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Sustainability Analysis of Sheep Farming in Norway Using the Sustainability Monitoring and Assessment RouTine (SMART)

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Abstract

Sheep production systems in Norway present complexity in the same way as other systems partaking in the climate challenges. Sustainability of these systems cannot be defined through single-impact indicators; hence a broader range of sustainability dimensions and trade-offs must be assessed. The present research uses the *Sustainability Assessment and Monitoring RouTine (SMART):* a multi-criteria sustainability assessment based on the *Sustainability Assessment of Food and Agriculture Systems (SAFA) Guidelines* which gathers data on the farms' performance through 327 indicators across 4 dimensions. Eight sheep farms in Norway were selected for assessment: four low-land coastal farms, and four inland mountain farms. Management practices which support sustainability were identified in all farms: high animal welfare, high number of days of access to pasture for the livestock, no/low use of synthetic chemicals, good water management, and high quality of life for farmers. Management practices which hinder sustainability and key areas for improvement were also identified: increased on-farm energy production, decreased use of externally sourced concentrate feed, and increased farmers' knowledge about externally sourced inputs. Some differences between the coastal and inland farms were also identified which were related to number of days of access to pasture for livestock, water consumption, participation for farmers in trainings and additional education, and political involvement. Using the SMART-Farm tool aided the process of identifying practices and systematically evaluating them through a global sustainability perspective.

Aggregated results from the SMART-Farm assessment indicated a high degree of goal achievement across dimensions. The farms scored on average above 80% on the Environmental Integrity and the Social Well-Being, and lower on the Economic Resilience and the Good Governance dimensions (76% & 71% respectively). To evaluate these results, a qualitative expert elicitation method was employed; this provided insight into shortcomings which were a result of the context-generic approach that the tool has and lack of inclusion of stakeholder participation in indicator selection and aggregation process. These shortcomings are important to consider when interpreting the results of numeral integration assessments which are used for decision-making. However, evaluating these scores was also a valuable outcome in itself since it uncovered knowledge gaps about the topic of sustainability of sheep farming in Norway.

Acknowledgments

In 2020, when most humanity was in a pandemic lockdown, I found myself throwing around clover seeds in a beautiful meadow in South-East of Norway where Gammelnorsk spæl sheep were going to graze in the summer. For that I thank Svein and Marit, who showed me how running a diversified farm is like and inspired me with their lifestyle.

Two years later, I moved to the West of Norway, to write this thesis on the sustainability of sheep farming in Norway. This would not have been possible without the help and support of some people who I would like to acknowledge and thank.

To the sheep farmers in West of Norway for welcoming us in their homes, gladly participating in the long interviews, and inspiring us with the lifestyle they embrace. To the three scientists who participated in the interviews and enriched this study with their insights and expertise.

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Preface

This thesis is a master thesis in the Agroecology program at NMBU, Ås. An influential scholar within the field of Agroecology, Gliessman (2015), included a chapter called *Indicators of Sustainability* under the section The Transition to Sustainability, in his book Agroecology: The Ecology of Sustainable Food Systems. In this chapter Gliessman explains that one of the main tasks of the science of agroecology is to build knowledge and expertise for identifying the sustainability of agroecosystems, and ways to improve them specifically to their bioregion and/or social context. In essence sustainability assessments and their contextualization are a core part of research within the field of Agroecology.

This master thesis research is also part of research project Amazing Grazing, conducted by The Norwegian Institute of Bioeconomy Research (NIBIO). Amazing Grazing has an objective to shed light on sheep grazing systems and examine how they can be part of sustainable food and fiber systems (NIBIO, 2022).

I presented this thesis and its preliminary results in the NJF Nordic Congress for Agricultural Sciences in Selfoss, Iceland. The same presentation was also given for my colleagues at NIBIO, my fellow colleagues from the first year of Agroecology program at NMBU, and for researchers at the Animal Science department at NMBU.

Abbreviations

FAO – United Nations' Food and Agriculture Organization

FiBL – The Research Institute for Organic Agriculture

GHG- Greenhouse Gases

IPCC- The Intergovernmental Panel on Climate Change

KSL- Quality System in Agriculture (Kvalitetssystem i landbruket)

MCA – Multiple Criteria Assessment

NIBIO - The Norwegian Institute of Bioeconomy Research (Norsk institutt for bioøkonomi)

NORSØK - The Norwegian Center for Organic Farming (Norsk senter for økologisk landbruk)

RSD- Relative Standard Deviation

SAFA- Sustainability Assessment of Food and Agricultural Systems

SMART- Sustainability Monitoring and Assessment RouTine

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1. Introduction

As our current food and agriculture systems are major drivers of pressures which threaten both humans and ecosystems, globally the sustainability of ruminant livestock production has been questioned. Reactive nitrogen, methane emissions, and use of croplands for production of feed, have been key reasons for questioning whether ruminants play a role in a sustainable food system all together (Cheng et al., 2022; Van Zanten et al., 2019). Certainly, greenhouse gas emissions and land use change are crucial environmental impacts to consider when climate mitigation strategies are urgently needed (IPCC, 2022). However, it must be acknowledged that ruminant production systems present complexity in the same way as other systems partaking in the climate challenges.

Studies show that under specific conditions, ruminant livestock production systems play an important role in sustainable agriculture and are vital for achieving many of the UNs Sustainable Development Goals (Oltjen & Beckett, 1996; Van Zanten et al., 2019; Varijakshapanicker et al., 2019). Ruminants serve a valuable function in converting resources from rangelands, pastures, and crop residues into high-quality protein and energy sources, hence increasing food security and reducing environmental impacts (Cheng et al., 2022; Oltjen & Beckett, 1996). At the same time, grazing of ruminants serves as a management strategy for preventing transitions to forests in mountains, maintain biodiversity and ecosystem services which are associated with open landscapes, and grasslands (Austrheim et al., 2016). Highly influential studies such as the EAT-Lancet Report (Willett et al., 2019), have suggested that there is a need to orientate agricultural priorities where food that nurtures human health and at the same time enhances biodiversity is a focus, and that ¨livestock production needs to be considered in specific contexts¨.

In the context of Norway, livestock production is responsible for 60% of GHG emitted from the agriculture sector (9% of total emissions), and ruminant production systems, specifically cattle and sheep, contribute to a total of 79 and 96% of the emissions of nitrous oxide (N2O), and methane (CH4) respectively (Harstad & Volden, 2009). Of the arable land area, 65% is grassland, used for ruminant feed. However, in Norway only 3% of the total land area is arable (map in Appendix 1), most of which is only suitable for grass cultivation. Through grazing, ruminants are able to utilize around 45% of the total land area (including unproductive land consisting of woodlands and mountains) (Rekdal, 2016). The use of these resources has been important for human survival through thousands of years, and it is still

prevalent and integrated in some present farming systems (Dýrmundsson, 2006; Ross et al., 2016).

Sheep production systems have traditionally developed in harmony with local climate conditions, altitude, and vegetation over centuries and today around 2 million sheep and lambs graze in the mountains in Norway every summer (Dýrmundsson, 2006; SSB, 2021b). The annual production cycle of sheep farming systems is distinctive to Norway and is tailored to use existing feed resources to the greatest extent (see Appendix 2). After grazing in cultivated grassland in the spring, sheep and their offspring are moved to woodlands or mountain areas where they graze during the summer. In autumn they are brought back to the farm, and the lambs are sent directly to slaughter or are finished on cultivated grassland.

Experimental evidence shows that sheep grazing sustains ecosystem functions and services long term and increases biomass production (Austrheim et al., 2016; Steinshamn et al., 2018). Grazing also maintains open landscape, grasslands and heathlands, areas which are a hotspot for biodiversity, play a key role in carbon sequestration, and contribute to albedo effect (Lind & Bryn, 2023; O'Mara, 2012). In some areas in Norway where there has been reduced grazing pressure, the encroachment of woodlands and scrub in grasslands and heathlands is seen as problematic (Ross et al., 2016).

Today in Norway trends towards larger and fewer farms have been evident in the whole farming sector, with a 50% reduction in the number of farm units in production in the last 20 years (Andgard et al., 2009; Wiborg & Bjørkhaug, 2011). This has also been the case for sheep farming (Appendix 3). In general, drivers for farmers to discontinue their activity include low income, aging farmer population, and remoteness/low population density (Terres et al., 2015). Although commonly there is less likelihood of exit for farms with higher profitability, factors influencing exit intentions specifically for Norwegian sheep farms are more social and community-based, and not always economical (Bragg & Dalton, 2004; Flaten, 2017).

It is evident that the sustainability of sheep farming systems in Norway cannot be interpreted through single impact categories (e.g., greenhouse gas emissions). The existing context-specific interlinkages between farming, ecology, and society in these systems need to be examined in order to learn about ‘sustainability’ which in its definition includes environmentally non-degrading, economically viable, and socially acceptable agricultural management strategies (FAO, 1994). In effort to contribute to this perspective, the present

study aims to investigate the sustainability of sheep farming in Norway using the Sustainability Assessment and Monitoring RouTine (SMART) Farm Tool.

SMART-Farm Tool is a Multiple Criteria Assessment (MCA) (Appendix 4) which adapts an environmental, social, economic, and governance thematic scope in its assessment. It operationalizes the Sustainability Assessment of Food and Agriculture Systems (SAFA) Guidelines by the Food and Agriculture Organization of the United Nations (FAO). The tool is globally applicable and context-generic, an approach which supports the identification of strengths and weaknesses of a farm or system from a global sustainability perspective (Gasso et al., 2015). In SMART-Farm, indicators based on the SAFA-Guidelines are aggregated using a weighted arithmetic mean (Curran et al., 2020). Tools which use weighting and mathematical methods to produce a ranking or a final score are categorized as vertical MCAs (Lindfors, 2021). In this study, the SMART-Farm tool was utilized in two ways. Indicators from SMART-Farm were used to reach the first objective: (1) to identify farm-level management practices which support or hinder the sustainability of sheep farming systems in a broader societal and environmental perspective. SMART-Farm was also employed as a vertical MCA for the second objective: (2) to assess the overall sustainability of sheep farming in Norway across four dimensions.

A growing body of literature points to the need for uncertainty management, certain degree of stakeholder participation, and inclusion of different perspectives when assessing sustainability through indicator-based tools (Bell & Morse, 2008; Gasso et al., 2015; Lindfors, 2021). In effort to address this, a third objective was: (3) to evaluate the overall outcomes of the SMART-Farm assessment in the context of Norway through a qualitative expert elicitation method.

2. Materials and Methods

A multiple-case study approach was used to investigate practices which support or hinder the sustainability of sheep farming in Norway. Cross-case conclusions were drawn with the goal of achieving broader generalizations based on the evidence, without going into great detail for any of the individual cases separately, as described in Yin (2009). The same cases were used to assess the overall sustainability of the sheep farms using SMART-Farm Tool as a vertical MCA. These results were used as a point of discussion for the qualitative expert elicitation method (Krueger et al., 2012), which allowed for the qualitative evaluation of the overall sustainability assessment outcomes.

2.1 Farm Cases

Eight sheep farms in North-West Norway were selected for the current study (Figure 1a,1b). The reason for selecting these farms was that they are located in two different agro-climatic zones. The farms on the west coast were located in a zone with higher rainfall (>2000mm per annum) and temperature (>5.5°C mean annual temperature) than the farms in central Norway inland (about 1300mm annual rainfall and 3.3°C mean annual temperature) (Borgen et al., 2012). However, large differences in precipitation exist even within these zones (See an example in Appendix 5). In addition, the farms already participated on the ongoing project, Survey of Account Statistics for Agriculture and Forestry (Norwegian FADN) conducted by Norwegian Institute of Bioeconomy Research (NIBIO, n.d.).

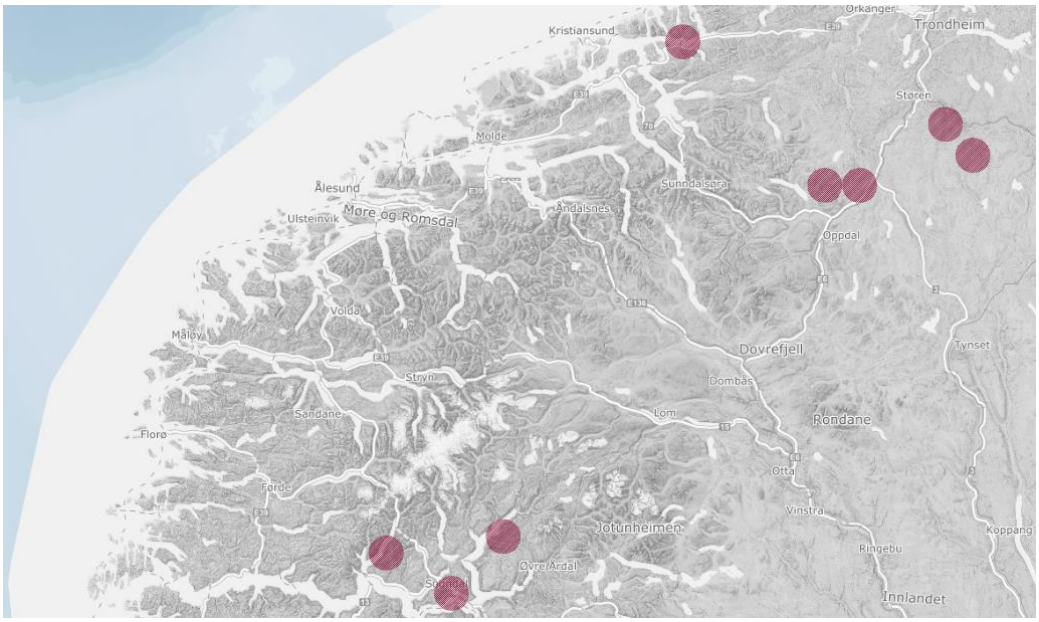

Figure 1a. Location of the selected farms in the map. Adapted from Norgeskart

Figure 1b. Location of the selected farms in the map. Adapted from Norgeskart

Table 1 provides an overview of the eight selected farms. It describes the farming environment, municipality, county, and the sheep breeds on the farms. More information about the different municipalities and sheep breeds present in the selected farms are in Appendix 6 & Appendix 7, respectively.

Table 1. Overview of the eight selected farms

Farm	**Description**
Farm_1	coastal farm in Sogndal municipality (213 active farms, and 12,097 inhabitants), in Vestland county. The main sheep breeds were Norwegian White Sheep (NKS) and some Blæset.
Farm_2	coastal farm in Sogndal municipality in Vestland county. The main sheep breed was NKS.
Farm_3	coastal farm in Heim municipality (157 active farms, and 5,884 inhabitants), in Trøndelag county. The sheep breeds were 80% NKS, and 20% Pelssau.
Farm_4	mountain farm in Oppdal municipality (458 active farms, and 6,814 inhabitants), in Trøndelag county. The sheep breed was NKS.
Farm_5	mountain farm in Rennebu municipality (304 active farms, and 2,556 inhabitants), in Trøndelag county. The sheep breeds were NKS and Old Spæl Sheep.

Farm_6	mountain farm in Oppdal municipality in Trøndelag county. The main breed was NKS and 15 % Spæl.
Farm_7	mountain farm in Rennebu municipality in Trøndelag county. The sheep breed was NKS.
Farm_8	coastal farm in Sogndal municipality in Vestland county. The main sheep breeds were NKS, and some Old Spæl Sheep and Steigar.

Table 2 provides an overview of characteristics of the selected farms. The farms varied in utilized agricultural area (15-54 ha), and number of animals (101-314 ewes).

Table 2. Characteristics of the selected farms

Farm no.	Utilized agricultural area (ha)	Breeding ewes (no. of animals)	Lambs per ewe (no. of animals)	Altitude (MSL)
1	16.3	101	1.6	30
2	37.4	217	1.6	200
3	33	114	1.4	30
4	14.9	110	1.5	600
5	54.1	286	1.7	600
6	44.6	249	2.1	600
7	29.2	314	1.5	600
8	21.6	137	1.8	50

2.2 Expert Elicitation Participants

Three experts were chosen to participate in the expert elicitation method, with the goal of obtaining expert opinion regarding results from the SMART-Farm assessment of the eight selected farms. The experts were chosen through purposive referral sampling, based on their expertise and relevance to the results from the sustainability assessment (Table 3). All three experts have taken education and training, made contributions through scientific research publications, and been working in the respective fields for many years. Moreover, they all have high levels of knowledge about sheep farming systems in Norway.

Table 3. Overview of participants in the Expert Elicitation

Expert	**Field of expertise**
Expert_1	Biodiversity and cultural landscape in Norway.
Expert_2	Grazing and feeding strategies for sheep in Norway. Greenhouse gas emissions from ruminants.

Expert_3	Social scientist/ expert in socio-economic sustainability of sheep farming in Norway.

2.4 Sustainability Monitoring and Assessment RouTine (SMART) Farm Tool

Sustainability Monitoring and Assessment RouTine (SMART) was used as a multi-criteria sustainability assessment tool. Out of 327 indicators of SMART-Farm, 302 were used to assess the sustainability of the eight selected sheep farms across four dimensions of sustainability as described in the SAFA-Guidelines: Social Well-Being, Economic Resilience, Environmental Integrity, and Good Governance. Within the four dimensions, there are 21 themes, and 58 sub-themes (Scialabba et al., 2013). In SMART-Farm, indicators are operationalized and aggregated into a ¨degree of goal achievement¨ (DGA) which is expressed in percentage (0% being no achievement and 100% being full achievement of the goal) (Curran et al., 2020). The DGA is also divided into five categories ranging from ¨Unacceptable¨ to ¨Best¨, with respective color codes as shown in Figure 2.

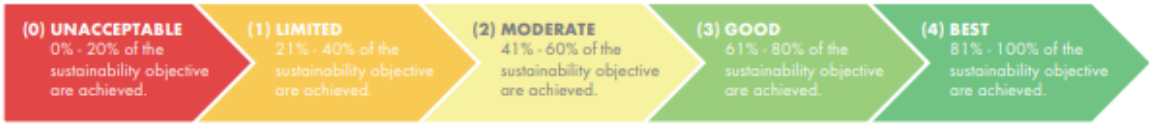

Figure 2. Scheme for the Assessment of the Sustainability Objective Achievement. Reprinted from FiBL (2016).

The DGA in SMART-Farm Tool is derived from the formula in Figure 3 (Schader et al., 2016).

$$DGA_{ix} = \sum_{n=1}^{N}(IM_{ni} \times IS_{nx}) / \sum_{n=1}^{N}(IM_{ni} \times ISmax_n) \forall \; i \; and \; x$$

Figure 3. SMART-Farm Degree of Goal Achievement Equation. Reprinted from Schader et al. (2016)

The degree of goal achievement (DGA) in a sub-theme (i) of a farm (x) is defined as the relation of the sum of impacts of the indicators (n=1 to N) which are relevant to a sub-theme i (IM_{ni}) (Schader et al., 2016). The most important part to highlight here is what this means; that the same indicators have different weights within the sub-themes at which they are relevant to. More information about the formula is in Appendix 8.

2.4.1 Structured Interviews for Data Collection with SMART-Farm Tool

To gather the data for the SMART-Farm assessment indicators, computer-assisted structured interviews using the SMART-Farm tool were conducted on each farm. Each of the interviews, including observational walks, took approximately three and a half hours to conduct. One interview was conducted online, and the remaining seven were conducted in person. Three of

the interviews were conducted by an agricultural advisor from Norwegian Center for Organic Agriculture (NORSØK) alone, and five other interviews were conducted by the same advisor together with me. The recording and categorization process was done during the interviews, using the offline version of the SMART-Farm Tool, V5.0, (SMART-Farm Tool; RRID: SCR_018197). Two interviewees were present in two of the interviews (in both cases it was the husband and wife) (more information in Appendix 9). The reference year was 2021.

