PRIMA SECTION 2

D.1.2 / SIF DESCRIPTION AND GUIDELINES

(WP1 Project baseline and sustainable innovation framework design)

SUSTEMICROP PROJECT

Development of eco-sustainable systemic technologies and strategies in Mediterranean crop systems contributing to small farming socio-economic resilience

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Project details and Deliverable information

✓ **Project Details**

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Table of Contents

List of abbreviations and definitions

Abbreviation	Definition
Triple Bottom Line	TBL
Sustainable Innovation Framework	SIF
Key Performance Indicators	KPIs
Workpage	WP
Technological Case Studies	TCS
Integrated Crop Management	ICM
Integrated Pest Management	IPM
Sustainable Development Goals	SDGs
Global Reporting Initiative	GRI
European Union	EU
Product Environmental Footprint	PEF

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Executive summary

The continuous technological advances as well as environmental pressure towards a more sustainable and responsible world is a central issue nowadays in our society. As it happens in other fields, in the agriculture context, farmers experience the pressure to produce more and higher quality food at a lower cost in an environmentally and socially sustainable manner. Thus, they are encouraged to introduce new practices and techniques in their production activity. Moreover, the climate conditions force farmers to develop more resistant variants of different crops to survive and to be competitive. Finally, although farmers need to pay more attention to their stakeholders, their main objective is to be economically autonomous and competitive in the long-term. In this sense, sustainable practices contribute to achieve the Triple Bottom Line (TBL) easily, i.e., manage to be economically, socially and environmentally sustainable.

The objective of this deliverable is to present the initial Sustainable Innovation Framework (SIF). The SIF, together with a set of tools, aims to guide farmers through the sustainable process following different stages and considering their stakeholders and relationships. This deliverable presents the following materials:

- The *initial SIF*, which provides a detailed overview of the framework as well as a description of all the steps needed to develop and implement it.
- The *measurement framework*, which provides tools to measure the economic, social and environmental performance before and after undertaking the innovation process by using Key Performance Indicators (KPIs).
- The *implementation guidelines*, which help farms in the implementation of the initial SIF and the application of the measurement framework.

The SIF proposed in this deliverable (D.1.2) is a conceptual and theoretical work that describes how farmers can implement sustainable production practices and how they can measure the TBL impact in their farms. This SIF is used in Work Package number 6 (WP6 - Evaluation and Acceptance of Agro-ecological Innovation) to be applied to different Technological Case Studies (TCS) and measured through a digital tool developed in WP5 (Sustainability Assessment through Novel Digital Tools).

1. Introduction

1.1. Project summary

In the past decades, the Mediterranean region has experienced unsustainable agricultural practices, low productivity, biodiversity loss and climate change that altogether represent an enormous challenge for small farming systems. The European Green Deal, launched by the European Commission, has been designed to deal with climate and environmental-related challenges, in an attempt to build a sustainable response. Among several topics, agricultural activities have been addressed. This includes measures (like the European Farm-to-Fork Strategy) dealing with the use of Plant Protection Products and fertilizers of synthetic origin, given their negative effect on air and water pollution, soil degradation, food safety, and human health. However, the accomplishment of all the established measures has become a challenge especially for small farmers, with lesser economic resources and limited training skills. There is an urgent need to address some of these threats effectively and achieve sustainable agro-ecological practices to improve small farmers' resilience and adaptation to climate change and regulation changes.

In this context emerges the SUSTEMICROP project which is a Research and Innovation project that aims to increase the resilience of Mediterranean cropping systems and the competitiveness of small farmers in a climate change-affected environment, through the development of innovative, affordable, and systemic solutions with positive economic, social, and environmental impacts. SUSTEMICROP delivers sustainable strategies, products, and tools that, when applied individually or adopted as a whole under integrated management, allow small farmers to increase their competitiveness, adopt innovations and achieve overall sustainability.

To achieve this main objective, the next specific objectives are addressed:

a) Design and validation of innovative solutions to address pests, pathogens, and adaptation to climate change in three Mediterranean crops (hop, date palm, grape vine – for both wine and table grape), by valorizing, selecting, and testing different natural resources: Bio-Control Agents (BCAs), biofertilizers based on BCA-enriched compost, biopesticides based on natural compounds, and detection of resistant varieties and breeding traits against the effects of climate change and diseases.

b) Design of a SIF to evaluate SUSTEMICROP practices/innovations applied in the selected crops by using a set of KPIs economic, social, and environmental.

c) Design of new crop management strategies to be used in Integrated Crop Management (ICM) or Integrated Pest Management (IPM) systems, by using the obtained solutions and evaluation of its replicability, utility and usability.

d) Understand the success and deterrent factors influencing adoption of innovative systemic solutions by smallholders, aligned with legislation, the Sustainable Development Goals (SDGs) proposed by the United Nations 2030 Agenda, and the European Farm-to-Fork strategy.

e) Maximize the outreach and the beneficial influence of the project results, reach the target users, and other interested stakeholders, through a communication, dissemination, and exploitation plan.

1.2. Document scope

The purpose of this document is to design a SIF to evaluate SUSTEMICROP practices/innovations applied in the selected crops, with a set of economic, social, and environmental KPIs. To achieve this main goal, in this D.1.2 we describe the state-of-the-art of the SIF that represents the core methodology developed within the SUSTEMICROP project that guide farmers to implement sustainable production practices in their farms. First, the document provides a brief background to understand the main challenges for farmers in terms of sustainable practices. It serves to introduce the key components, the objective, and the expected impact of the SIF. Secondly, we describe the literature review and the methodology used to develop the SIF. We also illustrate in this D.1.2 the relationship between this deliverable and other tasks, and/or work packages (WPs) along the project. Thirdly, we show the theoretical framework and the methodology used to develop the set of 136 KPIs. Finally, we provide a guideline for farmers to guide them in the process of implementation.

1.3. Document structure

The document is comprised of the following chapters:

Chapter 1 presents a summary of the project as well as the document scope and structure.

Chapter 2 introduces a brief review of the sustainable practices in the agricultural sector.

Chapter 3 shows the literature review and the main theories that justify the development of the SIF. Moreover, it illustrates the methodology followed in the development process of the SIF and it clarifies the relation to other activities within the project.

Chapter 4 describes the set of KPIs and the methodology used to develop them.

Chapter 5 describes the initial SIF and the guidelines for implementation.

Chapter 6 presents concluding remarks and future developments.

Chapter 7 provides the references.

Chapter 8 (appendix A) describes the KPIs included in the measurement framework.

2. Sustainability practices in the agricultural sector

The agri-food industry sector has a strict connection with sustainability issues, considering the fact that there is a common interest both from producers and consumers in environmental and health issues of food production. There is a broad scientific consensus on what is needed to achieve for a sustainable food system. Sustainable agriculture has the goal to meet the needs of present and future generations, and to achieve this by meeting sustainability goals in the three dimensions (economic, social and environmental).

The key principles of sustainability for food and agriculture are five (FAO et al., 2021):

- **Increase productivity, employment and value addition in food systems:** crop productivity needs to be increased to ensure sufficient supply of agricultural products, but at the same time safeguarding and enhancing the environment. This objective needs to be reached increasing the efficiency of technical inputs applied to crops.
- **Protect and enhance natural resources:** agricultural activities rely on natural resources, so sustainable agricultural activities need to reduce negative impacts and enhance the status of these natural resources.
- **Improve livelihoods and foster inclusive economic growth:** in order to be sustainable, agricultural activities need to provide fair employment conditions to those who practice it, in an economically and physical safe and healthy environment.
- **Enhance the resilience of people, communities and ecosystems:** policies, technologies and practices that increase producers' resilience to threats (i.e., extreme weather events, market volatility and civil strife) would also contribute to sustainability.
- **Adapt governance to new challenges:** effective and fair governance (i.e., right and enabling policy, legal and institutional context) can ensure the achievement of sustainability.

In order to achieve sustainability, it is then important to maintain agricultural yields and efficiency while decreasing the environmental burden on biodiversity, soils, water and air; reducing food loss and waste; and stimulating dietary changes towards healthier and less resource-intensive diets.

Sustainable practices to be implemented vary according to the cropping system considered, and they need to be defined by considering the particular conditions in which the farm operates. SUSTEMICROP considers Mediterranean cropping systems, and specifically grapevine (both table grape and for wine production), date palm and hops, by developing and implementing systemic eco-sustainable technologies and strategies, adapted to regional particularities. SUSTEMICROP aims to deliver more sustainable and viable agricultural solutions and techniques following a systemic approach, covering different solutions based on regenerative and circular agriculture by recycling and reusing farm waste; functional biodiversity by selecting a set of microbial species that contribute to improve plant and soil heath; new and environmentally friendly pest management by using natural crop protection products; and selection of varieties better adapted to climate change regarding water shortage, pest attacks, elevated temperatures, or CO_2 concentration.

One of the fundamental baseline ideas of SUSTEMICROP is that agricultural sustainability must be achieved with the development and implementation of integrated management strategies, adapted to each crop, region and context.

For this purpose, the research activity in this project aims to address the following main pillars: *i)* the development of functional biodiversity as crop defense by the identification of Bio-Control Agents (BCAs) and the use of crop residues enriched with BCAs; *ii)* the design and use of biopesticides and bio-fertilizers obtained from natural extracts and natural sources; *iii)* the use of novel and traditional varieties better adapted to adverse effects caused by climate change, and *iv)* agricultural practices (overall) sustainability assessment for improving decision-making process by small farmers.

All the new products developed will be used for the design of new crop management strategies for the three selected crops, to be used in current ICM or IPM systems, by using the innovative systemic solutions obtained in SUSTEMICROP and evaluate its replicability, utility and usability in Mediterranean crops.

3. The Sustainable Innovation Framework (SIF)

This chapter outlines how the SIF was built. Firstly, in section 3.1 we describe the development of the main elements and stages that make up the SIF. Secondly, in section 3.2 we describe the methodology used to build the SIF, which is the result of a mix of state-of-the art literature reviews and expert inputs. In section 3.3 we explain the methodology measurement framework, i.e., what lies behind the SIF and its potential application beyond the scope of SUSTEMICROP project. Finally, we describe the connexion between the SIF and other activities in the project grouped according to different WPs in section 3.4.

3.1. The SIF Theoretical Framework

The SIF is an iterative process, which helps agri-food actors, and in particular farmers, to assess the benefits for implementing sustainable production practices from a threefold perspective: economic, social and environmental. The SIF, along with a portfolio of tools, guides farmers through a process that starts from the identification of the baseline situation and the potential problems and moving towards developing and implementing sustainable production practices, which help them to obtain better results.

As mentioned above, a literature review was carried out in order to build the SIF. To do so, we relied upon Google Scholar, Scopus academic database as well as Science Direct where we entered key words such as “institutional theory”, “signalling theory”, “behavioural factors”, “resource-based view”, “stakeholders theory”, in combination with “sustainable practices”, “sustainability” and “agricultural sector”, “agriculture”, “agri-food sector”, and “farming”. The keywords included several variations of original keywords, for example, singular and plural variations, synonyms, and combinations of keywords; searches in different languages like English, Spanish and Italian were also carried out. Moreover, websites of leading organizations in sustainability and the link with food sector such as The United Nations Agenda and the SDGs, the Global Reporting Initiative (GRI) or the Ellen MacArthur Foundation were also checked. This literature search generated a total of 51 articles and documents which provided useful information to build the SIF.

As depicted in Figure 3.1, the SIF is composed of four main stages: *1)* definition, *2)* decision, *3)* implementation and *4)* evaluation. The next sections elaborate on these four key stages in more detail.

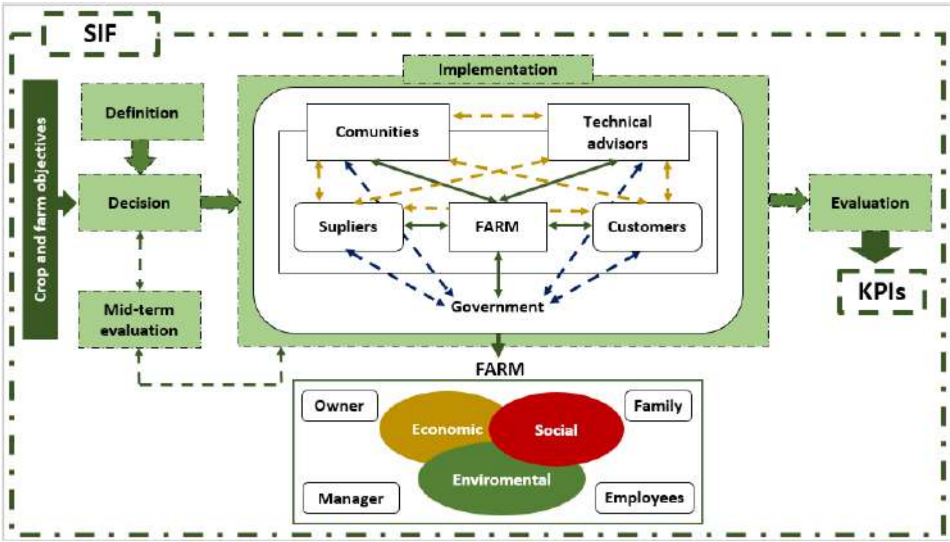

Figure 3.1. Sustainable Innovation Framework

3.1.1. Definition

This first stage refers to some key drivers that might influence farms' decision-making process when they considere developing and implementing sustainable production practices. These factors include the Institutional Context, the Signalling Theory and Farmers' Behavioural Factors.

Institutional Context

Firms operate in an institutional context that demands greater attention to sustainability criteria. According to Institutional Theory (DiMaggio & Powell, 1991), there are some kind of external pressures (social, political, economic, technological, etc.) that influence firm strategies and organizational decision-making as firms seek to adopt legitimate practices (Jennings & Zandbergen, 1995; North, 1990). International institutions, national governments, non-profit organizations, as well as publicly traded companies stress the importance of sustainability in its threefold perspective, i.e. economic, social and environmental (Van Gorp & van der Goot, 2012).

If we focus on the agri-food sector, for example, within the framework of SDGs developed by the United Nations' Agenda 2030 (United Nations, 2022), three of them are explicitly related to Sustainable Agricultural Development: SDG 2.3, SDG 2.4 and SDG 12.3 (Kusnandar et al., 2019). According to GRI, an independent, international organization that provide the world's most widely used standards for sustainability reporting, i.e., the GRI Standards (GRI, 2021), there is a specific pack (GRI 13) focused on Agriculture, Aquaculture and Fishing Sectors that covers a wide range of economic, social and environmental topics (e.g., economic inclusion, employment practices, food security and pesticide used) aligned with SDGs. Within the Circular Economy Scheme (Ellen MacArthur Foundation, 2022), both technical and biological cycles can be applied to agri-food sector. These cycles contribute to achieve more sustainable production and consumption, for example, through the the regeneration of food production or the reduction of food waste. Moreover, this influence of the institutional context on the agri-good sector and the transition of the adoption of sustainable practices have also caught the attention of the academia.

For example, the implementation of sustainable ways of production and changes along the agricultural supply chain, driven by regulatory frameworks (Higgins et al., 2010); the adoption of climate-smart agriculture driven by factors such as the climate change effects and the increasing demand of sustainable products (Mazhar, 2021) or how changes in social values, technological advancements, regulations, etc., might affect decisions regarding sustainable practices, such as green sustainable activities or environmental management (Glover et al., 2014).

Within the scope of our SIF and in order to analyse the different factors that institutional context includes and they can affect farms in their process towards the introduction of more sustainable production practices, based on PESTEL framework (see, for example, Yüksel, 2012), we identify the following factor categories:

- *Legal-political*: e.g., government policy, fair trade policy, environmental policy, trade restrictions, funding and grant opportunities, etc.
- *Economic*: e.g., interest rates, economic growth/recession investment availability, etc.
- *Socio-cultural*: e.g., health threats, lifestyle attitude, health consciousness, population growth rate, age distribution, safety emphasis, etc.
- *Technological*: relevant current and future technology innovation such as Internet of Things, Artificial Intelligence as well as copyrights and patents, General Data Protections Regulations, need for training and education, etc.
- *Environmental*: e.g., environmental policies and priorities, pollution and greenhouse gasses emissions, resources availability, global warming, extreme weather conditions and drought risks, etc.

Signalling Theory

According to Signalling Theory (Spence, 1973), which has been widely applied in describing behaviour when two individuals or groups have access to different levels of information (Connelly et al., 2011), firms' signals enable them to communicate their organizational image, intentions, behaviour and performance (Karaman et al., 2020). Signalling Theory holds a prominent position in different field of knowledge such as strategic management (Basdeo et al., 2006), corporate governance (Trevis, 2003) or human resource management (Leahey, 2007). Although it has only been in the last decade that this theory has gain relevance in the analysis of sustainability practices, there is still further research to be done in this area (Karaman et al., 2020), especially in the field of agriculture where it might help to explain what drives some farmers to adopt sustainable production practices (see, for example, Castro Campos, 2022).

As Dessart et al. (2009) states signalling motives may push farmers to adopt a particular practice or more sustainable practices in general. Thus, we include this factor within our SIF since we consider that leading farmers in implementing sustainable production practices might be lighthouses to other farms and serving as a role model that encourages them to become more sustainability oriented. Similarly, those farmers that decide to implement sustainable production practices by applying, for example, the SIF developed within SUSTEMICROP, might also serve as a reference of their commitment on sustainability to other parties (suppliers, consumers, society, etc.), which can be very well received and positively valued by them.

Moreover, this sustainable effort made by farmers might be a result of governments' legislative initiates. Specifically, regulation on sustainability in agri-food sector not only obligates firms to comply with a particular law, but also it might encourage them to take action that goes further, in order to protect themselves from possible legislative changes in the future.

Farmers' Behavioural Factors

Farmers' behavioural factors are also part of this set of key drivers that have a bearing on decision-making process towards more sustainable production practices.

According to Dessart et al. (2019), three types of behavioural factors can be distinguished: dispositional, cognitive, and social. Dispositional factors are relatively stable and include internal variables related to a given individual, such as personality, motivations, values, beliefs, general preferences and objectives (Malle, 2011). Cognitive factors are related to learning and reasoning and include farmers' perceptions of the relative benefits, costs, and risks associated with a particular sustainable practice or whether they feel that they are skilled enough to adopt this practice. Finally, social factors are related to farmers' interactions with other individuals (e.g. other farmers or advisors) and it includes social norms and signalling motives.

Regarding social factors, two points should be taken into account. Firstly, social norms and signalling motives has been previously analysed in the current sub-section (3.1.1.). as part of the Signalling Theory. Secondly, farmers´ interactions will be described under Stakeholder Theory umbrella at the implementation stage (sub-section 3.1.3.). In particular, the interactions that take place between farmers and both external and internal stakeholders will be analysed. The main reason is because, although undoubtedly stakeholders are part of the set of sustainable practice key drivers in this first stage of the definition of the SIF, from our point of view, stakeholders play their main role in the implementation stage.

3.1.2. Decision

The decision stage represents how farmers, pushed by the aforementioned set of key drivers (institutional context, signals sent by leading farmers' behavioural factors) tend to be more sustainability-oriented and they are more willing to introduce sustainable practices, from a threefold perspective (economic, social and environmental) in their production activities.

