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THE SUITABILITY OF THE « TOOL FOR AGROECOLOGICAL PERFORMANCE EVALUATION » (TAPE) IN A EUROPEAN CONTEXT

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Résumé

L’agroécologie est de plus en plus considéré pour traiter des problèmes de durabilité dans les systèmes agricoles actuels. Afin d'évaluer les impacts de cette nouvelle approche, la FAO a développé l'Outil d'Evaluation des Performances Agroécologiques (TAPE). Alors qu’il a été expérimenté avec succès en Argentine, à Cuba, au Cambodge et au Sénégal, cet outil n'a encore jamais été testé dans un contexte européen ni sur un territoire principalement dédié à l’élevage. Cette étude analyse les forces et faiblesses de TAPE sur un tel territoire. La mise en œuvre de cet outil a été menée dans les Monts du Lyonnais (France) qui ont ainsi servi de cas d’étude. Dans ce cadre, des acteurs locaux et agriculteurs ont été interviewés. Il a été montré que les différentes étapes de TAPE rendent globalement l’outil pertinent et complet pour évaluer la performance agroécologique d’un territoire. Cependant, on observe également que l’outil dispose d’indicateurs dont les méthodes de calculs ont été conçues pour évaluer des systèmes agricoles plutôt vivriers. Ainsi, quand ils sont déployés en Europe, certains indicateurs, comme l’émancipation des femmes, peuvent s’avérer peu pertinents. De nouvelles études sur d’autres territoires européens doivent être menées pour confirmer ces observations.

Mots-clés : agroécologie - analyse multicritères - élevage - Monts du Lyonnais

Abstract

Agroecology is increasingly being considered to address sustainability issues in current agricultural systems. In order to assess the impacts of this new approach, FAO has developed the Tool for Agroecology Performance Evaluation (TAPE). While it has been successfully tested in Argentina, Cuba, Cambodia and Senegal, this tool has never been tested in a European context nor a territory mainly dedicated to livestock production. This study analyzes the strengths and weaknesses of TAPE in such a territory. The implementation of this tool was conducted in the Monts du Lyonnais (France) which served as a case study. Within this framework, local actors and farmers were interviewed. It was shown that the different steps of TAPE make the tool broadly relevant and complete to assess the "agroecological performance" of a territory. However, it was also observed that the tool has indicators whose calculation methods were designed to evaluate agricultural systems that are mainly subsidiary. Thus, some indicators, such as women's empowerment, may not be sufficiently relevant when applied in Europe. New studies on other European territories must be conducted to confirm these observations.

Keywords: agroecology – multi-criteria analysis – livestock- Monts du Lyonnais

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Contents

Acronyms and abbreviations

CAET: Characterization of the Agro Ecological Transition.

CAP: Common Agricultural Policy

CIRAD: *Centre de coopération Internationale en Recherche Agronomique pour le Développement* - French Agricultural Research Centre for International Development.

CSA: Community Supported Agriculture.

DRAAF: *Directions Régionales de l'Alimentation, de l'Agriculture et de la Forêt* - the Regional Directorates of Food, Agriculture and Forestry (DRAAF)

FAO: Food and Agriculture Organization of the United Nations.

GIEE: *Groupement d'intérêt économique et environnemental* - Group of economic and environmental interest.

GVP: Gross Value of Production.

HCPC: Hierarchical Clustering on Principal Components.

HLPE: High-Level Panel of Experts on Food Security and Nutrition.

IDELE: *Institut de l'Elevage* – Institute of livestock.

INRAE: *Institut National de la Recherche pour l'agriculture, l'alimentation et l'Environnement* – French National Institute of Research for Agriculture, alimentation and Environnement.

ISARA: *Institut supérieur d'agriculture Rhône-Alpes* - Superior Institute of Agriculture Rhône-Alpes

PCA: Principal Component Analysis

SDG: Sustainable Development Goals

SEI: Surfaces of Ecological Interest

SIMACOISE: *Le Syndicat Interdépartemental Mixte pour l'Aménagement de la Coise* - The Syndicat Interdepartemental mixte for the management of the Coise river

TAPE: Tool for the Agroecological Performance Evaluation

UAA: Utilised Agriculture Area

UN: United Nations

VA: Value added

Units

ha: hectare m: meter

Introduction

Today's society is facing an important number of issues: climate change, population growth, large-scale pollution of soil and water, limitation of natural resources, poverty, hunger (United Nations, 2020). These issues impact the sustainability of food and farming systems. The current dominant agricultural model, inherited from the green revolution and based on the four main pillars: fossil resources, chemical inputs, mechanization and plant and animal selection (Claveirole, 2016), is today showing major social, economic and environmental limits and seems unable to sustainably address these issues. Alternatives are therefore proposed and among them: the agroecology.

Agroecology is a word that has been increasingly used in the last decade but which is still not unequivocal. Depending of the geographic area or even the context in which it is used, it can refer to different notion, can cover different meanings.

1 History and definitions of "Agroecology"

The term first appeared in 1928, in a book published by Bensin, a Russian agronomist as the use of ecological methods on commercial crop plants. Between the 1930s and the 1960s, the German ecologist and zoologist Tischler wrote several articles using the word agroecology and linked this notion with pest management, soil biology and plant protection. Then, for 2 decades, poor publications can be found using the word agroecology (Wezel and Soldat, 2009). It was not until the 1980s, that agroecology has emerged as the global study of agroecosystems protecting natural resources, to design and manage sustainable agroecosystems (Altieri, 1989).

During the 1990s, the number of publications related to agroecology increased tremendously (Wezel and Soldat, 2009) and up until the 2000s, agroecology was mostly the junction of "agronomy" and "ecology". However, in 2003, (Francis et al., 2003) defined agroecology as "the integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions, or more simply the ecology of food systems." The notion of agroecology thus became more complex and changed from the field or plot scales to the farm and agroecosystem scales. This change of scale leads to the integration of new disciplines such as geography, sociology, socioeconomics.

In the meantime, different interpretations of this word appeared worldwide as different institutions and countries adopted definitions that reflect their priorities (HLPE, 2019) and "agroecology" occurred to refer to, at the same time, knowledge, ideas and conceptual approaches and, production systems and practices.

In an attempt of synthesis, in 2009, Wezel et al. stated that agroecology can be understood as a science, a movement and/or a practice, depending on the history of the nations it takes place. However, if considered as a practice (or set of practices), agroecology may become normative that could be considered as incompatible with the former definition of agroecology as « the ecology of the food system » (Francis et al., 2003) and as « a transdisciplinary, participatory and action-oriented approach » (Méndez et al. 2016), in other words, a dynamic, systemic approach to thinking and acting.

Thus still today, no consensus is clearly reached on a specific meaning in the scientific community (Doré and Bello, 2019; FAO, 2021; HLPE, 2019; Lucas and Gasselin, 2018; Wezel et al., 2009). Nevertheless key principles can be identified.

2 Key principles of agroecology

The main principle of agroecology applied to farming systems is that agroecosystems should mimic the functioning of ecosystems in order to stimulate ecosystem services such as water regulation, nutrient regulation, pollination, soil formation and therefore generate agricultural products. Reproducing nature will make the agroecosystems more complex and interactions inside the system will increase. Recycling, biological control, the nutrient cycle will be stimulated and thereby, the overall efficiency of the system will be maximized (Altieri, 2015).

Now that agroecology has expanded to a bigger scale – landscape-scale – it does include social sciences, political ecology. Thus, agroecology seeks solutions in partnership with local stakeholders who, in addition to being the most concerned by the current state of territory, are the ones capable of changing it, thanks to the expertise and knowledge of the territory (Francis et al., 2003; HLPE, 2019). Indeed agroecology, as a methodological approach, can be applied worldwide but the results will differ from a territory to another or from an agroecosystem to another.

To promote the development of agroecology, the FAO identified a set of ten elements of agroecology in order to guide “the transition to agroecology”: diversity; co-creation and sharing of knowledge; synergies; efficiency; recycling; resilience; human and social values; culture and food traditions; responsible governance; circular and solidarity economy (FAO, 2019a). Here (and throughout this manuscript), the term ”transition to agroecology” means the transition towards sustainable agricultural practices informed by agroecology’s knowledge and principles. The next challenge for the FAO, along with other decision makers in the field of agriculture, is now to assess the performance of agroecosystems integrating agroecology principles.

3 Evaluation of performance of agroecosystems integrating agroecology principles

3.1 Agroecology's impacts on farming systems

The impacts of agroecology's principle on farming and food systems have been the subject of numerous studies. It would seem, that the implementation of agroecological approaches can improve the food security and nutrition of the farm's households. For example, it was observed that crop diversification including differences in harvest time, in Nicaragua, Southern Benin and the Peruvian Andes resulted in, respectively, a greater food availability throughout the year, a better diet for women as food production is mostly for self-consumption and a more diverse and micronutrient-adequate diet (Bellon et al., 2016; Bliss, 2017; Jones et al., 2018). Other studies, conducted in developing countries, support this positive correlation between crop diversification and food security and nutrition (Becerril, 2013; Ecker and Qaim, 2011; Kerr et al., 2016; Luna-González and Sørensen, 2018) as well as a positive correlation between practices informed by agroecology principles and crop yield (Epule and Bryant, 2016; Altieri and Toledo, 2011). As counterpoint, other authors state agroecology do not participate in improving small farmers living conditions, for example in Africa (Mugwanya 2019).

Despite the increasing number of studies on the impacts of sustainable agricultural practices informed by agroecology's knowledge and principles, multiples knowledge gaps still remain on: (i) the economic and social impacts of agroecology (HLPE, 2019), (ii) the relations between sustainable agricultural practices informed by agroecology's knowledge and principles, ecological processes, and ecosystem services (Andres and Bhullar, 2016; Duru et al., 2015) (iii) the agroecology's abilities to cope climate change (Altieri et al., 2015).

Considering these facts, there is an increasing claim for methods to evaluate agroecology as a whole instead of focusing on one of its dimensions (Dalgaard et al., 2003; HLPE, 2019) and therefore the development of different analysis frame and tools.

3.2 Tools to assess such an approach

The challenge is no longer just the evaluation of the performance of a farm through indicators such as productivity per person, per hectare, yield or profit but also to consider these performances in the light of the agreement of the agroecosystem to the agroecology principles. According to Hilbeck, Muller and Wiget (2020), four aspects need to be taken

into account to assess agroecological farming systems (AFS): *"(1) the adaptability to local conditions all over the world, (2) the involvement of farmers in the development process, (3) the consideration of the multiple functions of an agroecosystem in the definition and measurement of its productivity, and (4) the accounting for interactions between multiple agroecosystem functions and their measurement."*. Research teams, public institutions and working groups have tried to develop analytical tools. The Table 1 presents a non-exhaustive list of the main frameworks and tools for the assessment of sustainability of agroecosystems and gives indications on their geographical scope, if they focus on agroecological farming systems, and their main characteristics.

Table 1 Comparison of different assessment tools used over the world

Framework	Geographical scope	Level of application	Main characteristics	Objectives
IDEA - Indicateur de Durabilité des Exploitations Agricoles (Zahm et al., 2008)	France	Farm level	• Before using the framework, the indicators must be adapted to local farming • Self-assessment for farmers and policy makers • Based on 41 sustainability indicators covering the three dimensions of sustainability	Self-assessment for farmers and policy makers to support sustainable agriculture
Diagagroeco (Ministère de l'agriculture et de l'alimentation, 2021)	France	Farm level	• Self-assessment for farmers • Presence of suggestions to improve the system	Assessment of the place of agroecology on a farm
MESMIS - The Framework for Assessing the Sustainability of Natural Resource Management Systems (Lopez-Ridaura et al., 2002)	Latin America	System level	• A systemic, participatory, interdisciplinary and flexible framework • 6 steps: the first three steps is dedicated to the characterization of the system, its forces and drawbacks. In the last three steps, the use of indicators allows a multi-criteria analysis (based on both qualitative and quantitative data)	Obtain a value judgement about the resource management systems and to provide suggestions and insights aimed at improving their socio-environmental profile
MMF -Multiscale Methodological Framework (López-Ridaura et al., 2005)	Developping countries	Farm household and region	• Interdisciplinary approach • Quantitative system analysis tool	Indicate biophysical opportunities and limitations, rather than predicting behaviour of actors

RISE - Response-Inducing Sustainability Evaluation (Grenz et al., 2009)	Worldwide	Farm level	• Based on 12 indicators, for each indicator the “Driving force” (D) andthe “State” (S) are determined • Easy assessment tool	Offer a holistic approach for advice, education and planning
SAFE - Sustainability Assessment of Farming and the Environment (Van Cauwenbergh et al., 2007)	Worldwide	integration of three spatial levels: the parcel level, the farm level and the landscape, the region or the state	• composed of principles, criteria, indicators and reference values	Assessment tool for the identification, the development and the evaluation of agricultural production systems, techniques and policies

Most of the frameworks studied have a limited scope of application, with indicators that do not fully capture the different dimensions of agroecology. It also pointed out that even if these frameworks collect data and provide evidence on the impacts of agroecology, the data collected between frameworks are heterogeneous and difficult to compare (Wiget et al., 2020). At the same time, the international community has made several calls to FAO, the Food and Agriculture Organization, to develop a globally applicable diagnostic tool for the transition to agroecology at the territorial level. FAO has thus been working since 2016 to create TAPE: Tool for Agroecology Performance Evaluation.

3.3 TAPE as a tool to assess the degree of agreement of agroecosystems to the agroecology principles and their performance

Since 2014, FAO has played a key role to facilitate dialogues around the globe on agroecology thanks to multiple meetings gathering more than 2100 participants of 170 countries (FAO, 2019b). In the meantime, agroecology is generating growing interest from politicians, researchers, farmers and agribusinesses.

During the 2nd International Symposium on Agroecology (2018), there has been a call for FAO to *“take the lead on developing methodologies and indicators to measure the sustainability performance of agricultural and food systems beyond yield at landscape or farm level, based on the 10 elements of agroecology and experience in developing indicator 2.4.1”.* This call has been reiterated during the 26th Committee on Agriculture and by The High-Level Panel of Experts of the Committee on Food Security (2019) in a published report.

These initiatives resulted in the elaboration of a new framework: TAPE, “Tool for Agroecology Performance Evaluation”.

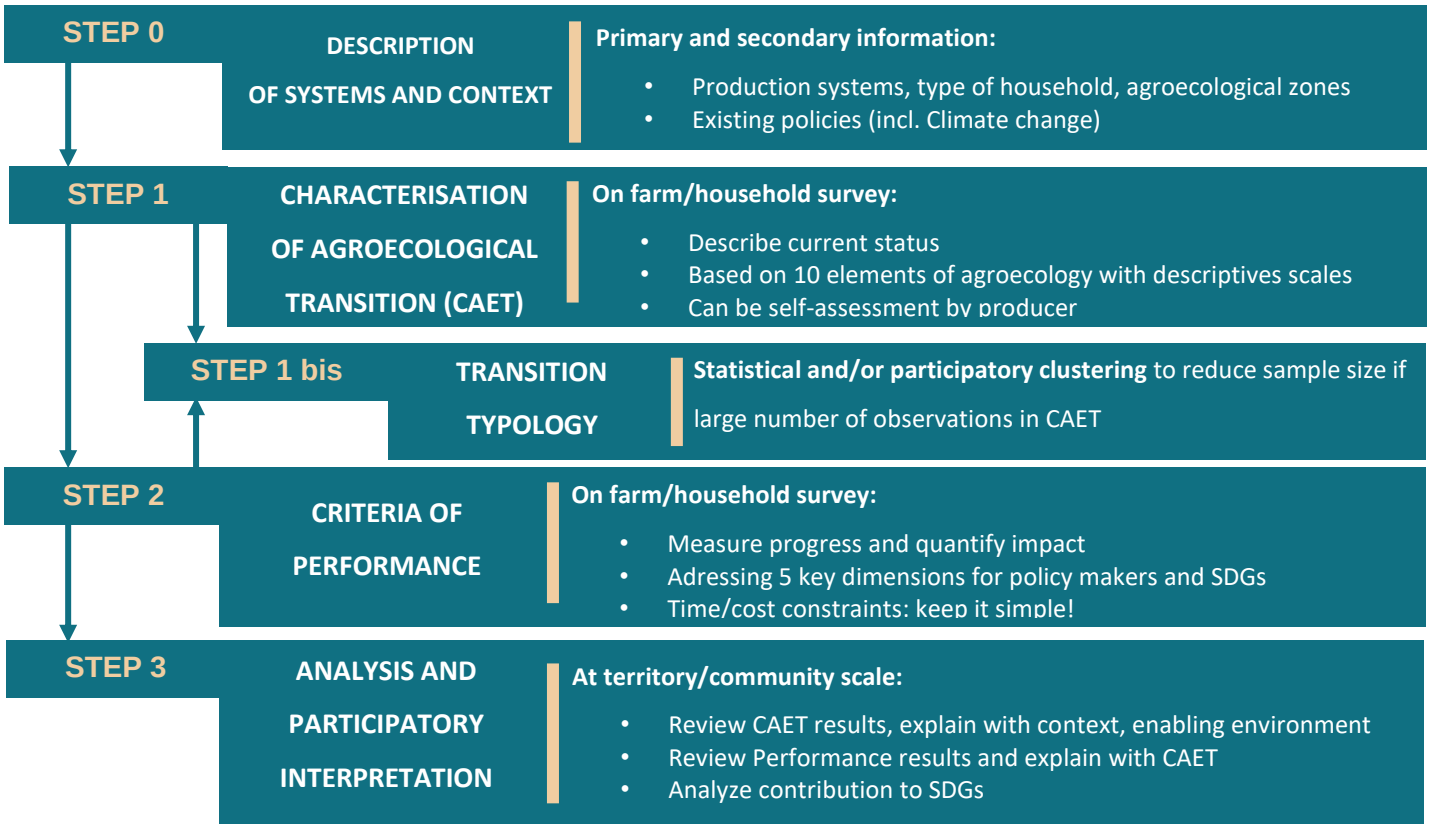

Figure 1 : The global analytical framework of TAPE, step by step (FAO, 2019c)

Developed between 2016 and 2018, TAPE is the result of the collaboration of over 450 people around the world throughout three different types of workshops: one was dedicated to the identification of the main indicators for the application of agroecology principles in farming systems the second was an international workshop with 70 participants, and the third was a more restricted workshop with 16 people who concretely created the analytical framework. TAPE aims to “produce and consolidate evidence on the multidimensional performances of agroecological systems (i.e. agroecosystem informed by agroecological thinking and knowledge)” (Mottet et al., 2020). TAPE was elaborated to be globally applicable and relevant at the territorial level, thanks to a collection of data at the farm unit. The collaborative process of creation results in a tool based on 4 steps (see Figure 1).

Step 0 is a preliminary step, which the main purpose is to understand the different drivers and characteristics of the studied territory. Information about the main socio-economic and demographic characteristics of the agricultural and food systems of the territory and an analysis of the enabling environment in terms of relevant policy, market, technology, socio-cultural and/or historical drivers are expected. This step can include interviews of the main

stakeholders influencing the agricultural food system: policymakers, main cooperatives, associations.

Steps 1 and 2 are based on a questionnaire filled up using farmers' interviews. Step 1, is called CAET for Characterization of the Agro-Ecological Transition. Thanks to a succession of questions with pre-set answers, each farm is assessed according to the 10 elements of agroecology adopted by FAO and its member countries[1] (Barrios et al., 2020). Step 2, the Core Criteria of Performance, addresses various dimensions of the sustainable development goals (SDG) that have been identified as key dimensions for policymakers (Mottet et al., 2020).

The final step, step 3 is "a participatory analysis of the results, where the multidimensional performances (step 2) are reviewed in the light of the level of transition to agroecology (step 1) and the context and enabling environment (step 0)" (Mottet et al., 2020). Here, the term "transition to agroecology" means the transition towards sustainable agricultural practices informed by agroecology's knowledge and principles.

3.4 Implementation of TAPE around the world

Since its conception, TAPE has been deployed in a dozen countries such as Cambodia, China, Central Angola, Thailand, Mali, Argentina to: (i) test the validity of the tool (ii) to start collecting evidence on the multi performances of agroecology (Álvarez et al., 2019; IRPAD, 2020).

However, TAPE has never yet been implemented in the European context. This context differs highly from the previous ones in terms of agricultural policies, agricultural organization and agriculture development. FAO is thereby interested to verify the tool suitability to assess the transition to agroecology of a territory located within Europe.

In France more specifically, agroecology has diffused significantly by different political programs as the "agroecological project for France" in 2012 (Wezel et al., 2018; Wezel and David, 2020). It may therefore be interesting to conduct a multi criteria analysis in a french

[1] diversity, synergies, resilience, responsible governance, circular and solidarity economy, culture and food traditions, co-creation and sharing of knowledge, efficiency and recycling, human and social values

territory, in order to investigate the place of agroecology in such a context. TAPE may be suitable to do so.

Thus with this thesis, I wanted to test the capabilities and limits of TAPE, to assess the transition to agroecology of a territory (i.e. transition to practices informed by agroecology principles), in a European context and more specifically in the French context, with a focus on livestock production. I wanted to investigate **to what extent can TAPE be used to assess the transition to agroecology of mixed farms and dairy cattle systems within a European context?**

The method I used to answer this research question is to implement TAPE on a given territory. It is important to keep in mind that the deployment of the four steps of TAPE, forms the body of the results of this master thesis work. Thus, the analysis of the agroecological transition of the territory, which corresponds to step 3 of TAPE, is an integral part of the "results" of the master thesis. The discussion will then focus on the capacity of TAPE to evaluate the agroecological transition of a territory dominated by livestock, in a European context, and here, in France.

The case study is the Monts du Lyonnais, a territory composed of 32 municipalities located west of the Lyon agglomeration (see Figure 2) This area was chosen for several reasons. First of all, it is an area where livestock farming is very present, with dairy cattle production being the mainstay of the area. Moreover, the research unit Agroecology and Environment of ISARA has been interested several times in this territory and its specificities in terms of rural dynamics. Many research teachers can therefore bring their expertise in the framework of the master thesis. From a more practical point of view, this territory is less than a 1h30 drive from ISARA; meeting local actors and conducting interviews with farmers will therefore be simple.

