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MEASUREMENT OF SUSTAINABILITY AT FARM-LEVEL: STAKEHOLDERS’ PERCEPTIONS AND INDICATORS OF THE SOCIAL DIMENSION.

Dissertation
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EXECUTIVE SUMMARY

With the pressure on the use of scarce natural resources, changes in the food system and technological advances, the need for information about sustainability is increasing. However, while there is a consensus between researchers, decision makers and consumers that an operationalization of the concept of sustainability is necessary, there exist huge disagreements on how to transform the multidimensional concept of sustainability into usable metrics.

Monitoring systems in the agricultural sector have to adapt to these new requests starting with the selection of what should be measured. Due to the multiple actors involved, diverse objectives and complex interactions, the selection of metrics to be monitored is expected to be science-based, but also relevant to the main concerns of the stakeholders. Actors have to agree on i) the normative theoretical concepts; ii) the methods to transform data into valid, reliable and available information and iii) the value of the information in influencing decision making.

How different stakeholders assess the adaptation of monitoring systems in order to measure the farm-level sustainability has been understudied. Moreover, the discussion on how to monitor sustainability has been more focused on the environmental and economic aspects, leaving the social pillar underdeveloped. This dissertation address these gaps investigating stakeholders' arguments about the suitability of a set of sustainability indicators in an accountancy agricultural information system for policy evaluation.

The thesis pursues two objectives. The first one is to elicit stakeholders' perceptions about the adoption of sustainability indicators into an established farm accountancy data system. The second one is to contribute to assess the usefulness of collecting indicators of social sustainability at farm-level. The research is framed in the FP7 EU-Project Farm Level Indicators for New Topics in Policy Evaluation (FLINT 2014-2016 Grant 613800) which purpose is to establish a tested data-infrastructure with additional farm level indicators for the monitoring and evaluation of the Common Agricultural Policy.

The first objective of the thesis is reached by exploring the Farm Accountancy Data Network (FADN) stakeholders' perceptions on feasibility and usefulness of a set of sustainability indicators. Using discussion groups and semi-structured interviews in nine European countries, we collected arguments about the measurement of sustainability at farm level. Participant stakeholders identified that the request of sustainability information of the farm is already taking place under simultaneous, embedded and sometimes overlapping requirements from regulations, markets or research agents. We found that stakeholders have diverging perceptions toward the value of that information, especially for those indicators not expected to be used for farm-level decision making. The perceptions towards feasibility and usefulness of the set of indicators depend on the agent who asks for the indicator, the attributes of the indicator, farm characteristics and farmer's attitudes toward the measurement.

For the second objective, two empirical studies were conducted using an integrated data set of FADN and FLINT project in a sample of 1100 FADN farms distributed in nine countries.

In the first study we explored the linkage between the use of advisory services by farm managers and the economic, environmental and social performance of farms. We identified three clusters of farms that have a different sustainability performance and that relate differently to advisory services. In the three groups of farms, the number of contacts with advisory services is positively correlated with the adoption of innovations, the number of information sources and the adoption of farm risk management measures. We failed to find linear relationship between advisory services and environmental and social sustainability. The main contribution of the research is to derive hypotheses that can be tested using harmonized indicators of advisory services to evaluate the role of advisory services in the achievement of multiple objectives in different groups of farms in multiple sites.

The second study investigated the influence of farm-level factors in farmers' satisfaction with farming and its relationship with the level of satisfaction they have with their overall quality of life. We propose a path model using a Structural Equation Model-Partial Least Squares (SEM-PLS) approach, testing the validity and reliability of a farmers' work satisfaction construct and determining on how far the farm variables are related with it. Results suggest that while it is valid and reliable to measure work satisfaction as a construct, the farm level data that is currently available explains farmers' satisfaction with their own standard and values only partially. Therefore a metric that measures those values should be further developed and tested.

Based on the findings presented above, this doctoral dissertation contributes to the identification and prioritization of standardized indicators of farm-level sustainability. Two main learnings can be implied from the findings. The first one is that ontological differences between the agents that are involved in the functioning and evolvement of an information system can be identified (but not solved) applying inter and transdisciplinary research methods. The second one is that standardized indicators of social sustainability are desirable, feasible and useful to be collected and integrated in the same data sets with economic and environmental indicators. That said, due to the complexity of the relationship between sustainability dimensions, the value of standardization of indicators is limited by how are they going to be used. In other words, the adaptation of monitoring systems requires a constant testing and improvement, where a dialog between data collectors and information users is necessary.

ZUSAMMENFASSUNG

Mit dem Druck auf die Nutzung knapper natürlicher Ressourcen, Veränderungen in den Ernährungssystemen und technologischen Fortschritten steigt der Informationsbedarf zu Nachhaltigkeit. Obwohl zwischen Forschern, Entscheidungsträgern und Verbrauchern Konsens darüber besteht, dass eine Operationalisierung des Nachhaltigkeitskonzepts notwendig ist, gibt es dennoch große Meinungsverschiedenheiten darüber, wie das mehrdimensionale Konzept in brauchbare Metriken umgewandelt werden kann.

Die Monitoringsysteme im Agrarsektor müssen sich an diese neuen Anforderungen anpassen, angefangen bei der Auswahl der zu messenden Größen. Aufgrund der Vielzahl der beteiligten Akteure, der unterschiedlichen Ziele und der komplexen Wechselwirkungen wird erwartet, dass die Auswahl der zu überwachenden Metriken wissenschaftlich fundiert, und gleichzeitig entsprechend den wichtigsten Anliegen der Interessengruppen erfolgt. Die Akteure müssen sich auf i) die normativen theoretischen Konzepte, ii) die Methoden zur Umwandlung von Daten in valide, zuverlässige und verfügbare Informationen und iii) den Wert der Informationen bei der Beeinflussung der Entscheidungsfindung einigen.

Es besteht Forschungsbedarf, wie verschiedene Interessengruppen die Anpassung der Monitoringsysteme zur Messung der Nachhaltigkeit auf Betriebsebene bewerten. Hinzu kommt, dass sich die wissenschaftliche Diskussion zur Berücksichtigung und Einhaltung von Nachhaltigkeitsanforderungen stärker auf die ökologischen und wirtschaftlichen Aspekte konzentriert und den sozialen Pfeiler unterentwickelt gelassen hat. Die vorliegende Dissertation zielt darauf ab, diese Lücken zu schließen, indem sie die Argumente der Interessengruppen über die Eignung einer Reihe von Nachhaltigkeitsindikatoren im Kontext der landwirtschaftlichen Buchführung für die Politikbewertung untersucht.

Die Dissertation verfolgt zwei Ziele. Das erste besteht darin, die Wahrnehmung unterschiedlicher Interessengruppenvertreter über die Adoption von Nachhaltigkeitsindikatoren in ein etabliertes landwirtschaftliches Buchhaltungsdatensystem zu erheben. Das zweite Ziel besteht darin, den Nutzen der Erhebung von Indikatoren für die soziale Nachhaltigkeit auf betrieblicher Ebene zu bewerten. Die empirische Forschung ist Teil des FP7 EU-Projekts Farm Level Indicators for New Topics in Policy Evaluation (FLINT Grant 613800, 01/14 – 12/16), mit dem Ziel, eine getestete Daten-Infrastruktur mit zusätzlichen Nachhaltigkeits-Indikatoren auf Betriebsebene für die Überwachung und Bewertung der Gemeinsamen Agrarpolitik aufzubauen.

Das erste Ziel der Arbeit wird durch die Untersuchung der Wahrnehmungen der Interessengruppen des Farm Accountancy Data Network (FADN) über die Machbarkeit und den Nutzen einer Reihe von Nachhaltigkeitsindikatoren erreicht. Mit Hilfe von Diskussionsgruppen und semi-strukturierten Interviews in neun europäischen Ländern haben wir Argumente zur Messung der Nachhaltigkeit auf betrieblicher Ebene gesammelt. Die teilnehmenden Interessengruppenvertreter stellten fest, dass die Anforderung von Nachhaltigkeitsinformationen über den Betrieb bereits unter gleichzeitigen, eingebetteten und sich manchmal überschneidenden Anforderungen von Verordnungen, Märkten oder Forschungsagenten erfolgt. Wir haben festgestellt, dass die Interessengruppen unterschiedliche Auffassungen über den Wert dieser Informationen haben, insbesondere für diejenigen Indikatoren, von denen nicht erwartet wird, dass sie für die Entscheidungsfindung auf Betriebsebene verwendet werden. Die Wahrnehmung der Machbarkeit und Nützlichkeit der Indikatoren hängt von dem Akteur ab, der den Indikator anfordert, den Attributen des Indikators, den Eigenschaften des Betriebs und der Einstellung des Landwirts zur Messung.

Für das zweite Ziel wurden zwei empirische Studien mit einem integrierten Datensatz des FLINT-Projekts mit einer Stichprobe von 1100 FADN-Betrieben in neun Ländern durchgeführt.

In der ersten Studie untersuchten wir den Zusammenhang zwischen der Inanspruchnahme von Beratungsdiensten durch Betriebsleiter und der wirtschaftlichen, ökologischen und sozialen Leistung von Betrieben. Wir haben drei Cluster von Betrieben identifiziert, die eine unterschiedliche Nachhaltigkeitsleistung aufweisen und sich unterschiedlich auf Beratungsleistungen beziehen. In den drei Gruppen ist die Anzahl der Kontakte zu Beratungsdiensten positiv korreliert mit der Einführung von Innovationen, der Anzahl der Informationsquellen und der Einführung von Maßnahmen des betrieblichen Risikomanagements. Es ist uns nicht gelungen, einen linearen Zusammenhang zwischen Beratungsleistungen und ökologischer und sozialer Nachhaltigkeit zu finden. Der Hauptbeitrag der Forschung besteht darin, Hypothesen abzuleiten, die mit Hilfe harmonisierter Indikatoren für Beratungsdienste getestet werden können, um die Rolle der Beratungsdienste bei der Erreichung mehrerer Ziele in verschiedenen Gruppen von Betrieben an mehreren Standorten zu bewerten.

Die zweite Studie untersuchte den Einfluss von Faktoren auf Betriebsebene auf die Zufriedenheit der Landwirte mit der Landwirtschaft, und deren Zusammenhang mit der Zufriedenheit mit ihrer allgemeinen Lebensqualität. Wir schlagen ein Pfadmodell mit einem *Structural Equation Model-Partial Least Squares* (SEM-PLS)-Ansatz vor, das die Validität und Zuverlässigkeit eines Konstrukts der Arbeitszufriedenheit der Landwirte testet und bestimmt, inwieweit die Betriebsvariablen mit ihm in Beziehung stehen. Die Ergebnisse deuten darauf hin, dass das Konstrukt gültig und zuverlässig ist, die Arbeitszufriedenheit zu messen, dass aber die derzeit verfügbaren Daten auf Betriebsebene die

Zufriedenheit der Landwirte mit ihrem eigenen Lebensstandard und ihren Werten nur teilweise erklären. Daher sollte eine Metrik, die diese Werte misst, weiterentwickelt und getestet werden.

Basierend auf den oben vorgestellten Ergebnissen trägt diese Dissertation zur Identifizierung und Priorisierung von standardisierten Indikatoren für die Nachhaltigkeit auf Betriebsebene bei. Aus den Ergebnissen lassen sich zwei wesentliche Erkenntnisse ableiten: Die erste ist, dass ontologische Unterschiede zwischen den Akteuren, die an der Funktionsweise und Entwicklung eines Informationssystems beteiligt sind, durch die Anwendung inter- und transdisziplinärer Forschungsmethoden identifiziert (aber nicht gelöst) werden können. Die zweite ist, dass standardisierte Indikatoren für die soziale Nachhaltigkeit wünschenswert, machbar und nützlich sind, und daher in denselben Datensätzen mit Wirtschafts- und Umweltindikatoren gesammelt und integriert werden sollten. Allerdings ist der Wert der Standardisierung von Indikatoren aufgrund der Komplexität der Beziehung zwischen Nachhaltigkeitsdimensionen dadurch begrenzt, wie sie verwendet werden. Mit anderen Worten, die Anpassung der Monitoringsysteme erfordert eine ständige Überprüfung und Verbesserung, wobei ein Dialog zwischen Datensammlern und Informationsnutzern erforderlich ist.

LIST OF ACRONYMS AND ABBREVIATIONS

AKIS	Agricultural Knowledge and Innovation Systems
AS	Advisory Services
AVE	Average Variance Extracted
AWU	Annual Working Units
CAP	Common Agricultural Policy
CL	Cluster
CMEF	Common Monitoring and Evaluation Framework
CR	Composite Reliability Index
DG-AGRI	Directorate-General for Agriculture and Rural Development
EU	European Union
FADN	Farm Accountancy Data Network
FLINT	Farm Level Indicators for New Topics in Policy Evaluation
FNVA	Farm Net Value Added
GHG	Greenhouse Gas Emissions
LV	Latent Variables
MV	Manifest Variables
OECD	Organisation for Economic Co-operation and Development
SCAR	Standing Committee on Agricultural Research
SEM-PLS	Structural Equation Model-Partial Least Squares
SES	Social- ecological systems
SO	Standard Outputs
SWB	Subjective Well Being
UAA	Utilized Agricultural Area
WHO	World Health Organization
UNDP	United Nations Development Programme

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Chapter 1

Introduction

1 Introduction

With the increasing pressure on the use of scarce natural resources, changes in the food system, and technological advances, there is a revolution taking place in the way knowledge and information is managed in the agricultural and food sector. Societal actors are demanding reliable metrics to inform, evaluate and take decisions that satisfy the common interest in sustainability and food security. Accordingly, agricultural monitoring systems that have been established to provide up-to-date information to different actors are constantly enforced to adapt in order to satisfy the information requirements and to make use of new opportunities created by the availability of many types of data and capabilities at different levels (Antle et al. 2017).

The adaptation of agricultural information systems to the demands of their users has proven to be an “untamed” problem due to the multiple valid perspectives and the high level of uncertainty involved. While there is a tacit agreement between researchers, decision makers, and consumers that an operationalization of multidimensional concepts such as sustainability and resilience is necessary, large disagreements on how to transform those concepts into usable metrics exist.

This general introduction of the dissertation begins with describing the motivation of the research project posing the question on how stakeholders perceive the introduction of a set of sustainability indicators in an agricultural information system. Secondly, it provides a description of the frame of the Farm Level Indicators in New topics for Policy Evaluation (FLINT project) in which the research was conducted. The third part of the introduction presents the research objectives and explains the structure and outline of the thesis.

1.1 Motivation

1.1.1 Adaptation of monitoring systems in agriculture to new knowledge requirements

Monitoring systems are applied systems thinking tools that help close the gap between past performance and forward planning (Blackie 1976). They are used from the farm level management (Blackie 1976; Fountas et al., 2006; Sørensen et al., 2010) to the regional, national, and global level to provide information to make decisions, conduct simulations, or forecast scenarios (Fritz et al., 2018). In the food sector, due to changes in the intensity of information in how business are conducted, complex monitoring has emerged among players in the value chains (Higgins et al., 2009), and technological advances such as precision agriculture have opened many possibilities to collect, store and use data to analyze the past and make predictions for the future (Jones et al., 2017). Collaborations between actors in the gathering and sharing of information have increased, and policy makers, researchers, consumers, and other decision makers are demanding a standardization of key performance indicators that are aligned with common global goals and that help evaluate policy instruments (Poppe and Vrolijk, 2018), increase farm efficiency (Reig-Martínez et al., 2011), create business competitive advantages (Beske-Janssen et al., 2015, Johnson and Schaltegger, 2015), increase transparency (Beske-Janssen et al., 2015), tackle food security challenges (Fritz et al., 2018), or help solve disputes (Bosch et al. 2015).

The evolvement of these systems, even with available sophisticated infrastructure and interoperability architectures, is driven by the selection on what should be measured, shared and synthesized by different agents. Central to the adaptation of the monitoring systems is the selection of what should be measured and communicated as a final knowledge outcome. Usually the output of a monitoring system is the “indicator”. An indicator is a piece of information that allows users to make decisions in order to change a reality. Indicators are considered to have three basic functions: (i) indicators are scientific units that represent a theoretical concept, (ii) indicators are monitoring instruments to track changes, and (iii) indicators are a management support tool to make decisions (Joumard and Gudmundsson, 2010). Hence, the choice of which indicators should be traced implies several settlements between actors: i) an agreement on a normative theoretical concept that frames the information system; ii) an agreement on the way how to transform data into valid, reliable, and available information representing that theoretical concept; and iii) an agreement on the potential to influence relevant decision making. In consequence, the selection of which information should be measured by those systems is not only science-based but also representative of the interests and concerns of the main actors involved (Turnhout et al. 2007).

For many authors the challenge is not the availability of data, but their real value for the actors involved, which is determined by their effective use (Fountas et al., 2015; Pannell 2003; Sydorovych and Wossink, 2008). Accordingly, the use is determined by the actors’ main objectives or strategies that could potentially be convergent or divergent, with an ill-defined structure, non-easily identifiable cause-effects and changing over time. Hence the agreements between actors become a complex problem (Batie 2008) that cannot be solved, only managed (Peterson, 2003).

Due to this complexity, the selection of indicators has been identified as a subjective process where no transparent and clear procedures have been established (Kühnen, 2018). Considering that indicators are a representation of theoretical concepts of a reality (Bonnen 1975), there are several factors that influence the level of subjectivity in the prioritization and selection of indicators.

One of those factors are the multiple ontological understandings in which actors tend to disagree on their concepts and their conceptualizations (Kühnen, 2018; McGinnis and Ostrom, 2014). This is extremely important in social-ecological systems like farms because i) several disciplines address the same problem (inter-disciplinarity); ii)multiple objectives in multiple dimensions are pursued (ecological-economic-social dimensions of sustainability); and iii) there are several nested systems and subsystems with different tiers and levels of analysis (global, national, supply chain, landscape, farm). Consequently, priorities in the selection of indicators change according to the agents involved (Bonisoli et al., 2018): while academia constantly explores the variables and their relationships, farmers prioritize indicators according to their own objectives and incentives, and policy evaluators select the indicators according to their potential to assess efficiency and effectiveness of programs.

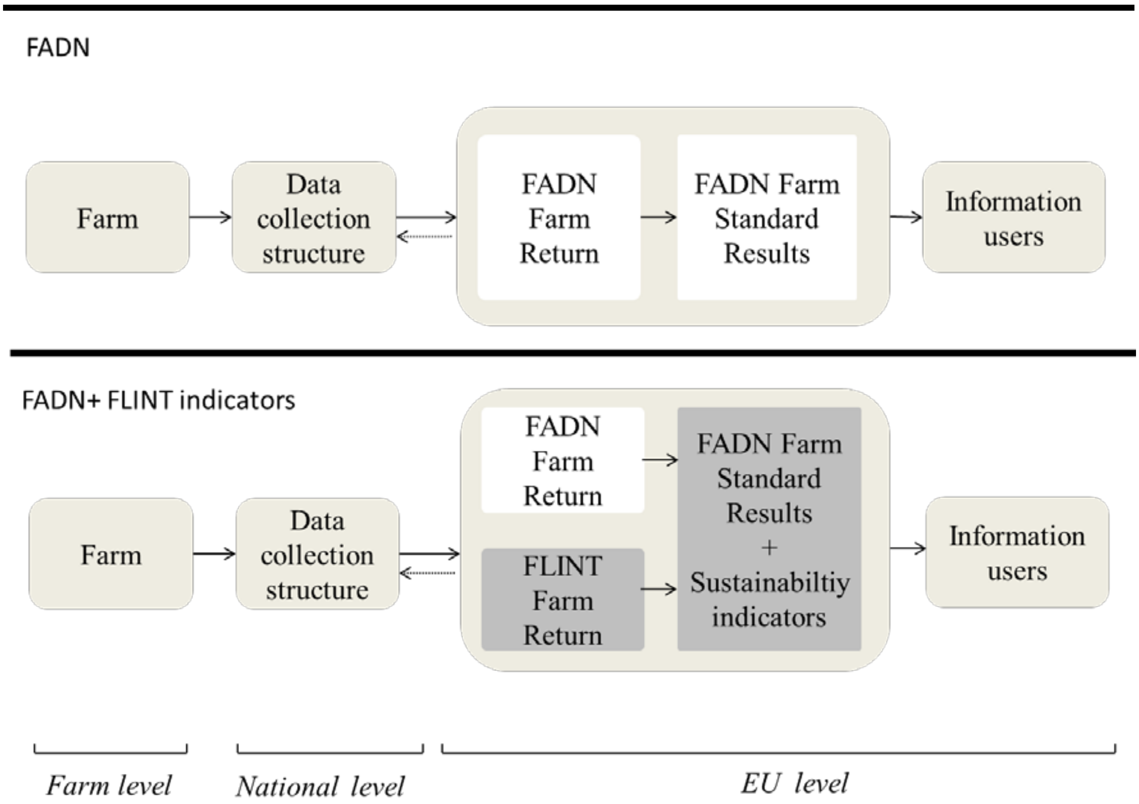
Several frameworks such as social-ecological systems-SES (Ostrom, 2007) or the Common Monitoring and Evaluation Framework (CMEF) have attempted to reach consensus on the concepts across several disciplines and actors to fill the need to align as much as possible global objectives with the farm as the decision making unit (Repar et al., 2017). However, differences in understandings, operationalization of theoretical concepts, and priorities are evident on the numerous instruments to assess sustainability at farm or firm level (Olde et al., 2016; Johnson and Schaltegger 2015). This "*knowledge representation problem*" (Beck et al., 2009) is one of the biggest barriers in the use of sustainability knowledge for actual decision making because without a consensual knowledge accepted by stakeholders, the information generated by the systems does not meet a required level of transparency, credibility, and legitimacy (Olde et al., 2018; Reidsma et al., 2018) necessary to the transferability of data and the interoperability between systems (Pinet et al., 2009).

1.1.2 FLINT project and Farm Accountancy Data Network (FADN)

From a policy evaluation perspective, changes in the Europe 2020 strategy have brought about changes in the knowledge instruments used to evaluate policies, such as the Farm Accountancy Data Network (FADN). FADN represents a source of standardized farm financial data in a sample of 80,000 agricultural holdings across the EU and is the only well-established farm level data collection system on the performance of farms in Europe (Vrolijk et al., 2016). Information generated by FADN is used for policy evaluation, research and for providing statistics for the public. Due to its harmonized structure, many authors consider it an adequate platform that, with some adaptations, would allow to collect many of the economic, environmental, and social information that is needed to monitor policies and assess agricultural systems sustainability (Kelly et al., 2018). Two main advantages are identified of using FADN: (i) the integration of several dimensions of sustainability at farm-level, (ii) a standardized data source that systematically and continuously would permit to scale-up in the analysis of changes of agricultural systems (Lynch et al., 2018) and to develop farm models for policy impact assessment in the European Union (Reidsma et al., 2018).

The adaptation of FADN towards sustainability concerns relies on the harmonization and alignment of different measurement frameworks, tools, and data assembling systems according to the additional knowledge requirements of the member states (Poppe et al., 2016). From 2014, FLINT project established a pilot network of 1100 farms to test indicators and methodologies to gather data representing the diversity of European farms. The reason for the testing is to provide recommendations on how new indicators could be part of the FADN, considering farmers´ willingness to provide data, the differences in national data gathering structures, the harmonized data processing and the users' needs of information (Figure 1).

Figure 1. Comparison of FADN information flow without and with addition of sustainability indicators tested by FLINT project.



Source: the author based on Poppe and Vrolijk (2016).

Farms are those agricultural holdings that are part of FADN. The data collection structures are the nine different organizational settings at national level that provide the flexibility necessary to adapt the data collection to the national contexts (Vrolijk et al., 2016). The different structures determine which agents are involved along the information chain of FADN: farmers, data collectors, farm advisors, liaison offices, agricultural authorities, agricultural research institutes, universities, and/or value chain actors.

The harmonization of methods and variables take place at EU level on the "***FADN Farm Return***" (Vrolijk et al., 2016) that is the common framework based on shared bookkeeping principles. Data collected is transformed into 186 economic and financial indicators named "***Farm Economic Standard Results***" (Table 1). With the FLINT project, a set of indicators were added to the information flow. Indicators and variables are harmonized in the "***FLINT Farm Return***" in which variables are grouped in ten tables. Those data are transformed in 214 "***Sustainability indicators***", distributed in 33 topics which represent the three dimensions of sustainability (Table 1).

Table 1. Overview of FADN Standard Results and FLINT sustainability indicators

Area	Topics/themes
FADN Standard Results	Sample and population Structure and yield Output Costs Subsidies Balances, subsidies, and taxes Income Balance sheet Financial indicators
FLINT indicators	
1. Land Management	E1 Greening: permanent grassland E2 Greening: Ecological Focus Areas E3 Semi-natural farmland areas EI5 Land fragmentation (Efficiency field parcel)
2. Soil	E6 Soil organic matter in arable land E11Farm management to reduce soil erosion
3. Pesticides	E4 Pesticide usage (pesticide risk score)
4. Nutrient Balance	E5 Nutrient balance (N, P) E10 Farm management to reduce nitrate leaching E12 Use of legumes
5. Energy	E7 Indirect energy usage E8 Direct energy usage E9 On-farm renewable energy production
6. GHG Emissions	E13 GHG Emission per ha E14 GHG emissions per product E15 Carbon sequestering land uses
7. Water	E16 Water usage and storage E17 Irrigation practices
8. Biodiversity	E18 Crop species diversity
9. Information and Knowledge	S1 Advisory services S2 Education and training S3 Ownership management
10. Community engagement	S4 Social engagement/participation S7 Social diversification: image of farmers/agriculture in local communities
11. Working Conditions	S5 Employment and working conditions
12. Quality of Life	S6 Quality of life/decision making
13. Market access	EI2 Producing under a label or brand EI3 Types of market outlet
14. Risk Reduction	EI7 Insurance EI8 Share of output under contract with fixed price delivery contracts EI9 Non-agricultural activities
15. Innovation	EI1 Innovation EI6 Modernization of the farm investment

Source: FADN Standard Results and Poppe and Vrolijk (2017).

1. 2 Research objectives and structure of the dissertation

To date, there have been very few studies on how different stakeholders assess the adaptation of monitoring systems in order to measure the sustainability information requirements. Moreover, the discussion on sustainability indicators has been focused on the development of frameworks and on the search for harmonised and robust environmental and economic indicators, but less conclusive on how to operationalize and include the social pillar of sustainability in monitoring systems or datasets (Reidsma et al., 2018; Kühnen, 2018).

Addressing this gap on how the adaptation of an information system to new knowledge requirements takes place, this dissertation has two main objectives: (i) elicit stakeholders' perceptions about the adoption of sustainability indicators for an established farm accountancy data system, and (ii) contribute to assess the usefulness of collecting indicators of social sustainability at farm level. Those objectives are translated into two research questions.

1. *What are the stakeholders' perceptions about the selection and addition of indicators of sustainability in an existing farm-level measurement system?*

To answer that question we explore stakeholders' opinions about the feasibility and usefulness of the introduction of a pilot sustainability indicators set in FADN. The main contribution is to identify and compare the arguments that researchers, farmers, data collectors, and users of the information have towards the selection, communication, and use of farm-level indicators of sustainability along the European agricultural sector. We used a mixed method approach in a sequence of steps that involve both the project partners and the stakeholders: (i) the identification of stakeholders, (ii) the development and pilot testing of the consultation method, (iii) the collection of perceptions through workshops and interviews, (iv) the qualitative analysis using coding and categorizing concepts. The results are described in **chapter 2** and **appendix 1**.

2. *To which extent are the proposed indicators valid measures to assess social sustainability at farm level?*

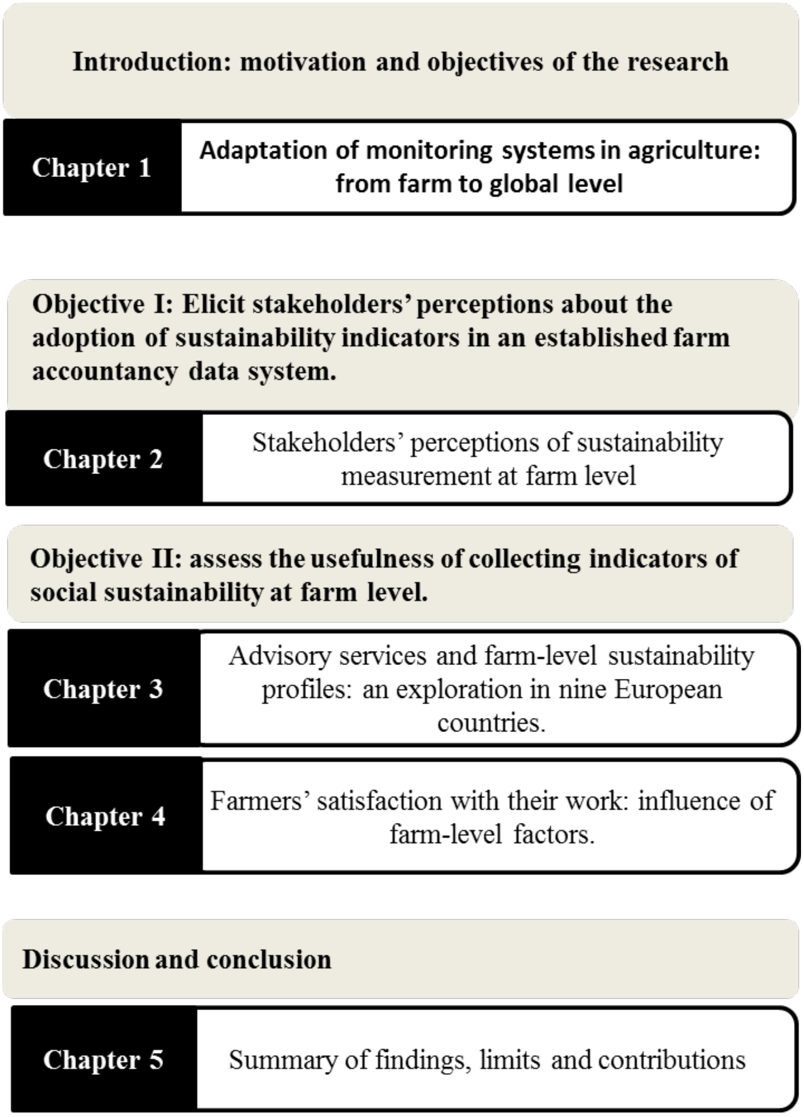
To answer this question, we conducted two investigations using the FLINT data set from the sample of farms located in nine countries combined with FADN available data. Both investigations were part of the case studies in order to analyse the usefulness of the information collected for research and policy evaluation.