At this point, farmers need to consider two key issues. First, they need to be clear about their main objectives and their stakeholders' demands to determine what kind of sustainable production practices are more suited to achieve them. Second, they must be aware of the resources and capabilities needed to be able to develop and implement such practices and manage them efficiently.

Farms' Objectives and Stakeholders' Demands

Within the SIF context, when we refer to farmer's objectives, we have not only considered objectives at strategic, competitive and functional levels (Thompson et al., 2022) but also those goals at higher levels that a farmer seeks to achieve, i.e. its mission and vision and values that are closely related to its organizational culture.

Mission can be described as how a firm defines itself and establishes the priorities of the organization (Jacopin & Fontrodona, 2009) and, if it is well-designed, it expresses the firm's primary and distinctive purpose. Vision refers to the current perception of what the firms will or should be in the future. It is the most general and long-term tool for future orientation and involves defining the strategic purpose or basic project of the firm (Hamel & Prahalad, 1989). Finally, organizational values refer to beliefs about the types of goals firm members should pursue, as well as ideas regarding standards of behaviour, organizational members should use to achieve these goals (Schein, 2010).

In addition, it should be noted that the farmers' objectives must also be aligned with the objectives or demands of their main stakeholders. This is because, as Cyert & March (1963) states, firms' objectives can be understood as the result of a process of negotiation and adjustment between the different groups involved so that all of them consider their particular objectives to be met, at least at a sufficient level.

Since the decision to adopt sustainable production practices should be considered as a tool to help farmers' to achieve their objectives, these sustainable practices must be coherent and perfectly aligned with them. As Galping et al. (2015) states, the more a farmer is oriented towards sustainability and the more sustainable the values that underpin its mission, vision and strategic objectives, the more likely the farmer will be to make the transition towards a more sustainable production process.

Farms' Resources and Capabilities

The Resource-Based View holds that the firms' sustainable development cannot be separated from strategic resources (Russo & Fouts, 1997). Considering that sustainable development should be understood in the TBL approach (Wilson, 1995), it means that firms must play a central role in achieving the goals of sustainable development strategies (Elkington, 1994) by channelling their resources and capabilities towards addressing economic, social and environmental challenges (Hart, 1995).

According to the two main assumptions of the Resource-Based View, firms are a heterogeneous combination of resources and capabilities that are not available to all firms under the same circumstances (Barney, 1991). These two founding arguments (heterogeneity and immobility) are those that can help firms to achieve a competitive advantage (Barney & Hesterly, 2012; Peteraf & Barney, 2003) and their business objectives as long as they are able to efficiently manage their resources and capabilities. Thus, if we focus on the agri-food sector, farmers must identify and assess, from a strategic perspective, which are the resources and capabilities they need that, when used efficiently and combined properly, make the likelihood of success of the development and implementation of sustainable practices further increased.

Resources are the stocks of tangible and intangible assets available (Barney & Hesterly, 2012). In particular, within the scope of this project, tangible resources refer to land, machineries, plants, distribution networks, proximity of the location to inputs and markets, financial resources, information technology infrastructure, trucks, vehicles, and raw materials, to name a few examples. These assets add economic value to the farm by facilitating the production and distribution of products in an efficient and cost-effective way (Barney et al., 2011). Intangible resources connote the non-physical resources or assets that a firm has its disposal (Barney et al., 2011). In this case, they include the knowledge, experience, motivation, commitment, etc., that workers put at the disposal of the farm and the landowner as well as the production processes and other technologies needed to manage the farm.

Capabilities are the abilities used by firms to identify and transform resources in order to achieve a particular result (Aghazadeh & Zandi, 2022). Thus, some examples of capabilities can be the abilities of farms' owners, managers, family members and employees to manage farms in a more sustainable and innovative way. It implies the ability to identify changes in the environment and deal with them as fast and flexible as possible while taking advantage of the opportunities that the environment provides (e.g., further development of sustainable production technology) and minimizing the effects of threats (e.g., water resource depletion).

The extended Resource-Based View (Barney, 2001; Lavie, 2006) states that resources might be derived from external sources, but more specifically they might come from interrelations with other firms or agents. This led us to talk about the next SIF stage (implementation) and the main theory in which it is mostly based, i.e., Stakeholders Theory. These issues will be dealt within the following section.

3.1.3. Implementation

Stakeholders are broadly defined as "*any group or individual who can affect or is affected by the achievement of the organization's objectives*" (Freeman 1984, p. 46). Firms' interaction with stakeholders play a central role within their corporate strategy (Dentoni & Peterson, 2011) since stakeholders' engagement influences the economic, social and environmental value of a firm in the medium- and long-term (Kassinis & Vafeas, 2006; Werther & Chandler, 2011). Thus, it is important that managers consider the whole stakeholders' network in which their firms are embedded (Rowley, 1997), as they can have an influence in key aspects related to their business management such as the decision-making process, target setting or implementation strategies, among others. For that reason, many firms establish lasting alliances with their stakeholders (Dentoni & Peterson, 2011).

This firm-stakeholder relationship is found in any sector of activity and, therefore, it also takes places in the agri-food sector. The development and implementation of sustainable production practices in agri-food sector require the engagement of all farms' stakeholders (i.e. internal and external) to reap the benefits. The establishment of "common sense" (Ferraro & Beunza, 2018) will be a key issue to take into account in order to get such coordination across both internal and external farms' stakeholders, which might have different understandings and desired outcomes (Nygaard et al., 2021) and they might use different mechanisms to influence the adoption of sustainable practices (Haleem et al., 2022). Only in this way, through active communication and coordination between both parties (farmer – stakeholders), farmers will be able to develop and implement sustainable production practices that are truly mutually beneficial and more likely to succeed.

Internal stakeholders, i.e., those who are part of the farm itself (e.g., owners, managers, family members and employees), are crucial and fundamental to the development and implementation of sustainable production practices (Meixell & Luoma, 2015). It is important that owners and managers are sustainability-oriented and embrace sustainability in its TBL. Moreover, they might have the ability to manage efficiently the resources and capabilities needed to undertake these practices and the know-how to transmit, share, and pass on these values to other farm's members (family and employees) to achieve their involvement and commitment with this process (Sarkis et al., 2011). All of these internal stakeholders are undoubtedly key players in the development and implementation of sustainable production practices.

Equally important is the engagement of farm's external stakeholders (e.g., suppliers, customers, associations, technical advisors, government, local community and environment), those who are not directly part of the farm but who are in some way related to it and its activities (Delmas, 2001). These stakeholders may also play a role in the development and implementation of sustainable production practices (Delmas & Toffel, 2004). For example, this kind of processes could not be carried out without a stable, long-lasting and trusting relationship with suppliers, who provide the raw materials and other supplies needed to carry out the production process. Similarly, it would not be possible without customers who value products resulting from these sustainable production practices and they are willing to buy them. It is also important the involvement of the local community and the existence of associations and institutions that support farmers (through advice, expertise, financial resources, etc.) as well as the existence of infrastructures and other elements that make it easier for farmers to implement sustainable practices.

3.1.4. Evaluation

Once farmers have implemented the previously selected sustainable production practices, it is essential to monitor them by performing an evaluation stage. The main purpose of this stage is to assess the impact that these sustainable practices might have in the crops from a TBL (economic, social and environmental) through a set of KPIs, in this case, 136, which have been developed from the literature and adapted specifically to this project. These KPIs and the methodology used to develop them are describe in the following section (Chapter 4).

At this point, it is important to highlight two issues. Firstly, this SIF should not be considered as a rigid linear framework where the four stages mentioned above (definition, decision, implementation, and evaluation) take place consecutively and in which the evaluation is the last of them. On the contrary, it should be understood as an iterative, flexible and adaptable SIF where there is a feedback process as the information that emerges from each of these phases helps to improve and enhance the SIF as a whole. Secondly, it should be noted that the evaluation stage does not necessarily to be performed only after the implementation stage, as it can be seen in Figure 3.1. Optional, but recommended in many cases, a mid-term evaluation could be carried out during the implementation stage, which allows the farm owner/manager to be aware of how the process is going and whether it might need to be redirected.

3.2. SIF development methodology

To develop the SIF framework as a baseline of the current project, a mix of the insights from the state-of-the-art literature as well as experts' own knowledge and experiences were used. Afterwards, a general overview of the literature review carried out and the SIF development with the experts is described.

As it has been stated in sub-section 3.1 (The SIF Theoretical Framework), the overall research process began with a *state-of-the-art literature review*. In this sense, the first and most important level of search was aimed to explore theories, tools, frameworks and other insights that could be used to develop the SIF. To do so, we rely on academic databases like Scopus or Google Scholar, and on different key words and combinations of them (singular, plural, synonyms, etc.) (more detailed description was already shown in sub-section 3.1 "The SIF Theoretical Framework"). These literature searches generated articles related to sustainability itself as well as the theories that may explain why firms are intended to incorporate sustainable practices in their strategy definition and in their day-to-day decisions.

Moreover, grey literature such as European Union (EU) deliverables on similar topics (Evans et al., 2014) and surveying websites of leading organizations in sustainability (e.g., GRI, the Agenda 2030 from the United Nations -SDGs-, United Nations Environment Programme-Society of Environmental Toxicology and Chemistry Life Cycle Initiative or the Flint EU project), sustainable practices in the food sector (e.g., FAO), innovation institutes (e.g., the Hasso Plattner Institute) as well as some PhDs directly related to the project's aim like Sánchez Fernández (2009) provided additional insights. It is necessary to mention that this literature review helps us to carry out the first two stages of our SIF framework (definition and decision). In particular, and as it has been stated before, allows us to identify the main concepts employed and the theoretical background (institutional and signaling theory and farmers' behavioural factors, among others) when explain the drives of the adoption of sustainability decisions.

Secondly, search about the KPIs, i.e., the key tool that it is going to be used in the evaluation stage of the designed framework, was also carried out. The objective of these indicators is to characterize the current state, dynamics and trends of development in the future. Thus, the analysis of these indicators should ensure decision-making system, including justifying the optimal directions of investment in sustainability practices as well as the creation of conditions for sustainable development of the farm. In particular, the literature search was focused on its concept, its main characteristics, and previous examples of indicators in specialized literature related to our topic. It follows a similar procedure relying on academic databases (e.g., Scopus) and international organisms in order to deriving a meaningful list of KPIs to be interesting for the development of the measurement framework and to capture insights on how to aggregate the different indicators. Although in section 4.2 more specific information will be provided, it is necessary to mention that three main domains were identified: economic, social and environmental. As it has been stated before, this TBL is an accounting framework that includes social, environmental and financial results as bottom lines (Elkington, 1997). Businesses, non-profit and governmental entities use TBL to evaluate their financial gains, as well as their social and environmental impact. All this information will help to develop the last stage of our SIF framework, the evaluation itself.

Both literature reviews were performance since July to October 2022, and complemented with punctual searches in 2022 year autumn.

Regarding the *involvement of experts* in the development of the general SIF, *four* different steps or *rounds* were undertaken. The study of the factors that determine the sustainable development of the enterprise is very difficult, because it is influenced by many different conditions, most of which cannot be directly quantified by a certain indicator. Therefore, in order to systematize the factors and establish their importance for sustainable development in a particular enterprise, it should use a method that allows processing the materials of the logical analysis of factors and evaluation of their mutual influence. To do this, the method of expert evaluation/recommendations is important because it allows identifying the dominant factors on which to focus (Zinina & Olentsova, 2020). Thus, along with the literature review, it is optimal to develop the initial framework by listening to experts in the field as they can provide knowledge on complex, interdisciplinary issues which involve new or future trends (Akkermans et al., 2003; Meredith et al., 1989). In fact, academic literature in similar fields also relied upon expert knowledge – see for example Sauer & Seuring (2019) who studied sustainability in the mineral value chain, Bocken et al. (2013) and Geissdoerfer et al. (2016, 2017) who studied the business model innovation process, or Prosman et al. (2022) which offers a guide to agri-food value chain actors through the innovation process.

The next sections describe each single round carried out with experts in more detail in order to build the initial SIF.

- *Round 1*

On 21-22 July 2022 a KICK-OFF MEETING was held in León as a first meeting among all the partners involved in SUSTEMICROP. The sessions took place using a hybrid format: face-to-face meeting and on streaming for partners that were not able to travel to León. Thus, that meeting allows us to be familiar with certain baseline concepts of the project and its steps. Moreover, it was a good opportunity to share information with the rest of partners about how designing our SIF and to draft a questionnaire to contact with farmers. This questionnaire aimed to collect preliminary information about our pilot farmers and to build the KPIs. Thanks to the use of an online meeting it was possible to collect information from all partners. However, it is true that a major drawback of using an online meeting with several experts connected at once may be the difficulty to express themselves correctly and the less personal contact among participants also reduces the possibility of strengthening ties.

Thus, in our study the first sub-group of supporting people considered is the 'outsider experts', that is, those from firms, universities and research institutions that attended to the KICK-OFF-MEETING. All outsider experts have developed deep knowledge of sustainability through research and policy making. As shown in Table 3.1, the experts represent various European Mediterranean countries, in particular from the University of León (ULE), the French Wine and Vine Institut (IFV), National Research Institute for Agriculture, Food and Environment (INRAE), Slovenian Institute for Hop Research and Brewing (IHPS), National Research Institute of Water, Forest and Rural Engineering – University of Carthage (INRGREF), Agrogenia Biotech S.L. (AGBIO), HORTA S.R.L. (HORTA), Mohamed I University (UMP), Mohammed VI Polytechnic University (UM6P) and Lebanese University (LU).

Based on the literature review a presentation was given about the main elements and goals of the SIF, i.e., a framework that represents all the relevant variables and dynamic innovation processes allowing the farmers to become more sustainable through control of pathologies (soil-borne fungal pathogens) - composting biofertilizers- and formulation of new biopesticies based on essential oils. Besides, this first round encompassed the reminder of the three objectives regarding the SIF framework (the framework itself, the definition of economic, social and environmental indicators and the evaluation of farmer's level of sustainability performance). Next, the project partners were asked to confirm, add, criticize the key elements of the SIF, and specially, about the initial online questionnaire to collect information about farmers, its main characteristics and stakeholders.

Table 3.1. Outsiders experts involved in the SIF development

Type	Country (Institution)	Number of Experts
University	Spain (ULE)	1
Research Organization	France (IFV)	3
Research Organization	France (INRAE)	2
Research Organization	Slovenia (IHPS)	1
University	Tunisia (INRGREF)	1
Small Medium Enterprise	Spain (AGBIO)	1
Small Medium Enterprise	Italy (HORTA)	1
University	Morocco (UPM)	2
University	Morocco (UM6P)	1
University	Lebanon (LU)	1

- ***Round 2***

With the suggestions received in the previous meeting, the framework as well as the designed initial questionnaire was improved. In particular, this last one was sent to HORTA, trying to get an even more improved version receiving the point of view of this particular expert before sending to the farmers. In addition, two online meetings were held with HORTA in the second half of July 2022 to organize the KPIs content itself and the corresponding procedure.

In addition, at the beginning of September meetings with colleagues from our own university who are familiar with corporate social responsibility issues also provided us useful ideas about the framework itself and the KPIs development.

- ***Round 3***

Another supporting subgroup is the people working in the agricultural activity (e.g., farmers, employees or technical officers) who are involved in implementing sustainability practices in their respective businesses. Thus, a field survey was conducted in this research among agricultural producers. For the successful conduction of the survey the questionnaire was sent to the coordinator of each WP and these partners collected the necessary information and sent to us. For example, issues such as farmer general information (assets, employees), type of crops and crop operation during the cropping season were asked. However, the key aspect of this questionnaire were related to the type of treatment and the timing for its application in order to design when the sustainability assessments after and before the treatment are going to be carried out in the evaluation stage. In addition, general information about the farmer's stakeholders was also asked in order to include KPIs related to all of them, especially in what concern to social indicators.

This information from people from the agricultural activity itself as well as the literature review performance may be useful to guide farmers and stakeholders in the implementation stage.

In particular, regarding the treatment applied in WP2 we received two filed questionnaires from Slovenia (hop crop), one questionnaire from Spain for each crop (hop and grape vine), and 17 questionnaires from Morocco. In addition, one filled questionnaire from France (INRAE/IFV) (grape vine) and another from Lebanon were sent to us (table grape). No information was received on the treatment applied to WP3, as this treatment will be tested in vitro instead of in commercial farms.

On the other hand, after the information shared with our university colleagues, the research team consolidated the individual contributions into a focus group to improve the overall framework used in this initial SIF.

- *Round 4*

In this last stage, the theoretical framework was obtained and written thanks to all the literature review, the suggestions received from the project partners as well as from colleagues at our university and the general information about the pilot farmers. SIF was performed and checked in collaboration with HORTA who enriched it with her point of views, experience and knowledge, mainly in the sustainability environmental dimension. In addition, a composition of a set of indicators from economic, social, and environmental sustainability, identifying their characteristics also was established; this is allows us to undertake the evaluation stage of our SIF framework.

3.3. Measurement framework methodology

The measurement framework proposed in this Deliverable 1.2 (D.1.2.) is designed to be used for farmers interested in the implementation of different sustainable practices. Thus, their main objective is to guide agri-food actors to rebalance their sustainable practices and enhance its sustainability (economic, environmental and social) through bio-fertilizers, bio-pesticides and more resistance plants. These sustainable practices can be complemented with other agricultural innovations. In this deliverable not only the farmer is the focus, but also its surrounding ecosystem is taken into account in order to optimize all possible relationships and to enhance farmer's sustainable performance. Moreover, although this framework was developed for the pilot farmers included in the project, we create this SIF with the aim of capture other sustainable practices in the sector and help farmers to take sustainable decisions and oriented them in the process.

The measurement framework proposed was composed by four stages (definition, decision, implementation and evaluation [ex-post]) and one optional phase (evaluation [ex-ante]). In this project, we created this SIF following the methodology described above. As it has been stated before, this SIF was also complemented by a set of KPIs for economic, social, and environmental performance that will be described deeply in Chapter 4.

Although this study integrates the measurement framework within the SIF for the farmers that participate in SUSTEMICROP, the development of the measurement framework itself for external farmers – i.e., which KPIs should be included – should be reformulated by an expert specialized on the crop.

While the stages proposed in our SIF can be implemented immediately by other farmers outside the scope of the project, KPIs will require an adaptation as the development methodology should be different for farmers included in the project and others farmers. In particular, the first two stages of our SIF (definition and decision) are defined for pilot farmers because each of them knows the crop selected and the sustainable practices that will be implemented in their farms. However, those farmers beyond the scope of the current project that may be interested in using the SIF to evaluate their sustainable performance will have to define and decide the optimal sustainable practices for its crop and farm. The implementation stage will be very similar for pilot farmers and future pilot farmers. Nevertheless, the type of crop will be determinant to implement the KPIs developed in this project. Finally, for the evaluation stage farmers can follow the guidelines proposed in Chapter 5. However, these guidelines would need again to be restructured according to the crop in which the treatment or sustainable practices are applied to offer a good evaluation to the farmers.

