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The suitability of using FAO's Tool for Agroecological Performance Evaluation (TAPE) in a Norwegian context

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Abstract

The present agri-food system, in Norway and globally, is facing severe challenges when it comes to ecological, economic, and social sustainability. To retain the presumptions for future generations to flourish on earth, business as usual is not an option. There is an identified need to gain knowledge and evidence of how different types of agricultural production systems are contributing towards achieving a more sustainable state. However, assessing the sustainability of farming and food systems is a challenging and complex task. Methods intending to do so need to be carefully evaluated. In this study, FAO's "Tool for Agroecological Performance Evaluation" (2019) was implemented on an organic dairy farm in Midwest Norway and evaluated for its suitability in this context.
TAPE characterizes the farming system by assessing it against principles within agroecological approaches and then evaluates its performance against dimensions considered relevant to achieve the Sustainable Development Goals (SDGs). The selected farm in this study performed best in dimensions regarding economy and efficiency and poorest in dimensions concerned with diversity. This was identified as a consequence of socioeconomic and political circumstances (the supra-system). It indicates that TAPE is an appropriate tool to identify specific characteristics of agricultural production systems and trace their potential causes to the circumstances of its supra-system. Several shortcomings and challenges for the suitability of using TAPE in a Norwegian context were identified and discussed. The main issues concerned poor adaptation of indicators to ecological, climatic, and socio-cultural conditions of Norway. However, these shortcomings were considered less relevant if TAPE is used and interpreted as a soft systems methodology, rather than a rigid method. TAPE was specifically recognized to be a promising tool to foster transformative discussions about sustainability in agricultural production systems through participatory learning processes with farmers, policymakers and other stakeholders.

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List of abbreviations

AA – Agroecological Approaches

EU – European Union

FAO – Food and Agriculture Organization of the United Nation

HLPE – High Level Panel of Experts on Food Security and Nutrition

IPES food – The International Panel of Experts on Sustainable Food Systems

IUCN- International Union for Conservation of Nature

MCA – Multi criteria analysis

NMBU - Norwegian University of Life Sciences

NORSØK- Norwegian Centre for Organic Agriculture

OA – Organic Agriculture

OECD - Organization for Economic Co-operation and Development

RISE - Response Inducing Sustainability Evaluation

SDGs – Sustainable Development Goals

SMART - Sustainability Monitoring and Assessment Routine

TAPE – Tool for Agroecological Performance Evaluation

UNEP- United Nations Environment Program

WCED- World Commission on Environment and Development

WHO – World Health Organization

WWF- World Wildlife Fund

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1. Introduction

1.1 Sustainability, what is it?

The development of human civilisation on earth has put society in a position of facing a global climate and ecosystems crisis. Our quality of life as human beings, diversity of life on earth and health of ecosystems won't be sustained without transformative changes. As society has become more aware of this issue, the discussion about *sustainability* has increased. Sustainable development was defined by the Brundtland Report (WCED, 1987, p.16) as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs".* The perspective of life quality was later included in the definition by (IUCN et al., 1991): *"Development that improves the quality of human life while living within the carrying capacity of supporting ecosystems".* Sustainability embraces the environmental, economic and social dimensions and has been declared a consensus frame (Brunori & Galli, 2016). Recently, the term has become more and more of a buzzword and is often seen as adopted by corporates, by the purpose of increasing sales (Brunori et al., 2016). However, there are uncertainties about the meaning of the term and what it should encompass. This confusion is often connected to the lack of a clear definition and a common understanding of what scale (in space and time) sustainability is to be achieved, as well as the discrepancy of values, norms, and interests(Bell & Morse, 2008). It has been recognized that the divergent perceptions of what sustainability is and how it should be achieved, can be a consequence of differences in how communities envision and pursue social and natural well-being (Miller et al., 2014).

1.2 Why assess sustainability?

The ongoing political discussions and debates related to sustainability and sustainable development is now ranging across several sectors. In this debate, the agricultural sector is often in focus. Industrial agriculture is successful in providing large amounts of food to global markets but not without negative consequences (IPES FOOD, 2016). It is mainly argued to be a driving force of climate change, loss of biodiversity, pollution, and global inequalities (Gliessman, 2013). This is caused by agricultural systems involving fossil fuel dependency, monocropping techniques, and unequal power dynamics (ibid.). Livestock farming is a concept were there is a failing consensus about to what extent its practices are sustainable. Several scientific and popular science reports have addressed the negative impact of livestock farming on climate and environment (such as emission of greenhouse gases and eutrophication (Kaufman & Cleveland, 2008) but the reported numbers and claims vary. Opponents argue that some management practices within livestock farming can have a positive environmental effect, e.g., rotational grazing leading to the regeneration of land (Savory & Butterfield, 2016). Organic agriculture (OA) is another concept where there is a failing consensus about to what extent its practices are sustainable. OA is defined as: "*a holistic production management system which promotes and enhances agro-ecosystem*

health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems" (FAO/WHO, 1999). Some scientists argue that OA is more sustainable than conventional agriculture (e.g.,Rahmann et al., 2017). They further argue that these organic production systems play a vital role in meeting sustainability challenges within food production. However, OA has a history of being contentious (Reganold & Wachter, 2016). Opponents argue that the claimed benefits of OA, such as better outcomes regarding soil fertility, leaching of nutrients and energy aspects, are not scientifically justified (Kirchmann et al., 2016). Debuschewitz & Sanders (2022), identified two main lines of discussion regarding the controversial debate about OA and its role in the development of more sustainable agriculture. The first was to what extent the aspect of food security should be included in the assessment. The second was to which extent the net environmental impacts or possible leakage effects due to lower yield levels should be considered. They also described that the choice of reference unit is significantly affecting the outcome. OA has lower environmental impacts when the unit is expressed per area, but a higher impact when expressed per unit output. Hansen et al., (2021) found that greenhouse gas emissions were significantly lower with organic than with conventional dairy production, when calculated per area, but when emissions were calculated per product, the difference decreased. In addition to this, Debuschewitz & Sanders (2022), describe that scientific debates about OA and its role in food security are influenced by normative assumptions about socioeconomic and agricultural development. This is a clear example of a discussion marked by contradictions that have understandably caused confusion among the public. Boogaard et al., (2011) mean that the public's perception of dairy farming varies from dreadful to idyllic. The controversial picture described above indicates that this dilemma is dealing with complexity, which creates challenges in defining, measuring, and communicating sustainability in agricultural production systems. Nevertheless, decision-makers are searching to develop policies for achieving a more sustainable food system and researchers have addressed the need to take a more holistic agri-food systems perspective that is going beyond productivity aspects (IPES FOOD, 2016). Assessments entailing complex ecological and economical interrelations are needed to create evidence on the performance of different farming systems (Seufert and Ramankutty, 2017). Gliessman (2015) argues that one of the most important tasks facing the science concerned with sustainability in agricultural production and food systems today is to bring forth the knowledge and skills to enable assessments of such systems. He further emphasizes that such assessments should identify whether these systems are sustainable or not and help envision the establishment of sustainable systems.

1.3 Agroecology and its role in the transition towards a more sustainable agri-food system

As mentioned above, the agri-food system is facing several challenges linked to sustainability. In response to this, *agroecology* is a concept receiving more and more recognition for being a promising way to guide the transition to a more sustainable system. Agroecology has been defined as the "ecology of the food systems" (Gliessman, 2007) and a transdisciplinary, participatory, action-oriented and holistic approach (Méndez et al., 2013). It stretches across ecological, agricultural, food, nutritional and social sciences (Wezel et al., 2020). Agroecological principles have evolved over the past few decades to encompass not only field, farm, and landscape-scale agricultural practices, but also social and cultural aspects of food systems (ibid.). The concept of agroecology developed through farmers, social movements, and scientists in a common effort to resist and find alternatives to industrial agriculture, perceived to cause social and ecological degradation in rural communities (Gliessman, 2015). The earliest pioneers of agroecological movements recognized the lack of relationship between agronomy and ecology (Gliessman, 2015) and the need to emphasize the food system from an ecological perspective has been further elaborated and developed throughout the years. Vandermeer & Perfecto (2017) argued that *ecological complexity* (ecology including ideas from complexity science that is concerned with complex, dynamic, and unpredictable systems and problems) is key to understanding and investigating agroecosystems. They further emphasized that ecological processes can be multiple in themselves, and therefore, looking at just a small piece of the whole, one risks missing crucial elements. This links back to research that was published almost fifty years ago. In 1974, the first issue of the journal "Agro-Ecosystems" was published, and the statement *"each part is a component of a whole and that at some point the whole itself must itself be a subject of study"* was highlighted (Harper, 1974).

In 2018, FAO described agroecology as "*an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems. It seeks to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system*" (FAO, 2018, p.1). In the same report, FAO determined the "10 elements of Agroecology" as diversity, synergies, efficiency, resilience, recycling, co-creation and sharing of knowledge, human and social values, culture and food traditions, responsible governance and circular and solidarity economy. The elements are described to be interlinked and interdependent. In addition to this, Sinclair et al., (2019) describes that there are no defined set of agroecological practices, since practices are context dependent and needs to be locally adapted. It is therefore more suitable to describe practices as being more or less "agroecological" (ibid.).

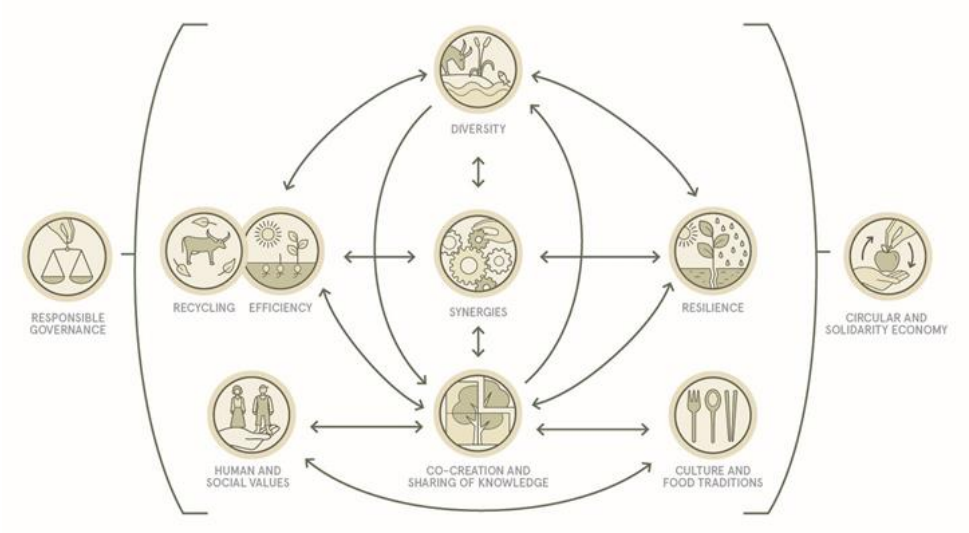

Figure 1. **The "10 elements of Agroecology"** with their interlinks and interdependences (FAO, 2018).

A more specific definition of *agroecological approaches* (AA) was stated by the High Level Panel of Experts on Food Security and Nutrition as:

"AA favor the use of natural processes, limit the use of purchased inputs, promote closed cycles with minimal negative externalities and stress the importance of local knowledge and participatory processes that develop knowledge and practice through experience, as well as more conventional scientific methods, and address social inequalities. AA recognize that agrifood systems are coupled social–ecological systems from food production to consumption and involve science, practice and a social movement, as well as their holistic integration, to address food security and nutrition" (HLPE, 2019, p.39)

FAO (2019) has recognized a growing political interest for the potential of application of AA to become the foundation for the transition to a more sustainable agri-food system. Examples of such attention is the suggested strategy for a common food policy in the EU by IPES (2019) and the "Farm to Fork" strategy in the "European green deal" (European Comission, 2020). Consequently, the need to build an evidence base of the performance of production systems operating in compliance with agroecological approaches has been recognized (Mottet et al., 2020).