Figure 2 : Map of the Monts du Lyonnais (Communauté de communes des Monts du Lyonnais, 2021).

PART 1: Materials and methods

This research was conducted from February to July 2021 in the Monts du Lyonnais territory. The objective was to implement TAPE on a French territory in order to evaluate its abilities to assess the "agroecological performances" on a territorial scale in dairy cattle systems within a European context. Therefore, the framework of the methodology used for this master thesis follows the one of TAPE but is adapted to the territory of the Monts du Lyonnais (see Figure 3).

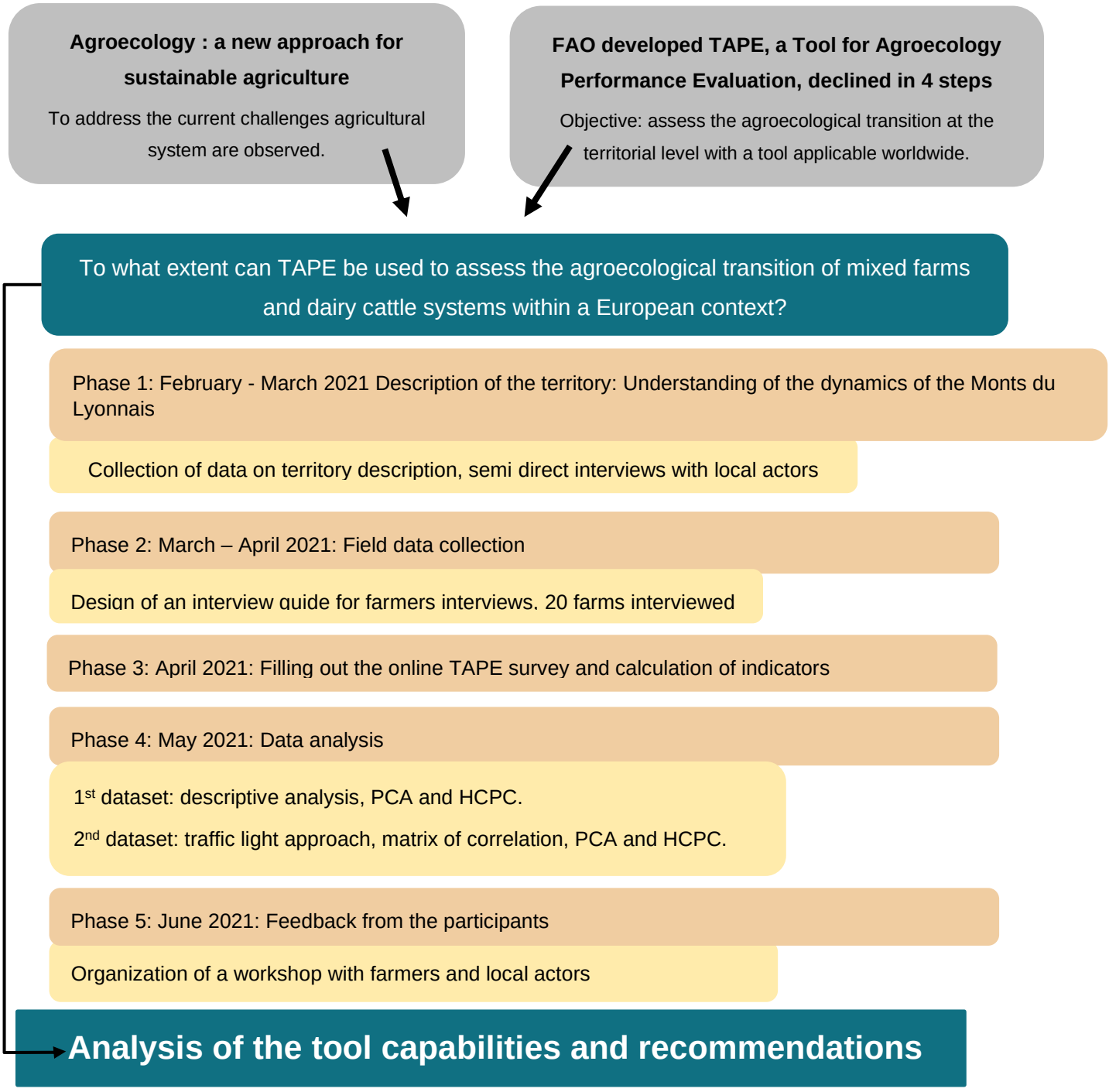

Figure 3: Thesis phases with the methods used

1 Phase 1: Description of the territory: Understanding of the typicity of the Monts du Lyonnais

In order to get a detailed description of the Monts du Lyonnais territory including the main socioeconomic and demographic characteristics, its ecological environment, the social and productive environment and the enabling environment for agroecology, a literature review was carried out, both in grey literature through public documents related to the Monts du Lyonnais and scientific channels through Web of Science and Google Scholar.

Semi directive interviews with local actors have also been conducted for additional information. These semi-directive interviews allowed us to better understand the territorial and rural dynamics of the Monts du Lyonnais and to directly get the perceptions of the people involved in the territory. This method of semi-directive interviews was chosen to allow the informants to bring their thoughts and opinions to further identify relevant and recurring themes (Adams, 2015). The common framework of the interviews (see Appendix 1) was designed according to the information collected during the literature review and the role the interviewee had on the territory. These interviews were conducted mostly over phone or video calls due to restrictions imposed by the COVID19 pandemic and lasted an hour on average.

Contacted by emails, 16 persons identified as key actors who could help to understand the dynamics of the Monts du Lyonnais were interviewed. They had 3 different profiles: researchers whose mission was related to the Monts du Lyonnais, people working with farmers (advisor for livestock, for the agroecological transition, for the pooling of equipment), and people working in public organizations that coordinate agricultural activities on the territory and the province's scale.

These two methods of information collection (literature review and semi-directive interview) allow fulfilling the "STEP 0" of TAPE.

2 Phase 2: Field data collection: interviews with farmers

Because of the time frame of the research and the amount of information requested per farmer, the size of the sample was limited to 20 farms. The focus was put on farms in polyculture dairy cattle breeding system, firstly to match the expectations of the FAO on this master thesis - to implement the tool in livestock systems - and secondly because dairy cattle system is the main one of this territory.

The interviewees were identified following 3 different ways:

- Searching for farmers on the internet, via websites referencing farmers in the communes of the Monts du Lyonnais, via websites of direct sales of local products on which farmers are presented, or via websites of farms.
- During the interviews of local actors in phase 1, the informants were asked if they had contacts of farmers in dairy farming who could be interested in this type of research. This is the 'snowball sampling' method, which is frequently used when it is difficult to get in touch with the targeted people (Naderifar et al., 2017).
- During the interviews with farmers, they were asked if they knew of other farmers who might be interested in this type of approach. This approach is also about snowball sampling (Naderifar et al., 2017).

All farmers identified were contacted by phone (no selection was made) to explain the context of the study and, if they agree to be interviewed, an appointment was set up. The interviews were conducted on farms because although most of the data could be communicated by email or telephone, it was also necessary to do a transect walk to get a more global idea of the functioning of the farm (see Figure 5). A description of each farm can be found in Appendix 2.

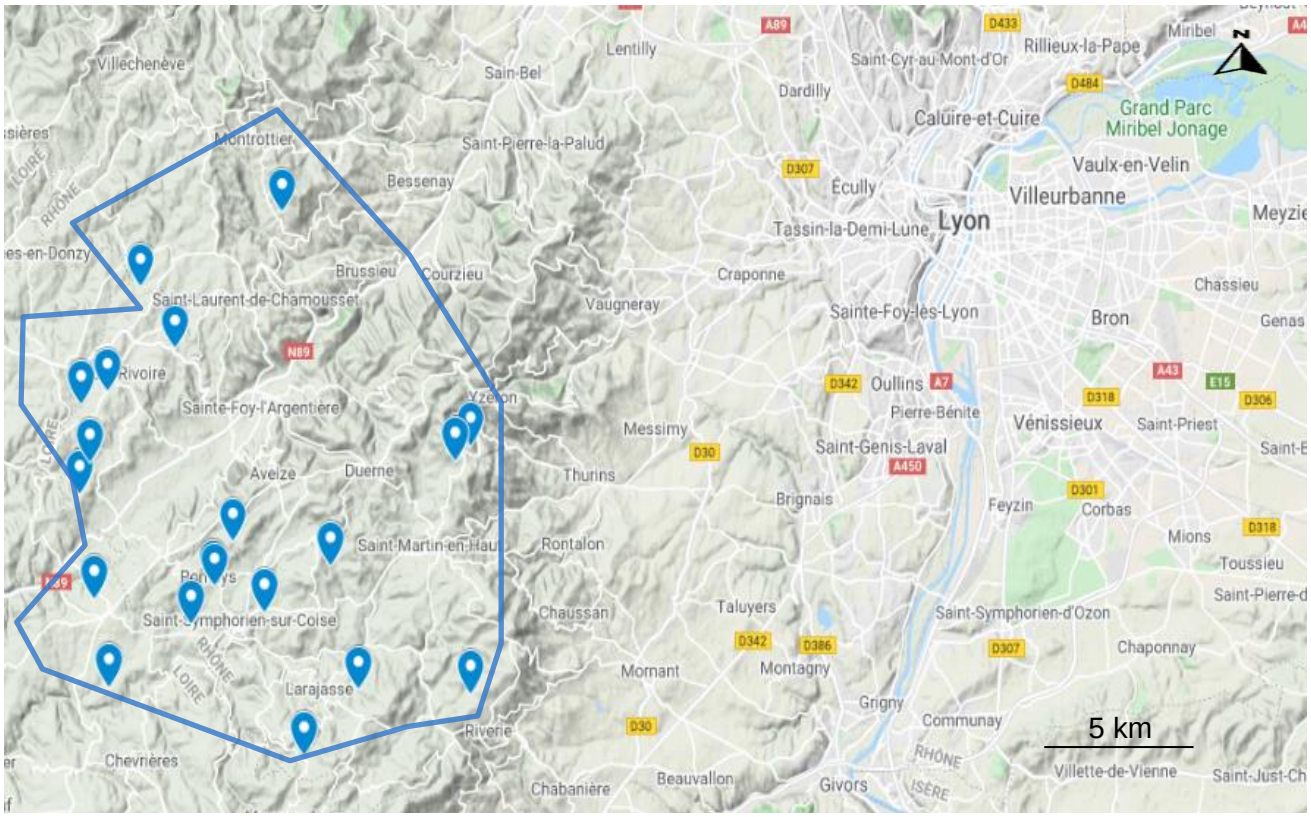

Figure 5 : Location of the 20 farms interviewed (blue: rough delimitation of the Monts du Lyonnais).

Before the meeting with the farmers, the accounting document was requested. Indeed, precise data on the expenses and income of the farm were needed for the study and this demand before the interview allow to reduce the length of the meeting with the farmer, who perceived the time of the interview as an important constraint.

An interview guide was designed to conduct the farmer's interviews. This guide contains all the information requested in the TAPE survey. It allows the interviewer to collect information by theme, which makes the interview more pleasant and concise (see Appendix 3). The interviews were recorded and lasted on average 2h30.

This step allows the collection of data, leading to fulfilling the step 1 and 2 of TAPE.

3 Phase 3: Filling out the online TAPE survey and calculation of indicators

3.1 Nature of the data collected

The data collected from farmers (answers to the questionnaire during the interview and technical/financial documents) were then used to fill out the online survey of TAPE thanks to a platform called “KoboToolBox”, which was made available by FAO. KoboToolBox allows us to answer the different parts of the survey and to retrieve the results in an analyzable form. The survey is structured into two parts:

- the Characterization of the Agro Ecological Transition (CAET) which corresponds to “step 1”.

The CAET evaluates the state of the transition to agroecology of a farm at the time of the interview according to 10 elements (see Figure 6). In the survey, each element is broken down into 3 to 4 questions (see Appendix 4) whose pre-determined answers give a score between 0 and 4, the scores are added together and standardized on a scale from 0 to 100. For example, if a farm has more than 3 crops adapted to local and changing climatic conditions, one species of animal raised, some tree of more than one species and two or three productive activities, then it will receive, for the element Diversity, a score of 3+1+2+1 = 7/16, 43.75% according to the TAPE survey.

The same method is applied to the ten elements. Systems with high scores are considered to be well progressed in terms of agroecological transition.

Figure 6: The 10 elements of step 1 of TAPE (Barrios et al., 2020).

- the Core Criteria of Performance, which corresponds to “step 2” (see Appendix 5).

This step documents the multiple outcomes of agroecology and addresses various dimensions of the sustainable development goals (SDG) that have been identified as key dimensions for policymakers (see Table 2).

Table 2 : Key dimensions addressed in step 2 of TAPE (Mottet et al., 2020a)

MAIN DIMENSIONS	CORE CRITERIA OF PERFORMANCE
GOVERNANCE	Secure land tenure
ECONOMY	Productivity Income Value Added
HEALTH AND NUTRITION	Exposure to pesticides Dietary diversity
SOCIETY AND CULTURE	Women’s empowerment Youth employment opportunity
ENVIRONMENT	Agricultural biodiversity Soil health

4 Phase 4: Data analysis

The data analysis phase had 3 objectives:

- to get an idea of the trends in terms of transition to agroecology in the Monts du Lyonnais.
- to understand the links between the CAET scores (step 1) and the criteria of performance (step 2).
- to validate the way scores are calculated for step 2.

In order to pursue these objectives, statistical analysis was used for the first dataset which corresponds to the results of the step 1 (CAET) and for the second dataset, the Core criteria of performance (step 2).

4.1 Statistical analysis on the CAET (step 1)

4.1.1 Descriptive analysis

Using descriptive analysis will be the first step to analyze the data. It's one of the statistical techniques to describe or summarize a set of data. It reveals the mean, median, standard deviation, minimum, and maximum of the ten elements of CAET. These data were analyzed in light of the context and the characteristics of the farms interviewed in order to try to identify the main trends in terms of agroecological transition.

4.1.2 Multivariate analysis

In order to try to highlight farm types, a Principal Component Analysis (PCA) followed by a Hierarchical Clustering on Principal Components (HCPC) were conducted. The PCA was used to explore a dataset that consists of several quantitative variables; the CAET scores. The PCA is used to determine the dispersion of the farms according to the CAET. The HCPC was conducted to determine if certain groups of farms are significantly different from others and if so, to determine the principal factors that characterize these farms.

4.2 Analysis of the criteria of performance (step 2)

4.2.1 Traffic light approach

Regarding the evaluation of the core criteria of performances, a traffic light approach is used (Mottet et al., 2020b). This approach provides a quick overview of the situation of the farms interviewed. For each indicator, an evaluation scheme has been determined based either on suggestions from FAO or national data available on the Internet (see Appendix 6). A comparison is done between the results obtained per criteria and per farm and the evaluation scheme. Based on this comparison, three colors can be given: green means that the farm is in a desirable situation, yellow, acceptable, and red, unacceptable situation.

Therefore, the main purpose of this traffic light approach is to get a visual idea of the trends in terms of agroecological performance in the Monts du Lyonnais.

4.2.2 Multivariate analysis

In order to try to highlight farm types, a PCA, Principal Component Analysis followed by an HCPC, a Hierarchical Clustering on Principal Components were conducted. The PCA was used to explore a dataset that consists of several quantitative variables; the core criteria of performances. The PCA is used to determine the dispersion of the farms according to the core criteria of performance. The HCPC was conducted to determine if certain groups of farms are significantly different from others and if so, to determine the principal factors that characterize these farms.

4.3 Analysis of the relations between step 1 and step 2

4.3.1 Correlation of Pearson

A correlation of Pearson is a non-parametric measure of statistical dependence between two variables. In this case, it will be used to determine the correlation between the ten elements of the CAET score (step 1) and the indicators of the core criteria of performances (step 2). It aims at understanding the links between different indicators calculated thanks to the farmers' interviews. If the indicators are highly correlated, it could mean that the

questionnaire is redundant and assess several times the same characteristics of a farming system.

5 Phase 5: Feedback from the participants

The objective of this last phase was initially to present the result of the study (including results/scores of Step 1 and 2 of TAPE) to all the participants (local actors and farmers). This approach aimed to match with the last step of TAPE, step 3. However, because of the restrictions due to Covid-19, it was impossible to gather the 16 persons interviewed during step 0 with the 20 farmers at the same place, as suggested by the methodology of TAPE for this step 3. Nevertheless, to even partially, perform this step 3 despite Covid-19, it has been decided that the workshop would be part of a bigger event, organized in the Monts du Lyonnais. Therefore, it took place on June, 29th, during a day dedicated to agroecology, called “Agroécologie à tout bout de champs” (agroecology in every field). The event was organized in the framework of the territorial contract and the agro-environmental project of the Coise by the Interdepartemental syndicate mixte for the management of the Coise River (Simacoise). It gathers farmers of the Monts du Lyonnais around thematics such as grazing management, protein autonomy and the importance of living soil. The workshop was therefore part of the schedule of the day. It included farmers interviewed for this master thesis, farmers not interviewed and local actors. The workshop was facilitated by the person who implemented TAPE, and aimed to (i) present the principal findings and discuss them with the participants and (ii) discuss and design possible ways forward to support the transition to agroecology(see Appendix 7). This workshop was done in a participative manner so that every participant could express freely their thoughts.

PART 2: Results

1 STEP 0: Understanding the typicity of the Monts du Lyonnais

A literature review and the interview of 15 local actors (see Appendix 8) resulted in a good overall description of the Monts du Lyonnais (see Appendix 9). The key elements of this description: global characteristics, ecological environment, social and economic environment and enabling environment for agroecology have been summarized in Appendix 9.

2 STEP 1: Characterization of the Agroecological Transition (CAET)

The interview of the 20 farmers allows us to evaluate the farms' state of progress in terms of transition to agroecology according to the ten elements identified by the FAO (step 1). This section will present and comment on the results obtained.

Table 3 : Main elements to describe the Monts du Lyonnais

Global characteristics	Ecological environment	Social and productive environment	Enabling environment for agroecology
• Group of 32 rural municipalities. • 30 km West from Lyon, Aura region. • Located between Lyon and St Etienne, two dynamics urban areas. • 35 057 inhabitants. • 88,3hab/km² : rural area • Important demographic growth due to urban sprawl and the standard of living offered. • High demand for housing leading to pressure for farming lands artificialization.	• Small valleys and slopes (locally > 30%) • Altitude: from 400m to 946m • Climate: temperate continental, with oceanic and sub-Mediterranean influences • Precipitation: 1,000 mm/year • Soil : poor and shallow, vulnerable to desiccation and erosion. • Numerous manmade water bodies used for maize irrigation, and rivers such as the Coise • Impacted by climate change	• 803 farms on the territory (high density of farm compared to the national average) • 2,7% are organic (2010) • 63% of the farms are dairy cattle farming systems mostly selling in long supply chains • Average UAA: 29ha, half of the national average with 1.2ha/field in average • Trends: -25% of farms in 10 years leading to farms expansion • Strong collective dynamic with the first farmer's shop of France	• Public strategies related to agroecology: 2012: the agroecological project for France; support given to farmers willing to scale up agroecology • Local structures and actors: La SimaCoise, Rhône Conseil Elevage, local actors participating to the transition • Private companies: Danone invests in regenerative agriculture in the Monts du Lyonnais

2.1 Scores for the 10 elements of step 1

The score's average obtained for each element show that there is a range of results between these 10 elements, from 40.6/100 for the diversity element to 100/100 for the Responsible Governance element (see Figure 7). This observation justifies an individual analysis of the elements in light of the questions asked in the survey, the type of farms and the context.

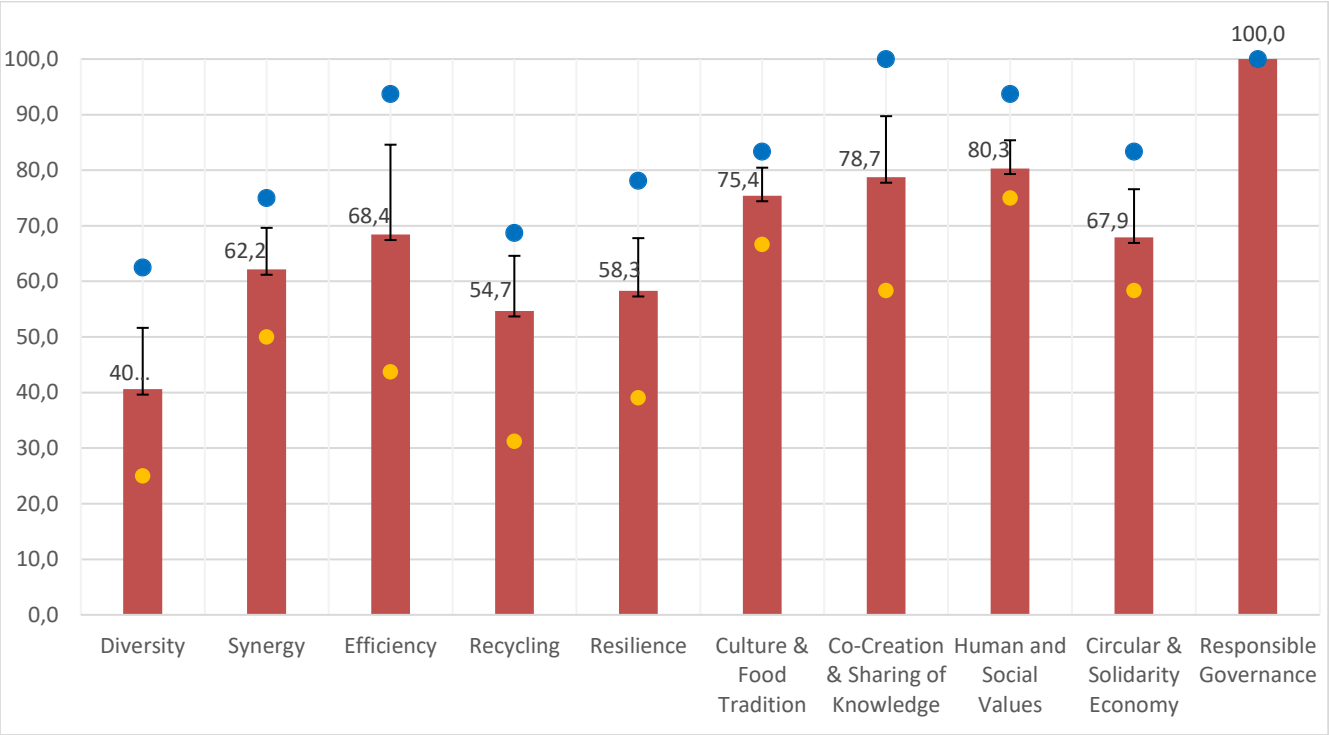

Figure 7: Scores (out of 100) obtained for each element of the Characterization of the Agro Ecological Transition ("CAET", step 1 of TAPE) (mean +/- SD, blue dot = maximum value, yellow dot = minimum value N=20 farms).