In the first case, we explored the use of advisory services by farm managers and its linkages with the economic, environmental, and social performance of farms. Our rationale behind this is to test to what extent a standardized indicator of advisory services could be used to evaluate the link between extension and the achievement of multiple objectives by different groups of farms in multiple sites. From a broad literature review, we selected an indicator of advisory services that was able to measure the intensity of contacts between farms and extension agents. During the analysis of the data, we identified different groups of farms according to their sustainability performance and determined their linkages with the use of advisory services. The research is presented in **chapter 3**.

In the second case, considering the results of the perceptions that stakeholders have on the use of social indicators, we explored the influence that farm-level factors have on farmers' satisfaction with farming and its relationship with their perceived quality of life. The contribution of this research is to assess the validity and reliability of indicators that measure social sustainability using an integrated dataset. Similar to the case presented above, we identified a set of possible indicators that represent the social dimension of sustainability and that could be possibly be collected and stored jointly with additional sustainability indicators. We developed categories of variables according to the current literature available and the possibilities of analysis. For conducting the analysis, we used a Partial Least Squares-Structural Equation Model approach for determining a system of linear relationships between multiple blocks of variables available in FADN and FLINT. The results are presented in **chapter 4**.

To summarize the findings and wrap up the research, **chapter 5** presents the overarching discussion, conclusion, and limitations of the dissertation. According to the main findings, theoretical and policy implications from this doctoral research project are addressed . Finally, the conclusion explains how the research gap was addressed, the main contribution and gives an outlook of potential future research. In this dissertation, we present the case studies as the final articles as they were published or submitted for publication. Figure 2 presents the overall structure of the thesis.

Figure 2. Structure of the dissertation



Source: the author

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Chapter 2

Stakeholders’ perceptions of sustainability measurement at farm level

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Stakeholders' perceptions of sustainability measurement at farm level

Increased attention for sustainability in agricultural production within the food sector has enhanced the need for farm-level information. This article aims to explore stakeholders' perceptions of sustainability measurement at farm level in an established monitoring system. Qualitative research, including discussion groups and semi-structured interviews in nine European countries, identifies existing divergences in perceptions, especially for those indicators not expected to be used for farm-level decision making. The perception of feasibility and usefulness of an indicator is determined by (a) indicators' intrinsic attributes, (b) the measurement system in which it is inserted, (c) farm characteristics and (d) farmers' attitudes toward the measurement. Identifying stakeholders' perceptions could help to improve the discussion between researchers and users in the selection, communication and use of sustainability information along the agricultural sector.

Keywords: stakeholder involvement, farm level sustainability indicators, qualitative research

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Introduction

As a response to the multiple pressures of climate change, natural resource degradation, societal demands and global markets, the food sector is facing the challenge of moving toward more sustainable ways of production, driven by regulatory frameworks and changes occurring along the agricultural supply chain (Higgins *et al*., 2010). Operationalising the concept of sustainability is believed to be necessary to define goals, track performance, induce behavioural changes and help to solve disputes (Bosch *et al*., 2015).

Owing to the multiple functions of indicators as a scientific unit, measurement unit and policy element (Joumard and Gudmundsson, 2010), the selection of a set of indicators has been argued to be both a scientifically and politically iterative process (Mccool and Stankey, 2004), located in a fuzzy area between the production and use of scientific knowledge (Turnhout *et al*., 2007). While considering users' perspectives in the selection of indicators helps to achieve transparency, relevance, ownership and public legitimacy (Moxey *et al*., 1998), it requires a dialogue between designers and users. This dialogue is considered an 'untamed problem', where multiple values are in conflict, outcomes are uncertain and there exists significant scientific disagreement (Batie, 2008). The aim of this study is to explore stakeholders' perceptions regarding the feasibility and usefulness of the introduction of sustainability indicators in an existing farm level monitoring system. Using the definition of stakeholders of Freeman (1984), we consider the perceptions of those individuals or groups who affect, or are affected, by the introduction of sustainability indicators. This research is part of the European Union (EU) Framework 7 project FLINT (Farm Level Indicators for New Topics in Policy Evaluation), the objective of which is to test the feasibility of establishing a common standard set of farm-level indicators for policy evaluation in nine EU Member States, ideally linked with the Farm Accountancy Data Network (FADN). This paper describes the methods used to collect stakeholders' perceptions, the main results and the conclusions.

Theoretical background

Agricultural information systems include both the production of data and the transformation of these data into information that is useful for a policy decision or a problem solution (Bonnen, 1975). Those systems rely on the measurement process, in which a concept is linked to one or more latent variables, and these are linked to observed empirical variables (Bollen, 1989). If the concept is complex or has different meanings for several actors – such as sustainability along the food chain – we can expect that the concepts and information derived from those systems have different values for the different actors. The values and perceptions of stakeholders can be divergent in conflicting ways, turning a complex problem into a 'wicked' one that cannot be solved, only managed (Peterson, 2013). Stakeholder involvement has been considered as a way to increase the likelihood of evaluation utilisation (Taut, 2008), a missing step in indicator validation (Cloquell-Ballester *et al*., 2006) and an important input while dealing with complexity, uncertainty and ambiguity (Renn, 2015).

Sustainability is identified as an untamed problem because of the complex and dynamic nature of the problem definition and radically different understandings (Batie, 2008). Nevertheless, in order to be measured, analysed and communicated, the sustainability concept is reduced to a limited number of indicators (Schindler *et al*., 2015). Indicators are defined as a *quantitative or qualitative factor or variable that provides a simple and reliable means to measure achievement, in order to reflect the changes connected to an intervention, or to help assess the performance of a development actor* (DAC-OECD, 2002, p.25). The assessment of indicator quality is made through a list of criteria. The more frequently used criteria are those developed by OECD (2001): policy relevance, responsiveness, analytical soundness and data availability. However, in general, there is no universal set of criteria to judge indicators, and there is no common understanding regarding the definitions of the criteria. Selection approaches such as rating, standardisation, weighting and combining (Rice and Rochet, 2005) have until now been a science-led process where the political or managerial context in which indicators are used is not fully

Table 1: Indicators of sustainability at farm level by dimension of sustainability.

Environmental	Economic and innovation*	Social
E1 Permanent grassland	***EI1*** Innovation	***S1*** Advisory services
E2 Ecological Focus Areas	***EI2*** Producing under a label or brand	***S2*** Education and training
E3 Semi-natural farmland areas	***EI3*** Types of market outlet	***S3*** Ownership-management
E4 Pesticide usage	***EI4*** Past/future duration in farming	***S4*** Social engagement/participation
E5 Nutrient balance (N, P)	***EI5*** Efficiency field parcel	***S5*** Employment and working conditions
E6 Soil organic matter in arable land	***EI6*** Modernisation of the farm investment	***S6*** Quality of life/decision making
E7 Indirect energy usage	***EI7*** Insurance: production, personal and farm (building structure)	***S7*** Social diversification: image of farmers/ agriculture in local communities
E8 Direct energy usage	***EI8*** Share of output under contract with fixed price delivery contracts	
E9 On-farm renewable energy production	***EI9*** Non-agricultural activities	
E10 Farm management to reduce nitrate leaching		
E11 Farm management to reduce soil erosion		
E12 Use of legumes		
E13 GHG emissions per ha		
E14 GHG emissions per product		
E15 Carbon sequestering land uses		
E16 Water usage and storage		
E17 Irrigation practices		

* Indicators that form part of the current FADN Farm Return are not included in this list
Source: own compilation

recognised (Turnhout *et al*., 2007; Rametsteiner *et al*., 2011).

Considering the increasing availability of data and the different users of information (Pannell and Glenn, 2000), the value of sustainability indicators is argued to rely on the relevance of data for optimising farm efficiency (Fountas *et al*., 2006) or the use of the information in the supply chain for creating competitive advantages through transparency and innovation (Beske-Janssen *et al*., 2015). An appropriate combination of methods to involve stakeholders would lead to the integration of scientific expertise, rational decision making and public values (Renn, 2015).

Methodology

To explore stakeholders' perceptions, a mixed-methods research approach was used, simultaneously collecting both quantitative and qualitative data in a concurrent embedded strategy within a qualitative predominant method (Creswell, 2009). Qualitative approaches are appropriate when it is necessary to involve participants with a specific interest and personal experience (Bitsch and Olynk, 2007), the results do not need to be generalised to a population (Patton, 2015) and the results could be used for evaluation and the development of policy recommendations as well as in action research (Bitsch, 2005). Four steps were conducted in order to involve stakeholders, of which steps 1 to 3 were conducted by project partners in each country.

The list of indicators (Table 1) was selected after an extensive literature review, analysis of information gaps and discussions within the project team. Stakeholders were identified based on who is involved in collecting, storing, analysing, reporting and using the information generated. Considering the expected level of availability of stakeholders and the list of preselected sustainability indicators, visualised group discussion tools and semi-structured interviews were designed and pilot-tested with farmers and farm advisors.

Sixteen group discussions and 42 individual interviews were conducted between September 2014 and January 2015. In total, 174 stakeholders were consulted through discussion groups, face-to-face individual interviews, group interviews, interviews by telephone and interviews by email. The discussion groups and semi-structured interviews tools consisted of two parts. Firstly, stakeholders answered three open-ended questions related to their experience about the collection of sustainability data (*Q1: How is farming being influenced by changes and demands coming from society, consumers, policy, trade partners? Q2: What kind of data are requested from you/do you request? Q3: What is your experience collecting and/or using those data?*). Secondly, stakeholders scored the feasibility and usefulness of each of the 33 indicators using a two-pole scale (--, -, +/-, + and ++) and giving their reasons for the assessment.

Eight stakeholder groups can be identified among the participants (Table 2). Farmers and farm data collectors of the FADN system account for 33 and 26 per cent respec-

Table 2: Stakeholder groups consulted about their perceptions of sustainability.

Group	Description
Farmers (58)	Diary, beef, arable and mixed crops farmers.
Farm advisors (13)	Technical experts or specialists, extension agents, and advisory and accountancy services whose work is realised at farm level.
Farm data collectors (46)	Professional data collectors and farm advisors who are involved in FADN data collection.
FADN representatives (9)	Contact persons of FADN liaison institutes, statistical offices, national representatives, coordinator or contact persons of national FADN systems.
Policy makers and / or policy evaluators (9)	Experts and head of units of agricultural authorities, directorates for agricultural ministries sections, policy evaluators and planners, rural development experts.
Scientists and academics (11)	Professors of universities, scientists of research institutes.
Farmers representatives (3)	Policy expert of a chamber of agriculture, a research director of farmers' union and a farmers' union representative.
Value chain actors (14)	Sustainability manager, farm service director and representative of dairy processors' and milk cooperative, director of a sugar company, director of a trade company, representative of a federation of agri-food industry, members of institutes for organic food associations and food chain quality, an organic bakery, marketing personnel of a food company.

Source: own compilation

tively of the persons consulted, and more than 50 per cent of them came from Spain and Poland. FADN representatives and actors involved in national policy evaluation initiatives make up 10 per cent of the respondents. Other stakeholders not directly involved in the current FADN measurement system, but potential users of the information (such as farmers' representatives, researchers and value chain actors), represent 28 per cent of the participants.

The quantitative scores assigned by stakeholders were used to generate the average numeric assessment of indicators. The analysis of the answers of the open-ended questions and qualitative comments on the indicators was made with the help of the 'ATLAS.ti7' software for qualitative analysis (ATLAS.ti Scientific Software Development GmbH, Germany). The coding was conducted in two steps: (a) an initial open coding of the qualitative answers, aiming to delimit categories, commonalities and differences; and (b) a second coding based on the categories established in the first stage, searching for patterns and generalised relations following grounded theory analysis principles.

Results and discussion

Here, the results of the coding process are presented, as are the quantitative scales that were used to classify indicators.

Identification of current sustainability monitoring systems

Stakeholders consulted identify three types of farm-related measurement systems: (a) regulations-based measurement; (b) market-led measurements; and (c) own farm measurement system. Regulations-based monitoring systems have as a purpose compliance with government rules or policy evaluation, for example cross-compliance mechanisms. Market-led measurement initiatives request information based on the commercial arrangements between farmers and their customers, for example information that is requested by traders, retailers or consumers. Farm monitoring systems include all the data and information management (digitalised or not) managed within the farm (Figure 1). According to the interviews, those systems have their own incentives and characteristics, being complementary or even 'redundant', depending on the features and requirements of the supply chain and the national contexts.

Interviewees agreed that the management of data and exchange of information is a time-consuming and costly process, with a high level of variability among farmers on the willingness to participate. Three factors affecting the exchange of information about sustainability were identified: (a) alignment of the farm system information with the required information and with the objectives behind the indicator; (b) expectations of the information exchange, including trust among actors, expected benefits and expected risks; and (c) cooperation of users beyond the farm level with regard to the calculation, analysis and the availability of information.

Alignment of required information with own farm management information system and farm objectives. Information exchange is determined by the availability of the information at the farm level. The current state of bookkeeping and use of digitalised information tools at this level is highly variable, according to the type of farming and the region. Gathering of variables that requires additional investments, time or knowledge from the farmers' side adds difficulties to the collection. Closely related is the compatibility of the objectives of the external actor to the farm's objectives: interviewees stated that information provision makes more sense if the information can be used for farm-level planning and decision making regarding business strategies or production factors use. Nutrient balance, for example, "can be used as part of a nutrient management plan".

Expected outcome of the information exchange. Farm advisors and other non-farm stakeholders mentioned that data gathering is not a one-sided data provision, but an exchange of knowledge, even in the short term. The level of trust between actors is identified as extremely important: the provision of accurate information can be highly influenced if the data are linked to an incentive or penalty. Also, a data collector should be a reliable agent, trained about the information to be collected and knowledgeable of the area and local farms in order to validate the data during the collection phase. Three main perceived benefits of information exchange were mentioned: professional support to the farmer, a farm-level customised report and the possibility of benchmarking.

Beyond farm level: cooperation among sustainability information users. Data gathering is the first step of knowledge generation. The conversion of the data into usable information includes calculating, interpreting, inferring, communicating and influencing decisions. During this process, issues arise outside of the farm level: (a) calculation of indicators is not standardised; (b) interpretation and inference of indicators can be misled without the necessary control variables and knowledge of the context; (c) indicators should be communicated back to the farmers, society or consumers in an understandable and complete way; and (d) conflicts between sustainability goals among actors requiring information. For all these issues, cooperation between stakeholders is needed. Potential conflicts between databases could be avoided with "collective databases that can be accessed by different parties" or the implementation of "unique data codes for indicators". Both solutions imply the creation of norms that are not yet developed.

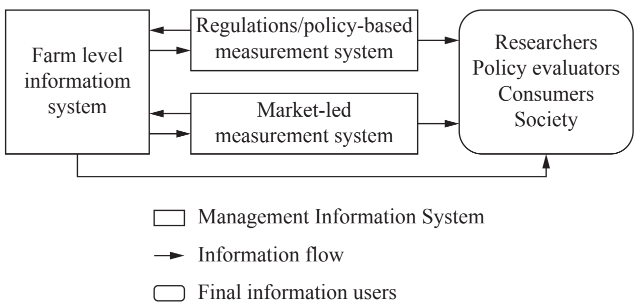

Figure 1: Schema of current sustainability information measurement systems and flows identified by stakeholders.
Source: own construction

Assessment of feasibility and usefulness of sustainability indicators

Across the whole group of surveyed stakeholders, on average, all indicators were considered useful and, with the exception of greenhouse gas (GHG) emissions, all the indicators were considered feasible. Nevertheless, few indicators are considered as being very useful (Figure 2).

The reasons for the differences in assessment of indicators are identified by grouping the concepts derived from the perceptions toward the indicators into categories.

Factors that determine perceived feasibility

The assessment of the feasibility of an indicator would not only depend on the characteristics of the indicator itself (type of data and evidence, level of measurement and allocation) but also on the characteristics of the measurement system in which it is embedded (availability of matching information), the farm characteristics (type, size, fragmentation) and the attitude of the farmer towards the measurement (Table 3).

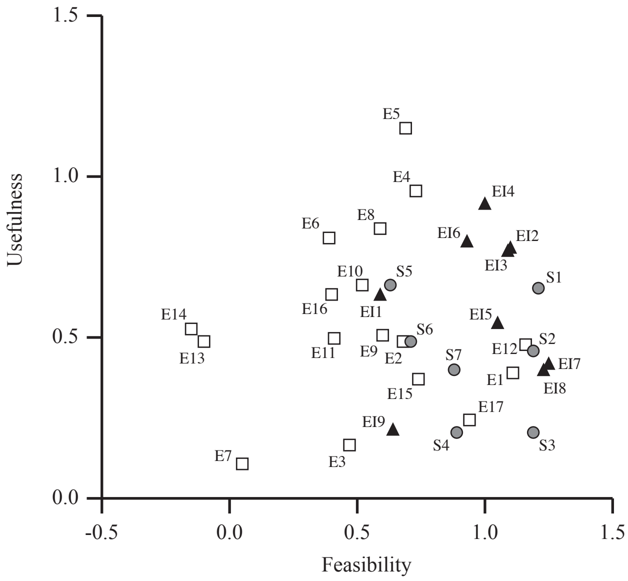

Figure 2: Stakeholders assessment of indicators according to perceived feasibility and usefulness**.**

Scale: 2=++; 1=+; 0=+/-; -1=--; -2=--
See Table 1 for names of indicators
Source: own composition

Table 3: Factors that determine the perceived feasibility of indicators of sustainability.

	Categories and coded attributes	Description and examples
Indicator's attributes	***Type of data***	
	Evidence-based data	Data that are measured with an established instrument and which is ascertainable, e.g. invoices, soil organic matter content.
	Best-estimated data	Data that are estimated or approximated according to the knowledge of the farmer, e.g. manure usage, farm practices, water usage, innovation, advisory services.
	Calculation	Information that is deducted using normative scales or standard coefficients, e.g. GHG emissions.
	Perceptions	Subjective opinions which are not possible to measure physically, e.g. quality of life perceptions.
	Level of data breakdown in collection and calculation	
	Household level Farmer level Farm level Plot /parcel/crop/field level Product level	Level at which the measurement or collection of variables of the indicators take place, e.g. soil organic matter is measured in sampling plots; pesticide usage can be measured at crop, parcel or farm level; emissions can be calculated by hectare or product.
Measurement system	***Availability of data***	
	Part of the recording system of the farm	Data and information are kept in different types of recording systems within the farm: books, software, databases and sheets. In some cases, they are digitalised. Example: farmers keep registers about pesticide usage, fertilisation, cattle movements, investments, contracts, and financial bookkeeping.
	Part of existing external and accessible databases	Farm level information that is collected and stored in databases outside the farm, e.g. Land Parcel Identification System, projects' databases.
	Agent requesting it	
	Regulations: mandatory at farm level	Information that is requested for compliance with regulatory issues, e.g. pesticide usage for regulations, cross compliance checks.
	Requested by clients: desirable or mandatory at supply chain level	Information that is required by traders or consumers, e.g. antibiotics usage, quality assurance per product, certification schemes labelling.
	Special programmes: optional	Information that is requested by special programmes, e.g. certification schemes, research projects, rural development programmes.
Farm	***Farm characteristics***	
	Size	Size of the farm: small/big farms.
	Type	Type of agricultural system, e.g. livestock, horticulture, orchards.
	Fragmentation	Dispersion of the fields and parcels.
	Region	Region, context in which the farm is located.
Farmer	***Farmer attitude toward information provision***	
	Sensitivity of the information	Information which provision can be seen as potentially harmful for the farmer, e.g. personal/private information, part of their business strategy.
	Trust in researchers and policy makers	Degree of trust on the use of information, e.g. doubts about how the information will be used: new taxes, regulations, new requirements.

Source: own compilation

Factors that determine perceived usefulness

Indicator usefulness depends mostly on the relevance for the stakeholders of the objective behind the indicator (Table 4). In two farmers' discussion groups, however, it was stated that is meaningful to collect some indicators even when they are not usable at farm level: a difference in the value for the farmer and the public value was highlighted.

For the interviewees, an indicator is a simplified metric of a complex reality expected to change; therefore, how well the indicator represents this reality is the second factor influencing the usefulness criterion. To infer and make valid conclusions, the adequate judgment would need to use contextual factors and control variables. As one consulted researcher pointed out: "There are facts, lies and statistics. It is not difficult to collect data; it is much more difficult to understand the data".

Perceptions toward indicators according to sustainability dimension

Crossing indicator assessment and using the schemes presented in Tables 3 and 4, this section discusses the stakeholders' perceptions of the indicators categorised in the three dimensions of sustainability.

About *environmental indicators*, stakeholders pointed out the importance of explaining the rationale and links between indicators, taking into account the 'cycles' in agriculture. National sustainability objectives could be translated at a farm level only if information could be consolidated or aggregated using a farm-level balance. Evidence-based data (soil organic matter, water use, energy production, energy consumption) is perceived as costlier and difficult to measure accurately; however, much significant information is already available from farm records (e.g. fertilisers, pesticide usage). Many variables of the indicators are best estimates: farm practices, percentages of allocation (between crops, activities or at the farm/household level) or calculations (water usage, manure usage). Those indicators that measure changes in quality of production factors were identified as usable for farm planning and management to reduce costs, increase productivity and foresee future demand (E5, E12, E10, E8, E9, E6, E16). Those related with greening were linked with access to subsidies (E1, E2, E3). The pesticide usage indicator was associated with complying with regulations and customers' requirements. GHG emissions, on the contrary, is an 'important' indicator used 'to inform', not usable at farm level, and important for the consumer; therefore, highly valued by the value chain actors and policy makers and poorly valued by farmers. Most of the stakeholders – except for value chain actors – considered measuring it as difficult. Indicators related to pesticide usage and nutrient balance were considered as possible sensitive indicators. The link between farm practice and impact was also stressed: there is the need to collect enough information to make the causality link possible; however, the complexity in some environmental indicators to establish this link was also identified: "some activities will lead to measurable changes over 20 years". The need for match information sources and methods using multiple databases, or measurement ini-

Table 4: Factors that determine the perceived usefulness of indicators at farm level.

	Categories and coded attributes	Description and examples
Indicator's attributes	***Relationship of the indicator with sustainability objectives***	
	Causality	Clear causality relationship between variables collected and objectives measured. From the scientific point of view, if the indicator is a valid representation of the expected problem to be measured.
	Interpretation	Existence of sufficient knowledge to interpret the indicator properly and link with management actions.
	Context variables	Availability of knowledge of 'context variables' that make it possible to infer valid conclusions and compare across time, farmers, countries and regions.
	Level of breakdown in reporting	
	Farmer level	Level at which the data is transformed into information that can be used for decision making, e.g. pesticide usage can be reported at crop, parcel or farm level; emissions can be calculated by hectare or product or reported by farm.
	Farm level	
	Plot /parcel/crop/field level	
	Product level	
Measurement system	***Perceived relevance of problem measured with the indicator***	
	Farmer	Relevance of the objective measured through the indicator for the stakeholder, e.g. farm advisors are interested in to know overall performance of the farm; consumers and society are interested in pesticide usage and emissions.
	Farm advisors	
	Policy makers	
	Consumers	
	Society	
	Perceived potential use of the indicator	
	Decision making	Potential to use the indicators for planning and management at farm level, advisor level, sector level, national level, policy level.
	Inform or communicate	Indicator main use is to inform other actors: researchers, policy makers, consumers, community.
Farm	***Farm characteristics***	
	Size	Size of the farm: small/big farms.
	Type	Type of agricultural system, e.g. livestock, horticulture, orchards.
	Region	Region, context in which the farm is located.
Farmer	***Farmer objectives***	
	Farmer objectives	Objectives, e.g. profit maximisation, organic agriculture, protect the environment.

Source: own compilation

tiatives with the same indicators were concepts particularly claimed by policy makers, FADN representatives and data collectors.

Indicators of social sustainability at farm level are perceived by stakeholders as best estimated data and perceptions. In general, they are not currently requested, except in specific rural development programmes or specific research surveys. Like the other indicators, the need for clearer definitions of variables was mentioned. Social indicators are perceived as indicators for informative purposes: they are information already known by the farmer, with low relevance for farm decision making, high usability for policy making and low importance in regard to informing consumers. Policy makers and researchers discussed the importance that social indicators have, and how they have been less present than economic and environmental indicators within the sustainability discussion, while farmers, farm advisors and value chain actors questioned to what extent their analyses will be effectively used. The indicator for employment and working conditions was assessed as the most useful one, despite the complexities of calculating seasonal labour and the number of working hours. Policy makers in particular found a link between social indicators and rural development programmes, even though the fact that having a common exhaustive list that could be relevant and applicable for all regions could be a challenging task.

The indicator based on subjective perceptions (S6) prompted divergent opinions from all stakeholder groups. Many stakeholders emphasised the importance of this measurement but, for others, personal perceptions were regarded as beyond the objectives of policy, and the subjective nature of the questions and the influence of multiple non-controllable factors make their analysis only useful for longitudinal research. Possible sensitive indicators identified were S1, S4, S6 and S7.

Most of the *economic indicators* presented to stakeholders are best estimates or are already accessible using existing bookkeeping on the farm, except for the innovation indicator EI1. This needed to be explained further; while some stakeholders mentioned its importance as part of the objectives of the EU's Common Agricultural Policy, there was a high level of divergence on the concept, the way to measure it, the objective behind its measurement and how it would be analysed. For some other indicators, the relationship with sustainability was not clear (EI2, EI, EI8). Market indicators such as labels and fixed contracts stimulated many different opinions: they have a value important for the farm, but they do not represent a sustainability objective in themselves. Possible sensitive indicators were also identified (EI8, EI9, EI6, EI4).

Conclusions

We have conducted a stakeholder analysis of the measurement of sustainability at farm level. Stakeholders acknowledge sustainability measurement as an important trend in the agricultural sector in which three information systems are identified: own farm system, regulation-based system and market-led system. Every system has its own institutional arrangements, goals and incentives. Information exchange within those systems is influenced by (a) the level of alignment between the farm and the agent requesting it: objectives, information requirements, trust, expected benefits and expected risks and (b) the cooperation of users of indicators beyond the farm level.

Stakeholders assessed 33 sustainability indicators based on feasibility and usefulness criteria. Overall, all indicators are perceived as useful and, except for GHG emissions, all are considered feasible to measure at the farm level. Environmental indicators are perceived as the most useful for all eight groups of stakeholders, especially those indicators expected to be related to farm productivity. Innovation and economic indicators (different from indicators already included in FADN) are perceived more feasible but less useful for sustainability measurement. Social indicators are perceived as important from the policy and research point of view but less useful from the farmers' and value chain actors' perspectives. In general, divergences between stakeholders' perceptions arise for those indicators that are not expected to be used for planning and management at the farm level. The differences in perceptions on how feasible and useful an indicator is could be explained not only by the intrinsic attributes of the indicators but also on the measurement system requiring it, the farm characteristics and the attitude of the farmer towards the measurement. This confirms the value of scientific but also societal criteria in the selection of indicators.

Although the testing of indicators in a monitoring system will be done in the subsequent steps of the FLINT project, stakeholders' consultation elicits the main arguments and different points of view that potentially could improve communication between researchers and users of information. Further assessment is needed of the influence of stakeholders' analysis in the process of introduction of a set of indicators of sustainability and its contribution to the current discussion about efficiency, trade-offs and sustainability development at farm, sector or supply chain level.

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Chapter 3

Advisory services and farm-level sustainability profiles: an exploration in nine European countries.

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Advisory services and farm-level sustainability profiles: an exploration in nine European countries

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ABSTRACT

Purpose: This study explores the use of advisory services by farm managers and its linkages with the economic, environmental and social performance of farms.
Design/methodology/approach: Using cluster analysis we determined groups of farms according to their sustainability performance and explored the correlations between contacts with advisory services and a set of farm-level sustainability indicators.
Findings: There exist significant differences in the number of farmers' contacts with advisory services across countries, type of farms, farmers' degree of agricultural education, utilized agricultural area, legal type of farm ownership and economic size of the farms. We identified three groups of farms that have different sustainability performance, are different in farm characteristics and relate differently to advisory services. The number of contacts with advisory services is positively related to the adoption of innovations, the number of information sources utilized and the adoption of farm risk management measures. We find no clear linear relationship between advisory services and environmental sustainability.
Theoretical implications: This study derives hypotheses to analyze causalities between indicators of farm-level sustainability and advisory services.
Practical implications: Results suggest the importance of taking into account the heterogeneity of farming systems for the design, targeting and evaluation of advisory services. In addition, results confirm the importance of selection of indicators that can be used in multiple sites.
Originality/value: We used a harmonized indicator of advisory services and a harmonized set of farm-level sustainability indicators in nine different EU countries that could be used to evaluate the role of advisory services in the achievement of multiple objectives in different groups of farms in multiple sites.

KEYWORDS
Multi-site assessment of sustainability indicators; agricultural extension; cluster analysis

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1. Introduction

Agricultural advisory services (AS) are seen as one of the most prominent instruments to promote innovation in farms (Hoffman et al. 2009; Labarthe 2009; Rivera and Sulaiman 2009). Although there is a significant amount of literature that investigates the role of information and AS on the adoption of agricultural technologies, the knowledge about the effectiveness and impact as a policy instrument remains fragmented (Labarthe et al. 2014; SCAR 2016; Knierim et al. 2017).

This fragmentation can be attributed to two reasons. Firstly, there is a broad diversity in the type of services and organizational settings that makes standardized evaluations nearly impossible (ADE 2009; Knierim et al. 2017). Secondly, there is still an overall lack of data and therefore inappropriate methodology to measure their efficacy considering the dynamic nature of the innovation adoption process (Doss 2006). In addition, the use of AS is expected to respond to multiple objectives either in policy or research agenda which makes the simultaneous assessment of achievement of these objectives challenging. It is argued that there is a gap on how to evaluate the role of AS in multiple dimensions of the farm and in multiple sites, especially if the purpose of the assessment is to provide inputs for farm-level sustainability assessments, communication between stakeholders or policy design (Angevin et al. 2017).

This article aims to contribute to filling this gap by (1) characterizing the use of AS in a sample of European farms, (2) identifying groups of farms according to their sustainability performance, and (3) exploring the relationship between sustainability and use of AS. For that purpose we tested an indicator of AS and a harmonized set of sustainability indicators applicable to multiple contexts. Through cluster analysis and correlations we identified similar groups of farms according to sustainability achievements and explored the underlying factors that influence it. Based on the results we discuss the implication of the findings.

2. Advisory services and multi-dimensional assessment of farm sustainability

Advisory service is defined as 'the process whereby the advisor aims to motivate and enable the client to solve his/her acute problems' (Albrecht et al. 1987; Hoffman et al. 2009). AS providers are part of the Agricultural Knowledge and Innovation Systems (AKIS) in a broad range of actors of the knowledge infrastructure (Knierim et al. 2015). The AKIS are part of the current Common Agricultural Policy (CAP) 2014–2020 (EU SCAR 2012, 2013) to enhance rural development through innovation support services aiming to improve co-operation and sharing of knowledge (EC 1305/2013).