1.4 How to assess sustainability in farming and food systems?

Previous sections indicate that there is a need of assessing different agricultural production systems and their performance in terms of sustainability. Processes that guide envisioning and decision-making toward sustainability have become known as *sustainability assessments* (Hacking & Guthrie, 2008). There are several methods within sustainability assessments. One such method, that has been repeatedly applied when it comes to farming and food systems is called multicriteria analysis (MCA). This is a

method that aims to support decision making by investigating the balance between the advantages and disadvantages of different alternatives (Geneletti and Ferretti, 2015). MCA's typically separates the environmental, social and economic dimensions of sustainability and assesses each one of them with indices, scoring and a weighing system. To enable this process, so called "indicators of sustainability" (conditions vital for and indicative of sustainability*)* must be developed (Gliessman, 2015). In terms of assessments concerned with agricultural production systems this can be done by; a) identifying specific characteristics that play key parts in the function of the agroecosystem, and b) define at what level or condition these parameters must be kept for a sustainable function to occur, as well as the length of time they need to be preserved (Gliessman, 2015). The decisions regarding which sustainability indicators to adopt for an assessment is crucial for the output, however the process of developing such indicators is often characterized by disagreements by developers and other stakeholders (Bell and Morse, 1999). Sustainability indicators are often criticized for trying to enclose complex and diverse processes in relatively few and primitive measures (Bell and Morse, 1999). This may not occur as a surprising phenomenon since sustainability assessments are basically an attempt to measure and quantify complex systems and situations that may not in practice be possible to quantify (ibid). However, Bell & Morse (1999) also describes that the development and use of sustainability indicators are means to keep the paradigm of sustainability alive.

MCA has been argued to be suitable when dealing with complex decision problems because of two key features: 1. They allow criteria two differ in their nature and in units of measurement as well as they can be both quantitative and qualitative, and: 2. they provide a transparent framework for decision making that takes into consideration different sets of values from several stakeholders (Geneletti & Ferretti, 2015).

1.5 FAO's Tool for Agroecological Performance Evaluation (TAPE)

In response to the recognized need for building an evidence base of the performance of production systems operating in compliance with agroecological approaches, mentioned in 1.3, FAO developed an MCA called Tool for Agroecological Performance Evaluation (TAPE). It first characterizes the system by measuring it against the ten elements of agroecology and then evaluates its performance against dimensions considered relevant for achieving the sustainable development goals. Bell and Morse (2008) advocates for participatory inclusion of stakeholders in the development process of any sustainability assessment or indicators. The process of developing TAPE included a participatory process with 70 representatives from relevant organizations around the world (Mottet et al., 2020). During this process, a review of existing frameworks and indicators for assessing sustainability in agriculture was also conducted, as well as a stakeholder consultation including 450 participants. This information indicates that TAPE was constructed in an authentic manner.

The process resulted in an official test version of TAPE as a global analytical framework with a comprehensive document of guidelines for stakeholders (FAO, 2019). The objectives of TAPE as

described in the guidelines (p.6) are, 1) *Build knowledge and empower producers through the collective process of producing data and evidence on their own practices, 2) Support agroecological transition processes at different scales and in different locations by proposing a diagnostic of performances over time and by identifying areas of strengths/ weaknesses and enabling/disabling environment, 3) Inform policymakers and development institutions by creating references on the multidimensional performance of production systems operating in line with agroecological approaches and their potential to contribute to the SDGs*.[1]

1.6 Assessment of sustainability of livestock farming in Norway

Concerning aspect of sustainability of livestock farming in Norway, most studies done on Norwegian dairy farms have only been focusing on some aspects within sustainability such as greenhouse gas emissions, environmental impact, technical efficiency, and productivity (e.g, Koesling, 2017; Hansen et al., 2018; Alem, 2021). There is a need to complement such studies by assessing agricultural systems from a more holistic perspective, including the three dimensions of sustainability.

Two other MCAs developed for sustainability assessments of farming and food systems, – Response Inducing Sustainability Evaluation, RISE, (Bern University of Applied Sciences, 2021) and Sustainability Monitoring and Assessment Routine, SMART, (Sustainable Food Systems Society, 2014), have been tested and evaluated in Norway. Martinez & Eiter, (2017) found that these could be useful tools in the development of a more sustainable agriculture in Norway. They further identified that the tools were suitable as a basis for discussion and planning for further development of the farms. However, they recognized the need to build up a good experience base for using the tools in a Norwegian context before further implementation. After piloting TAPE in several counties, it was claimed to be *"a global relevant tool which can be applied to all types of production systems, to generate information relevant to policymakers, scientists, international organizations, the private sector, and producers. It is at the same time broad in the number of dimensions of sustainability covered and simple in its application"* (Mottet et al., 2020, p.18). This indicates that TAPE could be a suitable tool for assessing sustainability of livestock farms in Norway. However, TAPE has not been applied in the Norwegian context yet. It needs to be tested and evaluated before further implementation.

[1] Sustainable development goals (SDGs)- developed by the United Nations (UN) in 2015. The 17 goals are targets within the *"2030 Agenda for Sustainable Development"* (UN, 2015)

1.7 Aim of the study

In summary, a transformative change is needed to achieve more sustainable agri-food systems. This triggers a need for assessing how different production systems at different stages of transition perform in terms of ecological, economic, and social sustainability. The recognized potential for production systems operating in compliance with agroecological approaches to become a foundation for a more sustainable agri-food system led to the development of TAPE, which is claimed to be a globally relevant tool (Mottet et al., 2020). The suitability for using TAPE in the Norwegian context has yet to be explored.

Therefore, the objectives were to:

- **Implement TAPE on a selected organic dairy farm in Norway**, in order to:
  - characterize its degree of compliance with agroecological approaches and
  - evaluate its sustainability performance on key dimensions identified by FAO (2019) as relevant for achieving the SDGs
- **Evaluate the suitability of using TAPE in the context of this study** and,
  - if needed, suggest possible modifications for TAPE to become more suitable in the Norwegian context

3. Method

To be able to evaluate and thoroughly discuss all parts of the process of implementing TAPE, a holistic single case study approach was applied to this project. Yin (2018, p.4) argues that such approach allows the researcher to *"retain the holistic and meaningful characteristics of real-life events*". An organic dairy farm in mid-west Norway was chosen as the case. This farm was chosen because of its connection to the Norwegian Center for Organic Farming (NORSØK), which made it possible to conduct a focus group discussion with the farmer, two advisors and two researchers, explained in section 3.2, and retain several perspectives throughout the evaluation of the tool. The research design of the process is explained in Figure 2. The initial work was about conducting the assessment by using TAPE (step 0-2) on the chosen farm for this case-study and compile its outcome. That process was followed by an implementation of TAPE Step 3 (participatory interpretation of the results from Step 0-2) through a focus group discussion with stakeholders, aiming to evaluate the suitability of TAPE in the context of this project. All work was carried out from August to November, 2022.

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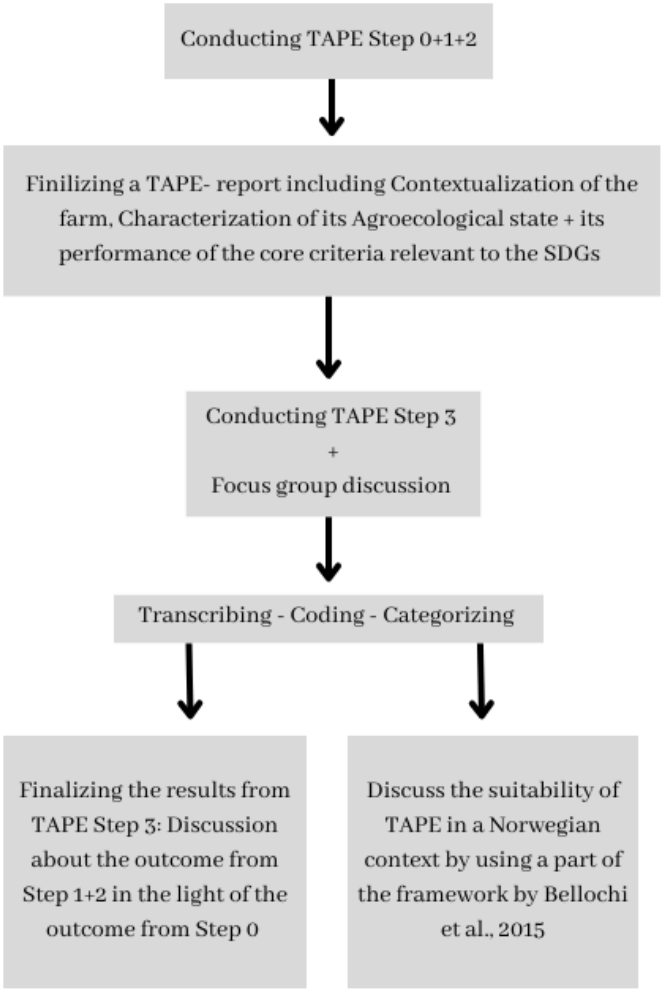

Figure 2. **Research design:** The initial work was about conducting the assessment by TAPE on the chosen farm and compile its outcome. That process was followed by a participatory interpretation of the results and a focus group discussion with stakeholders, aiming to evaluate the suitability of TAPE in the context of this project.

3.1 Conducting the assessment by using TAPE and compile its outcome

The method for assessing the farm in this project has followed the guidelines and principles of the two documents: FAO. 2019. *TAPE - Tool for Agroecology Performance Evaluation 2019 – Process of development and guidelines for application. Test version*. Rome, and Mottet et al., 2020. *Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE)*. According to these documents, TAPE is following a stepwise approach, which was adapted throughout this project:

TAPE Step 0: Description of systems and context. The preliminary step that includes a description of the main socio-economic and demographic characteristics of the agricultural and food systems and an analysis of the enabling environment in terms of relevant policy, market, technology, sociocultural and/or historical drivers. This step was conducted through a literature review.

TAPE Step 1: Characterization of agroecological transition (CAET). This step aims to characterize to what extent a system or territory is operating in compliance with agroecological approaches. This part of the assessment is also explained by Mottet et al., (2020, p.3) as "providing a diagnostic on where the system stands in terms of its transition toward sustainability". It is based on the 10 Elements of Agroecology developed by FAO, (2018) described in 1.3. Step 1 consists of descriptive scales used to establish scores. Each element is assessed with three to four indices that are scored by using pre-set statements on a scale from 1 to 4 (Appendix 1). The total number of indices to be scored is 37. The scores of the four indices are then summed separately for each element and calculated to receive a percentage for each dimension. For example, the element of "Diversity", is scored by the four indices: Diversity of crops, Diversity of animals, Diversity of trees, and Diversity of activities, products, and services. The scores of the four indices are summed (e.g., 2+3+3+4=12) and the totals are standardized on a scale from 0 to 100 percent (e.g., 12/16=75 percent) to obtain the general score for the element "Diversity" (FAO, 2019).

Information is required from the farm, household and territory scale. The data was collected through an interview with the farmer. For this purpose, an interview guide (Appendix 4) previously used for TAPE in France (developed by Anthonioz, 2021) was retrieved and slightly modified. This interview aimed to collect data needed to complete schemes used for conducting TAPE step 1 and partly step 2. These schemes were found in the supplementary material derived from Mottet et al., (2020) and the TAPE-guidelines (FAO,2019) (Appendix 1 & 2). The interview was then complemented with a transect walk to determine the criteria connected to landscape and the ecological environment, as well as a review of documents containing farm data.

TAPE Step 2: C**riteria of performance.** This step assesses the "*Core Criteria of Performance"* (FAO, 2019) linked to the key dimensions identified to be relevant to achieve the SDGs. It aims to "*measure in quali-quantitative terms the impact of agroecological systems on the various dimensions of sustainability"* (Mottet et al., 2020, p.3). Table 1 shows the key dimensions and core criteria, identified by FAO (2019). It also explains why they are perceived to be strategic to assess and communicate to inform policymakers, and which SDGs they are linked to.

Table 1. **TAPE Step 2**: Key dimensions, core criteria and the description and arguments by FAO (2019) of their relevance for assessment in relation to the specific SDG's.