The closed questions asked in the interview were dichotomous, rating scale, number, and percentage questions. All of the questions informed indicators which lay across pre-set themes and sub-themes. When conducting the interviews, SMART-Farm Tool facilitated the process of filtering questions which were irrelevant to the context. At the start of the questionnaire, a relevance check is conducted in regard to agricultural activities, inputs, region, and infrastructure. This mechanism enables the distinction of irrelevant questions in the context of the evaluated farming system, and removes them (e.g., questions about poultry production in a sheep farm). Additionally, the compliance check removes some questions from the questionnaire if the farm complies with a specific certification scheme (e.g., questions about pesticides in a certified organic farm). After the relevance and compliance check, the questionnaires for the eight selected sheep farms contained questions which answered the 302 indicators.

To lower the potential for intra-interviewer variability, the SMART-Farm tool questionnaire distinguishes two types of questions, questions for auditors (interviewers), and questions for farmers. Intra-interview variability refers to the inconsistency of the way in which the interviewer asks questions and records answers (Bryman, 2012). In the case of SMART-Farm Tool, the ¨auditor questions¨ describe what the auditor needs to know to answer the question. Since these questions often contain technical terms, which farmers might not always be familiar with, the program also displays an example of how the question can be asked in a clearer way. Additionally, the auditor is responsible for observing specific conditions on the farm to answer some of the questions (e.g., it can be assessed during the farm observation if the slurry stores are covered).

During the interviews, the auditor is in charge of evaluating the answer from the farmer and filling in the question in the questionnaire. Some of the questions are straight-forward (e.g., area of the farmland), and some of the questions have value judgement (e.g., have conflicts

been resolved in fair manners). The questionnaire was not available in Norwegian, and the questions were translated directly during the interview, with prior preparation.

To conduct the SMART-Farm interviews, the interviewer must be a trained and qualified auditor. This training process includes theoretical and practical training, which ensures standardization (Schader et al., 2016). The practical training is carried out through lessons on real farms and include final tests of the trainees that demonstrate a correct use of the tool (Schader et al., 2016). The agricultural advisor together with whom I conducted interviews for this study was a trained auditor at the time of when interviews were conducted. I took the SMART-Farm training later in the process of writing this thesis (See Appendix 10).

2.4 Expert Elicitation

Expert elicitation techniques are often used to quantify ranges for unknown parameters, when there is data-scarcity, or to develop qualitative issues related to assumptions, definitions, or conceptual models (Knol et al., 2010; Pashaei Kamali et al., 2017). The latter describes the purpose of expert elicitation in the present study and implies that expert elicitation here is not aggregated into the MCA, but rather used to contextualize and evaluate the results of a context-generic sustainability assessment. Here the expert elicitation is considered the qualitative part of explanatory design, the mixed method which this study adapts (Appendix 11). As such, for this method semi-structured interviews were conducted.

2.4.1 Semi-structured Expert Interviews

Each of the interviews with the experts lasted approximately an hour. These interviews took place after the analysis of the SMART-Farm results. The participants were sent brief information about the tool and the topic. These interviews were held and recorded in Teams and transcribed afterwards.

To *Expert_1*, questions about the DGA of the farms for sub-themes and indicators in the *Biodiversity* theme of SMART-Farm were asked. In the interview with *Expert_2*, questions concerning GHG mitigation practices, management, and DGA for indicators within the *Greenhouse Gases* theme of SMART-Farm were asked. Lastly, in the interview with *Expert_3*, questions regarding scores in the *Social Well-Being*, and *Economic Resilience* dimensions of the SMART-Farm assessment were asked. To all three experts, a question about the perceived importance of using such an approach for sustainability assessment was also asked.

2.5 Data Analysis

The data analysis process in this study was an adaption of the explanatory study design (Ivankova et al., 2006) (see Appendix 11). First, semi-quantitative data using SMART-Farm Tool was analyzed. This was done using the sustainability polygons (radar charts), detailed results page in SMART-Farm Tool, Excel data sets, descriptive statistics. A two-sample t-test was also conducted using Excel, to see if there are any differences in the scores within sub-themes between the two groups (coastal and inland farms). Because the DGA is expressed in respect to a sub-theme as described in Figure 3 in section 2.4, the result section of this study was organized in accordance with the themes and sub-themes of SMART-Farm.

After the analysis of the results from the assessment, there was a need for further clarification of the results, specifically about indicators of SMART-Farm in the context of Norway. For this, qualitative data obtained through expert interviews was collected and analyzed. The topics discussed in the interviews were pre-coded in accordance with SMART-Farm themes, and sub-themes. However, the interviews were coded again through an inductive process (Thomas, 2006) as new themes emerged while discussing the SMART-Farm indicators and assessment results. An example of this coding process can be found in Appendix 12.

3.Results

3.1 SMART-Farm Overall Sustainability Performance

The eight selected sheep farms scored above 80% for two dimensions: *Environmental Integrity* and the *Social Well-being* dimensions with an average of 84% & 89% respectively. The farms scored lower on the *Economic Resilience* and the *Good Governance* dimensions with an average score of 76% & 71% respectively. The overall sustainability performance results from SMART-Farm assessment for the eight sheep farms are displayed in the sustainability polygon in Figure 4. The farms ranked on average in the ¨Best¨ category for ten themes (*Participation, Water, Land, Materials and Energy, Animal Welfare, Product Quality and Information, Fair Trading Practices, Labor Rights, Human Safety* and *Health, Cultural Diversity*). The farms ranked in the ¨Good¨ category for nine themes (*Corporate Ethics, Rule of Law, Atmosphere, Biodiversity, Investment, Vulnerability, Local Economy, Decent Livelihood, Equity*). Lastly, the farms ranked in the ¨Moderate¨ category for two themes (*Accountability, Holistic Management*). The farms did not rank in the ¨Limited¨ and ¨Unacceptable¨ categories for any of the themes. The scores are illustrated in the sustainability polygon in Figure 4.

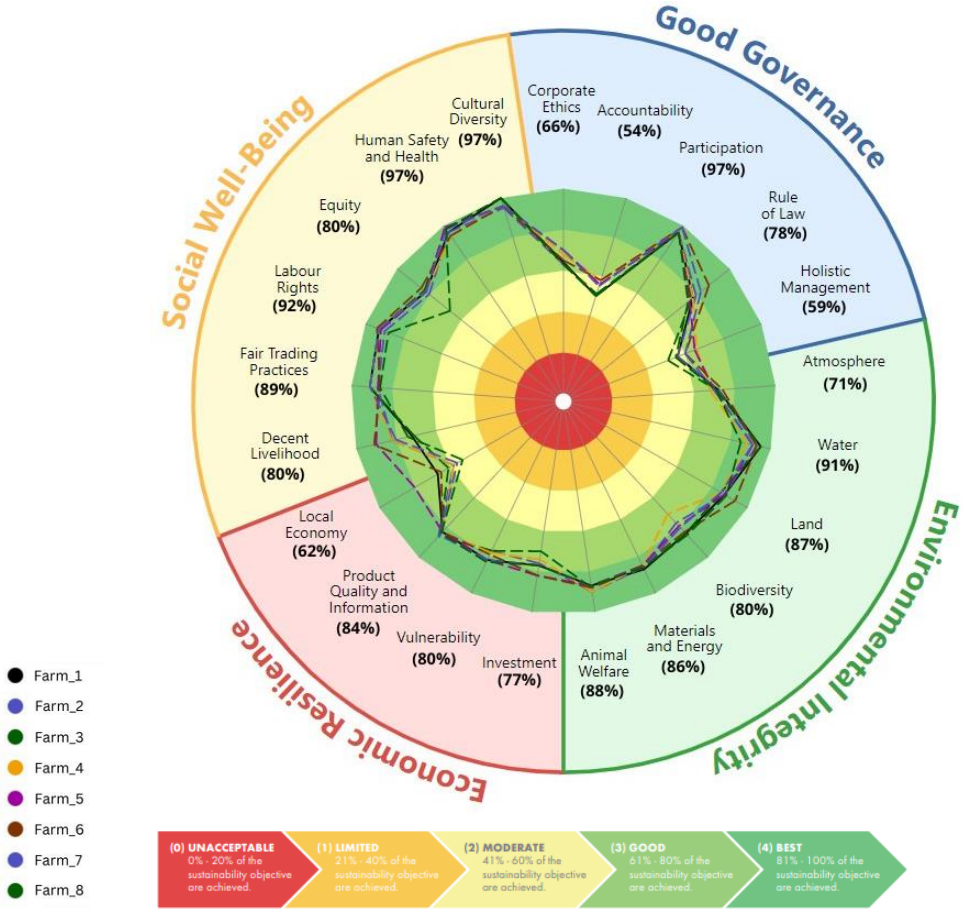

Figure 4. Sustainability Polygon for the Overall Sustainability Score for the Eight Selected Sheep Farms

3.2 *Good Governance*

In the *Good Governance* dimension the farms scored on average highest on the *Participation* theme (98%). In the *Rule of Law* theme, the farms scored on average 78%. Lower average scores were recorded on the *Corporate Ethics* (66%), *Holistic Management* (58%), and *Accountability* (54%). Results of the scores of the farms in different themes and sub-themes in the *Good Governance* dimension are displayed in the sustainability polygon in Figure 5. On average, the farms ranked in the ¨Best¨ category for seven sub-themes (*Due Diligence, Stakeholder Dialogue, Grievance Procedures, Conflict Resolution; Legitimacy, Remedy Restoration & Prevention, and Resource Appropriation*). The farms ranked on average in the ¨Good¨ category for one sub-theme (*Sustainability Management Plan*). The farms ranked on average in the ¨Moderate¨ category for six sub-themes (*Full-Cost Accounting, Mission Statement, Holistic Audits, Responsibility, Transparency, Civic Responsibility*). None of the farms were placed in the ¨Limited¨ and ¨Unacceptable¨ category for any of the sub-themes in *Good Governance* dimension. The scores are illustrated in the sustainability polygon in Figure 5.

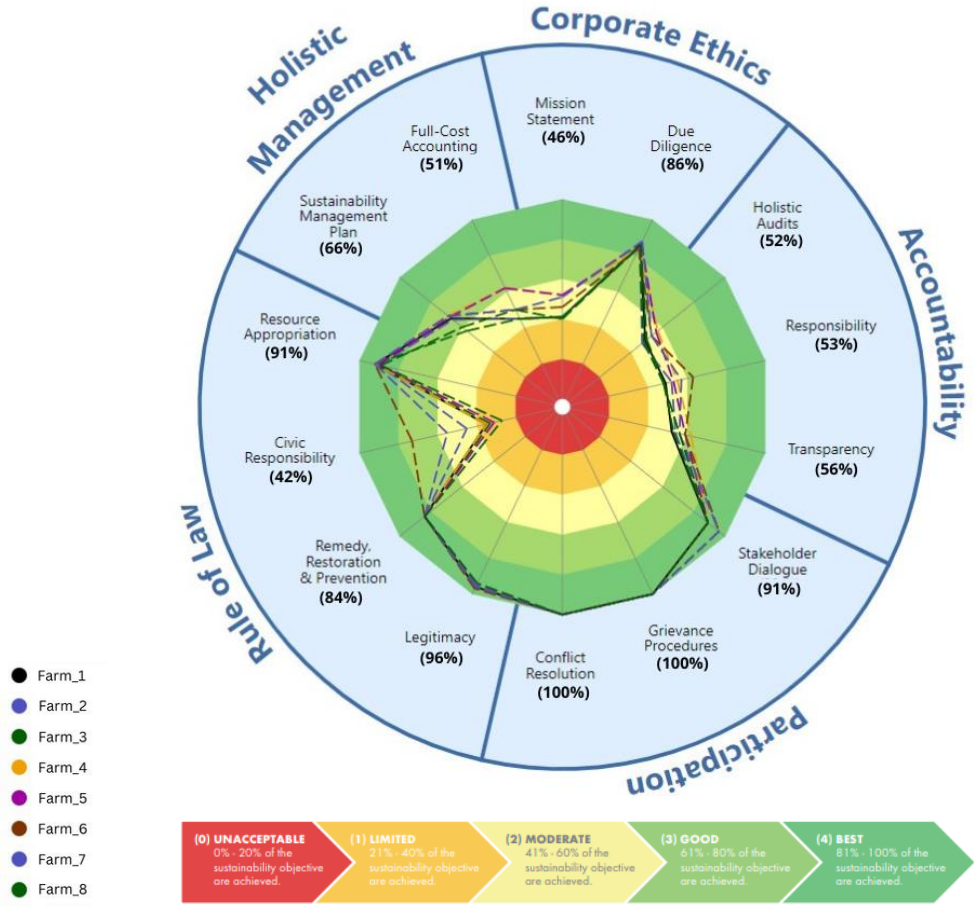

Figure 5. Sustainability Polygon for the Scores of the Eight Selected Farms in the Good Governance Dimension

3.2.1 *Participation*

In the *Grievance Procedures* sub-theme, the farms scored 100% in all the indicators. This sub-theme was linked to accessible and fair grievance procedures to reduce potential power asymmetries between stakeholders on the farms (Appendix 16). In this sub-theme, the freedom of employees of the farms to join unions and engage in bargaining, legally binding contracts, commitment against discrimination of vulnerable groups were important, and secured of in all of the farms.

In the *Conflict Resolution* sub-theme, the farms scored on average 100%. This sub-theme is concerned with resolutions of conflict with stakeholder groups or other collaborative partners, in a fair way. None of the farms had any problems with loan providers, or conflicts over resources with neighbors. All of the farms had mechanisms for preventing conflicts over resources (e.g., fences to avoid grazing conflicts). Moreover, none of the farms made decisions that could have negative environmental/social impacts to neighbors or other stakeholder groups, which would otherwise need to be communicated.

In the *Stakeholder Dialogue* sub-theme, the farms scored on average 91%. All of the farms had good customer relationships, and all employees were free to engage in collective bargaining. Performances of the farms in the *Conflict Resolution* and *Grievance Procedures* sub-themes were tightly linked to the performances in the *Stakeholder Dialogue* sub-theme. The reason for lower and more varying scores in this sub-theme compared to the others in the *Participation* theme were that none of the farms made efforts to cooperate with 'ethical financial institutions' (in this case banks). Also, some variation was due to farmers' different levels of involvement in political and social activities to improve sustainability in a policy level. This is closely related to the scores in the *Civic Responsibility* sub-theme presented in section 3.2.2.

3.2.2 *Rule of Law*

In the *Civic Responsibility* sub-theme, there was a high variation between the scores with a relative standard deviation (RSD) of 34.5%. The highest score was 73% (Farm_6) and the lowest score was 27% (Farm_8). Some reasons for the differences in scores were the levels of involvement in political and social activities to improve sustainability mentioned in the *Stakeholder Dialogue* sub-theme. The farmer in Farm_6 was involved in political activities for many years, and he was a board member in the Farmers' Union. The farmer in Farm_7 was also involved in the Farmers' Union, and he participated in a project where farmers of the

area partnered with Felleskjøpet to have a 'spin-off' shop closer in the area where both farmers and non-farmers can buy goods locally. The farmer in Farm_6 was also voluntarily involved in environmental protection activities on average 15 days per year. For all the farms, scores increased due to involvement in social activities outside of the farms. All of the farmers were involved on average 26 days in some social activities in forms of dugnads[1]. Low and varying scores in this sub-theme were due to environmental and social responsibility in procurement, where in most cases social and environmental criteria or certification was not accounted for five most important farm inputs.

In the *Legitimacy* sub-theme, the farms scored on average 96%. None of the farms had any cases of infringement of law in the last five years, all waste materials were properly disposed, and there were no cases of contaminated products. The reason for slight variation between the scores (Appendix 13) was because of environmental and social responsibility in procurement presented in Section 3.4.1. One enabling factor which ensured compliance with laws and regulations was Kvalitetssystem i landbruket (KSL) which all the farms complied with. This came up many times during the interviews with the farmers.

3.2.3 *Corporate Ethics, Holistic Management, and Accountability*

Mission Statement sub-theme is concerned with governance statements regarding farms' commitment to sustainability. This was tightly linked to other sub-themes: *Sustainability Management Plan,* and *Full-Cost Accounting.* These were the lowest-scoring sub-themes. None of the farms had any specific, publicly available sustainability plan, and written commitments to sustainability were not available to the public. However, all of the farmers were committed to principles of sustainability and importance of local procurement verbally. All farms had commissioned a sustainability report before, but not for all dimensions (social, economic, ecological). This report was not publicly available on any of the farms. None of the farms had any explicit written plans to improve sustainability in their holding, but all farmers were able to verbally describe planned sustainability improvements. None of the farmers measured impacts of their external environmental and social costs or integrated this information into the farms accounting via monetary valuation of impacts. The farms had committed themselves in writing to the principles of sustainable development indirectly and had a procurement strategy that prioritizes the purchase of inputs from local production. In the *Due Diligence* sub-theme there were high scores for the farms because the indicators here

[1] Norwegian word which refers to voluntary communal work with a goal of accomplishing a task which benefits the community.

were also linked to ensuring food safety and social standards which were high in all of the farms.

3.3 *Environmental Integrity Dimension*

In the *Environmental Integrity* dimension, the average overall score of the eight sheep farms was 84%. The farms scored on average the highest in the *Materials and Energy* theme (96%), followed by *Water* (91%), and *Animal Welfare* (88%). The farms scored on average 87% in the *Land* theme, and 80% in the *Biodiversity* theme. The theme with the lowest average scores was *Atmosphere* (71%). On average, the farms ranked in the ¨Best¨ category for seven sub-themes (*Water Withdrawal, Water Quality, Land Degradation, Material Use, Waste Reduction & Disposal, Animal Health,* and *Freedom from Stress*). The farms ranked on average in the ¨Good¨ category for seven sub-themes (*Soil Quality, Ecosystem Diversity, Species Diversity, Genetic Diversity, Energy Use, Greenhouse Gases,* and *Air Quality*). None of the farms were placed in the ¨Moderate¨, ¨Limited¨ or ¨Unacceptable¨ category for any of the sub-themes in the Environmental Integrity dimension. The scores are illustrated in the sustainability polygon in Figure 6.

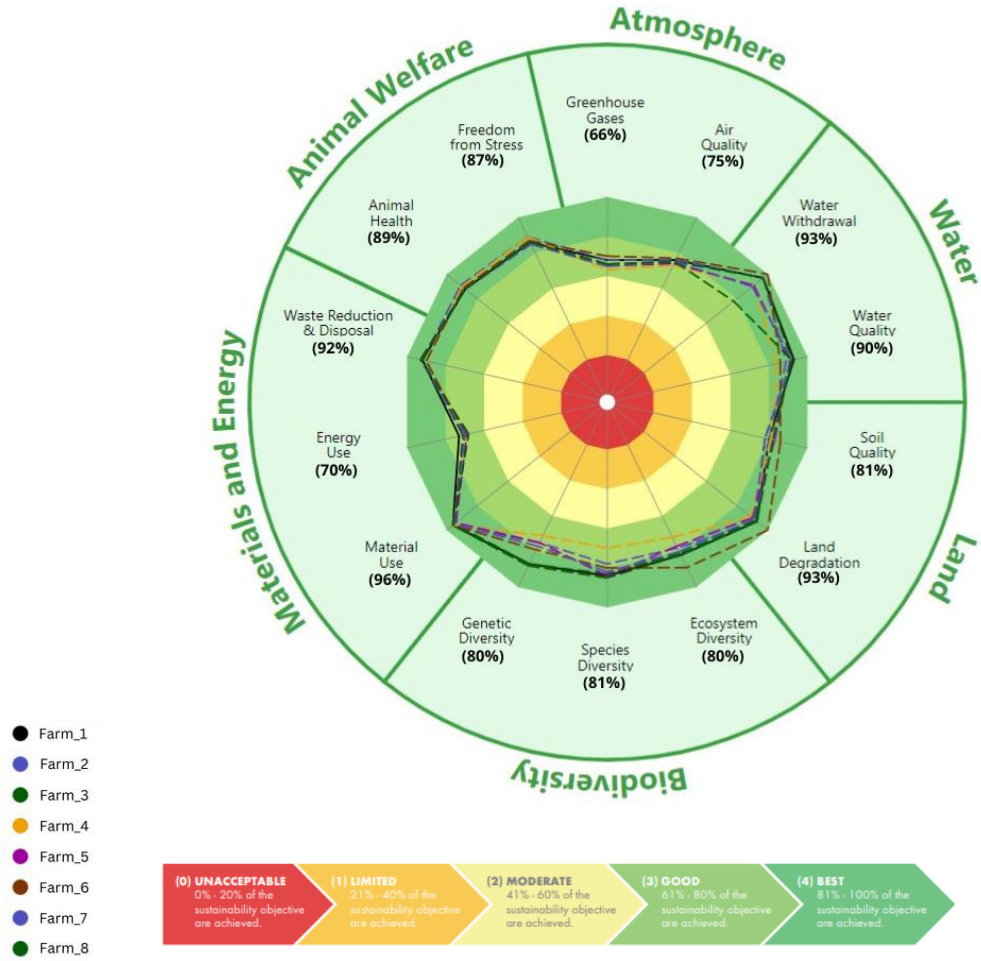

Figure 6. Sustainability Polygon for the Scores of the Eight Selected Farms in the Environmental Integrity Dimension

3.3.1 *Water*

The *Water Quality* sub-theme describes the farms' performances within practices which are widely known to affect water quality. Such practices include use of pesticides, fertilizers, regular water quality analyses, etc. The farms scored high in this sub-theme (scores ranging from 84% to 93%). Lower scores and variation were mostly linked to the use of plant protection products, and amount of fertilizer applied in the fields. None of the farms used any synthetic chemical fungicides, or insecticides. However, the farms differed slightly in the indicator about the use of herbicides. Three of the farms used herbicides which contained active substances. The scores remained high as the products contained only one active substance. According to the PAN International List of Highly Hazardous Pesticides (which is integrated in SMART-Farm), these substances had different toxicity levels for aquatic organisms (ranging from ¨Slightly¨ to ¨Moderately¨), persistence in the soil (3 to 96 days which was considered low), and water (35 to 223 days). These differences contributed to the variation in the scores.