The SIF development moves from a theoretical and conceptual SIF based on current literature and current understandings (i.e., the initial SIF presented in this deliverable) towards a consolidated and validated SIF for application outside of the SUSTEMICROP project. As such, the SIF development follows two stages: the initial SIF (current deliverable D1.2: SIF description and guidelines – M6) and the final consolidated SIF (deliverable D5.3: Report on the sustainability evaluation in the TCS – M36).

The initial SIF is based upon a literature review and integrates key aspects of existing framework into a comprehensive tool validated through a review process with experts. The initial SIF also includes guidelines to support the Pilot farmers in the adoption of the framework in Chapter 5. The final consolidated SIF is built upon the initial SIF and it integrates the results of the continuous co-creation process with the KPIs and provides a very practice-oriented approach. The evidence coming from the application of the SIF and the work performed in the other WPs (especially in WP5 and WP6) are the main resources to further improve and refine the initial SIF.

In WP5 a tool that allows farmers to evaluate their sustainable performance will be designed. In a first stage, we are planning to evaluate farmers included in the project but, in the future, the idea is also to provide a tool for whoever farmer interesting in measure its own sustainable performance. At the same time, in WP6 we present the pilot farmers that will be evaluated following this framework.

3.4. Relation to other activities in the project

The SIF described in this document represents the core approach of SUSTEMICROP and it comprehensively integrates the different tools and methodologies developed within the project. Therefore, the SIF development is very closely connected with most of the activities of the project providing inputs for the continuous refinement of the SIF. Figure 3.2 depicts the connection between the different activities grouped according to WPs.

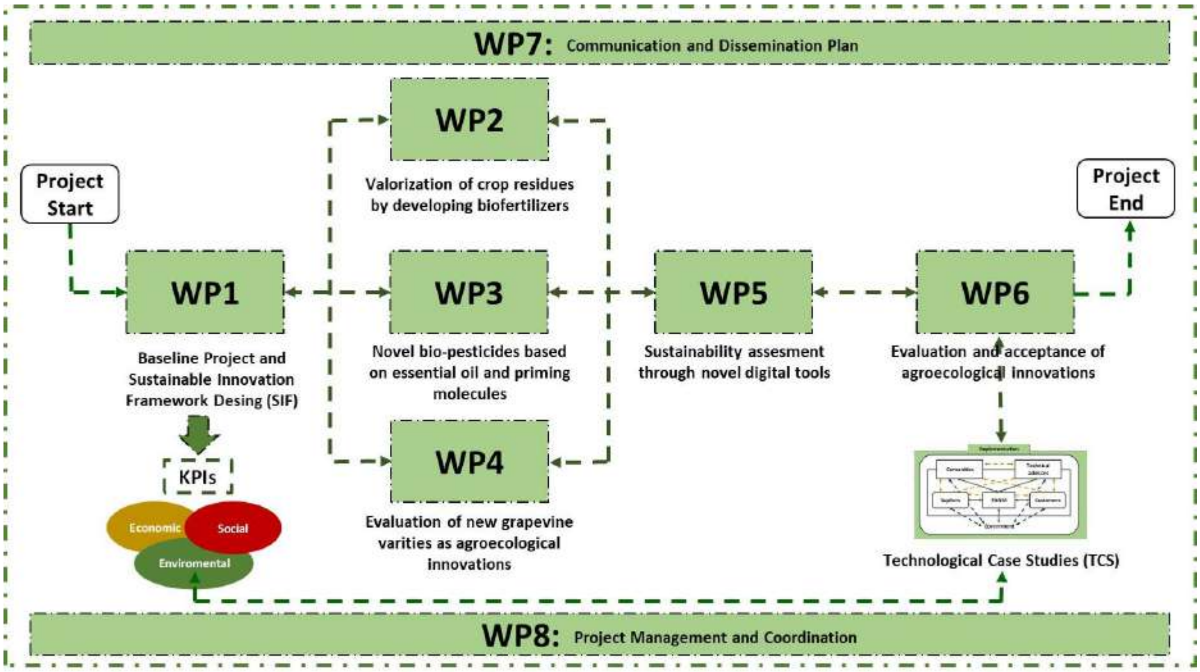

Figure 3.2. Connection between the SIF and other activities within the SUSTEMICROP project

The SIF development is performed in WP1 (Project Baseline and Sustainable Innovation Framework). Given the collaborative nature of the SIF development process, it means that a continuous coordination and alignment with the other WPs is and will be carried out. Coordination with HORTA (WP5 leaders) is especially important for the development of Tasks 1.2 (SIF Design) and Tasks 1.3 (Developing a KPI monitoring tool guideline).

Similarly, it is also important to highlight the coordination with other WPs. For example, great part of the information needed to build the initial SIF and their measurement tool – KPIs – (e.g., information regarding to the main farm's stakeholders, different phases of crops involved in the project, characteristics of the harvests, etc.), is obtained from the WP2 "Valorization of Crop Residues by Developing Biofertilizers", WP3 "Novel Bio-Pesticides Based on Essential Oil and Priming Molecules", and WP4 "Evaluation of New Grapevine Varieties as Agro-ecological Innovation".

As it was mentioned before, an intense coordination with the WP5 on Sustainability Assessment through Novel Digital Tools is also carried out. It is because this WP focuses on two main tasks: *1)* the operationalization of the KPIs (provided by WP1 through Tasks 1.2 and 1.3) by developing an online tool (Task 5.1), and *2)* the assessment on the sustainability of the project TCS (Task 5.2.)

There is also a close coordination with the WP on Evaluation and Acceptance of Agro-ecological Innovations (WP6), in which the economic, social and environmental sustainability assessment (KPIs set in WP1) of target crops and agro-ecological innovations from WP2, WP3, WP4 should be performed. This coordination task between WP1 and WP6 is carried out to ensure that the SIF effectively guides and supports the TCS.

Eventually, the suggested SIF is also promoted through the Communication and Dissemination Plan (WP7) that aims at maximizing the impact of results achieved through know-how transfer to a wider audience thus ensuring a broad adoption of the tool also beyond this project scope.

Finally, there is an obvious connection between the SIF and Project Management (WP8), which is in charge of providing the resources and managing the relevant issues (e.g. administrative, financial and legal management, scientific coordination and innovation management) needed to carry out the process successfully.

4. Key Performance Indicators (KPIs)

4.1. Concept

The measurement framework proposed in the current project consists of a set of KPIs for economic, social, and environmental performance. It is developed from the most widely used frameworks for assessing the sustainability performance (e.g., the SDGs and the GRI) with tailor-made adaption to encompass the specificities of each use case. As such, and it has been stated in the 3.1 section, the measurement framework helps both in understanding the problem as well as in evaluating sustainability practices along with the development and implementation stages.

From a conceptual point of view, a KPI is a metric, measuring how well an organization or an individual performs an operational, tactical or strategic activity that is critical for the current and future success of the organization (Kerzner, 2011). Similarly, according to the KPI Institute (2022), a KPI is a measurable expression for the achievement of a desired level of results in an area relevant to the evaluated entity's activity. It is a quantifiable measure of performance over time for a specific objective, providing targets for teams to shoot for, milestones to gauge progress, and insights that help people across the organization make better decisions. In this sense, the use of KPIs allows stakeholders to measure the progress towards a stated goal (Kerzner, 2011).

As it is stated in Dominguez et al. (2019), KPIs can be used with several purposes that can be classified in two groups taking into account whether their aim is to evaluate the performance (past or present –Pintzos et a., 2012) of a monitored system, or to predict the future behavior of a system. It must be noted that these two purposes are not exclusive, so that the same KPIs can be used for evaluation and prediction. Specifically, in the context of the current project, the use of KPIs is a method that may help to monitor the impact of farm activity in terms of sustainability (economic, social and environmental). By using KPIs, every farm owner will be aware of its positive impact on the environment or society as a whole and the damage it may cause. As a result, in the agricultural sector, KPIs may help increase productivity and profitability, help manage daily operations, contribute to informed business decisions and to improve the relationships with its stakeholders (The KPI Institute, 2022).

When analyzing KPIs, it is necessary to consider the different perspectives under which performance measures are proposed, the reasons or rationale why an indicator has to be defined must be exposed, and, finally, the scope should be taken into account in each case.

Regarding performance measurement perspectives, there is a variety of existing approaches. Among others and according to Looy & Shafagatova (2016), four criteria used for perspective definition can be mentioned: domain, focus, target groups and organizational level. The domain criterion is related with the strategic context in which performance measures are positioned (Neely et al., 1995). An example of the second criterion (focus) can be the differentiation between drivers and outcomes. The third criterion is the target group, differentiating among shareholders and top management, costumer, supplier, society, environment and employees.

The fourth criterion is the organizational level in which the KPI is defined. For example, this criterion is used by Estampe et al. (2013) differentiating three perspectives: strategic, tactical or operational.

The rationale of a KPI is the description of the reasons why it is necessary to define the performance measure (Livieri et al., 2014). As far as scope is concerned, it can be understood in two different senses. A priori, it is possible to consider the definition of generic KPIs (i.e., transversal to different contexts) although it is common that they are usually defined to be used in more specific ways. On the other hand, the scope of the KPIs can also be focused only on specific areas of KPIs application (Dominguez et al., 2019).

In addition, in order to define and develop a specific KPI, there are different features that can be considered. These properties range from basic characteristics, to calculation aspects, through related human resources and relationship aspects among KPIs. Next, a general overview of these general KPI characteristics is described.

The diversity of KPI definition proposals is manifested in the few properties that can be considered *basic characteristics*, present in many approaches, such as the KPI identifier, its name, and its textual description provided in the natural language. The *features* that have to do with *calculation* are, in practice, the most important because they are the ones that really provide the indicator with its intrinsic nature. The following features can be considered (Dominguez et al., 2019):

- Hardness. The hardness of a KPI is related to its subjective or objective nature. As described in Popova & Sharpanskykh (2010), an indicator is soft whether it is not directly measurable, qualitative, e.g. customer's satisfaction, and it is hard whether it is measurable, quantitative, e.g., number of customers.

- Calculation rule. It refers to the specific formula that gives rise to the calculation (Schutz & Schrefl, 2014).

- Value type. Especially in KPIs of quantitative type, it is necessary to specify the type of data in which the KPI is expressed (integer, double, date time, etc.) (Castellanos et al., 2005), together with the unit of measure (percentage, units of weight, length, currency, etc.)

- Filter. In many cases a KPI may be accompanied by one or more conditions that play the role of filter (Diamantini et al., 2014). For example, if a KPI can be calculated following a time-line, the KPI could be filtered so that its values are obtained only for a fragment of that time-line.

- Target. Since the use of a KPI is ultimately linked to the achievement of a particular business goal, the relationship of a KPI with an associated target value is also present in many approaches (Popova & Sharpanskykh 2010; Stefanovic, 2014). This value can be presented in an absolute form or in a range form, even with the specification of a deviation range or threshold (Friedenstab et al., 2012; Pintzos et al., 2012). As stated in works such as Popova & Sharpanskykh (2010), when a KPI runs out of a value range, actions to be carried out can be specified.

- Status options. The range of values of a KPI can be divided into several intervals, so that each interval represents a status with a particular meaning (for example, in Letrache et al. (2016) three statuses are differentiated –good, acceptable and bad– represented by means of traffic lights).

- Source. The source of a KPI refers to the entities, their relationships, and data and properties that are required to compute a KPI (Mattes et al., 2012). This information can be stored in databases, repositories, files, and other sources.
- Computation. The computation of a KPI refers to the way in which it is calculated.
- Measured aspects. KPIs can also be categorized according to the concrete aspect being measured. It is often possible to indicate at this level whether it is an indicator that measures duration, frequency, fulfillment of a certain condition, object's property, resource, cost, quality, etc. (Friedenstab et al., 2012; Korherr & List, 2006).

Another aspect to take into account is that when developed KPIs, there are different people, roles or even departments within an organization involved in their development (*related human resources*). For example, the owner can be considered, that is, a stakeholder in the enterprise responsible for the achievement of a defined KPIs (Mattens et al., 2012); the responsible person, referring the one who is in charge of the indicator being calculated (Del Rio-Ortega et al., 2013); and the informed person, that is, who is interested in the KPI and should be informed of its results (Del Rio-Ortega et al., 2013). Finally, it is necessary to state that dependencies between KPIs (*relationships*) can be explicitly specified representing, for example, the components used in the computation formula (Diamantini et al., 2014). This kind of relationships among components can lead to basic KPIs, compound or derived KPIs (such as the sum or the ratio of two existing indicators) or aggregated KPIs (for example, the average of other indicators).

4.2. Methodology to build the KPIs

According to the aim of this deliverable, that is, to design a SIF to evaluate SUSTEMICROP practices and innovations applied in the key Mediterranean crops (hop, date palm, grape vine, and table vine) and their context, with aggregated indicators, KPIs belonging to the economic, social and environmental domains have been analyzed and, more specifically, those that may be more justified according to above general aim. Regarding people involved in the development of KPIs, three researchers from ULE took part in the design and development of them, in collaboration with researchers from HORTA. In addition, as it was mentioned in section 3.2, the information and feedback from other project partners were also useful in the initial stage of the design.

The following paragraphs present the methodology behind the development of the measurement framework, i.e. which KPIs should be included in the third stage of the SIF developed in order to assess the farm sustainable performance. For that, two steps are followed: *1)* Building an exhaustive set of KPIs, and *2)* Construct a summarized, structured and complete set of KPIs with detail information of each of them.

In the first step, the aim is to obtain an exhaustive overview of possible KPIs to measure sustainable performance. To do so, we critically analyzed academic and practice literature as well as internationally recognized standards and assessments focused on measuring economic, social and environmental performance. Although in this initial search we did not limit ourselves to the agricultural context, specific literature in this context took priority. Economic indicators include proxies for the organization's impact on resources mainly at the shareholder level. Social indicators deal with labour practices, human rights and broader social issues affecting a broad range of stakeholders.

Environmental indicators deal with the measurement of an organization's impact on the environment via its products and services and its activities (Hřebíček et al., 2012).

To do so, we relied upon Google Scholar, Scopus academic database as well as Science Direct where we entered keywords such as "sustainability indicators", "sustainability assessment", "sustainable performance", "economic indicators", "social indicators", "environmental indicators", "sustainable KPIs", "economic KPIs", "social KPIs", "environmental KPIs", in combination with "agricultural sector", "agriculture", and "farming". The keywords included several variations of original keywords, for example singular and plural variations, synonyms, and combinations of keywords; searches in different languages like English, Spanish and Italian were carried out. This literature searches generated articles which provided useful information about how to measure sustainable performance in the agricultural sector. Moreover, websites of leading organizations in sustainability (e.g., GRI), sustainability in the food sector (e.g., FAO) or specific PhD thesis in the field like Sanchez Fernández (2009) were also checked. This search derives in a total of 70 documents.

Each of these documents was checked in detail in order to identify different ways of measure economic, social and environmental agricultural sustainability. Thus, we first grouped the KPIs under the three sustainability domains of the TBL: economic, social and environmental KPIs. It is necessary to mention that although there might be overlap between KPI and the domain to each belongs, the KPIs are grouped under the most direct impact. In addition, in those cases when similar indicators were shown in more than one paper we grouped them together. As a result, we derived a set of 326 potentially relevant and sustainable KPIs (125 economic indicators, 162 social indicators and 39 environmental indicators).

In the second step, we tried to structure the 326 KPIs into a condensed but complete set of KPIs following a three-step approach. Starting from the three sustainability domains, we then coded the themes of the KPIs to obtain further structure. As the majority of economic and environmental indicators may only have the farm itself and/or the shareholders/owner as targets, in this type of indicators the theme was considered as a first reference level of analysis. In what concerns to social indicators, stakeholders-related issues were considered, that is, in a first level several stakeholders (both internal and external) who the farm may have a relationship with were identified and then themes for each of them were coded. The literature reviewed showed that several stakeholders may be affected by the farm social commitment and practices, and for this reason social indicators were grouped in this double level (stakeholders and theme). It is also necessary to mention that in economic and social KPIs some filters were applied as some indicators were considered so general or difficult to apply to our context, keeping also those more frequently employed in previous literature. As for environmental indicators, the selection builds up on the work carried out by HORTA in the previous EU-funded projects PURE and INNOVINE. In that context, a set of 20 sustainability indicators concerning vineyard management practices were developed, with the final purpose of assessing impacts of the grape production. The indicator system was developed based on the relevant literature, which was retrieved through a systematic literature review. Methods retrieved in the literature were analyzed and selected based on the scientific relevance and their previous use in different contexts, and they were adapted to be calculated for each vineyard as a component of the Decision Support System for sustainable viticulture; simplicity and need of few, easily to determine inputs were relevant criteria for the indicator selection.

To complement this first set of indicators, European guidelines for monitoring the environmental impact of activities were reviewed, and indicators derived from the Product Environmental Footprint (PEF) guide were added to the initial set (Manfredi et al., 2012). Thus, we ended with 33 economic KPIs, 64 social KPIs, and 39 environmental KPIs (a total of 136 KPIs).

To increase the internal validity of the condensed and structured set of KPIs, some of the phases were carried out in pairs and another researcher was on charge of checking the work done and solved doubts and inconsistencies. Anyway, inconsistencies between the researchers were discussed until consensus was reached. Finally, we derived a hierarchical structure (i.e., the KPIs tree) which is consistent with some notable frameworks adopted for the measurement of different types of performance dimensions (e.g., SCOR framework by the Supply Chain Council) and it is coherent with the structure of several sustainable performance frameworks (e.g., SLCA and SAFA).

For each KPI its *basic characteristics* were described (identifier, name, and its textual description). Regarding *calculation features*, in general terms, the scheme presented in section 4.1 was followed. In this sense, both hard and soft variables have been proposed as in some cases the indicator has a qualitative nature (e.g., the assessment if the inter-generational continuation of farming activity is ensured, or if a farm helps to improve its community in terms of education, working conditions, quality of life), while in other cases it is a measurable and quantitative variable (e.g, farm total sales revenue or the total number of employees). In addition, the kind of data in which the KPI is expressed and its unit of measure are provided (e.g., local currency for economic variables, tonnes for mass production, percentage, a five point Likert Scale for the most subjective and qualitative measures, etc.). Specific formula that gives rise to the calculation is also showed when it is needed. In some cases, there is a relationship or dependency between some KPIs or the items used to build each of them. The target value or recommendation is also presented. As it has been stated in section 3.3, the computation itself of each indicator will be carried out using the novel digital tools that will be developed in WP5 thanks to the information that is going to be collected from the pilot farmers involved in the project.

4.3. Description of the KPIs

A comprehensive list of indicators was derived from the initial analysis of the existing frameworks. To structure the KPIs, we grouped the KPIs under themes. As for the ***economic domain***, the set of KPIs belongs to six themes based on the issues categories proposed by Warhust (2002) and Zahn et al. (2008):

- *competitiveness* which is the capability of a firm to sustainably fulfill its double purpose, i.e., meeting customer requirements at profit (four indicators, e.g., the share of market against competitors, the total production obtained, or the geographical distribution of sales);
- *economic independence* which refers to those indicators that measure the capability of the farmers to economically sustain their business over time (six indicators, e.g., farm level of liquidity, solvency, or leverage, as well as the subsidy dependence);
- *financial and economic performance* (10 indicators, e.g., economic results, profitability, or costs);
- *innovation* (one indicator related to research and development expenses, that is the input in the innovation process);
- *investments* (two indicators, related to gross fixed capital formation and farm net investment) and;

- *resource utilization* (10 indicators related to productivity –economic performance that compares the amount of goods and services produced (output) with the amount of inputs used to produce those goods and services– or efficiency –how well a farm can transform things like materials, labour and capital into services and products that produce revenue–).