2.1.1 Diversity

The average score for this element is 40.6/100, which is the lowest average of the 10 elements (see Figure 7). This element assesses the diversity of crops, animal species, trees and income sources at the farm level (see Appendix 4). The nature of the farms evaluated explains such a low score: they are dairy farms in the Monts du Lyonnais. They are therefore characterized by systems in which the cultivated plants (generally grass, cereals and corn) feed the cows, whose milk production, sold to dairy cooperatives, is often the only source of income. It should be pointed out that farms that process their milk into cheese have a

significantly higher score than others; 47.7/100 compared to 35.9/100 for those that do not process (see Appendix 13). In addition, farms, where animals are fed exclusively on grass, are at a disadvantage compared to the others since their score in crop diversity is lower. These systems can be assimilated to monoculture systems, connoted negatively in terms of transition to agroecology, whereas in some situations, grass can be the best option to face certain pedoclimatic situations.

2.1.2 **Synergies**

The average score in terms of synergies is 62.2/100 (see Figure 7). The standard deviation is low, the mean and the median are close: there are few differences in synergies between farms. This element evaluates the integration of crops, livestock and trees, the management of the soil-plant system and the place of trees in the farming system (see Appendix 4). Again, the systems evaluated are farms where the majority of crops produced on the farm are fed to animals. In addition, one of the questions focuses in part on the amount of land left bare, without crops or residues. In France, in order to receive CAP subsidies, no land must be left bare. Finally, the farms are located in the Monts du Lyonnais, a territory naturally provided with forests, groves and hedges and in which fruit trees are historically not very present in dairy farms. This results in scores that are fairly homogeneous and high for this question.

2.1.3 **Efficiency**

The efficiency score is calculated based on the use of synthetic fertilizers, pesticides, the proportion of inputs produced in the agro-ecosystem and the capacity of the household to meet these needs through agricultural activity (see Appendix 4). Although the average score is 68.4/100, there are wide disparities, with a large standard deviation (see Figure 7). This is because certified organic farms have significantly higher scores than conventional farms (see Appendix 14). This is due to the nature of the organic farming specifications which prohibit the use of synthetic fertilizers and pesticides.

2.1.4 **Recycling**

This pillar is based on the management of waste, water, the presence of renewable energies and the supply of seeds and animal seeds (see Appendix 4). Here the average is 54.7 with a fairly high standard deviation (see Figure 7). The responses are rather heterogeneous, with no particular trends observed.

2.1.5 Resilience

This element is based on income stability, the ability of the system to recover from shocks (in the broadest sense of the term), the ability of the community around the farmers to help in case of a shock, and the vulnerability of the territory to climate change (see Appendix 4). These questions count for 75% of the resilience's score while diversity score contributes to 25%. The interviews with farmers revealed a trend; although production is correlated to shocks that may affect the farming system, this is not the case for income. The majority of farmers decide to pay themselves a regular salary, regardless of the fluctuations, at the risk of jeopardizing the financial health of the farm. They consider that their income should not be an adjustment variable. They prefer working on other issues: input management, product valorization, etc.

2.1.6 Culture and food traditions

The average for this score is quite high at 75.8/100 (see Figure 7). Farmers tend to be more sedentary than the overall population, due to their professional activity. Food culture and traditions, therefore, tend to be more easily transmitted and respected. In addition, through interviews with farmers, it was stressed that they generally pay particular attention to promoting self-consumption through their own or their relatives' vegetable gardens and the consumption of local products to support the local economy.

2.1.7 Co-creation and sharing of knowledge

This element focuses on social mechanisms for horizontal knowledge creation and transfer, access to knowledge and interest in agroecology, and participation of producers in networks and organizations (see Appendix 4). This average score of 78.7/100 (see Figure 7) is important because, as identified in STEP 0, the territory has a very strong collective dynamic, resulting in many exchanges between farmers. Farmers generally have difficulty defining agroecology and see it as a set of agricultural practices that respect the environment. The lexical fields of autonomy, resilience and adaptation to climate change were very present.

2.1.8 Human and social values

Again, scores were quite strong, with a mean of 80.3/100 and a low standard deviation (see Figure 7). For this element, questions focused on women's empowerment, employee working conditions, animal welfare, and youth empowerment (see Appendix 4). For the first three questions, the results are rather homogeneous because French legislation covers these issues. If the scores are different, it is mainly on the attractiveness of agriculture for young people, a very heterogeneous notion depending on children's interest to take over the farms.

2.1.9 Circular & solidarity economy

The average score for this element, 67.9/100 (see Figure 7), is based on the presence and use of local markets as a distribution channel for agricultural products, the existence of operational networks that link producers and consumers, and finally the proportion of food consumed that comes from the territory or is purchased outside (see Appendix 4). Again, farms that process part of their milk production into cheese score significantly higher than farms that do not process because they sell directly (see Appendix 15).

2.1.10 Responsible governance

This element focuses on the state of the land, as the questions are producer empowerment in general, the presence of producer organizations and associations, and producer participation in the governance of the land and natural resources (see Appendix 4). Thus, the results are identical, regardless of the farm evaluated, and are worth 100/100 given the organizations present and the regular involvement of farmers in them (see Figure 7).

Step 1 provides an overview of the transition to agroecology of the farms interviewed. It shows that these farms are globally in agreement with the 10 elements of agroecology, with an average total score of 68.2/100. The collective dynamics and the strong attachment of farmers to their territory, notions identified in step 0, are also perceived here, through high scores in Culture & Food Tradition, Co-Creation & Sharing of Knowledge, Human and Social Values and Responsible Governance. This step also identifies a weakness that seems to affect all the farms observed: agricultural diversity and sources of income are low.

The descriptive analysis shows that some elements of step 1 have significant standard deviations (see Figure 7). This suggests that significant differences are present between farms. The following section focuses on identifying these differences.

2.2 Analysis of the different trends within the sample

2.2.1 Heterogeneous farms states of agroecological transition

The principal analysis component (PCA) conducted to identify the main drivers of the step 1 shows that the two first dimensions are worth 49.7% of the total dimensions (see Appendix 17) . It means that 49.7% of the dispersion of individuals can be explained by the dimension 1 and 2 (see Figure 8). Therefore, this graph helps to have a good understanding of the results found. Dimension 1, in abscissa, is mostly explained by the resilience and efficiency scores (res_score and eff_score on the Figure 8) and dimension 2 is mostly explained by human and social values and the recycling score (human_score and rec-score on Figure 8). Cocreation and sharing of knowledge cocr_score and div_score have the highest score of cos², meaning that these elements are part of both dimensions.

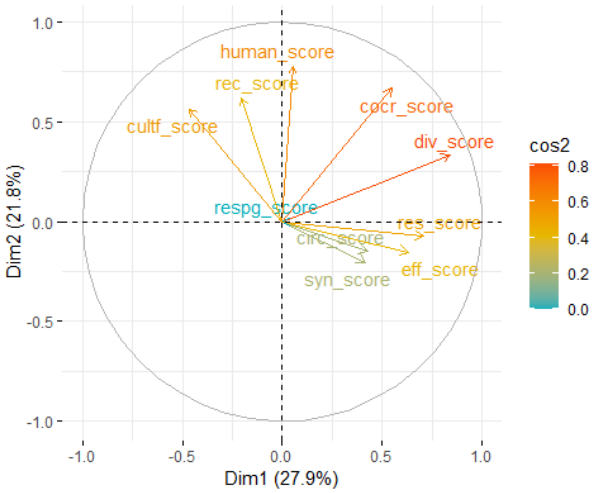

Figure 8: Graphical representation of the 10 elements (step 1 of TAPE) according to the two main dimensions identified by the PCA.

The dispersion of the farms, according to the PCA, is wide since farms are located in various positions on the graph (see Figure 9). In the meantime, we can also observe that some farms are very closed to each other, such as the farm 1 and 9. It could mean that these specific farms tend to have the same scores for the 10 elements of step 1, and therefore have the same degree of agroecological transition. In order to confirm this hypothesis, an HCPC (Hierarchical Clustering on Principal Components) has been conducted.

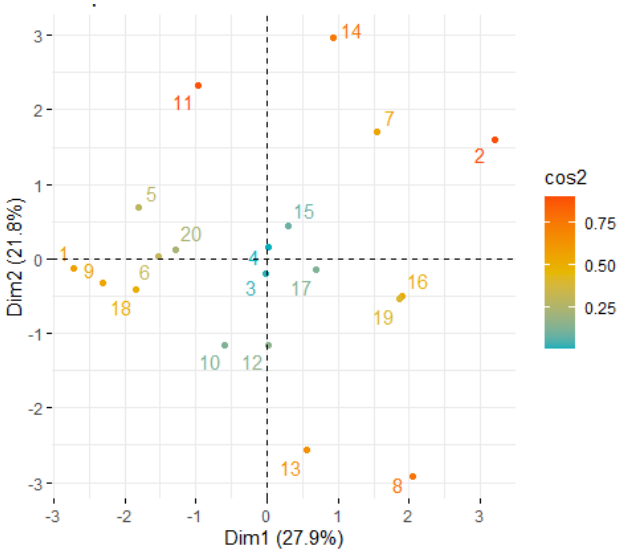

Figure 9: Graphical representation of the 20 farms elements according to the two main dimensions identified by the PCA for the step 1 of TAPE.

The HCPC identified different clusters whose farms have significantly similar CAET responses (see Figure 10). The relevant number of clusters, 4, has been decided using different simulations. This analysis was conducted to link the features of the 20 farming systems assessed with the score obtained for step 1. This statistical analysis revealed 4 different groups:

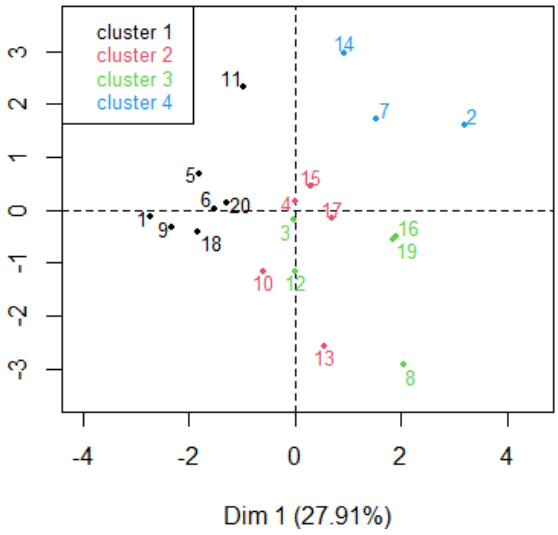

Figure 10: Identification of 4 farms' clusters thanks to the results obtained for the step 1 of TAPE.

- Cluster 1: Classic intensive system of the Monts du Lyonnais

This cluster is driven by a high score in culture and food traditions, low score in resilience, synergies, efficiency and diversity score. The farms are located left on the graph, it's the farm 1, 5, 6, 9, 11, 18, 20 (see Figure 10). In terms of characteristics, these farms are very similar; it's mostly conventional farms, which milk production is sold to a milking cooperative. There is no processing into the cheese factory and no use on short circuits. This cluster represents the most common dairy cattle farm systems that could be found in the Monts du Lyonnais. One of the hypotheses that could be formulated regarding the link between this model of farms and the high result in culture and food traditions, is that they are often farms managed by farmers whose families have been anchored for several generations in the territory. They could therefore be farms that feel more concerned by these themes.

- Cluster 2: Low impact farms

This cluster is driven only by a high synergy score and corresponds to the farm n°4, 10, 13, 15, 17 (see Figure 10). This group of farms could be called "low-impacts farms" because they don't have a significant impact, neither positive nor negative on the environment. These farmers do not produce intensively, some are organic. Thanks to their interview, it could be said that these farmers are aware of environmental issues and willing to participate in the change but that they prefer doing that on their own, without being committed to farmers' networks.

- Cluster 3: Farms with functioning adapted to agroecology

This cluster is driven by significantly high circular and solidarity economy and low human and social values score. It corresponds to the farms n°3, 8, 12, 16 and 19 (see Figure 10). 4 out of 5 of these farms process part of their milking production into cheese, and thereby use direct selling channels. These systems could be seen as farms with functioning adapted to agroecology. Dialogues with farmers revealed that they don't have a good understanding of agroecology meanings but are intuitively going in the direction of the agroecological transition.

- Cluster 4: The driving forces of the agroecological transition

Cluster 4 is characterized by a significantly high score of co-creation & sharing of knowledge, diversity, human and social values. It corresponds to the farms n° 2, 7 and 14 (see Figure 10). These farms could be seen as the driving forces of the transition to agroecology among the farms interviewed. They have common features: organic farming, a diversified production (either thanks to cheese production or other animal production), an awareness of today's farming issues and commitment to engage their farm in a transition toward more sustainable practices.

Figure 11: Mean score obtained per cluster identified by the HCPC for the step 1 of TAPE

Beyond the score obtained for the CAET, a significant difference in terms of mindset has been observed for the farms processing their milk into cheese. During the interviews, most of these farmers explained that processing part of their production into cheese was a decision made to diversify their source of revenue in order to be less dependent on the milk price fluctuations. They are aware of the potential market of Lyon, St Etienne and Roanne and use farmer's markets to valorise their production. Moreover, all these farms are organic, which confirms again their wish to valorise their production.

Therefore, Step 1 assesses the state of the transition to agroecology of the twenty farms evaluated. The scores are generally good with an average of 68.2/100. However, there is a high score's amplitude between the different elements as well as an important amplitude of score between farms (see Appendix 16). This observation led to further statistical analyses including PCA and HCPC to identify common characteristics of these farms. In the case of this study, step 1 reveals that farms with a rather intensive model (cluster 1) have generally lower scores for the step 1 than farms in cluster 4 (see **Erreur ! Source du renvoi i ntrouvable.**). However, this step is not sufficient to evaluate the agroecological performance of farms; step 2 provides new information on the agroecological performances of these farms.

3 STEP 2: The Core Criteria of Performance

Step 2 provides a new understanding of the agroecological performances of the farms interviewed thanks to a set of new indicators.

3.1 Findings with significant disparities

Thanks to the traffic light approach, wide disparities both within a criterion and between the different criteria are observed (see Table 4). Each criterion will be discussed in the following parts, considering the questions asked in the survey, the type of farms and the context.

3.1.1 Governance

For the man land tenure score, they all obtained the maximum score of 100 (see Table 4). It's because all the male farmers have an official document proving their rights on the land (either as user or owner), have the perception of secure access to land and have the right to manage (sell, bequeath, inherit) any of their parcels. Concerning the women's land tenure

score, it's shared between 50 for 14 farms and 100 for the rest (see Table 4). A score of 50 means that the person doesn't have any legal document proving he owns or rents the land, but that his perception of land tenure is good.

These indicators have to be understood within the context TAPE is implemented in, in this case, France. In France, some regulations fully frame land tenure; someone who rents or owns the land has necessarily an official document proving it.

Moreover, in France, the farming activity is hardly seen as subsistence farming, as it could be in African countries (Stoessel-Ritz, 2015). Farming is a professional activity that takes place often next to the family house and influences family life but doesn't always involve the man and the woman of the household. In the framework of this study, farmers are 15 out of 20 males, whose wife has a different occupation. In this case, the woman is not the owner of the land because she doesn't farm. If these women have a score of women land tenure equal to 50 it's because their perception of land tenure is good, since regulations provide them right. Concerning the 5 farms which have 100 for woman land tenure, it corresponds to farms in which women are involved. Therefore, even if the woman land tenure score could be seen as low compared to men land tenure, this indicator has to be in light of the agricultural French context.

3.1.2 **Economy**

- Productivity/ha

This criterion is measured by the gross output value divided by the Utilised Agriculture Area (UAA). The gross output value corresponds to the total volume of agricultural output: crops, animals, trees, and animal products. This number is different from the sales revenue because it considers that the entire production has been sold, whereas, for the 20 farms interviewed, most of the crop production feeds the animals. The productivity/ha has been compared to the local average to determine if the farms were in a desirable, acceptable, or unacceptable situation (see Appendix 6). We can observe that 19/20 farms are in a desirable situation whereas farm n°17 is considered acceptable (see Table 4). We can also observe a high range of results, going from 2 368€/ha (farm n°17) to 8 700€/ha (farm n°8). Farm n°17 is organic, has poor yields and does not process milk into cheese. Farm n°8 is organic as well but process most of it milk production into cheese. It explains the main difference of productivity/ha: processing milk into cheese is, according to the farmers interviewed the best way to valorise a product.

- Productivity/pers

This criterion is measured by the gross output value divided by the number of workers involved in the farms, both from the household and external workers. As observed for the previous criterion, most of the farms are in a desirable situation whereas only 5 farm's results are qualified as acceptable. The results' amplitude is high, going from 62 031€/pers (farm n°3) to 331 475€/pers (farm n°12) (see Table 4). This difference can mostly be explained by the features of the farms; farm n°3 process its milk production and have therefore 4 people working on the farm whereas farm n°12 is labor-intensive, with 160ha (leading to high gross output product) and only 2 farmers.

- Added value

This indicator results from the subtraction of operating expenses from the gross output value. In order to compare the different farm's situations, it was decided to compare not only the value-added but the value-added produced per worker to the local average (see Appendix 6). 16 farms are considered as in an unacceptable situation whereas 2 are in an acceptable situation and the last 2 are in a desirable situation (see Table 4).

The evaluation scheme for this criterion is more specific than the previous one. Indeed, it was decided to compare not only the added value to the local average but the added value produced per worker (equivalent annual work unit) to the local average. It helps to have a better understanding of the performances of farms, regardless of their size (in ha) or the number of cows.

According to the three last criteria, the productivity of the farms assessed is globally good, both in terms of productivity/ha and productivity/pers, whereas the added value is globally low. All of these criteria seem to show that operational expenses are important. This idea is in line with the information found in step 0: the soil and climate conditions of this territory make production costs higher than average.

Table 4 : Results obtained per farm for each indicator of the step 2 of TAPE in light with the traffic light approach

	Governance		Economy				Health and nutrition		Society and Culture		Environnement	
Farm	Man land tenure score	Women land tenure	Productivity/ha	Productivity/pers	Added value	Income	Exposure to pesticide	Dietary diversity	Women empowerment	Youth score	Soil health	Agricultural biodiversity
1	100	NA	5 360	143 119	221 816	35 029	50	70	NA	63	3,5	39
2	100	100	6 194	108 984	5 139	- 54 656	100	90	66	NA	3,8	72
3	100	50	4 965	62 031	73 693	21 435	100	70	50	75	3,3	66
4	100	50	2 707	72 300	56 019	17 701	50	70	45	NA	3,2	50
5	100	50	4 549	75 300	15 443	16 689	50	90	58	NA	3,6	72
6	100	50	4 650	132 430	18 658	22 136	50	80	48	0	3,6	50
7	100	100	5 562	207 363	40 605	21 157	100	90	68	50	3,3	50
8	100	50	8 700	179 735	287 817	70 015	100	80	59	50	3,0	44
9	100	50	3 849	166 024	71 746	- 16 311	50	90	56	67	2,8	44
10	100	100	4 820	104 822	137 868	77 316	100	90	66	NA	3,0	44
11	100	100	3 808	65 560	46 954	16 088	50	80	45	88	3,5	22
12	100	50	4 203	331 475	346 493	6 190	50	70	49	88	2,9	66
13	100	50	2 827	159 361	54 645	50 511	100	70	66	NA	3,3	50
14	100	50	5 405	118 570	229 176	49 489	100	90	63	70	3,1	50
15	100	50	4 276	107 337	102 446	51 417	50	70	50	NA	3,6	50
16	100	50	8 305	128 695	221 636	22 076	100	80	45	6	3,1	50
17	100	50	2 368	112 518	57 810	61 145	100	80	61	NA	3,6	66
18	100	100	3 935	130 593	95 220	16 783	50	80	60	NA	3,4	50
19	100	50	4 561	84 698	71 359	7 101	100	100	54	NA	3,0	77
20	100	50	4 058	138 661	167 554	33 040	27	70	53	NA	3,4	66

- Income

This criterion is calculated as the following: Income = Revenue from agricultural activities + Subsidies -the cost of inputs- (taxes, cost of hired labor, interest on loans, cost of renting land and depreciation of machinery and equipment). In order to assess the performance of these results, the evaluation scheme compares the income divided by the number of family workers to the local average. According to the traffic light approach, the farms' situation is very heterogeneous; 4 are desirable, 5 are acceptable and 11 are unacceptable (see Table 4).

This situation can be reviewed in light of the real-life situation. Indeed, the income calculated corresponds to the income generated only by the farming activity. It does not necessarily correspond to real-life situations, since the farmers' interviews showed that farmers prefer to pay themselves a decent salary, sometimes at the expense of the company's health.

3.1.3 **Health and nutrition**

- Exposure to pesticides

The assessment of the exposure to pesticides score is realized according to four main characteristics: the quantity used of synthetic pesticides compared to organic, the number of pesticides used considered as highly toxic (see Appendix 10), the number of mitigation techniques used when applying pesticides (mask, body protection, secure disposal of the empty containers after use) and the number of integrated techniques for pest management.

The 10 farms having a desirable situation with a score of 100 are organic and thereby have poor exposure to pesticides (see Table 4). 9 farms have a score of 50. It corresponds to conventional farms which use more synthetics pesticides than organic, does not use highly toxic pesticide and use as least 4 mitigation techniques listed in the survey (see Appendix 11). The farm n°20 has the poorest score because it uses less than 4 mitigation techniques.