The amount of N from fertilizer applied on the farms area ranged from 139 to 309 kg per hectare per year. This resulted in farms scoring mostly 0% in this indicator. The amount of P from fertilizers applied on the farm area ranged from 10 to 31 kg P2O5 per hectare per year, giving the farms scores between 25% to 50% in terms of Water Quality.

The *Water Withdrawal* sub-theme is concerned with farms' water management and consumption. Six of the farms used no water for irrigation purposes, only Farm_8, used 463 m3 of water per hectare annually. For Farm_6 which also used irrigation this question was left unanswered. Besides water used for irrigation, there was variation between the scores in water consumption. Farm_1,2,3 scored high (75%) because they used 2.6 to 3.3 m3 per hectare per year. Farm_4,5,7,8, consumed 28 to 93 m3 water per hectare per year resulting in lower scores in this indicator (25%). In this sub-theme Farm_6 received the highest score (100%) because two indicators which caused the biggest variation between the farms were left unanswered, hence it needs to be categorized as an outlier. Farm_8 scored 78%, with the lowest score in this sub-theme.

Other indicators in the sub-theme showed that there had not been any conflicts over water resources in any of the farms, there had been no decrease in the yields due to lack of water in the past 5 years, and all wastewater is correctly discharged in the eight farms. Overall, the farms had very high scores in both *Water Quality* and *Water Withdrawal*.

3.3.2 *Animal Welfare*

The average score in the *Animal Health* sub-theme for the farms was 88%, and the variation between the scores was low (RSD=1%) (Appendix 13). High scores were achieved because the farms had proper sized lying areas for the animals, clean stables, lights in livestock housing, and proper stocking density. The farmers stated that many of these are regulated by KSL, which all selected farms complied with. These conditions were evident during the observational walk on the farms before the interviews. Proper storage of silage and concentrate feed, and proper instruction for workers about animal welfare were also conditions which the farms met, which gave high scores in the sub-theme.

There was slight variation (between 92-98%) on the proportion of animals moved to alpine pasture in the summer. There were also varying scores between farms due to days of access to pasture for livestock ranging from 150-180. All year around outdoor access to animals was also an indicator where only one of the farms scored 100% (Farm_2). The last indicator in the *Animal Welfare* sub-theme where the farms had the highest variation was the transportation to the abattoir. As the transportation time varied between 10-120 minutes between the farms, the scores varied from 50% to 100%.

Freedom from Stress according to SAFA guidelines refers to a state where all animals are properly fed, do not experience discomfort, pain, injury or disease, and express normal behavior. Animal health was a key concern in this sub-theme as well. However, indicators such as access alpine pasture and its number of days, transportation duration to the abattoir, and daily outdoor access for animals had higher weights. The farms still scored on average 87% in this sub-theme. Lower scores in both Animal Health and Freedom from Stress sub-themes was as a result of the indicator concerning the hardness of lying area in the housing areas (which on the farms was wood). Some data error was detected in the indicator about whether the ruminants are dual-purpose breeds. The animals here were considered only meat breeds (not dual-purpose breeds), which lowered the scores in the sub-themes as well.

3.3.3 *Land*

In the *Land Degradation* sub-theme, the farms had an average high score (93%) and the variation between the farms was not large (RSD=3.4%). This sub-theme included indicators about practices which are known to reduce land degradation. These indicators were generally related to the management of grasslands, soil compaction, and management of woodlands on the farms.

Indicators about grassland management practices were important in this sub-theme and most focus was put on the permanent grasslands. The share of agricultural area devoted to permanent grasslands amongst the farms varied from 8% (Farm_7) to 50% (Farm_6) of the total area. Indicators showed that there has not been any conversion of permanent grasslands to other use (e.g., arable land) on the farms and that no portion of the permanent grassland were newly seeded in the past five years. There was some variation in the indicator about the share of extensively managed permanent grasslands where six farms scored 100%, and Farm_5 and Farm_8 scored 40% and 80% respectively. In this case extensive meant double mowing/ grazing, no use of inputs, including fertilizers.

Indicators regarding woodlands also affected the score of this sub-theme. The farms varied in scores in the indicator about the amount of woodland area in their farm, as some farms had lower proportion of it (e.g., Farm_4 had 4% of farmland) and some had higher (e.g., Farm_6 had 78% of farmland). The farms scored 100% in the indicator concerning deforestation as there were no areas on the farm which have been deforested over the past 20 years. There were no portions of degraded areas over the last 20 years that can no longer be used for farming in any of the farm cases. Other indicators showed that the farms were taking measures to reduce wheel load of machinery resulting in no soil degradation due to compaction from heavy machinery or livestock. One of the areas where the farms scored lower in this sub-theme was within the topic of agro-forestry systems. None of the farms had any agro-forestry [2] systems in place.

Many components of the *Soil Quality* sub-theme were similar to the *Land Degradation* sub-theme. The farms scored lower in this sub-theme due to differences in indicator weights, however, there was some variation in the scores in the indicator about the frequency of soil analyses performed on the farms in order to determine fertilizer requirements. Three of the

[2] Silvo-pasture, a practice within agroforestry, refers to the integration of trees and grazing livestock on the same land. In some areas in Norway, when the sheep are in the open pastures they often also graze in the forests. In the current study we answered that none of the farms had agro-forestry systems in place. A reason for this was that agroforestry is not a well-established term in the context of Norway (besides in some areas in Northern Norway), and in its definition includes some ¨intentionality¨ to create this system in order to utilize the forest. For sheep farmers, the intention is more that sheep graze outside in rangelands, whether that happens to be forest or alpine region, in order to utilize the resources.

farms received 50% scores because they performed soil analysis every 2-5 years. Five of the farms received 25% scores because they performed such analyses every 6 to 10 years. Variations in use of P from fertilizers indicator was also present amongst the farms as presented in section 3.3.1. However, in all the farms it could be guaranteed that there was no risk of usage of P-fertilizers with critical contents of cadmium or uranium. No use of fungicides, and herbicides was also positive for this sub-theme.

3.3.4 *Materials and Energy*

The sub-theme with the highest average score (96%) amongst the farms in the *Environmental Integrity* dimension was the *Material Use* (RSD = 0.74, Appendix 13). This sub-theme is mainly concerned with recycling practices, use of chemical agents, and fertilizers.

In the indicators concerning recycling, materials such as waste glass, paper/cardboards, waste oil, plastic, used batteries, and used tires are included. The waste recycling was something that the farmers did systematically. All the interviewed farmers stated they drive these sorted materials to the recycling station a few times a year. The amount and the ways in which these materials are handled and recycled afterwards is outside of SMART system boundaries.

High scores amongst the farms in this sub-theme were recorded because of low use of plant protection products. High scores were also recorded because of low usage of mineral K fertilizers[3], and no usage of peat[4]. The scores varied in the indicator about levels of P from fertilizers.

In the *Waste Reduction and Disposal* sub-theme the farms scored on average 92% with an RSD of 1.3% (Appendix 13). This sub-theme includes many of the same indicators as the *Material Use* sub-theme (recycling of different materials, and use of synthetic chemical herbicides, and fungicides). Some of the other indicators in this sub-theme were concerned with the topic of contamination (excluding antibiotics), and for the farmers this was also ensured through compliance with KSL. All the farms scored 100% in the indicators about measures taken to prevent cases of contamination which had a high weight in this sub-theme. There were no cases of contamination on any of the farms in the last five years.

[3] 100% score for this indicator meant that the farm uses mineral K fertilizer in a need-oriented way after soil analysis on all fields.
[4] 100% score for this indicator meant that the farms did not utilize any peat and no peat was necessary.

Energy Use was one of the sub-themes with the lowest scores in the Environmental dimension, although still in the green zone in the sustainability polygon. In this sub-theme the farms scored on average 70%, with low variation among the scores.

Some of the questions concerning this sub-theme were answered with the assumption that in Norway 98% of the electricity derives from renewable resources (including hydropower, wind, and thermal power), the farms scored high. In this case, 100% of electricity consumed on the farms was derived from renewable resources, and 100% of the heating-energy consumption was derived by renewable energy. In two of the ones that used irrigation practices such as low-energy irrigation technology and pumps, drip irrigation were used, also giving a high score in this sub-theme. The farms also received a higher score because none of the farms had any food waste, or if they did, it was redistributed to people or used as feed.

A very important indicator in this sub-theme where the scores varied slightly was concerned with electricity consumption (kWh/hectare/year). Five farms scored 75% in this indicator, two scored 50% and one was left unanswered. The number of sheep or the farm size was not correlated with the score in this indicator. The indicator also does not include electricity for private use in the houses.

Some of the areas where the farms scored lower were concerned with the proportion of electricity generated by farm's own installations. None of the farms produced any on-farm electricity from renewable resources, and none of the fuel used for vehicles and machinery was produced on-farm either.

Lastly, in the indicator about externally sourced concentrate feed all the farms scored 0% as they were sourcing all the concentrate externally. This affected the Energy Use and Material Use sub-themes.

3.3.5 *Biodiversity*

Within the three sub-themes of the *Biodiversity* theme the farms on average scored 80%. Many of the indicators in these sub-themes were linked to woodlands on the farm area, use of synthetic chemical agents for plant protection, and grassland management, which have been presented in the other sections of this results chapter. Access to pasture for ruminants also contributed to these sub-themes. However, there were some indicators which more specifically concerned areas for biodiversity promotion on the farm areas.

One of the indictors which was most directly linked to biodiversity showed information about the total share of area dedicated to biodiversity promotion on the farms. In this indicator all of the farms scored 100%, as the permanent grasslands were considered as areas for biodiversity promotion. This indicator was present in all the three sub-themes: *Ecosystem, Species, and Genetic Diversity*. Another indicator was concerned whether the farms implement measures on their agricultural areas to enhance connection of areas for biodiversity promotion and ecologically valuable landscape elements. All the farmers took such measures and that is explained also by other indicators which show low use of inputs in grasslands, livestock's access to alpine pasture. The indicator about the promotion of beneficial organisms was answered in these premises, as beneficial organisms were promoted and protected in all of the farms. However, these were untargeted measures (not aimed at specific species). These results were further discussed in the expert elicitation.

3.3.6 *Atmosphere*

Compared to the other sub-themes in the *Environmental Integrity* dimension, the *Greenhouse Gases* sub-theme has the lowest scores among the farms (average of 66%). In SMART, the *Greenhouse Gases* sub-theme includes indicators mostly from GHG mitigation practices described in SAFA Guidelines. The indicators which created the most variation between the eight farms in this sub-theme were share of woodlands in the agricultural area, share of permanent grasslands, and amount of N from fertilizers. Indicators concerning energy use greatly affected this sub-themes. These were the same ones presented in section 3.3.4. An especially relevant indicator related to energy in this sub-theme was on the proportion of organic matter utilized in a biogas plant, which for all of the farms was 0%.

As presented earlier, for the indicator concerning the amount of area of woodlands on the farms, six of the farms received 100% score, one received 75%, and one 25%. The percentages of share of woodlands in the agricultural areas were one of the main factors for the differences in the scores between the farms in this sub-theme. Coupled with this indicator the share of permanent grasslands in the agricultural area varied from 8% to 40%. This also had some impact in the difference in scores within this dimension, although they were not major (63%-70%). N from fertilizers also affected the score in this sub-theme. All of the farms used their own manure for fertilizing, and none of them imported any organic fertilizers. Access to pasture for ruminants was also an indicator which affected this sub-theme.

For all of the farms, 100% of the concentrate feed was externally sourced, which gave them a score of 0% for this indicator in the *Greenhouse Gases*, and *Air Quality* sub-themes.

Many of the indicators were the same for the *Air Quality* sub-theme. However, differences in overall scores in this sub-theme compared to the *Greenhouse Gases* was mostly due to differences in indicator weights in the sub-themes. An important indicator in the Air Quality sub-theme was concerned with a risk of contamination from exhaust emissions, factories, or airports, where all the farms scored 100%

3.4 *Economic Resilience*

In the *Economic Resilience* dimension, the average score of the eight selected farms was 77%. The theme with the highest scores on average was *Product Quality* theme (84%) followed by *Vulnerability* theme (80%). The farms scored lower on the *Investment* theme (77%), and *Local Economy* theme (62%). On average, the farms ranked in the ¨Best¨ category for six sub-themes (*Product Information*, *Food Quality*, *Food Safety*, *Risk Management*, *Liquidity*, and *Stability of Production*). The farms ranked on average in the ¨Good¨ category for seven sub-themes (*Stability of Market*, *Stability of Supply*, *Profitability*, *Long-Ranging Investment*, *Community Investment*, *Internal Investment*, and *Local Procurement*). The farms ranked in the Moderate category for one sub-theme (*Value Creation*). The farms did not rank in the ¨Limited¨ or ¨Unacceptable¨ category for any of the sub-themes in this dimension. These scores are displayed in the sustainability polygon in Figure 7.

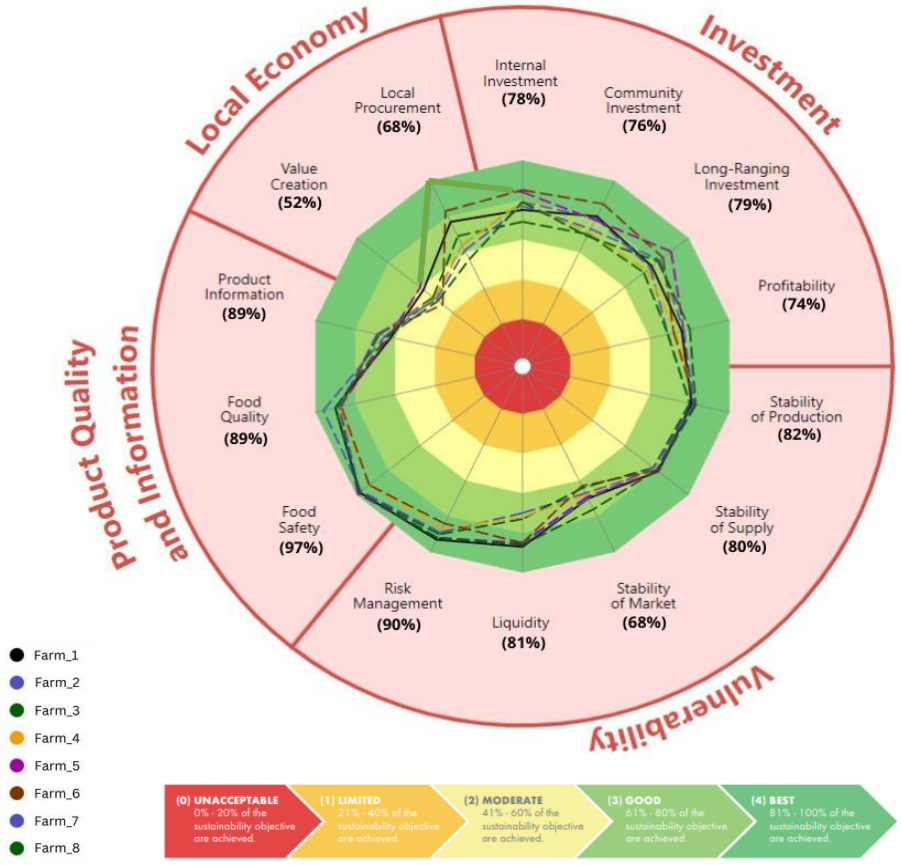

Figure 7. Sustainability Polygon for the Scores of the Eight Selected Farms in the Economic Resilience Dimension

* Data from Farm_5 is excluded because of inconsistency in the Local Procurement sub-theme (covered with a dark green line ——).

3.4.1 *Product Quality and Information*

The farms scored high on average in the *Food Safety* sub-theme (97%). Some of the indicators in this sub-theme were also linked to regulations present in KSL. For example, all the farms had correct storage of hazardous substances, and the employees of the farm were trained in that regard. None of the farms used antibiotics, or GMO crops. There were no incidents of contaminated products in any of the farms. The farms received low scores on the indicator about N from fertilizers.

The *Food Quality* sub-theme evaluated some of the same practices as the *Food Safety* sub-theme. Some of the other indicators more specific to *Food Safety* were also linked directly to KSL standards, such as proper stocking density. The farms complied with voluntary food safety standards on top of legal requirements, which had a positive impact in the score, coupled with good knowledge of welfare standards of slaughterhouses. These indicators were presented in the Section 3.2.3 and are linked to farmers' compliance with KSL. The two main indicators where the farms received varied scores were concerning daily outdoor access for animals all year round and access to pasture for animals (number of days).

The farms received lower scores in the *Product Information* sub-theme (66%) compared to other sub-themes in *Product Quality* theme. Indicators in this sub-theme concerned certification and transparency in production for both farm products and inputs. None of the farms had an environmental certification (e.g., organic production), however, production methods used on the farms were transparent to all buyers (e.g., Nortura). Compliance with KSL was a main channel for this transparency. The farmers who used pesticides had knowledge about the active substances and the risk associated with their use. The farms received low scores because of the indicator about transparency of production of important inputs. In six of the farms, environmental criteria or certifications were accounted for approximately half of the five most important products, and for the other two farms it was lower (30-40%). Social criteria or certification were also accounted for half the five most important inputs by five farms, and for the other three farms it was between 20-30%. Four of the farmers knew the origin of all five most important inputs, and four of them knew the origin of some.

3.4.2 Vulnerability

In the *Stability of Production* and *Stability of Supply* sub-themes, the farms scored on average 81%, and 80% respectively. The *Stability of Production* sub-theme is concerned with the farms' ability to maintain production levels at any given time, through environmental, social,

and economic shocks (Appendix 16). The *Stability of Supply* sub-theme is concerned with farms' ability to obtain input supplies to ensure expected production levels. In both sub-themes, overall use of inputs was an important factor. None of the farms used inputs such as herbicides, fungicides, insecticides, and imported organic fertilizers, which gave a positive score in these sub-themes. A high amount of woodland area on the farm also increased the score. In both sub-themes all the farms received low scores (0%) in indicators for use of externally sourced concentrated feed, and lack of on-farm renewable energy production. In the *Stability of Supply* sub-theme, the farms also received low scores on the amount of N and P from fertilizers used. For the other inputs that the farms did use, the *Stability of Supply* sub-theme was concerned with the supplier relationships. All of the farms' inputs were purchased from contracted and stable long-term suppliers (e.g., Felleskjøpet, Fiskå Mølle, and Norgesfôr). None of the farms have had any occasion in the last five years, where necessary farms inputs were not available. These increased the score in the sub-theme. In the *Stability of Production* sub-theme, indicators about workforce stability were also accounted for. Here, the farms received high scores because none of them experienced staff changes of permanent workers in the last five years. Moreover, none of them experienced staff shortages within the last five years, which could not be resolved. Overall, there were not a high number of workers in the selected farms. Overall, the farms did not use a large number of inputs, and this was reflected in their scores in both sub-themes. Moreover, the farms did not have high amounts of staff, which contributed to less dependence on workforce stability.