Despite their relevance, the assessment of the effectiveness of agricultural AS has shown mixed results. Multiple theoretical frameworks and methodological challenges make difficult to find patterns and derive lessons for policy making (ADE 2009; Birner et al. 2009). Cited methodological limitations are the inconsistency in the definition of inputs and outputs and the unavailability of data accounting for variations in the type of advice, agro-ecological factors and organisational settings (ADE 2009; EU SCAR 2016). Besides, a growing body of literature emphasises that AS evaluation should consider the role of other increasingly available sources of knowledge such as learning from peers

(Genius et al. 2014), the effects of information asymmetries (Anderson and Feder 2004) or the influence of neighbours (Läpple et al. 2017).

Two main assessment approaches exists in literature. The first one is the assessment of AS as a system, where the interactions of actors, their orientations, and the relevance of methods are evaluated using governance and institutional capacities criteria (Birner et al. 2009; Faure, Desjeux, and Gasselin 2012; Ragasa et al. 2016; Prager, Creaney, and Lorenzo-Arribas 2017).

The second stream is to assess the effectiveness of AS on the farm: use of knowledge for decision making (Feder, Murgai, and Quizon 2004); technology adoption (Doss 2006; Hennessy and Heanue 2012; Genius et al. 2014), and increment in productivity, efficiency, income or food security in the household (Dercon et al. 2009; Cumming and Fischer 2012; Davis et al. 2012; Ragasa and Mazunda 2018). In this case, AS are measured as the frequency or number of contacts with advisors (Dercon et al. 2009; Barnes, Islam, and Toma 2013; Nordin and Höjgård 2017), the number of farmers attended by an advisor (Birner et al. 2009; Ragasa et al. 2016; Knierim et al. 2017) or the coefficient of extension expenditure (Läpple et al. 2017), while the effect in the farm is based on the intervention logic (ADE 2009; Waddington et al. 2014). To overcome the absence of panel data, time lags, and lack of control groups, researchers use methods as difference in difference studies (Feder, Murgai, and Quizon 2004; Larsen and Lilleør 2014), randomized control trials and randomized differences (Nordin and Höjgård 2017), endogenous switching regression models (Läpple, Hennessy, and Newman 2013) propensity score matching analysis (Läpple and Hennessy 2015) or systematic reviews (Waddington et al. 2014).

Policy instruments and sustainability assessment usually involve the evaluation of more than one objective, comparing multiple and probably conflicting dimensions (Sadok et al. 2008). An assumption in those evaluations is that there are different bundles of farms that have similar production situations (biophysical and socioeconomic characteristics) and apply alike farm management strategies. This in turn results in facing common sustainability challenges (Lechenet et al. 2016). Therefore, the effects, synergies and trade-offs of an intervention can be evaluated comparing between dimensions (Rodrigues, Martins, and de Barros 2018) and between groups or classes of farms (Brown et al. 2001; Lu and van Ittersum 2004; Cheung and Sumaila 2008; Bernués et al. 2011; Ruijs et al. 2013). Identification of features and behaviour of those groups provides useful insights for policy making if changes are expected or desired (Queiroz et al. 2015; van der Zanden et al. 2017; Torralba et al. 2018). As the number of sustainability assessments increases, harmonization is a potential action to legitimize sustainability assessments tools (de Olde, Sautier, and Whitehead 2018).

To identify groups of farmers with similar characteristics that differ from one another, multivariate and latent class analyses are used. Those techniques are based on clustering farms in different typologies with managerial relevance, either measuring dissimilarities or developing probabilities models (Leisch 2004; Hair et al. 2006). With the rise in the availability of large data sets, comparing between groups makes possible to explain the variability between farming systems in multiple sites, determining the factors that influence the sustainability of those (Deytieux, Munier-Jolain, and Caneill 2016).

3. Methods

Using a data set from farm holdings that are part of the Farm Accountancy Data Network (FADN), we hypothesized that groups exist within the sample, having different farm characteristics, sustainability performance and reacting differently to the offer of AS.

3.1. Data and variables

A sample of 1100 agricultural holdings in Germany (DE), Greece (EL), Spain (SP), Finland (FI), France (FR), Hungary (HU), Ireland (IE), The Netherlands (NL), Poland (PL) was selected considering FADN typologies and farm economic size (Vrolijk, Poppe, and Keszthelyi 2016) in the framework of the Europe Union (EU)-funded FP-7 project 'Farm Level Indicators for New Topics in Policy Evaluation' (FLINT). Between 2015 and 2016, farm economic related information was collected from the FADN dataset (FADN Farm Return[1]), and environmental and social aspects were gathered using a dedicated questionnaire (FLINT Farm Return[2]).

To measure the use of farm advice among holdings, farm managers were asked about the number of contacts they had with AS providers during the last year, the type of providers and the themes on which they had sought advice. Six possible types of providers were asked to the farm managers: public, private, farmer-based providers, cooperatives, upstream and downstream companies and others. The content of the advice included the activities part of FADN Farm Return and were aggregated in to three major categories: 'advice for production', 'advice for management/finance' and 'others'.

The indicators of sustainability at farm level were chosen from a list of 33 topics developed by the FLINT project consortium taking into account policy needs (Kelly et al. 2015), a broad literature review (Latruffe et al. 2016), and feedback from stakeholders and FLINT partners (Herrera, Gerster-Bentaya, and Knierim 2016; Poppe et al. 2016). For each of the 33 topics, an exact specification of the variables and a data collection test were conducted (Vrolijk, Poppe, and Keszthelyi 2016).

Table 1 presents the set of sustainability indicators. The environmental dimension was measured using indicators of (1) permanent grassland management under intensive management, (2) greenhouse gas emissions, (3) water consumption, (4) pesticide usage, and (5) nitrogen farm gate balance. Indicators of the economic dimension included three areas: (1) farm revenues, (2) farm labour, and (3) adoption of innovation and risk management practices. The social dimension was represented by indicators that measure four topics: (1) access to information and knowledge, (2) workload as a proxy for work-life balance, (3) farm managers' satisfaction with their quality of life, and (4) involvement of the farmer in the community.

The sample is composed by eight types of farming systems, with a predominance of field crops and milk farms (Table 2). Around 70% of farms are family farms and 25% are classified as partnership farms. More than 70% of the holdings reports more than 50,000.00 Euros of annual Standard Outputs (SO) (Table 2).

3.2. Cluster and correlation analysis

A descriptive analysis of the indicators was conducted identifying and excluding 13 farms that reported more than 160 contacts with AS per year. The *variate* which is defined by

Table 1. Farm-level sustainability indicators.

Indicator (units)	Code	*N*	Mean	SD[a]
Environmental dimension				
Share of permanent grassland under intensive management (%)	E_1_1	863	5.15	354.17
Greenhouse gases (GHG) emissions, at farm level (tonnes CO_2 equivalent)	E_14_1	702	378.28	1459.13
Water consumption /kg of product (m^3/kg)	E_16_1	890	75.59	297.91
Pesticide usage (kg/ha)	E_4_1	681	0.00057	0.00372
Farm gate nitrogen balance (kg)	E_5_1	702	853.79	9165.44
Economic dimension				
Gross farm income (EUR)	SE410	1087	118,085.50	362,263.20
Family farm income (EUR) for family farms	SE420	1087	27,953.37	259,521.50
Farm net value added/AWU[b] (EUR)	SE425	1087	23,223.28	40,207.70
Total labour in AWU (AWU)	SE010	1087	3.24	10.80
Adoption of farm diversification (0 = no adoption; 1 = adoption)	EI_9_1	1087	0.47	0.50
Adoption of credit avoidance (0 = no adoption; 1 = adoption)	EI_9_4	1087	0.43	0.50
Adoption of contracts (0 = no adoption; 1 = adoption)	EI_9_7	1087	0.28	0.45
Innovation at farm level (0 = no innovation adopted and 1 = adoption of innovation)	EI_1_4	1087	0.41	0.49
Social dimension				
Number of sources of information (number)	S_1_4	1019	3.27	1.73
Number of persons participating in training events (number)	S_2_5	334	1.49	3.30
Working hours per week of the manager (hours)	S_5_18	912	34.71	12.20
Satisfaction with quality of life (scale from 0 to 10)	S_6_4	1055	6.97	2.05
Number of community initiatives in which the farm is involved (number)	S_7_2	1087	2.89	2.49

[a]SD = Standard Deviation.
[b]Annual working units (AWU) = full-time equivalent employment in the agricultural holding. AWU is computed by dividing the actual annual working time by the average annual number of hours worked in a full-time job (Eurostat 2016).

Hair et al. (2006) as the 'set of variables representing the characteristics used to compare objects' that allows establishing hypotheses concerning different facets of the concepts measured, was composed by five clustering indicators: Total number of contacts with AS (S_1_1); GHG emissions at farm level (E_14_1); Farm gate nitrogen balance (E_5_1); Farm net value added/AWU (SE425); Total labour (SE010). These indicators were selected considering that (1) they represent the three dimensions of sustainability and (2) have a low or a non-significant correlation between them ($r < 0.3$), avoiding multi-collinearity and disproportional weighting.

The indicators were transformed into standardized values to avoid the bias introduced by differences in the scales. A two-stage approach using hierarchical and non-hierarchical methods was applied. The identification of outliers and the specification of the number of clusters were made using the hierarchical methods (Ward), comparing the Duda-Hart coefficient. For the specified number of clusters we used a non-hierarchical method with the Euclidian average distance as the main parameter of clustering. The clusters were validated profiling each group with the farm variables and the sustainability indicators. Significant differences between groups were tested using mean comparisons (Kruskal–Wallis) and cross-tabulations (χ^2 or Fishers test), considering the non-normality of the data. We correlated (Spearman) the number of total advice contacts with the economic and social indicators by type of farms and clusters of farms. Linkages with environmental indicators were determined using the number of advice contacts related with crop and animal production only, assuming that production related advice leads to the adoption of agronomic practices to improve farm resources efficiency.

Table 2. Descriptive statistics of the sample.

Variables	*N*	%
Country (*N* = 1100)		
DE	52	4.78
EL	124	11.22
ES	128	11.78
FI	49	4.51
FR	280	25.11
HU	102	9.29
IE	64	5.89
NL	155	14.08
PL	146	13.34
Type of farming (*N* = 1100)		
1. Field crops	277	25.18
2. Horticulture	36	3.27
3. Wine	68	6.18
4. Other permanent crops	97	8.82
5. Milk	230	20.91
6. Other grazing livestock	181	16.45
7. Granivores	84	7.64
8. Mixed farms	127	11.55
Economic Size Groups according to Standard Outputs[a] in EUR (*N* = 1100)		
1. 2000 – 8000	19	1.73
2. 8000 – 25,000	120	10.91
3. 25,000 – 50,000	164	14.91
4. 50,000 – 100,000	231	21.00
5. 100,000 – 500,000	445	40.45
6. ≥500,000	121	11
Type of ownership (*N* = 1100)		
1. Family farm	765	69.55
2. Partnership	272	24.73
3. Company	63	5.73
Sex of farm manager[b] (*N* = 1039)		
1. Male	948	91.24
2. Female	91	8.76
Degree of agricultural education of farm manager[b] (*N* = 1039)		
1. Only practical agricultural experience	315	30.32
2. Basic agricultural training	308	29.64
3. Full agricultural training	416	40.04

[a]The standard output (SO) is the sum of all the standard outputs per hectare of crop and per head of livestock, as a measure of its overall economic size, expressed in Euro (Eurostat 2016).
[b]Farm manager: In farms where more than one manager is reported, we considered the one who stated most working hours on the farm.

4. Results

In this section we present the results characterizing the use of AS by identifying the typology of farms that exhibit similar sustainability performance and by exploring the relationship between sustainability performance and use of AS.

4.1. Description of the use of advisory services

On average, each farm has 26.86 contacts with AS annually. This number of contacts is unequally distributed: a quarter of the sample has on average only 6 contacts per year, half of the sample between 15 and 24 and a quarter has 59 or more advisory contacts. Most of the contacts are related to crop or animal production (15.95) with differences among countries (Table 3).

Table 3. Number of contacts per year per type of advice and country.

		Contacts per type of advice							
		All contacts		Crop and animal production		Accountancy, management, and investment		Other themes	
	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD
DE	45	12.71	12.49	6.07	7.48	6.27	7.43	0.38	1.11
EL	120	26.31	24.36	17.69	19.61	8.63	8.56	0	–
ES	125	21.05	13.16	11.31	10.25	7.79	6.11	1.94	3.47
FI	49	17.41	21.57	10.2	13.37	5.57	7.71	1.63	4.29
FR	253	28.8	28.88	18.82	19.79	8.77	12.63	1.2	4.28
HU	90	26.33	21.99	13.62	13.17	9.52	11.28	3.19	6.01
IE	59	11.41	7.84	5.11	5.77	5.03	5.25	1.25	3.58
NL	147	35.14	27.26	23.08	19.2	8.65	8.44	3.4	8.37
PL	145	34.77	27.07	17.17	17.6	17.32	13.26	0.28	1.11
Total	1033	26.86	24.98	15.95	17.35	9.41	10.76	1.49	4.7
Test of equality of means		$p = 0.0001$		$p = 0.0001$		$p = 0.0001$		$p = 0.0001$	
		chi-squared = 116.102 with 8 d.f.		chi-squared = 112.502 with 8 d.f.		chi-squared = 146.35 with 8 d.f.		chi-squared = 59.44 with 8 d.f.	

Differences in the number of contacts are also observed by type of farms and characteristics of the farm or the farm's manager. Farmers with full agricultural training have significantly more contacts with farm advisory services than farmers with less agricultural education. Companies and large farms have more contacts with AS than family farms. Farms of small economic size (EUR 2000–50,000 of SO) have less often contact than larger ones, and the number of contacts increases stepwise with the economic size of the farm. In general, granivores' farms (pigs and poultry) and horticultural farms report the highest amount of advisory service contacts compared to others type of farms (Appendix 1).

The organisational landscape of what type of service providers farm managers contact is diverse and differentiated by countries: sixty eight percent of the farmers reported having contacts with private advisors, followed by public advisors (65%), and upstream and downstream companies (47%). Farmers report having contacts with 2.5 types out of the six possible types of AS providers, with a comparatively higher diversification in the number of providers reported in France and the Netherlands (Figure 1).

4.2. Farm-level sustainability performance typology

Three groups of farms were identified within the sample. The first cluster (CL1) is characterized by a high farm net value added per AWU and an average value of AS contacts per year. Farms belonging to the second cluster (CL2) have on average the largest amount of contacts with AS providers and an average farm net value added per AWU. The third cluster of farms (CL3) is composed by smaller farms with the lowest number of AS per year.

4.2.1. Cluster's profiles

The profiling of the clusters shows differences in farm characteristics: CL1 is mainly composed by commercial and partnership farms with a large UAA and a comparatively high

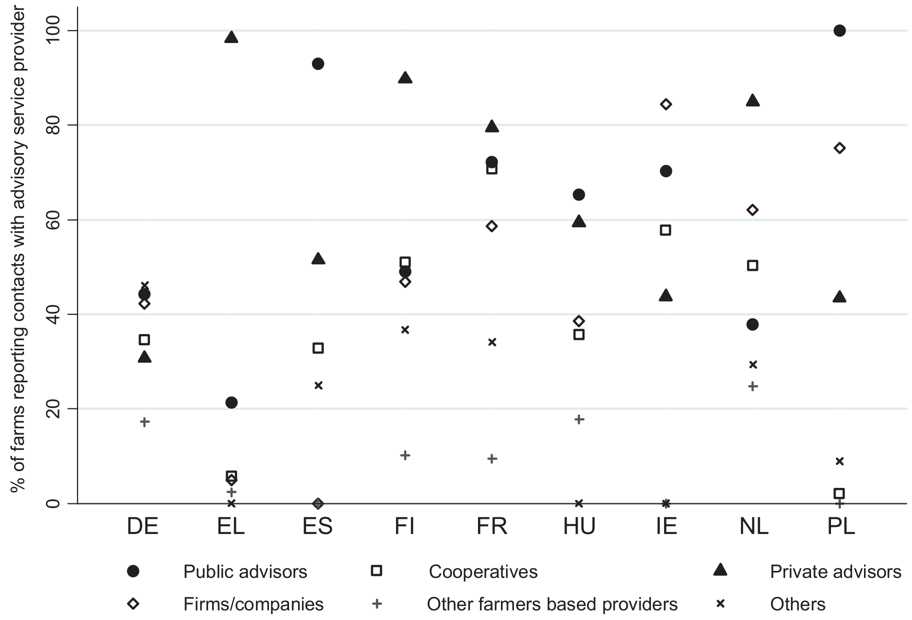

Figure 1. Percentage of farms reporting advisory service contacts with advisory service providers, by country.

proportion of horticultural farms; CL2 is a group of holdings primarily family owned and a high proportion of granivores' farms; CL3 groups mostly family farms with a larger proportion of small size farms from which 43% are operated by managers with only practical agricultural experience (Table 4).

4.2.2. Cluster's sustainability performance

The three typologies of farms also show differences in sustainability indicators. Figure 2 and Appendix 2 describe the average standardized value of sustainability indicators by farm groups depicting possible trade-offs between sustainability indicators.

CL1 includes 12% of the farms and stands out due to having an average contact with AS (27.10) and the highest values of farm income per farm (SE410), per AWU (SE425) and labour (SE010). Even though a large number of sources of information (S_1_4) are used in these farms, the adoption of innovations (EI_1_4) is lower than in the other groups. Despite farm managers of this group working on average more hours per week (S_5_18) than CL3, they are more involved within the community (S_7_2) and have the highest satisfaction with their quality of life (S_1_6). Divergent results are seen in the environmental indicators: while the farms report the highest value of GHG emission per farm (E_14_1), they also have the lowest water footprint per kg of product (E_16_1).

CL 2 includes 16% of the farms with a higher share of farm partnerships with lower values on farm income (SE410) and labour (SE010) than CL1. Those holdings are characterized by having more than the double of contacts with advisory service per year (69.13) than CL1 and almost three times the number of contacts with AS than CL3. Compared to the other groups, farms are using a larger amount of sources of information (S_1_4) and a

Table 4. Cluster profiles.

	CL1 N = 86	CL2 N = 110	CL3 N = 474	All farms N = 670[a]	Test of equality of means
Number of AS contacts per year per holding (mean)	27.10	69.13	17.14	26.95	0.0001
Number of AS related to accountancy, management or investments (mean)	8.30	23.66	7.13	9.99	0.0001
Number of AS related to crop and animal production and animal products (mean)	16.94	41.06	9.22	15.44	0.0001
Number of AS providers used per farm (mean)	2.81	3.00	2.08	2.33	0.0001
Utilized Agricultural Area (UAA) in ha (mean)	261.54	121.56	49.94	88.86	0.0001
					Test of equality of proportions
Economic Size Group (%)					0.000
2000 – 8000 EUR	0	0	3.38	2.39	
8000 – 25,000 EUR	2.33	3.64	21.52	16.12	
25,000 – 50,000 EUR	1.16	10.91	23.21	18.36	
50,000 – 100,000 EUR	6.98	23.64	21.10	19.70	
100,000 – 500,000 EUR	44.19	38.18	27.85	31.64	
≥500,000 EUR	45.35	23.64	2.95	11.79	
Type of ownership (%)					0.000
Family farms	46.51	71.82	87.55	79.70	
Partnerships	34.88	20.00	10.97	15.52	
Commercial farms	18.60	8.18	1.48	4.78	
Education manager (%)					0.016
Only practical agricultural experience	28.57	26.53	41.36	37.60	
Basic agricultural training	20.00	20.41	20.35	20.32	
Full agricultural training	51.43	53.06	38.29	42.08	
Type of farms					0.000
1. Field crops	29.07	25.45	21.94	23.43	
2. Horticulture	20.93	5.45	1.90	4.93	
3. Wine	1.16	0.91	0.84	0.90	
4. Other permanent crops	1.16	9.09	17.09	13.73	
5. Milk	25.58	18.18	24.05	23.28	
6. Other grazing livestock	8.14	9.09	17.72	15.07	
7. Granivores	3.49	18.18	5.27	7.16	
8. Mixed farms	10.47	13.64	11.18	11.49	

[a]The total sample was reduced due to missing values of the clustering variables.

larger share of them have been adopting innovations (EI_1_4) and farm diversification practices recently (EI_9_1). Farm operators in this group report working more hours per week (S_5_18) than the other clusters and also show a lower satisfaction with their quality of life (S_1_6) than CL1. This group of farms presents average values for the environmental indicators.

CL3 includes 70% of the farms, formed mostly by family farms of the smaller economic size segments of the sample which have the fewest number of advisory service contacts per year (17.47). These type of farms have the lowest farm income (SE410), farm net value added/AWU (SE425), and labour (SE010) compared to the other clusters. Despite farm managers from this group working less hours per week (S_5_18) than managers in CL1 and CL2, their involvement in the community (S_7_2) and their satisfaction with quality of life (S_1_6) is the lowest from the three groups. They also have a larger share of farms that practice credit avoidance (EI_9_4). Results from environmental indicators are diverse: farms in this group on average have the lowest farm gate nitrogen balance (E_5_1), the lowest amount of pesticides usage (E_4_1), and the lowest GHG emissions per farm (E_14_1).

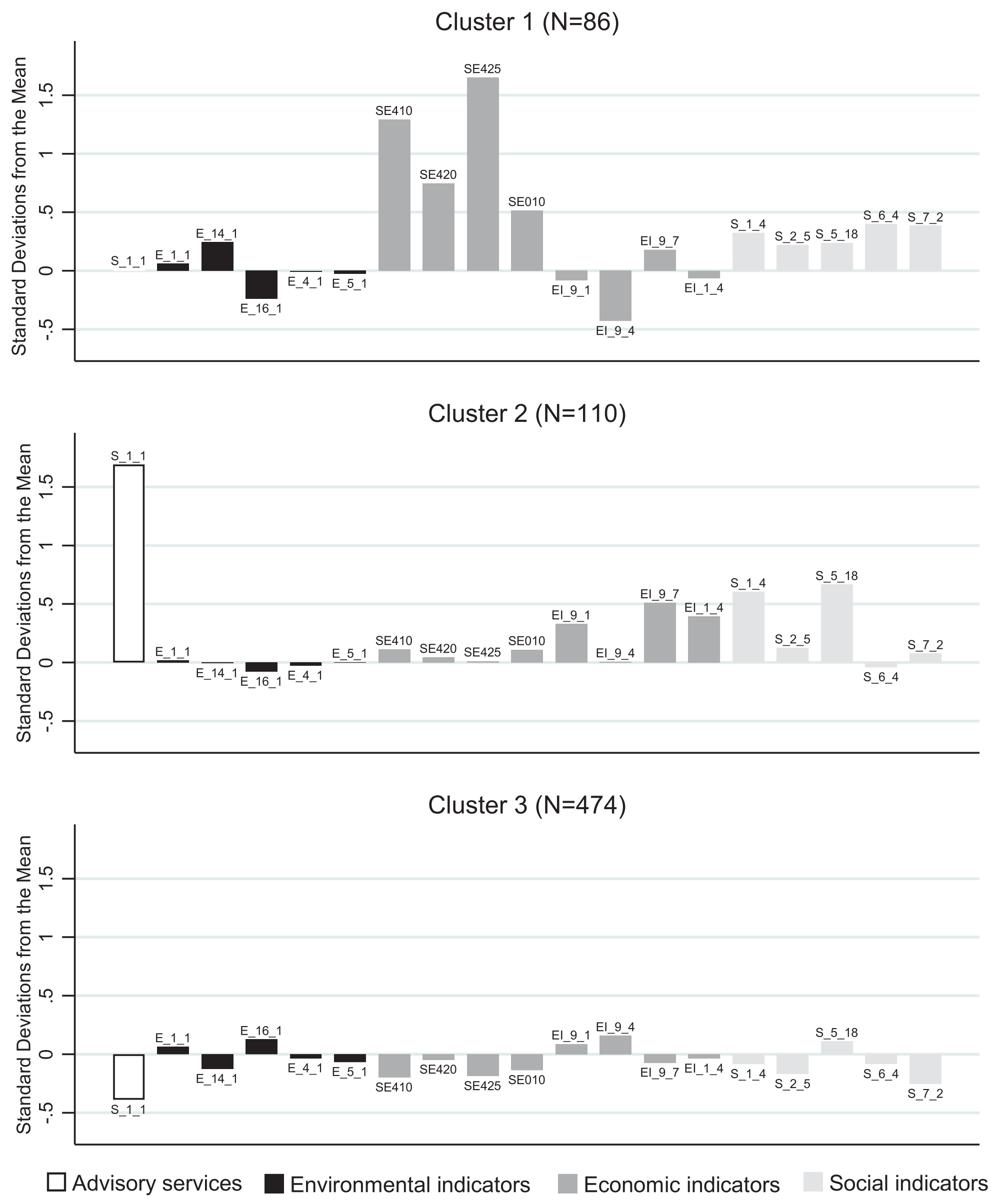

Figure 2. Sustainability performance by farm clusters (standardized normalized variables). **Environmental indicators**: E_1_1 = Share of permanent grassland under intensive management; E_14_1 = Greenhouse gases (GHG) emissions; E_16_1 = Water consumption /kg of product; E_4_1 = Pesticide usage; E_5_1 = Farm gate *N* balance. **Economic indicators**: SE410 = Gross farm income; SE420 = Family farm income; SE425 = Farm net value added/AWU; SE010 = Total labour; EI_9_1 = Adoption of farm diversification; EI_9_4 = Adoption of credit avoidance; EI_9_7 = Adoption of contracts; EI_1_4 = Innovation at farm level. **Social indicators**: S_1_4 = Number of sources of information; S_2_5 = Number of persons participating in training events; S_5_18 = Working hours per week of the manager; S_6_4 = Satisfaction with quality of life; S_7_2 = Number of community initiatives in which the farm is involved.

4.3. Links between advisory services and indicators of sustainability

We found that the advisory service contacts have different linkages with the indicators between and within the sustainability dimensions. There is a positive and significant relation between gross farm income and the number of contacts with AS ($r = 0.2022$) (Table 5). However this correlation is not the same for all farm types: it is higher for other permanent crops and wine and not significant for horticulture, sheep, and mixed farms (Appendix 3)

On average, farms with more advisory contacts are more diversified, have more production contracts, adopt more innovations and are less reluctant in taking credits; this pattern is similar when analyzing the behaviour according to the clusters (Table 6).

In five out of eight farm types, the number of contacts with AS is positively correlated with the number of information sources about the CAP ($r = 0.2306$), but no linkage was found between the number of advisory contacts and persons trained during the last year. Farms with more advisory service contacts are also part of a larger number of community organizations ($r = 0.1198$), and farmers with more advisory service contacts report working more hours per week (Table 7).

Linkages between farm advice on production activities and environmental sustainability were differentiated according to farm types (Table 8): for field crop farms, the more advisory contacts they report, the higher the farm gate N balance ($r = 0.2928$). For grazing livestock farms, the more contacts farmers have with AS, the larger the share of permanent grassland under intensive management ($r = 0.277$). Horticultural farms with higher GHG emissions at farm level have more contacts with AS per year ($r = 0.6397$).

Table 5. Correlation coefficients between AS and indicators of economic sustainability.

		Total		CL1		CL2		CL3	
Indicator	Code	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)
Gross farm income	SE410	1033	0.2022** (0.0000)	86	0.3298** (0.0019)	110	−0.0045 (0.9625)	474	0.0878* (0.0561)
Family farm income	SE420	1033	0.0196 (0.5302)	86	0.2664** (0.0132)	110	−0.0167 (0.8629)	474	0.0198 (0.667)
Farm net value added / AWU	SE425	1033	0.0203 (0.5155)	86	0.0714 (0.5138)	110	0.0046 (0.9619)	474	−0.0647 (0.1595)
Total labour input	SE010	1033	0.2910** (0.0000)	86	0.2729** (0.0110)	110	−0.0501 (0.6033)	474	0.2607** (0.0000)

**p* value < 0.10; ** *p* value < 0.05.

Table 6. Differences in annual contacts with AS between adopters and non-adopters of management practices as indicators of economic sustainability.

		Difference in average of AS contacts between adopters and non-adopters			
Indicator	Code	Total	CL1	CL2	CL3
Adoption of farm diversification (0 = no adoption; 1 = adoption)	EI_9_1	6.29**	11.54**	7.38	2.8**
Adoption of credit avoidance (0 = no adoption; 1 = adoption)	EI_9_4	−3.38**	−10.74**	−3.48	−2.34*
Adoption of contracts (0 = no adoption; 1 = adoption)	EI_9_7	14.29**	−1.12	10.87**	5.63**
Innovation at farm level (0 = no innovation adopted and 1 = adoption of innovation)	EI_1_4	8.67**	6.13	5.25	2.45**

**p* value<0.10; ***p* value < 0.05.

Table 7. Correlation coefficients between advisory service contacts and indicators of social sustainability.

		Total		CL1		CL2		CL3	
Social indicators	Code	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)
Number of sources of information	S_1_4	972	0.2306** (0.0000)	78	0.1564 (0.1715)	106	0.181* (0.0634)	440	0.1379** (0.0037)
Number of persons participating in training events	S_2_5	320	0.0503 (0.3697)	49	0.0918 (0.5305)	58	0.0007 (0.9956)	148	−0.0005 (0.9954)
Working hours per week	S_5_18	860	0.1811** (0.0000)	48	0.0544 (0.7135)	82	0.2234** (0.0436)	405	0.2195** (0.0000)
Satisfaction with quality of life	S_6_4	1006	−0.0405 (0.1992)	78	0.1068 (0.3521)	108	−0.0546 (0.5750)	459	−0.1201** (0.0100)
Number of community initiatives in which the farm is involved	S_7_2	1033	0.1198** (0.0001)	86	0.0059 (0.9572)	110	0.1623* (0.0902)	474	−0.0193 (0.6746)

*p value < 0.10; **p value < 0.05.

Table 8. Correlation coefficients between AS contacts and indicators of environmental sustainability.