Key dimension	Core Criteria	Description and arguments for the relevance of these criteria, by FAO (2019)	Linked to SDG's
Governance	**Secure land tenure**	A key component to social justice and gender equality is equitable access to land. It is a prerequisite for fostering incentives for long-term investments necessary to protect soil, biodiversity and ecosystem services.	1 2 5
Economy	**Productivity**	Data on productivity provides information on the number of resources necessary to produce a given quantity of a product. Improvements in agricultural productivity contributes to achieve food security, as well as it can be an important contributor to lower the environmental impact from agriculture.	2
	Income	The economic viability of a system is an important part of sustainability in agriculture. This is driven to a large extent by profitability, meaning the net income that the producer is earning from farming relative to the cost for investments.	1 2 10
	Added value	The added value can be described as an attempt to measure the contribution from the farm to the wealth of the society. In terms of agriculture, an example would be that that if you have a high income because you are renting out a lot of land, it lowers your added value, if you have a lot of employees, it increases your added value.	10
Health & Nutrition	**Exposure to pesticides**	Chemical pesticides are used in crop production to control pests and reduce loss of crop yield or damage. They can cause undesirable effects to human health and to the environment. It is fundamental to measure the benefits of agroecological approaches and two which degree it reduces the use of pesticides.	3
	Dietary diversity	To enable a recognition of the imbalances in our food systems and move towards a zero-hunger world while considering all forms of malnutrition, increasing production alone is not sufficient. This has to be done through re-balancing food habits, promoting healthy food production and consumption, and supporting the right to appropriate food.	2
Society & Culture	**Womens Empowerment**	Emphasizing human and social values and addressing gender inequalities by empowering women is central in the strive towards a sustainable food system. Women make up almost half of the agricultural global workforce, but they are not working under the same prerequisites as the men. Globally, they also tend to have less access to resources and therefor their decision-making capacity remains limited. In some areas of the world, this is resulting in lower agricultural productivity levels of female farmers, compared to the male.	2 5
	Youth Employment Opportunities	Monitoring the extent of decent work in agriculture, especially for young people, is relevant in assessing progress towards sustainable agriculture. The reason for this is that youth in rural areas is facing a crisis of employment in many countries. Consequently, many are migrating to urban areas.	8
Environment	**Agricultural Biodiversity**	The diversity of crop species and varieties, livestock species and breeds, wild plants, pollinators soil biota and other aquatic and terrestrial organisms are what makes agricultural production possible. Increasing agrobiodiversity is key for the transition towards a more sustainable food system that is supporting ecosystem services and preserving natural resources.	2 15
	Soil Health	Soil supports agricultural production and ecosystem function. Maintaining healthy soils is are key component of agricultural sustainability. They further describe that it is important for agricultural productivity as well as for environmental resilience.	2 15

The core criteria are measured with different metrics and previously known methods selected by FAO (2019) and provided in TAPE guidelines by FAO (2019). The data were acquired partly through the interview with the farmer, a survey with the farmer's partner (appendix 2 and 3), a transect walk, and an on-field soil assessment together with two researchers from the Norwegian Center for Organic Farming, who are both specialized in soil science. The "traffic light approach" was used to determine the level of sustainability by using specific thresholds for each indicator (Table 2). This approach allows the identification of desirable (green), acceptable (yellow), and unsustainable/critical (red) conditions of sustainability for each of the criteria. Table 2 describes the data collection and evaluation of each criterion and the thresholds used to determine level of sustainability by the traffic light approach.

Table 2. **TAPE Step 2: Data collection, evaluation, and determination of "traffic light thresholds",** the method used for data collection/calculation and the thresholds for application of the traffic light approach (used in Step 2), for each indicator.

Criteria	Data collection and evaluation	Traffic light thresholds
Secure land tenure	Data was collected through the interview with the farmer. According to the TAPE-guidelines, information about "the existence of legal recognition of access to land", "existence of formal document and presence of name on it", "perception of security of access to land" and "existence of the right to sell, bequeath, and inherit land, always disaggregated by gender" was collected.	Green (desirable): 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 Yellow (acceptable): 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 Red (unsustainable): No document possessed AND perception of insecure access to land AND/OR no right to sell/bequeath/inherit the land.
Productivity	The data needed for this calculation was collected during the interview with the farmer. According to the TAPE guidelines, productivity metrics need to go beyond the mere calculation of yield/ha and allow for an aggregation of the various agricultural production. Therefore, the productivity was calculated as the total farm output/ha. The farm output corresponds to the volume of agricultural output at the farm level taking into account the production of multiple outputs, e.g. crop and livestock, aggregated in terms of monetary value, NOK.	Green (desirable): Productivity value per ha is ≥ 2/3 of the national average value of production per hectare/ year Yellow (acceptable): Productivity value per ha is ≥ 1/3 and < 2/3 of the national average value of production per hectare/year Red (unsustainable): Productivity value per ha is < 1/3 of the national average value of production per hectare/ year
Income	This farm-data needed for this indicator was collected through the interview with the farmer. Income from all productive activities was included. The income was calculated as: Gross product (value of agricultural production +subsidies) - Cost of inputs and taxes - Cost of hired labor - Loans, interest, and cost of renting land - Depreciation of machinery and equipment	Green (desirable): Family net income/family worker > Median income in similar agroecosystem (e.g. from farm monitoring systems) Yellow (acceptable): Family net income/family worker > national poverty line (as defined by the World Bank) AND < Median income in similar agroecosystem (e.g. from farm monitoring systems) Red (unsustainable): Family net income/family worker < national poverty line (as defined by the World Bank

Added Value	The farm-data needed for this indicator was collected during the interview with the farmer and calculated as: Family net income - Subsidies and income from rented land + Cost of hired labor + Loans interests and cost of renting land	Green (desirable): The result is > 1.2 x national agricultural GDP per agricultural worker (FAOSTAT) Yellow (acceptable): The result is < 1.2 x national agricultural GDP per agricultural worker (FAOSTAT) AND > 0.8 x national agricultural GDP per agricultural worker (FAOSTAT) Red (unsustainable): The result is < 0.8 x national agricultural GDP per agricultural worker (FAOSTAT)
Exposure to pesticides	Data was collected during the interview with the farmer.	Green (desirable): Chemical pesticides are not used AND/OR other integrated techniques for pest management are used Yellow (acceptable): Quantity of synthetic pesticides used > quantity of organic pesticides used AND producers do not use pesticides of class AND at least 4 of the listed mitigation techniques are used when applying the chemicals AND organic pesticides and/or other integrated techniques are also used Red (unsustainable): Producers use highly hazardous pesticides and/or illegal pesticides OR producers use pesticides of class II and/or III with less than 4 of the listed mitigation techniques OR producers use chemical pesticides of any class AND no organic pesticides and no other integrated techniques are used
Dietary Diversity	Data was collected through a survey (appendix 2) with the woman in the household.	Green (desirable): score ≥ 7 Yellow (acceptable): 5 ≥ score < 7 Red (unsustainable): score < 5
Women's Empowerment	This data was collected through a survey (appendix 2) with the woman in the household of the farm. The survey collects data by following a modified version of the "Women's Empowerment in Agriculture Index" (A-WEAI), with 6 indicators.	Green (desirable): A-WEAI ≥80% Yellow (acceptable): A-WEAI ≥60% and <60% Red (unsustainable): A-WEAI <60%
Youth Employment	Data were collected during the interview with the farmer. The nr. of youth (aged 15–24 years) in the household not in education, employment or training is compared to the number of young people working in agricultural activities, the number of youths in education, the number of those working outside the system and the number of those who have emigrated. The criterion is calculated as the non-weighted average of two indices (appendix 2).	Green (desirable): Score ≥70% Yellow (acceptable): Score ≥50% Red (unsustainable): Score <50%
Agricultural Biodiversity	Data for this index were collected through interview with the farmer and through observations of the landscape. The level of biodiversity was then calculated by the Gini-Simpson diversity index for crops and animals + the "natural vegetation trees and pollinators-index" (see appendix 2). The averages of the three were used to score the criterion.	Green (desirable): Average score is ≥70% Yellow (acceptable): Average score is ≥50% Red (unsustainable):<50%
Soil Health	The data collection for this soil health assessment were done in the field. The field was chosen by consulting the farmer about the most average one in terms of yield levels. The indicators used in this assessment were developed by (Nicholls et al., (2004) Each indicator is evaluated separately and assigned a value between 1 to 5 (see scheme in appendix 2).	Green (desirable): Average score is ≥3.5 Yellow (acceptable): Average score is ≥2.5 and Red (unsustainable): <2.5

	The average score is then calculated. Three spots were assessed at the field to get an average.	

3.2 Implementing TAPE Step 3 and evaluating the suitability of TAPE in the context of this project

TAPE Step 3: Participatory interpretation of results with stakeholders. This part of TAPE aim to be a participatory interpretation of the results together with the concerned producers and relevant stakeholders. In this project, this step was used to discuss the results from step 1 and 2, in light of the findings from step 0, as suggested by TAPE- guidelines. In this case, Step 3 was conducted through a focus group discussion including the farmer, two advisors and two researchers from the Norwegian Center of Organic Farming (NORSØK), who all possess expertise relevant for this case.

Evaluation of the TAPE: The aim of the focus group discussion was to discuss and evaluate TAPE and its suitability in the context of this project. The outline of the discussion is attached in Appendix 7. The procedure was recorded and transcribed. The data was then coded and finally grouped into these categories:

- Dimensions/indicators considered less important in a Norwegian context
- Feedback on the weighting and scoring for this case
- Generic critique of TAPE
- Suggestions for improvement of TAPE and its usefulness
- Comparisons with other sustainability assessment tools
- Critique connected to the supra-systems (the socio-economic and political environment in Norway)
- Underlying values and opinions

To ensure systematic evaluation of the suitability of TAPE in the context of this study, a part of the framework for comprehensive model evaluation with stakeholders, developed by Bellocchi et al., (2015), was applied. This framework includes the categories: Context, Credibility, Transparency, Uncertainty and Background. These five categories were the ground for the process of data analysis and are present throughout the discussion section of this paper.

4. Results and Discussion, Part 1: TAPE-Report

4.1 Outcome of TAPE Step 0: Description of farming system and contextualization of territory

4.1.2 Description of farming system

The farm assessed in this study is an organic dairy farm with 25 dairy cattle and 36 ha of productive land. Calves are also sold to meat production. The main product is milk for sale. The crop produced today is a mixed of legume-ley, used for pasture and silage on the farm. It is run by one farmer whose partner is working outside the system assessed. The present farmer has been working on the farm for more than thirty years, and the conversion from conventional to organic management started in 1987.

4.1.3 Country, District, Location

Norway, Møre og Romsdal**,** (62°30′00″N 07°10′00″E)

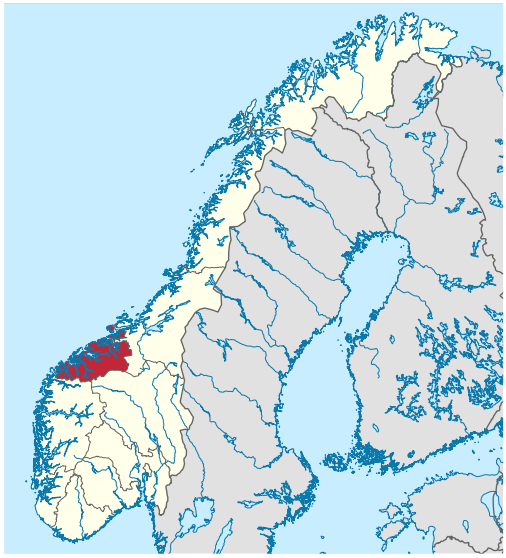

Figure 3. **Map of Norway, t**he county Møre og Romsdal is marked in red (Wikimedia Commons, 2020).

4.1.4 Demography

Møre og Romsdal is a county that has a land area of 13 840 km² and in total 265 840 inhabitants (SSB, 2021). Out of those, 74% are living in urban areas. 13 % of the inhabitants has another ethnicity than Norwegian. The median age of the inhabitants in the county is 40 years old and the dominating religion is Christianity, but more than half of the inhabitants in Norway do not consider themselves belonging to any religion (SSB, 2021).

4.1.5 Ecological Environment

The landscape in Møre og Romsdal is characterized by mountains, fjords and coastline. Of the county's area, 4 % is arable land and 31 % is forest (Stokkan & Thorsnæs, 2022). The early

precipitation varies between 1000-2000 mm, the average temperature in the winter is just below 0 °C during the coldest month and in the summer 14-15 °C during the warmest month (ibid.). The biggest concerns among producers in terms of climate-change and agriculture in this county is related to issues caused by an increased amount of the total annual precipitation and days with heavy rainfall (Zahl-Thanem et al., 2022). Predictions made in 2005 based on climate-modelling (scenario RCP 4.5 and RCP 8.5) showed that the annual precipitation is likely to increase with up to 11% (Hanssen-Bauer et al., 2017). For Møre og Romsdal, the number of days with heavy rainfall might increase by 45 % from year 2000 to 2060 (ibid.).