The farms scored on average 68% in the *Stability of Market* sub-theme. This sub-theme is primarily concerned with ways in which the farms ensure sales of their products. Diversification of sales and income were important components of the farms' performance in this sub-theme. Seven of the farms scored low (25%) on the indicator concerning diversification of sales. Only Farm_2 had two buyers[5] for the farm's products, and the rest had one buyer (Nortura). In six of the farms 100% of the sales profit were generated by Nortura. These farms received a score of 0 in this indicator. Farm_2 and Farm_8 received a 10% and 25% score respectively, as they had 80-90% of sales profit from Nortura. For Farm_8, 20% of sales were direct sales. Because there were a lot of reliance on the main buyer (which in the case of all of the farms was Nortura), the indicators concerning customer relationships were important. Four of the farms had a 30-year long customer relationship with

[5] 'buyer' in this case refers costumers the farms sell products to (e.g., wholesalers). Private individuals are not regarded as buyers.

Nortura. The other four had a 20–25-year long relationship. All farmers said they have good relationships and cooperation with the buyer. Despite these relationships being quite stable, the farmers were aware of alternative markets for the products if the buyer drops out, which gave a positive score in this sub-theme.

When asked about the diversification of income, only Farm_2 and Farm_3 had no other sources of income besides income from sale of meat. All the rest of the farms had one other source of income. In SMART-Farm these sources of income are only considered if they are from activities related to agriculture. One of the farmers was involved with fence-making, and for the others it was mostly forestry. Generally, the dependency of sales in one buyer was a main reason for lower scores in the sub-theme. However, awareness of alternative markets slightly diminished the risk of market instability in this context.

In *Liquidity* sub-theme, the farms scored on average 81%. This sub-theme is concerned with the farms' financial sources and ability to withstand liquidity crises. All the farmers stated that the liquidity of the farm is ensured. The scores varied in the indicator concerning debt. Farm_1 and Farm_3 had 90% of operating assets as own capital, followed by Farm_2 with 80%, and the rest 60-70%, with the exception of Farm_8 which had 40%. None of the farms had any problems with loan providers in the past five years, and all farmers stated they have access to credit in case of need. Lower scores in this sub-theme were mainly linked to yield level, which referred to the average relation of the farm's crop yield to the regional crop yield. The farms varied from an average of 0.6, which gave a score of 0% in the sub-theme, to an average of 1 for most of them, which gave a score of 50% in the sub-theme.

Risk Management was the sub-theme where the farms scored the highest on average (90%) within the Economic Resilience dimension. *Risk Management* sub-theme evaluated farms' ability to reduce and adapt against risks that are potentially harmful to the business.

The farms scored high in indicators which aimed to assess farmers awareness and knowledge about future scenarios. In five of the farms, the farmer was below the age of 55, in two farms the succession was relatively clear, and only in one farm it was completely clear. Moreover, all of them had adequate farm manager replacement in case of illness or holidays. All farmers were aware and informed of both future market challenges, and future policy changes / political challenges. Also, all farmers were aware of the predictions of climate changes in the region, but only one farmer was taking climate change adaptation measures. All farms were insured against natural hazards (e.g., floods), and fire damage.

Some indicators in this sub-theme were also closely linked to the *Food Safety* sub-theme, where the farms also scored high. For example, there were no cases of contamination and there were correct measures taken to avoid such scenarios. Also, a high proportion of areas not receiving synthetic chemical agents had positive impacts in the scores.

The farms received some low scores in this sub-theme because of full dependency on the main customer, and the low diversity of sales which were presented in the *Stability of Market* sub-theme. The farms also received low scores on the indicator about weekly working hours for the farm owners (variation between 55 to 75h per week), with exception to Farm_2 where the average was 43.5h per week.

3.4.3 *Investment*

In the *Internal, Community, and Long-Ranging Investment* sub-themes, the farms scored on average 78%, 76%, and 79% respectively. There was some variation between the farms within these sub-themes (Appendix 13). *Internal Investment* sub-theme is concerned with activities and practices in which the farms have invested in, to improve across different sustainability dimensions (Appendix 16). All farms received some low scores due to lack of on-farm energy production, and apprenticeships. There were variations in the scores between the farms because in some of them, the employees had access to external training up to 38 days, whereas in others it was 2 days. For all farms, no use of pesticides, water management practices, and measures against soil degradation increased the score in this sub-theme.

Community Investment sub-theme is related to the farms' contribution to addressing community needs, with an efficient use of resources (Appendix 16). The farms had scored well in indicators linked to biodiversity, but there was some variation due to the different sheep breeds they kept. The presence of Spæl sheep breed increased the score in the sub-theme because they are considered a rare breed. Some variation was also due to farmers' different levels of involvement in social activities outside of the farm. Lastly, there was some variation within the topic of procurement, where some of the farmers sourced a higher percentage of locally produced inputs than others.

Scores within the *Long-Ranging Investment* sub-theme were also a result of some of the same indicators of the *Internal* and *Community Investment* sub-themes. In this sub-theme a variation of the score was also a result of differences in amounts of investments to improve farms infrastructure. Here the more purchase of more productive land was also considered a long-term investment.

In the *Profitability* sub-theme, there was less variation between the farms' scores, compared to the other sub-themes in the Investment theme. Farm_8 scored the highest (80%) in this sub-theme, and Farm_2 & 3 scored lowest (69%). As opposed to the farms that scored lower, in Farm_8 there were long-term investments, such as improvement of farm infrastructure or purchase of more productive land. The farmer also stated that both profit and yield tendency in the last 5 years have been increasing. Moreover, the farmer in Farm_8 had another source of income related to agriculture, which increased the score in the diversification of income indicator, which had a positive effect in this sub-theme. Some of these were also prevalent in the other farms, however only Farm_8 scored high in all of the indicators whose scores had variation between the farms.

Other areas of high performance for all farms were linked to stability of supply, and risk management. The farms also scored 50% in the indicator regarding producer price vs market price level as the prices did not deviate. Areas of low performance for all the farms included lack of on-farm processing, and mowing frequency of permanent grasslands.

3.4.4 *Local Economy*

Value Creation sub-theme was concerned mostly with value created in terms of employment. Six of the farms scored 25% in the indicator concerning full-time job equivalents compared to agricultural area as they had less than 0.05 full-time job equivalents per hectare (additional to the farmer). Only Farm_1 had 0.5 full-time job equivalents per hectare, and for Farm_6 this question was left unanswered. None of the farms had any apprenticeships or other training opportunities on the farms. In seven of the farms there had not been any job cuts in the last five years (and no new jobs created). On Farm_5, new jobs were created.

The *Local Procurement* sub-theme was concerned with the local and domestical procurement of inputs at a supplier and producer level. In the supplier level, all the farms scored 100%. However, at the producer level there was variation ranging from 30% to 70% of the five most important inputs being produced locally or domestically. That was difficult to answer because the origin of all inputs was not known by all of the farmers.

3.5 *Social Well-Being*

In the *Social Well-Being* dimension, the average score of the eight selected farms was 88%. The themes with the highest scores on average were *Cultural Diversity* and *Human Safety* and *Health* themes (97%). The farms also scored high in the other themes, *Labour Rights* (92%), *Fair Trading Practices* (89%), *Equity* (80%) and *Decent Livelihood* (80%). On average, the farms ranked in the ¨Best¨ category for 13 sub-themes (*Freedom of Association and Right to Bargaining, Child Labour, Forced Labour, Employment Relations, Rights of Suppliers, Responsible Buyers, Fair Access to Means of Production, Quality of Life, Food Sovereignty, Indigenous Knowledge, Public Health, Workplace Safety and Health Provisions,* and *Gender Equality*). The farms ranked on average in the ¨Good¨ category for three sub-themes (*Support to Vulnerable People, Non Discrimination, and Capacity Development*). The farms did not rank on average in the ¨Moderate¨, ¨Limited¨ or ¨Unacceptable¨ category for any of the sub-themes in this dimension. These scores are displayed in the sustainability polygon in Figure 8.

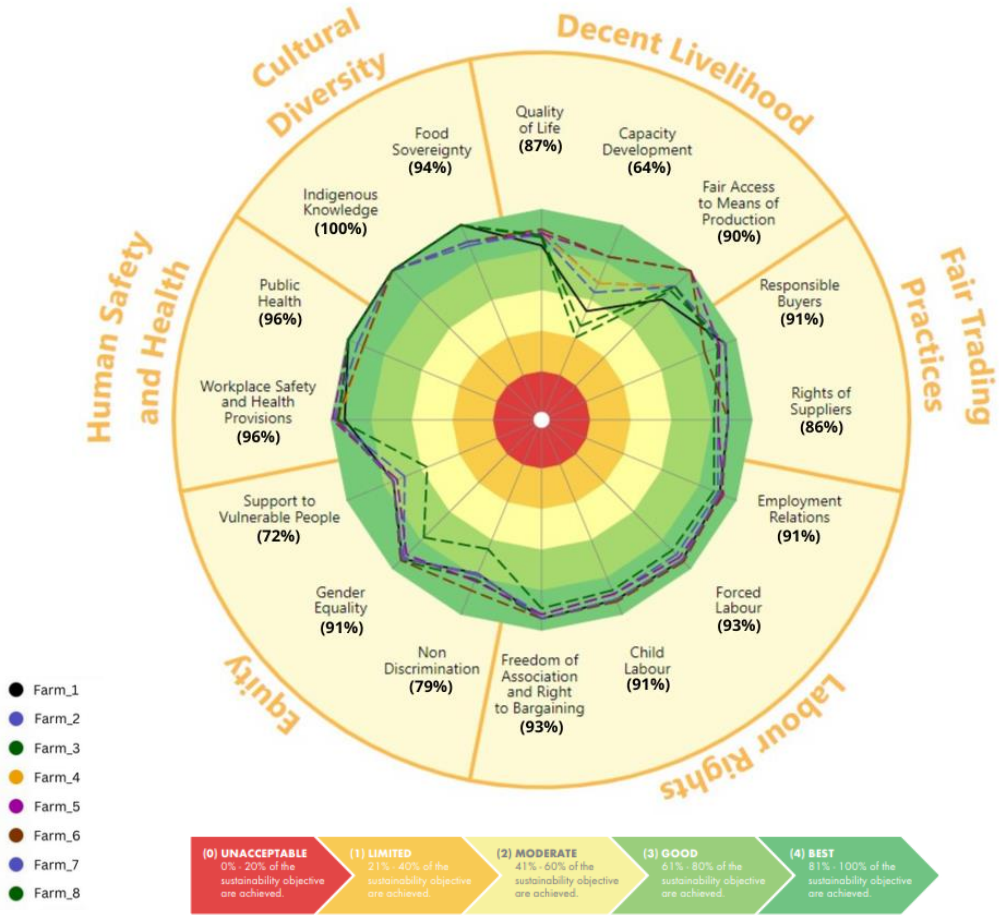

Figure 8. Sustainability Polygon for the Scores of the Eight Selected Farms in the Social Well-Being Dimension

3.5.1 Decent Livelihood

In the *Quality of Life* sub-theme, the farms received an average score of 87%. Some of the indicators were concerned with mechanization of e.g., feeding, harvesting, mucking, where the farm scored around 50%, as the mechanization of these activities was primarily medium (high mechanization increased the score of *Quality of Life*). Higher scores in this sub-theme were received in relation to workers permits, contracts, equal pay, access to medical care, regular breaks, regular meals. The average weekly working hours for farm employees was 40 hours a week. However, this was not the case for the farmers (farm owners). The weekly working hours for farms owners varied from 43,5h (Farm_2) to 75h (Farm_5), with an average of 60h weekly working hours for the eight farms. This resulted in an average of 15% score for the farms in this indicator, meaning that in terms of *Quality of Life*, the weekly working hours for farmers were too high. In the indicator concerning work-life-balance, the farms scored on average 65%. In two of the farms, the farmers took less than 5 days of holiday per year. Only in three of the farms the farmers took more than 15 days of holiday per year. However, these indicators were questioned by the farmers during the interviews because in many cases long working weeks, and holidays in the form of collecting sheep from mountains were a part of the lifestyle they chose to have. One farmer insisted that the answer should be 365 days of holiday, as none of the working days felt like work.

The last indicator where the farms scored lower was the one of subsistence farming where on average the farms scored 18%. This indicator was concerned with the extent of the farm supplying its own food needs and those of its workers. In general, the farms supplied their own needs with food from the farm about 18%, which is also explained by the fact that these farms have only production of sheep meat.

In the *Capacity Development* sub-theme, the farms scored on average 64%. According to the SAFA Guidelines, capacity development is important in terms of sustainability of an enterprise, as it offers opportunity for learning for new employees and primary producers to do their best to contribute to improvement. Of eight of the farms, six of them received some kind of training on sustainability. A part of this training could have been through advisory services, which all of the farms had access to in the last five years and had positive experiences. However, only employees in Farm_6 had access to financed external training in the past 5 years. All of the farms which were using plant protection agents received training for their use and storage. Lower scores were received in the sub-theme also because there were no apprenticeships in any of the farms.

3.5.2 *Fair Trading Practices*

In the *Responsible Buyers* sub-theme, the farms scored on average 91%. This sub-theme concerned the farms as buyers, and mostly focused on the cooperation with suppliers and other farms, which were generally good in all the farms. The only indicator where the farms scored lower was the one regarding social responsibility in procurement, because social criteria or certification was not accounted for all of the most important farm. This was also tightly linked to the *Rights of Suppliers* sub-theme where the farms scored on average 86%. Generally, the farmers bought their inputs from the closest ¨Felleskjøpet¨, and in this case accountability for social or environmental criteria depended more on the supplier.

3.5.3 *Labour Rights*

In all the sub-themes under the Labour Rights theme, the farms scored on average above 90%. There were no cases of any forced labour or child labour on the farms, the farms had legally binding contracts for all of their workers, workers had social protection, had freedom to join unions, and freedom to association. Only Farm_6 had a foreign worker, and the worker had working permit, and contract. A lower score was only received in the indicator regarding social responsibility in procurement, same as in the *Fair Trading Practices* theme. The matters which the indicators in this theme were concerned with are highly regulated by law in Norway.

3.5.4 *Equity*

The farms scored high in the *Gender Equality* sub-theme (91% on average). Some of the questions were irrelevant in the context of Norway, but also for seven of the sheep farms it was only family members working on the farms. All of the partners of the farmers had rights and social protection in case of divorce or death. All of the workers on the farms received equal pay, which was also relevant to *Non Discrimination* and *Support to Vulnerable People* sub-themes. The farms received lower scored on these two sub-themes because there were no disabled people working or living at the farms, and that there were no apprenticeships.

3.5.5 Human Safety and Health

In the *Workplace Safety and Health Provisions* sub-theme, the farms scored on average 96%. The indicators in this sub-theme linked to correct disposal of waste, knowledge about plant protection and animal treatment products if used, and other indicators linked to *Risk Management*, and *Quality of Life* sub-themes, where the farms scored high on average. The indicator where the farms varied and had lower scores was linked to social responsibility in

procurement, where social criteria had not been accounted for all of the five most important inputs in the farms.

In the *Public Health* sub-theme, the farms scored on average 96% as well. Many of the indicators were similar to *Food Safety, Water Quality, Soil Quality,* and *Due Diligence* sub-themes where the farms had high scores. Slight variation between the farms in this sub-theme was because of the proportion of woodland areas in the farms.

3.5.6 Cultural Diversity

The farms scored on average 100% on the *Indigenous Knowledge* sub-theme, and 94% on the *Food Sovereignty* sub-theme. None of the farms used GMO-crops, GMO feedstuff, and hybrid cultivars. Another indicator was concerned with the risk that the farms use methods which originate from traditional knowledge and have not been compensated for their commercial use (e.g., patented seeds), where all farms scored 100%. There were no risks that smallholders or local communities were dispossessed to establish the farms. There was slight variation in the *Food Sovereignty* sub-theme, where the farms with rare or endangered livestock breeds on the farm scored higher. Some of these questions were regarded as slightly irrelevant for the context of the eight sheep farms.

3.6 Differences between regions

3.6.1 Two-sample t-test

A two-sample t-test was conducted to compare the mean scores in the sub-themes for the coastal (M=81.7, SD=13.5) and inland farms (M=79.7, SD=16.1). The p-value for the two-tailed test was 0.48 (df= 114, α=0.05), meaning there was no statistically significant evidence to conclude that there were differences between the two groups.

3.6.2 Detailed Analysis of Indicators and Practices

However, through a detailed analysis of the indicators (non-aggregated data), some differences were discovered between the groups shown in Table 5. The green upward arrows indicate higher (positive) scores for one group compared to the other. Red downward arrows indicate lower (negative) scores for one group compared to the other. The detailed results include means (M) or discrete/ raw data.

Table 4. Detailed Analysis of Indicators with Differences between Regions

Dimension	Indicator/Practice	Inland Farms	Detailed results	Coastal Farms	Detailed results
Good Governance	Environmental responsibility in procurement (%)	↑	M=50%	↓	M=40%
	Written commitment to sustainability	↑	Yes, Yes, Yes, Yes.	↓	Partly, Partly, Partly, Yes.
	Involvement in improving laws and regulations	↑	No, No, Yes, Yes.	↓	No, No, No, No.
	Education or training per full-time equivalent (Number of days)	↑	M= 14.3	↓	M= 2.9
	Sustainability Training (Have competencies/knowledge relating to environmental, social, economic, and governance-related sustainability also been taught?)	↑	Yes, Yes, Yes, Yes.	↓	Yes, Yes, No, No.
Environmental Integrity	Soil analysis fertilizer requirements	↑	Between 2-5 years	↓	Between 6-10 years
	P from fertilizers (kg P205)	↑	M= 17.20	↓	M=19.08
	Transportation to abattoir (minutes)	↑	M=52.5 minutes	↓	M=112.5 minutes
	Annual Water Consumption (m3 per hectare per year)	↓	M= 38.6	↑	M=25.4
	Access to Pasture (days per year)	↓	160,160,160, 150 days	↑	180, 150, 165, 180 days

	Quantity of feed given to ruminants that would be suitable for human consumption (%)	↑	11, 9, 7, 2	↓	12, 17, 16
Economic Resilience	Lowest wage that the operation pays to its employees compare with the necessary living wage in the region	↑	M=2.28	↓	M=1.96
	Proportion of farms own capital (% of operating assets)	↓	70, 60, 60, 70	↑	90,80, 90, 40
	Diversification of income (Number of other sources of income)	↑	1, 1 ,1, 1	↓	1, 0, 0 ,1
	Calculated Indicator: Is the origin of the externally sourced inputs known? (%)	↑	100, 60, 100, 100	↓	40,80,100, 60
Social Well-Being	Mechanization reducing the physical workload when feeding roughage	↑	Medium, High, High, High	↓	Small, High, Medium, Medium
	Mechanization reducing physical workload when mucking out	↑	Small, medium, high, high	↓	High, high, high, high

3.6 Expert Interviews

3.6.1 Biodiversity Theme

During the interview with Expert_1 indicators concerning woodlands on the farms, and management of permanent grasslands in the context of biodiversity and sheep farming in Norway were discussed. These indicators were relevant to many of the sub-themes, but also greatly affected the *Biodiversity* theme.

It was established by the interviewee that although woodlands are very important ecosystems in some contexts, this might not be the case for the woodland area on the farms assessed. According to the expert, it is likely that woodlands in the farms are plantations, as farmers have a lot of woodlands which they use for timber production. These areas are not rich in biodiversity, and it is very hard to relate them to the topic. If these indicators were to have meaning in the context of Norway, there should be a distinction between plantations and e.g., old growth forests, which we know can be good in terms of biodiversity. This might also be different in Northern Norway where they have big areas which are referred to as ¨grazing forests¨.