This criterion provides different information, which is linked to the agricultural French context. First, none of the pesticides registered are classified as Highly toxic (see Appendix 10) because of the European regulations. Second, organic pesticides are barely used in farms of the mixed farming dairy cattle type. Moreover, according to the answers of the TAPE survey, mitigation techniques and integrated pest management techniques (use of cover crops to increase biological interactions, promote the reproduction of beneficial organisms for biological control, promote biodiversity and spatial diversity within the agroecosystem) are regularly used by farmers.

- Dietary diversity

This criterion aims to establish a quick diagnosis of the household's accessibility to a variety of foods which is also a proxy for nutrient adequacy of the diet of individuals (Mottet et al., 2020a). This criterion is calculated according to the woman's household diet because women often give priority to the nutrition of other family members (Mottet et al., 2020a). The woman's diet can therefore be considered as a representative of the nutritional status of individuals within the household. Based on a list of 10 groups of aliments, it was asked to the woman's household, which aliments' groups she consumed in the previous 24h. The sum of the numbers of aliments eaten was multiplied by 10 to have a score ranging from 0 to 100.

As we can observe thanks to the traffic light approach, the dietary diversity is positively homogeneous going from 70 to 100. This situation can be considered desirable for the 20 farms interviewed (see Table 4). This criterion shows that among the farms interviewed, the diet seems to be diversified and that there is no suspicion of hunger, micro-nutrient deficiencies or obesity.

3.1.4 **Society and culture**

- Women empowerment

In order to calculate this score, an abbreviated version of the Women's Empowerment in Agriculture Index has been used (USAID et al., 2012). According to the traffic light approach, the women empowerment score is unacceptable for 12 women interviewed out of 19 (see Table 4). These scores refer to women who have an income independent of their husband's farming activity, who have no attraction for farming and do not wish to be involved. They, therefore, do not make any decisions for the farm, and would not feel able to do so if they had the opportunity. If the scores remain fairly homogeneous for these 12 women, between 45 and 59, it is because they all participate in decisions concerning furniture and household tools, notions counting in the calculation. Concerning the 7 women who have an acceptable score, it corresponds to women who either work on the farm (4 out of 7) or participate in decisions or feel capable of taking decisions because they regularly discuss farming with their husbands.

According to this calculation, women empowerment is in the majority low for the farms interviewed. This result indicates that poor women are involved in farms and that they often

have their proper work. This situation is not limited to the Monts du Lyonnais and can be found in France and more widely, in Europe (Giraud and Rémy, 2008).

- Youth score

The traffic light approach brings to the fore the heterogeneity of answers. First, we can observe that 10 out of 20 farmers interviewed don't have any children older than 15 years old due to a sampling with a lot of young parents' farmers. 4 farms have a youth score considered as desirable, meaning that at least one of the farmer's children is willing to take over the farm.

The few scores considered unacceptable are, in reality, much more numerous. Indeed, in the Monts du Lyonnais and all over France, the lack of farm takeovers is increasingly observed given farmers' retirements. This is an important challenge that many actors in the agricultural sector are trying to manage.

3.1.5 **Environment**

- Soil health

The scores obtained go from 2.8 to 3.8 out of 5 and are considered acceptable or desirable (see Table 4). This score should be put into perspective because, as explained in step 0, the Monts du Lyonnais is a hilly area, with many plots with slopes of up to 30%. The average perceived by each farm does not, therefore, represent the variations in soil health that can be found on the same farm. Most farmers have plots that are not mechanizable because of the slope, are prone to erosion, have a lack of organic matter and others have soils with many aggregates, active soil life and good organic matter.

- Agricultural biodiversity

This criterion assesses the farms' agricultural biodiversity. It takes into account the raised animals, the crops cultivated, the presence of pollinators, wild fauna and flora. The results are very variable, going from 22/100 to 76/100, with 5 farms in an unacceptable situation, 12 in an acceptable situation and 3 in a desirable situation (see Table 4). This answer's diversity reflects the differences that have been observed in terms of agrobiodiversity in fields. Moreover, the information collected to calculate this criterion helped to have a good idea of farmers' relation to flora and fauna. Few trends can be described:

- Even if pollinators are commonly present on the farm, they are poorly raised.
- A local policy promoting the plantation of hedgerows encourages farmers to do so. Some farmers are bewildered by contradictory policies. Indeed, when they were young, they saw their parents receiving money to cut the hedge and now they receive subsidies to plant them again.

3.2 A new clustering based on Step 2

The principal analysis component (PCA) conducted to identify the main drivers of the core criteria of performances (step 2) shows that the two first dimensions are worth 45.2% of the total dimensions (see Figure 12). We can observe an important difference with dimensions 3 and 4, respectively equal to 14.1% and 12.7% (see Figure 12). It means that the two first dimensions suggest a good understanding of the dispersion of the farms. Dimension 1, in abscissa, is mostly explained by the productivity/pers and added value (see Figure 12) and dimension 2 is mostly explained by women empowerment and pesticide exposure.

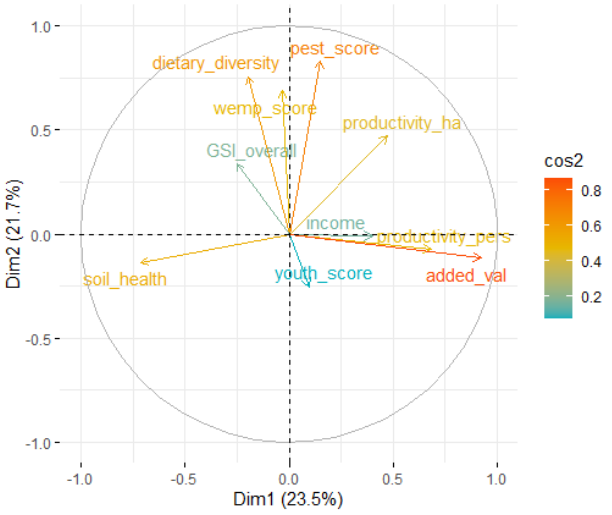

Figure 12 : Graphical representation of the core criteria of performances (step 2 of TAPE) according to the two main dimensions identified by the PCA

Thanks to the HCPC, 3 main clusters have been identified. The first one in black (see Figure 13) corresponds to farms with low scores for women empowerment, dietary diversity and pesticide exposure. The second one, in red, corresponds to the opposite, with farms having high scores for women empowerment, dietary diversity and pesticide exposure. The last cluster corresponds to farms with high scores of added value, productivity/ha, productivity/pers and low scores for soil health.

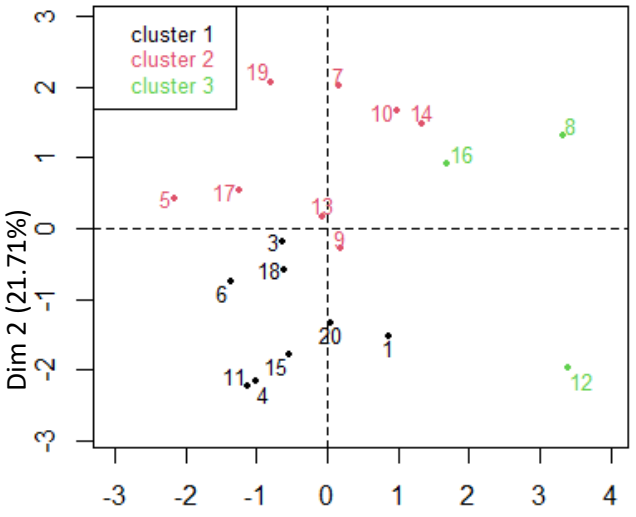

Figure 13: Identification of 3 farms' clusters thanks to the results obtained for the step 2 of TAPE

Unlike the PCA and HCPC conducted in step 1, this statistical analysis reveals that there are no clear relationships between clusters and farming features, regardless of the number of clusters chosen. Also, no links between the clusters present in step 1 and those of step 2 are observed. Given these results, other analyses have been carried out to understand the relations between step 1 and step 2. These are no longer multivariate analyses, but bivariate analyses, which allows a more segmented analysis.

4 The correlation between step 1 and step 2 is minimal

A matrix of correlation has been conducted in order to see the relations between the elements of step 1 and the criteria of step 2. Efficiency and pesticide exposure have the highest positive correlation (see Figure 14). Concerning the questions asked for efficiency, two are related to the use of synthetic pesticides or fertilizers. The high correlation is therefore due to organic farms that have both good scores on pesticide exposure (none for organic farms) and efficiency.

We can also observe a negative correlation between the culture and food traditions score and the productivity/pers. This result is hardly interpretable in light of the type of farms assessed.

This matrix of correlation shows that most of the elements (step 1) are poorly correlated to the criteria of step 2.

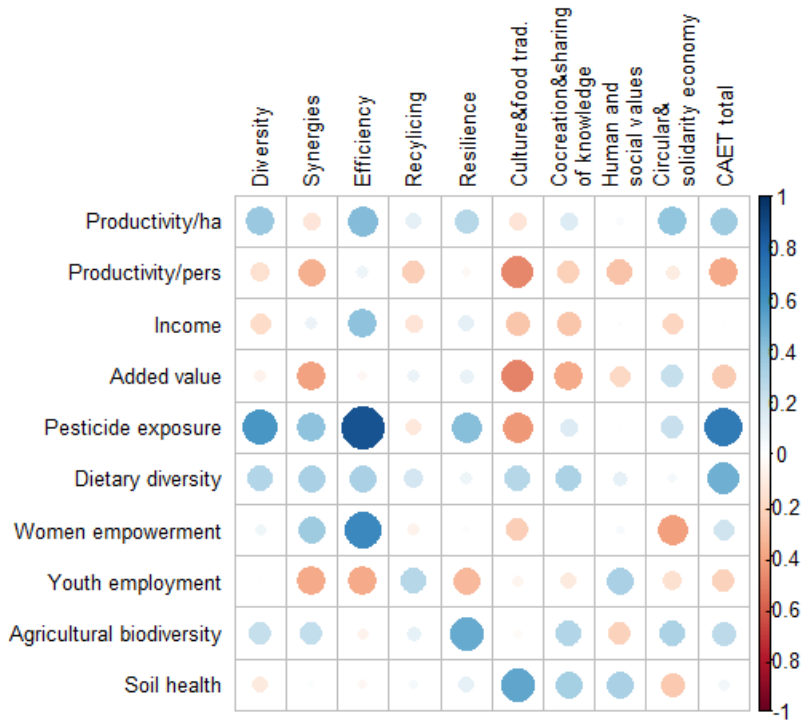

Figure 14: Matrix of correlation between step 1 (top) and step 2 (left), blue dot = high correlation, red dot = negative correlation, the size of the dot is proportional to the correlation.

5 STEP 3: Workshop with farmers and local actors

The workshop was an opportunity for farmers and local actors to express their opinion on how to scale up - including more people and progressing faster- the use of agroecological knowledge and principles in practical agriculture. The following sections highlight the levers discussed with farmers, both at the territorial and national levels.

5.1. The transition to agroecology on a territorial level

During this workshop, the participants (local actors and farmers) highlighted the essential points that allow the transition to agroecology on a territorial scale. 4 main elements were discussed: working within a collective, having access to technical training, receive grants to support farmers in their transition and the relevant role of CUMA's.

According to the farmers interviewed, working within a collective is the main way to progress in the transition. The interests of the collective are multiple according to the participants. It helps to stay motivated and to feel reassured in the face of uncertainty. The collective also allows mutualizing the risks and costs by working together. Finally, a horizontal transfer of knowledge takes place in these groups, which discuss both failures and successes.

Beyond the interests of the collectives, the discussion focused on the characteristics necessary for the proper functioning of these collectives. Four criteria were identified. First, there must be an atmosphere in which judgment is excluded. This makes it possible to discuss the progress and failures of each operation without fear. Criticism is still appropriate because it allows projects to move forward. It is also necessary to be ready to change and to forget some habits concerning time management, farming practices and breeding. The group must be composed of farms with diverse profiles: organic, conventional, intensive, processing, etc. This allows for a wide range of profiles. This makes it possible to have different farmer profiles, and thus a greater wealth of knowledge. Finally, conviviality was mentioned several times. It helps to motivate farmers to work together even in the most complicated times.

Secondly, farmers who are in the process of transition often participate in training courses to acquire knowledge about the soil, for example, ration calculations, grazing management, etc. This type of training is greatly appreciated by the farmers because it gives them specific skills that they can apply directly on their farms.

Moreover, the subsidies that help pay for the training are highly appreciated by farmers who feel supported in their transition. This allows them to avoid over-committing financially to

projects that may not work. Farmers even think that some of the subsidies should be for tests they undertake, such as soil tests. These costly tests make it possible to establish various diagnoses on the farm and to take action accordingly.

Finally, when a person wishes to acquire new expensive equipment, he often deals with a cooperative for sharing equipment (CUMA). It is then necessary that a certain number of farmers of the CUMA agree to contribute to buy it. Those who have contributed then have the right to use it. This operating system creates an opportunity to exchange new practices. Indeed, when it is an innovative material, which arouses curiosity, an exchange can take place with farmers who are not inclined to the transition to agroecology and those who wish to change their practices.

5.2. The transition to agroecology on a national level

Participants have highlighted the essential points that allow the transition to agroecology on a national scale: the CAP, independent advisors, the integration of climate and environmental issues into agricultural training, and the role of the downstream sector.

The CAP was identified by the participants as the first lever to engage more people in the agroecological transition. Indeed, the CAP could promote the principles of agroecology on a larger scale. The participants are convinced that the economic incentive is the most important to engage the transition. They also stated that the current reform of the CAP does not allow such a transition.

Moreover, participants also discussed the issue of advisors around the farm. They would like advisors to be focused on advising farms accordingly to their needs, instead of selling their company's products.

Moreover, many farmers noted that they were not aware of the contemporary climate and environmental issues, and the leverage that agriculture represents. They think that these subjects should be an integral part of their agricultural training. It would also be necessary to teach more about practices that are considered innovative today (sowing undercover, direct seeding) in farming education.

Participants highlighted the influence that downstream chains, such as dairy cooperatives, can have in the agroecological transition. If these companies encouraged farmers to change their practices by offering financial compensation or specific training -for grazing management, for instance, the transition would be more extensive and could involve more people.

To conclude, thanks to the information collected during the 4 steps of TAPE, a certain description of the place of agroecology in the Monts du Lyonnais can be established. Located in the low mountains, this territory has strong pedoclimatic constraints that have often forced farms to intensification to remain competitive. Rich of its agricultural density, and of the commitment of its farmers on the territory, the collective dynamics is one of the major assets of this territory.

All the interviews allowed us to observe that agroecology is an approach present on the territory, but in a silent way; the term is rarely used and the concepts linked to it are poorly understood, but the actions engaged on the territory (desire for energy transition, training in the management of the "water" resource and grazing, the valorisation of agricultural products, efforts on the maintenance of collective dynamics) are in agreement with the principles and values of agroecology.

Step 1 indicates that the transition to agroecology occurs at different speeds depending on the importance that farmers attach to it, and that a link can be determined between the scores obtained and the characteristics of the farms. Farms with a rather intensive model (cluster 1: conventional farms, no processing into the cheese factory and no use on short circuits) have generally lower scores for the step 1 than farms from cluster n°4: organic farms with a diversified and an awareness of today's farming issues and commitment to engage their farm in a transition toward more sustainable practices.

Step 2 analyzes the farms on transversal indicators. We observe a great heterogeneity of results between farms, and within the farms. We also observe that these results cannot be linked to the results of step 1: a farm with good scores in terms of agroecological transition (step 1) will not necessarily have good agroecological performance scores (step 2).

This study also highlights the main levers at the territorial and national levels that would allow more people to be involved in the transition; training, peer support and CAP reform are among these levers.

PART 3: Discussion

The implementation of TAPE in the Monts du Lyonnais provided information on the agroecological performances of this territory. The results show that the farms evaluated are in different states of transition to agroecology depending on the features of the farm and the commitment of the farmers to the transition. Beyond the analysis of the agroecological performance of the Monts du Lyonnais territory, the application of TAPE in the mixed crop dairy cattle system in the Monts du Lyonnais was the opportunity to detect some limitations of TAPE. Because this tool is oriented towards the assessment of subsidiary farms, some inconsistencies have been observed when applied in the European context. The following parts address first the limits of the study, then, the strengths and weaknesses of the tool and provide suggestions to improve it.

1 The study limitations

The major limitation of this study is the sampling methodology used. Two methods were used to contact farmers: convenient sampling and snowball sampling. It does not provide a representative sample of the mixed crops dairy cattle farmers' population for different reasons. First, it's not a random sampling; the twenty farms interviewed correspond to the twenty-first farmers who agreed to participate in the study. Second, it was also decided to focus only on mixed crops dairy cattle systems, being the most common one, in terms of farms' number and hectares allocated. However, other farming systems are present on the territory: beef cattle, arboriculture, market gardening and viticulture.

Therefore, we can assume that the score obtained with the sampling are higher than the average score of the Monts du Lyonnais. Indeed, farmers who accepted to participate in this study are most likely to know what agroecology is about, to be open to the discussion, to be involved in projects related to agroecology and therefore can perform better (Wallin, 1949). However, this sampling approach was the most ethical and practical given the duration of the study (6months) and the means made available.

Finally, the Monts du Lyonnais represents a case study to test the methodology of TAPE in a European context. This territory is relevant to partially address this question because it offers common farming systems, which can easily be found in Europe. However, it is necessary to deepen this question of suitability by carrying out new studies elsewhere in Europe where there are other cultures, mindsets, farming practices.

2 Performances of TAPE and suggestions

The TAPE process is divided into four steps, each of which enables the collection of information, both qualitative (step 0 and step 3) and quantitative (step 1 and 2), on agroecological performance within the territory. The following parts address, step by step, the strengths and weaknesses of the tool and provide suggestions to improve it.

2.1 Step 0: a great starting point to understand the dynamics of a territory

STEP 0 is comparable to a literature review. FAO has established an exhaustive list of information that should be collected (Mottet et al., 2020c). This step should not be underestimated as it enables an understanding of the different dynamics that influence the farming system within the studied territory. This step provides information on whether the territory is actually in a process of transition (which implies a movement from an initial state to a final state) or if it is a static state, information that cannot only be given by step 1, since the interview is a snapshot of the farm situation at a time t.

Moreover, in the case study of the Monts du Lyonnais, this step enabled to highlight the important role of agricultural collectives, the land pressure linked to the dynamic urban areas nearby, the important role played by the public administration of the MdL in maintaining agriculture, and the role of private companies in the agroecological transition. These are all elements that make up the specificities of this territory, and that it is important to know before starting the interviews with farmers. This step enables the identification of what constitutes the norm in this territory and thereby facilitates completing the survey.

In addition, during step 0, the main actors of the territory are interviewed. This provides a great source of information to compare the bibliographic information with that from the field. This contact is also essential to carry out the following stages of the study. Indeed, many actors of the territory shared the contacts of farmers that they had. These exchanges also facilitate the study to be talked about, which in the case of the Monts du Lyonnais was not linked to any local infrastructure.

2.2 Step 1: a condensed and globally relevant question set

The ten elements of step 1 deal with the different components of the farm. It can be noted that these elements enable the evaluation of the transition to agroecology in many forms;

agronomic, social, cultural, economic. This step is therefore in line with the different meanings of agroecology that can be found worldwide (Wezel et al., 2009b). This observation confirms that TAPE seems to be a reasonably robust framework for multi-criteria analysis of agricultural systems, perhaps regardless of which criteria (« agroecological » or not) the systems are being evaluated on.

Thanks to the descriptive analysis of the results of step 1, it can be observed, depending on the element, very low standard deviation. This is for example the case for “Humans and social values” and “Culture and food traditions”. This can be explained by the fact that the farms interviewed evolve in the French and thus European context meaning that there are specific regulations to follow. For example, if farmers want to be eligible for the CAP, their soils must never be bare. The answers regarding soil management of “Synergies” are therefore homogeneous. France also has laws on animal welfare and working conditions for employees, which again make the responses to the "Human and social values" element homogeneous. The same is true for the presence of farmer networks and the participation of farmers in them: because of French culture and history, farmer networks are important. Thus, the case study on the Monts du Lyonnais shows that, in a European context, and more precisely, French context, the questions asked in step 1, although relevant, are sometimes not enough discriminating.

It was observed, for the element Synergies, that part of the questions is too open to interpretation.

2.2.1 **The element “synergies” is too open to interpretation**

In step 1, the element "synergies" is calculated according to 4 questions that have, as for all the questions of this step, 5 answers (see Appendix 4). For the questions on "Integration with trees (agroforestry, silvopastoralism, agrosilvopastoralism)" and "Connectivity between elements of the agroecosystem and the landscape", the answers are open to interpretation because of the terms used: "small number of trees", "significant number of trees", "a few isolated elements", "several elements". No scale is provided to differentiate a "small number of trees" from a "significant number of trees". Whether the farmer or the interviewer answers this question, many biases can alter the answer. The subjectivity present on these answers can lead to incorrect analysis of the results since it impacts 2 questions of the element “synergies”, meaning 50% of the element’s score. An evaluation grid for each of the two questions should be established, so that the answers are less prone to subjectivity.

2.2.2 **Suggestion to improve the element “Synergies”**

In France, as in Europe, part of the subsidies granted to farmers is conditioned by the presence of at least 5% of SEI ; Surfaces of Ecological Interest (composed of trees, hedges, buffer strips). Since farmers calculate their SEI each year, this calculation could be included in the question "integration with trees" (see Table 5).

Table 5: Suggestion to improve question 3 of the element "Synergies" (step 1 of TAPE)

Integration with trees (agroforestry, silvopastoralism, agrosilvopastoralism)	No integration: trees (and other perennials) don't have a role for humans or in crop or animal production.	Low integration: small number of trees (and other perennials) **(SEI < 3.5 %)** only provide one product[2] or service[3] for humans crops and/or animals.	Medium integration: significant number of trees (and other perennials) **(SEI is between 3.5 % and 6.5 %)** provide at least one product or service.	High integration: significant number of trees (and other perennials) **(SEI is between 3.5% and 6.5%)** provide several products and services.	Complete integration: many trees (and other perennials) **(SEI > 6.5%)** provide several products and services.

Farmers who are not located in Europe do not calculate their SEI, so the interviewer would have to calculate it of each farm. This can be done with the help of satellite images, which give a good understanding of the integration of trees in an agroecosystem.