		Total		CL1		CL2		CL3	
Environmental indicators	Code	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)	*N*	*r* (*p* value)
Share of permanent grassland under intensive management	E_1_1	820	−0.0978** (0.0050)	62	−0.3678** (0.0033)	94	−0.0957 (0.3589)	355	−0.0784 (0.1403)
GHG emissions at farm level	E_14_1	676	0.0818** (0.0335)	86	−0.0579 (0.5963)	110	0.1062 (0.2697)	474	0.0512 (0.2663)
Water consumption/kg of product.	E_16_1	843	0.1258** (0.0003)	58	0.2416* (0.0677)	95	0.115 (0.2669)	383	0.1614** (0.0015)
Pesticide usage	E_4_1	653	0.0602 (0.1241)	50	0.4835** (0.0004)	85	−0.0038 (0.9723)	299	0.0867 (0.1348)
Farm gate *N*-Balance	E_5_1	676	0.2407* (0.0000)	86	0.082 (0.4529)	110	0.0776 (0.4207)	474	0.1970** (0.0000)

*p value < 0.10; **p value < 0.05.

Although the value of sustainability indicators varies according to the type of agricultural system, there are differences among the same type of farm according to the clusters of farms where they belong. For example, in all the clusters, *GHG emission per farm* are higher in milk and granivore farms than other type of farms, but those farms allocated in CL1 show higher values than farms in CL2 and CL3.

5. Discussion

5.1. Typology of farm sustainability performance and advisory services

The results show that, beyond farm characteristics and production systems, it is possible to identify groups of farms, in terms of sustainability achievement, that differ in the way they are linked with the available offer of AS. For farms in CL1, advisory service contacts are positively related to higher revenue, annual working units, number of information sources, working hours per week, water footprint, and nitrogen balance at the farm gate. In contrast, there is no relationship between the number of AS and sustainability indicators for farms belonging to CL2. For the farming holdings belonging to the CL3, advisory service is positively related to the total amount of labour, the number of sources of information used and the weekly working hours. It is also negatively related to their satisfaction with their quality of life.

The differences between contacts with AS and sustainability indicators according to the groups of farms has two implications. The first one is that identifying bundles of farms with similar performance portrays the differences in socio-ecological conditions and management: the achievement of multiple objectives in the farm is affected not only by the cropping system itself but also by the managerial situation and the specific production state (Pacini et al. 2004; Deytieux, Munier-Jolain, and Caneill 2016; Preissel, Zander, and Knierim 2017). Therefore, multi-site information systems based on harmonized variables that are able to capture local differences (biophysical conditions and farm management strategies) allows identifying which factors are determinant in the sustainability performance.

The second one is that groups of farms with different endowments face different sustainability challenges and use the information available through the AS systems in a distinct manner. Hence, the evaluation should consider not only indicators to compare farms (Bechini and Castoldi 2009), but also the nature of farm-advisor learning exchange relationship that is shaped by differences in knowledge, interpersonal skills and differences in power (Ingram 2008; Klerkx and Jansen 2010) and the modes of communication (Niu and Ragasa 2018). For policy and evaluation purposes it is necessary to tailor the design and assessment of AS according to the factors that influence the use of information in different groups and include variables that evidence the effects of the incentives that foster the demand (pull) or supply (push) of AS oriented to increase sustainability of farms and natural resources as a public good (Klerkx and Jansen 2010).

Use of advice is related to the adoption of innovations, the use of contract farming and farm diversification, numbers of sources of information and participation at community level. Those indicators can be directly linked to AS as advice is considered to be constitutive for farm development and farm level innovations (Rogers 2003) and as a tool to reduce information asymmetries according to how information-intensive the demand is (Anderson and Feder 2004). At the same time, for the smallest farms of the sample, there is a negative relationship between advice contacts and perception with the satisfaction of life and workload of the manager. Due to the larger causality chains that may affect those indicators, the linkage between access and use of advice and social indicators should be further studied considering the theoretical foundations of these relationships.

A linear link of advisory services and environmental indicators was more difficult to establish. There is a large body of literature on how advisory service affects the adoption of specific environmental technologies and practices. Although it is possible to relate the advice activity with the adoption of a specific innovation, the relationship between advice, changes in agronomic practices, and the final environmental outcome for some of the indicators can only be seen in the long term. Additionally, multi-objective assessment is expected to consider not only the trade-offs between objectives but also the temporal trade-offs between the expected outcomes in the short and long term, especially when evaluating environmental services or agronomical impacts (Rodríguez et al. 2006; Queiroz et al. 2015; Lechenet et al. 2017; Vasileiadis et al. 2017).

5.2. Methodological limitations

The study is explorative and descriptive and does not make casual inferences between sustainability indicators and advisory services but rather uses multivariate analysis to explore the linear relationship between the offer of advisory services and the sustainability of bundles of farms. Causality analysis considering the heterogeneity of farms, factors influencing the choice of advice providers, and theories of change behind the AS programmes are challenges for further research. Additionally, the sample intends to represent FADN farms only. The study contributes to testing the adequacy of an indicator of AS in multiple sites: suggested hypotheses can be tested with additional data sets. Also, the research assumes similar relative importance of sustainability indicators; in the future, optimization between objectives can be weighted assigning different relative importance to the objectives according to farm or policy priorities.

6. Conclusion

In this article we describe the use of advisory services, identify groups of farms with similar characteristics and sustainability performance and explore the linkages with farm-level economic, environmental and social performance in nine European countries.

Farm managers' and farming systems' characteristics play a determining role for the use of advisory services. On average, throughout all farm types and countries, the use of advisory services is distributed unequally. The number of contacts differs according to the type of farm, size of the farm, type of ownership, and education of the farm manager. Most farm managers make use on average of more than two types of advisory service providers according to the country-specific variability embedded in the national institutional contexts and AKIS.

Three clusters of farms were founded according to the similarities in five key indicators of sustainability. There are differences between the clusters in farm profiles, accomplishment of sustainability indicators and linkage with the use of advice. Results suggest a positive link between the number of advisory contacts and the degree of farm diversification, innovation adoption, and information sources used by the farm manager. There is also a correlation between the number of advisory contacts and both gross farm income and labour. Also, the results indicate that with the increase of farm size (area and economic farm size) the demand for advisory services increases. We found no direct linear relationship between environmental indicators and advisory services. Therefore we conclude that the attribution of effects of advisory services in multiple objectives at the same time is limited to characteristics of advisory service, farming systems, and managerial decisions. Identifying bundles of farms according to their sustainability performance leads to a better understanding of the influence of the advisory services and hence a better targeting and evaluation of policy instruments aiming to improve the knowledge management.

Notes

1. FADN Farm Return is a questionnaire, identical for all EU countries, which contains 14 tables on incomes of agricultural holdings. It is specified in Commission Regulation (EEC) No 2237/77 of 23 September 1977 (http://ec.europa.eu/agriculture/rica/collect_en.cfm#tfr).

2. FLINT Farm Return contains definitions of each of the variables of sustainability identified in FLINT project. The document is structured following FADN standards in ten tables and 1060 additional variables (http://www.flint-fp7.eu/downloads/reports/FLINT_data_definition.pdf).

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Appendices

Appendix 1. Annual advice contacts by farm and manager characteristics

	Characteristics	Mean	SD	*N*	Test of equality of means[1]
Sex of manager	Male	26.42	24.86	889	$p = 0.7814$
	Female	26.52	26.98	85	chi-squared 0.077 with 1 d.f.
Education of manager	Only practical agricultural experience	22.87	21.56	301	$p = 0.0065$
	Basic agricultural training	26.78	26.99	280	chi-squared 12.101 with 2 d.f.
	Full agricultural training	28.88	25.81	393	
Type of Ownership	Family Farm	24.27	23.10	721	$p = 0.0001$
	Partnership	32.38	27.90	254	chi-squared 27.910 with 2 d.f.
	Company	34.87	28.54	58	
Economic Size group	2000 – 8000 EUR	10.41	7.31	17	$p = 0.0001$
	8000 – 25,000 EUR	16.05	13.44	117	chi-squared = 88.972 with 5 d.f.
	25,000 – 50,000 EUR	20.83	17.46	160	
	50,000 – 100,000 EUR	25.39	23.59	220	
	100,000 – 500,000 EUR	29.19	26.13	404	
	> 500,000 EUR	43.33	32.27	115	
Type of farms	1=Field crops	29.85	25.75	254	$p = 0.0001$
	2=Horticulture	32.57	25.14	35	chi-squared = 51.315 with 7 d.f.
	3=Wine	22.63	21.52	65	
	4=Other permanent crops	20.50	17.66	94	
	5=Milk	23.77	19.85	216	
	6=Other grazing livestock	21.70	24.48	175	
	7=Granivores	41.38	34.45	79	
	8=Mixed farms	29.84	26.81	115	

Appendix 2. Sustainability performance by clusters

Indicator Code	Cluster 1			Cluster 2			Cluster 3			All farms			Test of equality of means
	N	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	*N*	Mean	SD	
Environmental indicators													
E_1_1	62	27.19	61.48	94	12.22	59.31	355	27.79	68.84	511	24.85	66.48	0.0192
E_14_1	86	734.77	1292.92	110	370.17	715.96	474	195.87	380.23	670	293.66	656.42	0.0065
E_16_1	58	4.48	12.88	95	52.36	195.41	383	113.40	382.20	536	90.79	335.35	0.0004
E_4_1	50	0.00	0.00	85	0.00	0.00	299	0.00	0.00	434	0.00	0.00	0.0071
E_5_1	86	616.71	1071.40	110	884.47	4312.18	474	230.49	570.96	670	387.43	1863.02	0.0001
Economic indicators													
SE410	86	586,584.20	109,4311.00	110	158,888.00	230,245.50	474	46,068.01	63,523.22	670	133,970.40	442,213.30	0.0001
SE420	86	221,775.70	521,196.50	110	39,717.98	105,811.80	474	15,503.56	45,191.12	670	45,955.79	205,959.70	0.0001
SE425	86	89,673.95	46,060.17	110	23,733.41	28,253.96	474	15,724.92	18,665.77	670	26,531.71	35,249.23	0.0001
SE010	86	8.81	15.10	110	4.42	6.17	474	1.76	1.55	670	3.10	6.53	0.0001
EI_9_1	86	0.43	0.50	110	0.64	0.48	474	0.51	0.50	670	0.52	0.50	0.0379
EI_9_4	86	0.22	0.42	110	0.44	0.50	474	0.51	0.50	670	0.46	0.50	0.0001
EI_9_7	86	0.36	0.48	110	0.51	0.50	474	0.25	0.43	670	0.30	0.46	0.0001
EI_1_4	86	0.38	0.49	110	0.61	0.49	474	0.40	0.49	670	0.43	0.50	0.0017
Social indicators													
S_1_4	78	3.83	1.91	106	4.32	2.16	440	3.12	1.63	624	3.42	1.83	0.0001
S_2_5	49	2.22	4.00	58	1.91	4.80	148	0.94	2.29	255	1.41	3.40	0.0569
S_5_18	48	37.63	15.12	82	42.87	12.51	405	36.08	14.26	535	37.26	14.27	0.0001
S_6_4	78	7.79	1.29	108	6.89	2.03	459	6.80	2.24	645	6.93	2.14	0.0011
S_7_2	86	3.85	3.08	110	3.08	2.30	474	2.26	2.28	670	2.60	2.46	0.0001

Appendix 3. Correlations of AS and sustainability indicators by type of farms

		Type of farms							
Code	All farms (1033)	Field crops (254)	Horticulture (35)	Wine (65)	Other permanent crops (94)	Milk (216)	Other grazing livestock (175)	Granivores (79)	Mixed farms (115)
E_1_1	−0.0978	−0.0403	−0.5238	0.087	0.1141	−0.1842	−0.2347	0.2024	−0.1314
	(820)	(214)	(10)	(61)	(39)	(179)	(166)	(51)	(100)
E_14_1	0.0818	0.1308	0.6397*	0.8857	0.22	0.2275	−0.1652	0.4062	0.3707
	(676)	(159)	(33)	(6)	(92)	(156)	(101)	(52)	(77)
E_16_1	0.1258*	−0.0152	−0.021	0.1488	0.3143	0.2312	0.1533	0.0461	0.0036
	(843)	(229)	(12)	(61)	(68)	(184)	(111)	(74)	(104)
E_4_1	0.0602	0.0809	−0.0258	0.3105	0.0322	0.2169	0.2397	−0.1001	0.1529
	(653)	(207)	(24)	(50)	(65)	(118)	(51)	(50)	(88)
E_5_1	0.2407*	0.2928*	0.2191	0.7143	0.208	0.1801	−0.0251	0.2433	0.3483
	(676)	(159)	(33)	(6)	(92)	(156)	(101)	(52)	(77)
SE410	0.2022*	0.2457*	0.4576	0.4024*	0.5283*	0.1844	0.0703	0.2269	0.1686
	(1033)	(254)	(35)	(65)	(94)	(216)	(175)	(79)	(115)
SE420	0.0196	0.115	0.4695	0.3328	0.2853	−0.0781	−0.0221	0.0304	−0.1283
	(1033)	(254)	(35)	(65)	(94)	(216)	(175)	(79)	(115)
SE425	0.0203	0.1237	0.3412	0.2873	−0.0686	−0.0141	−0.0761	0.1333	−0.0767
	(1033)	(254)	(35)	(65)	(94)	(216)	(175)	(79)	(115)
SE010	0.2910*	0.2277*	0.3705	0.2844	0.5732*	0.3175*	0.3114*	0.2647	0.2363
	(1033)	(254)	(35)	(65)	(94)	(216)	(175)	(79)	(115)
S_1_4	0.2306*	0.2665*	0.5258*	−0.2545	0.4015*	0.2496*	0.1124	0.1286	0.2779*
	(972)	(252)	(27)	(54)	(71)	(215)	(164)	(76)	(113)
S_2_5	0.0503	0.1213	0.5127*	0.5118	0.3065	0.0221	0.0965	−0.3151*	0.0439
	(320)	(65)	(21)	(14)	(26)	(85)	(24)	(42)	(43)
S_5_18	0.1811*	0.1558*	0.4339	−0.1519	0.5516*	−0.0143	0.1101	0.3823*	0.2815*
	(860)	(226)	(14)	(65)	(92)	(151)	(146)	(59)	(107)
S_6_4	−0.0405	0.0077	0.2079	−0.1897	−0.0513	−0.0806	−0.2530*	0.2544*	0.0734
	(1006)	(247)	(25)	(65)	(94)	(209)	(174)	(78)	(114)
S_7_2	0.1198*	0.1764*	0.5780*	0.1557	0.1039	0.1099	−0.0085	0.157	0.0634
	(1033)	(254)	(35)	(65)	(94)	(216)	(175)	(79)	(115)

ERRATA CHAPTER 3
Author: Beatriz Soledad Herrera Sabillón

24.05.2020

In pages 31 and 32 of Chapter 3, where it says S_1_6 should be read S_6_4. It should be noted that this mistake in the code writing has no implications in the analysis and interpretation of results.

Source:

Herrera, B.; Gerster-Bentaya, M.; Tzouramani I.; Knierim, A. (2019) Advisory services and farm-level sustainability profiles: an exploration in nine European countries, The Journal of Agricultural Education and Extension, 25(2): 117-137. DOI: 10.1080/1389224X.2019.1583817

Chapter 4

Farmers' satisfaction with their work: influence of farm-level factors.

Herrera, B.; Gerster-Bentaya, M.; Knierim, A. (2019). Farmers' satisfaction with their work: influence of farm-level factors. Working paper (submitted).

Highlights

- Satisfaction with farming influences largely farmers' satisfaction with their quality of life
- Farm-level factors determine less than one fifth of work satisfaction among farmers
- Monitoring social sustainability of agricultural systems implies the development and testing of a metric measuring farmers' perceptions

Abstract

Societal changes in the agrifood sector towards sustainability are demanding the use of metrics of well-being of farmers beyond the economic dimension. We contribute with the research on farmers' well-being, exploring how farm-level factors influence farmers' satisfaction with their work and with their quality of life, using a data sample of 1099 farms in nine European countries. Results indicate that satisfaction with the farm work has a significant and large influence on the satisfaction with quality of life. Farm-level aspects such as working time, age of assets, financial situation of the farm and social engagement significantly influence farmers' satisfaction with farming but their joint effect explains less than one fifth of it.

Keywords: work satisfaction, quality of life, sustainability, social indicators

JEL classification: Q12, I31

1 Introduction

Well-being is traditionally measured using indicators of income and consumption. The use of those indicators alone, may overestimate the utility derived from consumption and underestimate the disutilities associated with it (Hirschauer et al., 2015), prompting decision making that cause welfare differences within individuals and within generations (Gowdy, 2005). More and more, it is recognized that the progress measurement of the society involve multi-dimensional aspects of well-being in order to be able to predict changes in the factors that could affect it in the future, namely sustainability (Stiglitz et al., 2010).

So far, sustainability research has been focused on the discussion about environmental indicators, leaving a gap for a consensus on the social dimension. A social indicator is defined as "*a direct and valid statistical measure which monitors levels and changes over time in a fundamental social concern*" (OECD, 1976). Differences in values of social indicators for decision making are influenced by how actors perceive their reliability and validity, which poses a conceptual but also a measurement problem (OECD, 1976; OECD, 2013). Three levels of concerns are identified in the use of social indicators: (i) their conceptual and operational framework; (ii) the selection of their subcomponents and, (iii) the determination of their driving factors (OECD, 2013). Moreover, despite the abundant research and the presence of sustainability objectives in policy instruments, the use of sustainability metrics by producers, retailers, consumers and policy makers is still unclear.

Evolvement trends in the agricultural sectors, such as farm exit (Lips and Gazzarin, 2016), agricultural abandonment (van der Zanden et al., 2017), succession strategies in family farming (Suess-Reyes and Fuetsch, 2016) and changes in rural populations, call for an understanding of the determinants of rural quality of life (Arbuckle and Kast, 2012) in order to orient policies that foster skilled labour to work in the agricultural and biomass production.

The measurement of the concept of quality of life in agriculture is still in development (Howley et al., 2017). Quality of life is a subjective concept embedded in a cultural, social and environmental context that addresses individuals' perceptions of both positive and negative dimensions (WHO group, 1995). Two types of factors are acknowledged to affect the quality of life: the capabilities of the individual to cope with life (life-ability) and the characteristics or favourability of the social and natural environment of the individual (liveability) (Hirschauer et al., 2015).

To better understand the perceptions that farmers have about their quality of life, we investigated the influence of farm-level factors in farmers' satisfaction with farming and its relationship with the level of satisfaction they have with their overall quality of life. We developed a theoretical construct of farmers' work satisfaction using five domains and tested if farm-level indicators have an influence on these perceptions. We propose a path model using a Structural Equation Model-Partial Least Squares (SEM-PLS) approach, testing the validity and reliability of constructs and determining on how far the concepts are related between them. This article presents the results of our model, discussing the appropriateness of the indicators and concluding with the limitations of the research.

2 Quality of life, well-being and social indicators: concepts, use and measurement

Despite being studied for a long time, the concept of quality of life was mentioned first as non-economic welfare by Pigou in 1924 in *The Economics of Welfare*. The operationalization of the concept for research and policy making has been debated since decades and nowadays there is an agreement on its multidimensional and context dependent meaning as stated by the World Health Organization definition (1995:1405): "*Quality of Life is an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.*"

The terms quality of life, well-being, subjective well-being (SWB), happiness and life satisfaction are used interchangeable in a large body of literature. Overall, quality of life and well-being refers to a variety of dimensions that includes both observable and perceived indicators (Gasper, 2014; Eurostat, 2015) while SWB is limited to denote the individuals' perceptions about their life (OECD, 2013). The difference between the two is based on how the concept is operationalized. The first stream is based on the theory of capabilities, choices and functionings of the individuals that concretizes well-being using basic dimensions of human development (UNDP, 2015). In contrast, SWB researchers use satisfaction with life as a proxy for individuals' utility and as one of the key indicators of well-being. The main assumptions are that a reported self-satisfaction is correlated with the theoretical concept of well-being and that there is an interpersonal ordinal or cardinal comparability of satisfaction among individuals (Mora and Ferrer-i-Carbonell, 2009; van Praag et al., 2003). During recent years, satisfaction with life have been included in several surveys such as the European Quality of Life conducted in 2003, 2007, 2011, 2016 (Böhnke, 2005; Grijpstra et al., 2013) and in national statistical accounts like German Socio-Economic Panel or British Household Panel Survey.

Although many studies conclude that measuring perceptions is as reliable as measuring observable indicators, there are still concerns about the self-report state of well-being as a policy instrument because its isolated measurement could mask inequalities (Austin, 2016) or represent different hedonic or eudaimonic perspectives (McMahan and Estes, 2011). Consequently, monitoring initiatives such as EU Beyond GDP initiative , Eurostat's Quality of Life framework , OECD Better Life Index and ad-hoc commissions such as the German Enquete Commission measure the progress of society using observable well-being indicators such as income, health, knowledge and skills, safety, environmental quality and social connections (OECD, 2013; Eurostat, 2015) but also measuring the subjective individual perceptions on their well-being such as satisfaction with quality of life (Eurostat, 2016; Diener et al., 2013).

The link between subjective and objective indicators of well-being remains a challenge. In the agricultural sector, the topic is of particular importance due to the trend of aging population, low income reported in rural areas (Eurostat, 2017), farm abandonment or in risk to be abandoned (Pointereau et al., 2008; Terres et al., 2013), barriers to the entrance of young or new farmers in to the sector (DG AGRI, 2017), high psychosocial demands faced by farm operators (Lunner Kolstrup et al. 2013; Lips and Gazzarin, 2016) and perceived gaps between aspiration and opportunities among agricultural workers (Lunner Kolstrup et al., 2013; OECD, 2017; Agarwal and Agrawal, 2016). Peel et al. (2016) indicates that the poorer the perceived well-being of a farmer the more likely a farmer is to leave farming, with a moderation effect of farm size, profitability, age and off-farm income.

3 Hypotheses generation

To investigate the relationship between the satisfaction that farmers have with their work and the satisfaction with quality of life as predictor of farming continuity, we conducted the research hypothesizing that satisfaction with farming has a positive influence on the satisfaction that farmers have with their quality of life.

Quality of the work is one of the aspects that have a large influence on workers well-being; yet, there is no conclusive evidence on the direction of causation between work life and quality of life (UNDP, 2015; Haugen and Blekesaune, 2005), existing a possible reverse causality between the two aspects (Näther et al., 2015). Overall, quality of the work is defined as a concept that includes multiple observable characteristics of the job as they are experienced by workers (OECD, 2017) and is commonly measured with a set of indicators collected throughout national and international surveys[1] with different concepts, comprehensiveness, comparability, timeliness and sample size (OECD, 2017). Where there is no data available, job satisfaction is used as a related indicator of working conditions, despite its argued flaws (OECD, 2017). From a policy perspective, measuring working social conditions is claimed to improve workers health and well-being and consequently increase productivity, workers innovative behaviour and competitiveness (OECD, 2017; Helbling and Kanji, 2018; Rain et al., 1991). Although not yet standardized, either regulatory frameworks or certification labels include reporting on working conditions of agricultural labor (Krumbiegel et al., 2018) while job satisfaction in agriculture has been analyzed using theories such as Herzbergs theory (Bitsch and Hogberg, 2005) , the Warr's vitamin model (Meyerding, 2016) or the exchange based model (Mulinge and Mueller, 1998). With this background, we derive the first hypothesis:

H1. The higher farmers'satisfaction with their work, the higher farmers' satisfaction with their quality of life.

Previous research indicates that the individual perception that farm workers have on farming are affected by both farm characteristics and non-monetary benefits of farming. For example, farm related aspects include the content of the work, terms of employment, leisure time, supervision and income (Lips and Gazzarin, 2016; Mußhoff et al. 2013, Näther et al. 2015, Krumbiegel et al. 2018; Duc, 2008) but also specific farm traits such as farm loans (Howley et al., 2017; Näther et al., 2015), modernity of the farm (Näther et al. 2015), satisfaction with health conditions (Näther et al., 2015; Howley et al., 2017), perceived financial situation of the farm (Besser and Mann, 2015), perceptions of adequacy of income (Howley et al., 2017) or farm diversification (Mann and Besser, 2017). Structural factors that have been found to have an influence are farm size and the characteristics of the agricultural systems (Besser and Mann, 2015; Duc, 2008).

In contrast, non-monetary rewards or non-pecuniary benefits, defined as the differential on earnings that a farmer accept instead of what he or she could earn in an alternative off-farm occupation, are

[1] European Working Conditions Survey, European Quality of Life Surveys, European Social Survey, Eurobarometer in working conditions, International Social Survey Program, Gallup World Poll and national surveys

argued to be substantial for farm operators (Key and Roberts, 2009; Howley et al., 2017; Howley, 2015). Aspects such as life style, being self-employed, autonomy in decision making, friendship establishment and recognition are found in the literature influencing the farm decisions and farmer welfare (Howley, 2015; Key, 2005; Kliebenstein, 1980). Other criteria linked to how farmers evaluate life satisfaction are perceptions on time off, time with family, and reputation among other producers (Russell and Bewley, 2013). Similar to self-employees, entrepreneurs or family business owners, farmers are argued to value their independence (Key, 2005; Key and Roberts, 2009) and other non- monetary aspects, such as trainings (Krumbiegel et al., 2018).

Considering those aspects, we tested the relationship between farm aspects and satisfaction of farmers with their work with the following hypotheses:

H2. Farm operators working in farms with larger amount of holidays and free days have higher satisfaction levels with their work.

H3. Farm operators working in farms with larger weekly working hours during normal and peak seasons have lowers satisfaction levels with their work.

H4. Farm operators working in farms with older agricultural assets have lower levels of satisfaction with their work.

H5. Farm operators working in farms with higher values in income, assets and cash flow have higher levels of satisfaction with their work.

H6. Farm operators with more frequent access to trainings and information sources have higher levels of satisfaction with their work.

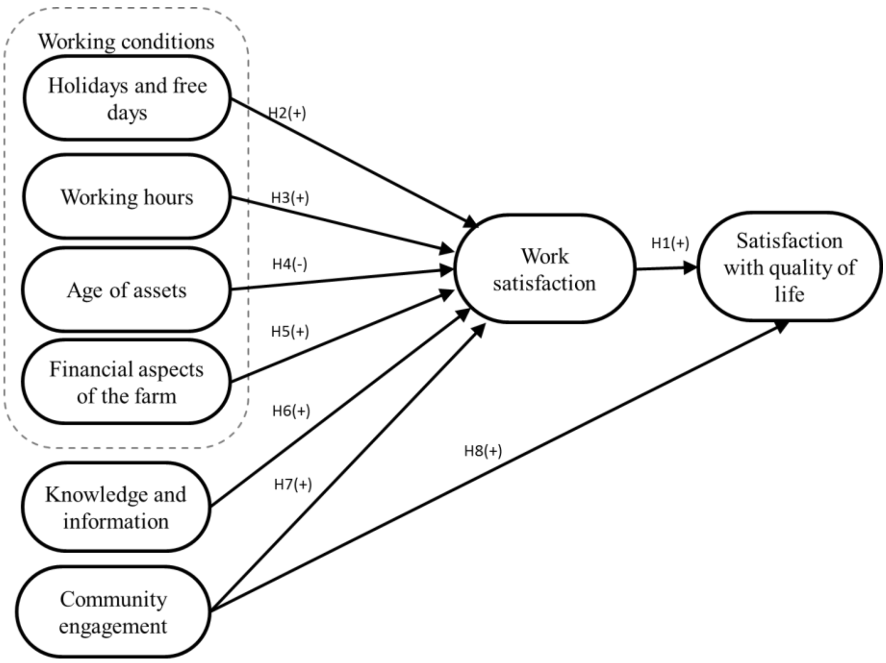
We also tested the community engagement, measured as the total number of community initiatives in which the farmer is involved on as a possible influencer in the satisfaction with farming. As community engagement is beyond the farm-level, we also expect that it has a positive direct influence in the perception farmer have about their quality of life:

H7. Farm operators with more involvement in the community have higher satisfaction levels with their work.

> **H8. Farm operators with more involvement in the community have higher satisfaction levels with their quality of life.**

The path diagram depicts the hypothesized relationships between the theoretical concepts that influences work satisfaction and the satisfaction with quality of life (Figure 1):

Figure 1. Path diagram for the hypothesized links between farm-level indicators, work satisfaction and farmers' satisfaction with their quality of life.



4 Methods

To test the linkage between quality of life and their determinants face several methodological problems: analysis of ordinal or cardinal scales, multicollinearity between determinants, presence of measurement errors, presence of unobservable variables and possible reverse causality (Hirschauer et al., 2015; OECD, 2013; Kristoffersen, 2015).

We have used a PLS-SEM approach for studying a system of linear relationships between the multiple blocks of variables in order to avoid the measurement errors and not assuming the normality of the data (Sanchez, 2013; Hair, 2010; Hair et al., 2014). The Structural Equation

Modelling (SEM) is useful to test theories that contain multiple equations involving dependence relationships simultaneously, allowing to estimate parameters for relationships between theoretical constructs and to assess complete behavioural science theories (Bollen 1989; Sanchez, 2013; Kline, 2016). Using latent variables or constructs permits extracting out the variance across various indicators, accounting for the measurement error argued to be present in social indicators where inaccurate responses may come from different understandings, respondents are unsure on how to respond, or there exists ambiguity or disagreement in the concepts behind the measurement (Hair, 2010; OECD, 2013; Bollen, 1989).

According to Sanchez (2013) and Hair et al. (2017), in PLS-SEM, the latent variables (LV) are represented by a score calculated as a weighted (ω_{jk}) sum of their manifest variables (X_{jk}):

$$LV = \sum_k \omega_{jk} X_{jk} \quad (1)$$

The score is computed maximizing the explained variance of the dependent variables (Sanchez, 2013) and is used later to calculate both a measurement model (the relationship between the theoretical construct and their indicators) and a structural model (the relationship between the theoretical constructs) (Sanchez, 2013; Hair, 2010; Kline, 2016; Hair et al., 2017).

The application of the analytical models was done in three stages. Firstly, we developed a measurement model determining latent variables (LV) that represent the theoretical concepts. For each latent variable, a set of manifest indicators (MV) was chosen in order to operationalize it and a latent variable score was computed, assuming that the manifest variables are a function of the latent variables (Trujillo-Barrera et al., 2016; Fischer et al. 2009; Hernández-Espallardo et al. 2013). We also included in the model two single-item variables. The measurement model was assessed according to their validity and reliability, using SMART-PLS software (Ringle et al., 2015). Results of the measurement model are shown in the section 4.2 in tables 2 and 3.

Secondly, we have used a multinomial logit model to assess the influence of the latent variables in the work satisfaction ordered scales. We have used a multinomial logit model because in our sample an ordered logit model did not to meet the parallel regression assumption for ordinal scales. Results of the model were computed using STATA and are presented in the section 5.2, Table 4 and 5.

Thirdly, we have determined the structural model. The structural model is the linear, non-recursive relationship between the latent variables. We have used SMART-PLS software (Ringle et al., 2015). Results of the structural model are presented in section 5.3, Table 6.