When discussing the extensive management of permanent grasslands, the farms received a low score because they mowed 1-2 times per year. There was some uncertainty behind this indicator and whether more mowing or less mowing would increase the score. However, both sides were discussed. First, it was established that mowing, together with grazing is recommended for farmers in Norway, and it is the best thing they can do in terms of biodiversity. At the same time, mowing one time is sufficient especially in areas that are not highly fertilized, and a higher mowing frequency would not be possible in Norway.

Besides, discussing indicators which might risk giving misinformation about biodiversity the context of Norway, during the interview possible missing information was also discussed. The first point was the presence and/or amount of semi-natural grasslands should be included in the indicator list. The expert stated:

¨I think it is even better if you can have some amount of semi-natural grasslands. Because we know that semi-natural grasslands are biodiversity hotspots, that's the meadows that are most important for both plants and insects and birds as well. ¨

It was further explained that the presence of red listed ecosystems that are semi-natural like semi-natural grasslands, and coastal heathlands would be very important to consider when discussing the biodiversity in farms.

The discussion also continued to the topic of livestock's' access to alpine pasture which was also covered through indicators in the biodiversity theme. According to the expert, today in Norway there are more sheep grazing in the mountains than ever before, but the encroachments are still a big issue. The high biodiversity areas are disappearing because there is not high enough grazing pressure due to sheep being so widely distributed in the mountain areas.

¨It is a big difference between how the mountain areas was grazed before when we had this mountain farming system where the sheep were more around the mountain farms but now, they are distributed all over the place… the sheep farmers don't use these mountain farm so much. But if they have any mountain farms- that would be a better indicator maybe. ¨

This meant that in the context of Norway, an indicator concerning the use of mountain farms would provide a lot of information regarding the sustainability of the farm, and its contribution to biodiversity.

When asked about the overall results and scores compared to what we know about biodiversity the expert explained that according to nature index system, and other indexes used to measure biodiversity, the status is in decline. The monitoring of semi-natural grasslands also indicates that they have a very low status and most of them are in encroachment processes. That is because they are not being used. To the expert's perspective, the *Biodiversity* theme score was quite high, but they explained:

¨… but it doesn't mean that its wrong because you have selected farms that have grazing animals and that are in used area. ¨

A concluding remark was related to the importance of such assessment. According to the expert: *¨…we haven't landed [a common value of each indicator] yet, we cannot say that biodiversity is more important than climate for instance… we can't say that water is more important than biodiversity and vice versa…¨*

3.6.2 Greenhouse Gases Theme

In this interview, the focus shifted to the importance of putting ruminant systems into a bigger context, and existing tradeoffs within sheep farming systems, knowledge we do not yet have, and knowledge that we might be overlooking, were discussed.

During the interview, mitigation practices such as additives, and type of feed were discussed in the context of trade-offs between animal health and welfare, and use of resources. According to the expert, there is a lot of emphasis on additives for mitigating enteric methane from ruminants, where the aim is to manipulate the rumen microbiomes to act differently. However, there needs to be awareness circulation of these additives in the manure, plants and back into animals and humans.

During the interview, areas where we currently do not have so much knowledge regarding sheep, especially in the context of Norway were covered. According to the expert, it is difficult to know how access to different kinds of pasture affects the production of methane from sheep. That is mostly because it is difficult to know what kind of plant species they are eating when they are out in pasture, as opposed to if it was a uniform pasture where the links are clearer. But overall, it was stated that we know from international literature that pasture reduces methane compared to indoor feeding, even if the indoor feeding is with high quality concentrate and silage.

The conversation continued to a bigger perspective, in terms of greenhouse gases, and the expert noted that grazing is also important in terms of energy use as it decreases the need for preserving, harvesting, making bales, fertilizing, which are all high energy demanding. Regarding that it was stated that *¨energy is also climate¨*.

One of the other points made for components of these systems that need more research on was regarding the tradeoffs between the albedo effect that open grasslands provide versus the GHG emissions that come directly from ruminants. This was highlighted as a very important aspect when we talk about GHG emissions from ruminant production systems as we know that these animals keep open landscape. The expert stated:

¨it is too easy to say that the animals produce enteric methane, so they are a problem. Because they do produce a lot of other things and they do produce open landscape, which is a benefit due to the albedo effect¨

This conversation highlighted the importance of looking at different components of a system and how they affect each other, rather than looking at one component in isolation.

The concluding remarks in this interview were that we need to take care of what we have, and we can solve issues by *¨using awareness and knowledge and being humble to food producers*¨.

3.6.3 Social Welfare and Economic Resilience Dimensions

In the SMART assessment, the farms scored low (58% on average) in the *Value Creation* sub-theme, in the economic dimension. This score was discussed in the interview, and the main question was linked to whether all components of ¨value creation¨ in economic terms are captured in the assessment.

Linked to this question, the discussion first departed on the topic of ¨the ontology of farming¨. Expert_3 stated: *¨we created this idea in Norwegian agriculture debate that one farming family should live from the income from one farm alone¨*. However, as opposed to other farmers, the sheep farmers' idea of the value they are creating is not necessarily connected to economic value in that way, but more towards the idea that they are carrying a certain culture, producing landscape, and very clean food.

In terms of purely economic value creation, according to Expert_3, most sheep farmers in Norway create a lot of value outside of the farm boundaries. It is almost impossible for sheep farmers in Norway to live from the income of their sheep farm alone, so this kind of farming has always been combined with something else e.g., farmers working as builders, construction workers, elderly care etc. The farmers do not move outside of the rural community, so once 'export oriented' industries which are located in the rural areas get renewed contracts, the farmers go straight back to work. In this case, it is beneficial for the industry owners to invest in the farmers competence, as they know they will be a reliable source of workforce. This is not as prominent in other kinds of farming systems for e.g., dairy. But this engagement outside of farming is very important to value creation as rural Norway needs a lot of workforce. In this case, this kind of 'value' is tightly linked to the existence of sheep farming in rural Norway.

This contextualized the reality of sheep farming in Norway, as opposed to assessing the farm in a vacuum, and as an enterprise which exists by itself. In this regard, the expert criticized the idea that reduces a farm into:

¨an isolated social system… which is not part of nature…and not part of the community¨.

Some context was also established for the sub-theme *Stability of Market* where the farms scored on average 79%. As the lower score was mostly due to dependency on one costumer, it was important to discuss this in the context of Norway. Farmers, including sheep farmers, have a secure delivery of products through the farmers' cooperative. The cooperative is obliged to come and pick up the meat, and as a farmer you have the right to deliver there. According to the expert, the stability should have a higher score and the only weak point about this way of distribution is that the farmers' cooperative, Nortura, has less than 60% of the meat market in Norway (meaning it should have more). This is especially relevant in the case of this study, because all the selected farms were delivering to the cooperative.

Lastly, the topic of the social sustainability of sheep farms was discussed. According to the expert, the scores, and sub-themes of the social dimension in the results, do not cover the whole picture, and do not address the core of the problem which is that there are less and less people who want to farm. For the young people who want to start farming, it is almost impossible to find farms to buy because when farmers want to close down, they rent/ sell the land to neighboring farms who wants to become a bigger entity. The small farms almost never make it to the market. And to improve social sustainability, it is important to make land accessible for people who want to start farming.

4.Discussion

Several management practices which are known to support and hinder the sustainability of farming systems were identified in all eight farms. Using the SMART-Farm tool aided the process of benchmarking these practices and systematically evaluating them through a global sustainability perspective. However, some shortcomings were identified regarding the second objective which was using SMART-Farm as vertical MCA to obtain numerical values about degree of goal achievement for the farms in each of the sub-themes.

In all of the selected farms the livestock had a high number of days of access to alpine pasture, a finding that can be generalized to sheep farms in Norway as this practice integrated into the sheep production cycle in Norway, as discussed in Section 1.2. Differences between coastal and inland farms can be explained by the average higher temperatures in the regions they are located in, allowing longer grazing periods for the coastal farms. Additionally, two coastal farms (Farm_1 and Farm_8) which had the largest number of days of access to pasture for the animals (180 days) had older sheep breeds in the farms such as Blæset, Steigar, and Old Spæl Sheep, which are known for being able to graze outside throughout the colder months in the coastal areas (NIBIO, 2016b). For farms located inland, an increase of days of access to pasture might not be possible due to long periods of snow cover and animal welfare concerns in the winter months. In this case, the aggregated score in the assessment for this indicator (which was on average 60% for the farms) may not be possible to improve in the context of Norway. This finding points to a limitation in using a globally applicable tool, where the important factors such as differences of agro-climatic zones are not considered into the aggregated scores. The sheep production cycle in Norway is intended to maximize the use of outdoor pasture, and that is not taken into consideration in the assessment when the number of days of access to pasture for livestock is held to standards of e.g., sheep farms located in the continental or Mediterranean agro-climatic zones. However, it was evident that the production cycle according to SMART-Farm contributes to food quality, biodiversity, lowering of greenhouse gas emissions, and animal welfare.

The farms carried out many practices which contributed to high scores on the *Animal Welfare* theme. Besides access to pasture for ruminants, proper sized lying areas for animals, clean stables, lights in livestock housing, proper stocking density, proper storage of silage, and concentrate feed were all practices present in the farms. Most of these areas are covered by KSL, meaning that these practices were enabled by farmers' compliance with KSL. In the

context of Norway, an important issue for sheep farmers linked to animal welfare and alpine pasture are losses due to predators (Hansen & Rødven, 2014) which was not covered in the SMART-Farm assessment. Management practices regarding mitigation of this issue such as electronic surveillance, or collaboration with weekly attention to the sheep in the mountains would be useful indicators of sustainability in this context (Herlin et al., 2021). This kind of information would also be useful for learning about farmers' vigilance in regard to diseases that affect small ruminants (ibid.).

Within the environmental dimension, the farms had the highest scores in the *Water* theme. In this theme, the biggest difference between the coastal and inland farms was due to the annual water consumption, where the average annual water consumption for the coastal farms was 25.4 m3 per hectare per year versus 38.6 m3 for the inland farms. Besides this indicator, all of the farms had high scores in this theme. In general terms, the farms' location in western Norway may have had some impact on the score as six of them did not use any irrigation. This finding can be generalized to sheep farms as most of them are located in the western part of Norway (Asheim, 1999), which it puts them into a favorable position to receive high scores in indicators about water usage considering that these areas have some of the largest amount of annual precipitation in the country. This might be different for sheep farms located in South-East of Norway or for farms like Farm_8 which used irrigation as it is likely located in a rain shadow. Another major reason for high scores in this theme was no use of fungicides or pesticides, and low use of herbicides on the farms. That is another finding that can be generalized to sheep farms in Norway considering that in 2017, only 6% of meadows for mowing and pastureland were treated with herbicides, and none of these areas were treated with fungicides or insecticides (SSB, 2021a).

Practices concerning the use of plant protection agents also contributed greatly to the *Biodiversity* theme, where the farms also received high scores. However, the topic of biodiversity was one the topics most affected by issues that emerge when using context-generic frameworks (like SMART-Farm) to address context-specific topics. In the interview with Expert_1 it was uncovered that in the *Biodiversity* theme some of the indicators hold limited information in context of Norway, and some may even give incorrect information. For example, mowing intensity of 1-2 cuts per year of permanent grasslands in the sheep farms received a score of 0% in SMART-Farm. However, according to Expert_1, 1-2 cuts per year is recommended and is positive in terms of biodiversity in Norway. Other important indicators in this theme were about the area of woodlands on the farms which according to

Expert_1 would be appropriate to learn about biodiversity in other contexts. However, in Norway it is less relevant because these woodlands are usually plantations very low in biodiversity. During the interview it was established that the presence of red-listed ecosystems such as semi-natural grasslands, heathlands, and old-growth forests on the farms would give much more information regarding the farms' contribution to sustainability in terms of biodiversity. The expert also explained that for the context of Norway an increased grazing pressure per area in order to inhibit the encroachment of woodlands and scrubs in grasslands is an important indicator. At the end it was suggested that for an assessment like SMART-Farm tool, this could be simplified to an indicator about the use of mountain summer farms for transhumance grazing. This discussion illustrated issues that even for topics within the environmental dimension, context-specificity is necessary when scores aim to provide numerical values to describe the state of a system. Numeral integration tools such as vertical MCAs are used for decision-making purposes in research, labelling, and policy (Lindfors, 2021; Van Passel & Meul, 2012). Because of that, indicators which are not relevant for a particular context could give misleading information regarding the direction a system needs to improve on to become more sustainable.

Besides practices which support sustainability of sheep farming systems in the *Environmental Integrity* dimension, key areas for improvement were also identified. Results showed that in order to improve in the *Energy Use* and *Greenhouse Gases* sub-themes, the farms would have to produce more on-farm energy, in particular biogas, which none of the farms were doing. This solution has been popular in other European countries, but it has been seen as less cost-efficient and feasible in Norwegian farms due to small-scaled structures and long distances between farms (Steinshamn et al., 2016). However, the current assessment showed that there were short traveling distances to facilities e.g., slaughterhouses, for the farms located in Oppdal and Rennebu, suggesting that these farms are in close proximity to each other and other services. For example, a model like Agroecological Symbiosis (AES), where farms and/or businesses of an area use a shared biogas facility (Koppelmäki et al., 2019) could be an appropriate solution in this particular context. However, more detailed modelling would be needed to assess the feasibility of such solutions in the context of Norway. In the *Greenhouse Gases* sub-theme in SMART-Farm indicators such as stocking rate management, rotational grazing of livestock with improved genetic and nutritional management etc. which are included in the SAFA-Guidelines (Scialabba et al., 2013), were not included. These were important topics for the current assessment and would be helpful if they were incorporated

into the tool for future assessments of animal production systems. Although the farms varied in size and numbers of animals as shown in Section 2.1, these differences were not shown in the assessment.

Moving towards no externally sourced concentrate feed was also a key area for improvement. According to the results in SMART-Farm, a decrease of externally sourced concentrate feed in terms of economics would decrease farms' vulnerability by increasing the stability of production, stability of supply and the risk management. For the environmental dimension such shift would contribute to improvement in air quality and lowering greenhouse gas emissions. Moving towards no externally sourced concentrate feed is also one of the main challenges ruminant farming systems in Norway face. High quality concentrate feed is important for sheep farmers in Norway because during the lambing season the ewes need high-quality protein to support milk production, and lambs need it in order to be robust enough to be able to be in alpine pasture. However, due to poor conditions for producing high-quality protein in the country, there is a heavy reliance on imports (Animalia, 2021; Landbruksdirektoratet, 2021). Breeds such as NKS which produce more lambs enhance this requirement. This difference was not apparent in SMART-Farm results although there were different sheep breeds present on the farms. In a study, it was found that the use of concentrate would decrease if the first lambing happens when the sheep become two-years-old instead of lambing them in the first year (Bhatti et al., 2020). This strategy was adopted on Farm_7 due to the need for reducing the workload and it was evident in the calculated indicator about the quantity of human-edible feed given to the ruminants. The amount of concentrate feed used on Farm_7 was lower than in any other farm when the answers were recorded. However, this difference was not apparent in the aggregated scores which presents generic shortcomings which can occur in aggregation methods, in particular issues of eclipsing and ambiguity where aggregated indexes do not fully reflect the real quality of the state of the variable assessed (Swamee Prabhata & Tyagi, 2007). At the same time, the finding regarding the use of externally sourced concentrate feed points to the need for increased knowledge and research regarding alternatives for the topic. In this case studies directly targeting this issue would be more useful to complement and build on the findings from the SMART-Farm farm assessment.

A decrease of externally sourced concentrate feed would also contribute to higher scores in *Materials and Energy* theme. It was previously established that there was no use of fungicides or insecticides, and little use of herbicides in the sheep farms. This, however, did not account

for the use of chemical agents for growing concentrate feed used on the farms, which were externally sourced for all eight cases. This is important because according to a monitoring report about plant protection products in animal feed in 2020, glyphosate traces were found in 10 out of 15 samples of Norwegian barley for feed, and 1 out of 5 samples of Norwegian oats for feed (NIBIO, 2020). While these levels were below the national limits, it is important to identify practices in the supply chain in which the farms are indirectly involved in, which are not always evident in a farm-level assessments.

The means of production of external inputs are also tightly linked to topics within the social sustainability dimension in SMART-Farm. There are indicators in SMART-Farm which seek to inform whether certification have been accounted for the five most important farm inputs. Accounting for this criteria would increase the scores in many of the sub-themes in the social and governance dimensions. However, the assessment showed that only half of the farmers knew the origin of all bought-in-farm inputs, and on average half of the five most important inputs were produced domestically. This is important because knowledge regarding the origin of the inputs is an incentive to account for social and environmental criteria for it. It is important to shed light to this topic through future research because lack of this kind of information can inhibit action, and knowledge about available alternative choices (ENRD, 2019). The awareness regarding the topic of externally sourced inputs is also tightly linked to indicators in the Economic Resilience theme, especially in the *Value Creation* sub-theme where the farms scored lowest.

The *Value Creation* sub-theme is an especially important topic to discuss because ¨increased value creation¨ is one of the four agricultural policy goals in Norway (Regjeringen, 2021). In the interview with Expert_3, it was established that in Norway there is a lot of value created from farmers being a very stable workforce for export-oriented industries in rural areas which was not considered through the indicators in the *Value Creation* sub-theme. Additionally, as opposed to the idea that one farm should provide livelihoods for one farming family and create value through employment, sheep farmers' idea of value is more linked to carrying a culture and producing landscape. For example, one of the farmers stated that he needs not more than 2000 Norwegian Kroner a month for himself, and he is content as long as he gets to farm sheep.

Similar reactions from the farmers were also linked to topics within the social sustainability dimension. The farmers scored low in some of the indicators about the number of working hours during a week, and amount of holiday they take in a year. One farmer explained that to

him a holiday is when he goes hiking in the mountains to collect the sheep after the grazing period. Another farmer stated that being at the farm is a lifestyle he wants to live, and he did not feel that there is a need to take holiday from this work. Lastly, another farmer insisted that the answer to this question as ¨365 days of holiday¨, as *¨none of the working days at the farm feels like work¨*.

This shows that the motivation for the sheep farmers was not primarily for economic profit, but rather for the lifestyle that the activity provides. This is important to establish because in the interview with Expert_3 it was stated that a problem linked to falling numbers of sheep farms is that young people are not interested in continuing farming. The common understanding relating to the topic of farming is that it is not economically viable because of the low profitability and long working hours (Forbord et al., 2014). While the economic resilience is very important, more attention needs to be directed to other types of ¨value¨ in a sustainability assessments. The inclusion of narratives and worldviews in sustainability assessments has been called for in different bodies of literature and one proposed way to address this issue has been through an increased participation of stakeholders not only in interpreting results but throughout the whole process of selecting, weighting, and aggregating indicators (Bell & Morse, 2008; Bond & Morrison-Saunders, 2011; Giampietro & Ramos-Martin, 2004). This kind of solution is especially suggested for the social sustainability dimension which is particularly difficult to operationalize (Boström, 2012; Röös et al., 2019).

Expert_3 established that even for young people who want to farm, it is usually very difficult to find a farm to buy because the small farms rarely make it in the market. There is an indicator in SMART-Farm which asks about the possibility of a risk that smallholders or local communities were disposed in order to establish the farm being assessed. While ‘dispossession’ is not relevant in the context of sheep farms in Norway, a meaningful indicator would rather address whether the pre-existent farm whose land is now utilized by a larger farm (typically neighboring farm) has been out in the market before land was rented out/sold. In the social context, this would illustrate the trade-offs between short-term benefits for a single farm versus contribution to the larger community if new people take over a smaller farm.