Under the ***social domain***, different themes cover the effect on different stakeholders, which are the main actors impacted by the activities carried out by the farmers. Social themes therefore include aspects connected to eight stakeholders (farm itself, owner, employees, suppliers, customers, associations, local community and environment). Then, we identified themes (as a whole, 18 different themes were identified in this type of indicators). In particular, the number of indicators and themes considered in each stakeholder are shown in Table 4.1.

Table 4.1. General overview of Social KPIs

Stakeholder	Number of KPIs	Themes or Issues
Farm itself	3	Survival, networks, resilience
Owner	10	Support, education and training, autonomy, management, motivation, satisfaction, wage and income level
Employees	23	Career, diversity, labour, satisfaction, education and training, wage and income level
Supplies	5	Diversity, autonomy, budget, network, responsible practices
Customers	6	Food, networks
Associations	4	Networks
Local community	10	Networks, labour, social commitment
Environment	3	Environmental commitment

For example, ‘Education and Training’ includes the percentage of the owner/employee’s hours spent on improving his/her training. ‘Networks’ refer to the stability of the relationship between the farmer and his/her suppliers, the intensity of the relationship between consumer and producer or to the number of professional organizations in which the farmer is involved, among others. ‘Satisfaction’ is another theme that expresses farmer’s satisfaction level with his/her financial situation or his/her physical and psychological wellbeing as well as employee’s satisfaction with the quality of working conditions or his/her training. Social themes include also aspects connected to ‘labour’ category or theme like, for example, labour conditions in terms of workload, health, risk, safety and security at work or employee’s freedom to negotiate as individuals or groups. The farm job creation in terms of local employments is also considered. ‘Environmental commitment’ measures the farm’s level of commitment to avoid pollution at local level, to circular economy, or to the quality of landscape elements. Food category presents issues related to customer’s topics like the existence of responsible buyers of the farm or their assessment of the product quality. Finally, other social themes covered farm survival, resilience, the owner’s/suppliers autonomy and management, or the owner and employee’s wage and income levels.

It is also worth mentioning that in this domain a possible gender bias is taking into account considering that women seem to be more ethical and committed with corporate social responsibility and sustainability (Bear et al., 2010; Cabeza-García et al., 2018; Post et al., 2011) and their traditional participation in agriculture activities (Sign, 2014). Specifically, the number of female employees in the farm, gender-based wage differentials, and the involvement of women in decision-making processes about agricultural activities, are taken into account when defined the KPIs.

Finally, in the ***environmental domain*** we consider the main environmental aspects affected by agricultural practices. By means of environmental indicators, it is possible to better understand the complex issues in the field of agriculture and environment, to show developments over time, and to provide quantitative information. This kind of indicators can also be the tools to analyze productive systems' sustainability, as they allow the comparison of the effects of the crop management on the environment and on human health. Different aspects can be investigated with agro-ecological indicators, starting from the nutrients management, fossil energy use, pesticides and fertilizers use, organic matter use, pollutants emissions in the natural environment, crop rotation, arriving to biodiversity and landscape assessment. The following themes have been identified as more relevant:

- Human Health compartment: three indicators are available, evaluating the impact of farming activities on human health
- Air compartment: two indicators related to emissions in air are considered.
- Soil compartment: five indicators are available, aiming to evaluate the impact of farm on soil.
- Biodiversity compartment: two indicators evaluating the impact of farming on biodiversity are considered.
- Energy compartment: three indicators are available, evaluating the use of fuel and waste production during crop operations.
- Water compartment: five indicators are available to evaluate the impact of farming activities on water.
- Product Environmental Footprint (PEF): 19 indicators are available, aiming to thoroughly evaluate the impact of the production phases.

This kind of indicators can help to transform physical and monetary data about human activities and the state of the environment into decision supporting information, allowing the selection of more sustainable practices to be implemented in the field.

Figure 4.1 shows the 'hierarchical structure of the KPIs measurement framework', including the organization in three main levels in the hierarchy.

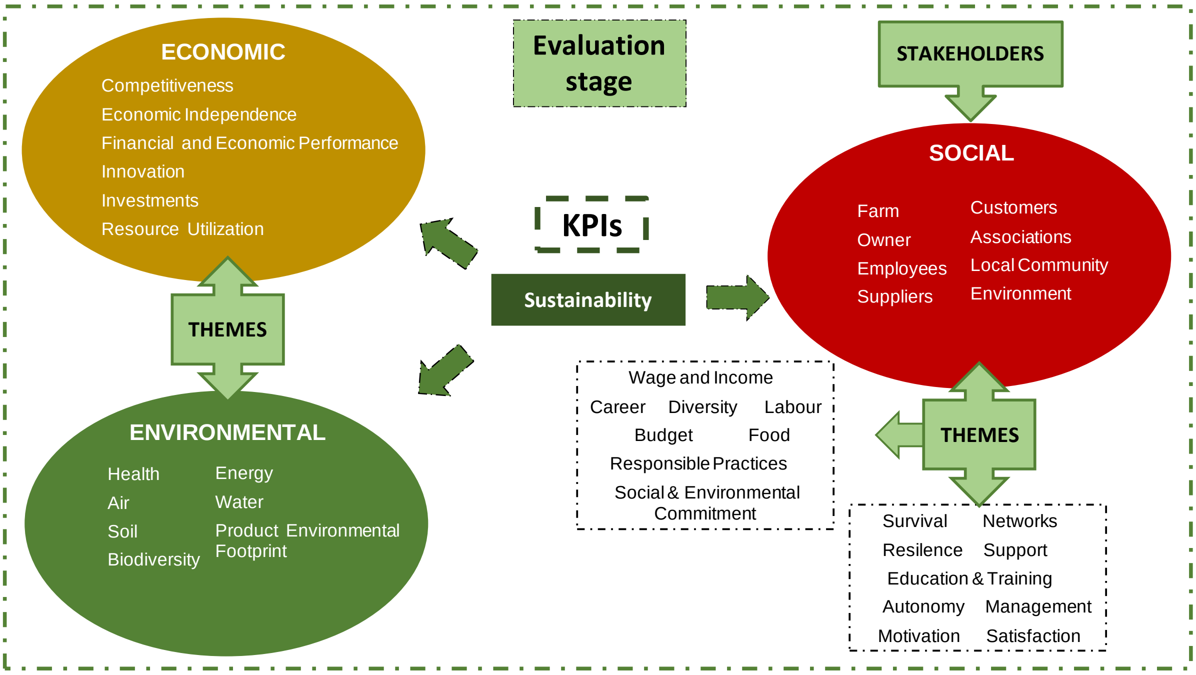

Figure 4.1. Measurement framework

In summary, Table 4.2, Table 4.3 and Table 4.4 list the KPIs belonging to each domain and theme are presented. It is enriched with the individual bibliographic sources from which we derived the metrics and the description of the KPIs. In some cases, the bibliographic references for metrics and description were refined according to the specific nature of our context where we kept in mind the goal to maintain a good balance between exhaustiveness and effort required for the measurability. The full set of economics, social and environmental KPIs including their metrics, unit of measurement and interpretation can be found in Appendix 1, 2 and 3, respectively.

Table 4.2. Summary of economic indicators

ID	Domain	Theme	KPI	References
EC-1	Economic	Competitiveness	Market Activity	Adapted from Wrzaszcz & Zegar (2014)
EC-2	Economic	Competitiveness	Market Share	Singh et al. (2019); Wohlenerg et al. (2022)
EC-3	Economic	Competitiveness	Total Production	Paternoster (2011); Simon (1989); Zhen & Routray (2003)
EC-4	Economic	Competitiveness	Weight Yield of Crop	Agency of Partnership for Progress (2010); BOCYL (2022); DOUE (2006); Rasmussen et al. (2017); United States Department of Agriculture (1955)
EC-5	Economic	Economic Independence	Farm Diversification I	Dantsis et al. (2010); Gómez-Limón & (2009); Wohlenerg et al. (2022); Zhen & Routray (2003)
EC-6	Economic	Economic Independence	Farm Diversification II	Dos-Santos & Diz (2019); Rogelj et al. (2020); Sánchez Fernández (2009); Valkó et al. (2017); Wohlenberg et al. (2022)
EC-7	Economic	Economic Independence	Debt to Equity	Nurmet (2011); Zawadzka et al. (2021)
EC-8	Economic	Economic Independence	Liquidity	Business at Speed (2022)
EC-9	Economic	Economic Independence	Solvency	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)
EC-10	Economic	Economic Independence	Subsidy Dependency	Sadok et al. (2009); Valkó et al. (2017)
EC-11	Economic	Financial and Economic Performance	Production Cost	Pellegrini et al. (2017); Tsolakis et al. (2018)
EC-12	Economic	Financial and Economic Performance	Production Cost per Hectare	INSPIA (2022); Zhen & Routray (2003)
EC-13	Economic	Financial and Economic Performance	Income (Price)	Santiago-Brown et al. (2015); Smith & McDonald (1998); Wohlenerg et al. (2022); Zhen & Routray (2003)
EC-14	Economic	Financial and Economic Performance	Market Indicator	Santiago-Brown et al. (2015); Sarkar et al. (2021)
EC-15	Economic	Financial and Economic Performance	Profitability I	Sánchez Fernández (2009); Santiago-Brown et al. (2015); Wohlenerg et al. (2022); Zhen & Routray (2003)
EC-16	Economic	Financial and Economic Performance	Profitability II	Sadok et al. (2009); Wohlenerg et al. (2022)
EC-17	Economic	Financial and Economic Performance	Economic Results I	Castoldi & Bechinni (2010); Vivas et al. (2019)
EC-18	Economic	Financial and Economic Performance	Economic Results II	Business at Speed (2022); Gómez-Limón & Riesgo (2009); Paternoster (2011)

ID	Domain	Theme	KPI	References
EC-19	Economic	Financial and Economic Performance	Economic Results III	Brandt & Geeson (2015); INSPIA (2022); Roy & Chan (2012); Smith & McDonald (1998); Talukder et al. (2020); Van Calker et al. (2004); Wohlenerg et al. (20222); Zhen & Routray (2003)
EC-20	Economic	Financial and Economic Performance	Economic Results IV	Castoldi & Bechinni (2010); Talukder et al. (2020)
EC-21	Economic	Innovation	R&D Investment	Adapted from Valkó et al. (2017)
EC-22	Economic	Investments	Investment in Farms I	Gerdessen & Pascucci (2013)
EC-23	Economic	Investments	Investment in Farms II	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)
EC-24	Economic	Resource Utilization	Productivity (Labour)	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); INSPIA (2022); Sridhara et al. (2022); Valkó et al. (2017); Wrzaszcz & Zegar (2014)
EC-25	Economic	Resource Utilization	Productivity (Land)	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); Garrido et al. (2011); Rogelj et al. (2020); Sridhara et al. (2022); Wrzaszcz & Zegar (2014)
EC-26	Economic	Resource Utilization	Plant Lifespan	Santiago-Brown et al. (2015)
EC-27	Economic	Resource Utilization	Resource Efficiency (Energy)	Garrido et al. (2011)
EC-28	Economic	Resource Utilization	Resource Efficiency (Labour)	Adapted from Latruffe et al. (2016) and Valkó et al. (2017)
EC-29	Economic	Resource Utilization	Resource Efficiency (Land) I	INSPIA (2022); Latruffe et al. (2016); Santiago-Brown et al. (2015); Sridhara et al. (2022);Talukder et al. (2020); Valkó et al. (2017)
EC-30	Economic	Resource Utilization	Resource Efficiency (Land) II	Valkó et al. (2017)
EC-31	Economic	Resource Utilization	Resource Efficiency (Operational)	Zahm et al. (2008)
EC-32	Economic	Resource Utilization	Resource Efficiency (Production)	Rasmussen et al. (2017)
EC-33	Economic	Resource Utilization	Resource Efficiency (Water)	Garrido et al. (2011)

Table 4.3. Summary of social indicators

ID	Domain	Stakeholder	Theme	KPI	References
S-1	Social	General (firm)	Survival	Farm Future	Reed & Courtney (2013); Röös et al. (2019); Van Cauwnbergh et al. (2007)
S-2	Social	General (firm)	Networks	Internal Networks	Röös et al. (2019)
S-3	Social	General (firm)	Resilience	Resilience	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)
S-4	Social	Owner	Support	Advice	Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021); Rasmussen et al. (2017); Talukder et al. (2020)
S-5	Social	Owner	Support	Cultural Level	Gerdessen & Pascucci (2013); Nambiar et al. (2001); Talukder et al. (2020); Van Cauwnbergh et al. (2007)
S-6	Social	Owner	Education and Training	Training I	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021); Talukder et al. (2020)
S-7	Social	Owner	Autonomy	Management (Enterprise - Autonomy)	Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021)
S-8	Social	Owner	Management	Management (Enterprise - Law)	Röös et al. (2019)
S-9	Social	Owner	Management	Management (Personal)	Diazabakana et al. (2014); Kelly et al. (2018); Kelly et al. (2021)
S-10	Social	Owner	Motivation	Motivation (Sustainability)	Fourriè et al. (2013); Kelly et al. (2021)
S-11	Social	Owner	Satisfaction	Satisfaction (Finance)	Röös et al. (2019)
S-12	Social	Owner	Satisfaction	Satisfaction (Quality of Life)	Brennan et al. (2018); Fourriè et al. (2013); Kelly et al. (2021); Röös et al. (2019)
S-13	Social	Owner	Wage and Income Level	Income Level I	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)
S-14	Social	Employees	Career	Capacity Development	Röös et al. (2019)
S-15	Social	Employees	Diversity	Diversity (Age)	Gerdessen & Pascucci (2013)
S-16	Social	Employees	Diversity	Diversity (Gender) I	Paternoster (2011)
S-17	Social	Employees	Diversity	Diversity (Gender) II	Talukder et al. (2020)
S-18	Social	Employees	Diversity	Diversity (Gender) III	Paternoster (2011); Talukder et al. (2020)
S-19	Social	Employees	Labour	Job (Health Risks) I	Fourriè et al. (2013); Kelly et al. (2021)
S-20	Social	Employees	Labour	Job (Health Risks) II	Fourriè et al. (2013); Kelly et al. (2021)
S-21	Social	Employees	Labour	Job Creation (Quality)	Fourriè et al. (2013); Gómez-Limón & Riesgo (2009); Kelly et al. (2021); Mazuela (2017); Paternoster (2011); Sánchez Fernández (2009); Zahm et al. (2008)

ID	Domain	Stakeholder	Theme	KPI	References
S-22	Social	Employees	Labour	Labour Rights (General)	Röös et al. (2019)
S-23	Social	Employees	Labour	Labour Rights (Diversity)	Röös et al. (2019)
S-24	Social	Employees	Labour	Labour Rights (Freedom)	Röös et al. (2019)
S-25	Social	Employees	Labour	Safety at Work I	Röös et al. (2019)
S-26	Social	Employees	Labour	Safety at Work II	Röös et al. (2019)
S-27	Social	Employees	Labour	Working Hours (General)	Fourriè et al. (2013); Kelly et al. (2021); Lebacq et al. (2013); Röös et al. (2019)
S-28	Social	Employees	Labour	Working Hours (Family members)	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); El-Osta & Ahearn (1996)
S-29	Social	Employees	Labour	Working Hours (Workload)	Dantsis et al. (2010); Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); Eurofound (2016); Fourriè et al. (2013); Gómez-Limón & Riesgo (2009); Kelly et al. (2021); Mazuela (2017); Röös et al. (2019); Sánchez Fernández (2009); Umstätter et al. (2022); Zahm et al. (2008); Wohlenberg et al. (2022)
S-30	Social	Employees	Satisfaction	Satisfaction (Decent Work)	Rasmussen et al. (2017); Wohlenberg et al. (2022)
S-31	Social	Employees	Satisfaction	Satisfaction (Quality of Working Conditions)	Aparisi (n.d.); Business at Speed (2022); Kelly et al. (2018); Röös et al. (2019)
S-32	Social	Employees	Satisfaction	Satisfaction (Training/ Knowledge)	Röös et al. (2019)
S-33	Social	Employees	Satisfaction	Satisfaction (Wellbeing)	Brown et al. (2021); Fourriè et al. (2013); Kelly et al. (2021); Santiago-Brown et al. (2015)
S-34	Social	Employees	Education and Training	Training II	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021); Röös et al. (2019); Talukder et al. (2020); Wohlenberg et al. (2022)
S-35	Social	Employees	Wage and Income Level	Wage I	Röös et al. (2019); Zahm et al. (2008)
S-36	Social	Employees	Wage and Income Level	Income Level II	Fourriè et al. (2013); Kelly et al. (2021)
S-37	Social	Suppliers	Diversity	Diversity of Seed Variants	Röös et al. (2019); Talukder et al. (2020)
S-38	Social	Suppliers	Autonomy	Local Supplies (Autonomy)	Röös et al. (2019)
S-39	Social	Suppliers	Budget	Local Supplies (Budget Spent)	GRI Standards (2016)
S-40	Social	Suppliers	Networks	Supply Networks	Adapted from Al Shamsi et al. (2018) and Wohleneg et al. (2022)
S-41	Social	Suppliers	Responsible Practices	Responsible Suppliers	GRI Standards (2016); Röös et al. (2019); Wohlenberg et al. (2022)
S-42	Social	Customers	Food	Food (0 km)	Röös et al. (2019)
S-43	Social	Customers	Food	Food (Fair trade)	Röös et al. (2019)
S-44	Social	Customers	Food	Food (Label)	Ingrassia et al. (2017)