4.1.6 Social and productive environments

Even though only 4 % of the land in Møre og Romsdal is agricultural land, farming and fishery are important activities, which characterize the landscape, market and settlements (Zahl-Thanem et al., 2022). The conditions for farming in the county vary, in many places the agricultural landscape is dominated by small-scale livestock-farms. The average farm distributes between 10-25 ha of agricultural land (ibid). Forage-based livestock production is the most common farming-system in the county. Møre og Romsdal is the county in Norway which has the second highest number of cows in relation to the agricultural area, with 129 cattle per 100 ha (Stokkan & Thorsnæs, 2022). In 2020, there were 637 producers who operated with dairy cows, 316 with beef cattle, 1065 with sheep, and 231 focused on crop production (Ruud, 2022). Producers farming organically are a minority within all production systems in Møre og Romsdal. The biggest share of organic procedures is within vegetable production 17 % and the lowest within dairy production 2 % (Ruud, 2022). The relative share of organic producers to the total amount of producers has declined during the last ten years, from 5,5 % in 2010 to 4 % in 2020 (ibid.), which also reflects the trend on the country level. This indicates that policies on a national and regional level have not been favorable for organic farmers. Norway has the lowest share of organic agricultural relative to the total agricultural area in the country compared to the neighboring countries Sweden, Finland and Denmark (FiBL and IFOAM, 2021).

4.1.7 Market context

The market context in Møre og Romsdal is characterized by the national cooperatives TINE and Nortura. Most dairy producers in Norway deliver milk to TINE 2-3 times a week. TINE is the dominating Norwegian dairy cooperative owned by milk producers who supply milk to the company. The core business is the production and sale of milk, cheese and other dairy products in Norway and abroad. It is owned by 10 120 milk producers. Regarding meat and eggs, most farmers are operating through the cooperative Nortura. This is the biggest food supplier in Norway with 5 000 employees and is owned by about 17 100 owners. Other distribution channels and local markets exist but they are occasional, or not well established.

4.1.8 Governance (farm-, region- and national level)

The farm is certified organic, but the farmer is trying to achieve an operating plan that goes beyond the minimum requirements set by the regulations for organic production. Good animal welfare and animal health are important, and emphasis is placed on the animal's ability graze outfield. An important goal for the farmer is to reduce the proportion of concentrate as well as achieving the best possible economy without letting go of the ecological principles. It is essential to address that the farm has been connected to the Norwegian Center for Organic Agriculture (NORSØK) since its establishment in 1986. It became a demonstration unit for organic farming in Norway and tenants began the conversion to organic in the spring 1987 (Ebbesvik et al., 2014). At that time, there was little documentation of organic operations in Norway. A central question was to find out what it meant to farm organically in the area, with mountainous landscape and varying soil conditions. During the first ten years, diversity was a priority goal in the production system. Because of financial and workload related reasons, the farmer has gradually downgraded this goal and concentrated on milk production. The economic situation on Norwegian farms changed a lot with time and the farmer adapted the operations to the changed economic conditions (ibid). Norwegian agriculture underwent a structural rationalization due to the recognition by the governance for this to be a necessary strategy. This meant that the farmers had to make operations more efficient to maintain the profitability of the farm. The structural rationalization has led to an agricultural environment throughout the country characterized by larger and fewer farms, a trend that continues today. Three out of four farms were shut down between the years of 1959 and 2007 (SSB, 2011). Figure 4 shows the development of the number of farms in 1999 measured in relation to the level of farms in 1979, for each county in Norway.

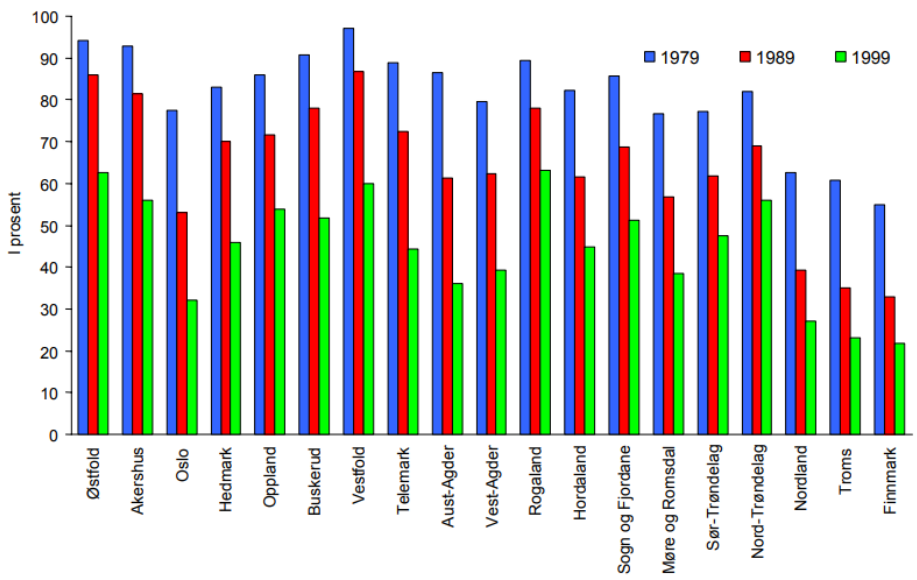

Figure 4. **The development of the number of farms in each county of Norway**, measured in relation to the level of farms in 1969 (Econ analyse, 2004, p.44.)

Another important feature within the Norwegian agricultural policy is to sustain agricultural activity in rural areas across the country. One strategy aiming to do so is the "kanaliseringspolitikk" (channelization policy). Channelling of production is about distributing the market for the various forms of production in a way that aims to achieve agriculture throughout the country, a high overall production, and a high degree of self-sufficiency on a national level (Johnsen & Smedshaug, 2016). This means that different forms of production are distributed in the areas of the country where they are suitable climatically and topographical (ibid.). For Norway, this means that the cereal production is canalized to the areas with favorable conditions for crop-production (mostly the south-eastern parts of Norway) and livestock farming is prioritized in less favorable areas (such as mountainous areas and northern areas).

The Organization for Economic Co-operation and Development (OECD) recognizes that relatively to most other countries worldwide, Norway provides high levels of support to agricultural producers. The national policy is characterized by limited reforms and high border protection; hence the Norwegian agricultural sector remains relatively isolated from international markets. According to OECD (2021), the share of support that is targeted to environmental objectives within the Norwegian agricultural policy is low, even though climate-change ranks high in the current policy debate. However, OECD (2021) also states that it will be difficult to reduce greenhouse gas emissions without significant policy reform.

The current regional agricultural policy in Møre og Romsdal indicates that measures are being taken regarding sustainability. The latest annual report from the county administrative board (Statsforvalteren i Møre Og Romsdal, 2021) indicates that resources have mostly been focused on extension services linked aiming to reduce farm-derived greenhouse gases, research projects connected to greenhouse gases from agriculture, and soil mapping. Agricultural producers can also apply for subsidies connected to several environmental and natural resource management objectives such as improved drainage, harvest of steep areas, care of protected cultural heritage and grass-covered edge zones etcetera (ibid).

4.2 Outcome of TAPE Step 1: Characterization of Agroecological Transition

The average score of the characterization of agroecological transition of the farm assessed was 61%. Figure 5 shows the results for each of the 10 elements of Agroecology. The elements "responsible governance", "efficiency" and "synergies" were the ones that received the highest scores. The lowest scores achieved was within "diversity", "recycling" and "circular and solidarity economy".

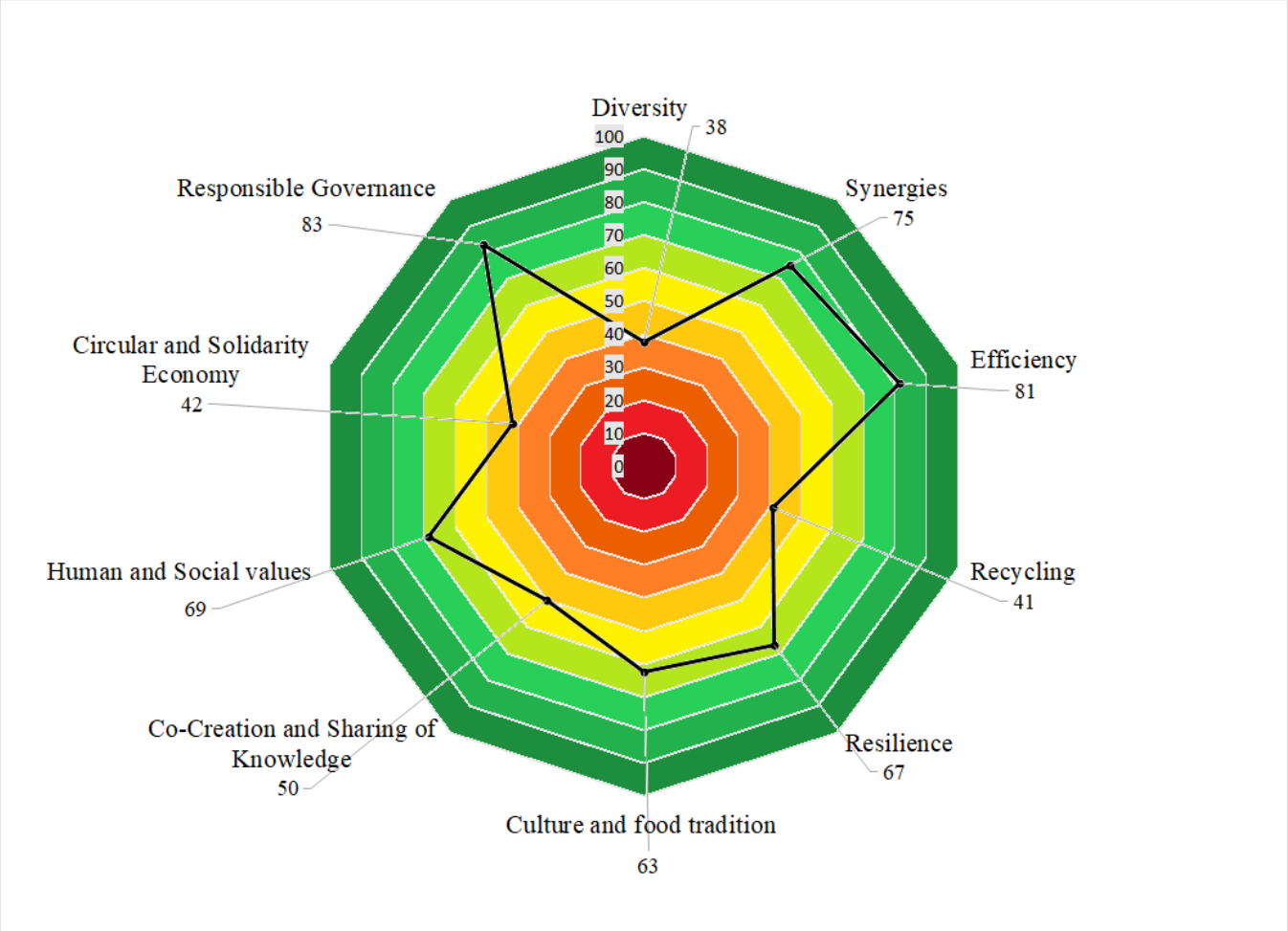

Figure 5. **Results from characterization of Agroecological Transition of the selected farm,** results for each of the "10 elements of Agroecology" (%).

Table 3 shows the indicators used to assess the "10 elements of Agroecology" and whether their scoring affected the results in a positive, neutral, or negative way. The indicator "Water saving" in the dimension "Recycling" was not included, as a result of the focus group discussion, further explained in section 5.1. The indicator "local or traditional identity and awareness" was not assessed due to difficulties gaining valid data.

Table 3. **The indicators with belonging pre-set statements and their effect on the scoring for this case-farm** and a description of whether the indicator is affecting the score in a positive, negative, or neutral manner.