This also links to the discussion with Expert_3 where it was explained that the indicators do not address a core problem, referring to the continuous decline in sheep holdings in Norway (Appendix 3). This is important to consider because SMART-Farm adapts a mixed perspective on sustainability (meaning it aims to answer both questions: ¨Is the entity

economically healthy and developing on a resilient pathway? ¨ and ¨Does the entity contribute to sustainable development of society? ¨) (Appendix 15). This supports findings from a study done with Swedish livestock farmers, where it was concluded that SAFA indicators fail to capture several aspects which are important for describing the social situation for the farmers there (Röös et al., 2019). Moreover, this study found that there were many aspects in the social dimension which were more appropriate for contexts with working conditions much less controlled than in Sweden (ibid.). This also applies to the context of Norway and results from this study, where many of the indicators related the *Labour Rights* theme (including *Forced Labor* and *Child Labor*) are not areas where a social sustainability assessment needs to focus.

Lastly, within the economic dimension, the results from SMART-Farm showed a lower score for the stability of market for the sheep farms compared to other sub-themes. However, the indicators did consider that reliance on a single buyer meant that the farms were part of the farmers' cooperative where they sold the meat. In Norway the cooperative system has been in place for decades, and the way it is organized ensures that the farmers will sell their products. This was discussed in the interview with Expert_3 where it was established that dependency on one buyer is not a hindering factor in the context of Norway; rather it increases the stability of market and provides farmers a secure delivery. In the context of Norway, other aspects of this topic need to be considered (e.g., how much power do the farmers have to influence decisions) in terms of sustainability.

In the *Good Governance* dimension, the inland farms performed better than the coastal farms for five indicators linked to involvement in improving laws and regulations, education/training for the farmer including sustainability training, and environmental responsibility in procurement. A reason for this could be that there is easier and less time-demanding access for inland farms (located in Oppdal and Rennebu) to training and information. Another reason could be more established farmers unions and/ or more connection with the agricultural consulting services (NLR, Norwegian Agricultural Extension Service) in Trøndelag due to the county being the largest provider of animal products produced in Norway. However, the inland farms also had a lower proportion of farms own capital (higher loans), which could affect the perceived need for more engagement to shape laws and policies that affect them. A reason for lack of differences found between the two regions using a t-test was likely due to the small sample size.

The farms' low scores regarding many sub-themes within the *Good Governance* dimension (e.g., *Mission Statement, Full-Cost Accounting*) can be explained by the fact that these indicators are drawn from corporate sustainability reporting literature as explained in Curran et al. (2020). These indicators were not relevant for the small/medium farms in the present study.

4.1 Implications and Future Directions

These findings illustrate the different components and trade-offs present in sheep farming systems which must be taken into consideration when discussing their sustainability. These components risk being overlooked when single-impact indicators are used to form an understanding of the sustainability of a production system. Here using SMART-Farm tool provided an analysis which can be used as a starting point for further research. This was also concluded in Schader et al. (2016). Considering that this study dealt with 302 indicators spread across four dimensions, it was difficult to go in-depth into one topic and find major differences between farm cases (e.g., differences in amount of concentrate feed used). For this, more detailed studies are necessary. In Schader et al. (2016) it was concluded that such studies, which are more targeted to single topics are also needed for the topics of biodiversity, or greenhouse gas emissions. Coincidentally, these two topics, together with the social dimension, the ones that needed most contextualization after conducting the SMART-Farm assessment for the sheep farms.

Using an expert elicitation method made it evident that using the SMART-Farm tool to attain precise numerical measurements of topics such as biodiversity, GHG emissions, or social situations in the context of Norway may not be sufficient. Implications of using a multi-criteria assessment for the second objective in the present study are supported by previous findings in the book by Bell and Morse (2008), where the use of context-generic sustainability indicator tools as vertical tools is referred to as ¨bad application of good science¨. In SMART-Farm a Delphi process was implemented where 67 experts from 21 countries evaluated the uncertainty of the indicator weights, and Monte Carlo Simulations were also used to incorporate uncertainty into the aggregated results (Schader et al., 2019). However, these standardized sets still impose some value-based choices. These choices often do not take into consideration local specificities (Gasso et al., 2015). However, although using SMART-Farm Tool as a vertical MCA in the context of Norway might present some shortcomings regarding context specificity, using the expert elicitation method to evaluate these results lead to

uncovering some knowledge gaps about the topic of sustainability of sheep farming in Norway.

For example, categorization of grasslands into permanent, or temporary grasslands during the SMART-Farm assessment was not straightforward because in Norway a different categorization system is used (¨innmarksbeite¨, ¨overflatedyrka¨, and ¨fulldyrka¨), which according to Expert_1 is based on what the farmers use the area for, and not how they are managed. In terms of biodiversity, having this classification does not provide sufficient information. However, more developed mapping systems for ecosystems such as semi-natural grasslands in Norway would be useful to learn about the sustainability of a farm; if these ecosystems are present in the farm area or used for grazing.

Also, when discussing the indicator about access to pasture for ruminants with Expert_2, it was difficult to judge whether its' weight in the *Greenhouse Gases* sub-theme in the Norwegian context should be different because we do not yet know whether the albedo effect from open landscape that grazing of sheep counterbalances the GHG emissions they produce. It was acknowledged that it is also still unknown to what extent grazing is a sound strategy for lowering methane emissions from sheep in Norway.

Including expert elicitation in the study to evaluate the results did not directly address the need of incorporating stakeholder participation in the assessment, nor did it aggregate the data from it into the scores. The validity of this method can even be questioned (Morgan, 2014). However, applying this method also showed that there are many adjustments that could be made to indicators to provide more information about the sustainability of a specific context, and become a strong basis for further research. Although the goal of the SMART-Farm tool is to generate results that are comparable, here it was evident that adjusting indicators to the specific context of Norway would provide more meaningful data regarding the state of the assessed farms. This is especially important when inquiries with larger samples sizes using SMART-Farm need to be conducted, which is a resource intensive process.

Assigning indicator weights to reach a sustainability index would still be a very complex even when having local experts participate in the process. As described by Expert_1 during the interview we have not yet landed a common understanding of what sustainability entails and we cannot say, for example that biodiversity is more important than climate, or that water is more important than biodiversity and vice versa. On the other hand, this statement illustrates the importance of considering trade-offs within the topic of sustainability and it is important

that methods like SMART-Farm which take them into consideration continue to get improved and developed. If the tool should be used as a vertical MCA, there needs to be an increase in context-specificity and inclusion of local experts and stakeholders (e.g., farmers) in selecting indicators, and determining their weights. If the tool should be used as a horizontal MCA, to benchmark practices (as used here), to support decision-making for future research inquiries, or for sustainability learning as used in Halland et al. (2021), then SMART-Farm is an appropriate.

5. Conclusion

Shedding light on the multi-faceted topic of sustainability of sheep farming systems in Norway using a multi-criteria sustainability assessment was the main aim of this research. Assessing the selected sheep farms was useful for the first objective which was to identify management practices which support or hinder the sustainability of these systems. There were many management practices present in the farms which contributed to their sustainability including: high animal welfare, high numbers of days of access to pasture for the livestock, no/low use of synthetic chemicals, good water management, and high quality of life for farmers. These practices, according to SMART-Farm, contributed to animal health, food quality, biodiversity, greenhouse gases mitigation, and decent livelihoods. Management practices which hinder sustainability and key areas for improvement were also identified: increased on-farm energy production, increased farmers' knowledge about external inputs used, and decreased use of externally sourced concentrate feed. In SMART-Farm such improvements would increase the stability of production, stability of supply, risk management, product information, contribute to greenhouse gas mitigation, higher air quality, and in turn better use of energy and materials.

Conducting this assessment using SMART-Farm tool, together with the expert elicitation were useful for learning about what is important in terms of global sustainability, discovering where the farms stand in that respect, and identifying knowledge gaps for the specific context. This further contributed to placing the topic of sustainability of sheep farming systems in Norway into a perspective which recognizes the complexity presented by the need to improve production systems in consideration to both humans and ecosystems.

Using SMART-Farm tool as a vertical MCA which was the second objective of this study, indicated a high degree of goal achievement for the farms across dimensions. The farms scored on average above 80% on the Environmental Integrity and the Social Well-being dimensions, and lower on the Economic Resilience and the Good Governance dimensions (76% & 71% respectively). The expert elicitation method provided insight into shortcomings which must be considered when interpreting these aggregated results and using them for decision-making. These shortcomings were mostly linked to lack of context-specificity and stakeholder involvement in the weighting and aggregating process.

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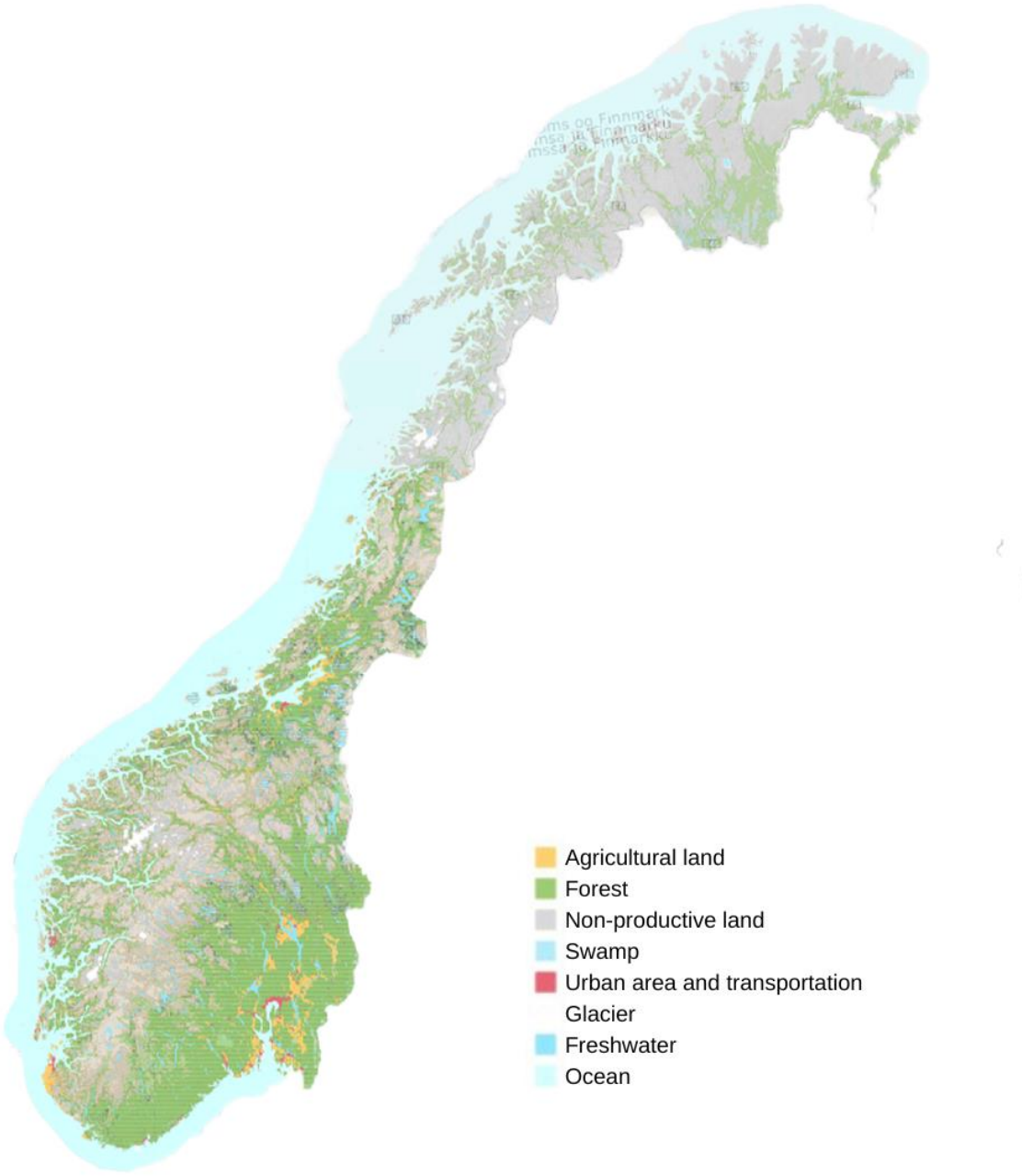
7. Appendices

Appendix 1. Land resource map. Source: Arealressurskart AR250 (NIBIO, 2016a)



Appendix 2. Sheep Production Cycle in Norway

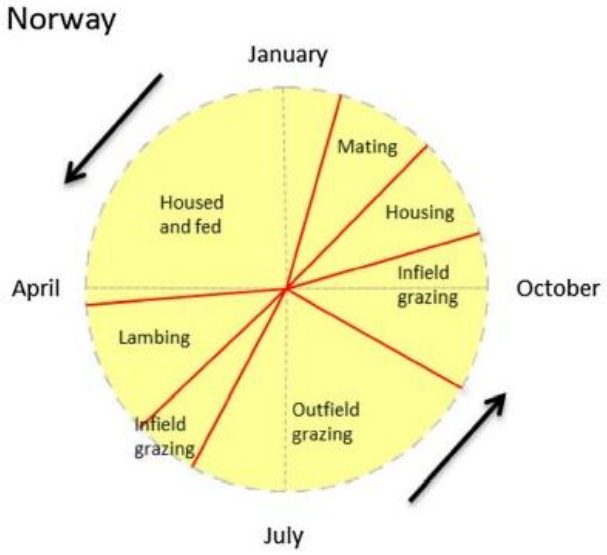


Figure 9. A typical year on a sheep grazing farm in Norway. Reprinted from Ross et al. (2016).

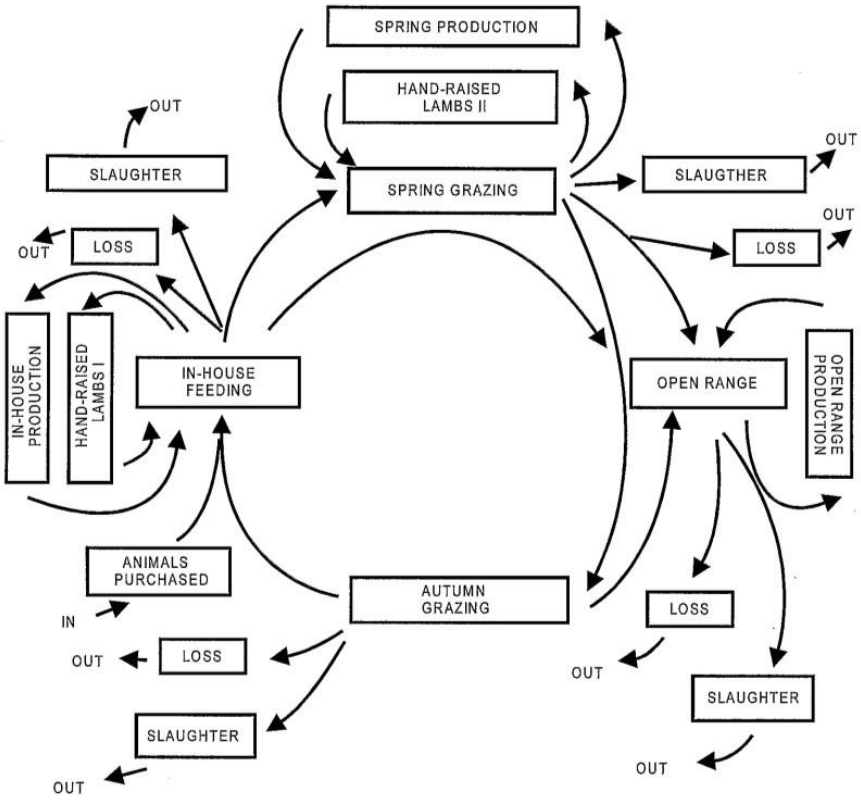


Figure 10. Yearly production cycle in the Norwegian sheep farming system. Reprinted from Asheim (1999).

Appendix 3. Statistics About Numbers of Winter Fed Sheep in Norway and Sheep Holdings in Norway

Sheep flock sizes are location dependent but have been historically dominated by 50-99 size of flock range. In the last 20 years however, flocks with more than 150 sheep have been increasing (SSB, 2022). In 2022, the total recorded number of winter feed sheep in Norway was 932,841 and the number of holdings was 13,356 (SSB, 2022). Data of winter feed sheep numbers from 1998 to 2022 presented in Figure 9 show generally stable numbers throughout the years, with some declining trend from the year 2017. However, Figure 10 shows a decline in sheep holdings. These numbers indicate a trend towards fewer and bigger sheep farms in Norway.

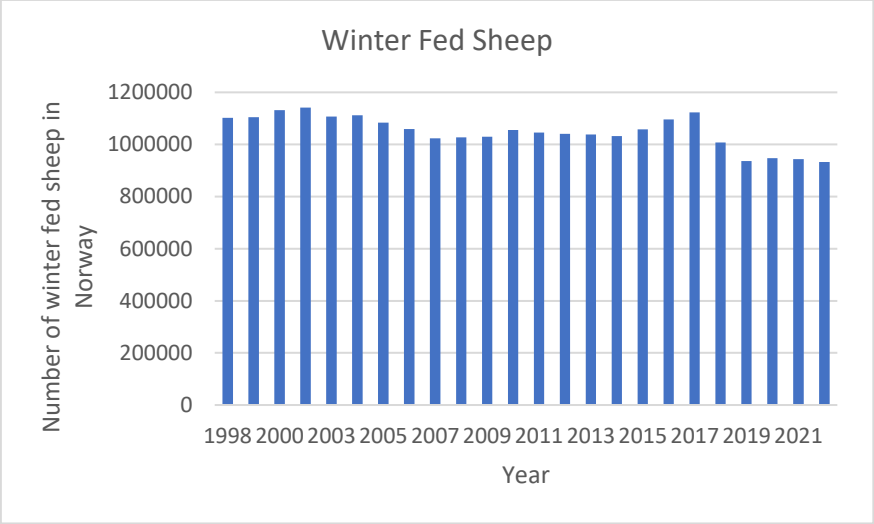


Figure 11. Winter feed sheep numbers from 1998-2022 in Norway. Generated with data from SSB (2022).

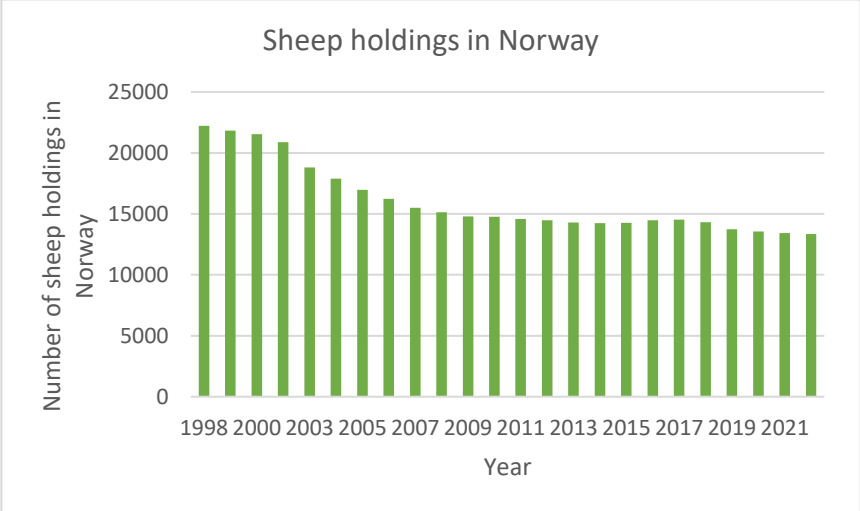


Figure 12. Numbers of sheep holdings from 1998-2022 in Norway. Generated with data from SSB (2022).