ID	Domain	Stakeholder	Theme	KPI	References
S-45	Social	Customers	Food	Food (Quality)	Agency of Partnership for Progress (2010); Aramyan et al. (2006); Santiago-Brown et al. (2015); United States Department of Agriculture (1955); Wohlenerg et al. (2022)
S-46	Social	Customers	Networks	Agricultural Networks I	Brennan et al. (2018); Ecolabel Index (2022); Kelly et al. (2021); Röös et al. (2019); Roy & Chan (2012); Saifia & Drake (2008)
S-47	Social	Customers	Networks	Customers Networks	Brennan et al. (2018); Ecolabel Index (2022); Kelly et al. (2021); Röös et al. (2019); Roy & Chan, (2012); Saifia & Drake (2008)
S-48	Social	Associations	Networks	Agricultural Networks II	Diazabakana et al. (2014); Fourriè et al. (2013); Galdeano-Gómez et al. (2017); Kelly et al. (2021)
S-49	Social	Associations	Networks	General Organization Networks	Diazabakana et al. (2014); Fourriè et al. 2013; Kelly et al. (2021); Lebacq et al. (20213)
S-50	Social	Associations	Networks	Professional Networks	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)
S-51	Social	Associations	Networks	Research Networks	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)
S-52	Social	Local Community	Networks	Community Relationships	Santiago-Brown et al. (2015)
S-53	Social	Local Community	Labour	Job Creation (General)	Paternoster (2011); Röös et al. (2019)
S-54	Social	Local Community	Labour	Job Creation (Local Workers)	Fourriè et al. (2013); Kelly et al. (2021); Diazabakana et al. (2014)
S-55	Social	Local Community	Labour	Job Creation (Seasonal Workers)	Röös et al. (2019)
S-56	Social	Local Community	Social Commitment	Community Social Indicators	Brennan et al. (2018); Kelly et al. (2021)
S-57	Social	Local Community	Social Commitment	Community Tradition Respect	Röös et al. (2019)
S-58	Social	Local Community	Social Commitment	Local Participation (Formal)	Kelly et al. (2018); Kelly et al. (2021); Reed & Courtney (2013); Wohlenberg et al. (2022); Zahm et al. (2008)
S-59	Social	Local Community	Social Commitment	Local Participation (Inormal)	Aparisi (n.d.); Diazabakana et al. (2014); Kelly et al. (2018); Kelly et al. (2021); Röös et al. (2019); Wohlenberg et al. (2022)
S-60	Social	Local Community	Social Commitment	Public Health	Röös et al. (2019)
S-61	Social	Local Community	Social Commitment	Sustainable Law	Rasmussen et al. (2017)
S-62	Social	Environment	Environmental Commitment	Circular Economy	Kelly et al. (2021); Röös et al. (2019); Zahm et al. (2008)
S-63	Social	Environment	Environmental Commitment	Quality of Landscape	Kelly et al. (2021); Röös et al. (2019); van Cauwenbergh et al. (2007); Zahm et al. (2008)
S-64	Social	Environment	Environmental Commitment	Risks	Ramirez et al. (2008); Reglamento 396 (2005)

Table 4.4. Summary of environmental indicators

ID	Domain	Theme	KPI	References
EN-1	Environmental	Health	Human Tox Score	Adam-Blondon et al. (2017)
EN-2	Environmental	Health	Dose Area Index	Adam-Blondon et al. (2017)
EN-3	Environmental	Health	Treatment Frequency Index	Adam-Blondon et al. (2017)
EN-4	Environmental	Air	Carbon Footprint	Adam-Blondon et al. (2017)
EN-5	Environmental	Air	Carbon Sequestration	Adam-Blondon et al. (2017)
EN-6	Environmental	Soil	Ecological Footprint	Adam-Blondon et al. (2017)
EN-7	Environmental	Soil	Organic Matter	Adam-Blondon et al. (2017)
EN-8	Environmental	Soil	Soil Coverage	Adam-Blondon et al. (2017)
EN-9	Environmental	Soil	Erosion	Adam-Blondon et al. (2017)
EN-10	Environmental	Soil	Soil Compaction	Adam-Blondon et al. (2017)
EN-11	Environmental	Biodiversity	Biodiversity (Land Use-Based)	Adam-Blondon et al. (2017)
EN-12	Environmental	Biodiversity	Eco Tox Score	Adam-Blondon et al. (2017)
EN-13	Environmental	Energy	Fuel Use	Adam-Blondon et al. (2017)
EN-14	Environmental	Energy	Renewable Fuel	Adam-Blondon et al. (2017)
EN-15	Environmental	Energy	Waste	Adam-Blondon et al. (2017)
EN-16	Environmental	Water	Water Footprint	Adam-Blondon et al. (2017)
EN-17	Environmental	Water	Water Supply	Adam-Blondon et al. (2017)
EN-18	Environmental	Water	Water Use Technical Efficiency	Adam-Blondon et al. (2017)
EN-19	Environmental	Water	Acidification I	Adam-Blondon et al. (2017)
EN-20	Environmental	Water	Eutrophication	Adam-Blondon et al. (2017)
EN-21	Environmental	PEF	Climate Change	Manfredi et al. (2012)
EN-22	Environmental	PEF	Climate Change, Fossil	Manfredi et al. (2012)
EN-23	Environmental	PEF	Climate Change, Biogenic	Manfredi et al. (2012)
EN-24	Environmental	PEF	Climate Change, Land Use and Transformation	Manfredi et al. (2012)
EN-25	Environmental	PEF	Ozone Depletion	Manfredi et al. (2012)
EN-26	Environmental	PEF	Human Toxicity, Non-Cancer Effects	Manfredi et al. (2012)
EN-27	Environmental	PEF	Human Toxicity, Cancer Effects	Manfredi et al. (2012)
EN-28	Environmental	PEF	Respiratory Inorganics	Manfredi et al. (2012)
EN-29	Environmental	PEF	Ionizing Radiation HH	Manfredi et al. (2012)
EN-30	Environmental	PEF	Photochemical Ozone Formation	Manfredi et al. (2012)
EN-31	Environmental	PEF	Acidification II	Manfredi et al. (2012)
EN-32	Environmental	PEF	Terrestrial Eutrophication	Manfredi et al. (2012)
EN-33	Environmental	PEF	Freshwater Eutrophication	Manfredi et al. (2012)
EN-34	Environmental	PEF	Marine Eutrophication	Manfredi et al. (2012)
EN-35	Environmental	PEF	Freshwater Ecotoxicity	Manfredi et al. (2012)
EN-36	Environmental	PEF	Land Use	Manfredi et al. (2012)
EN-37	Environmental	PEF	Water Scarcity	Manfredi et al. (2012)
EN-38	Environmental	PEF	Resource Use, Energy Carriers	Manfredi et al. (2012)
EN-39	Environmental	PEF	Resource Use, Mineral and Metals	Manfredi et al. (2012)

Note: PEF denotes Product Environmental Footprint

5. Sustainable Innovation Framework (SIF) Guideline

Figure 5.1 describes the sustainable innovation framework (SIF) presented in Chapters 3 and 4. Although this SIF will be initially implemented in the three crops analyzed in the SUSTEMICROP project, as it has been stated before, in the future it can be also implemented in other crops and farms.

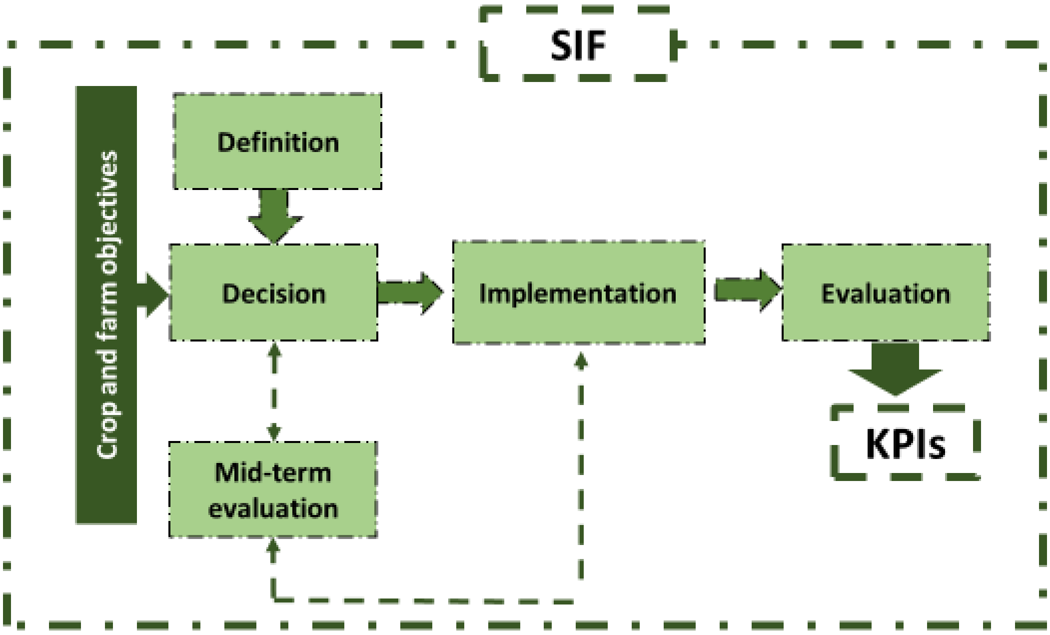

Figure 5.1. SIF stages

The SIF is composed of four main stages: definition, decision, implementation and evaluation. To implement sustainable practices into the firm it is necessary to consider previously a definition of all the sustainable practices that can be applied. From all of them, the firm would select those practices that are better aligned with farm objectives and those most relevant for the crop of the farm. In the implementation stage, two main elements should be considered. First, the firm and its internal stakeholders, that is, the family or owner of the farm, the manager/s, and the workers should be considered. In this phase, the firm should take into account its sustainability priorities (economic, social and environmental) into its decisions. Secondly, in this stage it is necessary to analyze the farm ecosystem, i.e. the relationships between the farm and their internal and external stakeholders. The relationships with the external stakeholder like suppliers and their customers are traditionally addressed in previous literature and explained in Chapter 3. Local communities and technical advisors are equally relevant for the farm but their relationship with other external stakeholders are limited because in most of the cases are unidirectional. In addition, in this implementation stage the role of government is important to carry out or not the implementation of these sustainable practices and because of its influence on other stakeholders. Finally, the KPIs allow the firm to evaluate their performance obtained through the sustainable practices implemented.

This evaluation considers the TBL perspective and measures the awareness of the farm with itself as well as with the rest of the agents from the ecosystem.

5.1. KPI Interpretation

Appendix 1, 2 and 3 show the KPI to provide guidelines to farmers directly involved or not in the project. In these charts, a specific section describes the interpretation of each indicator or at least a recommendation of the best values. However, as we previously mentioned, we provide several economic, social and environmental indicators that measured similar themes from different perspectives. To capture a valid value of each theme and to avoid biased results, we have proposed different indicators that can be interpreted jointly. Next, we will describe how to interpret each theme.

Appendix 1 shows the economic indicators. Each economic KPIs contain the theme, description, metrics, interpretation and references. It can serve as a guideline for farmers and readers to use them.

Competitiveness: In this economic theme, we consider several proxies for the market activity, market share, total production, and the quality of the crop. The underlying justification is to assess the position of the farm in the market, its international outreach and if the farm offers high quality products. Overall, the recommendation would be that the farm should sell high quality products that allow the firm to capture the national and international market.

Economic Independence: In this economic theme, we analyzed some indicators such as farm diversification, or financial ratios like liquidity, solvency, or subsidy dependency. They provide information about the financial situation of the farm and its dependence (or not) from external sources of funding. In addition, we have also included a farm diversification indicator to analyze the main sources of farm incomes. In the optimal situation, farmers should obtain the majority of their income from agriculture activities. We also recommended focusing on one specific crop to become an expert on it, but diversification in different crops reduces risk. So, this indicator is not mandatory. Moreover, the farm should not rely so much on subsidies and maintain a balance between internal and external finance.

Financial and Economic performance: In this economic theme, we analyze internal and external variables related with cost, prices and market values. All of them provide information about the profitability of the firm and the economic results of the farm. Although we consider mainly accountability indicators, farm reputation is also measured through market value and price. Overall, the recommendation would be that farms have lower production and general costs and higher income. In addition, it would be very positive for its financial situation to achieve a high market value and price because it would mean that the firm has good quality products and the people's opinion about the firm is positive.

Innovation: In this economic theme, we analyze the capacity of the firm to explore new options in terms of new products, new processes, new organization methods, new assets, new research networks, etc. More specifically, we selected the firm investment on R&D and their investment in assets to improve processes, and the human capital investment. In the optimal situation, farms should invest large amounts (and be efficient with these investments) in order to be at the forefront of new production methods, new machinery, new seeds, and to have agile, dynamic, and flexible human capital.

Resource utilization: This economic theme is one of the most relevant to measure the economic situation of the farm. It combines two main groups of indicators that cover all the economic indicators mentioned previously, productivity, and efficiency.

Firstly, we try to capture the economic productivity of the farm in terms of land, labour, and crop. Secondly, we evaluate the capacity of the firm to produce more using fewer resources. Water, energy, labour, land, and assets are the resources considered to evaluate farm efficiency. Overall, the recommendation would be that farms should have greater values of productivity, which would mean that the farm is making many profits. At the same time, the farm should be efficient with its resources applied, not only because of the sustainable aspects but also because it means that the process of the farm is the right one.

Appendix 2 provides a guideline for farmers about the social indicators. In this case, the theme is related to the stakeholder or target group. We will explain below each them:

General (firm): In this social theme, we analyze the future of the farm, its internal networks and its resilience. In particular, in this theme we want to know whether the farm is likely to exist in the future, that is, if an inter-generational continuation of farming activity is ensured. We also evaluate their internal networks, the collective work performed, the pooling of equipment and services in the farm and their networking activities. Finally, due to the complexity of the agricultural sector and the influence of macroeconomic policies because of the globalization of the sector, we consider the resilience of the firm analyzing aspects like the capacity of the farm to overcome experiences of loss of production or a threshold of loss that is considered significant. Our recommendation for the company is that be able to train one member of the family in order to have an heir that allows thus the continuation for the farm's activity. This will allow them to continue working for the area and to develop the planned sustainable policies. It is also important to strengthen group work within the company, to create solid networks that will allow the company to move forward stronger and safer. This will increase the farm's resilience in a sector so exposed to global changes.

Owner: This is a social theme that focuses on the person who manages the farm or at least has the property. Several indicators are included in this theme that address personal characteristics of the owner like its education and cultural level, its autonomy to take decisions, its level of personal wellbeing, and its level of satisfaction. We also include in this items other objective indicators like the total number of hours used for training, if the owner complies with legal standards, if the owner established connections and he/she reported taking suggestions and/or advices from agricultural extension workers, NGO, bank, advisory, extension professionals, input suppliers, and the finally its wage received. Our recommendation is similarly to employees' owners should be satisfied with their salary, personal life and working conditions. A high cultural or educational level is recommended for owners, and participation in training courses is also important. In addition, owners should receive advice from technical agents and should take decisions jointly with other agents.

Employees: This in an internal stakeholder. The more than 20 indicators that have been included to evaluate the relationships between the firm and employees, evidence the relevance of this group for the farm. Social aspects such as their capacity development in the farm, the diversity of employees and the social practices that support this diversity in terms of gender or age are included in this theme. Due to the fact that in the farm, and more specifically in this project, we are using pesticides and fertilizers, we want to analyze the health risks and safety for employees and how they can be reduced through using bio pesticides and bio fertilizers. In this sense, we include some indicators about the legal relationship between both agents and the capacity of the farm to create new high quality jobs.

Moreover, as we previously mentioned, employees satisfied with their working conditions, the training courses received, and generally, with higher levels of personal wellbeing (standard of living, personal health, personal relationships, happiness, community connectedness, etc.) produce more and help farms to achieve their goals quickly. Finally, we also evaluate the training received, the total work performed, and the wage and income received in order to capture if the farm provides employees the enough knowledge to develop their work, if there is a workload and the salary conditions in comparison with regional standards. Overall, our recommendation for the farm is to guarantee safety and health of employees through sustainable practices that do not damage their health, and provide them with enough knowledge to develop their work without any problems. It will be advisable for farms to hire a diversity of workers, paying them at least the same salary as the mean of the region, and avoid workload and other illegal practices.

Suppliers: In this stakeholder, we want to explore the relationships of the farm with its suppliers. Firstly, we include an indicator that captures the access to inputs such as local seeds and breeds and traditional variants, but we are also interested in evaluating how autonomous are the farmers to choose for example the supplier of its fertilizers or seeds. Similar to customers, it is important to buy and sell products in a short trade. In this case it is advisable to buy products from local suppliers. Sometimes, having closing suppliers is important for the stability of the relationships between both partners and often these suppliers can visit the farm to advise farmers about the specific products to their needs for the crop. Finally, for sustainable farms it is important to recognize and support primary producers and suppliers' rights to freedom of association, to collective bargaining, and other social aspects. In this line, our recommendation is to increase transactions with sustainable suppliers, to buy products to local suppliers, and to strengthen these relationships that serve as a means to reinforce sustainable practices in the farm.

Customers: In this stakeholder, we include several indicators that capture the relationships between the farm and its direct or indirect customers. More specifically, we include some indicators that analyze the long or short trade of food products from the farm to the customer. We also consider if customers are paying attention to fair trade practices and they are responsible buyers or not. To have a good and strong relationship with responsible buyers, it is important to provide them information about the food and the process through clear and complete labels and to inform about the certifications got. Finally, it is very important for farms to provide food and products with high quality standards. Our recommendation for the farm is that they should comply with food quality standards and try to obtain sustainable certifications that demonstrate their awareness of customer health. Moreover, in terms of nutrition it is quite relevant for customers to buy products directly from the farms or at least with the least intermediates possible.

Associations: In this stakeholder, we consider several proxies of the relationship established between the farm and NGO, technical, and civil associations. In particular, we measured the network established between these agents and how positive or negative the relationships are between them. As it can be seen in Appendix 2, there are some non-profit associations related with voluntarism or donations and others focused on research and technical aspects. In some cases, there is a bidirectional relationship and in some others there is a unidirectional relationship. Both types provide social benefits for the farm and for the associations. Good and strong relationships with NGO, voluntarism and civic associations contribute to increasing firm reputation.

In addition, farms should have and strengthen contact with technical associations and research centers because it allows introducing in the farm new developments and at the same time reinforcing the idea of group and their pressure with suppliers, governments and civil society. It is a 'cheap method' to be informed about new techniques, new seeds, etc.

Local community: In this social theme, we include some indicators that capture the relationships between the farm and the local agents in which the farm is located. More specifically, we consider if the farm has good neighbors or happy neighbors, if the number of incidents/complaints of local agents with the farm per year are low, and if the farm avoids pollution of the local community. We also analyze how firms contribute to increase educational levels and to improve working conditions of the local community. In this theme, we evaluate if the farm recognizes and respects the rights of indigenous communities upheld though fair contracts. Moreover, we measure the work created for the farm and the type of work created and if the farm is involved in formal and informal governments and civic organizations.

Our recommendation for the firm is to reinforce their networks with formal and informal institutions through its participation as a member of local/regional/national government or being actively connected with the local community/environment through its participation in local festivals, local farmers' markets, local farming fairs, local nature conservation or local competitions. Farms should hire local people and strengthen their networks with local agents subsidizing sporting events, school competitions, agricultural training, etc.

Environment: In this social theme, we want to explore the awareness of the firm with their local environment. Although there are some similarities with the environmental KPI in this theme, we only include three indicators that connect social and environmental indicators. These indicators are related with the awareness of the firm to implement circular economy practices, the commitment with the landscape elements, e.g. hedges and trees, including the maintenance of old buildings and the architectural quality of new buildings to maintain rural heritage and the toxicity risk associated with management practices.

Appendix 3 provides a guideline for farmers about environmental indicators, which are grouped in seven main areas, which were identified as the relevant ones for sustainability.

Air: In this environmental theme, we want to explore the impact of field activities have on the air compartment. The indicators belonging to this group are related to the measurement of the amount of greenhouse gases emitted in connection to human activities, and the estimation of the amount of carbon sequestered by plant tissues during the growing season. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to choose among the available cropping techniques, the one which are less impacting on the air compartment, and to choose efficient crops, which allow for an increased carbon sequestration.