Dimension	Positive (↑)	Neutral (↕)	Negative (↓)
Diversity	↑ **Trees:** Significant number of trees (and/or other perennials) of different species	↕ **Diversity of activities products and services:** More than three productive activities are carried out	↓ **Animals:** Only one species is raised and kept.
			↓ **Crops:** One crop covering more than 80% of cultivated area
Synergies	↑ **Soil-plants system management:** All the soil is covered with residues or cover crops. Rotational grazing is systematic. Soil disturbance is little.	↕ Integration **with trees:** Medium integration: significant number of trees provide at least one product or service.	
	↑ **Connectivity between element of the agroecosystem and the landscape:** High connectivity- the agroecosystem presents a mosaic and diversified landscape, many elements can be found between each plot of cropland or pasture	↕ **Crop-livestock-aquaculture integration:** Medium integration- animals are mostly fed with feed produced on the farm and grazing, their manure is used as fertilizer.	
Efficiency	↑ **Management of soil fertility:** No synthetic fertilizers are used, soil fertility is managed only through a variety of organic practices.		↓ **Use of external inputs:** The majority of the inputs is purchased from the market.
	↑ **Management of pests and diseases:** No chemical pesticides and are used. Pests and diseases are managed through a variety of biological substances and prevention measures.		
	↑ **Productivity and household's needs:** Production covers household's needs for food and surplus generates cash to buy essential and to have sporadic savings.		
Recycling*	↑ **Recycling of biomass and nutrients:** Most of the residues and by-products are recycled. Only a little waste is discharged is discharged or burnt.		↓ **Management of seeds and breeds:** More than 80 % of seeds/animal genetic resources are purchased from the market
			↓ **Renewable energy and production:** The majority of the energy is purchased from the market. A small amount is self-produced (animal traction, wind, turbine, hydraulic, biogas, wood…).
Resilience	↑ **Stability of income/production and capacity to recover from perturbations:** Income and production are stable and increasing over time. They fully and quickly recover after shocks/perturbations.	↕ **Diversity:** This index is the average score (2,75) for the element of Diversity.	↓ **Environmental resilience and capacity to adapt to climate change:** Local environment suffers from climatic shocks and the system has little capacity to adapt to climate change.
	↑ **Mechanisms to reduce vulnerability:** Community is very supportive for both men and women. Access to credit is available but insurance covers only specific products/risks.		
Culture and food tradition**	↑ **Appropriate diet and nutrition awareness:** Food is sufficient and diverse. Good nutritional practices are known but not always enforced.	↕ **Use of local varieties/breeds and traditional (peasant & indigenous) knowledge 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.	

Co-creation and sharing of knowledge	↑ **Platforms for the horizontal creation and transfer of knowledge and good practices:** 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.	↕ **Access to agroecological knowledge and interest of producers in agroecology:** 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.	↓ **Participation of producers in networks and grassroot organizations:** Producers have sporadic relations with their local community and rarely participate in meetings and grass-root organizations.
Human and Social values	↑ **Women's empowerment**: Women are completely empowered in terms of decision making and access to resources. Women organisations exist, are functional and operational.		↓ **Youth empowerment and emigration:** Most young people think that agriculture is too hard and many wish to emigrate from the local community
	↑ **Labour (productive conditions, social inequalities):** 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.		
	↑ **Animal welfare:** Animals do not suffer from hunger, thirst or diseases but can experience stress, especially at slaughter.		
Circular and Solidarity Economy	↑ **Networks of producers, relationship with consumers and presence of intermediaries:** Networks exist and are operational, including women. Direct relationship with consumers exists.		↓ **Products and services marketed locally:** Local markets exist but hardly any of the products/services are marketed locally.
			↓ **Local food system:** 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.
Responsible Governance	↑ **Producers' organizations and associations:** More than one organization exists. They provide market access and other services, with equal access to men and women.	↕ **Producers empowerment:** Producers' rights are recognized and respected for both men and women. They have small bargaining power but are not stimulated to improve their livelihoods.	
	↑ **Participation of producers in governance of land and natural resources:** 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.		

*The indicator "water saving" was not assessed due to its perceived irrelevance in the context of the assessed farm, described in 4.5.1. **The indicator "Local or traditional (peasant / indigenous) identity and awareness" was not assessed, due to a lack of data.

4.3 Outcome of TAPE Step 2: Core criteria of performance

Table 4 shows the results of the core criteria of performance linked to the main dimensions identified by FAO (2019) to be relevant for achieving the SDGs.

Table 4. **Results from the TAPE-assessment step 2**. Green = desirable, Yellow = Acceptable, Red = Unsustainable.

Step 2: Core criteria of performance linked to the SDG's		
Main dimension	**Core criteria of performance**	**Results**
Governance	**Secure land tenure**	Has a formal document with the name of the holder on it, a perception of secure access to land and has at least one right to sell/bequeath/inherit any of the parcel of the holding
Economy	**Productivity**	Gross productivity value/ha is higher than the national average (51 900 kr/ha to 41 800 kr/ha, calculated with data from FAOSTAT, 2020)
	Income	Farm net income is higher than the median income in similar agroecosystems (according to NIBIO- Driftsgranskinger, 2020)
	Added value	Gross added value/family worker > 1.2 x national agricultural GDP per agricultural worker calculated with data from FAOSTAT and https://tradingeconomics.com/norway/gdp-from-agriculture
Health and nutrition	**Exposure to pesticides**	Pesticides are not used, only other integrated techniques for pest management
	Dietary Diversity	Minimum dietary diversity for women: Score 8/10.
Society and Culture	**Womens Empowerment**	Score 88,75 %.
	Youth Employment	Young people do not want to continue in the agricultural activity of their parents, but are currently enrolled in education and working in another system
Environment	**Agricultural biodiversity**	Gini-simpson diversity index + "natural vegetation, trees and pollinators index" score 42,3 %
	Soil Health	Average score of 4,4, All 10 indicators according to the guidelines assessed.

As shown in Table 4, the first criterion **"Secure land tenure"** shows that the farmer has a formal document with the name of the holder on it, a perception of secure access to land, and has at least one right to sell/bequeath/inherit any of the parcels of the holding. This makes the farm reach above the threshold for the green level of this criterion.

For the second criterion **"Productivity"**, the gross productivity value/ha is 51 900 NOK/ha which is greater than the national average value of production per hectare/ year 41 800 NOK/ha. This is as well above the threshold for green. The average gross value/ha for Norway could not be found in any

national data-base but was calculated by summing all values for gross production for all agricultural products in Norway divided by the total agricultural area (arable land + land under permanent crops + land under permanent meadows and pastures). These data were derived from FAOSTAT (2020).

The result for **"Income"** also exceeds the threshold for the green level because the farm net income is higher than the median income in similar agroecosystems (according to NIBIO- Driftsgranskinger, 2020)

For **"Added Value"** the data for gross added value for agroecosystems in Norway could not be obtained, and the second option for determination against traffic light thresholds had to be chosen (Table 2). This resulted in 138 500 NOK added value/worker, which was more than 1.2 x bigger than the national agricultural GDP per agricultural worker, which is 97 385 NOK, meaning that the green level was exceeded.

Regarding the criteria **"Exposure to pesticides"**, the green level was achieved, since the farm adapts an integrated pest management, and no chemical or organic pesticides are used.

For **"Dietary Diversity"** the total score from the scheme (Appendix 2) filled in by the farmer's partner was 8. This result is above the threshold for the green level.

For **"Women's Empowerment"**, the score for the scheme (Appendix 2) filled in by the farmer's partner in the household was 89 %. This result is above the threshold for the green level.

The criteria **"Youth Employment Opportunities"** only reached up to the yellow level, this was because none of the young people in this household is working on the farm, however, they are all enrolled in education or employed outside the system, preventing the result to drop down to the red level.

The criteria **"Agricultural Biodiversity"** was the only core criterion ending up on the red (unsustainable) level. The farm only has cows, of the same breed, and one type of crop (ley for pasture and silage). The scores for the Gini-Simpson index for animals and for crop, were both 0 %. The score for the "natural vegetation, trees and pollinators"-index was 55,3%. The average of the three indices was then 18,4 %.

The **"Soil Health"-** criteria scored 4.4 out of the maximum possible score 5, reaching the threshold for the green level by great margin (3.5).

4.4 Outcome of TAPE Step 3: Participatory interpretation of results with stakeholders

As seen in the results section for Step 1 and 2, the lowest score received was for the element "Diversity" (Step 1) and the core criteria "Agricultural biodiversity" (Step 2). The dimension for "Efficiency" (Step 1) and the three core criteria for "Economy" all scored above the threshold for the green level, by a large margin. The element "Diversity" (Step 1) is measured with the indices: Crops, Animals, Trees and Diversity of activities, products, and services. The core-criteria "Agricultural biodiversity" is measured by a combination of species, breeds and varieties of both animals and plants in addition to the presence of pollinators and natural vegetation. When the results were reviewed during the participatory interpretation with stakeholders (described in section 3.2), the group was first surprised. However, after a short moment of reflection, they agreed that the low score on the factors linked to diversity and the high scores linked to the economic factors are a consequence of the findings in the contextualization of the farm (step 0) dealing with the Norwegian agricultural policy. Some of the comments they gave regarding the matter were:

Farmer: *It becomes clear that the larger units you operate, the more difficult it becomes to meet the requirements in TAPE. You would probably receive higher scores if the agriculture was like it was here in the 50's.*

Advisor B: *It is not strange that the farm is receiving very low scores for "agricultural biodiversity". That's how it is if you are a dairy farmer in Norway today. It is a consequence of the agricultural policy.*

Advisor A: *Yes, I think it is a problem on a systems level, and it would be very difficult for the farmer to improve this score.*

Advisor B: *And in general, the agricultural development is pretty much going against everything in TAPE…*

Farmer: *Yes, and what will it take to achieve higher scores in TAPE? It's not small adjustments. There are major changes that need to be implemented.*

As described in 4.1, one focus of this farm about thirty years ago was to have a diversified production system, however, socioeconomic changes pushed the production in another direction. The farmer gradually shifted towards specialization, resulting in dairy production exclusively (including forage production for self-sufficiency and sale of live animals to the meat industry). Even though the farmer has been focused on maintaining a high level of animal well fare and reducing the environmental impact, a more diversified farming system was not perceived as a feasible option to reach a high

efficiency and good economy. This shift can be explained by two of the main strategies characterizing the agricultural policy in Norway, "structural rationalization" and "kanaliseringspolitikk" (channelization-policy), described in Step 0, section 4.1.7, and recognized by the stakeholders during the participatory interpretation of the results. As mentioned in the contextualization of the farm (Step 0), these strategies have resulted in fewer, bigger, more specialized, and less diversified farms.

Another factor defined in the contextualization (Step 0) that links to the low scores for "diversity" and "agricultural diversity" is the absence of direct marketing channels within the local community. This could potentially be an obstacle to maintaining a more diversified production system. As explained in 4.1.6, the distribution of most milk and meat in Norway is done by large national cooperatives (often via warehouses) with the supermarkets as the destination before reaching the customer. A study in Sweden by Björklund et al., (2009) showed that vegetable farms and livestock farms that were selling locally enhanced or maintained agricultural diversity. Selling locally increased the producer's motivation to sell different crops. This was partly a consequence of having more direct interaction with customers. In addition to this, the usage of more direct market channels also resulted in better income thanks to fewer middlemen. As displayed in Table 3, the dimension "circular and solidarity economy" only received 33% due to downgrading scores for the indicator "Products and services marketed locally" and "Local food system". This is because hardly any of the products or services are marketed locally and few goods and services are exchanged or sold between local producers. IPES FOOD (2016) identified the need to develop new market relationships that bypass "*conventional retail circuits"* as a key to diversifying agri-food systems. Thus, if more local markets and direct distribution channels were established within the local community, the possibilities for the farmer to sell locally and diversify the production again could potentially increase. This would result in higher scores for the dimensions "diversity" and "circular and solidarity economy" (Step 1) as well as the core indicator "agricultural diversity" (Step 2).

Since the low scores for the core criteria "agricultural diversity" were mainly identified as a result of the Norwegian agricultural policy, changes to make it possible for an organic dairy farm in Norway to score high on this factor are needed on the socioeconomic and political level (the supra-system). Therefore, suggested improvements on the farm level are to increase focus on measures that can have an impact on a supra-systems level, such as the farmer's participation in organizations and activities that can increase producer's influence, e.g., farmer's organizations, cooperative boards, and events connected to local and regional policymaking. Another relevant measure in the context of Norway is for the farmer to stay updated with information from the agricultural extension service on what kind of support is available that could enhance agricultural diversity.

On a supra-systems level, local, regional, and national policies need to put more emphasis on measures that can make it possible for farmers to re-diversify their farms. Such measures must favor diversified

farming systems rather than specialized ones, as well as promote initiatives aiming to establish local markets.

The recognition addressed earlier in this section by the farmer and advisors, that the scores of TAPE would be higher "*if the agriculture was like in the 50's"*, "*the development is pretty much going against everything in TAPE"* and "*there are major changes that need to be implemented"* is not surprising, since several multi-national organizations (e.g., IPES food, 2016) have recognized that agri-food systems need to undergo transformative and remarkable changes in order to become more sustainable. However, one of the findings by Mottet et al., (2020) needs to be considered in this matter. When piloting TAPE in several geographic regions and production systems they found that TAPE seem to be more directly applicable to small-scale family farming than to large scale commercial farming. This was also recognized during the implementation of TAPE in this study. An example of this, is the indicator "Crop-livestock-aquaculture integration" in the dimension "Synergies". One of the pre-set statements that the farm must live up to in order to receive a higher score, states that animals on the farm should provide traction (Appendix 1). This practice might enhance the synergies on the farm. However, if FAO has the intention that TAPE should "*support agroecological transitions in all forms of production…but requires some adaptation for assessing the large scale and corporate farming"* (Mottet et al., 2020., p.17) indicators that could be perceived as backward should be considered. From the experience of implementing TAPE, it is not perceived as misleading that the results indicate that major changes are required to achieve a more sustainable farming system. However, it might be detrimental to the motivation of the stakeholders if their impression is that time needs to be reversed in order to reach the desired state as visualized by TAPE. Therefore, the findings of the present research underline the importance of the implications linked to this issue stated by Mottet et al., (2020,) and mentioned above.