4.1 Sample

To conduct the research we made use of a 1099 agricultural holdings data set that integrated farm level information derived from the Farm Accountancy Data Network (FADN) and farm level sustainability indicators developed by FLINT project. Farms in the sample are located in nine countries: The Netherlands (NL), Hungary (HU), Finland (FI), Poland (PL), Spain (ES), Ireland (IE), Greece (GR), France (FR) and Germany (DE). The holdings were chosen following a selection plan aimed to represent the composition of FADN farms in terms of type of farms and farms' economic size (Vrolijk et al., 2016). The sample is composed by eight types of farming, predominantly field crops (25.18%) and milk farms (20.91%). Around 70% are family farms and more than 70% of the holdings reports more than 50,000.00 Euros of annual Standard Outputs (Table 1).

Table 1. Sample description

	N (1099)	%	Work Satisfaction standardized values[1]	
Country			**Mean**	**SD**
DE	52	4.78	-0.093	1.117
EL	124	11.22	0.066	0.953
ES	128	11.78	0.081	1.049
FI	49	4.51	0.383	0.736
FR	280	25.11	-0.122	0.985
HU	102	9.29	-0.097	1.125
IE	63	5.89	0.518	0.917
NL	155	14.08	0.366	0.571
PL	146	13.34	-0.533	1.051
Type of farming				
Field crops	277	25.18	0.213	0.950
Horticulture	36	3.27	0.502	0.444
Wine	68	6.18	0.132	0.781
Other permanent crops	97	8.82	0.140	1.001
Milk	229	20.91	-0.159	1.011
Other grazing livestock	181	16.45	-0.043	1.059
Granivores	84	7.64	-0.226	0.975
Mixed farms	127	11.55	-0.290	1.062
Economic Size Groups according to Standard Outputs[2] in EUR				
2,000 - 8,000	19	1.73	-0.201	1.185
8,000 - 25,000	120	10.91	-0.085	1.066
25,000 - 50,000	164	14.91	-0.115	1.084
50,000 - 100,000	231	21.00	-0.058	1.012
100,000 - 500,000	444	40.45	0.024	0.960
6>500,000	121	11	0.295	0.833

[1] Work Satisfaction Standardized Values are normalized values of the weighted sum of the manifest variables of Work Satisfaction construct (see page 7 and 8).
[2]The standard output (SO) is the sum of all the standard outputs per hectare of crop and per head of livestock, as a measure of its overall economic size, expressed in Euro (Eurostat, 2016).
Source: the authors

4.2 Data and measurement model

The first stage of the analysis consisted in using factor analysis to analyse the measurement model proposed (Table 2). The measurement model in PLS path models depicts the linear relationship between the latent variable and its manifest variables, considering the total variance, similar to principal component analysis (Sanchez, 2013; Hair et al., 2010). To assess the uni-dimensionality of the constructs we considered the factor loadings of the variables on each of the constructs, while to assess their reliability we computed Cronbach's alpha (α), Composite Reliability index (CR) and the Average Variance Extracted (AVE) (Table 2).

Table 2. Variables and factor analysis of the measurement model

Latent variables and manifest variables	N	Mean (SD)[1]	Factor loading (p-value)[2]
QOL- Quality of life			
MV1.Satisfaction with quality of life (scale from 0 to 10)	1068	6.97 (2.05)	na
WS-Work Satisfaction (α[3] =0.713;CR[4]=0.823; AVE[5]=0.546)			
MV2. Satisfaction with daily job tasks (scale from 0 to 10)	1095	7.23 (1.76)	0.822 (0.000)
MV3. Satisfaction with work life balance (scale from 0 to 10)	1092	6.30 (2.18)	0.795(0.000)
MV4. Satisfaction with being a farmer (scale from 0 to 10)	1094	7.58 (2.09)	0.792(0.000)
MV5. Satisfaction with freedom of decision making (scale from 0 to 10)	1090	7.47 (2.12)	0.485(0.000)
MV6. Stress perception (scale from 0 to 10, reverted)	1081	5.88 (2.35)	dropped
KI-Knowledge and Information (α =0.379;CR=0.731; AVE=0.607)			
MV7. Number of providers of advisory services (number)	1099	2.52 (1.34)	dropped
MV9. Number of total contacts of advisory service per year (number)	1046	29.89 (37.94)	0.443(0.064)
MV8. Number of main information sources about CAP (number)	1032	3.291 (1.74)	0.969(0.000)
HF-Holidays and Free days (α =0.438;CR=0.833; AVE=0.715)			
MV10. Holiday days (days)	1014	19.01 (32.39)	0.708(0.000)
MV11. Free days per week (days)	938	0.82 (0.81)	0.863(0.000)
WH-Working hours (α =0.562; CR=0.772; AVE=0.531)			
MV12. Unpaid labour input in annual working units (AWU)	1099	1.52 (0.76)	0.790(0.000)
MV13. Average weekly working hours of manager (hours)	924	34.76 (12.21)	0.652(0.000)
MV14. Average day working hours during peak season (hours)	1062	11.64 (2.72)	0.671(0.000)
AA-Age of assets (α =0.385; CR=0.756; AVE=0.619)			
MV15. Average age of machinery (years)	1077	14.13 (7.16)	0.917(0.002)
MV16. Average age of agricultural buildings (years)	1018	22.88 (7.16)	0.590(0.026)
FA-Financial aspects of the farm (α =0.802; CR=0.912; AVE=0.775)			
MV17. Farm net value added per AWU (1000 EUR)	1099	23.36 (40.61)	0.842(0.000)
MV18. Total assets value (1000 EUR)	1099	1023.15 (2304.86)	0.746(0.000)
MV19. Expenditure for the accounting year without operations on capital and on debts and loans (1000 EUR)	1099	120.49 (671.65)	0.838(0.000)
SE-Social Engagement			
MV20. Number of organizations and local events in which the farm takes part (number).	1099	2.93 (2.53)	na

1. SD = Standard Deviation
2. Factor loadings (λ_{jk}) represent the coefficient of the latent variable (*LV*) in the regression of each manifest variable .
; p-value computed bootstrapping 500 samples.
3. α= Cronbach's alpha
4. CR=Composite Reliability;
5. AVE= Average Variance Extracted
Source: the authors

Based on the dimensions of the quality of the work, the construct called **Satisfaction with the work (*WS*)** includes five domains: (i) satisfaction with *daily job tasks* that evaluates perception of the farming tasks in a typical work day (*MV2*); (ii) satisfaction with *work-life balance* referring to the personal assessment of the amount of time that the farmer has to do things that she or he likes doing

(*MV3*); (iii) satisfaction with *being a farmer* assessing the perception of the profession chosen and its associated life style, considering its advantages and disadvantages (*MV4*); (iv) satisfaction with *freedom of decision making* evaluating to the autonomy in decisions making from external influences (*MV5*); and (v) perceived *level of stress* on the job on a typical day(*MV6*). All the items of this construct were measured in an 11 points scale from 0 to 10. We reversed the coding of scale of perceived *level of stress* (*MV6*) in order to have the same direction in the set of indicators. We applied statistical analysis to continuous data following Ferrer-i-Carbonell & Frijters (2004), who argue that analysis of the cardinal measure of welfare data is applicable to ordered scales. Missing values of the indicators represent less than one per cent. The construct **Satisfaction with the work WS** explain more than 50% of the variance of the indicators that form it (AVE>0.5) and presents internal consistency reliability (CR between 0.6 and 0.9) as well as discriminant validity. All loadings of the construct are significantly different of zero at $p<0.005$. The variable *perceived level of stress (MV6)* was dropped from the final model given its low factor loading.

Farm-level variables hypothesized to influence work satisfaction were grouped in to five constructs: (i) **Working hours-WH** includes three manifest variables: the amount of labour input expressed in annual working units (*MV12*), the average weekly working hours of the manager (*MV13*) and the average day working hours during the peak seasons (*MV14*); (ii) **Free days and holidays-HF** represent periodic leisure time and includes the amount of estimated holidays per year (*MV10*) and free days per week (*MV11*) ; iii) **Age of assets- AA** concept is a proxy of farm modernity, formed by one indicator of average age of machinery (*MV15*) and one indicator of average age of agricultural buildings (*MV16*) (iv) **Financial aspects of the farm concept-FA** includes three manifest variables derived from FADN Standard Results[2] : the Farm Net Value added (FNVA) per annual working unit as an indicator of agricultural income (*MV17*), the total assets value of the

[2] FADN Standard Results are indicators calculated from FADN data (http://ec.europa.eu/agriculture/rica/annex003_en.cfm)

holding summing fixed and current assets (*MV18*) and the farm cash flow as the holding's capacity for saving and self-financing (*MV19*) Considering their skewness, these indicators of income, assets and cash flow were log transformed; (v) **Knowledge and information-KI** represent the access to knowledge and information and is operationalized through three manifest variables: number of providers of advisory services (*MV7*), number of sources of information of the CAP (*MV8*) and the total contacts that the farm operator has with advisory service providers per year (*MV9*). As seen in Table 2, four of the five constructs explain on average more than 50% of the variance of their indicators (AVE>0.5) and have an acceptable composite reliability (between 0.6 and 0.9). Cross-loadings between manifest and latent variables evidence discriminant validity for all the constructs (Table 3).

Table 3. Crossloading coefficients of manifest variables on latent variables

	Latent variables							
Manifest variables	**QOL**	**WS**	**KI**	**HF**	**WH**	**AA**	**FA**	**SE**
MV1.Satisfaction with quality of life	1.014	0.719	-0.046	0.189	-0.112	-0.119	0.239	0.174
MV2. Satisfaction with daily job tasks	0.524	0.825	-0.130	0.167	-0.128	-0.034	0.214	0.085
MV3. Satisfaction with work life balance	0.616	0.797	-0.101	0.239	-0.147	-0.056	0.186	0.079
MV4. Satisfaction with being a farmer	0.584	0.795	-0.042	0.079	-0.041	-0.141	0.205	0.146
MV5. Satisfaction with freedom of decision making	0.308	0.487	-0.018	0.187	-0.123	0.054	-0.010	0.007
MV8. Number of main information sources about CAP	-0.050	-0.111	1.002	-0.014	0.105	-0.005	0.080	0.164
MV9. Number of total contacts of advisory service per	-0.005	-0.029	0.458	-0.028	0.194	-0.133	0.157	0.162
MV10. Holiday days	0.092	0.156	-0.035	0.759	-0.334	0.155	-0.063	-0.018
MV11. Free days per week	0.211	0.213	-0.002	0.925	-0.283	0.063	0.175	0.036
MV12. Unpaid labour input in annual working units	-0.101	-0.132	0.074	-0.298	0.815	-0.160	0.080	0.113
MV13. Average weekly working hours of manager	-0.044	-0.063	0.131	-0.280	0.673	-0.136	0.177	0.003
MV14. Average day working hours during peak season	-0.076	-0.096	0.131	-0.217	0.692	-0.068	0.065	0.078
MV15. Average age of machinery	-0.108	-0.076	-0.039	0.108	-0.132	0.936	-0.152	-0.022
MV16. Average age of agricultural buildings	-0.075	-0.036	-0.009	0.086	-0.155	0.602	-0.148	-0.048
MV17. Farm net value added per AWU	0.188	0.232	0.034	0.166	-0.031	-0.071	0.916	0.202
MV18. Total assets value	0.241	0.184	0.137	-0.014	0.207	-0.219	0.811	0.295
MV19. Expenditure for the accounting year without operations on capital and on debts and loans	0.186	0.169	0.123	0.059	0.170	-0.197	0.910	0.262
MV20. Number of organizations and local events in which the farm takes part	0.171	0.117	0.184	0.014	0.108	-0.036	0.287	1.000

Source: the authors

5 Results

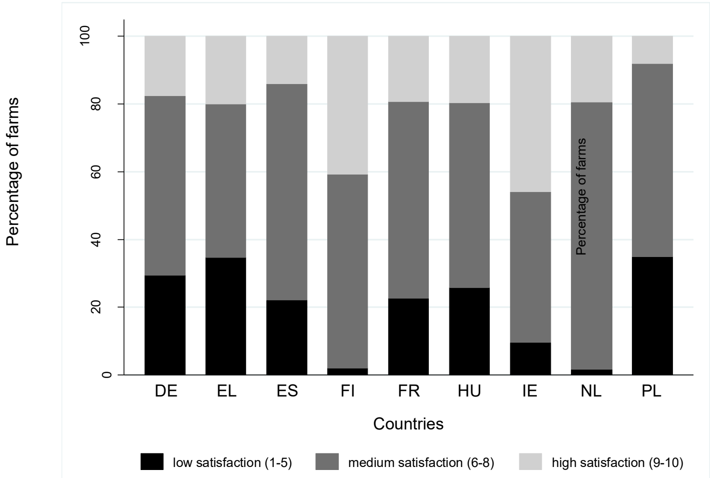
The results of the analytical models are presented in three sections: (i) the distribution of farms according to the level of satisfaction that farm operators have with quality of life; (ii) the distribution of farms according to the level of satisfaction that farm operators have with works satisfaction domains; and (iii) how farm factors relate with both work satisfaction and satisfaction with quality of life.

5.1 Farmers' satisfaction with their quality of life

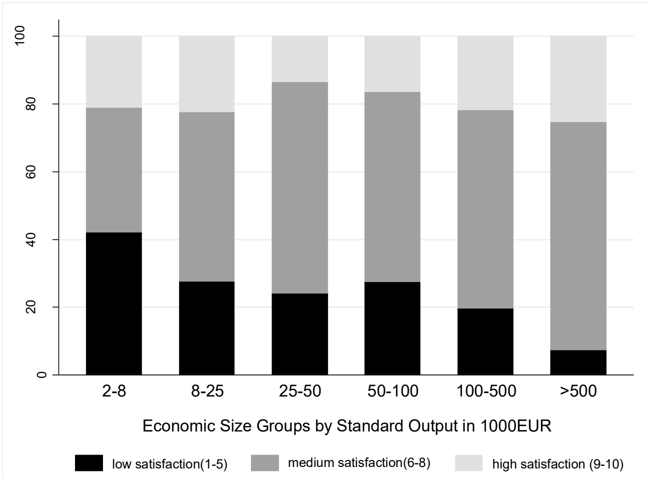
Around 22.8% of farm operators expressed a low satisfaction with their quality of life (between 0 and 5); 58 % expressed a middle satisfaction level (between 6 and 8), and about 20% stated high levels of satisfaction (higher than 9). This distribution differs according to the country and economic size of the farms. In general, a larger proportion of farmers in Ireland and Finland stated higher satisfaction with their quality of life. By contrast, a higher proportion of farmers in Poland and Greece expressed low satisfaction with their quality of life. The proportion of farmers with low satisfaction scores with their quality of life decrease with the increment in economic size of the farm (Figure 2).

Figure 2. Distribution of farms (%) according to the satisfaction levels with their quality of life, by Country and Economic Size Group

a) by Country



a) by Economic Size Group



*Scores between 0 and 5 are considered low satisfaction scores, medium scores range between 6 and 8 and high satisfaction scores range from 9 to 10 (Eurostat, 2015). Economic Size Groups are based in the Standard Results Definition of FADN

5.2 Farmers’ satisfaction with their work

Farm operators could be distributed according to their levels of satisfaction with the dimensions of the work’s satisfaction: a higher proportion of the farmer expressed high satisfaction with the choice of being a farmer (34%) and freedom of decision making (34%) while also a higher proportion of farmers expressed a low satisfaction with their work-life balance (34%). Satisfaction with work-life balance is the work domain with lower satisfaction on average (6.29 out of 10) while being a farmer is the highest (7.59 out of 10) (Table 4).

Table 4. Distribution of farms according to work satisfaction domains.

	Work satisfaction domains			
	Satisfaction with daily job tasks MV2	**Satisfaction with work- life balance MV3**	**Satisfaction with being a farmer MV4**	**Satisfaction with freedom of decision making MV5**
N	1095	1092	1094	1090
% of farms				
Low level (Score between 0-5)	17.9	33.88	16.27	18.44
Middle level (Score between 6-8)	63.29	54.30	49.36	47.06
High level (Score between 9-10)	18.81	11.81	34.37	34.50
Mean (0-10)	7.23	6.29	7.58	7.47
Standard Deviation	1.76	2.18	2.09	2.12
Median	8	7	8	8

*According to Eurostat (2015), scores between 0 and 5 are low satisfaction scores, scores between 6 and 8 are medium satisfaction scores; and scores from 9 to 10 are high satisfaction scores.

Source: the authors

The multinomial regression presented in Table 5 for each of the work satisfaction domains evidence the odds that a farmer belong to the "highly satisfied farmers" (namely scores between 9 and 10) compared to the other groups ("medium satisfied" or "low satisfied"). In general, a farmer in a holding with higher values of FNVA, assets and cash flow is more likely to be highly satisfied with his tasks, his work-life balance and being a farmer. Farmers with a larger amount of working hours per week and during peak seasons have higher chances to belong to the group with lower satisfaction with work-life balance. The amount of holidays and free time increases the chances that farmers are more satisfied with the job tasks, work-life balance, being a farmer and the freedom of decision making. A higher number of involvement in the community also increase the odds that a farmer is highly satisfied with the job and the farming profession, while access to more sources of information increases the odds that a farmer belongs to the group with low satisfaction with their work (Table 5).

Table 5. Odds ratios of work satisfaction levels due to farm factors.

	Work satisfaction domains[1]							
	Satisfaction with daily job tasks MV2		Satisfaction with work life balance MV3		Satisfaction with being a farmer MV4		Satisfaction with freedom of decision making MV5	
	High vrs Low [2]	High vrs Medium[2]	High vrs Low	High vrs Medium	High vrs Low	High vrs Medium	High vrs Low	High vrs Medium
Knowledge and Information KI	0.591***	0.921	0.745**	0.971	0.764**	0.810**	1.007	0.955
	(0.00)	(0.362)	(0.013)	(0.795)	(0.01)	(0.005)	(0.94)	(0.536)
Holidays and Free days HF	1.652***	1.11	1.852***	1.244**	1.249*	1.099	1.594***	1.351***
	(0.00)	(0.258)	(0.00)	(0.035)	(0.059)	(0.25)	(0.00)	(0.00)
Working hours WH	0.843	0.942	0.749**	0.780**	0.902	0.988	0.878	0.93
	(0.165)	(0.536	(0.025)	(0.039)	(0.349)	(0.881)	(0.213)	(0.379)
Age of assets AA	0.929	1.04	0.865	1.003	0.696***	0.923	1.028	0.882*
	(0.51)	(0.655)	(0.200	(0.979)	(0.00)	(0.299)	(0.781)	(0.094
Financial aspects of the farm FA	2.202***	1.255**	1.339**	0.935	1.729***	1.064	1.019	0.738**
	(0.00)	(0.023)	(0.03)	(0.584)	(0.00)	(0.475)	(0.87)	(0.001)
Social Engagement SE	1.2478*	0.9265	1.154	0.939	1.465**	1.125*	1.064	0.881*
	(0.074)	(0.376)	(0.229)	(0.561)	(0.001)	(0.099)	(0.544)	(0.092)
N	1010		1007		1010		1005	
LR	112.94		105.24		80.98		63.12	
Prob>Chi^2	0.000		0.000		0.000		0.000	
PseudoR^2	0.0611		0.0547		0.0395		0.0302	
Log-likelihood	-867.0211		-908.854		-985.1334		-1012.181	
AIC	1.745		1.833		1.978		2.042	
BIC	-5155.993		-5048.62		-4919.768		-4826.165	

1. Coefficients represent the change in odds for one unit increase in the value of the latent variables. In parenthesis p-values for Z test Hausman test.
2. Base category: farms with high level of satisfaction (scores between 9 and 10). Comparison categories: low level (scores between 0-5); medium level (scores between 6 and 8).
3. Hausman test of Independent Irrelevant Alternatives (IIA) and Small and Hsiao test of IIA of the five models confirm the hypothesis that odds are independent of other alternatives.
* (**) (***) Statistically different from zero at 10%, (5%), (1%) significance level.

Source: the authors

5.3 Influence of farm factors on work satisfaction and satisfaction with quality of life

To assess the links between the theoretical constructs, we measured the direct effects based on the hypothesis depicted in the path model. We found that work satisfaction influences the satisfaction that farmers have with their quality of life: an increase in one unit in the construct WS increases on average 0.690 the satisfaction that farmers have with their quality of life (Table 6).

As seen in Table 6, the financial aspects of the farm (FNVA, assets and cash flow) is the farm level factor that has the largest positive direct effect on the satisfaction with the work (path coefficient = 0.215), followed by holidays and free days (path coefficient=0.182) and social engagement (path coefficient=0.090). By contrast, and contrary to the results expected, contacts with advisory services and number of sources of information of CAP has the largest negative direct effect on work satisfaction (path coefficient=-0.183). Working hours during the year, week and peak seasons also has a negative direct effect on WS (path coefficient=-0.116). Farmers in holdings with older assets are also less satisfied with WS (path coefficient= -0.082).

Table 6. Structural model estimation results

Path between theoretical constructs	Path coefficients[1]	t	p-value[2]	Confidence Intervals	
				2.5%	97.5%
H1: Work Satisfaction WS → Quality of Life QOL	0.690	33.817	0.000	0.648	0.730
H2: Holidays and Free days HF→ Work Satisfaction WS	0.182	5.174	0.000	0.112	0.247
H3: Working Hours WH→ Work Satisfaction WS	-0.116	3.683	0.000	-0.175	-0.052
H4: Age of Assets AA → Work Satisfaction WS	-0.082	2.229	0.026	-0.132	0.052
H5: Financial Aspects FA → Work Satisfaction WS	0.215	8.449	0.000	0.165	0.264
H6: Knowledge and Information KI→ Work Satisfaction WS	-0.132	3.955	0.000	-0.193	-0.066
H7: Social Engagement SE→ Work Satisfaction WS	0.090	3.275	0.001	0.038	0.140
H8: Social Engagement SE→ Quality of Life QOL	0.088	4.560	0.000	0.051	0.125
R^2 of farm level factors on WS	0.124				
R^2 of WS on QOL	0.509				
SRMR	0.082				
NFI	0.579				

[1]The path coefficient represents linear regression weights.
[2] p-value computed bootstrapping 500 samples.
Source: the authors

The results about the influence of farm aspects on the perception of quality of life confirm most of the hypotheses established, suggesting that there exists an influence of the financial aspects, workload size and social engagement in the perception that farmers have with their work. Differences in the magnitude on how those factors influence the perception were also as expected.

Contrary to our expectations, the influence of knowledge and information has a negative influence on the perception of farming. Two possible causes may explain this result. The first one is that the variables selected as part of the construct do not capture the complexities of access to information and knowledge of farm, leaving a gap in the validity of the concept. The second one is that the variables selected (number of advisory services, number of advisory services providers and number of information sources about the CAP) are shaped by the institutional context of the farm (Knierim et al., 2017). In other words, the magnitude of its influence is due to the place or specific situation of the farm and not to the access to information per se.

5.4 Policy Implications

The joint influence of farm level factors in the work satisfaction is relatively low (R^2=0.120). According to Hair et al. (2014), this value could be considered as weak in business research, while it is similar to the values described by OECD (2013), between 3 and 35% mentioned in the studies aimed to find drivers of subjective well-being indicators. Current research argues that other spaces beyond farm level influence work satisfaction and quality of life. The first domain outside the farm-level is the environment surrounding the farmer or the so called liveability of the environment: regional or local indicators of well-being beyond farm-level have found to have an influence on perceptions about quality of life (Jantsch et al., 2016; Engelbrecht, 2009). Examples of those indicators include socio-economic indicators such as employment and regional GDP, but also indicators that describe place-based specific characteristics such as ecosystem services (Bieling et al., 2014), land use (Fagerholm et al., 2016) or location specific factors (Gilbert et al., 2016; Brererton et al. 2008; Howley et al., 2014). The second domain outside the farm-level is the individual dimension. Many authors highlight the importance of personality traits (Ferrer-i-Carbonell and Frijters, 2004; Lykken and Tellegen, 1996) and the intrinsic motivation of the individual towards his or her job (Krumbiegel et al. 2018). Limitations in the availability of the longitudinal data do not allow to separate those factors and other individual time invariant variables that may have a moderating or mediating effect on our model.

The research is also limited by the current debate on the techniques used to test multiples hypothesis and the methods to control for the measurement model. While we have used variance based methods, some authors point out the need to confirm the theories based on covariance based methods. Further research to compare robustness of both analytical methods is necessary.

6 Concluding remarks

We investigated the farm level factors that influence farmers’ perceptions about their work and their quality of life. Our research indicates a strong link between the perceptions that farmers have in several domains of their work with the way that they perceive their position in life in relation to their goals, expectations and value systems. In contrast, we have found that farm level factors can explain those farmers’ perceptions only partially.

The results suggest that is valid and reliable to use a multi-dimensional concept that measure work satisfaction of farmers considering four aspects: satisfaction with daily job tasks, satisfaction with work-life balance, satisfaction with being farmer and satisfaction with freedom of decision making.

The results also confirm that farm-level features available in FADN and FLINT questionnaire such as financial aspects of the farm, age of assets, working time and social engagement have a significant influence in the satisfaction that farmers have with their work. However, the magnitude of the influence is rather weak; in other words, the largest proportion of the satisfaction with farming is determined by variables not included in the available farm-level data set, suggesting that the current monitoring systems are not suited enough to measure all dimensions of sustainability. This has an important implication for the development of information systems for policy evaluation: in order to elicit quality of life and measure the progress on rural areas considering all aspects of sustainability, is necessary to further develop and use a metric that measures social concerns from the farmers’ point of view.

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Chapter 5

Discussion and conclusion

5. Discussion and conclusion

As seen in the chapters two, three and four, this dissertation addressed the way agricultural monitoring systems adapt to measure sustainability information. In this discussion section I will summarize the main findings according to the research objectives and will discuss the main theoretical and policy implications. Based on the limitations faced, I propose possible future research paths.

5.1 On the involvement of the stakeholders in the selection of indicators: What are the stakeholders' perceptions about the selection and addition of indicators of sustainability in an existing farm-level measurement system?

5.1.1 Summary of findings

We identified three information flows related with sustainability measurement already taking place at the farm level: the own farm system, a regulation-based system, and a market-led system. Those systems may be redundant or diverse, according to the objectives of the actors involved in each of one. Accordingly, each flow has its own governance structure, goals and incentives and is affected by the level of technology (digitization) involved. The governance of information flows depends on how the farm information is aligned with the actors asking for information, what in turn depends on the level of cooperation of information users outside the farm level. Therefore, the exchange of information is not only highly influenced by the formal requirements but also by the trust between actors and the perception of risks and benefits of sharing "sustainability" information.

Those aspects influencing the information flow also influence the perception that stakeholders have towards indicators that should be measured. We found that stakeholders perceive the feasibility and usefulness of indicators differently according to the different dimensions of sustainability. Environmental indicators are perceived as the most useful for all the groups of stakeholders, especially those indicators that are able to measure changes in farm resources and therefore can be used to manage farm productivity. In that sense, environmental indicators represent biophysical aspects of the farm and their measurement signalize the existence of "assets" that, although valued by the farmers, are not yet clearly visible in the normal financial accounting systems. Making their value more evident through bookkeeping would support frameworks such as the "*environmental accounting*" or the identification of productivity indicators (OECD, 2014) that include aspects traditionally classified as "*externalities*" in the technical efficiency and productivity calculations (DG AGRI, 2016). Additionally, the use of those indicators can close the actual information gap between global environmental concerns and farm management (Repar et al., 2017) and also provide a means to have better shared information about the real environmental costs of the agricultural production which many authors say is still lacking in research and policy making. Their measurement, however, is perceived as more difficult, not only because their gathering requires a change in the farm bookkeeping practices but also due to significant divergences in the scientific knowledge on i) the appropriate methods of measurement and ii) the outcomes that a specific farm practice can have in biophysical aspects in the long run. A crucial element is the delimitation of scales in the measurement process: in contrast with financial information, many of the environmental indicators are shaped by biophysical boundaries differing from farm unit such as fields, crops, or landscapes. The scale of measurement also affects the way the data is reported which in turn may affect the design and evaluation of policy targets (Meunier, 2019).

By contrast, social indicators are perceived as "soft" information that have a higher value for policy evaluators and researchers but a lower value for farmers and value chain actors. Social indicators represent information that could be used to track changes not at farm level but in a wider spatial location such as landscapes, communities, regions, or countries. Their value is perceived therefore in supporting policy makers and researchers to evaluate the outreach and efficacy of rural development programs, to measure the quality of life of farmers, and to forecast continuity in the farming sector. Although the perceived feasibility of collection is higher than the environmental indicators, social indicators are questioned by their reliability and validity.

5.1.2 Theoretical and policy implications

With our findings we support that the differences in concepts and visions amongst stakeholders constitute a barrier to make the sharing of knowledge more valuable to the agents involved. Standardization of information is believed to be necessary to scale up knowledge between users of information and could be used for the expected digitization of the sector. In that sense the concept of ontologies having been applied during the last decades by knowledge engineers to develop information systems is a potential approach to overcome those barriers. Taken from the philosophy field, an ontology with the words of Gruber (1993) is a "*formal explicit specification of a shared conceptualization used to help programs and humans share knowledge*". An ontology should contain a vocabulary of terms, a set of term definitions for identifying concepts and interpretations, a model representing the relationship between concepts and a community of ontology users (Pinet et al., 2009). To build an ontology, complex systems are decomposed into their smallest interacting elements which are mathematical equations (Beck et al., 2009). However, the development of ontologies is not a software problem but a knowledge representation problem (Beck et al., 2009). The claimed shift from a research-driven to a user-driven agricultural information system will require more collaboration between science and policy (Reidsma et al., 2018). In this regard, the question on who and how have to participate in the development of ontologies for public data sets could potentially be addressed by the transdisciplinary research principles because this type of research structures the process of joint problem definition, problem solving, and temporary cooperation between researchers and practitioners (Lang et al., 2012). In our research, we have seen that methods of involvement of stakeholders can serve the purpose of elucidate arguments from different agents which constitute a basis for conducting a dialog between the different actors.

5.1.3 Limitations and research outlook

Our research is limited to the case of FADN and its boundaries, with limitations in the generalization of the findings to other contexts. Challenges in the application of participatory methods should also be mentioned. In the development of the tools, we have pilot-tested methods and trained interviewers and facilitators. However, the application of the methods varied according to the countries, availability of stakeholders and facilitation skills of project partners. While this mix of methods provides a means of consistency in the results, the findings can be related to the case only. Finally, the involvement of stakeholders in this research project was at the consultation level. Further research could also test the involvement of stakeholders in the design of the research, the development of ontologies, the development of scenarios for using the outcomes of the information system, the assessment of visualization tools, and the evaluation of the impacts of transdisciplinary research in the adoption of changes. A potential field of research is the analysis of the governance along the knowledge chains, including the impacts that adaptations of the information systems have over decision making and interactions between actors. Parallel to this, aspects of the governance of information systems such as incentives, rights, and data ownership are possible fields of research.