For the question on "Connectivity between elements of the agroecosystem and the landscape", an evaluation by satellite image can also be performed to calculate the average number of linear meters present per hectare. This number could be compared to the territory average (see Table 6).

[2] fruits, timber, forage, medicinal or biopesticides substances

[3] shade for animals, increased soil fertility, water retention, barrier to soil erosion

Table 6: Suggestion to improve question 4 of the element "Synergies" (step 1 of TAPE)

Connectivity between elements of the agroecosystem and the landscape	No connectivity: high uniformity within and outside the agroecosystem, no semi-natural environments, no zones of ecological compensation.	Low connectivity: a few isolated elements **(< 0.8 times the local average of the linear meter)** can be found in the agroecosystem, such as trees, shrubs, natural fences, a pond or a small zone of ecological compensation.	Medium connectivity: several elements **(between 0.8 and 1.2 times the local average of the linear meter)** are adjacent to crops and/or pastures or a large zone of ecological compensation.	Significant connectivity: several elements **(between 0.8 and 1.2 times the local average of the linear meter)** 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.).	High connectivity: the agroecosystem presents a mosaic and diversified landscape (> **1.2 times the local average of the linear meter)**, 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.

2.3 Step 2 provides a more detailed analysis but contains some discrepancies

Step 2 provides new information on the agroecological performances of the farms interviewed thanks to its 12 indicators (Mottet et al., 2020c). The correlation matrix shows that there is little correlation between the elements of step 1 and the indicators of step 2. This statistical analysis is positive because it shows that there is little or no redundancy between the steps, which assess different aspects of the same farming system. It means that one of the characteristics of a system (organic farming, dairy processing) does not influence the indicator calculations too much. The correlation matrix corroborates the idea that TAPE has a good structure to evaluate the agroecological performance of a given territory.

The case study reveals that there are inconsistencies in the way some indicators are calculated.

2.3.1 Limits of women empowerment and women land tenure indicators

Women empowerment is one of the 12 indicators assessing the agroecological performances of the farms. According to the evaluation scheme (see Appendix 6), none of the women interviewed are in a desirable situation, 7 are in an acceptable situation whereas 12 are in an unacceptable situation. The same trend can be observed for the women land tenure indicator: the scores are surprisingly low; 14 farms have a score of 50/100 and are in an acceptable situation while 5 have the highest score and are in a desirable situation. These results are striking given the field observations which suggest that women are rather empowered and emancipated. Since the scores obtained and the field observations are different, the way these indicators are calculated have been given particular focus.

Concerning women empowerment score, we note that many questions concern the involvement of the woman on the farm, the ownership of the crops, seeds and animals, their participation in farmers' networks (see Appendix 12). If the woman answers negatively to these questions, then they have a score of 0 for these questions. This explains why 14 of the women interviewed have a score considered unacceptable. These are women who are not involved in the agricultural activity because they have their own business, a concept that TAPE does not take into account when calculating this indicator's score. This explanation also applies to women land tenure's score: if the woman has no document but has the perception of secure land and has at least one right to sell/bequeath/inherit the land, the situation is not considered as desirable but acceptable (see Appendix 6).

It is therefore an indicator whose calculation method is neither adapted to the European nor the French context. TAPE tends to consider farming as a subsidiary activity, which is the case in most of the developing countries. In these countries, it's important for women's empowerment to be involved in farming and to have a formal document to prove they own the land. In France, women who aren't involved in the farm, and therefore do not participate in the farm's making decision process and don't own the land, have mainly their own profession. They are educated, financially independent, and therefore empowered. This vision is lacking from TAPE.

2.3.2 Suggestion to improve women empowerment and women land tenure indicators

One of the first questions asked in the survey is “How many of these [the people living in the household] work in the agricultural production of the system assessed?”. This answer could be integrated into the calculation of the women empowerment score. If the answer to this question is “no women” then, the questions related to women’s implication in the farming system would not be taken into account.

Moreover, the way “time use” participate in the scoring of women empowerment is questionable, both in a European and developing countries context. Indeed, according to the current calculation, if women spend less than 10.5 hours working per day, they would have a lower score than women working more than 10.5 (see Appendix 5). This element should be deleted from the calculation since comparing the time spent to farm for the male and female of the system assessed doesn’t indicate how a woman is empowered.

If the current way of calculation is turned into the one suggested above, the women empowerment score would be more in line with the current women empowerment that can be observed in the systems assessed. For instance, 8 women (out of 20) would be considered as in an acceptable situation rather than an unacceptable situation (see Table 7).

Table 7: Score obtained per farm for the women empowerment according the current and the suggested calculation

Farms	Women empowerment with the initial calculation	Women empowerment score with the suggested calculation
1	NA	NA
2	66	68
3	50	59
4	45	59
5	58	65
6	48	67
7	68	67
8	59	67
9	56	68
10	66	57
11	45	60
12	49	73
13	66	67
14	63	63
15	50	59
16	45	56
17	61	63
18	60	70
19	54	62
20	53	63

In the same manner as for the women empowerment score, the question “How many of these [the people living in the household] work in the agricultural production of the system assessed?” should be integrated into the calculation of the women land tenure score. If the answer to this question is “no women” then, the questions related to the women's ownership of the land would not be taken into account. This suggestion would help to have a score that is more in line with the current women's land tenure reality.

2.3.3 **Limits of productivity/ha, productivity/pers and added value**

3 of the 4 performance indicators of the "Economy" dimension are calculated according to the « Gross Output Value » (see Table 8). In order to calculate this Gross Output Product, all the crops, animals and animals products, such as milk and cheese are considered as sold. Therefore, in the survey, it's mandatory to estimate the value of these 3 elements. Concerning the animals and the animal's products, the estimation is easily done since part of the production is already sold; the market prices are well known. However, in the context of polyculture dairy cattle systems, little, if any fodder is sold. Therefore, it is complicated to know the fodder's market price, because it varies greatly depending on the month, the season, the year, the crop, the quality and the territory in which it is sold. It is also complicated to find these price references.

Thus, it is important to keep in mind that the estimates made by TAPE do not necessarily accurately represent the agroecological performance of farms for 3 of the 4 indicators of the "Economy" dimension.

Table 8 : Method to calculate the economic performances (Mottet et al., 2020b)

Dimension	Indicator	Method of calculation
Economy	Productivity/ha	Gross Output Value[4] / ha
	Productivity/pers	Gross Output Value[5] / (family workers+external workers)
	Added Value	Gross Output Value[5] – Expenditures for inputs
	Income	Income from crops +animals +other activities + subsidies – inputs – operating expenses – depreciation – taxes – interests

Another limit with these indicators can be observed. Although it's interesting to base the calculation of productivity/ha and productivity/person and the added value on the total

[4] Gross Output Value = (crop production*crop price) + (animal production*animal price) + (animal products production*animal products price).

production (and consider it as sold), it is important to note that, in a European context, this method is poorly used. Indeed, in France, in the accounting document, the productivity/ha, productivity/pers and the added value are always calculated based on the effective sales figures. Therefore, there is a lack of references to compare these indicators with.

2.4 Step 3: a valuable time for discussion between local actors, but difficult to set up

Finally, FAO has made a non-exhaustive description of the concepts that can be discussed during the workshop of step 3. This gives great flexibility to the person conducting the study, who can orient the subject of the workshop according to the issues of the territory and the results obtained. Contrary to the previous steps, step 3 provides a discussion framework about concrete actions that could enable scaling up agroecology. This information will then be taken up by the FAO to discuss new policies that would promote the development of agroecology worldwide.

The implementation of TAPE in the Monts du Lyonnais showed one of the tool's weaknesses: it requires a strong commitment from the actors of the territory (including farmers). While local actors were available to discuss the dynamics of the territory (step 0) and farmers agreed to be interviewed for steps 1 and 2, it was more difficult to encourage these interviewees to participate in step 3. We observed a lack of commitment on their part, which is mainly explained by:

- an inability to be available because of their heavy workload
- a lack of farmer's interest in the study due to poor concrete actions resulting from this diagnosis.

In order to address this, it would be interesting to have a local structure involved in the implementation of TAPE. This would have a greater unifying effect on the project and would enable farmers and local actors to be more motivated to carry it out. The local infrastructure is also more likely to know the best ways to communicate about the study.

All of the above suggestions are specific to the question of the adaptability of TAPE to assess the agroecological performance of a livestock-dominated territory in a European context. The following section will address the limitations of using the tool in its current state, focusing on the coding that allows, from the completed questionnaire, to calculate the indicators.

2.5 Coding errors that distort the results

Coding is a very important phase in TAPE because it calculates the indicators for steps 1 and 2 from the completed questionnaire. Errors have been detected in this coding, which results in erroneous indicators that do not reflect reality. The following errors should be corrected :

- For the calculation of the expenses, the amount of subsidies has been considered as a charge instead of a product.
- In the survey, one of the questions is about the expenditures for rental of machineries, equipment and other services. This expense is missing from the total expenditures calculation.
- The pesticide score is calculated only if organic pesticides have been used. In the case of the 20 farms studied, only chemical pesticides were used. Therefore, no pesticide score have been automatically calculated.
- When land tenure worths 100, the calculation is missing from the code.
- Added value and income are missing from the code.

3 Perspectives of the tool

The FAO aims to generalize the use of this tool so that a maximum of harmonized information is collected on the state of agroecological performance in the world. These data are then stocked in a global database that will allow making recommendations for policymakers (Mottet et al., 2020c).

In Europe, the use of TAPE could be widespread. In order to know its application fields, it is fundamental to understand the intention of this tool.

TAPE is a tool for diagnosing the agroecological performances within a territory. It is important to use it as such and try not to draw conclusions that the tool does not permit. For example, the tool does not identify improvement levers or report on the spatiotemporal management of a farm. Indeed, information such as grazing management methods, rotations, and animal health monitoring is not requested during the interviews and are therefore not provided in Steps 1 and 2. Thus, it is important to recognize that TAPE has its place in the transition to agroecology’s process because it takes a snapshot of the situation at a given moment, but it does not permit to initiate the transition, since it does not provide any technical information.

In France, different situations can lead to the use of TAPE. For example, since 2015, groups of farmers can be labeled Economic and Environmental Interest Groups (GIEE). The GIEEs allow official recognition by the State of the collective commitment of farmers in the modification or consolidation of their practices by aiming at economic, environmental and social performance. This labeling gives access to subsidies to support the collective in its projects. To be eligible for this certification, each farmer of the collective must perform a diagnosis of his farm in order to:

- raise awareness, if necessary, of the collective's farmers to agroecology
- identify the strong points on which to base the future project.
- provide the main performance indicators of the farms (Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt Auvergne-Rhône-Alpes, 2020).

The choice of diagnosis is specific to each farmer of the collective. TAPE could very well be used in the context of these applications. Since 2015, 12,000 farms have received the GIEE label. This represents an important number of French farms that could contribute to the FAO database. For this to happen, farmers must become aware of this tool. It would therefore be relevant to contact the Regional Directorates of Food, Agriculture and Forestry (DRAAF), which is in charge of the GIEE application files, in order to present this tool to them, so that it can be referenced among the available diagnosis tools.

Other actors of the agricultural world can also adopt TAPE daily and allow to increase the database of the FAO. Research institutes (Institut de l'Elevage, INRAE), private actors, such as Danone, who accompany farmers in their change of practice, public actors (Chamber of Agriculture) who also accompany farmers on a daily basis as well as professional networks such as the FNAB (National Federation of Organic Agriculture).

Conclusion

Between February and October 2021, the « Tool for Agroecology Performance Evaluation » (TAPE) was implemented in the Monts du Lyonnais. This geographical zone has been used as a case study to reflect on TAPE's ability to assess a territory's « agroecology performance » in a European and livestock context.

Despite some weaknesses, TAPE is a robust tool to assess the agroecological performances of a territory. Globally, this tool is well framed and well structured.

It was found that Step 0 of TAPE allows the collection of information on the study territory to understand its dynamics, the main actors, and its specificities. This step is essential to give perspective to the results obtained in the following steps.

Step 1 seems to be well structured; the 10 elements chosen to characterise the agroecological transition are relevant, and the field observations are in line with the scores obtained for each element. However, the Monts du Lyonnais case study highlighted that, for the element « synergies », the pre-set answers provided by the survey are too open to interpretation. It is recommended to specify the terms chosen.

Step 2 allows us to deepen the evaluation of agroecological performance by looking at transversal indicators. This study demonstrates little redundancy between steps 1 and 2, meaning that a farm's characteristic doesn't influence too much the scores obtained. However, it was also observed that some indicators' calculation method was designed to assess subsistence agricultural systems. Thus, when applied in Europe, these indicators may not be in line with the real-life situation.

Finally, Step 3 is a valuable time for discussion between local actors. The framework of this step allows participants to orientate the debate towards topics relevant in light of the territory's challenges. In order to federate farmers and local actors around this step, it is recommended that TAPE be used as part of a territorial project.

Although sufficient to understand some strengths and weaknesses of the tool, this case study does not allow us to draw general conclusions on the robustness of TAPE in all the agroecosystems present in Europe. Several other case studies in other European countries should be conducted.

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APPENDIX

Appendix 1: Framework of the semi directive interviews for step 0

1. Could you present your career path, your current position and the missions related to it?
2. How would you describe the territorial dynamics of the Monts du Lyonnais?
3. How would you describe agriculture in the Monts du Lyonnais?
4. What are the challenges to be coped in the Monts du Lyonnais in the next 20 years?
5. What do agroecology and transition to agroecology mean?
6. How do you participate in the transition to agroecology of this territory?
7. What are the drivers and hindering forces that play a role in the agroecological transition?
8. What should be undertaken to scale up agroecology? What could be the next step?
9. What are the main local actors playing an important role in the agroecological transition?
10. Do you think policies related to agroecology are appropriate to scale up agroecology?
11. Do you know farmers who could be interested in participating to this study?

Appendix 2 : Description of the 20 farms interviewed

Farm 1

Based in Pomeys, this farm is a conventional-mixed-crop farm with 75 dairy cows and 80 hectares managed by 3 young farmers. This farm produces in average 700,000 liters of milk per year which are sold to Sodiaal, a French-cooperative. The main farmers' objective is to maintain the profitability of the farm they've just taken over 2 years ago. This farm is involved in the GIEE Methamoly who invested in a methanizer in which the livestock effluents are processed into gas and digestate, which is then returned to the farm as fertilizer.

Farm 2

This farm is co-managed by 4 farmers and raises 38 Montbéliarde-dairy-cows on 67ha. Half of the production is sold to an organic milk cooperative while the rest is processed on the farm as yogurts and cream desserts which are sold in public catering. Farmers are involved in different projects in the Monts du Lyonnais territory such as a milking factory and the GIEE Altermonts which objective is to create a cheese factory. They are also engaged in other farmers' groups to plant hedgerows, to learn new practices and community supported agriculture (CSA).

Farm 3

This farmer manages a 48-hectare organic farm with 35 dairy cows. He employs 3 people, who work with the cattle or in the cheese factory where 80% of the milk produced is transformed and then sold in a farmer's store. Since the milk crisis in 2009, this farmer, without being part of a GIEE, is showing an interest in and is being trained in new practices: management of the nitrogen cycle, rotational grazing, covered seeding. This farmer seeks to use to the maximum the potential of his soil, which he perceives as a fundamental element of his farming system.

Farm 4

In 1998, this farmer and his brother took over their father's farm. Located in Chazelles sur Lyon, this conventional farm has 55 cows on 60ha. The milk production is sold to Sodiaal, a milk cooperative. Having a particular tax regime, with a turnover not to be exceeded, this farm does not wish to expand. About ten years ago, following a major rainstorm, one of the farmers observed a large erosion on one of his fields. Since then, the farm is committed to

a conservation agriculture approach, with an almost total stop of ploughing and a simplified work of the soil, including direct seeding.

Farm 5

In 2012, this farmer took over his parents' farm of about 34ha with 45 cows. All the milk production of about 340 000 L is sold to Sodiaal. In order to face climate change, this farmer started conservation agriculture and direct seeding to try to improve his soils' resilience to repeated droughts. In this context, he is the referent farmer of the GIEE Conserva'Terre. His wife will join him on the farm next year.

Farm 6

This farmer has 31 ha, 35 dairy cows and sells his entire milk production to Sodiaal. This farmer has diversified his production a bit and sells chopped steaks and veal meat to his neighbors and friends. Aware of the issues related to climate change that he has perceived on his farm for the last ten years, this farmer is not interested in new practices because he retires within two years. Nevertheless, he has been practicing simplified seeding for a long time.

Farm 7

This couple of farmers took over this farm 20 years ago. In 2003, they started simplified sowing and stopped plowing. 13 years later, they converted their farm to organic farming. Nowadays, they have 78ha with meadows and crops, 80 Holstein and 800 laying hens. The entire production of milk is sold to Sodiaal, and they sell eggs only in short circuits. They are engaged in a methanization project and are follow formation to learn more about agronomy.

Farm 8

This farm is in the process of being passed on, there are currently two people working on the farm: a young farmer ready to take over and an old farmer, close to retirement. A young man will very soon join forces with a new young farmer ready to take over. On this farm, 40 cows are raised on 53 ha. The farm became organic two years ago and transforms half of its milk into cheese and sells it in a producer's store. The rest of the milk is sold to the Biolait cooperative.

Farm 9

This farm in polyculture breeding based in St Clement les Places is managed by 2 farmers of about fifty years. They raise 95 Montbéliards dairy cows in conventional farming. The milk production is completely sold to the French cooperative Sodiaal. The UAA of 102ha is composed of 40ha of pasture which allows the animals to graze in the summer and 62ha of crops consumed by the animals in winter. One of the two farmers works part-time on the farm to devote the rest of his time to various positions as a representative of the agricultural community, both in the private sector (administrator at Sodiaal, Groupama and Bovicoop) and in the public sector (representative at the departmental and regional Chamber of Agriculture, former president of the Jeunes Agriculteurs).

Farm 10

This farm is managed by a couple of young farmers, who doesn't have any agricultural background. They raise 35 Montbéliardes dairy cows on 45 hectares in an extensive way. ¾ of the milk production goes to Biolait, an organic-milk cooperative while the rest is processed into cheese on the farm and sold in different local markets. They aim for autonomy both in their cropping system, in which they want to produce all the feed for their livestock, and in their lives, in which they do not seek out agricultural collectives or advisors.

Farm 11

This conventional farm managed by a father and his son, is about 68 hectares with 50 dairy cows. They process half of the production into cheese, which is sold to a farmer's store. In 2008, the father followed a course on the use of energy in agriculture, and started to question his way of farming. It's one of the reason why he decided to take part into a project of methanization in 2016. This farmer tried to create a new dynamic, leading to the transition to agroecology when he was president of the "CUMA des 4 saisons".

Farm 12

This conventional farm managed by two brothers has 160 hectares and 115 dairy cows which produce about a million liters of milk, directly sold to Sodiaal, a dairy cooperative. This farm is involved in a methanization unit, for which they give all their livestock effluents, and from which they get a digestate. The farmers show an interest for agroecology, but are not interested in being part of this transition, seeing their system working well for few years.

Beside the farm, the farmers managed a company which offers farming service such as the management of a field from seeding to harvesting.

Farm 13

Installed in 2015, with his father, this farmer is now alone to raise 38 Prim Holsteins on 62ha. Since 2016, this farmer has converted to organic farming and stopped growing corn, which was considered too expensive and time-consuming. During his conversion to organic farming, he stopped growing corn, which was considered too expensive and time-consuming. This farmer is the president of the CUMA of his commune and desires to be trained by different organizations on the conduct of grazing, accounting.

Farm 14

This family farm has been established on the territory since the 18th century. Today, the farm is in the process of being passed on between the parents and the children. On 80ha, this farm raises 42 dairy cows whose milk is partly transformed into cheese, 150 laying hens whose eggs are sold in short circuit. This family is very attached to the peasant values: hard labor, passion, strong ancestral roots. They are also involved in several groups, for the management of the accountancy, the agricultural material and the animal health. They are also part of a GIEE which works on the theme of peasant seeds.

Farm 15

This conventional farm was taken over by a young farmer 2 years ago. Based in Larajasse, it has 56 dairy cows on 72ha. This conventional farm sells its entire milk production to Sodiaal, a French dairy cooperative. This farm has started to think about converting to organic farming, but he concluded that it would limit his leviers to cope with climate change. Autonomous in fodder but buying rapeseed meal, this farm expects to diversify its production with beef cattle in few years.

Farm 16

This farm has 45ha, and raises 25 dairy cows and 60 goats. All of the ewe's milk is transformed on the farm into cheese, as is 1/3 of the cow's milk production, the rest is sold to Biolait, an organic milk cooperative. The cheese is sold in short circuits, to local grocery stores or supermarkets. Engaged in the agricultural life of the territory as President of a

Cuma and responsible for a farmers' union when he was younger, he now wishes to let the young people take their place.

Farm 17

Installed in 2008, after his parents, this farm was converted to organic in 2016. On 55ha, this farmer raises 40 cows. Self-sufficient in both fodder and concentrates, this farmer has decided to stop growing corn and does not want to push his cows too much into production. This farmer is not involved in any GIEE but is involved in various groups to work on his grazing management.

Farm 18

This farm is co managed by two farmers for 10 years. They raise 70dairy cows on 80 hectares. Their stabulation can welcome 100 dairy cows but they prefer being autonomous in forage rather than producing more milk. They sell their entire production of conventional milk to Sodiaal and grow on 1.5 ha potatoes that they sell directly to shops and friends.

Farm 19

This farm is in a period of transmission between a farmer’s couple and their son. On 46ha they raise 30 dairy cows. After the milk crisis of 2009 they decide to convert the farm into organic. Not interested in spending time driving tractors, they want their system to be simple, with a maximum of grazing for cows, and a minimum soil perturbation. They process part of their production into cheese which they sell in local shops and CSA and the rest of milk is sold to Biolait. They also raise suckling claves and sell their production in local markets.

Farm 20

This farm is managed by 3 farmers, has 120 ha, 110 dairy cows and sells about 1.1 million liters of milk per year to a milk cooperative. This farm is involved in a methanization site, to which livestock effluent is given, and from which they get their digestate and gaz. When they took over the farm, the farmers had committed themselves to an intensive system, with heavy investments that do not allow them to undertake a transition to a less intensive production system. Nevertheless, they remain interested in new farming practices.