Biodiversity: In this environmental theme, we want to explore the impact of the field activities on biodiversity. The indicators belonging to this group evaluate the farm's biodiversity, on the base of the different types of land use, and assessing the chemical ecosystem hazard score. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to increase the biodiversity in the farm, and to choose Plant Protection Product taking also into consideration risk phrases and toxicity classes indicated on the label.

Energy: In this environmental theme, we want to explore the use of energy in the field activities. The indicators belonging to this group consider the amount of fuel used for the mechanized operations carried out in the field, the use of fuel from renewable sources, and the farm's waste management. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to choose cultivation techniques that reduce the amount of fuel used, to increase the use of energy from renewable sources, and to improve the management of all kind of wastes generated during farm activities.

Human Health: In this environmental theme, we want to explore the impact of field activities have on the human health of people working in the field. The indicators belonging to this group evaluate the chemical's hazard to humans, the exposure of individuals to chemical products and the surface treated with pesticides. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to choose Plant Protection Product taking also into consideration risk phrases and toxicity classes indicated on the label, and to minimize the number of treatments to the necessary ones.

Soil: In this environmental theme, we want to explore the impact of field activities have on the soil compartment. The indicators belonging to this group estimate the risk of soil compaction; the loss of soil due to water-caused erosion; the duration of soil coverage; the percentage of organic matter contained in the soil; evaluate land surface necessary to provide the resources. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to choose among the available cultivation techniques, the ones that lead to a lower impact on soil or promote its health.

Water: In this environmental theme, we want to explore the impact of field activities have on the water compartment. The indicators belonging to this group assesses the water footprint; evaluates the types irrigation system and water used for crop irrigation; the emissions of compounds causing acid rains and the effect of excess of nutrients on water ecosystems. The recommendation for the farmer to decrease the environmental impact of the cultivation phase is to choose among the available cultivation techniques, the ones that lead to a lower impact on water.

Product Environmental Footprint: In this environmental theme, we want to assess in a multi-criteria perspective the environmental performance of agricultural activities, throughout the life cycle. A PEF Guide was developed by the Joint Research Centre of European Commission, providing a method for environmental assessments, and it is publicly available. The indicators assess the global warming potential; the ozone depletion potential; the impact on human health and ecosystem; the effect on freshwater and marine; impact on soil quality; and it evaluates resource depletion. The recommendation for the farmer to decrease the environmental impact of the cultivation phase, is to choose among the available cultivation techniques, the ones that lead to a lower impact on environment.

5.2. Implementation guidelines for the Sustainable Innovation Pilots

In the previous subsection, the SIF that can be implemented in the farms is described. Although this framework is developed to be implemented in three different crops (grapevine, hop, date palm), the idea is that other farms not directly involved in SUSTEMICROP would be able also to implement this framework. The different stages go from the very preliminary understanding of the problems and challenges to be addressed in the farm to the evaluation of the sustainable practices implemented. This framework takes into account the different contexts in which the sustainable practices are developed. The next subsections describe the guidelines for the pilots on how to use the SIF.

5.2.1. Establishing the starting point

As it was previously mentioned in Chapter 3, the starting point of the SIF was established in July, 2022. However, we had some pilot farmers interested in using these sustainable practices (biopesticides and biofertilizers) in their farms before SUSTEMICROP was formally started. Thus, the contact with these farmers started a few months before July, 2022. In order to obtain conclusions that would be valid for other crops and context, we expanded our sample to different farmers from the same crops but from different regions. This stage took three months, from July to October, 2022. In the stage of '*Define*' we explored new crops and farmers to apply the treatment. This stage was related to the '*Decision*' stage to decide the most relevant sustainable practice for each farm. Both of them were developed during these initial months. Moreover, although this SIF has been elaborated for these pilot cases, the framework is available for other farmers interested in including sustainable practices in the future or for those firms that want to evaluate their sustainable performance nowadays. The third stage of the SIF, however, represents a fundamental tool to analyze the farm ecosystem, thanks to its non-linear and iterative processes between the farm and its internal and external stakeholders. This stage was the longest phase of the framework because of its complexity and it varies widely between one farm and another. Finally, it is necessary to remark that before starting to apply the SIF, it is highly recommended to assess the starting point of each farm through KPIs, paving the way for a more thorough analysis and evaluation in the different stages of the sustainable process.

5.2.2. Using the SIF and its tools

In this Deliverable 1.2, a SIF that will be applied to different farms is described. However, as it was commented in Chapter 3, the tool itself will be developed in WP5 of the Project. In this stage of the project, the farmers that will implement the sustainable practices have been chosen and we explain the SIF to them. ULE and HORTA had organized some meetings with experts, farmers, managers, farm workers, and other farmers' stakeholders in order to guide the pilot farmers in the process. Some of these meetings have been in group and other has been bilateral meetings. During these six initial months, we have had monthly group meetings with experts, and at least one bilateral meeting with each farmer (owner, manager, or both) was organized. The aim of these initial meetings was to create a consolidate SIF, a useful framework for all the crops and countries analyzed in the current project. After this initial stage, we will develop with HORTA (leader of WP5) a digital tool which allows farmers to evaluate their sustainable performance. As we proposed in the project, we will evaluate their sustainable performance through KPI (described in Chapter 4) in three different moments: at the beginning of the project, in the middle of the project and at the end of the project. We will organize bilateral meetings with all of them to guide pilot farmers in the assessment or at least to explain the use of the online tool.

We proposed in Chapter 4 to assess firm sustainable performance through 33 economic indicators, 64 social indicators and 39 environmental indicators. Besides, for environmental indicators information about the crop operations carried out in the cropping season in field is also needed. To collect information about these economic and environmental indicators we can ask directly to the owner or farmer. However, in the case of social indicators, it would be also highly recommended to contact with farm' stakeholders to be completely objective and have information from different points of view. For each phase of the SIF, the use of the applicable tools (after WP5) will be explained by the experts of the relevant WP during farmers meetings, dedicated expert meetings and, if needed, ad-hoc meetings.

5.2.3. Using the measurement framework

To reach a balanced, complete and sustainable oriented framework, 136 indicators that cover most of the economic, social and environmental actions of the farm has been developed. However, it is necessary to remark that it is not mandatory to achieve a minimum score in each of the indicators. In addition, for many of these indicators only recommendations can be made, as it will depend on other factors. Detailed descriptions of the KPIs can be found in the appendixes. In this first stage of the project, we selected those KPI to perform the baseline assessment of each crop. In WP5, a digital tool that allows farmers to evaluate their sustainable performance will be designed. In this tool the indicators will be adapted to each crop and country characteristics. Regarding to the definition, decision and implementation stages for the pilot farmers, the partners involved in WP2, WP3, WP4 and WP6 advise pilot farmers on the most appropriate sustainable techniques for their crops, helping them to make decisions on which of these techniques to apply. Finally, between WP1 and WP6 will advise farmers on the implementation of these techniques and guide them in their relationship with stakeholders.

Those farmers not directly involved in the project can consider the sustainable practices suggested in this project, and they should analyse other sustainable practices in the market in the case of their own crops. Then, as we suggested in our SIF, they can organize meetings with experts and technical advisors to evaluate the most relevant practices for each crop and farm. Then to address the implementation part, farmers can open their management practices and work together with other stakeholders. Finally, to evaluate their sustainable performance, they can use the digital tool that will develop in WP5.

6. Conclusions

This deliverable presents the initial SIF and how it was developed. We provide a SIF made up by four main stages (definition, decision, implementation and evaluation), which together with a set of tools (economic, social, and environmental KPIs, and practical guidelines), guides farmers along the implementation process of sustainable practices. The SIF takes into account several key drives that might influence the adoption of sustainable practices such as the institutional context, farmers' objectives, farms' main stakeholders and their relationships with them, as well as the farmers' resources and capabilities.

The SIF presented in this deliverable plays an important role in the SUSTEMICROP project and great effort has to be done in order to develop it. Despite this initial SIF is still in an early development stage itself, it shapes up to be a promising useful tool for guiding farmers in the development of sustainable practices. It provides farmers technical support throughout four stages considering the main factors that might influence this kind of processes while allows them to choose the type of sustainable practice more aligned with their objectives.

The SIF is provided with a measurement tool (KPIs) and guidelines, which can be adapted according the type of crop, that allow farmers to perform an assessment of their activity from a threefold perspective. It means that farmers can focus on their main concern (be economically autonomous and competitive) while they can reach social and environmental objectives imposed by legislation, society, customers, etc.

Based on the lesson learnt in the TCS in which the SIF is intended to be applied (WP6) and based on the knowledge developed in other WPs, the SIF will be continuously updated throughout the course of the project.

This SIF can be considered a starting point to guide farmers along the process of implementing sustainable practices. However, at the end of the 'SUSTEMICROP project' the SIF will be empirically validated and consolidated in order to support the replication of sustainable practices also in different contexts different from those addressed in this project (i.e., countries, types of crops, etc.).

Similarly, the measurement framework will be further developed. For example, a more detailed time horizon of the KPIs and how to measure them will be developed based on different contexts.

In conclusion, this deliverable provides the SUSTEMICROP project with an initial SIF which will be further improved in the remainder of the project.

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8. Appendix

Appendix 1: Economic indicators detailed description

EC-1	**Market Activity**
Domain	Economic
Theme	Competitiveness
Description	It measures the geographical distribution of sales as percentage of the farm total sales
Metrics	[National market sales; International market sales; Own consumption]
Unit of measurement	[%] (Sales are measured in local currency)
Interpretation	n.a.
References	Adapted from Wrzaszcz & Zegar (2014)

EC-2	**Market Share**
Domain	Economic
Theme	Competitiveness
Description	It measures a farm's sales revenue as percentage of the market total sales
Metrics	[Total sales revenue of the farm/Market's total sales revenue] * 100
Unit of measurement	[%] (Sales are measured in local currency)
Interpretation	Herfindahl-Hirschman (IHH) $IHH = \sum_{i=1}^{n} s_i^2$ Perfect competition IHH < 0.2 Monopolistic competition IHH = 0.2 Oligopoly 0.2 – IHH – 0.6 Monopoly IHH > 0.6
References	Singh et al. (2019); Wohlenerg et al. (2022)

EC-3	**Total Production**
Domain	Economic
Theme	Competitiveness
Description	It measures the farm total production
Metrics	[Total mass production in each crop per farmer]
Unit of measurement	(Mass production is measured in tonnes)
Interpretation	Higher values are recommended
References	Paternoster (2011); Simon (1989); Zhen & Routray (2003)

EC-4	**Weight Yield of Crop (Quality)**
Domain	Economic
Theme	Competitiveness
Description	It measures the proportion of production that is produced and sold according to certification schemes
Metrics	[Production that is produced and sold to various standards and certification schemes]
Unit of measurement	[%] (Production is measured in tones)

Interpretation

HOP

Characteristics	Description	Minimum quantity (% in weight)	
		Processed hop	Unprocessed hop
Humidity	Water content	12	14
Leaves and steams	Leaf parts of shoots, shoots, leaf or cone pendulums; cone pendulums are only considered as stems from 2.5 cm length onwards	6	6
Hop waste	Small particles resulting from machine harvesting, ranging in colour from dark green to black, not usually originating from the cone; the maximum levels indicated may include particles of hop varieties other than those to be certified, up to 2% by weight	3	4
In case of "hop without seeds", seeds	Cone fruits that have reached maturity	2	2

GRAPE VINE AND TABLE GRAPE

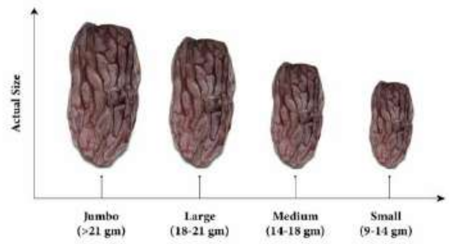
The grapes must be harvested as carefully as possible, using only healthy grapes with a minimum natural alcohol content of 19.1 degrees Brix (11 degrees Baumé) for red varieties and 17.9 degrees Brix (10.5 degrees Baumé) for white varieties for the production of protected wines, in each partial delivery or weighing on the scales. Failure to comply with this requirement is grounds for self-disqualification of the lot. The winegrower is obliged to inform (point c of the same section) if the grape is affected by hail, powdery mildew, mildew, grey rot, etc.

DATE PALM

Price:

QUALITY	VARIETY	PRICE		
		Wholesale/producer price ($ per kg)	Price in Wooden box ($ per kg)	Price in Cardboard Carton ($ per kg)
1st	Mejhoul	6.3	10.0	15.0
	Boufeggous	1.9	2.5-3.1	4.4-6.3
	Bouskri	1.5	1.9	3.0
	Aguellid	1.3	1.9	2.5
	Jiehl	1.3	1.9-2.5	3.1
2nd	Bourhar	1.3	1.9	2.5
	Raslahmar	1.0	1.5	1.9
	Bouserdoun	0.8	1.0	1.5
	Bouserdoun	0.6	1.0	1.5
3rd	Bousthammi	0.6	1.0	1.5
	Iklane	0.4	0.6	0.8
	Ahardane	0.4	0.6	0.8

Size (Medjool variety):



Visual characteristics (Meedjol variety): lack of visual defects, abnormality, skin puffiness, sunburn, insect damage, uniformity of colour and size, decay, fermentation, and mechanical damage.

Quality	Sizes	Skin
Premium Medjool	Small; medium; large; jumbo	0% loose skin separation (5% error margin)
Fancy Medjool	Small; medium; large, jumbo, super jumbo	Loose skin from one side (5% error margin)
Choice Medjool	Small; medium; large, jumbo, super jumbo	Loose skin on more than one side (5% error margin)

References	Agency of Partnership for Progress (2010); BOCYL (2022); DOUE (2006); Rasmussen et al. (2017); United States Department of Agriculture (1955)

EC-5	**Farm Diversification I**
Domain	Economic
Theme	Economic Independence
Description	Crop diversity: The number of different crops cultivated in each farm apart from the target crops
Metrics	[Number of crops cultivated in the farm apart from the target crop]
Unit of measurement	n.a.
Interpretation	n.a.
References	Dantsis et al. (2010); Gómez-Limón & Riesgo (2009); Wohlenerg et al. (2022); Zhen & Routray (2003)

EC-6	**Farm Diversification II**
Domain	Economic
Theme	Economic Independence
Description	Farm revenues from the other gainful activities to total revenue
Metrics	[Income from non-agricultural activities/Total income] * 100
Unit of measurement	[%] (Income is measured in local currency)
Interpretation	At least 20% of farm income should came from agricultural activities
References	Dos-Santos & Diz (2019); Rogelj et al. (2020); Sánchez Fernández (2009); Valkó et al. (2017); Wohlenberg et al. (2022)

EC-7	Debt to Equity
Domain	Economic
Theme	Economic Independence
Description	It measures the farmer's leverage level
Metrics	[External Finance/Equity] * 100
Unit of measurement	[%] (Debts and funds are measured in local currency)
Interpretation	A ratio above 2 could be alarming because of the high level of leverage. A ratio equal to 1 would tell us that the farm combines debt and equity in equal parts. A ratio below 0.4 means that the farm has a very conservative management and does not want to take risks with debt
References	Nurmet (2011); Zawadzka et al. (2021)

EC-8	Liquidity
Domain	Economic
Theme	Economic Independence
Description	Liquidity is the ability to convert assets into cash quickly and cheaply
Metrics	[Current assets/Current liabilities] * 100
Unit of measurement	[%] (Assets and liabilities are measured in local currency)
Interpretation	A good liquidity ratio should be greater than 1. This would indicate that the farm is able to cover its current liabilities with its current assets. If the ratio is less than 1, it means that the farm has too many current liabilities to cover with current assets alone, and may have to borrow additional funds
References	Business at Speed (2022)

EC-9	Solvency
Domain	Economic
Theme	Economic Independence
Description	Solvency relates to a farm's overall ability to pay debt obligations and continue business operations
Metrics	[Total assets/Total liabilities] *100
Unit of measurement	[%] (Assets and liabilities are measured in local currency)
Interpretation	A solvency ratio of less than 1 means that the farm is in technical bankruptcy. The ideal recommended value is 1.5
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)

EC-10	Subsidy Dependency
Domain	Economic
Theme	Economic Independence
Description	It measures the farm dependence of agricultural direct subsidies
Metrics	Agricultural direct subsidies: [Direct subsidies/Gross profit] * 100
Unit of measurement	[%] (Subsidies are measured in local currency)
Interpretation	Recommended to be lower than 1
References	Sadok et al. (2009); Valkó et al. (2017)

EC-11	Production Cost
Domain	Economic
Theme	Financial and Economic Performance
Description	It measures the total cost imputed to the production
Metrics	[Direct labour (including imputed labour costs) + Direct material (seeds, fertilizers, energy) + Overhead costs on manufacturing]
Unit of measurement	(Costs are measured in local currency)
Interpretation	Lower values are recommended
References	Pellegrini et al. (2017); Tsolakis et al. (2018)

EC-12	Production Cost per Hectare
Domain	Economic
Theme	Financial and Economic Performance
Description	It is the value of intermediate consumption or variable production costs related to agricultural activity include labour costs imputed per utilized agricultural area (UAA)
Metrics	[Production cost/Utilized agricultural area]
Unit of measurement	(Costs are measured in local currency)
Interpretation	Lower values are recommended
References	INSPIA (2022); Zhen & Routray (2003)

EC-13	Income (Price)
Domain	Economic
Theme	Financial and Economic Performance
Description	It measures the price oscillation in the market
Metrics	[Product price]
Unit of measurement	(Price is measured in local currency)
Interpretation	Higher values are recommended
References	Santiago-Brown et al. (2015); Smith & McDonald (1998); Wohlenerg et al. (2022); Zhen & Routray (2003)

EC-14	Market Indicator
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes a farm overall value
Metrics	[Market value estimation]
Unit of measurement	(Estimation of farm market value is expressed in local currency)
Interpretation	Higher values are recommended
References	Santiago-Brown et al. (2015); Sarkar et al. (2021)

EC-15	Profitability I
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes farm profitability in terms of return on assets (ROA) which indicates the effectiveness of the farm's management, i.e., the capacity of its assets to generate value
Metrics	[Operating profits/Total assets] *100
Unit of measurement	[%] (Operating profits and total assets are measured in local currency)
Interpretation	Higher values are recommended because few assets are required to archive a high profit
References	Sánchez Fernández (2009); Santiago-Brown et al. (2015); Wohlenerg et al. (2022); Zhen & Routray (2003)

EC-16	Profitability II
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes farm profitability as a percentage of sales revenue (ROS); this ratio helps businesses assess how efficiently a farm can convert revenue to operating profit
Metrics	[Sales revenue – Operational costs]/[Sales revenue] * 100
Unit of measurement	[%] (Sales revenue and operational cost are measured in local currency)
Interpretation	For most companies, a ROS between 5% and 10% is excellent. ROS above 0 means that business is heading into financial trouble; ROS below 0 means that farm is turning a profit
References	Sadok et al. (2009); Wohlenerg et al. (2022)

EC-17	Economic Results I
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes farm gross income, that is, the income associated with farm sales
Metrics	[Yield of harvested product multiplied by its price]
Unit of measurement	(It is measured in local currency)
Interpretation	Higher values are recommended
References	Castoldi & Bechinni (2010); Vivas et al. (2019)