5. Result and discussion, Part 2: Evaluation of the suitability of using TAPE

The focus of this section is to evaluate and discuss TAPE as a tool rather than the state of the farm. During this project, many challenges on the implementation of TAPE in the Norwegian context were identified and therefor, much of the focus was allocated to evaluating the tool. Here, the biggest strengths and weakness of the tool are discussed. The findings in this section were obtained through the focus group discussion with stakeholders and the experience of implementing the tool.

5.1 Context dependent challenges of TAPE

5.1.1 Perceived relevancy of dimensions, core criteria, and indices in the context of this study

During the focus group discussion aiming to evaluate TAPE and its suitability in the context of Norway, the participants were asked to rank the elements on a scale with the statements "not important" and "very important" at each end of it. The participants were reminded specifically to consider the Norwegian context while doing this exercise.
Through this ranking, the core criteria "women's empowerment" and "dietary diversity" (from Step 2) in addition to the dimension "Culture and Food traditions" (from Step 1) were recognized as less important indicators in terms of assessing sustainability of farming and food system in Norway. The main arguments regarding this were that these three factors are not perceived as limiting to the sustainable development of Norwegian agriculture. The perception was also that relative to other countries, Norway does not have significant problems within these areas, and the focus should be on other areas where there is a greater concern. The indicators that ranked highest towards "very important" were Youth employment, Income, Soil Health, Resilience, Efficiency, Diversity and Recycling and Responsible Governance.

In addition to this, the group agreed that they would have liked to see more emphasis put on the extent of self-sufficiency of the food and farming system. They described this as one of the most important factors regarding the sustainability of the Norwegian agricultural system today. Self-sufficiency (on municipality, regional- and national levels) should be more clearly communicated and visualized in TAPE

Afterwards, the group brought up the topic of the opportunities of weighted indicators for context specificity. This topic came up when discussing the indicator ¨water saving¨ as mentioned in 4.2. This indicator belonging to the dimension "Recycling" was not assessed. If assessed according to the current guidelines of TAPE, the farm would receive zero points for this indicator, which would lower the score for "Recycling" remarkably. However, this result did not seem to be valid since saving water is not considered a necessary measure due to very high amounts of precipitation in Western Norway. The spontaneous reaction by the group was that water saving is not important in the context of the

farm assessed in this study. However, after some more consideration, it was recognized that the water-saving system could have been beneficial some years ago, when there was a dry summer in the area. Nonetheless, most of the growing seasons have lately been very wet and as mentioned in 4.1 (Step 0), climate predictions are showing that the precipitation will be increasing in Møre og Romsdal and that farmers are concerned with issues related to this. The TAPE guidelines suggest that a "*discussion on the possible weighting of indices within each element to emphasize critical aspects in the analysis to ensure contextualized relevance"* (FAO, 2019, p. 48) should be done. In the focus group discussion, it was questioned whether the criteria for "water saving" (Appendix 1) under the dimension "Recycling" could be weighted differently. However, this discussion failed to reach any agreement on new weighting for this indicator. These difficulties led to a relevant discussion concerning the suggested strategy by FAO (2019) to add different weights to specific indicators to make the tool more suitable for different contexts. It was discussed that such work is difficult and risks becoming vastly time-consuming. The weighting of indicators was also perceived by the group as a complicated task since even on a country level, there could be large differences in relevancy between nearby geographical areas:

Moderator: *But what about developing a specific weighing system for Norway? That would only be a one-time job?*

Advisor B: *Yes, but if you come to another place in Norway, then this with water saving is relevant. So, there are also big differences within Norway.*

Besides potential indicator weights, another concrete suggestion that came up during the group discussion was to have a function within the tool (and described in TAPE guidelines) that would make it possible to "skip" indicators that are not considered relevant for the system assessed. It was suggested that this would be a less time-consuming measure to implement, rather than developing different weighting for each index. Finally, that is how the issue with the non-relevance of the "water-saving" indicator was dealt with in this assessment. It made the scoring of the concerned dimension fairer in the context of this project and was a simple measure to implement that could possibly be applicable to other projects as well.

After discussing more generic challenges with indicators and their context relevancy, the group carried on discussing specific indicators of TAPE Step 1 more in depth. Additional indicators for sustainability in the context of the farm were also discussed.

Linked to the previous discussion about the indicator for "water saving", it was also suggested to develop an indicator for "drainage". The stakeholders agreed that this is an important measure to implement in the area where this farm is located. A system that allowed for a such indicator to be adapted when using TAPE in the areas where this is considered relevant, would be useful for other projects adopting TAPE. However, it was discussed that an indicator for "drainage" would not fit in

the dimension for recycling, where the indicator for "water-saving" is currently placed. However, it can be considered that artificial drainage prevents the loss of nutrients (Castellano et al., 2019), which can have an indirect effect on enhanced nutrient recycling.

The criteria for "Renewable energy and production" (Table 5), belonging to the dimension for "recycling", it is focused on the household's self-sufficiency for energy supply. It was discussed that if it is purchased from the market, it would be relevant to include more clearly in the statements of this indicator to what extent the purchased energy is renewable or not. It was also discussed that the statements for this indicator could be redesigned in a way that it would promote energy self-sufficiency on small community levels, and not solely self-sufficiency on-farm levels. An implication for this is presented in Table 5.

The indicator "Management of seeds and breeds", which belongs to the dimension "Recycling" (Step 1), was also discussed. It was noticed that many farmers and other stakeholders would not understand why they got low scores on "Recycling" as a consequence of following regulations and national advice regarding genetic resources. In Norway, management strategies linked to genetic recourses are generally associated with the prevention of diseases, pests, and weeds. Breeding of plants and animals by scientific institutions is seen as an important part of the work towards a more sustainable and resilient agricultural system. An example of this is from a document with guidelines developed for farmers and the Norwegian Agricultural Extension Service, about how to avoid the spread of dangerous plant pests: "*Use certified plant material throughout the growing season. Then you are sure that tubers, cuttings, seeds, or small plants are fresh when you are going to sow or plant*" (Skuterud-Vennatrø et al., 2020, p. 4). Linked to this, it was discussed that many farmers might not agree that cultivation of all your own seed and genetic resources would be the best practice to reach a sustainable development of Norwegian agriculture:

Advisor A: *But then you miss out on other things that can affect sustainability... For example, you must buy new seed potatoes every year to avoid diseases.*

Advisor B: *Yes, you must have a proper plan. So, for sowing seeds, it could be suitable to have perhaps 50% own cultivated and 50% purchased.*

The role of recycling genetic resources within the local community should still be emphasized in terms of farmers' empowerment, food sovereignty, and conservation of heritage cultivars and breeds. However, to gain a high score in the context of Norway, it was agreed that it does not make sense that a community should have to be completely self-sufficient in terms of genetic recourses. Some institutional support should be allowed.

Another shortcoming was identified regarding the indicator "Crops" which belongs to the dimension "Diversity" (Step 1). It was discussed that it could be designed differently to better reflect the nuances

of different cropping systems. Currently, it is focused on the number of crops, which clearly is relevant for diversity. However, the result of this is that a farmer who has an organic ley receives the same score as a farmer who has a conventional cereal field. An organic ley often contains several species and varieties and should therefore receive a higher score than a monoculture field. This was noticed during the group discussion:

Moderator: *If one should suggest an improvement for this indicator…Could there be more focus on different species, in addition to crops?*

Advisor B: *Yes, so that you get a higher score if having an organic ley compared to a conventional cereal field or a ley with only ryegrass, for example.*

As a result of this discussion, a few suggested adjustments to increase the suitability of TAPE in the context of Norway was developed. Table 5, 6, and 7 show these suggested adjustments of pre-set statements for scoring three of the indices discussed above.

Table 5. **Suggested adjustments to increase suitability of the indicator "Renewable energy and production"**, for the Norwegian context.

Original version (FAO, 2019)

	0	**1**	**2**	**3**	**4**
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.

Suggested improvement

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 **on farm or within the community.** Negligible use of fuel and other non-renewable sources.	All of the energy used is **renewable and the household or close community is 90% self-sufficient for energy supply, which is guaranteed at every time** Use of fossil fuel is negligible.

Table 6. **Suggestions of adjustments for better suitability of the indicator "Management of seeds and breeds"**, for the Norwegian context.

Original version (FAO, 2019)

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.

Suggested improvement

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.	**Less than 80% of seeds/animal genetic resources are purchased from the market. Some exchange with farmers in the local community is done.**	**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 neighboring farms.**	**The majority of seeds/animal genetic resources are self-produced or exchanged. Some specific genetic resources are purchased from the market.**

Table 7. **Suggestion for improvement of the indicator "Crops".**

Original version (FAO, 2019)

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

Suggested improvement

Crops	Monoculture (or no crops cultivated)	One crop covering more than 80% of cultivated area	Two or three crops **or ley with more than 1 species**	More than 3 crops adapted to local and changing climatic conditions/ **or more than 1 crop + ley with more than 1 species and several varieties**	More than 3 crops and varieties adapted to local conditions. Spatially diversified farm by multi-, poly- or inter-cropping / **or more than 2 crops + ley with more than 1 species and several varieties**

5.1.2 Context-related challenges regarding TAPE Step 2

Some of the suggested method for assessing and measuring the criteria of Step 2 were identified as not to be suitable in the context of this study. This matter is further explained below.

During the focus group discussion, the stakeholders agreed that "Soil health" is an important and very relevant core indicator in the context of Norway. However, during the preparation for the field assessment, it was found that the sheet for the soil health assessment adapted by TAPE (Appendix 2), is developed by Nicholls et al., (2004) to suit the context of vineyards in California. As mentioned in3.1, the process of conducting the soil health assessment was supervised by two soil scientists from the Norwegian Centre for Organic Agriculture. Since the climatic, biogeochemical, and biophysical conditions in Norway are remarkably different from California, the choice of using the method

developed by Nicholls et al., (2014) was questioned by the two soil scientists who supervise this process. The main points discussed during this field assessment were:

- Some of the indicators in this method will be highly dependent on soil type and texture. E.g., sandy soil will have aggregates that break easier than clay soil. The color is another indicator that will be dependent on soil type and texture. A lot of knowledge and experience in evaluating different soils are needed to retain a valid and reliable outcome.
- The indicator "Presence of invertebrates" will be dependent on the weather and time of the year. This has to be taken into consideration when scoring.
- The indicator "Water retention" must be adapted to fit in the context of a farm in West Norway. It was suggested that an indicator for "Water infiltration", with suitable characteristics could be developed and adapted.
- For the indicator "Compaction", it is described to use of a wire flag to determine the compactness of the soil. However, the characteristics (e.g., diameter, stiffness) of this wire flag are not described. This must be added if the data should be comparable.

Healthy soil can have different characteristics in different regions and cropping systems (Weil & Brady, 2017). In consideration to that, an implication for the TAPE guidelines is to explain that a local tool for soil health assessment should be applied, if accessible. If no local tool is available, one that is developed in similar conditions to the system assessed should be adapted.

Besides the limitations of the suggested methods to measure soil health in the context of Norway, other limitations were identified. The methods to measure levels of "Productivity", "Value added" and "Income" requires relative values to determine the threshold levels. The national averages for each of them, respectively, should be used (see Table 2). TAPE guidelines further suggest that such data can be withdrawn from the database belonging to FAO, namely FAOSTAT. However, at the time of compiling the results of Step 2, national averages for Norway could not be found for the units needed to determine the thresholds for the core criteria "Productivity" and "Added Value" (Table 2) but had to be calculated. The TAPE guidelines do not contain any detailed descriptions of how to calculate these national averages. If results should be comparable, the guidelines must be clearer regarding this.

5.1.3 The potential risk of focusing on irrelevant parameters

The points discussed above, underline a generic issue that was recognized during the group discussion; the risk to put light on irrelevant (in terms of development work) parameters in the outcome. This was recognized as a consequence of poor adaptation to the context:

Advisor A: We do not manage to create a tool that is correct for the whole world and can generate an answer with two underlines. But we must work towards a sustainable change and that can still be

easily done at farm level. But if we use such a standard model, we risk being affected by things we can't do anything about. And there might be other things that do not appear in the results that we can easily change, to improve sustainability.

