farmers through sustainable land management, agroecological intensification and by creating a favorable governance context for sustainable food systems. In this context, evaluating the agroecology of these farms helps identify their strengths and weaknesses in the quest to build more sustainable systems.

This assessment is conducted using the TAPE tool developed by the FAO. This tool takes the form of a lengthy questionnaire that the farmers answer. The first part evaluates the 10 elements of agroecology through semi-closed, multiple-choice questions. The second part collects quantitative data on the core criteria of performance considered essential for the multidimensional sustainability of productive systems. This study mainly focuses on the first part, analyzing the overall level of agroecology and examining the levels of each element to understand the positioning of the farms in relation to agroecology. The objective was also to identify what influences the level of agroecology on these farms by examining the data based on their farming system, environment, etc. A cross-analysis of the two parts is undertaken to understand the interaction between agroecology and economic performance.

This study provided an opportunity to reflect on the construction of the TAPE tool. After uncovering the significant impact of enumerators on response levels, this study provide insights for a more relevant structure of TAPE.