Appendix 3: Interview guide for the farmers' interview

General description of the system

- Number of people in the household and whether they work on the farm.
- Willingness of children to migrate/settle, current professional or educational activity.
- Presence of other employees and degree of investment in decision making.
- Social and economic proximity between farmers and employees.
- Days worked and amount paid per employee.

Agronomy

- Crop rotation: for each crop (including the one present in a vegetable garden): surface, type (organic or conventional), yields, self-cultivated, sold or given ? market price, management of crop residues.
- Soil work: which one ? Is bare soil sometimes present?
- Trees: number of hectares, quantity, location (on the edge, in the plots), service provided (firewood, shade for animals), connectivity between trees/hedges and production areas, % of area covered by natural or diversified vegetation.
- Biodiversity: presence/rearing of bees, presence of other beneficial animals in the agroecosystem.
- Pest management: type of prevention (rotation, biodiversity base areas, homeopathy, hedges, planting of naturally repellent plants).
- Chemicals: source (from within the agroecosystem or outside), organic, mitigation strategies (mask, goggles, gloves, visible sign of danger after spraying, community is warned). Name of each product used, on how many hectares, for which pest.
- Fertilizers: management of fertilizer effluent, addition of chemical fertilizers, purchase of compost.
- Water collection: wells, retention ponds, use of catchment crops, cover crops.
- Renewable energy: photovoltaic panels, wind turbines, electric cars, share of self-generated/consumed energy.
- Waste recycling management
- Seeds and genetic resources: provenance (local/self-produced/agroecosystem/exchanged), adaptation to climate.
- Adaptation to climate change: sensitivity, impact on activity, on benefits, capacity to adapt, related reasoning, seed adaptation.

Livestock

- For each species present: number of animals present on the farm, number of births in the last year, number of natural deaths, number of different breeds and whether they are adapted to local climate . How and where is the slaughter carried out?
- Antibiotics: when? use of homeopathy?
- Animal welfare : where are the animals slaughtered? How?
- Feed: purchased from the agroecosystem or outside, self-produced, grazing
- Number of products from the farm and for each: quantity produced, sold, self-consumed, selling price per unit.

Economy

- Other income generating activities: number, which ones?
- Income: satisfaction of household needs, ability to save money, stability of income in relation to climate change, evolution of income over the last 3 years, sensitivity of income to shocks, ability to return to normal, share of agricultural income/household income.
- Sale of products: which distribution channel, direct sale, presence of intermediaries.

Social

- Social mechanisms: access to credit/capacity to be helped by the community after shocks?
- Farmers' networks: social mechanisms already present to share knowledge, horizontal transfers, participation in these networks, direct sales networks, networks between farmers, organizations to access markets, frequency of participation in these groups.
- Food system: independence of the community in their food supply, place of food in the family, diversified diet, purchase of products in a short circuit, respect for traditions, amount spent on food.
- The place of women: place in the different networks mentioned above, access to resources and emancipation, dietary diversity for women (note what they have eaten in the last 24 hours).
- The place of agroecology: their vision of this term, access to knowledge related to agroecology, what agroecology lacks to develop.

- Level of education of the man and woman of the household, work time for agricultural production, for the preparation of meals and for other lucrative activities per person per day.

Soil health

- susceptibility to erosion, soil depth, plant degradation capacity, microbial and vertebrate life in the soil.

Appendix 4 Questionnaire for STEP 1 of TAPE

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

	Index	0	1	2	3	4
SYNERGIES	**Crop-livestock-aquaculture integration**	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.	Low integration: animals are mostly fed with purchased feed, their manure is used as fertilizer.	Medium integration: animals are mostly fed with feed produced on the farm and/or grazing, their manure is used as fertilizer.	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.	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	Soil is bare after harvest. No intercropping. No crop rotations (or rotational grazing systems). Heavy soil disturbance (biological, chemical or mechanical).	Less than 20% of the arable land is covered with residues or cover crops. More than 80% of the crops are produced in mono and continuous cropping (or no rotational grazing).	50% of soil is covered with residues or cover crops. Some crops are rotated or intercropped (or some rotational grazing is carried out).	More than 80% of soil is covered with residues or cover crops. Crops are rotated regularly or intercropped (or rotational grazing is systematic). Soil disturbance is minimized.	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 threes (agroforestry, silvopastoralism, agrosilvopastoralism)	No integration: trees (and other perennials) don't have a role for humans or in crop or animal production.	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.	Medium integration: significant number of trees (and other perennials) provide at least one product or service.	High integration: significant number of trees (and other perennials) provide several products and services.	Complete integration: many trees (and other perennials) provide several products and services.
	Connectivity between elements of the agroecosystem and the landscape	No connectivity: high uniformity within and outside the agroecosystem, no semi-natural environments, no zones of ecological compensation.	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.	Medium connectivity: several elements are adjacent to crops and/or pastures or a large zone of ecological compensation.	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.).	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.

	Index	0	1	2	3	4
EFFICIENCY	**Use of external inputs**	All inputs are purchased from the market.	The majority of the inputs is purchased from the market.	Some inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.	The majority of the inputs is produced on farm/within the agroecosystem or exchanged with other members of the community.	All inputs are produced on farm/within the agroecosystem or exchanged with other members of the community.
	Management of soil fertility	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).	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.	Synthetic fertilisers are used on a few specific crops only. Organic practices are applied to the other crops and/or grasslands.	Synthetic fertilisers are only used exceptionally. A variety of organic practices are the norm.	No synthetic fertilisers are used, soil fertility is managed only through a variety of organic practices.
	Management of pests & diseases	Chemical pesticides and drugs are used regularly for pest and disease management. No other management is used.	Chemical pesticides and drugs are used for a specific crop/animal only. Some biological substances and organic practices are applied sporadically.	Pests and diseases are managed through organic practices but chemical pesticides are used only in specific and very limited cases.	No chemical pesticides and drugs are used. Biological substances are the norm.	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	Household's needs are not met for food nor for other essentials.	Production covers only household's needs for food. No surplus to generate income.	Production covers household's needs for food and surplus generates cash to buy essentials but doesn't allow savings.	Production covers household's needs for food and surplus generates cash to buy essentials and to have sporadic savings.	All household's needs are met both for food and for cash to buy all essentials needed and to have regular savings.

	Index	0	1	2	3	4
RECYCLING	**Recycling of biomass and nutrients**	Residues and by-products are not recycled (e.g. left for decomposition or burnt). Large amounts of waste are discharged or burnt.	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.	More than half of the residues and by-products is recycled. Some waste is discharged or burnt.	Most of the residues and by-products are recycled. Only a little waste is discharged or burnt.	All of the residues and by-products are recycled. No waste is discharged or burnt.
	Water saving	No equipment nor techniques for water harvesting or saving.	One type of equipment for water harvesting or saving (e.g. drip irrigation, tank).	One type of equipment for water harvesting or saving and use of one practice to limit water use (e.g. timing irrigation, cover crops).	One type of equipment for water harvesting or saving and various practices to limit water use.	Several types of equipment for water harvesting or saving and various practices to limit water use.
	Management of seeds and breeds	All seeds and/or animal genetic resources (e.g. chicks, young animals, semen) are purchased from the market.	More than 80% of seeds/animal genetic resources are purchased from the market.	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.	The majority of seeds/animal genetic resources are self-produced or exchanged. Some specific seeds are purchased from the market.	All seeds/animal genetic resources are self-produced, exchanged with other farmers or managed collectively, ensuring enough renewal and diversity.
	Renewable energy and production	No renewable energy is used nor produced.	The majority of the energy is purchased from the market. A small amount is self-produced (animal traction, wind, turbine, hydraulic, biogas, wood…).	Half of the energy used is self-produced, the other half is purchased.	Significant production of renewable energy, negligible use of fuel and other non-renewable sources.	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.

	Index	0	1	2	3	4
RESILIENCE	**Stability of income/production and capacity to recover from perturbations**	Income is decreasing year after year, production is highly variable despite constant level of inputs and there is no capacity to recover after shocks/perturbations.	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.	Income is overall stable, but production is variable from year to year (with constant inputs). Income and production mostly recover after shocks/perturbations.	Income is stable and production varies little from year to year (with constant inputs). Income and production mostly recover after shocks/perturbations.	Income and production are stable and increasing over time. They fully and quickly recover after shocks/perturbations.
	Mechanisms to reduce vulnerability	No access to credit, no insurance, no community support mechanisms.	Community is not very supportive and its capacity to help after shocks is very limited. And/or access to credit and insurance is limited.	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.	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.	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.
	Environmental resilience and capacity to adapt to climate change	Local environment is highly prone to climatic shocks and the system has little capacity to adapt to climate change	Local environment suffers from climatic shocks and the system has little capacity to adapt to climate change	Local environment can suffer from climatic shocks but the system has a good capacity to adapt to climate change	Local environment can suffer from climatic shocks but the system has a strong capacity to adapt to climate change	Local environment has a strong natural capital base, climatic shocks are rare and the system has a strong capacity to adapt to climate change
	Diversity	This index is the average score for the element of Diversity already assessed.				

	Index	0	1	2	3	4
CULTURE & FOOD TRADITION	**Appropriate diet and nutrition awareness**	Systematic insufficient food to meet nutritional needs and lack of awareness of good nutritional practices.	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.	Overall food security over time, but insufficient diversity in food groups. Good nutritional practices are known but not always enforced.	Food is sufficient and diverse. Good nutritional practices are known but not always enforced.	Healthy, nutritious, diversified diet. Good nutritional practices are well known and enforced.
	Local or traditional (peasant / indigenous) identity and awareness	No local or traditional (peasant / indigenous) identity felt.	Little awareness of local or traditional identity.	Local or traditional identity felt in part, or that concerns only part of the household.	Good awareness of local or traditional identity and respect of traditions or rituals overall.	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	No use of local varieties/breeds nor traditional knowledge for food preparation.	A majority of exotic/introduced varieties/breeds are consumed, or there is little use of traditional knowledge and practices for food preparation.	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.	The majority of the food consumed comes from local varieties/breeds and traditional knowledge and practices for food preparation are implemented.	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.

	Index	0	1	2	3	4
CO-CREATION & SHARING OF KNOWLEDGE	**Platforms for the horizontal creation and transfer of knowledge and good practices**	No platforms for co-creation and transfer of knowledge are available to producers.	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.	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.	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.	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	Lack of access to agroecological knowledge: principles of agroecology are unknown to producers.	Principles of agroecology are mostly unknown to producers and/or there is little trust in them.	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.	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.	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	Producers are isolated, have almost no relations with their local community and do not participate in meetings and grass-root organisations.	Producers have sporadic relations with their local community and rarely participate in meetings and grass-root organisations.	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.	Producers are well interconnected with their local community and often participate in the events of their grass-root organisations, including women.	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.

	Index	0	1	2	3	4
HUMAN & SOCIAL VALUES	**Women's empowerment**	Women do not normally have a voice in decision making, not in the household nor in the community. No organisation for women empowerment exists.	Women may have a voice in their household but not in the community. And/or one form of women association exists but is not fully functional.	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.	Women take full part in decision making processes but still don't have full access to resources. And/or women organisations exist and are used.	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)	Agricultural supply chains are integrated and managed by agribusiness. There is a 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.	Working conditions are hard, workers have average wages for the local context and may be exposed to risks.	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.	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.	Agriculture is based on family farmers which have full access to capital and decision-making processes in gender equity. There is a social and economic proximity between farmers and employees.
	Youth empowerment and emigration	Young people see no future in agriculture and are eager to emigrate.	Most young people think that agriculture is too hard and many wish to emigrate.	Most young people do not want to emigrate, despite hard working conditions, and wish to improve their livelihoods and living conditions within their community.	Most young people (both boys and girls) are satisfied with working conditions and do not want to emigrate.	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]	Animals suffer from hunger and thirst, stress and diseases all year long, and are slaughtered without avoiding unnecessary pain.	Animals suffer periodically/seasonally from hunger and thirst, stress or diseases, and are slaughtered without avoiding unnecessary pain.	Animals do not suffer from hunger or thirst, but suffer from stress, may be prone to diseases and can suffer from pain at slaughter.	Animals do not suffer from hunger, thirst or diseases but can experience stress, especially at slaughter.	Animals do not suffer from stress, hunger, thirst, pain, or diseases, and are slaughtered in a way to avoid unnecessary pain.

	Index	0	1	2	3	4
CIRCULAR & SOLIDARITY ECONOMY	**Products and services marketed locally**	No product/service is marketed locally (or not enough surplus produced), or no local market exist.	Local markets exist but hardly any of the products/services are marketed locally.	Local markets exist. Some products/services are marketed locally.	Most products/services are marketed locally.	All products and services are marketed locally.
	Networks of producers, relationship with consumers and presence of intermediaries	No networks of producers for marketing agricultural production exist. No relationship with consumers. Intermediaries manage the whole marketing process.	Networks exist but do not work properly. Little relationship with consumers. Intermediaries manage most of the marketing process.	Networks exist and are operational, but don't include women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.	Networks exist and are operational, including women. Direct relationship with consumers exist. Intermediaries manage part of the marketing process.	Well established and operational networks exist with equal women participation. Strong and stable relationship with consumers. No intermediaries.
	Local food system	Community is totally dependent on the outside for purchasing food supply and agricultural inputs and for the marketing and processing of products.	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.	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.	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.	Community is almost completely self-sufficient for agricultural and food production. High level of exchange/trade of products and services between producers.

	Index	0	1	2	3	4
RESPONSIBLE GOVERNANCE	**Producers empowerment**	Producers' rights are not respected. They have no bargaining power and lack the means to improve their livelihoods and develop their skills.	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.	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.	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.	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	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.	One organisation of producers exists but its role is marginal and support to producers limited to market access.	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.	One organisation of producers exists and provides support to producers for market access and other services with equal access to men and women.	More than one organisation exists. They provide market access and other services, with equal access to men and women.
	Participation of producers in governance of land and natural resources	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.	Producers participate in the governance of land and natural resources but their influence on decisions is limited. Gender equity is not always respected.	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.	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.	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.

Appendix 5 : Questionnaire for STEP 2 of TAPE

Some sections of this step will ask information about expenditures, revenues or prices. Please specify the currency in which these values will be expressed:

_____

LAND TENURE

Do you have any legal recognition of your land? *(for Pastoralists: is your mobility legally recognized?)*

Mark only one per category

	MEN	WOMEN
Yes		
No		

If yes, which type of FORMAL DOCUMENT do you have?

Mark only one per category

	EN	OMEN
tle deed		
rtificate of customary tenure		
rtificate of occupancy		
gistered will or registered certificate of hereditary acquisition		
gistered certificate of perpetual / long term lease		
gistered rental contract		
cure mobility corridor		
her		

Secure land tenure: perception and rights:

Mark YES or NO per category

	MEN	WOMEN
If yes, is your NAME listed as owner / use right holder on the recognized documents?		
Do you PERCEIVE that your access to land is secure, regardless of whether this right is documented? (for Pastoralists: do you perceive that your mobility is secure?)		
Do you have the RIGHT TO SELL any of the parcels of the holding?		
Do you have the RIGHT TO BEQUEATH any of the parcels of the holding?		
Do you have the RIGHT TO INHERIT land?		

AGRICULTURAL BIODIVERSITY, INCOME AND PRODUCTIVITY

This part of the survey can be conducted using a farm walk or a combination of farm walk and household survey

Output and earnings

Take as reference the last year of productive activity

Crops and trees

How many crop/tree species do you grow?

List top 20 most important crops or trees. For each of them, specify:

1. Name of the crop species or type of crop.
2. Total production (kg).
3. Quantity sold (kg).
4. Price at the gate (currency/kg).
5. Quantity given for free (gift, present) (kg)
6. Land under production (ha).
7. Number of varieties/species produced.

Natural vegetation, trees and pollinators

Productive area covered by natural or diverse vegetation (natural pasture, grasslands, wildflower strips, stone or wood heaps, trees or hedgerows, natural ponds or wetlands, etc.). Consider communal land.

Mark only one
□ Abundant: more than 25% of the system is covered with natural or diverse vegetation
□ Significant: at least 20% of the system is covered with natural or diverse vegetation
□ Small: less than 10% of the system is covered with natural or diverse vegetation
□ Absent: area covered with natural or diverse vegetation is negligible

Beekeping.

Mark only one
□ Yes, bees are raised within the agroecosystem
□ No, bees are not raised but are widespread within the agroecosystem
□ No, bees are not raised and are rare within the agroecosystem

Presence of pollinators and other beneficial animals within the agroecosystem?

Mark only one:
□ Abundant
□ Significant
□ Little
□ Absent

Animals

How many different animal species do you raise?

List top 20 most important animal types. For each of them, specify:

1. Name of the animal species.
2. Total number of animals of this species currently raised into the farm
3. Total number of animals of this species born during the last 12 months
4. Total number of animals of this species died of natural cases during the last 12 months
5. Number of different breeds within these species.
6. Number of animals sold.
7. Price at the gate (currency/animal)
8. Number of animals given for free (gift, present)

How do you feed your animals?

Mark only one:
□ Mostly with feed
□ Both with feed and on pasture
□ Only on pasture

Animal products

How many different animal products do you produce?

List top 20 most important animal types. For each of them, specify:

1. Name of the animal product.
2. Unit of measure for this product:
   - □ Kg
   - □ L
   - □ Number of
   - □ Other (specify)
3. Total quantity produced.
4. Quantity sold.
5. Price at the gate (currency/unit of measure)
6. Quantity given for free (gift, present)

Other activities/services related to agricultural production within the farm

How many other activities/services are you engaged in?

List top 20 most important other activities/services. For each of them, specify:

1. Name of the activity/service produced or provided.
2. Total revenue.

Expenditures for inputs

Take as reference the LAST YEAR of productive activity. Please express this value in the currency previously specified.

Total expenditures for FOOD for self- consumption:
_____

Total expenditures for SEEDS:
_____

Total expenditures for FERTILIZERS:
_____

Total expenditures for FEED:
_____

Total expenditures for VETERINARY SERVICES:
_____

Total expenditures for LIVESTOCK PURCHASES:
_____

How many external workers did you engage in agricultural production of the system assessed?

For each of them, specify:

- How many days did he/she work?
- How much did you pay him/her?

Energy, machinery and maintenance

Total expenditure for MACHINERY/EQUIPMENT and MAINTENANCE:
_____ *Please express this value in the currency previously specified*

How many different pieces of machinery/equipment do you own?

List top 20 most important machineries/equipment. For each of them, specify:

1. Name of the machinery/equipment.
2. Quantity owned.
3. Price ad purchase (per unit).
4. For how many years have you been using this machinery/equipment?
5. How many more years are you planning on using it/them (on average)?

Total expenditures for FUEL:
_____

Total expenditures for ENERGY:
_____

Total expenditures for
TRANSPORTATION:_____

FINANCIAL INFORMATION

Take as reference the LAST YEAR of productive activity. Please express this value in the currency previously specified

Total TAXES paid:
_____

Total SUBSIDIES received:
_____

Total INTEREST ON LOANS paid:
_____

Total COST FOR RENTING LAND:
_____

The essential of household's revenue comes from:
Mark only one
□ Mainly from agricultural production
□ Both from agricultural production and other external sources of revenue
□ Mainly from external sources of revenue

Qualitative perception of earnings and expenditures

How do you compare your income compared to three years ago?

□ More income

□ Same income

□ Less income

EXPOSURE TO PESTICIDES

Consider the LAST 12 MONTHS as reference period.

How many different chemical pesticides have you used in the last 12 months of productive activity?

List top 10 chemical pesticides used. For each of them, specify:

When selecting the level of toxicity for each pesticide, please refer to the table below:

CATEGORIES		SIGNAL WORD	ORAL LD50 (mg/kg)	DERMAL LC50 (mg/kg)	INHALATION LD50 (mg/L)
I	Extremely/highly toxic	DANGER POISON / DANGER	0 to 50	0 to 200	0 to 0.2
II	Moderately toxic	WARNING	50 to 500	200 to 2000	0.2 to 2.0
III	Slightly toxic	CAUTION	500 to 5000	2000 to 20000	2.0 to 20
	Relatively non-toxic	CAUTION [optional]	5000+	20000+	20+

1. Name of the pesticide.
2. Level of toxicity.
3. Quantity of product used (*l* or *g*).
4. Amount of area in which the pesticide has been used (ha).
5. On which crop?
6. For treating which pest?

Total expenditure for **chemical** pesticides: -

_____

How many different **organic** pesticides have you used in the last 12 months of productive activity?

List top 10 organic pesticides used. For each of them, specify:

1. Name of the organic pesticide.
2. Source: self-produced or purchased?
3. Quantity used (l or g).
4. Amount of area in which the pesticide has been used (ha).

Total expenditure for **organic** pesticides: -

_____

Mitigation strategies when applying?

Select as many as necessary.

□ Mask
□ Body protection (glasses, gloves, etc.)
□ Special protection for women and children
□ Visible signs of danger after spraying
□ Community is informed of the danger
□ Secure disposal of the empty containers after use
□ Other:
□ None of these

Ecological management of pests.

Select the techniques systematically applied within the system assessed. Select as many as needed.

□ Cultural control (more resistant varieties are chosen for production; plants and fruits presenting
signs of disease are removed manually; crops are grown in crop rotation and intercropping schemes, etc.)
□ Plantation of natural repelling plants
□ Use of cover crops to increase biological interactions
□ Favor the reproduction of beneficial organisms for biological-control
□ Favor biodiversity and spatial diversity within the agroecosystem
□ Other:
□ None of these

Which type of pesticides are more important for your production?

Mark only one option
□ Pesticides use is negligible (neither chemical nor organic) ecological management is more important.
□ Organic pesticides are more important.
□ Nor organic, nor chemical, no ecological management.
□ Chemical and organic pesticides have the same importance.
□ Chemical pesticides are more important.

Do you use antibiotics on your livestock?

□ I do not use antibiotics at all
□ For treatment of diseases only
□ For prevention of diseases
□ For both prevention of diseases and growth promotion
□ For growth promotion

YOUTH EMPLOYMENT AND EMIGRATION

How many young members (15-34 years) are there in the system assessed (including those emigrated and currently living outside it)?