The identified risk of ending up focusing on the wrong things, instead of the low-hanging fruit, might be inhibiting the development work on all levels. Such risk needs to be considered and carefully recognized.

5.2 The strengths of TAPE's participatory and stepwise approach

During the focus group discussion, it was evident that the farmer in this case study did not perceive the results of TAPE Step 0-2 useful for the development work on the farm. The group was also asked how they perceived the usefulness of TAPE for advisors, researchers, and policymakers and was in doubt when it came to the usefulness of the results solely. However, the usefulness of the potential learning process when adapting TAPE was discussed:

Researcher A: Actually, I think it has more in it for them that they read through what it takes to receive high scores in TAPE. Competent people have put a lot of time into developing it. Learning about the different dimensions and indicators behind this framework can in it-self be a fruitful process.

It was discussed that step 1 of TAPE could be a useful tool for creating transformative discussions among farmers and other stakeholders such as policymakers. An idea was to incorporate such activity in a workshop where several farmers could make a TAPE Step 1 assessment of each one's farm while discussing the indicators with each other in the light of the explanation of the "10 elements of Agroecology". It was expressed that this could generate a new way of thinking:

Researcher A*: It would have been interesting to have, for example, a gathering in every district where you have some organic farmers and some conventional farmers come together and try to conduct a TAPE for their farm. It is possible with TAPE, because you don't need so many prerequisites and you don't need to bring all the accounts and the entire nutritional balance with you, as with other farm assessments. This is more "come as you are". They could fill in such a form each for their farm while discussing and reviewing the results together. It could lead to many interesting discussions and possibly make them rethink things. Such activity seems easier to do with TAPE than with e.g., SMART.*

Advisor B: *Yes, and it is important to forward those results to decision-makers.*

Researcher A*: Or the decisionmaker could be a "fly on the wall" in such an activity.*

This insight corresponds to some of the findings by Halland (2022) who implemented sustainability assessments within stakeholders' discussions in workshops, in Arctic Norway. This was proven to be a valuable strategy and the outcome resulted in concrete improvements to enhance sustainability at

farms. In the same study, the participating farmers reported that they "*gained new insights into the content and complexities of the sustainability concept, further raising their consciousness regarding the efforts needed to increase the level of sustainability on their farms"* (p.61). This can be linked to Armson's (2011) idea that the starting point for response is good experiences. She describes that one example of such experience can be attentive and respectful conversations with *legitimate others* (people whose experience and understanding are as rich as one's own). Moreover, she means that such conversations, accompanied by alternative observations and interpretations, offer the potential to change people's minds. A similar finding was recognized by Bell and Morse (2008) who set up a framework for learning, development, and implementation of sustainability indicators and tested it in a project concerned with coastal zones in the Mediterranean. The result of this was not a perfect collection of sustainability indicators. Nevertheless, the very process of creating the indicators in a participatory manner with stakeholders informed the community about sustainability and identified context-related problems. In this sense, the very process of developing indicators was valuable, as it encouraged sustainable practices. This can also be linked to one of the findings by Mottet et al., (2020., p.18) who concluded that "*the application of TAPE itself can help support the co-creation and sharing of knowledge and spread agroecological practices at community level".*

Nevertheless, the group discussed that in order to achieve a fruitful discussion, the enumerator need to review what is behind the results. Without looking at the indicators and scoring behind the results, it became clear that looking solely at the outcome of TAPE step 0-2, was not considered useful, by the stakeholders:

Farmer :*...the first thing one wonders is what is behind it? What are these indicators and how are they scored?*

Researcher A: *Yes, we must see it to be able to discuss it.*

The realization that the results only were understood when discussed by reviewing the indicators with their statements and scoring is both positive and negative. If the results are not reviewed through a participatory process together with stakeholders, including a discussion about the scoring and weighting of indicators, the usefulness as well as the validity of TAPE decreases. This can be considered a risk since the process of including many stakeholders might be time and resource-demanding and risks to be disclosed in projects with limited resources. However, the simple design with the statements and scoring system of TAPE Step 1 makes the process of applying a participatory interpretation of the result possible and can be considered a good opportunity for fruitful discussion, as discovered during the participatory interpretation with stakeholders, in section 4.4. A reflection from the experience of implementing TAPE, is that these findings would certainly not have been clear without the contextualization of the farm by Step 0. Neither it is likely that they would have been as thoroughly discussed without the participatory interpretation of the results with stakeholders, during

Step 3. It becomes clear that Step 0 and 3 makes the suitability of TAPE increase. As described in 1.3, the importance of applying a holistic approach when studying agroecosystems has repeatedly been recognized by researchers. Armson (2011) describes that "*holistic thinking attends to the entity in its context and in relationship with other entities".* This underlines the importance of TAPE's adoption of the stepwise approach, where step 0 contextualizes the assessed object. It is therefore crucial to advocate for all four steps of TAPE to be carried out and fulfilled in projects.

It should be mentioned that the stepwise approach requires some skills of the enumerator. The experience of implementing TAPE revealed that the method for assessment of Step 2 was more complicated than Step 1. This also made the participatory interpretation of the results from this step more difficult. Due to time limitations, the results of Step 2 did not receive as much attention as the results from Step 1 during the participatory interpretation with stakeholders (Step 3) in this project. However, the criteria that received the lowest scores was discussed in the light of the findings from Step 0, an approach that seemed helpful to recognize the situation of the socioeconomic and political system and its impact on the farm, as discussed in section 7. Prioritizing what to discuss during step 3 was perceived to be a challenging task. To retain the transparency of TAPE it is required that the moderator of the activity is presenting the results in a clear and structured way. This is challenging considering that the TAPE do not provide a guide on how to conduct the participatory interpretation of the results (Step 3). A suggestion to improve this step, is to collect experiences from several conductors of Step 3 and from their experiences create more specific guidelines on how to carry out Step 3 of TAPE. This would be helpful in order to prioritize and gain the most valuable input from stakeholders during this process.

5.3 Purpose dependent strengths and weaknesses of TAPE

During the focus group discussion, it was recognized that in comparison to other MCAs used for assessing farming and food systems, e.g., SMART and RISE (mentioned in 1.6), TAPE is less knowledge-intense and has fewer indicators. One of the founding principles of TAPE was to *"minimize the cost of data collection, especially the burden on producers in providing data"* (FAO, 2019, p.8). However, some drawbacks of this simplification were discussed. For example, in some of the statements, several factors are put together to score one indicator, "Management of seeds and breeds" under the dimension of Recycling (Appendix 1) where genetic resources of plants and animals have been fused in the statements of one indicator:

Reseracher A*: Yes, but then one must ask how you can equate raising calves and growing seeds? It is very difficult.*

A suggestion for improvement regarding the identified problem with fused indicators in the statements, as for the example above, would naturally be to separate them and create several

indicators. However, if this is to be applied in numerous indicators, TAPE might lose some of its simplicity. This presents a trade-off that needs to be carefully considered.

Another trade-off linked to the relatively simplicity of TAPE was encountered when implementing TAPE. As seen in 4.3, and explained in Table 2, the core criteria "Agricultural biodiversity" is scored by calculating the average of three indices, in this case the score for two of the indices were 0, since the farm only has one species of animals (cows) and one type of crop (ley for pasture and silage). The score for the third index called "natural vegetation, trees and pollinators" was 55.3%. This resulted in the average of 18,4 %, which is the final number used to determine the state of this core criteria. However, it must be questioned whether an average number deriving from the results 55.3, 0, and 0 can be considered valid. The score 18,4% in "agricultural biodiversity" does not represent the diversity in either animal and crops nor natural vegetation, trees and pollinators in the assessed farming system. One can question what the number 18,4% really represents in this case? This dilemma can be linked to the generic challenge regarding sustainability indicators identified by Bell and Morse (1999., p.22) who explains that *"simplifying systems complexity into single values that allow easy comparison has a definite appeal…but the risk of implementing such approach is an inevitable loss of information as we create a simple index out of complex data."*

Another challenge linked to the simplicity of TAPE was discovered during the focus group discussion. Several times, confusion related to definitions within the titles of dimensions, indicators, and concepts within the statements was experienced. One of many examples of this concerned the word "local" which is present in several statements e.g., "local community" and "local markets".

Advisor A: *What is the definition of local?*

Researcher A*: It is very important if you are going to try and compare different systems and countries, that there are clear definitions for such things.*

Since one of the aims of TAPE is to create globally harmonized data (FAO, 2019), it is highly crucial to reduce the potential uncertainties linked to different perceived definitions of words, concepts, and statements. This could be done by collecting information from people who have gained experience with conducting TAPE and consulting them regarding where the guidelines need to improve explanations and clarify definitions. Improved guidelines linked to this could potentially reduce misunderstandings.

From the experience of implementing TAPE, it was recognized that, as well as the simplicity of the tool, can result in shortcomings, it can also be beneficial. In terms of transparency, a less comprehensive tool is preferable as it allows for a participatory review of the scoring of each indicator together with the farmers or other stakeholders. Participatory reviews of the outcome from more

comprehensive tools e.g., RISE and SMART, are likely to be time and resource-demanding, and risk being de-prioritized or omitted. Von Eschenbach, (2021., p.14) found that transparency of scientific models is "a necessary condition for trust". This underlines that the transparency of TAPE is essential in terms of stakeholder's willingness to implement it as well as value and believe in its outcome. Another factor linked to this is the open access to the TAPE guidelines. RISE and SMART, requires the completion of a training to become an auditor, and use the method. A result of this is that only a few people have access to the databases behind these tools, hence visualizing all the inputs and how they are affecting the outcome might be complicated. Auditing and understanding of models that are not opaque is challenging (von Eschenbach, 2021; and Adler et al., 2018). This indicates that the open access to TAPE and its guidelines, is an important factor to retain the transparency of the tool.

Despite that FAO has developed a comprehensive document with guidelines explaining how to use TAPE, the impression of conducting TAPE was that there is a lot of space for interpretation. This means different TAPE assessments on the same production system will likely differ depending on the conductor. This means that the simpleness and openness of TAPE, which was identified as positive in terms of transparency, can as well be a weak point in terms of uncertainties. The material that is given to conduct Step 1 in TAPE is the indicators of each dimension and the statements for scoring (Appendix 1). It is up to the conductor to design an interview guide aiming to gain all the information needed to score the indicators. One aim of FAO (2019) is to create multinational, harmonized data through the outcome of TAPE around the world. It can be questioned how such data can be comparable when much space is left for interpretation on how to conduct the assessment. The participatory interpretation of results (Step 3) when scoring, weighting and determining thresholds for the traffic-light approach can be an important contributor to reduce uncertainties of the outcome. However, it might not be enough. A suggestion to reduce the risk of having different outcomes between different conductors could be to offer more online courses aimed to learn how to conduct TAPE. Another suggestion is to be several conductors doing the assessment simultaneously of the same object followed by a discussion of the scoring. This could reduce the risk of having an outcome influenced by biases, assumptions, or uncertainties of the conductor. However, such a process would require a lot of resources and might not be considered a viable option for most projects. There is also a risk that being several conductors, does not solve the problem, since they might share the same biases.