Appendix 4. Sustainability Assessment Tools and their Characterization

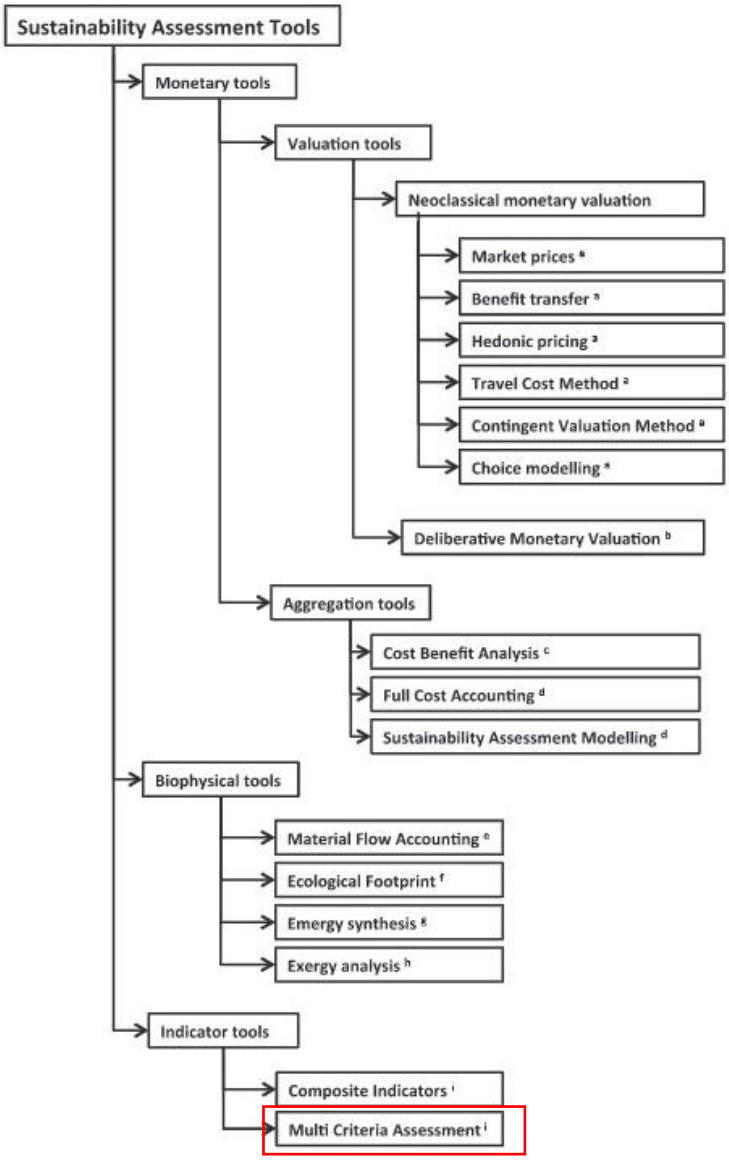


Figure 13. Topology of sustainability assessment tools. Reprinted from Gasparatos and Scolobig (2012).

To take actions towards more sustainable agriculture, knowledge on different practices and their potential to hinder, or support sustainability is needed. For many years, agricultural research has had a focus on land productivity, crops, and farming inputs (Struik et al., 2014). However, as environmental concerns grew in the 1960s, ecological sustainability of agriculture became a crucial aspect to research and measure to reduce ecological footprint and environmental degradation (Struik et al., 2014). The science of ecology has provided plenty of methodological tools to quantify ecosystem characteristics such as energy flows, nutrient cycling, species dynamics and interactions, and habitat modifications (Gliessman, 2014). These methodological tools have been used to study agroecosystems and attempt to define their carrying capacities, which are a key element in the sustainability concept (Bell & Morse,

1999). In more recent years, research on sustainability assessment has pointed out that the ecological dimension of sustainability is favored in modeling and assessments (Binder et al., 2010; von Wirén-Lehr, 2001). That is considered a shortcoming (ibid.) because humans are a central part of agricultural systems and measuring the sustainability of the life quality of people involved must be also taken into consideration (Gliessman, 2014). This is important because today 2 billion people depend on agriculture for their livelihoods, and the agricultural sector is considered the backbone of rural economy and development (Horlings & Marsden, 2011). Decision-making and management practices carried out by people directly affect the environmental sustainability of farming systems.

Because of that, besides ecological analyses which provide useful information to move towards ecologically based approaches, a comprehensive understanding of agriculture as a socioecological system is needed (Mendez et al., 2015, p. 4). To gain this understanding, methodologies developed by rural and environmental sociologists which consider access to economic resources, social networks, political or economic status, and empowerment are used (Gliessman, 2014). These methodologies provide pathways for incorporating economic and social dimensions of agroecosystems in sustainability assessments.

These methodologies also focus on different scopes and scales, some assessing certain pillars of sustainability, and some covering a wider variety of these pillars (Cinelli et al., 2014). Gasparatos and Scolobig (2012) group sustainability assessment tools into three general categories according to assumptions and perspectives for valuation: monetary, biophysical, and indicator-based sustainability assessments (Figure 11). Monetary tools such as the cost-benefit analysis are used to estimate net-social benefits through aggregation which includes commensurability of issues of sustainability. Biophysical tools measure physical parameters regarding natural resources and incorporate them into a unit of measurement (e.g., ecological footprint). Indicator-based tools include methodologies which deal with selection of indicators, weighing, normalization to perform sustainability assessment. The indicator-based tools allow for inclusion of environmental, economic, and social dimensions of systems in assessments, thus providing a non-reductionists (single metrics indicators) approach for which researchers have called for (Binder et al., 2010; Gasparatos et al., 2008; Kaufmann & Cleveland, 1995). These tools are especially appropriate when there is a need for a broader picture of sustainability and its legitimate perspectives (Gasparatos & Scolobig, 2012). Multi-criteria analyses (MCAs) are indicator-based tools which encompass different areas, perspectives, stakeholders, values, and uncertainties (Cinelli et al., 2014). Moreover, they

enable the exploration of the balance between pros and cons of different alternative, and as a result supporting decision making (Geneletti & Ferretti, 2015). MCAs are considered a sound methodology for assessing sustainability, however specific targets or goals should be set for different issues in the indicators (Gasparatos & Scolobig, 2012).

Appendix 5. An example of differences in annual precipitation in the same region

Table 5. Three stations in the same region and differences in annual precipitation. Source: Meteorologisk institutt (MET).

Name	Year	Annual Rainfall
Balestrand	2021	1348.9
Skardsbøfjellet	2021	1032.8
Skjolden	2021	745.8

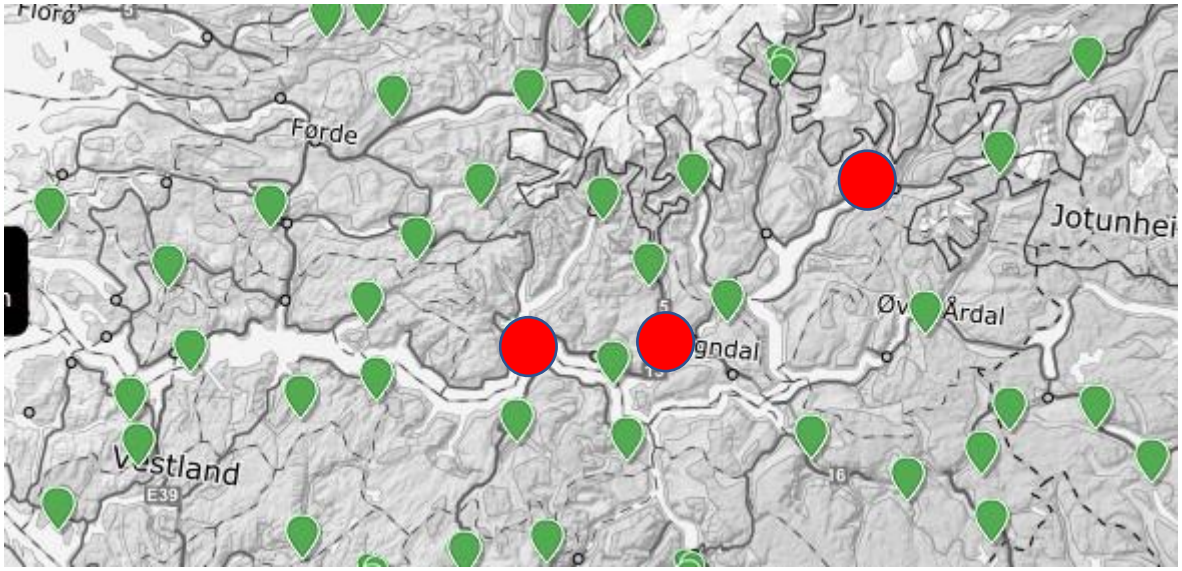


Figure 10. Location of the stations from Table 5. showing proximity. Source: Meteorologisk institutt (MET).

Appendix 6. Information about the Sheep Breeds Present on the Eight Selected Farms

Today in Norway, 74% of the ewes are Norwegian White Sheep (NKS) (Animalia, n.d.). The NKS is a composite breed, with emphasized meat production traits (although it is considered dual-purpose for meat and wool), well known for high growth rates and prolificacy (Oliveira et al., 2020). Blæset breed is a Norwegian sheep breed which is considered endangered, worthy of conservation since 2008 (Holene, 2017a). Today there are close to 1,000 winter-fed ewes of this breed in Norway, but it has been a struggle to keep the stocks high because farmers get paid less for black/brown wool compared to the white (NSG, n.d.). The Steigar breed is a productive breed with good wool quality. There has been an increasing interest in this breed, and since 2019 it is no longer endangered (Holene, 2017c). Gammelnorsk spælsau (Old Spæl Sheep) is considered the original sheep breed of Norway. It was a common breed until the 17th century, until other breeds with higher slaughter weights, and finer wool started being imported from the UK. However, since the 1910s there has been a growing interest in this breed and from 2015, the it was no longer considered endangered (Holene, 2017b).

Appendix 7. Information about the Regions the Eight Selected Farms were located.

Oppdal is a municipality in the Trøndelag county. Oppdal is Norway's largest 'sheep municipality', where more than 40,000 sheep graze there every summer. The municipality has an area of 2,2274 km2, and a population of 7256 inhabitants. 6,8% of Oppdal's population is employed directly in agriculture, and there are 220 active farms with 74,000 acres productive agricultural area (Bondelaget, n.d.). Oppdal is a mountainous municipality and today it is known for having one of Norway's largest alpine resorts, and around 4,234 leisure cabins (ibid.). Rennebu is also a municipality in the Trøndelag county which borders Oppdal. It has an area of 942 km2 and a population of 2,556 inhabitants (SSB, n.d.). Around 16,000 sheep graze in Rennebu in the summer. The main activities in Rennebu are linked to agriculture, forestry, and tourism industries. Sogndal is a municipality in the Vestland county. It has a total area of 1258 km2, and a population of 12,198 inhabitants (SSB, n.d.). Total number of winter-fed sheep holdings in the Vestland county in 2022 was 3543 (SSB, 2021b). Heim municipality in the Trøndelag county. It has an area of 1024km2 and a population of 5880 inhabitants (SSB, 2021b).

Appendix 8. SMART-Farm Tool Sustainability Performance Formula

Components of the formula as described in Schader et al. (2016).
DGA- degree of goal achievement
x- farm
i- sub-theme
(n=1 to N)- sum of impacts of all indicators
i (IMni)- relevant sub-theme
N (ISnx)- indicator
ISmaxn- maximal performance possible

Appendix 9. Structured Interviews

Structured interviews standardize the process of asking questions and recording answers, and if properly executed, they provide a highly valid strategy in both qualitative and quantitative research (Bryman, 2012). Such interviews contain a set of closed questions which are asked to the interviewee, and these questions often allocate the answers in categories, or provide numerical factors for indicators. Consequently, closed questions facilitate the processing of the data by pre-coding it into categories prior to the interview (Bryman, 2012). During the interviews for the SMART-Farm assessment, occasionally, when recording and categorizing answers me and the advisor discussed which category best reflected the answer of the interviewee. There were also discussions regarding questions which were potentially irrelevant in the context of Norway. As our backgrounds were different, being able to discuss issues that one encounters using a tool designed for global use, two interviewers increased the validity of this study.

According to Bryman (2012), structured interviews likely have one specific individual as an object to questioning, and it is advisable to discourage the participation of more than one interviewee. However, in the case of the interviews conducted for this study, for the most part, the focus was not the farmer but the farming system. The participation of the second interviewees offered more insight, especially in questions where they had to recall situations (e.g., conflict resolutions over resources questions).

Appendix 10. My SMART-Farm Training Experience

During the summer of 2022, I participated in the first Module of SMART-Farm User Training course by the Institute for Organic Agriculture (FiBL). Module 1 of the training includes the theoretical part, which was held online, and the practical part was held in the University of

Wageningen, Netherlands. The practical part was a one-week course aimed at training experts in the practical application of the SMART Farm Method for the sustainability assessment and monitoring of farms. To do this, during the course we spent a couple of days on an organic dairy farm in Wageningen. Although we had already finished the process of conducting the interviews for this thesis, my participation in the training aided my learning of the SMART-Farm software, and especially the thinking behind the SMART method. This equipped me with additional knowledge for interpreting the results from the interviews conducted.

Appendix 11. Explanatory Design

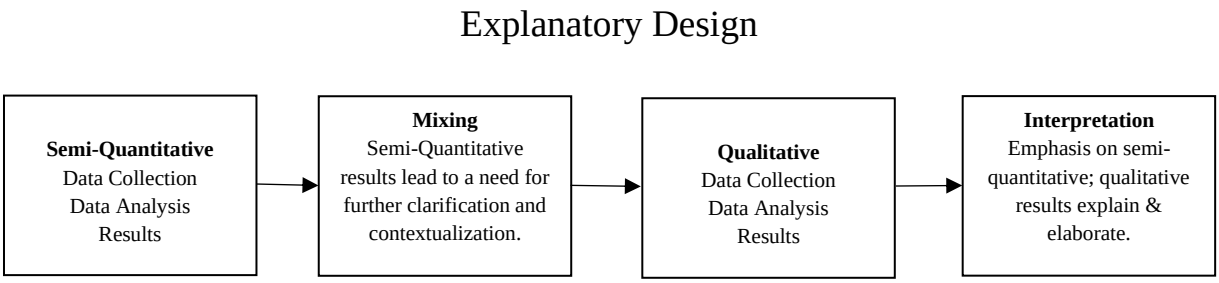


Figure 2. Adjusted steps of the Adapted Explanatory Design as used in this paper. Adapted from Ivankova et al. (2006)

The explanatory research design is considered a mixed method. In this design, first quantitative data is collected and analyzed (Ivankova et al., 2006). Then, in need for further clarification and contextualization, qualitative data is collected and analyzed. In the interpretation part, results from both parts are combined, where thesis is still emphasis on the quantitative findings (ibid.). In the present study, the data gathered with the SMART-Farm tool was considered semi-quantitative. The qualitative findings were incorporated to contextualize some of the findings which were a subject to the shortcomings from using a context-generic assessment.

Appendix 12. Expert Elicitation Interviews Coding Sample

Initial Code	Category	Theme
¨Yeah, this is always a problem when we I work a lot with seminatural grasslands. And it's always a problem that we have no maps of this in Norway the mapping system is based on not the ecosystem per se but what the area is used for. is based on what the farmers used area for and not like how they are managed. Umm yeah. ¨	There is no data regarding an indicator in SMART	More knowledge, research, monitoring is needed
what we don't know is how many animals versus the albedo versus, you know only forests open landscape for the reflection of the radiation. How does that counterbalance each other? We don't know that. But that is really something that needs	We do not have knowledge regarding trade-offs between indicators and sub-themes within SMART.	More knowledge, research, monitoring is needed

to be looked more into and it's a very, very, very, very difficult thing to measure. But it's too easy to say that the animals produce enteric methane, so they are a problem. Because they do produce a lot of other things and they do produce open landscape, which is a benefit due to the albedo effect. But how those counteract each other? We don't know		
¨There is a lot going out on the other end, and that produces a lot of methane. And when they are on a pasture, we don't really know. In a uniform pasture, a monoculture pasture, we can see OK, they are eating so much, and we know that they're eating and the quality of grass. But once they're in the mountain pasture, they might have 70 or 100 or 150 different plant species they can feed on, and we don't know which they're eating or what is the proportion of them. So, we don't know so it's very difficult¨	We do not know how much an indicator should weight in SMART in the context of Norway	More knowledge, research, monitoring is needed
¨I will guess that a lot of this woodland in Norway are plantations. And at least you have to separate out plantations if you should make any meaning of it. I think because the plantations are not good for biodiversity in any way. But maybe it makes more sense in other countries where woodlands are scarce. But in Norway we have so much woodland. All farmers have a lot of woodland, and they are used for timber productions, most of it. ¨	The indicator weight is too high for Norway	Indicators/weights are not relevant in the context of Norway
Yeah, but the stability of market, I mean they are, delivering they kind of have a secure delivery of their products... I mean Nortura doesn't have more than 60% of the meat market in Norway. So that is actually a very weak part of that. I mean compared to the dairy market which Tine has 95% or so.	The indicator gives the wrong information in the context of Norway	Indicators/weights are not relevant in the context of Norway

Appendix 13. Descriptive Statistics for the Sub-Themes in different Dimensions

Descriptive Statistics for the Sub-Themes in the Good Governance Dimension

Sub-themes	Mean	Median	Min	Max	SD	RSD
Mission Statement (%)	45.50	43.5	40	52	5.07	11.15
Due Diligence (%)	85.63	85.5	84	88	1.32	1.54
Holistic Audits (%)	51.63	51.5	47	57	3.46	6.71
Responsibility (%)	53.13	52.5	48	63	4.83	9.10
Transparency (%)	56.38	56	52	62	3.20	5.67
Stakeholder Dialogue (%)	90.75	89	89	96	3.03	3.34
Grievance Procedures (%)	100.00	100	100	100	0.00	0.00
Conflict Resolution (%)	100.00	100	100	100	0.00	0.00
Legitimacy (%)	95.75	96	94	97	0.83	0.87
Remedy, Restoration & Prevention (%)	84.00	84	84	84	0.00	0.00
Civic Responsibility (%)	41.75	35	27	73	14.42	34.54
Resource Appropriation (%)	91.13	92	89	92	1.17	1.28
Sustainability Management Plan (%)	65.63	67.5	57	69	4.30	6.55
Full-Cost Accounting (%)	51.13	50	45	62	6.64	12.99

Note: N = 8.

Descriptive Statistics for the Sub-Themes of Environmental Integrity Dimension

Sub-themes	*M*	*Median*	*Min*	*Max*	*SD*	*RSD*
Greenhouse Gases (%)	66.38	66	63	70	2.06	3.10
Air Quality (%)	75.13	75	73	77	1.17	1.56
Water Withdrawal (%)	92.63	94	78	100	6.50	7.02
Water Quality (%)	89.88	91.5	84	93	3.06	3.40
Soil Quality (%)	81.00	80.5	78	86	2.50	3.09
Land Degradation (%)	92.63	92.5	89	100	3.12	3.37
Ecosystem Diversity (%)	80.13	80.5	72	89	4.57	5.70
Species Diversity (%)	80.75	82.5	70	85	4.60	5.70
Genetic Diversity (%)	79.88	78	71	88	6.15	5.70
Material Use (%)	95.50	96	94	96	0.71	0.74
Energy Use (%)	70.00	70	68	73	1.41	2.01
Waste Reduction & Disposal (%)	91.88	92	90	93	1.17	1.27
Animal Health (%)	88.88	88.5	88	91	1.05	1.18
Freedom from Stress (%)	86.63	86	85	89	1.49	1.72

Note: N = 8.

Descriptive Statistics for the Sub-Themes of Economic Resilience Dimension

Sub-themes	*M*	*Median*	*Min*	*Max*	*SD*	*RSD*
Internal Investment (%)	78.38	79	69	85	4.72	6.02
Community Investment (%)	75.88	75.5	69	87	5.80	7.65
Long-Ranging Investment (%)	79.38	79	72	89	5.29	6.66
Profitability (%)	74.13	74.5	69	80	3.76	5.07
Stability of Production (%)	81.75	82	80	83	1.20	1.47
Stability of Supply (%)	79.75	80	78	81	1.09	1.37
Stability of Market (%)	68.38	68.5	63	76	3.77	5.52
Liquidity (%)	80.50	85	70	87	6.91	8.58
Risk Management (%)	89.88	91	84	93	2.89	3.22
Food Safety (%)	96.50	98	92	99	2.65	2.74
Food Quality (%)	89.38	88	87	96	2.69	3.01
Product Information (%)	66.13	66.5	62	69	2.76	4.17
Value Creation (%)	52.13	51	46	60	4.34	8.33
Local Procurement (%) *	67.71	64	56	83	8.71	12.87

Note: N = 8.
*N=7 Data from Farm_5 excluded because of inconsistency.