EC-18	**Economic Results II**
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes farm earnings before interest, taxes depreciation and amortization, that is, it is a way to measure the impact of savings on operating costs
Metrics	Two alternatives proxies can be used: • EBITDA = Net Income + Taxes + Interest Expense + Depreciation & Amortization • EBITDA = Operating Income + Depreciation & Amortization
Unit of measurement	(EBITDA is measured in local currency)
Interpretation	Higher values are recommended
References	Business at Speed (2022); Gómez-Limón & Riesgo (2009); Paternoster (2011)

EC-19	**Economic Results III**
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes net farm income (net profit)
Metrics	[The gross output that occurred during a specified accounting period minus the expenses]
Unit of measurement	(It is expressed in local currency)
Interpretation	Higher values are recommended
References	Brandt & Geeson (2015); INSPIA (2022); Roy & Chan (2012); Smith & McDonald (1998); Talukder et al. (2020); Van Calker et al. (2004); Wohlenerg et al. (20222); Zhen & Routray (2003)

EC-20	**Economic Results IV**
Domain	Economic
Theme	Financial and Economic Performance
Description	It denotes farm gross margin (also called gross profit margin or gross margin ratio). It is a farm's sales minus its cost of goods sold (COGS), expressed as a percentage of sales. Put another way, gross margin is the percentage of a farm's revenue that it keeps after subtracting direct expenses such as labour and materials
Metrics	[Total farm sales – (Cost of goods sold)/Total farm sales] *100
Unit of measurement	[%] (Sales and cost are expresses in local currency)
Interpretation	Higher values are recommended
References	Castoldi & Bechinni (2010); Talukder et al. (2020)

EC-21	R&D Investment
Domain	Economic
Theme	Innovation
Description	It denotes farm investment in Research and Development (R&D), that is, it captures observable innovation inputs (resources and incentives used to finance innovation task)
Metrics	[R&D in agriculture/Net farm income] * 100
Unit of measurement	[%] (R&D and net farm income are expressed in local currency)
Interpretation	Higher values are recommended
References	Adapted from Valkó et al. (2017)

EC-22	Investment in Farms I
Domain	Economic
Theme	Investments
Description	It consists of resident producers' investments, deducting disposals, in fixed assets during a given period. It also includes certain additions to the value of non-produced assets realized by producers or institutional units. Property, plant, and equipment are standard fixed capital items
Metrics	[Gross fixed capital formation in agriculture] (per farm)
Unit of measurement	(It is expressed in local currency)
Interpretation	Higher values are recommended
References	Gerdessen & Pascucci (2013)

EC-23	Investment in Farms II
Domain	Economic
Theme	Investments
Description	It describes the farm net investment regarding to the total utilized agricultural area (UAA)
Metrics	[Total investment/Utilized agricultural area] * 100 (local currency)
Unit of measurement	[%] (Total investment and utilized agricultural area are expressed in local currency)
Interpretation	Higher values are recommended
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)

EC-24	**Productivity (Labour)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the farm gross added value obtained per annual work unit (AWU)
Metrics	[Farm gross added value/Annual work unit] * 100
Unit of measurement	[%] (Farm gross added value is measured in local currency)
Interpretation	Higher values are recommended
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); INSPIA (2022); Sridhara et al. (2022); Valkó et al. (2017); Wrzaszcz & Zegar (2014)

EC-25	**Productivity (Land)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the farm gross added value obtained per each utilized agricultural area (UAA)
Metrics	[Farm gross added value/Utilized agricultural area] * 100
Unit of measurement	[%] (Farm gross added value is measured in local currency)
Interpretation	Higher values are recommended
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); Garrido et al. (2011); Rogelj et al. (2020); Sridhara et al. (2022); Wrzaszcz & Zegar (2014)

EC-26	**Plant Lifespan**
Domain	Economic
Theme	Resource Utilization
Description	It measures the longevity of the plant
Metrics	[Number of years that are disease free, virus free, etc.]
Unit of measurement	[Number] (It is expressed in years)
Interpretation	Higher values are recommended
References	Santiago-Brown et al. (2015)

EC-27	**Resource Efficiency (Energy)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained per each energy unit consumed
Metrics	[Total mass crop production/Consumed energy in the production]
Unit of measurement	[Ratio] (Total mass crop production is measured in tonnes and consumed energy is measured in MJ)
Interpretation	Higher values are recommended
References	Garrido et al. (2011)

EC-28	**Resource Efficiency (Labour)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained per annual work unit (AWU)
Metrics	[Total mass production/Annual work unit]
Unit of measurement	[Ratio] (Total mass production is measured in tonnes)
Interpretation	Higher values are recommended
References	Adapted from Latruffe et al. (2016) and Valkó et al. (2017)

EC-29	**Resource Efficiency (Land) I**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained per each harvested area (i.e., utilized agricultural area [UAA])
Metrics	[Total mass production/Utilized agricultural area]
Unit of measurement	[Ratio] (Total mass production is measured in tonnes and utilized agricultural area is measured in ha)
Interpretation	Higher values are recommended
References	INSPIA (2022); Latruffe et al. (2016); Santiago-Brown et al. (2015); Sridhara et al. (2022);Talukder et al. (2020); Valkó et al. (2017)

EC-30	**Resource Efficiency (Land) II**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained per utilized total agricultural area
Metrics	[Total mass production/Total agricultural area]
Unit of measurement	[Ratio] (Total mass production is measured in tonnes and total agricultural area is measured in ha)
Interpretation	Higher values are recommended
References	Valkó et al. (2017)

EC-31	**Resource Efficiency (Operational)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained in relation to the amount operating expenses
Metrics	[Total mass production /Operating expenses]
Unit of measurement	[Ratio] (Production is measured in tonnes and operating expenses are measured in local currency)
Interpretation	Higher values are recommended
References	Zahm et al. (2008)

EC-32	**Resource Efficiency (Production)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the difference between the actual farm performance and its potential performance when optimal nutrients and pest control treatments are applied
Metrics	[Total mass production per utilized agricultural area (UAA) with the traditional production system/Total mass production per UAA with new treatment]
Unit of measurement	[Ratio] (Total mass production is measured in tonnes)
Interpretation	0 < ratio < 1
References	Rasmussen et al. (2017)

EC-33	**Resource Efficiency (Water)**
Domain	Economic
Theme	Resource Utilization
Description	It measures the amount of product obtained in relation to the amount of water used
Metrics	[Total mass crop production/Total water consumption] *100
Unit of measurement	[%] (Mass production is measured in tonnes and water consumption is measured in m3)
Interpretation	Higher values are recommended
References	Garrido et al. (2011)

Appendix 2: Social indicators detailed description

S-1	**Farm Future**
Domain	Social
Stakeholder	General (firm)
Theme	Survival
Description	It describes if inter-generational continuation of farming activity is ensured
Metrics	[Likehood that farm will exist in the future, according to farmers' point of view]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Existence); 0: No (Non-existence)
References	Reed & Courtney (2013); Röös et al. (2019); Van Cauwnbergh et al. (2007)

S-2	**Internal Networks**
Domain	Social
Stakeholder	General (firm)
Theme	Networks
Description	It describes the internal networks in the farm (collective work, pooling of equipment and services, networking, …)
Metrics	[Intensity of the internal networks]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-3	**Resilience**
Domain	Social
Stakeholder	General (firm)
Theme	Resilience
Description	It describes how the farm resilience is taking into account if it has experienced loss of production, the threshold of loss that is considered significant
Metrics	[Level of resilience of the farm]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)

S-4	**Advice**
Domain	Social
Stakeholders	Owner
Theme	Support
Description	It measures if a farmer takes into account suggestions and advices from external parties such as agricultural extension workers*, NGO, bank, advisory services, extension professionals, input suppliers, etc. **It is considered that an extension worker is an experienced farmer, selected and hired by the government to mentor and train local farmers, using their credibility as a farmer to approach their clients.*
Metrics	[Frequency of farmers taking into account suggestions and advices from external parties]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021); Rasmussen et al. (2017); Talukder et al. (2020)

S-5	**Cultural Level**
Domain	Social
Stakeholders	Owner
Theme	Education and Training
Description	It measures the farm owner's cultural level
Metrics	[1: Primary school or less; 2: Secondary school; 3: University studies or more]
Unit of measurement	[Ordinal scale (1-3)]
Interpretation	1: Worst; 3: Best
References	Gerdessen & Pascucci (2013); Nambiar et al. (2001); Talukder et al. (2020); Van Cauwnbergh et al. (2007)

S-6	**Training I**
Domain	Social
Stakeholders	Owner
Theme	Education and Training
Description	It measures the percentage of the owner's working hours spent on improving his or her training
Metrics	[Total number of training and education hours of the owner /Total number of hours the owner work] * 100
Unit of measurement	[%] (Hours)
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021); Talukder et al. (2020)

S-7	**Management (Enterprise - Autonomy)**
Domain	Social
Stakeholders	Owner
Theme	Autonomy
Description	It measures the farmer's autonomy degree in the decision-making process on issues such as farm's practices, product prices, etc.
Metrics	[Intensity of the farmer's decision-making capacity]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Fourriè et al. (2013); Kelly et al. (2018); Kelly et al. (2021)

S-8	**Management (Enterprise - Law)**
Domain	Social
Stakeholders	Owner
Theme	Management
Description	It measures if the farm complies with the decent work standards established in the relevant human rights conventions and agreements
Metrics	[Presence or absence of a minimum level of wellbeing at work as legislation and global standards states]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Presence); 0: No (Absence)
References	Röös et al. (2019)

S-9	**Management (Personal)**
Domain	Social
Stakeholders	Owner
Theme	Management
Description	It measures with whom the farm's owner/manager makes decisions
Metrics	[1: Sole; 2: Jointly with family members; 3: Jointly with the management board]
Unit of measurement	[Nominal scale (1-3)]
Interpretation	Options 2 and 3 are recommended
References	Diazabakana et al. (2014); Kelly et al. (2018); Kelly et al. (2021)

S-10	**Motivation (Sustainability)**
Domain	Social
Stakeholders	Owner
Theme	Motivation
Description	It measures the farmer´s motivation level to produce organically
Metrics	[Intensity of the farmer´s motivation to produce with organic processes]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Fourriè et al. (2013); Kelly et al. (2021)

S-11	**Satisfaction (Finance)**
Domain	Social
Stakeholders	Owner
Theme	Satisfaction
Description	It measures the farmer's satisfaction level with his/her financial situation
Metrics	[Intensity of the farmer's satisfaction with his/her financial situation]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-12	**Satisfaction (Quality of Life)**
Domain	Social
Stakeholders	Owner
Theme	Satisfaction
Description	It measures the level of the farmer's physical and psychological wellbeing
Metrics	[Intensity of the farmer's physical and psychological wellbeing]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Brennan et al. (2018); Fourriè et al. (2013); Kelly et al. (2021); Röös et al. (2019)

S-13	**Income Level I**
Domain	Social
Stakeholders	Owner
Theme	Wage and Income Level
Description	It measures the percentage of family farm income over total income
Metrics	[Family farm income/Total farm income] *100
Unit of measurement	[%] (Family farm income and total farm income are measured in local currency)
Interpretation	Around 25%
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019)

S-14	**Capacity Development**
Domain	Social
Stakeholder	Employees
Theme	Career
Description	It measures if farm employees have opportunities for capacity development, e.g. through attending training or conferences, or by discussing opportunities for advancement openly and fairly with management
Metrics	[Employees possibilities to capacity development]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-15	**Diversity (Age)**
Domain	Social
Stakeholder	Employees
Theme	Diversity
Description	It measures the intergenerational balance
Metrics	[Total farmers < 35 years/Total farmers ≥ 55 years]
Unit of measurement	[Ratio] (Farmers are expressed in number)
Interpretation	Higher values are recommended
References	Gerdessen & Pascucci (2013)

S-16	**Diversity (Gender) I**
Domain	Social
Stakeholder	Employees
Theme	Diversity
Description	It measures the female presence in the farm
Metrics	[Number of female employees/Total employees] *100
Unit of measurement	[%] (Employees are expressed in number)
Interpretation	Around 50%
References	Paternoster (2011)

S-17	**Diversity (Gender) II**
Domain	Social
Stakeholder	Employees
Theme	Diversity
Description	It measures the gender-based wage differentials
Metrics	[(30 – D) / 3] D: wage difference in percentage terms between men and women's labour
Unit of measurement	[%] (Income is measured in local currency)
Interpretation	30 is the percent differential as the poorest
References	Talukder et al. (2020)

S-18	**Diversity (Gender) III**
Domain	Social
Stakeholder	Employees
Theme	Diversity
Description	It measures the involvement of women in decision making about agricultural activities
Metrics	[Women involvement in decision making about agricultural activities/Total people involved in decision making] *100
Unit of measurement	[%] (Women and people are expressed in number)
Interpretation	Higher percentages are recommended
References	Paternoster (2011); Talukder et al. (2020)

S-19	**Job (Health Risks) I**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the risk of toxicity associated with pesticides for users
Metrics	[Total of pesticides of level 5/Total employees exposed]
Unit of measurement	[Ratio] (Pesticides are expressed in liters per year and employees in number)
Interpretation	Lower values are recommended
References	Fourriè et al. (2013); Kelly et al. (2021)

S-20	**Job (Health Risks) II**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the health risks for employees
Metrics	[Presence or absence of risky practices (excluding pesticides)]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Presence); 0: No (Absence)
References	Fourriè et al. (2013); Kelly et al. (2021)

S-21	**Job Creation (Quality)**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the quality of the job created based on the type of labour contract
Metrics	[Partial contracts/Total contracts] * 100
Unit of measurement	[%] (Labour contracts are measured in number)
Interpretation	n.a.
References	Fourriè et al. (2013); Gómez-Limón & Riesgo (2009); Kelly et al. (2021); Mazuela (2017); Paternoster (2011); Sánchez Fernández (2009); Zahm et al. (2008)

S-22	**Labour Rights (General)**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the labour rights of the farm. In particular, if there are written agreements with employees that meet at least national and international labour treaties including social security and that employees understand them
Metrics	[Existence or non-existence of written agreements with employees that meet at least national and international labour]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (existence); 0: No (nonexistence)
References	Röös et al. (2019)

S-23	**Labour Rights (Diversity)**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures employees' diversity. In particular, the occurrence of discrimination of groups or by sexual identity in hiring, job allocation, promotions and firing, are evaluated. In addition, the support to disabled, young, and aged workers within the farm operation is taken into account
Metrics	[In which degree the farm takes into account the following aspect regarding to their employees: No discrimination of groups or by sexual identity, job allocation, promotions and firing; support to disabled, young and aged workers]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-24	**Labour Rights (Freedom)**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures different aspects of employees' freedom
Metrics	Three items are considered jointly in this indicator: a. Employees' freedom to quit work or raise grievances without fear. b. Employees' freedom to negotiate as individuals or groups. c. Employees' freedom to be part of a union that represents them.
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-25	**Safety at Work I**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the health and security at work, considering aspects such as training, health coverage, as well as safe and clean workplace
Metrics	[Quality of the health and security at work]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-26	Safety at Work II
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the quality of reception and accommodation for temporary workers and trainees, safety of facilities and equipment
Metrics	[Quality of reception and accommodation for temporary workers]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-27	Working Hours (General)
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the number of working hours per each worker's category
Metrics	[Hours worked by each category of worker in a time interval/ Total hours that employees should work in a time interval (according to law)] *100
Unit of measurement	[%] (Time interval is measured in weeks)
Interpretation	Ratio equal to 1: ideal situation; Ratio below 1: the employee is working less than he/she should do; Ratio above 1: the employee is working more than he/she should do
References	Fourriè et al. (2013); Kelly et al. (2021); Lebacq et al. (2013); Röös et al. (2019)

S-28	Working Hours (Family members)
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the percentage of work done by family members over the total work performed
Metrics	[Hours worked by family members/Total hours worked (family members + hired labour)] * 100
Unit of measurement	[%] (Work is measured in hours)
Interpretation	n.a.
References	Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); El-Osta & Ahearn (1996)

S-29	**Working Hours (Workload)**
Domain	Social
Stakeholder	Employees
Theme	Labour
Description	It measures the work intensity by job category by considering the total annual hours worked
Metrics	[Total annual hours worked / Annual working unit (AWU)]
Unit of measurement	[Ratio] (Hours)
Interpretation	Approximately the number of annual hours is around 1,800 hours (minimum legal hours per year)
References	Dantsis et al. (2010); Dos Santos & Ahmad (2020); Dos-Santos & Diz (2019); Eurofound (2016); Fourriè et al. (2013); Gómez-Limón & Riesgo (2009); Kelly et al. (2021); Mazuela (2017); Röös et al. (2019); Sánchez Fernández (2009); Umstätter et al. (2022); Zahm et al. (2008); Wohlenberg et al. (2022)

S-30	**Satisfaction (Decent Work)**
Domain	Social
Stakeholder	Employees
Theme	Satisfaction
Description	It measures if the production process respect basic rights of employees
Metrics	[Farmers perceived that their legal rights (included in the contract) are recognized and protected]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Rasmussen et al. (2017); Wohlenberg et al. (2022)

S-31	**Satisfaction (Quality of Working Conditions)**
Domain	Social
Stakeholder	Employees
Theme	Satisfaction
Description	It measures the level of satisfaction of farm employees in terms of the quality of working conditions (number of holidays, weekend worked, among other issues)
Metrics	[Level of employees' satisfaction with their working conditions]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Aparisi (n.d.); Business at Speed (2022); Kelly et al. (2018); Röös et al. (2019)

S-32	**Satisfaction (Training/ Knowledge)**
Domain	Social
Stakeholder	Employees
Theme	Satisfaction
Description	It measures the level of satisfaction of farm employees in terms of the training and/or knowledge received
Metrics	[Level of employees' satisfaction with their initial and ongoing training]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-33	**Satisfaction (Wellbeing)**
Domain	Social
Stakeholder	Employees
Theme	Satisfaction
Description	It measures the level of overall wellbeing of farm employees considering the following items in this indicator: 1= Standard of living 2 = Personal health 3= Achieving in life 4= Personal relationships 5= Personal safety 6= Community connectedness 7= Future security 8= Work happiness
Metrics	[Level of overall wellbeing of farm employees in each item]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Brown et al. (2021); Fourriè et al. (2013); Kelly et al. (2021); Santiago-Brown et al. (2015)

S-34	**Training II**
Domain	Social
Stakeholder	Employees
Theme	Education and Training
Description	It measures employees' training in terms of the number of hours of training, that is, the sum of all estimated hours that the labour have used in order to attend a course
Metrics	[Total number of training and education hours for all employees/Total number of employees]
Unit of measurement	[Ratio] (Training and education are measured in hours and employees in number)
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021); Röös et al. (2019); Talukder et al. (2020); Wohlenberg et al. (2022)

S-35	**Wage I**
Domain	Social
Stakeholder	Employees
Theme	Wage and Income Level
Description	It measures the percentage variation of income of the lowest paid employees compared with the national legal minimum wage
Metrics	[(Hourly gross pay of the lowest paid worker - legal minimum wage)/Legal minimum wage] * 100
Unit of measurement	[%] (Wage is measured in local currency)
Interpretation	Positive values are recommended
References	Röös et al. (2019); Zahm et al. (2008)