2. **On the integration of social indicators in data sets with economic and environmental indicators: to what extent are the proposed indicators valid measures to assess social sustainability at farm level?**

5.2.1 Summary of findings

The two studies exemplify two cases of analysis using data bases that integrate social indicators with economic and environmental farm-level variables, integration that is frequently neglected in the modelling and development of agricultural data bases. We found that a standardized indicator of number of advisory services for multiple sites could be used to identify bundles of farms and to relate their characteristics to their sustainability performance. However, its usefulness is limited to the knowledge of contextual factors not captured in our study. We explored the linear relations between the use of advisory services and farms under different production situations. Our results suggest a linear link with diversification, innovation, and adoption of risk management practices. By contrast we do not find a linear relationship with environmental and social indicators of sustainability. As we did not develop causality chains between farm practices and sustainability outcomes, the study is a first step to relate the use of advisory services with a common framework of sustainability performance. Further work could develop those causality chains based on hypothesis and causal models. Besides, including local variables and contextual factors of the advisory services can help to separate the effect of the heterogeneity of farms and type of advice.

In the second study we found that a measure of work satisfaction in the farming sector including subjective perceptions on daily job tasks, satisfaction with work-life balance, satisfaction with being farmer, and satisfaction with freedom of decision making is valid and reliable. We also found that the largest proportion of the variance of the satisfaction with farming is determined by variables not included in the available farm-level data set. Our results suggest that current farm-level data set are not enough to measure changes in the way that farmers perceive their position in life in relation to their goals, expectations, and value systems. Therefore, a metric for measuring those aspects should be developed.

5.2.2 Theoretical and policy implications

From the findings we can derive theoretical and policy implications. The first implication is that with the use of harmonized variables in several sites it is likely to identify those factors determining sustainability of farms because it allows separating the effect of local differences shaped by biophysical conditions and farm management strategies. As Deytieux et al. (2016) point out, large data sets provide the opportunity to compare between production situations and diverse cropping systems, and therefore to identify the drivers of sustainability performance.

A second implication of the findings is that the integration of social indicators in agricultural data sets traditionally collecting bio economic information is not only feasible but also usable for research and policy analysis. While the conceptualization and definition of causal chains would remain a challenge, the use of indicators of intangible aspects influencing behaviour provides inputs for policy making related with the development of rural spaces. Additionally, the analysis of the social aspect along with environmental and economic concerns also raise possible answers to the question if the centre of the sustainability analysis should be the human well-being (Kühnen, 2018), the capacities of biophysical resources to recover and provide ecosystem services in the future (Fuglie et al., 2016), or the synergies and trade-offs between both.

5.2.3 Limitations and research outlook

The two cases are limited in both conceptual and methodological aspects. As both cases have the testing of indicators as a purpose, caution has to be taken on the underlying hypotheses and theories, especially the relationship between farm practices and final sustainability indicators.

In the advisory service study, causality chains were developed nor treatment groups compared. Those aspects have to be included in further research with additional data sets and could be complemented with qualitative research that can provide insights on the use of knowledge. From the methodological point of view, our research is also limited to be representative of FADN farms only. The data used for both cases is from one year only, which limits the robustness of findings and the application of longitudinal analysis.

5.3 Conclusion

In this dissertation we addressed the evolvement of an agricultural information system by exploring the arguments of their stakeholders and by developing and assessing the usefulness of a set of indicators of social sustainability.

Our findings summarized in the three chapters suggest that the differences existing between stakeholders on the conceptualization and operationalization of complex concepts such as social sustainability can be elicited through methods like transdisciplinary approaches. Our findings also suggest that the development of common concepts are necessary to scale up the knowledge about sustainability in farming systems as a basis for policy evaluation and research agendas.

Limited by the case study boundaries, our main contribution lies in the area of how to develop and test ontologies shared and used by several agents. We used several methodologies to define and pilot the indicators, and we answered the research questions as an illustrative example. While the research gap was addressed, further research could validate our findings applying similar approaches in more case studies at different levels.

Finally, this dissertation points out the importance of governance in the sharing of knowledge between agents. Changes occurring rapidly in the agricultural data systems will demand agreements of those influencing the decision making, and therefore continuous piloting and testing of methodologies to facilitate the dialog between users and producers of information could be a role for future research in social science.

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Appendix

LIST OF INDICATORS

CODE	INDICATOR	ACRONYM
E1	Greening: permanent grassland	E1_PERMGRASSLAND
E2	Greening: Existing/created areas of Ecological Focus Area	E2_EFA
E3	Semi-natural farmland areas	E3_SEMINATURALFARMLAND
E4	Pesticide usage (Pesticide risk score)	E4_PESTICIDE USAGE
E5	Nutrient balance (N, P)	E5_NUTRIENTBALANCE
E6	Soil organic matter in arable land	E6_SOIL ORGANIC MATTER
E7	Indirect energy usage	E7_INDIRECT ENERGY
E8	Direct energy usage	E8_DIRECT ENERGY
E9	On-farm renewable energy production	E9_RENEWABLE ENERGY
E10	Farm management to reduce nitrate leaching	E10_NITRATELEACHING
E11	Farm management to reduce soil erosion	E11_SOIL EROSION
E12	Use of legumes	E12_LEGUMES
E13	GHG Emissions per ha	E13_GHG/HA
E14	GHG emissions per product	E14_GHG/PRODUCT
E15	Carbon sequestering land uses	E15_CARBON SEQUESTERING
E16	Water usage and storage	E16_WATER USAGE
E17	Irrigation practices	E17_IRRIGATION
EI1	Innovation	EI1_INNOVATION
EI2	Producing under a label or brand	EI2_LABELS
EI3	Types of market outlet	EI3_MARKETOUTLET
EI4	Past/Future duration in farming	EI4_SUCCESION
EI5	Efficiency field parcel	EI5_FRAGMENTATION
EI6	Modernization of the farm investment	EI6_MODERNIZATION
EI7	Insurance: production, personal & farm (building structure)	EI7_INSURANCE
EI8	Share of output under contract with fixed price Delivery contracts	EI8_CONTRACTS
EI9	Non-agricultural activities	EI9_NON-AGRICULTURAL
S1	Advisory services	S1_ADVISORY SERVICES
S2	Education and training	S2_TRAINING
S3	Ownership-management	S3_OWNERSHIP
S4	Social engagement/participation	S4_SOCIAL ENGAGEMENT
S5	Employment and working conditions	S5_WORKING CONDITIONS
S6	Quality of life/Decision Making	S6_QUALITY OF LIFE
S7	Social diversification: image of farmers/agriculture in local communities	S7_SOCIAL DIVERSIFICATION

1. OVERVIEW

1.1 FINAL SET OF INDICATORS

Dimension	Area[1]	Indicators[2]
Environmental	Land Management	E1: Greening: permanent grassland
		E2: Greening: existing/created areas of Ecological Focus Area
		E3: Semi-natural farmland areas
		E10: Farm management to reduce nitrate leaching
		E11: Farm management to reduce soil erosion
		EI5: Efficiency field parcel
		E6: Soil organic matter in arable land
	Pesticides	E4: Pesticide usage (pesticide risk score)
	Nutrient Balance	E5: Nutrient balance (N, P)
		E12: Use of legumes
	Energy	E7 : Indirect energy usage
		E8 : Direct energy usage
		E9: On-farm renewable energy production
	GHG Emissions	E13 GHG Emission per ha
		E14 GHG emissions per product
		E15: Carbon sequestering land uses
	Water	E16: Water usage and storage
		E17: Irrigation practices
Social	Information and Knowledge	S1 : Advisory services
		S2 : Education and training
		S3: Ownership management
		S4: Social engagement/participation
		S7: Social diversification: image of farmers/agriculture in local communities
	Working Conditions and Quality of Life	S5: Employment and working conditions
		S6: Quality of life/decision making
		El4: Past/future duration in farming
Innovation	Innovation	EI1: Innovation
		EI6 : Modernization of the farm investment
Economic	Economic	EI2: Producing under a label or brand
		EI3: Types of market outlet
	Risk Reduction	EI7: Insurance
		EI8: Share of output under contract with fixed price delivery contracts
		EI9: Non-agricultural activities

1 Classification of indicators according the data definitions for FLINT (Farm Return Data Definitions for FLINT WP4)
2 Classification of indicators on the first list based in dimensions of sustainability (Warsaw List-WP1)

2. INDICATORS

1.2 Environmental

1.2.1 E1 Greening: permanent grassland

1. Description	
The European Commission is now making about 30% of the direct payment conditional on Greening. One of the Greening measures relates to permanent grassland. This measure is considered important because of the ability of permanent grasslands to capture organic matter in the soil, which contributes to reducing losses of greenhouse gas from farmland.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Total area of permanent grassland -Total area of permanent grassland extensively used -Total area of permanent grassland intensively used	

	n[1]	average[2]
Feasibility	102	1.11
Usefulness	118	0.40

4. Stakeholders	
On concept and variables -Improve definition of intensive or extensive (8) -Common pastures are included?(1) -Those policies are a motivation to preserve natural plantation (1) but also risk if a field has to be turned into production (1) can represent low earnings (1) or may endanger good soils (1)	**On perceived potential uses** -Determine value of subsidies (5) -Monitor environmental guidelines and sustainability (2) -Important for climate change (1) -Measure attitude from farmer toward environment (1) -Can be used as part of the feed plan (1) -Not relevant for all types of farms (4) -Does not measure farm performance (3) -Difficult to use at farm level (2)
On data collection and analysis -Available from direct payments (8) -Easy to collect on farms in rural development programs(2) difficult on other farms, especially farms with less than 6ha (1) -Will be collected in 2015 (3) -Level of detailed can make the collection difficult and an additional burden: “Easy at farm level; complicated at parcel level” (2) especially if parcels are fragmented (1) -Easy to collect (1) -LPIS not fully implemented and difficult to separate crops (1)	**Recommendations** -Could be collected by crossing maps (1) -Differentiate highly productive and low productive grassland(1) -Ask number of cuts, grazing yes/no, pasture or rotational grazing (1) -Determine grass available per year per livestock unit and then decide whether it was intensive or extensive (1) -Distinguish between utilized and not utilized permanent grassland (1) -Add an indicator arable land/grassland (1) -Split the farm into hill or low land (1)
5. Final variables	
-Permanent Grassland that receives less than 50 kg N/ha per year and it is dominated by native species without any form of nature protection -Permanent Grassland that receives less than 50 kg N/ha per year with any form of nature protection	

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.2 E2 Greening: existing/created areas of Ecological Focus Area

1. Description

The European Commission is now making about 30% of the direct payment conditional on Greening.One of the Greening measures relates to a new policy issue Ecological Focus Areas. This measure is considered important because of its intended contribution to increase the area and quality of habitat for protection of biodiversity on EU farmland. This is one of the aims of Greening. Some farms are exempt from this measure.

2. Variables presented to stakeholders

-Ecological Focus Area presence
-Habitat types contributing to EFA
-Area of EFA including existing habitats
-Area of EFA that had to be created

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	**95**	**0.68**
Usefulness	**115**	**0.50**

4. Stakeholders

On concept and variables

-Define EFA: methodology and criteria (6)
-What is the link the indicator to environmental sustainability and sustainability of the farm? (3) and with programs and regulations? (1)
-Difficult to compare changes across time (1) and across countries (1)
-May not be a good incentive: national objective is not clear (1), may respond to a foreign policy (1), its implementation can reduce land leasing values (1) or affects the availability of good soils for production (1).
-Declaration and classification of parcels as an EFA is not clear (1)

On perceived potential uses

-Determine value of subsidies (2); useful to collect (3)
-Monitor environmental policies and sustainability (2)
-Important for climate change and environment conservation (2)
-Important for the market (2) and common citizen (1) not for farm management (4)
-Relevant for farms applying greening (1) not all sizes of farms (2)
-Does not measure farm performance (3)
-Difficult to use at farm level (2)
-There are labels related with it (1)

On data collection and analysis

-Already in developed or developing database, will be available 2015 (7)
-Farmers don't know: they should ask advisors (4); potential to annoy farms (1) and additional burden (1) or may be sensitive (1)
-Easy to collect in farms in RD programs (3)
-Separate areas created and existing can make difficult to collect (2)
-If we know the plots, it will be easy to know if it is located on an EFA (1)
-Ownership issues (1) or farm size (1) can affect the collection

Recommendations

-Match information sources (4)
-Ask for size of the area (1) ↔ Not feasible to ask area (1)
-Differentiate between existing and created (1)
-Cross maps or use GIS to collect (2)
-Classify parcel margins in classes (1)
-Declare what accounts as an EFA (1)

5. Final variables

EFA-Land laying fallow
EFA-Terraces
EFA-Landscape features
EFA-Buffer strips
EFA-Area of agro-forestry
EFA-Strips of eligible area along forest
EFA-Area with short rotation coppices
EFA-Afforested areas
EFA-Areas with catch crops or green cover
EFA-Areas with nitrogen-fixing crops

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.3 E3 Semi-natural farmland areas

1. Description	
The CAP aims to contribute to increase the area and quality of habitat for protection of biodiversity on EU farmland. One of the best indicators of biodiversity on farmland is the area (or percentage) of farmland occupied by wildlife habitats.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Area with ecological infrastructures or habitats including extensively managed species-rich grassland	see table below
4. Stakeholders comments	
On concept and variables Clear definition required: list necessary (11) Difficult to compare across countries, regions, areas, farmers (2) Difficult to measure in terms of outcomes (2) and is not linked with policy objective and current focus (2) It would be necessary to link with programs and regulations (2) It is not the business of the farmer	**On perceived potential uses** -Useful to collect (5) ↔ not useful for farmers (4) -Evaluation of environmental sustainability and climate change (3) monitor accomplishment of guidelines (1) part of greening indicators (2) -Assess if such areas are created as a capital or good or constitute an additional burden (1) -Differentiate areas with or without environmental limitations (1) -Important for the market (1) ↔ market will not appreciate that (1) -There are possible labels related with it (1)
On data collection and analysis Needs visual assessment: ortophotos, maps for agri-environmental schemes (3); but drawing a map would be unreasonable for a large business (2) -Easy for farmers under agri-environmental schemes, rural development program, GLAS has a sustainable farm management plan (3) or located in a designated area (3), other farmers will not know how to answer (3) and make information not reliable (1). -Available from other sources: department of agriculture, water authorities, LPIS(3); subsidies application forms(1) -% of farm area is possible: total area more complicated (1)	**Recommendations** -Separate infrastructure and habitats (1) -Match information sources (3) -Cross maps or use GIS (4)
5. Final variables	
Area of native woodlands Area of ponds and lakes Other areas of semi-natural vegetation without any form of nature protection Other areas that is designated for any form of nature protection	

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	95	0.47
Usefulness	101	0.17

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.4 E4 Pesticide usage (pesticide risk score)

1. Description

The recent legislative changes to the use of pesticides is likely to cause a change in the pattern of pesticide usage, and this information can help identify farmers' responses to this new situation, in terms of product type, volume of usage and costs. Pesticides can have an important impact on water quality, and can affect water quality for human consumption, livestock consumption and for aquatic habitats and wildlife.

2. Variables presented to stakeholders

-Amount (kg/ha)per pesticide per farm per year
-Name of pesticides

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	93	0.73
Usefulness	107	0.98

4. Stakeholders comments

On concept and variables

-To know environmental or food risk, an indicator must be calculated: toxicity, frequency index? A defined calculation is needed (3). Other aspects can influence the indicator: weather, time of application, soil porosity (1)

-How will the information be used?(4) With what will be compared? (1) How to educate farmers on this indicator? (1)

-It can be complicated to measure:
--The name and brand of pesticides should be converted to active ingredients (name of pesticides, vademecum, manufacturers´ specification) and there exists large and changing ranges of products on the market and differences on the products used for different agricultural production (grass, tillage) "nightmare to capture". Could be collected electronically in the future (1)
--Mixed pesticides are used
--Same products can be used on different crops: mixed cropping

On perceived potential uses

-"A must" (1) it should be there (1); important from legislation (4) traceability (1) and customers point of view (2)
-To prevent bad use of pesticides (2)
-Relationship with farm economics (1)
-Benchmarking (1)
-Identify sources of pollution (1)
-Assessments of GHG emissions (1)
-Not interesting for dairy farmers (1)
-Determine subsidies and restrictions (1)

On data collection and analysis

-Record keeping is essential (7). As it is part of cross compliance, mandatory and national regulations (5), farmers know area and use of pesticides (1) and part of the data is already collected (1)
-Reliability problems: farmholders opposition (1), "cautious" statements from farmer or not accurate data from farmer, not disclosing true information on what type and how much is really used (3), reliability would depend on the quality and availability of the recording (2)
-More reliable from organic farmers (1) and participants of AE programs: they are obliged to record detailed management activities (1)
-Would be more easy to collect on farm level (1), more difficult on crop or plot level (1)

Recommendations

-Collect name and brand and refer to manufacturers to get active ingredients (1)
-As a sensitive topic, careful handling is needed (1)
-Link with other initiatives: environmental yardstick (1) and use external sources (2)
-Simplify pesticides list: identify those with highest interests (2)
-Include pesticides stock (1)
-Ask machinery used (1)
-Link to a plot (2)

5. Final variables

-Volume, the volume (in kg or L per crop, or in average rate kg or L/ha)
-Active Substance, the active substance used on the crops

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.5 E5 Nutrient balance (N, P)

1. Description

The basis for determining the optimal dosage of fertilizers is formed by the balance of the primary nutrients, i.e. nitrogen, phosphorus and potassium. The balance of the ingredients can be prepared by different methods and at different levels, for example at the level of field, farm, region, country. A balance provides valuable information about the correctness of fertilisation and allows for proper planning of the fertilizer economy – and hence it is an important agrienvironmental indicator that demonstrates the correctness of the management of mineral components.

2. Variables presented to stakeholders

-Stock of fertilizer N at Jan 1st; -Stock of fertilizer N at Dec 31st; -Bought/purchase of N fertilizer; -Legume grains
-Sold crops (invoice); -Sold forage; -Purchased forage crops; -Purchased feed; -Purchased livestock; -Sold livestock

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	99	**0.69**
Usefulness	114	**1.18**

4. Stakeholders comments

On concept and variables

-Area of strong relevance (1); it is currently required at parcel, farm or product level, according to the product (2)
-When working with balances: may be fine-tuned or do not show the complete picture (2)
-Types and quantities used are easy to collect; exported quantities more difficult to assess (1); also, content of organic fertilizer, manure and slurry are best estimates (2)
-Define level of measurement: Parcel level or farm level? (1)
-Interesting for crop nutrients: difficult to assess animal feed, content of concentrates (2)
-Many variables are not important for permanent crops (1)
-Method of calculation of the balance should be specified (1). What is the purpose of stock? (1)
-Where will be used the requested data? (3)
-What will be the incentive of the farmer to give that information? (2)

On perceived potential uses

-Useful to collect (5) ↔ not an advantage for farmer (1)
- Optimize use of nutrients, production, cost saving (6)
-Benchmarking (2) standard analyzing protocols are necessary (1)
-Know dependency on external supply (1)
-For intensively used or vulnerable areas, may be useful to determine subsidies or restrictions (1)
-Improve advisory services (1)
-Estimate GHG emissions (1)

On data collection and analysis

-Mostly available or partially in developed databases (FADN, cross compliance) (6)
-Collected already, in the farm registers and in nutrient management plans for certain programs (GLAS; KULAP) but not controlled (3)
-Record keeping is necessary (7), some producers do not keep input-output logbook (1)
-The accuracy and reliability of the farm registers can be questionable (11); probably most of the farms have these data but some don’t like or doubt to share that information (2) or if it is related with legal compliance, it may not coincide with reality (1)

Recommendations

-Give information about the use of the data (3)
-Provide the farmer with customized data related to his farm (2)
-Do not stress or complicate the indicator (3)
-Include quantities on FADN (1)
-Compare several methods: cross compliance documentation vs. self-calculated balance (1)
-Break into percentages of protein, country of origin (1)
-Use current online calculators from authorities(1)
-Separate fertilizers from livestock feed (1)
-Standardize the calculation. (1)
-Include stocks (1)
-Calculate input per kg of product (1)
-Include legumes (1)
-Add P; K; and micronutrients (1) -Collect pH (1)
-Estimate contents of N of organic fertilizer, manure, slurry using coefficients (1)

5. Final variables

-Livestock (opening, closing, purchase and sales quantities)
-Animal products (protein content %)
-Crops (opening and closing quantities)
-Concentrates (opening, closing, purchase and sales quantities)
-Purchased forage feed (opening, closing, purchase and sales quantities)
-Purchased seed (opening, closing, purchase and sales quantities)
-Manure (purchased and sold quantities)
-Slurry (purchased and sold quantities)

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.6 E6 Soil organic matter in arable land

1. Description

On arable land, soil organic matter is important for soil fertility. It is also important for sequestering of carbon in the soil, which helps reduce Greenhouse Gases in the atmosphere and improves the environmental sustainability of farming practice. The soil organic matter is a set of all organic compounds except for the non-decomposed parts by plants, the remains of animal and the living microorganisms. Balance of soil organic matter is considered an important ecological indicator, an important element of assessment of the organisation and plant production and the basic principle of good management in agriculture.

2. Variables presented to stakeholders

-Soil organic matter
-Farm practices adoption (soil sampling, use of nutrient management plan, incorporation of crop stubbles, ploughing frequency)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	137	0.39
Usefulness	149	0.83

4. Stakeholders comments

On concept and variables

-Good measure (1) a fundamental topic for CAP (1) and vital factor for soil fertility, soil structure and soil biology (2)
-Difficult to draw a link between farm practices and soil organic matter (1). Current organic matter measurement does not show any relationship to soil quality (1).
-The soil type influences the organic matter content (1)
-Uniform method of calculation necessary (2)
-Relevance depends on type of farm: not relevant for grass farmers (1); more important for organic farmers (1); more likely to be provided by big farms (1)
-What is the concern of EU and government to know indicators for organic matter? (1)

On perceived potential uses

-Manage crop rotation (1), optimize fertilizers use (3), calculate production and yields (1); know the state of the soil, relation with fertility and productivity (1) ↔ In practice, not often used as an important factor to manage productivity (1)
-Useful to measure carbon stocks (1); classify reduced tillage, direct sowing and setting up soil maps (2)
-Benchmarking(1) ↔ Not usable for accounting advice (1)
-Important for society and market (1)
-Lead to effective policy making decisions (1); commission is asking but some member states are resisting (1)

On data collection and analysis

-Complex (2). Not possible to obtain this indicator at farm level because most of the information will be available with several samples at each plot level (2). Problematic in case of fragmented fields (2).
-Soil management practices are easy to collect (3) ↔ Easier to ask producers to provide soil samples testing, rather than to record his cultivation practices (1): more precise (5)
-Unlikely that many farmers have this information ready in their farm (5): soil testing is expensive, time consuming (3), no equipment (2), only farms with RD program will have it every four years (2)
-It is possible to collect the data from other sources (1) but some databases are not accessible (1). Already obligatory in case of nitrate vulnerable areas (1) and part of cross compliance prescriptions (1).
-Different experiences: very low amount of farmers make a soil humus analysis (1) and bad experience in RDP: no control on sampling, data is likely to being corrupted (1)

Recommendations

-Ask use of recommendations derived from soil tests: fertilizing plan, nutrient management plan, use of plan (3)
-Ask appreciation of soil quality (1) and soil type (2)
- Focus on organic matter balance (2)
-Use currently used calculator such ISIP (1)
-Extend the list of practices linking with GHG emissions, carbon sequestering (2)
-Link farm economics (1)
-Link with E5 (1)
-Tell the farmer the potential benefit to measure soil carbon (1)

5. Final variables

-Soil organic matter (results of soil sampling and requirement)
-Type and area of soil practices

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.7 E7 Indirect energy usage

1. Description	
This would largely reflect the energy impact and contribution to Greenhouse Gas emissions from farming activities. Note that these data can be calculated from current FADN data. Amounts of feed and nitrogen fertiliser purchased can be multiplied by a weighted average N_2O and CO_2 emission factor. Should be expressed in equivalent CO_2/unit of production.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Current FADN data	

	n[1]	average[2]
Feasibility	37	0.05
Usefulness	38	0.11

4. Stakeholders comments	
On concept and variables -Not relevant if it is not associated with other indices (1). -Explicit calculation to calculate indirect energy standards: different calculations systems (3) -Balance total energy use on farm level (1); consider exports of energy (1)	**On perceived potential uses** -Not useful for farmers (2): not able to influence it directly (1). Unimportant for farm economic advisory (1). -Interesting in the case of future label (1) -Determine carbon foot print (1) -Benchmarking (1) -Check efficiency among sectors (1) and farmers (1) -Determine subsidies or restrictions (1) -Monitor rural development programs (1)
On data collection and analysis -Some information available on FADN, costs of energy principally (2) -Depending on the variables to collect, farmers don't know the answer (4): forage and purchased feed not recorded actually (1) timing of application (1), type of machinery (1), quantities of feed (1)	**Recommendations** -Estimate content of organic fertilizers using coefficients (1) -Add purchase feed and forage to current FADN (1) - Consider energy use for transportation for feed, fertilizer, final product (1) -Provide indicator per product (1)
5. Final variables	
No need to ask farmers questions about this indicator.	

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.8 E8 Direct energy usage

1. Description

Direct energy use is a substantial cost for the farm enterprise and contributes to greenhouse gas emissions. Understanding these factors can help to develop devices that use energy produced in a more sustainable way ("green economy" and GHG issues). Understanding the details of direct energy use can contribute to better design of relevant interventions (e.g. RDP).

2. Variables presented to stakeholders

-Electricity supplier; -Expenditure on direct energy use; -Time of energy use; -Energy intensive operation (drying, heating, isolation of buildings)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	97	0.59
Usefulness	117	0.86

4. Stakeholders comments

On concept and variables

-Important for economic and ecological perspective (2) related to production (1). "If greenhouses would have a cost…" (1) and demanded by the customers (1). Depends on choices and conditions (e.g., if the product is stored) (1).
-Some information can be based on estimations (2)
-Difficulties to separate farm and household/own consumption: it would depend on the availability of a separate meter (2); also, difficult to separate for each production process and activities (3)
-Have a perspective on the cycles to account for compensations (1), would be developed an index? (1)
-Some variables seem meaningless asking too much information (2): energy use schedule, timing (2)
-Energy consumption in organic production tends to be higher and employees needs better training (1)
-Costs include not only rates (night, flat or standard rate) (1) but also transmission costs, quality costs, active-energy costs, network charge, license charge, subscription charge, transitional charge (1)
-Consumption of fuel does not reflect the real use of fuel: some farmers use fuel to pay external services (1) and diesel can be subsidized (1)
-Acute question since the law of cooperation is changing (1)

On perceived potential uses

-Farmer can influence it (1); supports management and is useful to collect (2) ↔ farmer already knows (1)
-Reduce costs: cheap energy, cost saving technology (3)
-Set classifications and determine subsidies (1); benchmarking (1)
-Develop self-consumption/self-sufficiency, know energetic costs (not only economic) and energy dependency and decide if create own sources (3)
-Assess what influences energy use (e.g., building isolation) (1)
-Program RDP (1)

On data collection and analysis

-Expenditures already in FADN (3); energy figures are rarely collected (3); but may be available increasingly in a digital form (1)
-Timing, building isolations and energy-sensitive technologies would be very difficult to collect (3)
-Some variables are not recorded, farmer does not know the answer (3)

Recommendations

-The indicator should be provided also by product (1)
-Add a list of what influences energy use: building isolation (1)
-Include energy use for transportation (of feed, fertilizers, final product) (1)

5. Final variables

-Quantity, costs, usage and share of usage of fuel, coal, gas, firewood, and electricity
-On farm renewable energy quantity, costs, usage and share of usage for electricity, heat and fuel

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.9 E9 On-farm renewable energy production

1. Description

Energy use is a substantial cost for the farm enterprise and contributes to greenhouse gas emissions. Use of renewable energy can reduce costs and improve environmental sustainability, although there can be substantial capital investment required. Renewable energy production might address multiple issues in the focus of the CAP. Depending on the type of RE (wind, solar, biomass) and the technology used (photovoltaic vs. thermal; biofuel vs. biogas) the overall contribution mix (GHG mitigation, biodiversity, labour, investment need) will be different.

2. Variables presented to stakeholders

-Technology used (energy crops, wind, water, solar, biomass, anaerobic digestion)
-Energy production (kWatt/joules production units)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	120	**0.60**
Usefulness	140	**0.52**

4. Stakeholders comments

On concept and variables

-Essential expenditure, it introduce inputs (1), important from environmental objectives and farm costs (1) and fits with actual trends (1). Needs an economic driver, so it should be linked with farm economics (1).
-It may not be relevant for all the farms or regions (7). More relevant for bigger farms (2). Interesting for those who have made that kind of investment (1). Exploratory or prospective indicator for farmers interested on invests on that type of production (2).
-In some regions, there is lack of knowledge or not information about how to implement (2). There are several types of support for that type of investment (2). Some rules and legislations are bureaucratic (1) or unreliable due to changing conditions (1). Systematic and long term support and its monitoring is needed (1).
-There is a debate about how sustainable renewable energy is (1) or how this affect farm sustainability (1)
-Quantifying the production depending on the type of technology or separating the production (to the farm or other purposes or if it is exported) can be difficult (2)
-Kw implies only electric energy but there is other energy as biomass produced at farm level (indirect energy production) (1)
-Would it be included in the farm or other related enterprises?

On perceived potential uses

-Source of farm income (1) or cost reduction (2); decide if create own energy sources (1); search for cheaper energy use (1)
-Know level of energetic self-sufficiency of farms (2)
-Know perspectives on renewable energy (2) and to promote renewable energy using waste (2)
-Meet bioenergy targets at macro level (3) and know energy balance of the countries (1)
-Knowledge of energetic costs saving technology (3)
-Indicates the way of production not the product itself: difficult to communicate to the consumer (1)
-Monitoring programs (1)

On data collection and analysis

-Collected in FADN as other gains activities (only as an output) (1) and information on energy crops in FADN already (2)
-Farmers with investments in that type of production will know and have information (2); others most likely don't know many of the answers (1)

Recommendations

-Add use of renewable energy created out of the farm or green suppliers (2)
-Look at the energy supply contracts (1)
-Link with farm economics (1)
-Link with programs (1)
-Ask area and yield of energy crop for calculating indirect energy production (1)
-Take practical circumstances into account: height of windmill, position sun collector on roof, sun and effects of shadow and sun hours (1)

5. Final variables

-Biomass (production, sales, price, own, loan, subsidies and share) for electricity, heat and fuel
-Geotermal, solar and wind energy (production, sales, price, own, loan, subsidies) for electricity, heat and fuel

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.10 E10 Farm management to reduce nitrate leaching

1. Description

The careful matching of crop requirements to application of fertiliser and nutrients is a cost-effective and environmentally beneficial management practice. Prevention of nitrate leaching often means that available nutrients are not wasted, and can result in reducing costs of fertilisers without a loss in production. In addition prevention of nitrate leaching is an important aim of the Nitrates Directive, which is aimed at protecting water quality.