Descriptive Statistics for the Sub-Themes of Social Well-Being Dimension

Sub-Themes	**M**	**Median**	**Min**	**Max**	**RSD**
Quality of Life (%)	87.13	87.5	82	90	2.59
Capacity Development (%)	63.50	66.5	40	83	23.42
Fair Access to Means of Production (%)	90.25	89	80	100	7.00
Responsible Buyers (%)	91.38	92.5	83	94	3.87
Rights of Suppliers (%)	85.88	88	81	88	3.26
Employment Relations (%)	90.88	91	88	93	1.50
Forced Labour (%)	92.50	94	87	95	2.76
Child Labour (%)	90.75	92	87	93	2.19
Freedom of Association and Right to Bargaining (%)	92.88	94	89	94	1.82

Non Discrimination (%)	78.50	78.5	65	87	7.46
Gender Equality (%)	90.88	93	78	94	5.51
Support to Vulnerable People (%)	71.75	75	57	75	8.24
Workplace Safety and Health Provisions (%)	96.38	96	93	99	1.72
Public Health (%)	96.38	99	91	99	3.63
Indigenous Knowledge (%)	100.00	100	100	100	0.00
Food Sovereignty (%)	94.13	91	89	100	4.88

Note: N = 8.

Appendix 14. T-Test for comparing coastal and inland farms.

t-Test: Two-Sample Assuming Equal Variances

	Inland	*Coastal*
Mean	81.68534	79.71552
Variance	184.8214	265.126
Observations	58	58
Pooled Variance	224.9737	
Hypothesized Mean Difference	0	
df	114	
t Stat	0.707231	
P(T<=t) one-tail	0.240433	
t Critical one-tail	1.65833	
P(T<=t) two-tail	0.480866	
t Critical two-tail	1.980992	

Appendix 15. Characterization of the SMART-Farm method

Table 6. Characterization of the SMART-Farm method according to the topology for characterizing and comparing the scope of the sustainability assessment approaches. The green check marks show that SMART-Farm adopts the class for the criteria. The topology for Criteria and Classes is adapted from Schader et al. (2014).

Criteria	Classes	SMART-Farm method
Primary Purpose	• Research	✓
	• Monitoring	✓
	• Policy advice	-
	• Certification	-
	• Farm advice	✓
	• Self-assessment	-
	• Consumer Information	-
	• Landscape Planning	-
Level of assessment / System Boundaries	• Agricultural sector level	-
	• Landscape / region	-
	• Field, farm, or company level	✓
	• Product / supply chain level	-
	• Standards level	-
Geographical scope	• Applicable globally	✓
	• Applicable to a specific country or region	-

Sector scope	• General, i.e., applicable to all agricultural / food products or farm types	✓
	• Applicable to specific products or farm types	-
Thematic scope	• Environmental	✓
	• Social	✓
	• Economic	✓
Perspective on sustainability	• Farm/business perspective (Is the company economically healthy and developing on a resilient pathway?)	-
	• Societal perspective (Does the company contribute to sustainable development of society?)	-
	• Mixed perspective (Farm / business perspective and societal perspective are mixed)	✓

Appendix 16. Indicators from SAFA-Guidelines.

List of SAFA Indicator Questions. Reprinted from Scialabba et al. (2013).

Environmental Integrity Dimension

Energy Saving Practices: What practices and activities has the enterprise implemented that effectively reduced the energy requirements in its operation?
Energy Consumption: How has the total direct energy consumption changed during the last 5 years?
Renewable Energy: What share of total direct energy use is generated from sustainable renewable sources?
Waste Reduction Target: Has the enterprise set a target in reducing the generation of waste, as well as the hazardousness of this waste, in or by its operations?
Waste Reduction Practices: What practices and activities have been implemented that effectively reduced waste generation in the enterprise's operation?
Waste Disposal: How much solid waste does the enterprise generate that is not segregated, stored and treated such that it is rendered non-hazardous to humans and environment at the point of release from the enterprise?
Food Loss and Waste Reduction: What is the share of food that is lost or wasted in the enterprise's operations and what share is reused (charities, feed), recycled or recovered (compost, bioenergy)?
Animal Health Practices: What activities and practices has the enterprise implemented that effectively promoted the health of animals, while reducing the use of veterinary drugs and preventing animal losses due to disease and injuries?
Animal Health: What share of the enterprise's animals are healthy and have not required any treatment with veterinary drugs against illness or disease?
Humane Animal Handling Practices: Which practices and activities has the enterprise implemented that effectively reduced the suffering and risk of injury of animals during all phases of their life, including transport and killing?
Appropriate Animal Husbandry: What share of the enterprise's animals have the possibility to behave according to their specific needs?
Freedom from Stress: What share of the enterprise's animals have sufficient freedom to move around, live free of pain, discomfort and distress all the time, during all phases of their life, including during transport and killing?
GHG Reduction Target: Has the enterprise set a target in reducing GHG emissions?
GHG Mitigation Practices: Which activities and practices has the enterprise implemented that have effectively reduced GHG emissions?
GHG Balance: What is the net direct GHG emission (i.e. annual emissions minus sequestration) of the enterprise?
Air Pollution Reduction Target: Has the enterprise set a target in reducing the emission of air pollutants?
Air Pollution Prevention Practices: Which activities and practices has the enterprise implemented that have effectively reduced air pollutants?
Ambient Condentration of Air Pollutants: What is the percentage of days of the year when standard air pollution values have been exceeded in the surroundings of the enterprise?
Water Conservation Target: Has the enterprise set a target for reducing water consumption or water withdrawals?
Soil Organic Matter: On what share of the utilized land are content and quality of soil organic matter high in consideration of the local climate and bedrock?
Land Conservation and Rehabilitation Plan: Does the enterprise have a plan which describes the steps of conserving or enhancing soil health and rehabilitating degraded soils?
Land Conservation and Rehabilitation Practices: Which effective soil conservation techniques and/or rehabilitation measures have been implemented and/or regularly practiced in the operation?
Net Loss/Gain of Productive Land: What is the ratio between rehabilitated land and degraded land in the enterprise's operations?
Landscape/Marine Habitat Conservation Plan: Does the enterprise have a plan that describes how to conserve or rehabilitate a diversity of habitats within its sphere of influence?
Ecosystem Enhancing Practices: What activities and practices have been implemented that have effectively enhanced the functioning of ecosystem services, as well as the connectivity of ecosystems?
Structural Diversity of Ecosystems: On what share of utilized area does the enterprise have a high structural diversity of habitats?
Ecosystem Connectivity: What share of the natural and semi-natural ecosystems in the operation are connected with similar ecosystems (within and adjacent to the operation's borders) in a way that allows an exchange between populations of key species?
Land Use and Land Cove Change: Were any primary habitats (e.g. wetlands, primary forests, grasslands, protected waterways) converted during the last 20 years by the enterprise's operations, including areas where its inputs are sourced?
Species Conservation Target: Has the enterprise set a target for the conservation and rehabilitation of the populations of rare and endemic species in its sphere of influence?
Species Conservation practices: What activities and practices has the enterprise implemented to protect , maintain and/or rehabilitate the integrity of populations of wild plants and animals in its sphere of influence?
Diversity and Abundance of Key Species: Have the diversity and abundance of threatened or vulnerable wild species on the one hand, and invasive species on the other, increased in the operation? If so, by what share?
Diversity of Production: On what share of the utilized area does the enterprise have a diverse crop rotation and/or use several species at the same time?
Wild Genetic Diversity Enhancing Practices: What activities and practices has the enterprise implemented that have effectively helped to conserve or rehabilitate the genetic diversity of wild species in its operation?
Agro-biodiversity in-situ Conservation: For each species, what is the share of production from others than the most common genetic lineage/breed?
Locally Adapted Varieties/Breeds: What is the share of production accounted for by locally adapted varieties/breeds and by rare and traditional (heirloom) varieties and breeds?
Genetic Diversity in Wild Species: How big is the share of the enterprise's operations that shows a high genetic diversity in non-utilized plants, animals and microorganisms?
Saving of Seeds and Breeds: Does the enterprise's operation save seeds, or engages with breeding work to conserve traditional and/or rare breeds on farm?
Material Consumption Practices: What practices and activities has the enterprise implemented that effectively replaced virgin non-renewable materials by recycled/reused/renewable ones in the operation and replaced synthetic inputs with natural inputs?
Nutrient Balances: What is the nutrient balance of the operations (supply vs demand, or imports vs exports at farm or parcel level) for nitrogen and phosphorus?
Renewable and Recycled Materials: What share of the enterprise's total material use is generated from off-operation virgin sources?
Intensity of Material Use: How has the quantity of materials used per unit produce in the operations changed during the last 5 years?
Renewable Energy Use Target: Has the enterprise set a target for the share of renewable and sustainable energies in its total direct energy use?
Water Conservation Practices: Which activities and practices has the enterprise implemented that have effectively increased the efficiency, or reduced the amount of, the freshwater used in the operation?
Ground and Surface Water Withdrawals: What is the share of annual withdrawals of ground and surface water as a percentage of total renewable water?
Clean Water Target: Has the enterprise set a target for improving the quality of the water affected by the operations?
Water Pollution Prevention Practice: Which activities and practices have been implemented that have effectively reduced or prevented the release of water pollutants?
Concentration of Water Pollutants: What is the percentage of days of the year when standard water pollution values have been exceeded in water (groundwater, surface water, coastal and marine water) as a result of the enterprise's operations?
Wastewater quality: What is the share of wastewater with a good water quality (concentrations of faecal coliforms, heavy metals, BOD and COD below critical levels) as a percentage of the total wastewater from the enterprise's operations?
Soil Improvement practices: What activities and practices have been implemented that have effectively increased the quality and fertility of soils?
Soil Physical Structure: On what share of the utilized land are the conditions of soil physical structure good in consideration of the local climate and bedrock?
Soil Chemical Quality: On what share of the utilized land is the chemical quality (e.g. synthetic compounds, pesticides) of soil high in consideration of the local climate and bedrock?
Soil Biological Quality: On what share of the utilized land is the biological quality of soil high in consideration of the local climate and bedrock?

Economic Resilience Dimension

Cost of Production: Has the enterprise completed a process to determine the total cost of the product sold and per unit of production to calculate your break-even point?	Regional Workforce: Has the enterprise hired during the last five years regional employees when similar skills, profile and conditions are offered to other candidates?
Price Determination: Has the enterprise considered a break-even point to negotiate with their buyer'(s) selling price in all contracts?	Fiscal Commitment: Does the enterprise pay the applicable taxes as indicated by local regulations?
Guarantee od Production Levels: What are the actions and mechanisms that the enterprise has put in place to reduce the negative impact of the risks that could affect meeting the target volume of production and quality standards?	Local Procurement: Has the enterprise procured from local suppliers when equal or similar conditions apply in comparison to non-local suppliers?
Product Diversification: Does the enterprise produce more than one product, specie or variety of plant or animal for income generation?	Internal Investment: In which activities and practices has the enterprise invested during the last 5 years to improve and monitor its social, economic, environmental and governance performance?
Procurement Channels: Which actions and mechanisms has the enterprise put in place to reduce the risk of having input supply shortages, including maintaining ongoing business relationships with suppliers?	Community Investment: How has the enterprise's investments contributed to address and meet community needs, with an efficient use of resources and maintaining an environmental balance?
Stability of Supplier Relationship: What share of supplier contracts/ business relationship has remained on-going over the last 5 years?	Long Term Profitability: Do the enterprise' investments aim to establish and reinforce the conditions to maintain, generate and increase the enterprise profits in the long-term?
Dependence on the Leading Supplier: What share of inputs comes from the leading supplier?	Business Plan: Does the enterprise have a business plan or an up-to-date document articulating revenue streams, growth plan, and a operational action plan that projects the generation of financial resources for the future?
Stability of Market: Which actions and mechanisms has the enterprise put in place to ensure a diversified and consolidated income structure from product sales or from the services provided?	Net Income: Does the earned revenue that the enterprise retains exceed the total expenses, including interests and taxes associated with producing the goods sold, during the last five years?
Net Cash Flow: Has the enterprise generated a positive net cash flow in the last five years?	Food Contamination: Were there any documented incidents where pesticide residues in ingredients or products have exceeded the maximum allowed limits during the last 5 years, or were there any other documented incidents of chemical or biological food contamination (e.g. due to the use of heavy metals, unapproved GMOs, mycotoxins, etc) during the last five years?
Safety Nets: Does the enterprise have access to formal or informal financial sources to withstand liquidity crises?	Food Quality: What share of the total volume of production complies with the required quality norms and standards?
Risk Management: Does the enterprise have a plan to reduce and adapt itself against risks that could potentially threaten the business?	Product Labelling: Are applicable product labeling codes fully complied with, and can the enterprise show evidence of exceeding these standards wherever possible?
Control Measures: Does the enterprise have food hazards and safety control measures in place that comply with correspondent and applicable regulations?	Traceability Systems: Does the system ensure traceability over all stages of the food chain so that products can be easily and correctly identified and recalled?
Hazardous Pesticides: Have any of the employees handle, store or use any highly hazardous pesticides during the last five years?	Certified Production: Can the enterprise identify all ingredients and inputs used by it in its enterprise and can it provide evidence of certified sustainable sourcing of these?

Good Governance Dimension

Legitimacy: Does the enterprise's policy, or producers' code of practices, explicitly demand that all applicable laws and regulations, voluntary standards, adopted or existing, be reported to the governance body, members or employees, and regularly reviewed for compliance and congruence with mission?	Mission Explicitness: Is the mission of the enterprise articulated in all enterprise reporting and understood by all employees or members?
Remedy, Restoration and Prevention: Can the enterprise show evidence of a prompt and responsible response to legal, regulatory, international human rights and voluntary code breaches, including detailed response on how the breach was remedied, how the effects of the breach will be restored or compensated and the policies and processes instituted to prevent further breaches?	Mission Drive: Is the enterprise's mission evident in codes and policies, and can the governance body demonstrate the impact of its mission on developing policy and practice?
Civic Responsibility: Within its sphere of influence, does the enterprise proactively and transparently support the improvement of the legal and regulatory framework on all four dimensions of sustainability, and does it not seek to avoid the impact of human rights or sustainability standards or regulation through the corporate veil, relocation, or any other means?	Due Diligence: Does the enterprise have a clear policy for impact assessment, appropriate tools for assessment and is it able to show that these are being used to inform decisions which will have long term impacts on area of sustainability?
Free, Prior and Informed Consent: Is the enterprise aware of stakeholders' pre-existing access to land, water and resources, has it mapped this to the satisfaction of all affected stakeholders and agreed to take no action to reduce this access until it has fully informed stakeholders, negotiated on equal terms and provided for mutually agreeable compensation, sufficient to allow sustainable livelihoods?	Holistic Audits: Does the enterprise use an internationally recognized framework for sustainability reporting such as the Global Reporting Initiative, or is social auditing being used by the enterprise?
Tenure Rights: Is the enterprise aware of stakeholders' pre-existing tenure and access to land, water and resources, and can the enterprise prove that it has fully and promptly co-operated with any inquiry and remedy process to the satisfaction of affected parties in case of any (alleged) breach of tender rights.	Responsibility: Can the enterprise show, through governance papers or internal dialogue, that performance against mission is regularly evaluated with appropriate stakeholder input?
Sustainability Management Plan: Does the enterprise have a sustainability plan, endorsed by its governing body (or producers' association members or contractors), which provides a holistic view of the enterprise's sustainability and covers each of the environmental, economic, social and governance dimensions, including references to mission and demonstration of progress against the plan, or how the plan has driven specific decisions and their outcomes?	Transparency: Does the enterprise have a policy which requires management to report on how policies, procedures, decisions and decision making processes are made accessible to stakeholders?
Full-Cost Accounting: Is the business success of the enterprise measured and reported to stakeholders taking into account direct and indirect impacts on the economy, society and physical environment?	Stakeholder Identification: Can the enterprise identify all material stakeholders and describe the process by which they were identified?
	Stakeholder Engagement: Does the enterprise use appropriate mechanisms to engage with each group of stakeholders?
	Engagement Barriers: Is the enterprise aware of, and addresses barriers to participation of less powerful stakeholders?
	Effective Participation: Can the enterprise describe actual stakeholder participation (including of "least-powerful" stakeholders), its impact on their decision making and how this impact was communicated to stakeholders?
	Grievance Procedures: Can the enterprise describe grievance procedures for each stakeholder group, how they are publicized (especially with "least powerful" stakeholders) and their current usage?
	Conflict Resolution: Can the enterprise identify potential conflicts of interest with and among various stakeholder groups, and provide examples of resolution through collaborative dialogue, based on respect, mutual understanding and equal power?

Social Well-Being Dimension

Right to Quality of Life: Do all primary producers, smallholders and employees in enterprises of all scales have time for family, rest and culture, and the ability to care for their needs such as maintaining adequate diets?	Support to Vulnerable People: Does the enterprise accommodate varying levels of ability and disability, young workers and aged ones and provide resources to the community to support vulnerable people with social and health services, training, and cultural events for women, minorities and the disadvantaged?
Wage Level: Do all primary producers who supply enterprises and all employees earn at least a living wage?	Safety and Health Training: Does the enterprise provide training in health and safety for 100% of employees, that are understandable by employees, tailored to their workspace, and effective?
Capacity Development: Do primary producers and employees have opportunities to increase skills and knowledge, to advance within the enterprise in which they work or to build the future of their own enterprise?	Safety of Workplace, Operations and Facilities: Does the enterprise maintain a safe, clean and healthy workplace including all grounds and facilities, and all practices?
Fair Access to Means of Production: Do primary producers, including indigenous people, have access to the equipment, capital and knowledge or training necessary to make a decent livelihood feasible?	Health Coverage and Access to Medical Care: Does the enterprise provide adequate health coverage per legal requirements, and ensure timely access to medical care in emergencies for employees?
Fair Pricing and Transparent Contracts: Do buyers through their policies and practices recognize and support suppliers' (particularly primary producers) rights to fair pricing and fair contracts and agreements?	Public Health: Does the enterprise take measures to avoid polluting or contaminating the local community and contribute to the health of the local community?
Rights of Suppliers: Do buyers explicitly recognize and support suppliers' (particularly primary producers) rights to freedom of association and to collective bargaining?	Indigenous Knowledge: Does the enterprise recognize and respect the universal rights of indigenous communities to protect their knowledge? If appropriated and acquired, has the enterprise remunerated indigenous communities in a fair and equitable manner, based on mutually agreed upon terms?
Employment Relations: Does the enterprise or employees' subcontractors have written agreements with their employees that at least meet national and international labor treaties including social security, or, for enterprises that are primary producers at least a clear understanding based on verbal agreement between employer and employees?	Food Sovereignty: Does the enterprise contribute to the food sovereignty of their region by exercising their ability to preserve and use traditional, heirloom and locally adapted varieties or breeds, as well as supporting others in pursuing this goal?
Forced Labour: Does the enterprise or employees' subcontractors employ people who are not free to quit or who cannot raise grievances without fear of retaliation?	
Child Labour: Does the enterprise or its subsidiaries or sub-contractors employ minor children, 16 years of age or younger, who are working full time or more, engaged in jobs that are dangerous to them physically, mentally or morally, and who are deprived of the opportunity to live as children, to attend school and/or other appropriate training?	
Freedom of Association and Right to Bargaining: Are the employees in an enterprise free to negotiate as individuals or as groups or through a union or representatives of their choosing to set the terms of their employment?	
Non Discrimination: Does the enterprise discriminate against any employee or prospective employee based on race, creed, colour, national or ethnic origin, gender, age, handicap or disability (including HIV status), union or political activity, immigration status, citizenship status, marital status, or sexual orientation in hiring, job allocation, promotions and firing or in awarding contracts to primary producers for supplies?	
Gender Equality: Does the enterprise discriminate against women in hiring, remuneration, training, and advancement, access to resources or firing?	

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