For each of them specify:

- Name (optional)
- Sex of the youngster
- Has this youngster already emigrated for lack of employment?

If the answer to this last question was “no”, please specify:

What is the occupation of the youngster?

□ Working in the agricultural production within the system assessed
□ Both working in the agricultural production within the system and also employed outside the system
□ Employed outside the system assessed
□ Both working in the agricultural production within the system and also enrolled in formal education

□ Enrolled in formal education
□ Not working nor studying
□ Works in his/her own farm

This youngster would like to be a farmer in the future? Yes/No

What is the occupation of the youngster? Yes/No

WOMEN'S EMPOWERMENT

Survey to be conducted only with the main woman in the household without the presence of a man in a safe environment.

Is the woman answering with the presence of a man? Yes / No

If yes: has the man refused to leave despite knowing that this? Yes / No

Education level

	MEN	**WOMEN**
Cannot read nor write		
Able to read and write		
Elementary		
High		
University		

Time burden

Leave the spot empty if a category is missing.

Number of hours spent working on AGRICULTURAL PRODUCTION within the system assessed

	MEN	**WOMEN**
Number of hours spent working on AGRICULTURAL PRODUCTION within the system assessed		

Number of hours spent working on FOOD PREPARATION and other DOMESTIC WORKS		
Number of hours spent working on OTHER GAINFUL ACTIVITIES (outside agricultural production)		

Decision making

Do women make decisions on what to produce? Do women make decisions around what to do

with the outputs produced (such as control over the income, and whether to consume at home)?

Mark only one per category

	MYSELF (Women)	**MY HUSBAND (Men)**	**BOTH OF US**	**SOMEONE ELSE**
Who is the owner of the CROPS and the SEEDS?				
When decision are taken about CROP PRODUCTION, who normally takes these decisions?				
Who is the owner of the ANIMALS?				
When decision are taken about ANIMAL PRODUCTION, who normally takes these decisions?				
Who is the owner of the assets for other economic activities within the household?				
When decision are taken about other economic activities within the household, who normally takes these decisions?				
Who is the owner of MAJOR HOUSEHOLD ASSETS? (house, machineries, etc.)?				
When decision are taken about MAJOR HOUSEHOLD ASSETS, who normally takes these decisions?				

Who is the owner of MINOR HOUSEHOLD ASSETS? (small tools, garden, etc.)?				
When decision are taken about MINOR HOUSEHOLD ASSETS, who normally takes these decisions?				

Decision-making about REVENUE:

Mark only one per category

	Did not contribute or contribute in few decisions	Contributed in some decisions	Contributed in most decisions
How much did you contribute to the decisions about the use of the REVENUE generated through CROP PRODUCTION?			
How much did you contribute to the decisions about the use of the REVENUE generated through ANIMAL PRODUCTION?			
How much did you contribute to the decisions about the use of the REVENUE generated through OTHER ECONOMIC ACTIVITIES?			

Perception about decision-making

Mark only one per category

	I think that I cannot take any decision	Just little decisions	Some decisions	In great part / totally
If you wanted, do you feel that you can take decisions about CROP PRODUCTION?				
If you wanted, do you feel that you can take decisions about ANIMAL HUSBANDRY?				
If you wanted, do you feel that you can take decisions about OTHER ECONOMIC ACTIVITES?				

If you wanted, do you feel that you can take decisions about MAJOR HOUSEHOLD'S EXPENDITURES?				
If you wanted, do you feel that you can take decisions about MINOR HOUSEHOLD'S EXPENDITURES?				

Do you have access to credit?

Mark only one per category

	MEN	**WOMEN**
Possible in official and secure channels (bank or similar)		
Possible in non-official channels		
Not possible. Access to credit is too hard or too risky		

Leadership

Men and women face different barriers to participation. Within the country/context, are both men and women within the household included and able to participate in the agroecology projects?

	Does this group exist in your community? YES/NO	**How often do you participate in activities and meetings organized by this group (if it exists in your community)?**			
		Never/almost never	Sometimes	Most of the time	Always
Women's associations and organizations					
Cooperatives for rural production					
Social movements					
Unions of rural workers					
Political groups linked to a party					
Religious groups					

Training organized for capacity development					
Others					

MINIMUM DIETARY DIVERSITY FOR WOMEN

This section should preferably be conducted with a woman aged 15-49 years old. If there are no family members with such requirements, the survey may continue to be conducted with the family member who was already being interviewed.

Select what you ate or drank in the last 24 hours. Please include all foods and drinks, any snacks or small meals, as well as any main meals. Remember to include all foods you may have eaten while preparing meals or preparing food for others.

Mark only one per category

Food groups:	Yes, I ate it in the last 24 hours	No, I did not eat it in the last 24 hours
GRAINS, WHITE ROOTS and TUBERS (bread, rice, pasta, flour, white potatoes, white yams, manioc / cassava / yucca, taro, etc)		
PULSES (beans, peas, fresh or dried seed, lentils or bean / pea products, including hummus, tofu and tempeh)		
NUTS and SEEDS (Tree nut, groundnut/peanut or certain seeds, or nut / seed "butters" or pastes)		
DAIRY products (Milk, cheese, yoghurt or other milk products but NOT including butter, ice cream, cream or sour cream)		
MEAT, POULTRY, FISH (Beef, pork, lamb, goat, chicken, fish, seafood, animal organs)		
EGGS from poultry or any other bird		
DARK GREEN leafy VEGETABLES (any medium to-dark green leafy vegetables, including wild / foraged leaves)		
DARK YELLOW or ORANGE FRUITS and VEGETABLES (mango, papaya, pumpkin, carrots, squash, orange sweet potatoes)		
other VEGETABLES (cucumber, eggplant, mushroom, onion, tomato, etc.)		
other FRUITS (avocado, apple, pineapple, etc.)		

SOIL HEALTH

For the soil assessment, choose a surface of the productive area that most reflects the average status of its soils.

Mark every category with a score comprised between 1 and 5 following examples.

Indicators	Established value	Characteristics	Score (from 1 to 5)
Structure	**1**	Loose, powdery soil without visible aggregates	
	3	Few aggregates that break with little pressure	
	5	Well-formed aggregates – difficult to break	
Compaction	**1**	Compacted soil, flag bends readily	
	3	Thin compacted layer, some restrictions to a penetrating wire	
	5	No compaction, flag can penetrate all the way into the soil	
Soil depth	**1**	Exposed subsoil	
	3	Thin superficial soil	
	5	Superficial soil (> 10 cm)	
Status of residues	**1**	Slowly decomposing organic residues	
	3	Presence of last year's decomposing residues	
	5	Residues in various stages of decomposition, most residues well-decomposed	
Color, odor and organic matter	**1**	Pale, chemical odor, and no presence of humus	
	3	Light brown, odorless, and some presence of humus	
	5	Dark brown, fresh odor, and abundant humus	
Water retention (moisture level after irrigation or rain)	**1**	Dry soil, does not hold water	
	3	Limited moisture level available for short time	
	5	Reasonable moisture level for a reasonable period of time	
Soil cover	**1**	Bare soil	
	3	Less than 50% soil covered by residues or live cover	
	5	More than 50% soil covered by residues or live cover	
Erosion	**1**	Severe erosion, presence of small gullies	

	3	Evident, but low erosion signs	
	5	No visible signs of erosion	
Presence of invertebrates	**1**	No signs of invertebrate presence or activity	
	3	A few earthworms and arthropods present	
	5	Abundant presence of invertebrate organisms	
Microbiological activity	**1**	Very little effervescence after application of water peroxide	
	3	Light to medium effervescence	
	5	Abundant effervescence	

Appendix 6 : Evaluation scheme adapted to the territory and used for the traffic light approach

Main dimensions	Indicators	Desirable	Acceptable	Unacceptable
Governance [1]	Man land tenure score	Has a formal document with the name of the holder on it and has perception of secure access to land and has at least one right to sell/bequeath/inherit any of the parcel of the holding.	Has a formal document with the name of the holder on it and perception of insecure access to land and/or no right to sell/bequeath/inherit the land or Has a formal document even if the name of the holder is not on it or Has no document but has perception of secure land and has at least one right to sell/bequeath/inherit the land.	No document possessed and perception of insecure access to land and/or no right to sell/bequeath/inherit the land.
	Women land tenure score			
Economy [2]	Productivity/ha	Productivity value per ha is ≥ 2/3 of the local average value of production per hectare/year.	Productivity value per ha is ≥ 1/3 and < 2/3 of the local average value of production per hectare/year.	Productivity value per ha is < 1/3 of the local average value of production per hectare/year.
	Productivity/pers	Productivity value per person is ≥ 2/3 of the local average value of production per pers/year.	Productivity value per person is ≥ 1/3 and < 2/3 of the local average value of production per pers/year.	Productivity value per person is < 1/3 of the local average value of production per pers/year.
	Added value	Net value added /family worker > 1.2 x median net value added in similar agroecosystem.	Net value added /family worker < 1.2 x median net value added in similar agroecosystem AND > 0.8 x median net value added in similar agroecosystem.	Net value added /family worker < 0.8 x median net value added in similar agroecosystem.
	Income	Income > average salary/family worker.	Income between the minimal salary and the average salary/family worker.	Income < minimal salary/family worker.
Health and nutrition [1]	Exposure to pesticide	Quantity of naturally derived pesticides used ≥ Quantity of synthetic pesticides used and pesticides of class I and II (highly and moderately toxic) are not used and at least 4 of the listed mitigation techniques are used when applying chemical pesticides; or chemical pesticides are not used and naturally derived pesticides and/or other integrated techniques for pest management are used.	Quantity of synthetic pesticides used > quantity of naturally derived pesticides used and producers do not use pesticides of class I[3] (Highly toxic) and at least 4 of the listed mitigation techniques are used when applying the chemicals and naturally derived pesticides and/or other integrated techniques are also used.	Producers use highly hazardous pesticides (Class I) and/or illegal pesticides or producers use pesticides of class II and/or III[3] (Moderately toxic and Slightly or relatively non- toxic) with less than 4 of the listed mitigation techniques or producers use chemical pesticides of any class AND no naturally derived pesticides and no other integrated techniques are used.

	Dietary diversity	score ≥ 70	50 ≤ score < 70	score < 50

Society and Culture [1]	Women empowerment score	score ≥ 80	60 ≤ score ≤ 80	score ≤ 60
	Youth score	score ≥ 70	50 ≤ score < 70	score < 50
Environnement[1]	Soil health	score ≥ 3.5	2.5 ≤ score < 3.5	score < 2.5
	Agricultural biodiversity	score ≥ 70	50 ≤ score < 70	score < 50

[1] Mottet 2020, [2] : Idele 2019 et Mottet 2020.

Appendix 7 : Questions asked to the participants of Step 3

- At your farm's scale, what are the obstacles you encounter to scale up agroecology?
- At the Monts du Lyonnais territory's scale, how can we engage more farmers in the agroecological transition?
- At the Monts du Lyonnais territory's scale, how can we go faster in the agroecological transition?
- On a national scale, how can we engage more farmers in the agroecological transition?
- On a national scale, how can we go faster in the agroecological transition?

Appendix 8 : List of the local actors interviewed in step 0

Person interviewed	Job position (company)	Main topics adressed
Interview 1	In charge of the supervision of collectives towards the agroecological transition (Fr CUMA)	Loi d'avenir, Dynamics of the GIEE, definition of agroecology
Interview 2	Agroecology project leader, regional PRDAR and RID referent (DRAAF)	Process of GIEE's labelization, the hindering forces of the agroecological transition
Interview 3	Aura regional delegate, in charge of human relations (TRAME)	Missions of TRAME, the importance of collectives in the transition
Interview 4	Coordinator of the GIEE Conserva'Terre des Monts (Chambre d'agriculture de la Loire)	The dynamics of the GIEE "Conserva'Terre", the differences between GIEE and the groups' DEPHY.
Interview 5	Trainer for farmers on topics such as the forage autonomy, pasture management (CDA)	Definition and limits of agroecology, key elements to facilitate farmers' transition
Interview 6	Researcheur and teacher on sociology (ISARA)	Groups dynamics in the Monts du Lyonnais and in France, dynamics of the GIEE
Interview 7	Coordinator of GIEE Méthamoly and project manager (SimaCoise)	Creation of the GIEE, missions of SimaCoise, dynamics and limits of GIEE
Interview 8	Consultant in agriculture, agro-ecological and energy transition (ISARA Conseil)	Definition and limits of agroecology, the dynamics of collectives, the roles of assessment tools in the transition
Interview 9	Coordinator of the GIEE "Altermonts" (AFOGC)	His missions, the GIEE Altermonts
Interview 10	Forage expert (Rhône Conseil Elevage)	His profession, the importance of collectives for the transition, the role of advisor, the impact of climate change on the territory
Interview 11	Territory Milk Network Engineer (Idele, Institute of livestock)	The important of milk production in the Monts du Lyonnais, the mission of IDELE
Interview 12	Researcher and teacher on rural sociology, PhD related to the Monts du Lyonnais (ISARA)	The collectives dynamics in the Monts du Lyonnais, the role of the downstream sector to enhance the transition
Interview 13	Responsible for the Monts du Lyonnais area (Chambre d'agriculture du Rhône)	Main characteristics of the Monts du Lyonnais, programmes to support farmers to face climate change, the different types of collectives, the relative importance of diagnosis, definition of agroecology.
Interview 14	Referent coordination capitalization GIEE (Chambre d'agriculture Aura).	Assistance to the structures that support the GIEEs, definition and limits of agroecology

1. Location of the territory

TAPE was implemented in France, in Auvergne Rhône Alpes region and more especially in the group of municipalities, ”les Monts du lyonnais”. Located in the middle of three dynamic urban areas, St Etienne, Roanne and Lyon, this rural territory takes place mostly in the Rhône department with 25 municipalities, and a little part is located in the Loire, with 7 municipalities (see Figure X). Monts du Lyonnais are called a *communauté des communes* in French, which means a grouping of municipalities recognized by the State, managed by a council whose aim is to federate municipalities within a space of solidarity by pooling their means, in order to implement a common and coherent development project (Observatoire partenarial, 2013). Beyond the administrative aspect, the Monts du Lyonnais is defined above all as a political territory, in the strong sense of the term, invested by the inhabitants as a space of action (Vandenbroucke, 2013).

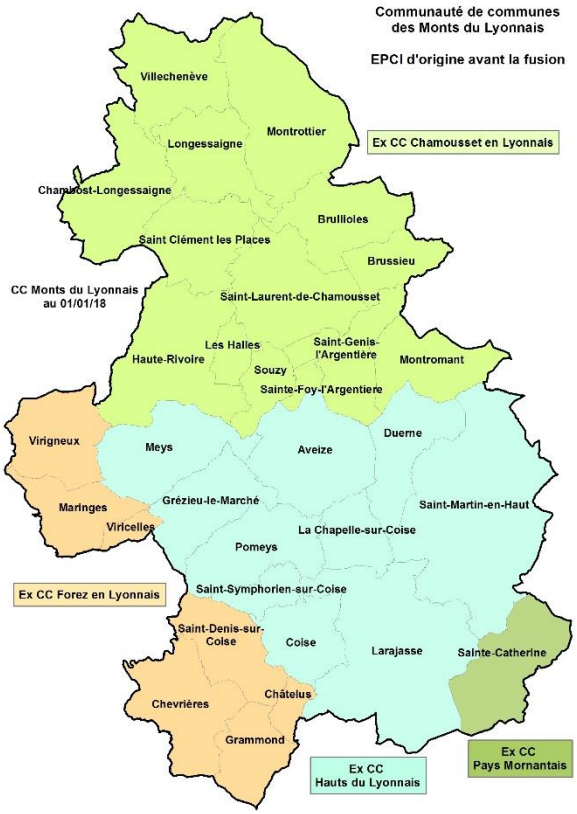

Figure 15: Map with the 32 communes of the Monts du Lyonnais (Monts du lyonnais, 2014).

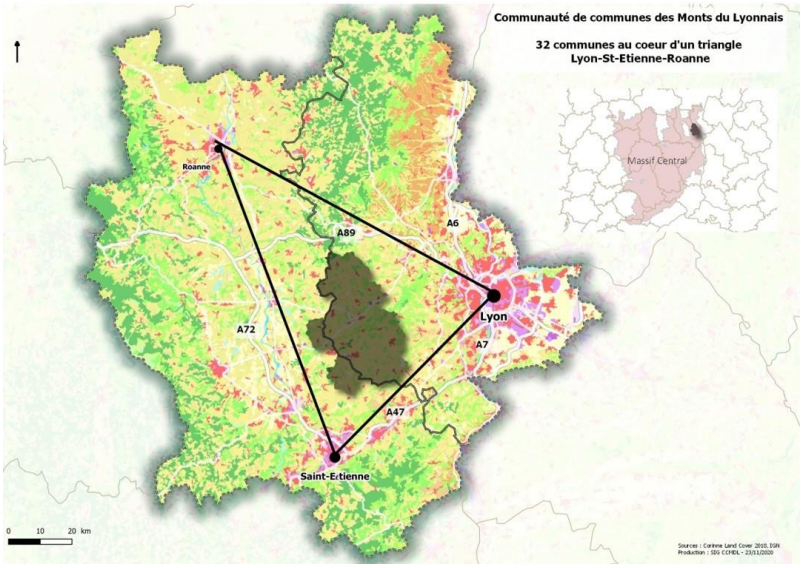

Figure 16: Monts du lyonnais : within an attractive triangle (Monts du lyonnais, 2014).

2. A rural area exposed to urban sprawl

In 2017, the population of the Monts du Lyonnais was about 35,057 inhabitants, a figure that has been steadily increasing since 1975 (INSEE, 2021a). The population density is about 88.3 inhabitants/km², corresponding to a density inferior to the French average of 105.1inhabitants/km² (INSEE, 2021b). For the last ten years, an important demographic growth has been observed in the Monts du Lyonnais, as a result of the quality of life that this territory can offer. Indeed, located in the peri-urban area of the agglomerations of St Etienne and Lyon, this territory benefits from geographical proximity with economically dynamic areas and offers a rural lifestyle to its inhabitants (Agence d'Urbanisme de l'aire métropolitaine Lyonnaise et al., 2020). This territory attractiveness increases the price of housing, and thus impacts the profile of the inhabitants, who used to be mainly families with children, with modest incomes, and now tends to be families with greater purchasing power.

For the 803 farms present in the territory, the land pressure is also tangible, and one of the threats recognized by the politics is land fragmentation, which could lead to the loss of farms (Agence d'Urbanisme de l'aire métropolitaine Lyonnaise et al., 2020).

3. Ecological environment

3.1. Topography and soil

The territory of the Monts du Lyonnais belongs to the eastern foothills of the Massif-Central. The relief is medium mountainous and relatively gentle. Numerous peaks rise to altitudes of 800-900 meters and are surrounded by numerous valleys, most often oriented northeast-southwest, such as the two main ones, the Coise and the Brévenne (Vandenbroucke, 2013). Located on the eastern edge of the primary Massif Central, this territory is essentially made up of migmatites, gneiss and granites; soils are considered as acids and shallows and are therefore are vulnerable to desiccation and erosion. This hilly topography containing significant slopes, locally over 30% are punctuated by plateaus (SIMA COISE, 2014). This environment favors livestock farming with multi-annual meadows rather than annual crops.

3.2. The climate

The climate of the Monts du Lyonnais is temperate continental, with oceanic and sub-Mediterranean influences, to which are added the local effects of the topography. According to the Köppen climate classification, it corresponds to Cfb. In terms of temperature, the summer is warm but the maximum temperatures are moderate due to the altitude (data.gouv.fr, 2021). Winter is cold with a significant number of days of frost from October to April.

The thermal amplitude is rather high, around 20°C. In terms of precipitation, the territory has an average rainfall of about 1,000 mm/year which is 1.6 higher than the national average (data.gouv.fr, 2021). In addition to the two main rivers, the Coise, which flows from East to West in the South, and the Brévenne, which flows from West to East in the center, many small streams drain the area; Turdine, Thoranche, Orjolle, Rossand, Potensinet, Gimond. (Vandenbroucke, 2013). The territory is also characterized by numerous water bodies. Some are natural, others artificial, like the water bodies built for the irrigation of red fruit crops (raspberries, strawberries), which were very developed in the 1960s (interview 13).

Spring and autumn are the most watered seasons. On the contrary, winter and summer are the dry seasons. However, the summer period is marked by episodes of stormy rains whose violence does not allow rehydration of the soils suffering from drought (SIMA COISE, 2014).

Over the last ten years, the State has recognized that the Rhône department and thus the community of communes of the Monts du Lyonnais has suffered 9 years of a particularly rough climate, which represents an "agricultural calamity for the damage suffered on fodder

(meadows and corn) by the farmers of the department". This recognition has allowed the release of financial compensation for farmers to compensate for agricultural losses. The frequency of these climatic episodes, 9 times over the last ten years, is proof that climate change is felt on this territory and that agricultural production is strongly impacted (interview 10).

4. Social and productive environment

4.1. Agricultural endeavors

Agriculture is the key economic sector of the Monts du Lyonnais and covers more than 75% of the territory (Simoly, 2013). It's a dynamic rural agricultural basin that differs in many ways from the agriculture present on a regional or national scale. Indeed, in 2010, 903 farms were present on the territory, which corresponds to a density of 25 farms/commune, well above the regional average of 13.5 (SIMA COISE, 2014). This high density is often perceived as a strength of the territory which manages to maintain an important agricultural social network (Vandenbroucke, 2013). This territory is nevertheless subject to problems that can be found on a national scale: the phenomenon of concentration and enlargement of farms (Agence d'urbanisme pour le développement de l'agglomération lyonnaise and Observatoire partenarial, 2013). Between 2000 and 2010 the average UAA (Utilized Agricultural Area) in the Monts du Lyonnais went from 22ha to 29ha, which is still much lower than the national average for dairy cattle farms; 79ha (Agence d'urbanisme pour le développement de l'agglomération lyonnaise and Observatoire partenarial, 2013).