2. Variables presented to stakeholders

-Area of arable fields
-Presence of catch crop, alfalfa, temporary grassland
-Farm equipment concerning natural fertilizers and waste
-% of slurry and manure spread
-Use of laboratory test to measure N or P content of the slurry and manure
-Slurry spreading methods
-Record keeping of chemical/organic fertilizer applications

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	114	**0.52**
Usefulness	125	**0.68**

4. Stakeholders comments

On concept and variables

-Important (3) and a relevant problem for some areas (2). Related to water protection and linked with water directives (2). Indicator related to nutrient management, greening, soil, and water protection (4).
-Explicit the calculation of real nitrate leaching (3) not European protocol defined (2); difficult to obtain comparable results (1)
-Other variables influences nitrate leaching such as soil type, surface, draining and timing of application (4)
-Quality of records or best estimates of content of nitrogen of natural fertilizers can be questionable (4). No analysis of organic fertilizers at labs (2).
-It identifies techniques, but not efficiency (1). Difficult to use farm practices as a measurement of improvement, because they are changing constantly (1).

On perceived potential uses

-To know need of fertilizers and optimize fertilizers use (2); to minimize nutrient loss: annual nutrient cycling (2)
-Farmers cannot influence nitrate leaching (1) ↔ important for farm management (monitoring and planning) (3)
- Benchmarking: know what other farmers are doing (1) ↔ Farmers already know the information (2)
-Develop agro-environmental measures (1)

On data collection and analysis

-Easy to collect (4) ↔ Complex, too much information, difficult to collect: farm records of various years, lot of paperwork and information not recorded (6)
-Available from farmers participating in programs that keep records of the farm. For others not verifiable, not reliable (4).
Some not reliable (slurry, liquid slurry, organic fertilizer) or not properly collected (land cover, soil erosion).
-Information could be collected from helpful, positive farmers (1)

Recommendations

-Link with nutrient management, soil, GHGH emissions, greening indicators, water protection (5)
-Provide short list of measures (1)
-Include liquid manure (1)
-Separate variables from verifiable form best estimates (1)
-Estimate % of slurry and content of nitrogen (1)
-Ask nutrient management practices (1)
-Ask drainage (1)
-Measure nitrate concentration in ground water (1)
-Feasible to measure in the framework of a research program (1)

5. Final variables

-Area catch crop harvested before Sept. 1st
-Area catch crop harvested after Sept. 1st

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.11 E11 Farm management to reduce soil erosion

1. Description

Soil is an important resource that sustains agricultural production. Soil erosion is a serious threat to soil resources. In addition, soil erosion has considerable further consequences for farm production, profitability, and environmental effects (e.g. knock-on effects water quality in watercourses). The index of arable land vegetation cover in winter is considered one of the agri-ecological indicators designed for synthetic assessment of resources at the surface of agricultural land, the balance of ecosystems and the degree of implementation of sustainable production system in agriculture. Vegetation cover during the winter prevents negative impact of climatic factors on soil, such as rain and wind. Growing plants on arable land during the period between the two main crops reduces water pollution (it reduces the risk of nitrate leaching) and protects the soil from erosion.

2. Variables presented to stakeholders

-Area with reduced tillage
-Area with low soil cover during drainage period
-Area at risk soil erosion
-Management strategies of soil erosion

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	80	0.41
Usefulness	104	0.51

4. Stakeholders comments

On concept and variables

-Objective and important indicator (3) that measures sustainability (1) and is a big problem in certain regions (1), but not relevant or applicable for others (2). Willingness to act to solve it is low (1).
-Difficult to get data comparable among countries (1) and among several years (1)
-Variables need clarification and more details (2). All of them are not relevant for permanent crops (1).
-Define variables that may influence: slope, type of soil, organic matter content (2)
-Relevant for some type of farming (2) farms on specific regions (1)

On perceived potential uses

-Farmer cannot influence it (1); not useful for farmer (3) ↔ supports management decision (1)
-Assess environment conservation and attitude of farmer toward environment (2)
-Assess food safety at macro scale and long term farm management assessment (1)
- Inform area covered (1) and identified techniques to minimize soil erosion (1)

On data collection and analysis

-Information available (2), easy to collect from farmers involved in programs RDP-AE (2). For others not likely to be answered (5) or not in the records (2).
-Not verifiable (1)
-Only the collection of erosion vulnerable farm area is feasible (on LPIS) (1); cross compliance controls for erosion measures (1)

Recommendations

-Add types of erosion (wind, water) and use of agri-environmental schemes (1)
-Do not ask spreading organic fertilizer in winter: ask instead use of catch crop during winter crop (1)
-Add selection list of measures (1)
-Evaluate risk of erosion at farm level (1)

5. Final variables

-Area associated with erosion risk
-Area associated with erosion risk and was not ploughed
-Area associated with erosion risk and catch crop was grown and it was incorporated before winter
-Area associated with erosion risk and catch crop was grown and it was incorporated after winter
-Area of soil cover in every row for vineyards or orchard
-Area Soil cover in every second row for vineyards or orchard

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.12 E12 Use of legumes

1. Description

Legumes are able to capture nitrogen from the atmosphere and provide 'free' nitrogen fertiliser. This can help reduce the expenditure on nitrogen fertiliser and improves yields. It also contributes to improved soil fertility, and is important in crop rotations. The reduced use of chemical N fertiliser reduces energy used to make fertiliser, reduces losses of nitrogen to water as nitrate leaching, reduces losses of nitrogen as greenhouse gases, and can improve carbon sequestration. This makes it a very cost-effective environmentally-friendly practice.

2. Variables presented to stakeholders

-Area of land sown with any legume in grassland (white clover, red clover, alfalfa)
-Areas of arable land sown with legume as protein crops (peas, beans, soybeans)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	45	**1.16**
Usefulness	63	**0.49**

4. Stakeholders comments

On concept and variables
-Link with nutrient management and nutrient leaching E5; E10, E6 (2)
-Not problem in arable land; difficult on grass land (1)
-In some cases use of legumes can have adverse consequences on health of soil-e.g. nematodes (1)

On perceived potential uses
-Interesting from economic point of view (1)
-Part of rotation management of nitrogen, organic matter, and good environmental practices (3)
-Self-sufficiency in animal production (1)
-Limited usefulness for farmers (2)
-Part of the greening: monitor guidelines (2)

On data collection and analysis
-Available; easy to collect (2)

Recommendations
-Ask area and type of legumes (1)
-Collect share of legumes for mixed grasslands (1)
-Add yields of protein crops to calculate N quantities (2)

5. Final variables

The variables are collected in the new FADN return for arable land , thus no new data collection necessary. Grassland is not accounted for. This could be incorporated into the N Balance accounting for clover in swards of permanent grassland

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.13 E13 GHG Emission per ha

1. Description	
Greenhouse Gas emissions are a major issue for agriculture, as the agricultural sector is a major source of GHGs. There is a very strong pressure on farm producers to reduce their GHG footprint as part of sustainability schemes and producers' specifications. The accumulation of several small changes in farm practice can have important improvements in GHG emissions for a farm enterprise. There is a need for improved information on the production of greenhouse gases across different farming systems, and geographical areas, and there is an opportunity to learn and better transmit best practices to reduce GHG emissions.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Quantities of purchased feed; -Length of outdoor grazing season; -Age at first calving rate; -Live weight gain; -Fertilizer use; -Slurry spreading; -Calving rate, live weight gain, age at first calving; *May need system-specific questions	(see table below)
4. Stakeholders comments	
On concept and variables -Methods to determine GHG are not fixed or known (5); important to define detailed standard vocabulary methodology and documentation; normative information about the indicator has to be developed (3). Direct energy not a major drive, more important fertilizers, feed and daily live weight gain (1). -Lack of knowledge of farms on the indicator (2). Objectives on this indicator are defined at national level (1) and there is no objective defined at farm level (3): it does not represent a difference in advantage for farmer (3) and farmer has not direct influence on it (1). -Difficult to interpret form the economic point of view (1)	**On perceived potential uses** -Trend, important, measure sustainability and impact of farming on the environment, useful to know (5) -It could be used as defensive information (1) ↔ It can show bad image of the sector (1) -Can be used on the next round of greening (1) -Useful to advisors, to identify more efficient farmers (1) -Determine subsidies or restrictions (1) -Determine emissions thresholds (2) -Important for the customers and easy to relate to the product (1) ↔ Not demanded by retailers or distribution chains (1)
On data collection and analysis -Most required data already available in FADN - Collected previously: no issues, mostly invoice based using standard coefficients; possible to estimate if there are available information on inputs and extent of the production (6) ↔ Complex, too much information required, not so easy; machinery "I cannot assess this" (6) -Would require additional cost to the farm (4) ↔ Linking with existing data sets makes this an easier calculation for farms (1)	**Recommendations** -Include carbon sequestration to get net contributions as an off set (2) -Link with other indices and indicators E7 & E8 & E92 -Measure baseline, farm practices and improvements across time (2) -Match information sources (4) and use external sources of the farm (2)
5. Final variables	
No variables to ask farmers.It will be calculated linked with variables of the other indicators (energy usage, nutrient balance, soil organic matter)	

3. Stakeholders average scoring

	n[1]	**average**[2]
Feasibility	79	-0.10
Usefulness	82	0.50

1Total number of opinions

2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.14 E14 GHG emissions per product

<table>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">1. Description</td></tr>
<tr><td colspan="2">Many food processors are interested in the carbon footprint associated with the farm enterprise that is involved in the production of their chosen product. Thus, a grain company may be interested in the carbon footprint associated with the production of 1 kg of grain, whereas a milk processor will be interested in the carbon footprint associated with the production of 1 litre of milk. For mixed farms, this presents a specific challenge to allocate farm inputs and outputs to different products.</td></tr>
<tr><td>2. Variables presented to stakeholders</td><td>3. Stakeholders average scoring</td></tr>
<tr><td>-Indirect energy usage (fertilizer, purchased feed)
-Direct energy usage (electricity and fuel from non-renewable sources)
*May need system-specific questions</td><td><table><tr><td></td><td>n[1]</td><td>average[2]</td></tr><tr><td>Feasibility</td><td>34</td><td>-0.15</td></tr><tr><td>Usefulness</td><td>54</td><td>0.54</td></tr></table></td></tr>
<tr><td colspan="2">4. Stakeholders comments</td></tr>
<tr><td>On concept and variables
-Linked with E13 (3); E7 and E8 (3)
-Methods to determine GHG are not fixed (1); many data and many variables involved, too complex and calculation would be based on average values or estimations (2). Neutral investigation would be necessary (1).
-Difficult to allocate for products, especially in farms which have diverse products (2). Also, difficult to compare according to farm type (1).
- -Fear of negative image (1)</td><td>On perceived potential uses
-Farmer does not have direct influence (1); not useful for farmers (1) and is not demanded (1)
-Calculate emissions thresholds, strategies for reduction (1)
-Determine subsidies or penalizations (1)</td></tr>
<tr><td>On data collection and analysis
-Additional person to collect is necessary (1)</td><td>Recommendations</td></tr>
<tr><td colspan="2">5. Final variables</td></tr>
<tr><td colspan="2">No variables to ask farmers.It will be calculated linked with variables of the other indicators (energy usage, nutrient balance, soil organic matter)</td></tr>
</table>

1Total number of opinions

2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.15 E15 Carbon sequestering land uses

1. Description

Greenhouse Gas emissions are a major issue for agriculture, as the agricultural sector is a major source of GHGs that contribute to climate change. There is a very strong pressure on farm producers to reduce their GHG footprint as part of sustainability schemes and producers' specifications. There are a number of land use types that can capture carbon, and thereby reduce the farm-level carbon footprint.

2. Variables presented to stakeholders

-Area of wooded or afforested areas
-Area under agroforestry
-Permanent grassland
-Information already in FADN

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	42	0.74
Usefulness	60	0.38

4. Stakeholders comments

On concept and variables

-Too complex: "I cannot assess this" (2)
-Carbon sequestration capacity depends on the crop, forest characteristics, usage, region, soil type, agricultural activities - e.g., peaty soils after tillage activities (4)
-Fixing CO2 is a positive function of agriculture but the cycle needs to be taken into account: a crop can be a high sequestering crop, consumption gives carbon emissions and forest fixes carbon, but "*wood cannot be eated*" (2)
-Forest area is a complex issue: it may not be part of the statistics; it is part of the farm; it is part of a company that is not the farm? (2)
-Clear definition and calculation necessary to make a comparison across countries (1)

On perceived potential uses

- Important (1) especially in livestock production (1)
-Useful at macro level to establish carbon cycle (1)
-Not very useful at farm level (2) but useful at sector level to show net contribution of emissions of the sector(2)

On data collection and analysis

-Data available on FADN (2)

Recommendations

-Cross maps or use GIS to get information (1)
-Define variables related with forest management: type of area, slow/fast growth species, age of the forests, usage (2)
-Provide all possible options and collect less known practices (1)
-Linked with soil organic matter, link with other indicators (2)

5. Final variables

No new data collection necessary.

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.16 E16 Water usage and storage

1. Description	
Fresh water is a scarce resource. The challenge of water scarcity and droughts needs to be addressed both as an essential environmental issue and also as a precondition for sustainable economic growth in Europe. An effective strategy towards water efficiency can make a substantial contribution from economic, social and environmental point of view. On average, 44 % of total water abstraction in Europe is used for agriculture. Agriculture can impact in different ways on the good chemical and good quantitative status of groundwater and surface waters. Water quality may be negatively affected by the presence of pesticide residues, nutrients from fertilisers, or sediments from soil erosion.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
--Water consumption, irrigation, livestock -in m3; -Tap water (m3); -Irrigation water (m3); -Capacity for storage (m3); -Source types	(see scoring table below)
4. Stakeholders comments	
On concept and variables -Important variable (4); quality of water is also important (3) -Water usage will depend on crop requirements, cropping plan, soil type, regions and period/reasons of water usage (growing, before harvest), evaporation, precipitation → weather/climate conditions (6) -There are local regulations and restrictions (retaining water, water permits, usage rights) (3) and cooperation difficulties among authorities (ministry of agriculture, ministry of environment) (1) -Farmers renting lands or draws very fragmented, so they are not trying to control costs on it (1) -Reluctance of farmers to reveal usage (2), risks of commercialization, new tax on water sources (1) -Not relevant for some contexts or crops or type of farms (5). More important for vegetable farms (2)	**On perceived potential uses** -Essential expenditure (3); supports farm management decision (2) ↔ Farmers already know that (2) -Calculate water consumption per crop (2), recommend new crops (2) and, with more difficulty, water foot print (1) -Estimate water demand (3), water balance (1) and improve water management (2) -Measure water waste (1) -Establish water pricing policy (1) -Compare water supply with product quality (1) -Show public we don't rely on irrigation (1)
On data collection and analysis -Farmers know volume of paid water usage paid (bills) or water pipes (3). However, for free water usage, especially wells and rivers or old irrigation structures, it is difficult to collect because there are not water meters and estimations should be done (7). Farmers in specific programs (KULAP; smart farming) may have more information available (2). -Difficult to separate volumes of usage between farm and household or other activities (2) and allocate between products (2) because of multiple uses or because fees can be charged by area or volume used. -Sensitive, not reliable, there could be differences in administrative registers and real usage (1). What if sources of information do not coincide? (1)	**Recommendations** -Ask water for pesticide application (3) -Dirty water production storage, re-dairy washings and re-water storage and water treatment (3) ↔ Re-use of rinse/cleaning water is marginal (1) -Ask about quality (2): use water districts registers (1) -Ask type of crops, area of crops; volume of water/ha/crop (1) -Ask type of water storage (1) -Ask source, method of water pumping, number of waterings, amount of water per watering (1) -Ask total quantity consumed and ask for shares for crops or livestock (1) -Use data of sensors that are available (1) -Collect number of animals (1) -Rainwater harvesting (1)
5. Final variables	
-Volume of consumption recorded by water meter, by type of source (rainfall storage, surface watercourses, groundwater) and end use (livestock, irrigation) -Estimated volume of real water consumption, by type of source (rainfall storage, surface watercourses, groundwater) and end use (livestock, irrigation)	

Stakeholders average scoring:

	n[1]	average[2]
Feasibility	132	0.40
Usefulness	144	0.65

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.2.17 E17 Irrigation practices

1. Description	
Irrigation helps improve crop productivity and reduce risks due to dry periods, making it possible to grow more profitable crops. However, irrigation is also the source of a number of environmental concerns, such as the excessive depletion of water from subterranean aquifers, irrigation-driven erosion and increased soil salinity. On the other hand, traditional irrigation systems create diverse and intricate landscapes, which support a variety of wildlife and have important cultural and historic value. Irrigation is one of the most important causes of water consumption and its efficiency depends on the irrigation practices. The most intensive irrigation agriculture can be an important contribution to groundwater pollution (fertilizers, pesticides) and eutrophication of surface waters. Over-exploitation of aquifers can degrade the quality of water. The amount of water used for irrigation depends on factors such as: climate, crop type, soil characteristics, water quality, cultivation practices.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Area under irrigation; -Type of irrigation system; -Energy consumption on irrigation; -Irrigation community?	

	n[1]	average[2]
Feasibility	84	0.94
Usefulness	109	0.25

4. Stakeholders comments	
On concept and variables -It would be necessary to define context variables to interpret indicator: soil use, soil type, weather conditions, regions, and water deficit (5) -Related with E16 (2) -In some cases, there are legal controversies that may make the responses not transparent (1): farmers don't know what to expect and can refuse to declare anything at all -Some variables may be meaningfulness in some contexts: irrigation communities, water associations (2) -More relevant for horticultural farms and farms with permanent plantation (1); many farmers do not irrigate: not relevant information (4)	**On perceived potential uses** -Irrigation can save money (2) and influence soil fertility (1) -Indicator to inform, not useful for farmer (3) -Measure farm level infrastructure and crops intensity (1) -Precaution for dry years (1); measure drought resistance (1) -Compare efficiency of irrigation systems (1) -Foresee demand of water (2) and irrigation demand and trends (2) -Important role in the future (1) -Generate specific RDP measure (2)
On data collection and analysis -Should be available in FADN (only provided by Spain) (1). Area and irrigation data in FADN (1). -Energy in irrigation more difficult to collect (4): best estimate may be calculated using hours of running and type of irrigation	**Recommendations** -Unify indicator with E16 (2) -Separate dry land and wetland (1) -Collect area of crops under irrigation and volume of water/ha/crop (2) -Ask average values (1) -Integrate in a system in order to be used (1) -Collect illegal irrigation (1) -Collect water for spraying (1)
5. Final variables	
-Use of water distribution network - Type of organization of water distribution network - Presence of water payments -Type of fees (proportional) for water consumption	

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3 Social

1.3.1 S1 Advisory services

1. Description	
Advisory service provision is an important component of the knowledge, information and innovation system in agricultural holdings. It is expected that those farms accessing to advisory services are better informed, produce better knowledge and therefore, may be more innovative. Advisory services are variable among countries and systems involving several public and private actors such as national, regional or local advisory agencies, research centres, universities, agricultural schools, NGOS, companies (upstream and downstream), consultants or agricultural advice companies, farmers cooperatives, chambers of agriculture, farmers groups. Due to this diversity on providers and type of service (from individual advice, group advice or simply information exchange), only a main part of the information would be possible to collect.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Frequency of advisory services received -Type of provider	see table below
4. Stakeholders comments	
On concept and variables -Give a very clear definition (4) -Frequency and costs not a good measure (2) -Type of service more important: scheme or business planning, taxes, investment, bookkeeping… (3) -Paid or free service? Public or private? (3) Staff from the companies (suppliers, processors) gives also advice services (2) -The proper question should be oriented on sustainability issues (1) or advisory objectives (2) -Depending on the FADN data collection, it can result in a high biased sample (100% of FADN farmers have advisory services) (4) -Accessibility and quality of advisory services is variable (2) and farmers have several experiences (1)	**On perceived potential uses** -Determine farmers' needs for information and knowledge (3) and advisory services demand (2) -Assess impact of those services on farm performance, quality of management and income (3) -Suppliers can find out niches, make decisions and assess professionalization of the sector (3) -Assess social capital (1) -Compare quality and advisory firms (2) and compare between territories and countries (1) -Program specific RDP measures (1) -Not useful at farm level: does not measure farm performance (3)
On data collection and analysis -Easy to collect (3) -Could be sensitive information (2) -Difficult to establish a list (1) -Partially available for private services on bills (3) for others not reliable (1) or verifiable (1)	**Recommendations** -Selection list should be made (4) -Include services for specific technologies correlating with amount and technology level (1) -Separate type of advice (3), fees (2), public and private (2), type of contract (1)
5. Final variables	
-Quantity and type of advisory services (accountancy, management, crop production, livestock production, animal products and services, other gainful activities, investments) received, by type of provider (public advisor, cooperatives, other farmer based providers, private advisors, industries) - Main information Sources about CAP and Cross Compliance	

3. Stakeholders average scoring

	n[1]	**average[2]**
Feasibility	111	1.21
Usefulness	110	0.67

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.2 S2 Education and training

1. Description	
Education is a variable that represents the qualifications of human resource. Level of education can be related with other social and economic aspects of agriculture. While formal level of education is not influenced by specific projects on rural development, non- formal education (such as trainings) is intended to develop specific skills and competences to improve job productivity. Both factors describe agricultural labour and human capital.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Person days training per year	

	n[1]	average[2]
Feasibility	101	1.19
Usefulness	102	0.47

4. Stakeholders comments	
On concept and variables -A very clear definition is needed. How is the baseline determined? Difficult to have a clear and homogenous definition (5): distance course (365 days of training) ruins the average of the farms? (1) -Link between education and farm performance is not clear (1) -Type and quality of trainings and education is more important than quantity: farmers assist only in necessary trainings (1) and exchanges are more useful for farmers than trainings (1) *"Which organization measures it?"* (1)	**On perceived potential uses** -Important for social and human capital (1) -Assess the knowledge and knowledge needs (5) on production, ecology (1) and meet quality requirements form the markets (1) -Benchmarking (1) -Measure impact on farm performance (1), monitor RDP (3) -Implement courses and trainings (1) -Not so relevant (2): it will not change (1) not usable for farmers (3)
On data collection and analysis Easy to collect (6) ↔ Difficult to establish a list (1) -Imprecise: memory errors possible (1) and non-verifiable (2) -Available from programs (RDP; supply diary chain) (3) or in national FADN (1)	**Recommendations** -Include self-training (2) and reading press for farm knowledge (1) -Link to advisory services (1) and innovation (1) -Ask number of occasions, not number of hours (1) -Collect information of all associates, if there are any (1) -Develop the list of trainings (1) defining types and motivation for training (1) -Add gender and age to make comparisons by sectors (1)
5. Final variables	
-Number of days of training per year for farm manager and other labour.	

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.3 S3 Ownership- management

1. Description	
Management and ownership information provide a basic yet important starting point in terms of farm level decision making. Additional information regarding external knowledge and advisory services can contribute better understanding the factors influencing the farm level decision making. This structural information may provide insight of the complex process of decision making. All of this has effect on the resilience of decision making. Finally it can shed the light of non-family type multiple enterprise structures exist for different optimization reasons (e.g. taxing).	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Share of ownership structure	

	n[1]	average[2]
Feasibility	57	**1.19**
Usefulness	56	**0.21**

4. Stakeholders comments	
On concept and variables -Question relate to ownership, not management (1), those categories do not match (1) -Not addressing social sustainability issues. Why is it in this category? (2) -Not interesting or relevant (3) -Trends on rapid data exchange is encouraging glassy companies, are farmers already being too transparent? (1)	**On perceived potential uses** -To know control on share (1); to know family farm and wealth distribution (1) -Not useful for farmers (2)
On data collection and analysis -Succession and questions about decision making can be sensitive (4). Concern that data will be used for controlling (1). -Ownership already collected (3). Management and their reasoning can be more difficult to measure (1).	**Recommendations** -Separate indicator a) ownership, b) management -It should be asked what is done in sub or separate enterprises: How many business units belong to the farm? Define the boundary of the farm (2). -Add complexity of the farm structure (1) -Distinguish between active and passive (by non-agricultural share) participation (1) -Distinguish between tax units and legal units (1) -Add national or foreign ownership (1) -Change category of indicator (1)

5. Final variables
-Financial involvement in number of agricultural (related) businesses -Type of technology used (internet, modern technologies, modern management tools)

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.4 S4 Social engagement/participation

<table>
<tr><td colspan="2">1. Description</td></tr>
<tr><td colspan="2">The social engagement of a farm/farmer into different groups (e.g. farmers' union, environmental group, educational association, local political party, farmers' groups, etc.) may help understanding some of the orientations undertaken at farm level. Information on social engagement is often used in the literature to capture farm/farmer's awareness on particular issues (e.g. environmental awareness). Such a characteristic is for instance one of the common drivers explaining the uptake of action benefiting to the environment (e.g. conversion to organic farming, implementation of agro environmental schemes (AES), etc.). AES participants (compared to non-participants) are for instance more likely involved in Farmer's Unions, farming groups with nature orientation, and environmental association. Furthermore, the magnitude of the engagement/participation can be important as being for instance a member of a nature association or a board member of a nature association does not imply similar commitment.</td></tr>
<tr><td>2. Variables presented to stakeholders</td><td>3. Stakeholders average scoring</td></tr>
<tr><td>-Involvement and type of membership on: farmers unions, professional organizations, local farmers groups, environmental associations, civil associations, religious associations, recreation organization, education association, local political party, local government, other clubs</td><td><table><tr><th></th><th>n[1]</th><th>average[2]</th></tr><tr><td>Feasibility</td><td>111</td><td>0.89</td></tr><tr><td>Usefulness</td><td>112</td><td>0.21</td></tr></table></td></tr>
<tr><td colspan="2">4. Stakeholders comments</td></tr>
<tr><td>On concept and variables
-Different perceptions toward farmer engagements and associations: the more engaged the individual, the greater likelihood that rural area will survive (1) and the more sustainable the agricultural sector is (1). Others consider that farmers are already part of it (1) and that some farmers do not want to engage (1) or that engagement do not represent a difference (e.g., all farmers are part of the chamber of agriculture) (2); age and physical access can influence (1).
-Important from the social and human factor as a "social fabric" (2) and it is linked with services for society and multifunctional activities of the farm (1)</td><td>On perceived potential uses
-Important and useful (4); difficult to explain usefulness for the farmer (3)
-In the future, can be important in some markets, showing the human and social side of the supply chain (2) ↔ Not relevant for the supply chain partners (2). More asked on global supply chain (from developing countries) (1).
-To know if farmer engages and feel part of the community (2), contact other farmers and exchange experiences (1), occupation of the farmers on those associations (1) or have an idea of organization level and hobbies (1)
-Analyze social engagement (1) and may be a good proxy for propensity of cooperation (1)
-Show social image (1)</td></tr>
<tr><td>On data collection
-Easy to ask and collect (6)
-Sensitiveness on religion or politics (5)
-Already collected in some cases (1) and can be derived from personal communication (1)</td><td>Recommendations
-Do not get into religion or politics; more about local interest groups (6)
-Could ask "how many hours?" (1)
-Collect information of all farm associates, in case of partnerships (1)
-In some countries, chamber of agriculture is compulsory: don't ask that question (2)
-Distinguish between levels of participation (1): active and passive engagement: Am I only member or part of the board? (2) Use "active member" instead of "board member" (2).
-Categories may be less detailed (1). Divide them into two categories: agricultural and non-agricultural (general public or civil) (2).
-Include: where people are doing business, buying farm products, farm inputs, village local spending, and exchange with other farmers (1)
-Ask rural isolation (3)
-Ask farmers perceptions: Are you happy with what you are doing? Are you happy with where are you living? (1)
-Ask cooperation with other farmers informally (1)</td></tr>
<tr><td colspan="2">5. Final variables</td></tr>
<tr><td colspan="2">Type of involvement (member or board) in farmers unions, professional organisation, farmers groups, associations, civil associations, government or other groups.</td></tr>
</table>

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.5 S5 Employment and working conditions

1. Description

Jobs creation is one of the positive impacts of agriculture in rural areas. Among Europe, agriculture involves around 25 million of persons and an estimated equivalent of 10 million of full-time equivalents jobs. Agriculture occupation has special characteristics such as prevalence of family labour, part-time regular employment and seasonality occupation. As a decisive part of the quality of life, the measurement of quantity and quality of the job in the agricultural sector is one of the crucial dimensions in social sustainability.

2. Variables presented to stakeholders

-Workforce per year/ -Working hours per week/ -Working weekends per year/ -Holidays per year/ -Annual rate of accidents, occupational diseases and lost days due to sickness/ -Availability of replacement in case of sickness.

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	113	0.63
Usefulness	114	0.68

4. Stakeholders comments

On concept and variables

-Important indicator that measures sustainability (6) and can be used to know about employment in rural area (3) and link with rural development (1)
-Agricultural employment characteristics influence the relevance of the indicator
-Many family farms have only one employee (2) or report only one employee as a full time worker (1); the farmer, as an entrepreneur is available 24 hours, multitasking (2) or works only part-time on the farm (1)
-Seasonal labor characteristics: seasonal unemployment for specialized labour (1); seasonal employment for non-specialized labor (1), sometimes without contract (1)
-Farmers may not have a need to use relief workers (1) or it may be difficult to get local trained individuals (1)
-Covered by legislations (3)

On perceived potential uses

-Usable at farm, sector or society level (1) ↔ Not useful for farmer (2) ↔ No special interest from markets (2)
-Measure AWU in a more realistic way (1) and compare AWU per sector (1)
-Show farmers' time to rest (1) and farmers' working schedule (1)
-Can be used to define policies and rural development programs (1)
-Occupational injuries and safety of work could be relevant for supply chain (2)

On data collection

-Accuracy and reliability of the answers questionable: farmers tend to overestimate their work hours, difficult to quantify, not detailed evidence, especially for unpaid labor (13)
-Numbers of days of sickness and accidents may be sensitive (3)
-Part of the information is already available in FADN data (4) but it could be only estimations (1)

Recommendations

-Develop methodology to collect working hours (2); consider dividing labor input into used for crop, livestock, services and general (1)
-Collect information on peak periods: number of peak periods, average duration, average number of working days during the peak periods (3)
-Include replacement services in case of annual leave, trainings, holidays (2)
-Ask not hours but actual working days(1)
-Ask the numbers of Sundays and Saturdays instead of weekends (2)
-Ask for fluctuation of the staff, the stability of the staff (1)
-Consider seasonal unemployment for specialized work and seasonal labor for non-specialized work (1)
-Measure cooperation among farmers (1)
-Take productivity into account (1)
-Link with investments, modernity, type of machinery (1)
-Define the term *holidays* (1); distinguish short holidays from long holidays (1)

5. Final variables

Number of holiday days taken by the farmer; Number of days-off per week
Months considered as peak season on the farm in terms of workload
Length of the peak season and low season in number of days
Average number of hours work on days during peak season and low season
Professional replacement in case of illness; Professional replacement in cases of other than illness

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.6 S6 Quality of life/decision making

1. Description

Autonomy and meaningfulness of the job is one of the characteristics with more influence on job satisfaction and hence quality of life. These characteristics cannot be measured with quantitative indicators and many other non-controllable aspects (such as individual, economic and cultural factors) can have an influence on them. However, quality of life is one of the main objectives of rural development policies, so it is worth to make an attempt to measure it in a subjective way.