In relation to the context-dependent challenges of TAPE, section 5.1, the "open interpretation" of how to use TAPE, can also be an opportunity. In terms of adapting the tool to a specific context, it needs to have quite an open character. This makes TAPE appealing in the sense that it could possibly be easier to modify in order to make it relevant to the context, in comparison to the more comprehensive tools. This links to a comment from one of the advisors:

Advisor A: *Measuring sustainability is demanding. Especially if we are going to have a global tool. There are big local differences, so what may be relevant indicators on this farm may be wrong just four miles from here. It would be better if you could go into each criterion and judge what is relevant in terms of sustainable production.*

The dilemmas described in this section, in addition to its shortcomings related to poor contextual adaptation (e.g., the irrelevance of the "water saving"- indicator), and the risk of focusing on irrelevant parameters (section 5.1.3), led to questioning the possibility of creating a global assessment tool for agri-food systems. In addition, considering that "agroecology" is an approach with no set of pre-defined practices, the ambition to develop a global assessment tool to create harmonized data on the "*performance of Agroecology*" (FAO, 2019), can seem close to impossible. In this matter, it is relevant to consider the finding by Ison (2008., p. 155), who describes that "*several authors and practitioners have recognized the usefulness of adopting the term methodologies rather than methods while working with complex systems"* (e.g., farms). *Methods* were further described by Ison described as "*a given, much like following a recipe in a recipe book, whereas a methodology can be adapted by a particular user in a participatory situation".* This corresponds to the description of "soft" and "hard"- systems methodologies and methods. The first aim to analyze and contribute to improvements of complex systems and messy situations and the later has a starting point in structured problems and is designed to generate data with absolute values (Armson, 2017; Checkland, 1999). From this point of view, the extent of the suitability of TAPE depends on whether it is used and interpreted as a hard method or a soft systems methodology. Several characteristics of TAPE described during the discussion of this thesis, have been identified as both positive and negative. Some examples of this are the "open interpretation" and "simplicity" of TAPE. These are positive if the tool is adopted as a soft systems methodology, but negative if used and interpreted as a hard systems method. In addition, the fact that TAPE is dealing with a complex issue, namely assessing farming and food systems, it would be suitable to consider it as a global soft systems methodology, with the flexibility to choose indicators accordingly to their relevance for the context. This can be a more appealing and feasible approach complying better with the key elements within agroecological approaches rather than a tool with pre-set indicators scored by standardized statements. However, one objective of FAO is to*"ensure that TAPE remains sufficiently harmonized to allow consolidation and comparison at the global scale"* (Mottet et al., 2020., p.18). Consequently, it must be evaluated to what extent the methods for retrieving and compiling data can be flexible, for the outcome to remain harmonized. The previously recognized potential for TAPE to be a promising discussion-tool, might decrease if it develops to become more rigid.

5.3 Summary of considerations relevant for the suitability of TAPE

The challenges, weaknesses and suggested improvements that were discussed in this thesis, is summarized in Table 8. They are presented for farm-level, supra-systems level (socioeconomic and political circumstances) and aspects linked to the characteristics of TAPE identified as relevant for its suitability. If TAPE should be further applied in a Norwegian context, the suggested improvement presented in Table 8 could be considered, as well as adding more piloting projects around Scandinavia.

Table 8. **Summary of the identified challenges on farm level, supra-systems level and for the suitability of TAPE, while used in the context of Norway**. These challenges are described in different parts of the discussion section of this thesis.

Identified challenges and weaknesses	**Implications and Suggested improvements**	**Described on page** (no.)
Farm Level		
Low scores for "Diversity and "Agricultural Diversity" on the assessed farm due to Norwegian agricultural policy's	Increase the farmer's participation in organizations and activities that can increase producer's influence, such as farmer's organizations, cooperative boards, and events connected to local and regional policymaking. The farmer can also stay updated with information from the agricultural extension services regarding available support that could enhance agricultural diversity on the farm.	29
Supra-Systems Level		
Low scores for "Diversity and "Agricultural Diversity" on the assessed farm due to Norwegian agricultural policy's	Local, regional, and national policies need to emphasize measures that make it possible for famers to re-diversify. Such measures must favor diverse farming systems rather than specialized, as well as promoting initiatives aiming to re-establish local markets.	30
Aspects of the suitability of TAPE		
Irrelevancy of the indicator "Water Saving" in the context of West Norway	Skip indicator when considered irrelevant, and make it possible to add an indicator for "drainage" when considered relevant	32
Weighting of indicators perceived as a time-consuming and resource demanding task	Add a function in the guidelines which explains that irrelevant indicators can be skipped.	33
Insufficient statements for the indicator "renewable energy and production"	Table 5	36
Less irrelevant statements regarding the indicator "management of seeds and breeds" in the context of Norway	Table 6	36
Improvement of the indicator "Crops" to put more emphasis species and varieties	Table 7	36

Outcome of Step 0-2 not considered useful without reviewing indicators and scoring behind it	Advocate for to always implement all four steps of TAPE in projects.	40
Trade-offs concerning the simplicity of TAPE	Test and carefully consider which indicators that needs to be split to several ones	40
Challenges with identifying the usefulness of TAPE	The usefulness of TAPE in learning processes was identified. E.g., it can be used as a tool in participatory workshops to generate fruitful discussions.	38
TAPE seems more adapted to family-farming than commercial farming	Better adaptation, through more pilot testing and evaluation, as suggested by (Mottet et al., 2020).	31
Uncertainties linked to the lack of definitions of crucial words and concepts	Improve definitions in the guidelines by consulting people who have experience with conducting TAPE. Discuss explanations and which definitions that need to be clarified.	41
The potential risk of focusing on irrelevant parameters	The outcome should be considered as a starting point for discussion, rather than an absolute tool that generates concrete answers about practices. TAPE could also be considered to use in combination with other assessment tools suitable for the purpose of assessment.	37
Context related challenges regarding the Soil Health assessment	The TAPE-guidelines should suggest that a local tool for soil health assessment should be applied. If not available, one developed in similar conditions to the system assessed should be adapted.	36
Challenges with reviewing Step 2 + High requirements for good moderating skills during Step 3	Collect experiences from several conductors of Step 3 and by the help of their experiences create more specific guidelines on how to carry out this part of TAPE.	40
Uncertainties linked to determination of "traffic-light thresholds" in Step 2	Develop guidelines for how to calculate reference data when it is not retrievable in FAOSTAT.	37
Risks linked to open interpretation of how to conduct TAPE	Have multiply conductors simultaneously performing the assessment of the same object. Follow this process with a discussion about the scoring, to increase consistency. Offer more online courses aimed to learn how to conduct TAPE-assessments.	42
Dealing with the demanding task of "*measuring the immesurable* (Bell and Morse, 1999)"	Consider TAPE as global soft systems methodology, which is flexible and can be conducted in a participatory manner, rather than a rigid tool aiming to provide absolute data.	43

The possibilities and strengths that were identified during this project and discussed in this thesis, is summarized in Table 9. They are presented for farm-level, supra-systems level (socioeconomic and political circumstances) and aspects linked to the characteristics of TAPE identified as relevant for its suitability.

Table 9. **Summary of the identified possibilities and strengths on farm level, supra-systems level and for the suitability of TAPE, while used in the context of Norway**, described in different parts of the discussion section of this thesis.

Identified Possibilities and Strengths	**Described on page** (nr)
Farm level	
"Efficiency" (Step 1) and the three core criteria for "Economy" all scored above the threshold for the green level, by a large margin.	24, 27
Supra-Systems level	
The current regional agricultural policy in Møre og Romsdal indicates that measures are being taken regarding sustainability.	22
Aspects of the suitability of TAPE	
It is a useful tool to link the cause of some characteristics of the production system to the circumstances of the supra-system (socioeconomic and political circumstances)	29-30
It can be a useful tool for creating transformative discussions among farmers, policymakers, and other stakeholders (e.g., in workshops)	38
Its stepwise approach enables holistic assessment in a participatory manner with stakeholders	38-40
It is a transparent tool with open access	41-42

6. Conclusion

The aim of this research was to implement TAPE on an organic dairy farm in Norway and evaluate its outcome and suitability for the context. The most remarkable findings for the assessed farm in this case study, was that it received low scores in the criterion of "Diversity", and "Agricultural diversity" and high scores for the criterion "Efficiency" and "Economy". These outcomes were identified to be a result of socioeconomic and political circumstances. The initial step of contextualizing the farm, shed light on the political strategies in Norway which have led farms towards specialization and streamlining. In the context of this research, these political strategies were identified as barriers for farming in compliance with agroecological approaches. This finding illustrated the power of policies to decrease or increase prerequisites for agri-food systems to operate in a more sustainable manner.

The stepwise approach of TAPE includes a contextualization, a characterization of the compliance with agroecological approaches, an evaluation of the sustainability performance, and a participatory interpretation of the results with stakeholders. In this research, the stepwise approach was recognized as a strength of the tool since it was a prerequisite for attaining some of the main findings. The last part of TAPE, which includes the perceptions and opinions of stakeholders, was considered especially useful, and increased the suitability of TAPE in the context of this study. It was further recognized that TAPE could be an appropriate tool to foster fruitful discussions with farmers, policymakers, and other stakeholders, in Norway.

Several challenges and shortcomings of using TAPE in a Norwegian context were identified throughout this project. The majority of them were a consequence of poor adaptability of indicators to the ecological, climatic and sociocultural context of Midwest Norway. This led to questioning whether a global assessment tool for agri-food systems can be suitable in different contexts. However, it was evident that some of the challenges and shortcomings only were considered relevant if TAPE is used as a "hard" systems tool, aiming to collect data to quantify the degree of sustainability performance. Consequently, TAPE was considered a suitable tool in a Norwegian context, if used as a soft systems methodology aimed at participatory learning processes about agroecology. If applied as such, TAPE can contribute to visualizing the desired, more sustainable state of the agri-food system in Norway and help identify what needs to overcome in order to achieve it.

7. References

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8. Appendices

8.1 Appendix 1 : Scheme's for TAPE Step 1

Indicators and scoring schemes for TAPE step 1, retrieved from supplementary material of Mottet et al (2020).

Step 1: Characterization of agroecological transitions

	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	Local environment suffers from climatic shocks and the system has little	Local environment can suffer from climatic shocks but the system has a good capacity to	Local environment can suffer from climatic shocks but the system has a strong capacity to	Local environment has a strong natural capital base, climatic shocks are rare and the system

		capacity to adapt to climate change	capacity to adapt to climate change	adapt to climate change	adapt to climate change	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	Producers have sporadic relations with their local community and rarely participate in meetings and	Producers have regular relations with their local community and sometimes participate in the events of their	Producers are well interconnected with their local community and often participate in the events of their grass-root	Producers (with equal participation of men and women) are highly interconnected and supportive and show a very high

		meetings and grass-root organisations.	grass-root organisations.	grass-root organisations but not as much for women.	organisations, including women.	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.

8.2 Appendix 2: Scheme's TAPE Step 2

The survey was retrieved from the supplementary material of Mottet et al., (2020).

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.)		

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					

Scheme for assessing the core criteria **"Youth employment opportunities"** (FAO, 2019). Indicators, weights and scores for the calculation of the criteria.

DOMAIN	INDICATORS	SCORE	WEIGHT
Employment / activity	% of young people working in the agricultural production of the system assessed	1	½
	% of young people in education or training	1	
	% of young people working outside but currently living in the system assessed	0.5	
	% of young people not in education, nor working in agricultural nor in other activities	0	
	% of young people who already left the community for lack of opportunities	0	
Emigration	% of young people who want to continue the agricultural activity of their parents	1	½
	% of young people who would emigrate, if they had the chance	0.5	
	% of young people who already left the community for lack of opportunities	0	

Scheme for assessing the“natural vegetation, trees and pollinators”-index

INDICATOR	ANSWER	SCORE
Beekeeping	No	0
	Yes, wild	0.5
	Yes, raised	1
Productive area covered by natural or diverse vegetation	Absent	0
	Small	0.25
	Medium	0.5
	Significant	0.75
	Abundant	1
Presence of pollinators and beneficial animals	Absent	0
	Little	0.33
	Significant	0.66
	Abundant	1

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	
	1	Dry soil, does not hold water	

Water retention (moisture level after irrigation or rain)	**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	

8.3 Appendix 3: Focus group discussion

Objectives with this meeting

- Verify the adequacy and performance of TAPE in a Norwegian context
- Revise and confirm the assessment of the farm by TAPE
- Discuss the current state of sustainability of the farm and possibility to improve it

Outline

1. **Presentation of TAPE** (including questions)

2. **Discussion about the method**

   - Consider the dimensions of step 1 and the indicators of step 2. Rank them on a scale from very important to less important, in the Norwegian context.
   - What are the benefits or constraints with this method, in a Norwegian context?

3. **Presentation of the results of the analysis of the farm**

4. **Participatory interpretation and discussion about the results (TAPE-step 3)**

   - Was this result as expected?
   - Do the results reflect your perception of the status of sustainability of the farm?

- In Step 1 - Could any indicator be weighted differently to fit better in a Norwegian context?
- Take the results as a starting point to discuss the way forward for the sustainability of this farm. Discuss for at least 15 minutes. Did you perceive the results useful for this purpose?
- Does the result contribute to existing processes of decision-making? How?
- How are these results useful for, farmer? advisor? researcher? policy-maker?

5. **Individual reflection**
6. **Participatory Summary**

- Identifying main themes and open for additional comments

8.4 Appendix 4: 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 management strategies? 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 selfgenerated/consumed energy.

- Waste recycling management

- Seeds and genetic resources: provenance (local/selfproduced/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, selfconsumed, 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: farmers' interpretation of this term, access to knowledge related to agroecology, what agroecology lacks to develop, other farmers' (in the community) interest and knowledge about agroecology

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.

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