Mixed crop and dairy cattle farming is the dominant system in this territory, and represents 58% of the farm's system in the Monts du Lyonnais (Agence d'urbanisme pour le développement de l'agglomération lyonnaise and Observatoire partenarial, 2013). The Monts du Lyonnais has one of the highest dairy densities in the region. The importance of livestock farming can also be seen in the distribution of agricultural land: 84% of the UAA is used for fodder crops, 70% is grassland. Farming systems are considered as intensive in this region, both in terms of milk production per dairy cows and the number of cows per hectare (SIMA COISE, 2014).

In 2009, the Monts du Lyonnais suffered the full force of the milk crisis that affected dairy farms nationwide which led to numerous protests throughout France, with some farmers even spreading their milk in front of dairy cooperatives (Roullaud, 2010). According to several local actors interviewed, this event marked a turning point for many farms. In order

to maintain the economic viability of their farms, many farmers have decided to convert to organic farming, create a cheese processing workshop, sell directly, or diversify their production.

Apart from the production of dairy cattle, the Monts du Lyonnais has rich and diversified agriculture: market gardening, arboriculture, viticulture, are present on the territory. This can be partly explained by the presence of the metropoles of Lyon and St Etienne, which demonstrates a strong demand for local products. The farmers of the Monts du Lyonnais take advantage of this demand in participating to local markets in the area but also in the city of Lyon ; 27% of the farms in the Monts du Lyonnais market their products in part through short circuits (Agence d'urbanisme pour le développement de l'agglomération lyonnaise and Observatoire partenarial, 2013).

Regarding organic farming, 90 farms were registered as organic in 2019, which corresponds approximatively to 10% of the farms (Agence Bio, 2019).

The Monts du Lyonnais is often presented as a territory with a significant, even exceptional, agricultural collective dynamism. Many studies have tried to characterize and understand the reasons for such a collective movement. Perrine Vandenbroucke's thesis (2013) explains in particular that beyond the issues around which the actors meet, it is these actors, with certain leaders among the farmers, the elected officials, the presidents of associations or their animators, who are able to create this territorial identity, with adhesion of a large group.

This collective dynamism is threatened by the lack of farms' takeovers according to the interviewee n°7. Indeed, because farms tend to be bigger, farmers are less likely to share equipment (and prefer to buy their own), to share time together (because they have less time). They tend to be more individualist and therefore less connected to the farmer's population.

4.2. The main destination of the dairy cattle production

The main market for the milk produced in the Monts du Lyonnais is the dairy industries such as Sodiaal or Lactalis; 73% of farms use this channel. Although the soil and climate conditions of this territory make production costs higher than average, Sodiaal has always maintained its activity in the Monts du Lyonnais (SIMA COISE, 2014). This territory appears to be a strategic collection area thanks to the density of dairy farms, the quantity of milk produced, and the investment of farmers in the cooperative, notably in the board (Ricard, 2015). Other dairy industries are also present on the territory but less importantly and more recently such as Biolait, which collects only organic milk.

A new trend, which is observed throughout France, is the increase of short circuits as distribution channels for agricultural products. 27% of the farms in the Monts du Lyonnais sell at least one of their products in a short circuit, which corresponds mainly to direct sales at farmers' markets. Farmers using short circuits process part of their milk production into cheese in order to offer consumers a large diversity of products. It has been observed that poor farms only sell in a short circuit: often, farms process half of their production into cheese, while the other half is sold thanks to long supply chains (interview 10).

The strong collective dynamic present in this territory can also be observed throughout various farmers' initiatives related to direct selling. In 1981, the first farmers' store in France was created in the Monts du Lyonnais: Uniferme (Michel, 2013). Thanks to its success, several extensions have been made. Today, it is a store with more than 300m² of sales area and 18 associates who govern the store in a shared manner (Michel, 2013). More recently, 4 organic farms got together to create a cheese factory: Altermonts. They present themselves as passionate farmers who wish to participate in the ecological transition of the territory by working on the planting of hedges, pasture management, energy autonomy, and the valorization of agricultural products (AlterMonts, 2021).

5. Enabling environment for agroecology

5.1. The stimulus provided by public strategies

France is the first country in Europe to implement action plans promoting agroecology thanks to the "Plan pour l'agroécologie", presented by Stéphane Le Foll, the French Ministry of Agriculture (Wezel and David, 2020). This plan includes a series of actions whose aim is to scale up agroecology. One of the initiatives set up is the GIEE: Group of Economic and Environmental Interests. It is a group of at least 5 farms, which, on a territory scale, commits to implement a set of actions related to agroecology to help improve the competitiveness of farms while preserving the ecosystems in place. In 2020, 900 collectives obtained the GIEE recognition (Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt Auvergne-Rhône-Alpes, 2020).

The recognition of these collectives, granted for 3 years, renewable once, allows dedicated, prioritized or subsidized access to two types of subsidies (Ministère de l'agriculture et de l'alimentation, 2020b). First of all, the subsidies allow the payment of a facilitator whose role is to assist the collective in the successful completion of their project. The training is also paid by subsidies. According to the Ministry of Agriculture 2020, the average amount received by the GIEEs in 2020 was about 31 700€ (Ministère de l'agriculture et de

l’alimentation, 2020b). Recognition as a GIEE also gives priority access to equipment subsidies, equipment that is used to carry out the collective's project.

In the Monts du Lyonnais, an important concentration of GIEEs is observed since 4 GIEEs are currently in progress:

- POPECOLES: for Paysans autOnomes pour la Production et Les Echanges Collectifs de Semences: this collective works on the varietal selection of population corn in order to reappropriate their local practices, to improve their autonomy and their profitability, the purchase of seeds being one of the most important expenses (Plateforme de la R&D Agricole, 2017a).
- AlterMonts, organic, collective and farmer cheese factory, a renewal for the dairy industry and its practices, as mentioned above, this group of 9 farmers created a cheese factory to recycle waste, improve the autonomy of their systems, share their knowledge and become more resilient to climate change (AlterMonts, 2021, interview 9).
- AgriENR, is a methanization project led by 11 farmers who aim to valorise livestock effluents and bio-waste from the community and diversify their sources of income (Plateforme de la R&D Agricole, 2017b, interview 7).
- The GIEE des 4 saisons, is a project carried by some farmers of an agricultural cooperative for materials usage who wish to work on the theme of soil management concerning dairy cattle breeding practices (interview 15).

Thanks to the semi-directive interviews, few structures and persons have been identified as keystones for agroecology transition in the Monts du Lyonnais. The SIMACOISE, the Interdepartemental syndicate mixte for the management of the Coise river, is in charge of the second river contract, which is a contractual procedure for the protection of the water resource. The SIMACOISE aims at global, concerted and sustainable management of the resource and aquatic environments (SIMA COISE, 2014). In order to meet the goal set, a series of measures is being implemented and concerns farmers: farming systems desintensification, grazing management, reduction of the use of phytosanitary products, plantation of hedgerows. Therefore, the SIMACOISE participates in the creation of farmers' collectives that are trained by external speakers who master these themes in accordance with the principles of agroecology. This structure is very present in the 2/3 of the Monts du Lyonnais (the area where the Coise is located) and is proving to be an important driving force for the agroecological transition of the territory.

5.2. The presence of committed local actors

Throughout the various interviews with local actors and farmers, a few people were mentioned several times and are considered to be key actors in the transition to agroecology in the Monts du Lyonnais. These people are members of agricultural organizations, such as CUMAs or Rhone Conseil Elevage, an association of 400 farmers from several territories who contribute to employ livestock advisors. Although some of these people have the technical knowledge to assist in the agroecological transition, their main strength is to organize exchanges between farmers and stakeholders around different themes related to the agroecological transition. They participate in the sharing of knowledge and mutual aid between farmers, in the learning of new practices and in the destruction of certain patterns that prevented the adoption of certain agricultural practices.

The administrative structure that governs the Monts du Lyonnais, i.e. the Communauté des Communes des Monts du Lyonnais (CC MdL) is also a very important actor on the territory (interview n°16). This structure coordinates the different stakeholders and implements local policies, which are particularly oriented towards preserving agriculture on the territory. The CC MdL has supported various methanization projects that are part of the territory's energy transition. It is also working on a territorial food project whose three main axes are (i) the conservation of agricultural potential, (ii) raising awareness of the interests of short circuits, (iii) and the structuring of agricultural sectors. Finally, the CC MdL is interested in other issues such as the pressure on agricultural land and water management, a major challenge in light of climate change.

5.3. The presence of private companies supporting the agroecological transition

Danone is one of the French leaders in milk collection. However, this company has little presence in the Monts du Lyonnais as a milk collector but supports farmers in the transition to agroecology (Danone, 2020). The Monts du Lyonnais is located upstream from the Badoit mineral water source. The company of the same name, a subsidiary of Danone, sells this water. Danone is therefore faced with a major challenge: the quality of its mineral water depends on the quality of runoff water, particularly from the Monts du Lyonnais (interview 7). Created in 2010, the association La Bulle Verte, supported in particular by Danone, is working with farmers, and more particularly with breeders in the Monts du Lyonnais, to work on their farming practices and their grazing management, in order to have a minimum of water runoff that could be polluted (SIMA COISE, 2014).

Another example shows the capacity of private companies to participate in the transformation of agricultural models on a territorial scale, particularly in the Monts du

Lyonnais. About fifteen years ago, when agroecology was unknown in this territory, organic agriculture was showing a very important development. Seeing the increased demand, Sodial wanted to encourage farmers in the area to convert to organic farming to meet the demand for organic milk. A group of 20 farmers was formed to prepare their conversion together. Although a quarter of the farmers decided, after a year of consultation, not to convert, a reflection was nevertheless conducted.

Appendix 10 : Scheme to determine the toxicity of a chemical

Table 9: Scheme to determine the toxicity of a chemical

CATEGORIES		**SIGNAL WORD**	**ORAL LD50 (mg/kg)**	**DERMAL LC50 (mg/kg)**	**INHALATION LD50 (mg/L)**
I	Extremely/highly toxic	DANGER POISON / DANGER	0 to 50	0 to 200	0 to 0.2
II	Moderately toxic	WARNING	50 to 500	200 to 2000	0.2 to 2.0
III	Slightly toxic	CAUTION	500 to 5000	2000 to 20000	2.0 to 20
	Relatively non-toxic	CAUTION [optional]	5000+	20000+	20+

Appendix 11 : List of mitigation techniques presented in the questionnaire of TAPE

Mitigation strategies :

- Mask
- Body protection (glasses, gloves, etc.)
- Special protection for women and children
- Visible signs of danger after spraying
- Community is informed of the danger
- Secure disposal of the empty containers after use
- Other:
- None of these

Appendix 12 : Calculation method for the women empowerment and land tenure score

- Calculation method for the women empowerment score

DOMAINS	AREAS OF ASSESSMENT	ANSWER	SCORE	WEIGHT
Productive decisions	About crops production, animal production, other economic activities	» Myself or Both of us » My Husband or Someone else	1 0	¼
	About major and minor household expenditures	» Myself or Both of us » My Husband or Someone else	1 0	¼
	Perception of decision making about crops production, animal production, other economic activities	» No decision » Just little decisions » Some decisions » In great part/totally	0 0.33 0.66 1	¼
	Perception of possibility of decision making about MAJOR & MINOR HOUSEHOLD EXPENDITURES	» No decision » Just little decisions » Some decisions » In great part/totally	0 0.33 0.66 1	¼
Access to and decision-making power about productive resources	Secure land tenure for men and women (From the results of 3.4.1)	» Green for women » Yellow for women, yellow or red for men » Yellow for women, green for men » Red for women, red for men » Red for women, yellow for men » Red for women, green for men	1 0.75 0.5 0.25 0.1 0	¼
	Access to credit	» Possible for women in secured channels » Possible for women in non-official channels only, not possible for men » Possible for women in nonofficial channels only, possible for men non-official channels only » Possible for women in nonofficial channels only, possible for men in official channels » Not possible for women, not possible for men	1 0.8 0.75 0.5 0.25	¼

		» Not possible for women, possible in non-official channels for men » Not possible for women, possible in secured	0.1 0	
	Ownership of CROPS, SEEDS, ANIMALS, and OTHER PRODUCTIVE ASSETS	» Myself or Both of us » My Husband or Someone else	1 0	¼
	Ownership of MAJOR & MINOR HOUSEHOLD ASSETS	» Myself or Both of us » My Husband or Someone else	1 0	¼
Control over use of income	Decisions about the use of the revenue generated by CROP PRODUCTION, ANIMAL PRODUCTION and OTHER ECONOMIC ACTIVITIES	» I did not contribute or I contributed in few decisions » I contributed in some decisions » I contributed in almost all the decisions	0 0.5 1	1
Leadership in the community	If these groups exist in your community, how often do you participate in their activities and meetings? WOMEN'S ASSOCIATIONS AND ORGANIZATIONS	» Never/almost never » Sometimes » Most of the times » Always	0 0.33 0.66 1	½
	COOPERATIVES FOR RURAL PRODUCTION Social Movements, Union of Rural Workers, Political Groups, Religious Groups, Training for Capacity Development, Other	» Never/almost never » Sometimes » Most of the times » Always	0 0.33 0.66 1	½

Time use	More than 10.5 hours spent working per day	» Women no » Women yes, men yes » Women yes, men no	0 0.5 1	½
	Time spent in AGRICULTURAL ACTIVITIES + FOOD PREPARATION & DOMESTIC WORKS + OTHER GAINFUL ACTIVITES	» Women's time > men's » Women's time < = men's	1 0	½

If there are **no** men in the household, some scores will be calculated in a different way. For the area of assessment "Secure land tenure for men and women" only the Secure land tenure for women will be taken into account, assigning a score equal to 1 if green, 0.5 if yellow, and 0 if red. "Access to credit" will refer to the access to credit of the woman, assigning the score 1 if the access to credit is "possible for women in official channels, 0.5 if it is "possible for women in non-official channels only", and 0 if it is "not possible for women". Then, the domain "Time use" will be calculated by assigning score 0 if "the woman is working **more** than 10.5 hours per day" and score 1 if "the woman is working **less** than 10.5 hours per day".

Appendix 13 Comparision of the score for the element Diversity

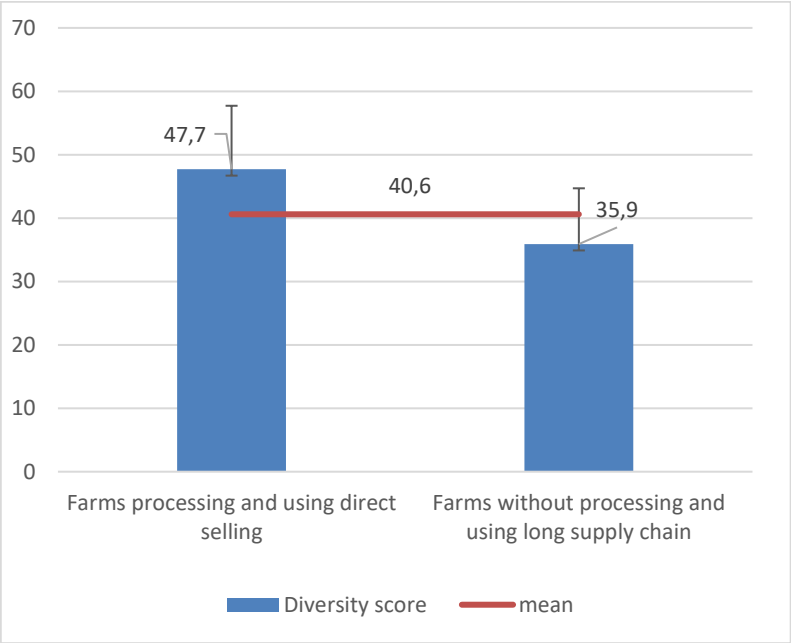

Figure 17 : Mean (+/- SD) score obtained for the element Diversity for the farm processing milk into cheese and using direct selling (n=8) compared to the farms that don't process neither use long supply chain.(n=12).

Appendix 14 : Comparision of the score obtained for the element Diversity for the organic farms compared to the conventional farms.

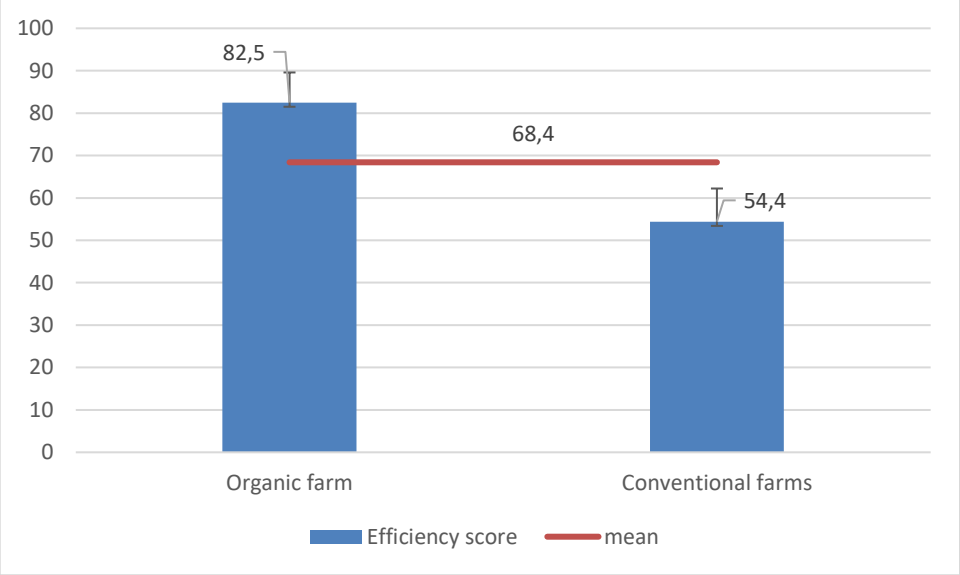

Figure 18 : Mean (+/- SD) score obtained for the element Efficiency for the organic farms (n=10) compared to the conventional farms (n=10).

Appendix 15 : Comparision of the score for the element Circular and solidarity economy

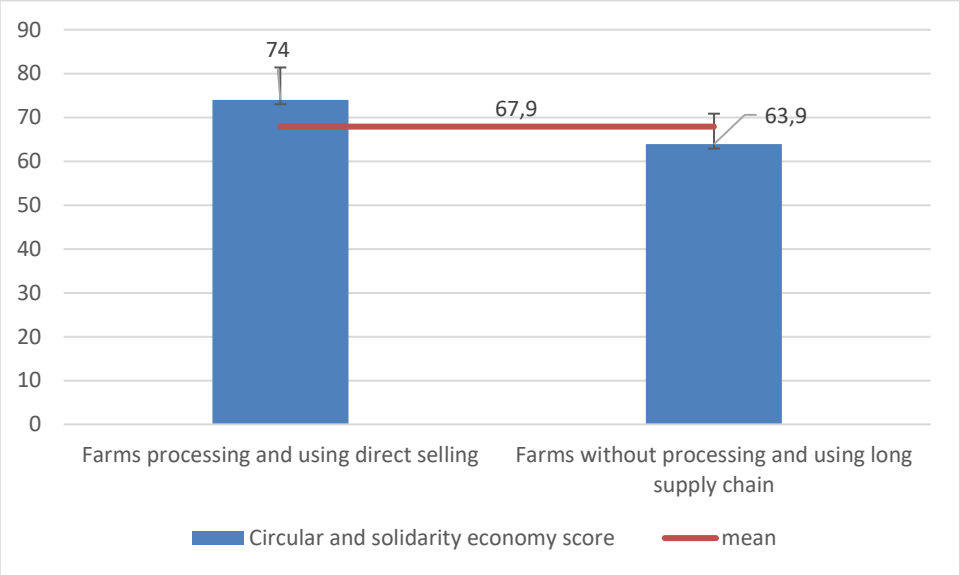

Table 10 :Mean (+/- SD) score obtained for the element Circular and solidarity economy for the farm processing and using direct selling (n=8) compared to the one that don't (n=12).

Appendix 16 : Average score obtained per farm for the step 1 of TAPE

Table 11 : Average score obtained per farm for the step 1 of TAPE

Farm	Average score for the step 1 (/100)
1	63,5
2	77,2
3	68,0
4	68,4
5	66,9
6	65,4
7	74,1
8	68,2
9	61,0
10	68,4
11	69,4
12	65,3
13	66,4
14	74,0
15	67,9
16	73,5
17	70,1
18	65,2
19	74,1
20	66,3

Appendix 17: Eigen values resulting from the PCA conducted

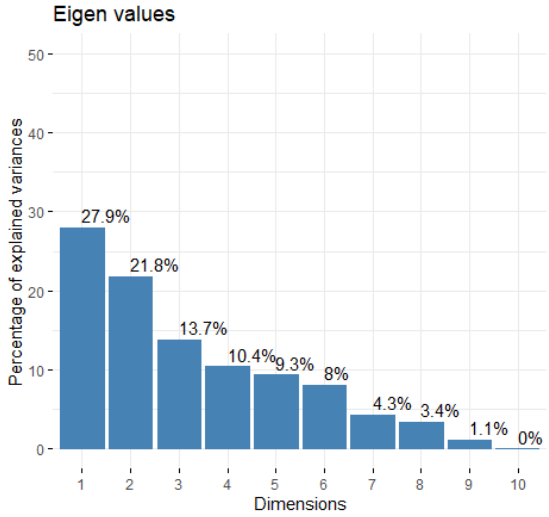

Figure 19 : Eigen values resulting from the PCA for the step 1 of TAPE

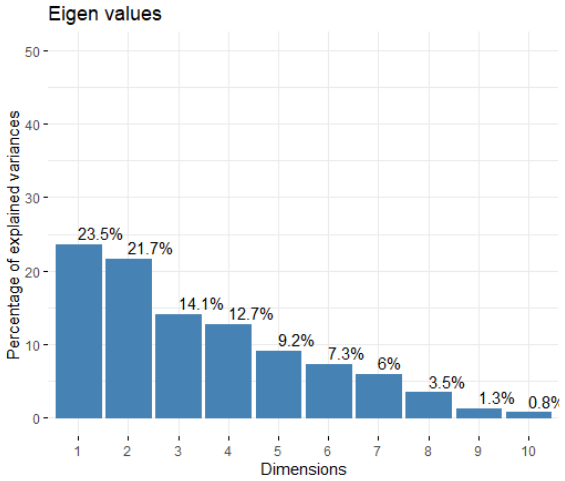

Figure 20 : Eigen values resulting from the PCa for the step 2 of TAPE

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