2. Variables presented to stakeholders

-Perceived degree of autonomy; -Perceived degree of job satisfaction; -Perceived degree of quality of life satisfaction

3. Stakeholders average scoring

	n[1]	**average[2]**
Feasibility	126	0.71
Usefulness	125	0.50

4. Stakeholders comments

On concept and variables

-Measure social sustainability (1), it is important (2) shows social cultural life (1) and how quality of life changes (1)
-Other aspects are not evaluated such as the choice of farming (1) or the passion for agriculture (1)
-Subjective information (13) the answer depends on the people, not the activity (7). Specific situations, mood, timing and order of questions can dictate answers (5) and farmers tend to complain (4).
-Clear definition of autonomy is necessary (5) and it might be difficult to segregate life satisfaction from job satisfaction (1)
-Caution with Likert scales: tend to answer the median option: search for alternatives (1)
-Farmers can perceive this as soft indicators (2)

On perceived potential uses

-Gives information on future of farming and forecast future employment in rural areas(1) and shows trends in farm structure/ abandonment (1)
-Influences farm performance (1): happy farmer works more efficiently (1) and is willing to work on farm (1)
-Show life choices and self-realization of farmers with their life decisions (3)
-Shows how attractive the activity is (1), information that could be used for other people considering possibility to be farmers (1)
-Evaluate progress over time (1)
-Benchmarking: organic-traditional; regions (1)
-Detect mental problems (1)
-Could be used to complain (1) ↔ Not useful for farmers as they know that information (1)

On data collection

-Some can hide their true opinion(1) ↔ You will get and honest response(1)
-Producers have difficulty understanding the questions (2)
-The data would be difficult to compare, but could be used to evaluate progress over time (2)
-Data can be collected based on thorough conversation with farmers (1)

Recommendations

-Include rural isolation/loneliness (5)
-Ask wish for children to farm (3)
-Ask the reason for the 5. Final variables (2)
-Ask spouse or other family members (2)
-Question on job satisfaction can be doubled: at the end of the year and in general (1)
-Ask succession (1)
-Check the existing barometer (1)
-Consider: risk of poverty indicator (1)
-Compare changes in autonomy in five years (1)
-Ask for perceived assessment of the CAP and EU membership (1)
-Ask solid and straightforward questions: (2) do you find it hard to pay your bills? (1)
-Ask social benefits from discussions groups (1)
-Ask perceived degree of stress (1)

5. Final variables

-Perceived satisfaction on daily job tasks, work life balance, being a farmer, quality of life, freedom of decision making
-Perceived level of stress
-Perceived evolution of stress level and autonomy
-Attitude toward farming

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.3.7 S7 Social diversification: image of farmers/agriculture in local communities

1. Description

Social Diversification refers to the expansion of the range of rural activities both inside and outside the farm. The indicator "Social diversification" can support the agricultural income, the social security, and the social capital of the community. The new generation of farmers is at the centre of the new food system, and they need a diverse knowledge base and applied strategies to succeed as entrepreneurs. Diversification of agricultural income is a common risk management strategy for diversified farming systems. Farmers try to have the opportunity for a wider market access and better market flexibility. They try to implement many other active sales or to redirect their sales towards new markets (like on farm sales, direct selling, farmer markets or fair/exhibitions).

2. Variables presented to stakeholders

-On farm sells
-Giving apprenticeships, hosting open day events
-Participation in nature conservation, quality certification programs

3. Stakeholders average scoring

	n[1]	**average[2]**
Feasibility	111	0.88
Usefulness	112	0.41

4. Stakeholders comments

On concept and variables

-Look beyond the primary function of the farm (1) with an important role in the future (1); better indicator than S4 (1) ↔ Difficult to use as an indicator (1), not measurable (1) other indicators (S1-S6) more important (1)
-Related with EI9, EI3 economic feasibility: feels more like an income indicator than a social one (3). Non-agricultural activities can be included as a social indicator (1).
-Excepting direct sales, the concept is too vague (1); the current list may be not exhaustive (1): insufficient representation of the efforts of the farmers (1); as generic information (1), no useful analysis (1).
-Relevant for a small sample of the farms (3); more important for younger generations (1)
-Biosecurity risk associated with this type of diversification: health and safety for employees, risk around disease control (2)

On perceived potential uses

-Analyze direct sales (3), promotion activities (3), presence in vocational life (1) and show a better image of the farm (1)
-Measure rural engagement (1) and relation social environment vs. isolation (1)
-Develop commercialization subsidies (1)
-Show openness for innovation and entrepreneurship of farmers (2)
-Impact on farm performance (1)
-Important for society and policy perspective (4), not useful for farmers (3)

On data collection

-Easy to collect (5), farmers willing to tell (3) ↔Some farmers will not answer: private issues (1); it can be derived from conversation with farmers (1)
-Feasible indicator (3); better than S4 (1) ↔Too vague, infeasible to ask (1)

Recommendations

-Consider hosting days and organizing agricultural fairs (2)
-Include how many programs in rural development they participate in (1)
-Include holidays, trips (1)
-Include mental health, farmer health (1)
-Include farmers market as direct sells (1)

5. Final variables

-Participation in local festivals, farmers' markets, local farming fairs, local nature conservation, local competitions, hosting open day events in the farm, allowing public visit in the farm, giving apprenticeships, other.

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4 Innovation and economics

1.4.1 EI1 Innovation

1. Description

An innovation is the introduction of a new or significantly improved product, process, organisational method, or marketing method by your farm. The innovation must be new to the farm, although it could have been originally developed by other farms / enterprises.

2. Variables presented to stakeholders

-Questionnaire (yes/no) about new improved methods during the last three years on: logistics, supporting activities, goods, improved services, product design, product promotion, product placement, pricing methods

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	**110**	**0.59**
Usefulness	**108**	**0.65**

4. Stakeholders comments

On concept and variables

-Abstract concept, difficult to breakdown in a survey: changes on farm can be due to changing situations on farm or a response to markets not necessarily sustainability (losing land, using different markets, get a better price, membership of a producer group, moving from cooperative to cooperative) and vary across regions and type of farming (5)
-Innovation is not the same as farm development (2); an investment is not necessarily an innovation (2); innovation is not the same as modernity (1)
-Difficult to assess impact of innovations: interesting only if leads to environmental or social improvements (3)
-Product and process innovations more applicable at farm level (2) Marketing innovation may only be relevant for those who make direct sales: some questions do not apply to typical farms which sale unprocessed products (4). Some questions only relevant for bigger farms (1).
-Not all farmers are innovators: attitude from farmers toward innovation is different (2)

On perceived potential uses

-More related with business strategy than sustainability (1) but useful to monitor competitiveness and progress over the time as a factor of economic sustainability (4)
-Measure level of technology and engagement (2)
-Evaluate innovations and its impact on sales, monitor farm development and progress, show directions to increase sales, evaluate growth and competitiveness (5)
-Compare farms, see how companies are reacting, see relationships with processors (3)
-Evaluate tendencies on the sector and trends of production (2)
-Evaluate farmer motivation toward farm development (1)
-It is related with EIP (Entrepreneurship and Innovation Partnership) initiative

On data collection

-Difficult to establish a unique list (2): generic not specific information (1); innovations will come without being previously considered on the list (1) and that would make difficult to obtain useful analysis (3)
-Some questions can be interpreted in different way by farmers (2)
-Only if data collectors know the farm, can check if there are innovations (1)
-Easy to collect (2) ↔ Difficult to collect (1)

Recommendations

-Need to give examples, catalogue of ideas, refine the questions (more precise) and provide a complete list (5)
-Include material and non-material innovations (collective land management, new crop, technology adoption) (2)
-Separate innovations by areas (2)
-If it serves to monitor policies then it should be complemented by information on laws and subsidies relating to innovation (2)
-Link with an objective (records, energy/inputs efficiency) (3)
-Ask market innovations for those who sells directly (1)
-Define normative or subjective frames of innovation (1)

5. Final variables

-Product not new to the market (developer)
-Product new to the market (developer)
-Process not new to the market (developer and costs)
-Process new to the market (developer and costs)
-Market and organisational (type of innovation)

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.2 EI2 Producing under a label or brand

1. Description

Producing under such quality label(s) is made possible through public and private certification schemes: Producing under a brand or a label is one way for the farmer to signal the quality of his/her products (by taking advantage of brand or label reputation). Consumers are usually willing to pay a premium for labelled products and as a consequence product labelling can provide some insurance against price uncertainty and volatility. Assessing the impact of labelling on farm's income and income volatility can provide useful information to farmers. These would provide an estimate of the benefits of labelling, that farmers can then compare to the costs of the certification process. The farmer may also be interested to relate this information to farm performance (e.g. profitability) to see if it is worth it. A farmer may also be interested to see where he/she stands in comparison to other farmers in his/her type of production (e.g. dairy) and region. This may give the farmer an indication whether producing with higher value is possible in his/her case.

2. Variables presented to stakeholders

-Share % total output crops and total output livestock under certification label
-Number of markets for certification label production
(Examples of certification label: Protected Designation of Origin, Protected Geographical Indication, Traditional Speciality Guaranteed, organic farming, other private certification label)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	80	1.10
Usefulness	90	0.80

4. Stakeholders comments

On concept and variables
-Small share of PGI/PDO/TSG: not relevant in some countries (3)
-Unclear what is covered (3)
-Not an economic indicator of sustainability (2) or an objective in itself (1)
-Audit or marketing are done in the processor or marketing side: the farmer doesn't know (2)
-Labels represent value for the farmers (3) depending on the type of certification labels (1) and on the different experiences (1); license to produce (1)

On perceived potential uses
-Useful (4) or interesting indicator (1) ↔ Not so interesting (1), not useful for farmers (3)
-Communicate quality of the products to the consumer (2) ↔ Not useful as communication support
-Develop marketing channels (1)
-Analyze added value, price differentials, certification costs (3) and economic benefits (3)
-Benchmarking (1) and determine subsidies (1)
-Improve advisory services (1)
-Risk assessment (1)
-Develop programs for integration (1)
-Know the market size and get information about production model (2)
-Difficult to define a benchmark (1) unless clear criteria for the certifications are known (2)

On data collection
-It's known by the farmer and verifiable (4), easy to collect (4) and partially available (4) ↔ Too much information (1)
-Difficult to answer quantitative shares per type of label, as some products are under several labels (1). Shares of area is also possible to ask (1).
-Time of data collection is important (1)

Recommendations
-Include quality assurance schemes, organic and identify labels (4)
-Include producers groups membership that can access better prices (2)
-Add data such as label sale destination (export/non-export) (1)
-Ask for the quantity sold (3)
-Separate organic (1)
-Add share of land under contract (1)
-Differentiate how data will be used (1)
-Ask the labels to identify the producers (2)

5. Final variables

-Share of of revenue from sales of livestock and livestock products , crops and crop products, livestock of certified organic labels, EU public quality label, other quality label
-First year of when the farm produces under this quality label or certification of certified organic labels, EU public quality label, other quality label
-UAA Label of certified organic labels, EU public quality label, other quality label

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.3 EI3 Types of market outlet

1. Description

This information provides information on economic and social sustainability. Economic sustainability: shows if the farm is at risk of losing its outlets (stability of market outlets). Social sustainability: shows the operators in rural areas benefit from farming activities. The decision to contract with distributors may allow the farmers to hedge against the risk of demand uncertainty and volatility. Understanding who, in the farmers' population, decides to sign agreements with distributors and how such contracts impact on farm income and income volatility can help understanding another aspect of risk management on the farm. This directly addresses the FLINT policy topic of market stabilisation and risk diversification in bringing a product to a new/alternative market.

2. Variables presented to stakeholders

-Share % of farm output sold to processors, retailers, cooperative, middleman, consumers, other farms, other
-Type and time period of contract

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	117	1.09
Usefulness	112	0.79

4. Stakeholders comments

On concept and variables

-Improve categories (1): distinction between middleman and private retailers unclear (1); add share of output sold to producers group (1), supply chain (1)
-Not a measure for sustainability (1) what is the objective behind it? (1)
-Contracts are not always beneficial for farmers (1)
-Small share of production under contracts (1) ↔ Most sale under contract (1)

On perceived potential uses

-Compare outputs and prices (2), make sales plan (1), identify new market channels (1), identify sales target (2), know development possibilities (1), foresee prices (1), analyze farm liquidity (1)
-Learn about sales structures and links to the market (2), analyze market scenarios (1), balance market risk and production risks (1), know level of integration and diversification (1), know market protection (1), compare price differentials (1),
-Inform about quality of the product (1), know food systems (1)
-Detect market anomalies (1), develop and evaluate market support programs (1), assess subsidies and promote commercialization types (1)
-Interesting for farmers (1) ↔ Not useful for farmers (3) and not relevant for some types of crops (1)

On data collection

-Sensitiveness issues (4): producers' concerns about the reasons behind the question (1): nature and duration of contract could rise suspicions among farmers (1), part of business strategy (2) and difficult to get if there are signed contracts (1)
-Market outlet easy to collect (4), the share is more feasible (2) ↔ The share is more difficult (2)
-Farmers know (3) but time consuming evidence (2)
-Easy to answer if the products are sold under contract and in wholesale, more difficult if the producers market their product by their own (1)
-Available from some databases: AIMS (1) or horticultural registers (1), difficult to get a complete specific list of markets (1)

Recommendations

-Add short supply circuits (2)
-Ask for volumes, not shares (2)
-Ask quality systems (1)
-Add the production of final products (1)
-Add sales to production groups (1)
-Consider regional differences (different market according different types of soils) (1)
-Add middleman (1)
-Distinguish on farm sale, no farm company sells, farm processing and sale out of the farm (1)

5. Final variables

-Share of the revenue from sales to cooperatives. (%)
-Share of the revenue from direct sales to final consumers. (%)
-Share of the revenue from sales in another outlet. (%)

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.4 EI4 Past/future duration in farming

1. Description

The issue of inheritance is an important issue for farm level decision making. Current decision making and future decision making is largely influenced by existing farm governance structures. Who influences or makes the final decision on the farm. It is expected the number of years' experience as the main farm decision maker also influences the decision. The presence or absence of an heir is also influential in identifying farmer's objectives and future intentions. The issue of succession on farm directly relates to the core of sustainability focusing on future generations of farming. Given the intergenerational ties between families and farming tradition, farm succession is a key issue emerging for future policy. It is important for policy makers to identify who is the decision maker to tailor a suited policy approach in influencing change in farm level activities. It is equally important for farmers to think about this as an issue for the future of their farms. Identifying a successor gives additional security and increased autonomy in decision making.

2. Variables presented to stakeholders

-Identified successor to take over the farm

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	50	**1.00**
Usefulness	51	**0.94**

4. Stakeholders comments

On concept and variables

-Relevant only for family farms (1) and only relevant for farmers older than 50 years (3)
-Can express more a "desire" than a reality (3)
-Depending on emotional, family or wealth factors (1). While it is a widespread problem (1) young generation may not be interested (2) or is not feasible to pass if there is more than one child in the family (1).
-Not necessary a CAP issue (1)

On perceived potential uses

-Provide information about the continuity of the farm (1), farm development (1), expected dynamic of the farm (1), progression of the farm (1) or study farm evolution (1)
-It can determine farm choices or long term investments on farm (2) ↔ Does not determine decisions (1)
-Identify declining sectors (1) or make analysis according to age or ageing (1) and develop subsidies according this (1)
-Not useful for farmer (1)

On data collection

Easy to answer for management, not for other employees (1)
Easy to ask (3) ↔ May be sensitive (2) sometimes farmers don't know (2)
-It can be derived from personal communication (1)

Recommendations

-Ask birth year and year of settling down (1)
-Define time horizon (1)
-Ask: your farm will be farmed by a family member? (1)

5. Final variables

-Starting year as the main decision maker on the specific farm
-Reason for giving up farming in the next five years
-Successor identified

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.5 EI5 Efficiency field parcel

1. Description

Long distances from farms to field plots and small field plots increase the energy consumption and for example labour costs. Field parcel data/indicators with the economic indicators of the same farms can offer valuable information about the influence of long distances to field plots to production costs of the farms. The size of farms is growing rapidly and new field plots are rented or purchased by the farmers. Very often the distances from the farm to new field plots are growing longer and longer. Long distances will increase production costs and consumption of energy as well. LPIS indicators connected to economic indicators will offer possibility to study these issues. Field parcel indicators can also be supplied to farmers.

2. Variables presented to stakeholders

-Number of plots; -Size of plots; -Average distance of the plots

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	**50**	**1.00**
Usefulness	51	**0.94**

4. Stakeholders comments

On concept and variables

-One of the major structural problems in some countries (2), it cannot be influenced by the farmer (2)
-Average distance from the farm needs to be defined and questions carefully thought out (2)
-Clear definition needed: parcels, fields, plots? (1)
-Its influence depends on the type of production, livestock, agriculture (3)
-LPIS and cataster maps are available, but they face some limitations:
--include only farmers receiving subsidies (1)
--represent groups of parcel under the same crop (1)
--does not include vineyards (1)
--are expensive: farmers can change parcels informally to avoid administrative burden or tax obligation (1)
--does not include rented or sharecropped or changed parcels without contract or formal agreement (2)
--does not include communal plots (1)
--catastral references and agronomic use may not coincide (1)
--is not available in all countries, or farmer are not willing to share maps (1)
-Distrust of the intentions of collections (1)

On perceived potential uses

-Farmer cannot influence it (2)
-Calculate unitary costs (1) potential efficiency and expenditures (1)
-Know efficiency of the farm structure (1) and better understanding of fragmentation (1)
-Know share of inactive properties (1)
-Degree of organization of production (1) and relation with labor, and labor costs (2)
-New integration process to increase size (1), land consolidation and land rent (2)
-Related with soil quality (1)

On data collection

-No access to LPIS would make collection difficult (1); easier to ask in the frame of advisory services (1)
-Data is available, except distances of the plots (1)

Recommendations

-Interesting would be the variance of the field sizes, forest margins, margins to ditches (1)
-Distances and sizes must be checked manually (1
-Identify special areas (sharecropping without contract, communal grassland) with the assistance of farmholders (1)
-Define average distance and location of the farm (1)

5. Final variables

-Number and distance of all parcels
-Perception of how favourable the field pattern is
-Distance of furthest parcel
-Distance of closest parcel

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.6 EI6 Modernization of the farm investment

1. Description

Investments in the processing and marketing of existing products, as well as in the development of new products, processes and technologies can improve the added value to agricultural and forestry products. Such investments could be the construction, acquisition or improvement of immovable property, the purchase or lease-purchase of new machinery and equipment and general costs linked to expenditure such as patent rights and licences. Increasing the competitiveness of the agricultural sector requires an improvement of the productivity of physical capital. Modernisation of farms is crucial to improve their economic performance through better use of the production factors including the introduction of new technologies and innovation. Modernization is viewed as a technological progress in order to reach and/or maintain sustainable development/growth. Productivity growth can be enhanced through two pathways: technological change (TC) and technical efficiency change (TEC). TC captures the improvement in best practice through adoption of new technologies resulting in more efficient farming systems (i.e. the best farms getting better). TEC captures improvements in TFP arising from 'slower moving' farms adopting currently available technologies and knowledge. It reflects the aggregate influence of 'average' farms catching up to the best-performing farms. The Malmquist index method allows total factor productivity change (TFPC) decomposition over time into a catching-up effect (technical efficiency change (TEC)) and a frontier shift effect (technological change (TC)), which in fact one of the new impact indicators of the RDP 2014-2020, based on aggregate level data. This requires output and input variables already available in the FADN.

2. Variables presented to stakeholders

-Depreciation of assets
-Financial investment

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	43	0.93
Usefulness	68	0.82

4. Stakeholders comments

On concept and variables

-Essential information (amortization and investments) (1); part of operational management (1) to measure continuity and uncertainty of the farm (1)
-It may be not an indicator of sustainability as modern is not always better (2). It is only valid if the investment is functional to the farm (2).
-It could be linked with EI1-Innovation (1) ↔ Is not necessarily linked with innovation due that in some cases, it is just reposition of machinery and infrastructures (1)
-For fiscal reasons, the value of investments and depreciations in books may be higher than the real figures (2)
-Improve definition (5):
- description of financial investment
- time horizon
-calendar year, economic year,
-% of capital stock is used
-calculation methods of real amortizations and depreciation
-status of depreciation

-More useful for buildings, not for machinery (second hand, age, different ways of depreciation)

On perceived potential uses

-Measure form of production, level of dependency in the market (1)
-Measure continuity of the farm (1)
-Modernization and bank investment (1)
-Useful for organic farming: prove you are farming well (1)
-Benchmarking the market orientation (1)
-Not useful or adding value for farmers (2)
-Analyze RDP sources of financing (1)

On data collection

-Data already available in accounting records of the farm (4) partially in FADN-depreciation (2)
-Financial investment could be difficult to get (1): may be sensitive information (2) or farmers with low education can experience difficulties answering the question (1)
-Difficult to obtain useful analysis (1)

Recommendations

-Describe depreciation method: question should distinguish between machinery and building depreciation (2)
-Ask detailed financial sources, as many of them are related with RDP (1)
-Ask oversize or not of the capital (1)
-Ask functionality of the investment (1)

5. Final variables

- Age group and quantity of agricultural machinery-
- Age group and quantity of agricultural buildings-

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.7 EI7 Insurance

1. Description

Insurance of farm equipment, personal health, weather effects etc. can reduce the risks a farmer encounters in every day practice. In case of an accident the damage or losses are compensated. This reduces the loss of income in case of an accident. Insurances provide protection when unanticipated/unavoidable events occur; if such events result in losses (production/assets/personal injury) the farmer is compensated. It provides reduced risk in relation to farmer's income. The information about insurances in agriculture will help to monitor the risks awareness of farmers.

2. Variables presented to stakeholders

-Presence and amount of insurance (production, assets, personal)

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	68	1.25
Usefulness	82	0.43

4. Stakeholders comments

On concept and variables

-The indicator, related with the management of risk, does not involve broader risk concepts:

- -harvest risk, harvest certainty, financial/capital risk (3)
- -actual or perceived risks (1)
- -individual attitudes toward risk (1)
- -different risks for different farming activities (2)

-Insurances markets are different among countries: in some countries small share of farms have insurances (2) and in others they have many of them (1). There are different levels of availability of insurances (protecting from storm, wind damage, yield losses, isolated incidents) (3)
-It is desirable to distinguish between personal and business insurance is. Not in line with FADN New return document.
-Unclear how private insurance relates with sustainability (4) not relevant indicator (6)

On perceived potential uses

-Measure the degree of awareness and welfare (1), protection and farms capacity of overcoming unfavorable situations (1)
-Describes the production model (1)
-Evaluate insurance efficiency (1)
-Interesting to see what is happening on sector level (1)

On data collection

-Feasible and available (6), obligatory, verifiable with insurance certificate (1)
-Could get information at macro level or insurance suppliers (2)
-Quantities and values could be difficult to get (1)

Recommendations

-Include harvest certainty (1)
-Go to insurance suppliers or macro levels rather than farms (2)
-Separate private from production insurance (1)
-Ask for insurance certificate (1)
-Categorize insurances well (1)

5. Final variables

-Crop insurance type (hail, storm, rain, draught, frost damage)and direct or indirect damages
-Building insurance type (hail, storm, rain damage) and direct or indirect damages
-Personal disability i
-Livestock(direct or indirect damages)

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.8 EI8 Share of output under contract with fixed price delivery contracts

1. Description	
Prices of agricultural products are getting more and more volatile due to less price and market protection from governments (EU). With fixed price delivery contract the farmer can reduce the price risk for the output products. The share of output under contract with fixed price delivery contracts tells whether the farmer is operating entirely on the "free" market or controls the output prices risk with fixed price contracts. With this information research can be done, for example, whether farmers with fixed price contracts perform financially better than farmers who do not use these contracts.	
2. Variables presented to stakeholders	**3. Stakeholders average scoring**
-Share % of farm output sold to processors, retailers, cooperative, middleman, consumers, other farms, other -Type and time period of contract	(see scoring table below)
4. Stakeholders comments	
On concept and variables - It is an important market decision (1) but there are different types of contracts (1): useful for measure stability (magnitude of sale, quality, date of delivery, penalty) but generally contracts do not guarantee price (8). Some farmers have had bad experiences with them (1). -Under contracts, outputs cost analysis can be hindered because many times inputs are provided that are deducted from the sale price (1) -It should be linked with EI3 (9), and EI2 (1) -According to the farming system: the use of contracts tend to increase (1) ↔ Or to decrease (1) -Farmers selling to factories do not know how to answer (2)	**On perceived potential uses** -Assess level of market stabilization (1) and show long-term relationships within the supply chain (1) -Know demand of farm products (1), how much production will be sold (1) and foresee farm liquidity (1) -Analyze price differentials (1) and foresee prices (1) -Complementary market information (1) -Analyze impact of market policies, as a protective measure (1) -Not very useful for farmers as they already know (1)
On data collection -Feasible to collect (3) -It is part of the recording system of the farm (4), but it could be sensitive: could raise suspicions among holder farmers and some are not willing to say (2)	**Recommendations** -Ask the value of the contract and calculate the share % afterwards (1) ↔ Quantities would be difficult to obtain, better asking the share (1) -Link with EI3 (4) -Distinguish type of contract: B2B contract, volume contract, price contract (1)
5. Final variables	
-Type of contract : price type, quantity type, duration type,other -Share in turnover	

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	92	1.23
Usefulness	93	0.41

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

1.4.9 EI9 Non-agricultural activities

1. Description

Income diversification is a well-known way to lower the risk of income losses from agricultural production. Agricultural output prices are getting more and more volatile. This means a farmer does not have the guarantee of a sufficient income from agricultural production. Income from non-agricultural activities can have a substantial share in the total income of the farm. Insight in the income from non-agricultural activities can help farmers to benchmark with colleagues who also develop non-agricultural activities.

2. Variables presented to stakeholders

-Revenues from health-care; -Revenues from energy sales; -Revenues from agricultural wildlife management

3. Stakeholders average scoring

	n[1]	average[2]
Feasibility	69	0.64
Usefulness	68	0.22

4. Stakeholders comments

On concept and variables

-Off-farm income is an extended and important phenomenon (2): very few farms depend totally on agriculture (1); some farms even survive from this type of revenues (1)
-Seems an indicator of good financial management instead of sustainability indicator (1) ↔ Important for economic sustainability (1) but it has a weak link with sustainable food production or sustainable food producers (1)
-Some off-farm incomes are different business branches that have different balance sheets or are not directly associated to the farm (2) even when they involve farm resources (machinery, labor). That makes consolidation of data difficult (1); what is the object of research: farm business, farmholder, household? (2)
-Important to know off-farm jobs, revenue of farm employment, % of total incomes derived from off-farm (2) % of the off-farm incomes used on the farm (1) ↔ Only interested in the type of off-farm activities, not income quantities (1)
-Little relevance: not meaningful in some areas (2) or type of farms (1)

On perceived potential uses

-To know risk exposure and agricultural dependence (2), related with management (1) concerns with management; it can be used by farmer for access to financial resources (2)
- To have an overview of all revenues (1) and to follow up the development of the incomes as part of the total income (1)
-Those revenues are reflected in social fiber/activity in community (1), gives an idea of the diversification of rural environment (1) and the situation and type of farms with off-farm activities (1)
- Usefulness for farmers is personal (1): not useful for farmers as they already know

On data collection

-Difficult to get: results will be not reliable (3): although is partially available in the accounting records (1) and farmers know the answer (1), most likely the farmers are not willing to tell (4)
-Difficult to ascertain if all activities should be included: part time agriculture would be contemplated? (1)
-Difficult to collect net income or gross margin from some activities (1): only big farms can provide detailed information (1)

Recommendations

-The monetary figure may be not useful: instead of quantities, ask yes/no questions, shares or relative importance or whether the contribution is essential for farm (3) ↔ Ask gross income and net income of the activities (1)
-Improve selection of non-agricultural activities (7): rental houses, energy sales, rural tourism, on farm stays, machinery leasing,…
-Distinguish and present indicator for each activity (1)
-Link to indicator S3 (1)
-Use current databases and other national sources to get national picture (1)
-Record activities of the farmer and the partner (1)

5. Final variables

-Hours of off farm employment for farmer and spouse
-Type of measures that could contribute to risk reduction (on farm processing or sales, diversification, off-farm investments, avoiding use of credits, hedging, financial reserves)
-Type of other gainful activities

1Total number of opinions
2 Average based on a scale from 2 to -2 where 2=++; 1=+; 0=+/-; -1=-; -2=--

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Stuttgart 18.03.2019

Place, date

Signature

Annex 3

Declaration in lieu of an oath on independent work

according to Sec. 18(3) sentence 5 of the University of Hohenheim's Doctoral Regulations for the Faculties of Agricultural Sciences, Natural Sciences, and Business, Economics and Social Sciences

1. The dissertation submitted on the topic

Measurement of sustainability at farm-level:stakeholders' perceptions and

indicators of social sustainability.

is work done independently by me.

2. I only used the sources and aids listed and did not make use of any impermissible assistance from third parties. In particular, I marked all content taken word-for-word or paraphrased from other works.

3. I did not use the assistance of a commercial doctoral placement or advising agency.

4. I am aware of the importance of the declaration in lieu of oath and the criminal consequences of false or incomplete declarations in lieu of oath.

I confirm that the declaration above is correct. I declare in lieu of oath that I have declared only the truth to the best of my knowledge and have not omitted anything.

Stuttgart, Germany 30.04.2019

Place, Date

Signature