S-36	**Income Level II**
Domain	Social
Stakeholder	Employees
Theme	Wage and Income Level
Description	It measures the farm income level regarding the total annual work (AWU)
Metrics	[Farm income per annual work unit]
Unit of measurement	[Ratio] (Farm income is measured in local currency)
Interpretation	Higher values are recommended
References	Fourriè et al. (2013); Kelly et al. (2021)

S-37	**Diversity of Seed Variants**
Domain	Social
Stakeholders	Suppliers
Theme	Diversity
Description	It measures how easy is get access to inputs such as local seeds and breeds and traditional variants
Metrics	[Accessibility to relevant inputs for the farmer (local seeds, etc.)]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019); Talukder et al. (2020)

S-38	**Local Supplies (Autonomy)**
Domain	Social
Stakeholders	Suppliers
Theme	Autonomy
Description	It measures how the autonomous the farmer is to choose the suppliers of local fertilizers, local seeds, etc.
Metrics	[Autonomy to choose local suppliers]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-39	**Local Supplies (Budget Spent)**
Domain	Social
Stakeholders	Suppliers
Theme	Budget
Description	It measures how much of the total budget is used to purchase from local suppliers
Metrics	[Procurement budget spent on local suppliers/Total supply budget] * 100
Unit of measurement	[%] (Budget is measured in local currency)
Interpretation	Higher percentages are recommended
References	GRI Standards (2016)

S-40	**Supply Networks**
Domain	Social
Stakeholders	Suppliers
Theme	Networks
Description	It measures the degree of stability of the relationship between the farmer and his/her suppliers
Metrics	[Stability of relations with suppliers]
Unit of measurement	[Ordinal scale (1-10)]
Interpretation	1: Low; 10: High
References	Adapted from Al Shamsi et al. (2018) and Wohlenerg et al. (2022)

S-41	Responsible Suppliers
Domain	Social
Stakeholders	Suppliers
Theme	Responsible Practices
Description	It measures the farmer´s recognition and support of primary producers’ and suppliers’ rights to freedom of association and to collective bargaining and other social aspects
Metrics	[Suppliers using social criteria/Total number of suppliers] * 100
Unit of measurement	[%] (Suppliers are measured in number)
Interpretation	Higher percentages are recommended
References	GRI Standards (2016); Röös et al. (2019); Wohlenberg et al. (2022)

S-42	Food (0 km)
Domain	Social
Stakeholder	Customers
Theme	Food
Description	It measures the short trade (local and direct sales)
Metrics	[Total short trade sales/Total sales] *100
Unit of measurement	[%] (Sales are measured in local currency)
Interpretation	Ratio close to a 1: ideal situation
References	Röös et al. (2019)

S-43	Food (Fair trade)
Domain	Social
Stakeholder	Customers
Theme	Food
Description	It measures the responsible buyers of the farm. More specifically, the following issues are considered to define a responsible buyer: Fair pricing, transparent contracts, primary producers’ rights to fair pricing, contracts or agreements
Metrics	Two metrics were considered to measure this indicator: a. [Number of responsible buyers/Total buyers] *100 b. [Total sales in fair trade products/Total sales revenues] *100
Unit of measurement	[%] (a. Buyers are expressed in number; b. Sales are measured in local currency)
Interpretation	Higher values are recommended
References	Röös et al. (2019)

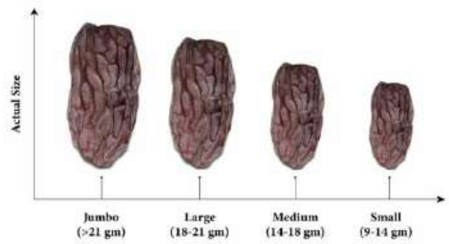
S-44	**Food (Label)**
Domain	Social
Stakeholder	Customers
Theme	Food
Description	Information on labels
Metrics	[Amount of information (number of additional characteristics) on the food label in addition to mandatory information]
Unit of measurement	[Number] (Additional information is measured in number)
Interpretation	Higher values are recommended
References	Ingrassia et al. (2017)

<table>
<tr><th>S-45</th><th>Food (Quality)</th></tr>
<tr><td>Domain</td><td>Social</td></tr>
<tr><td>Stakeholder</td><td>Customers</td></tr>
<tr><td>Theme</td><td>Food</td></tr>
<tr><td>Description</td><td>Quality of the final product: It measures the intrinsic (physical) attributes of the product, e.g., humidity, protein content, alcohol content, pesticide residues, tenderness, color etc. Different kind of attributes should be taken into account depending on the type of crop: hop, grape wine, table grape and date palm</td></tr>
<tr><td>Metrics</td><td>HOP
<table>
<tr><th rowspan="2">Characteristics</th><th rowspan="2">Description</th><th colspan="2">Minimum quantity (% in weight)</th></tr>
<tr><th>Processed hop</th><th>Unprocessed hop</th></tr>
<tr><td>Humidity</td><td>Water content</td><td>12</td><td>14</td></tr>
<tr><td>Leaves and steams</td><td>Leaf parts of shoots, shoots, leaf or cone pendulums; cone pendulums are only considered as stems from 2.5 cm length onwards</td><td>6</td><td>6</td></tr>
<tr><td>Hop waste</td><td>Small particles resulting from machine harvesting, ranging in colour from dark green to black, not usually originating from the cone; the maximum levels indicated may include particles of hop varieties other than those to be certified, up to 2% by weight</td><td>3</td><td>4</td></tr>
<tr><td>In case of "hop without seeds", seeds</td><td>Cone fruits that have reached maturity</td><td>2</td><td>2</td></tr>
</table>
GRAPE VINE AND TABLE GRAPE
The grapes must be harvested as carefully as possible, using only healthy grapes with a minimum natural alcohol content of 19.1 degrees Brix (11 degrees Baumé) for red varieties and 17.9 degrees Brix (10.5 degrees Baumé) for white varieties for the production of protected wines, in each partial delivery or weighing on the scales. Failure to comply with this requirement is grounds for self-disqualification of the lot. The winegrower is obliged to inform (point c of the same section) if the grape is affected by hail, powdery mildew, mildew, grey rot, etc.

DATE PALM
<u>Price</u>:</td></tr>
</table>

QUALITY	VARIETY	PRICE		
		Wholesale/producer price ($ per kg)	Price in Wooden box ($ per kg)	Price in Cardboard Carton ($ per kg)
1st	Mejhoul	6.3	10.0	15.0
	Boufeggous	1.9	2.5-3.1	4.4-6.3
	Bouskri	1.5	1.9	3.0
	Aguellid	1.3	1.9	2.5
	Jiehl	1.3	1.9-2.5	3.1
2nd	Bourhar	1.3	1.9	2.5
	Raslahmar	1.0	1.5	1.9
	Bouserdoun	0.8	1.0	1.5
	Bouserdoun	0.6	1.0	1.5
3rd	Bousthammi	0.6	1.0	1.5
	Iklane	0.4	0.6	0.8
	Ahardane	0.4	0.6	0.8

Size (Medjool variety):



Visual characteristics (Meedjol variety): lack of visual defects, abnormality, skin puffiness, sunburn, insect damage, uniformity of colour and size, decay, fermentation, and mechanical damage.

Quality	Sizes	Skin
Premium Medjool	Small; medium; large; jumbo	0% loose skin separation (5% error margin)
Fancy Medjool	Small; medium; large, jumbo, super jumbo	Loose skin from one side (5% error margin)
Choice Medjool	Small; medium; large, jumbo, super jumbo	Loose skin on more than one side (5% error margin)

Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (fulfill the standards); 0: No (non-fulfill the standards)
References	Agency of Partnership for Progress (2010); Aramyan et al. (2006); Santiago-Brown et al. (2015); United States Department of Agriculture (1955); Wohlenerg et al. (2022)

S-46	**Agricultural Networks I**
Domain	Social
Stakeholder	Customers
Theme	Networks
Description	It measures the quality of the products and land: Quality of foodstuff produced; whether products are certified (e.g., organic and linked to the territory); value system and ethics, food demand, food safety and health aspects, food security and distribution
Metrics	[Is the farm adhered to an ethical system or obtained any certifications and labels]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Adhered or certificated); 0: No (Non adhered or certificated)
References	Brennan et al. (2018); Ecolabel Index (2022); Kelly et al. (2021); Röös et al. (2019); Roy & Chan (2012); Saifia & Drake (2008)

S-47	**Customers Networks**
Domain	Social
Stakeholder	Customers
Theme	Networks
Description	It measures the level of interest in the relationship between consumer and producer
Metrics	[Intensity of the relationship between consumer and producer]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Brennan et al. (2018); Ecolabel Index (2022); Kelly et al. (2021); Röös et al. (2019); Roy & Chan (2012); Saifia & Drake (2008)

S-48	**Agricultural Networks II**
Domain	Social
Stakeholder	Associations
Theme	Networks
Description	It measures the farm commitment with professional associations
Metrics	[Number of professional organizations in which the farmer is involved]
Unit of measurement	[Number]
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Galdeano-Gómez et al. (2017); Kelly et al. (2021)

S-49	**General Organization Networks**
Domain	Social
Stakeholder	Associations
Theme	Networks
Description	Involvement in associations linked to the environment (membership in civil /voluntary/associations such as: village renewal, religious, sporting, nature conservation, living in the area, other)
Metrics	[Number of associations in which the farmer is involved]
Unit of measurement	[Number]
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. 2013; Kelly et al. (2021); Lebacq et al. (20213)

S-50	Professional Networks
Domain	Social
Stakeholder	Associations
Theme	Networks
Description	It measures the informal networks of knowledge through farmer exchanges
Metrics	[Technical exchanges between farmers]
Unit of measurement	[Number] (Days per year)
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)

S-51	Research Networks
Domain	Social
Stakeholder	Associations
Theme	Networks
Description	It measures the involvement of farmers in informal networks of knowledge and research
Metrics	[Total days involvement in research activities]
Unit of measurement	[Number] (Days per year)
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)

S-52	Community Relationships
Domain	Social
Stakeholder	Local Community
Theme	Networks
Description	It describes how the relationships with the community are considering jointly issues such as good neighbouring, happy neighbours, number of incidents/complaints per year, good communication with neighbours, good neighbours relations, and reducing spray drifts to neighbours
Metrics	[Type of the relationship (positive or negative) of the farm with their neighbours]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Santiago-Brown et al. (2015)

S-53	**Job Creation (General)**
Domain	Social
Stakeholder	Local Community
Theme	Labour
Description	It defines the farm creation of on-farm jobs in recent years
Metrics	[Total jobs created in the last five years/Total employees]* 100
Unit of measurement	[%] (Jobs and employees are expressed in number)
Interpretation	Higher values are recommended
References	Paternoster (2011); Roos et al. (2019)

S-54	**Job Creation (Local Workers)**
Domain	Social
Stakeholder	Local Community
Theme	Labour
Description	It measures the share of employees in all employees, that is, the farm job creation in terms of local works
Metrics	[Number of local workers/Total number of employees] * 100
Unit of measurement	[%] (Local workers and total employees are expressed in number)
Interpretation	Higher values are recommended
References	Diazabakana et al. (2014); Fourriè et al. (2013); Kelly et al. (2021)

S-55	**Job Creation (Seasonal Workers)**
Domain	Social
Stakeholders	Local Community
Theme	Labour
Description	It measures the percentage of seasonal workers who live in the neighbourhood
Metrics	[Total seasonal workers who live in the neighbourhood/Total employees]*100
Unit of measurement	[%] (Seasonal workers and employees are measured in number)
Interpretation	Higher values are recommended
References	Röös et al. (2019)

S-56	**Community Social Indicators**
Domain	Social
Stakeholder	Local Community
Theme	Social Commitment
Description	It describes how a farm helps to improve its community in terms of education, working conditions, quality of life
Metrics	[Farm involvement in the improvement of the community]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Brennan et al. (2018); Kelly et al. (2021)

S-57	**Community Tradition Respect**
Domain	Social
Stakeholder	Local Community
Theme	Social Commitment
Description	It measures the farm recognition and respect to the rights of indigenous communities upheld though fair contracts
Metrics	[Level of farm recognition and respect the rights of local communities]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Röös et al. (2019)

S-58	**Local Participation (Formal)**
Domain	Social
Stakeholders	Local Community
Theme	Social Commitment
Description	It measures if the family farm is member of some kind of government: 1= Local government 2= Territorial government (regional or national) 3= Municipality government
Metrics	[Presence or absence of the participation in each level of government]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Presence); 0: No (Absence)
References	Kelly et al. (2018); Kelly et al. (2021); Reed & Courtney (2013); Wohlenberg et al. (2022); Zahm et al. (2008)

S-59	**Local Participation (Informal)**
Domain	Social
Stakeholders	Local Community
Theme	Social Commitment
Description	It measures if the family farm takes part in some kind of local activities: 1 = Participation in local festivals; 2 = Participation in local farmers' markets; 3 = Participation in local farming fairs; 4 = Participation in local nature conservation; 5 = Participation in local competitions; 6 = Hosting open day events in the farm, e.g., harvest festivals, themed seasonal events, etc.; 7 = Allowing public visit in the farm, e.g. farm walks, trails or self-guided walks, etc.; 8 = Giving apprenticeships
Metrics	[Presence or absence of the participation in the eight aforementioned activities]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Presence); 0: No (Absence)
References	Aparisi (n.d.); Diazabakana et al. (2014); Kelly et al. (2018); Kelly et al. (2021); Röös et al. (2019); Wohlenberg et al. (2022)

S-60	**Public Health**
Domain	Social
Stakeholders	Local Community
Theme	Social Commitment
Description	It measures the farm's level of commitment to avoid pollution at local level
Metrics	[Intensity of farm's commitment to avoid pollution at local level]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst, 5: Best
References	Röös et al. (2019)

S-61	**Sustainable Law**
Domain	Social
Stakeholders	Local Community
Theme	Social Commitment
Description	It measures how a farm's commitment in sustainable practices reinforce institutional law to promote sustainable production
Metrics	[Intensity of farm's commitment in sustainable practices to reinforce institutional law to promote sustainable production]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Rasmussen et al. (2017)

S-62	**Circular Economy**
Domain	Social
Stakeholder	Environment
Theme	Environmental Commitment
Description	It measures the farm commitment with circular economy (processing of non-organic waste, avoidance of burning organic waste and sorting and reuse of organic waste on-sit), that is, its interest on trying to reduce waste to a minimum
Metrics	[Level of commitment of farm with the main principles of circular economy]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Kelly et al. (2021); Röös et al. (2019); Zahm et al. (2008)

S-63	**Quality of Landscape**
Domain	Social
Stakeholder	Environment
Theme	Environmental Commitment
Description	It describes the commitment of a farm with the quality of landscape elements, e.g., hedges and trees, including the maintenance of old buildings and the architectural quality of new buildings to maintain rural heritage
Metrics	[Farm’s commitment with the quality landscape elements]
Unit of measurement	[Five point Likert Scale]
Interpretation	1: Worst; 5: Best
References	Kelly et al. (2021); Röös et al. (2019); van Cauwenbergh et al. (2007); Zahm et al. (2008)

S-64	**Risks**
Domain	Social
Stakeholder	Environment
Theme	Environmental Commitment
Description	It describes the farm level of employment of toxicity pesticides
Metrics	[Use of pesticides not allowed by European Commision]
Unit of measurement	[Dummy variable (1, 0)]
Interpretation	1: Yes (Presence); 0: No (Absence)
References	Ramirez et al. (2008); Reglamento 396 (2005)

Appendix 3: Environmental indicators detailed description

EN-1	Human Tox Score
Domain	Environmental
Theme	Health
Description	The indicator assesses a chemical's hazard to humans
Metrics	[Sum of the scores assigned to each Risk Phrase (RP) and Toxicity Class (TC) listed on the label of the pesticide used by the farmers during the crop season, modified depending on the quantity used]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-2	Dose Area Index
Domain	Environmental
Theme	Health
Description	It assesses the exposure of individuals to chemical products
Metrics	[It is based on the dose of the plant protection product applied to the crop, its maximum dose and the treated surface area]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-3	Treatment Frequency Index
Domain	Environmental
Theme	Health
Description	It measures the chemical pressure on the fields.
Metrics	[It takes into account the agricultural area treated with pesticides during the cultivation season compared to the total area of the field]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-4	Carbon Footprint
Domain	Environmental
Theme	Air
Description	It assesses the amount of greenhouse gases directly or indirectly released into the atmosphere due to human activities
Metrics	[It takes into consideration all the greenhouse gases that can alter the climate, listed in the Kyoto Protocol]
Unit of measurement	CO_2 eq t/t
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-5	Carbon Sequestration
Domain	Environmental
Theme	Air
Description	It estimates how much carbon is sequestered by plant tissues (both above- and below-ground) during the growing season
Metrics	[It calculates the carbon sequestration in terms of ton of CO2-sequestration/hectare, based on the harvest obtained and the estimated plants' development]
Unit of measurement	t of Carbon/ha
Interpretation	The higher the score, the more positive the evaluation.
References	Adam-Blondon et al. (2017)

EN-6	Ecological Footprint
Domain	Environmental
Theme	Soil
Description	It evaluates the productive land and water surface areas necessary to both provide the resources and to absorb the emissions created by producing a certain good or service
Metrics	[The calculation includes all the operations carried out during the crop season and all the inputs that enter into the crop growing process]
Unit of measurement	global ha/ha or global ha/t
Interpretation	The higher the score, the more negative the evaluation.
References	Adam-Blondon et al. (2017)

EN-7	**Organic Matter**
Domain	Environmental
Theme	Soil
Description	It estimates the percentage of organic matter contained in the soil
Metrics	[The higher the percentage of organic matter, the more fertile the ground will be, and the longer the productive cycle will last]
Unit of measurement	%
Interpretation	The higher the score, the more positive the evaluation.
References	Adam-Blondon et al. (2017)

EN-8	**Soil Coverage**
Domain	Environmental
Theme	Soil
Description	It estimates time in a year that the soil has coverage
Metrics	[The Soil Coverage indicator estimates the number of days in a year that the field has crop or crop-residue coverage]
Unit of measurement	days
Interpretation	The higher the score, the more positive the evaluation
References	Adam-Blondon et al. (2017)

EN-9	**Erosion**
Domain	Environmental
Theme	Soil
Description	It estimates the tons of soil lost per hectare due to water-caused erosion
Metrics	[The calcuation takes into consideration the monthly rain data (in mm/month); the texture and the organic matter content of the soil; slope length and steepness; soil management; watering system used]
Unit of measurement	t soil/ha
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-10	**Soil Compaction**
Domain	Environmental
Theme	Soil
Description	It estimates the risk of soil compaction.
Metrics	[The calculation takes into consideration are soil texture; precipitation and irrigation; farm machinery weight and paths made by tires or tracks; number of machinery passes in a field; soil management (e.g. seeded with grass versus fallow)]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-11	**Biodiversity (Land Use-Based)**
Domain	Environmental
Theme	Biodiversity
Description	[It evaluates a farm's biodiversity, on the base of the different types of land use]
Metrics	The indicator assesses land use, based on the different types of land use
Unit of measurement	n.a.
Interpretation	The higher the score, the more positive the evaluation
References	Adam-Blondon et al. (2017)

EN-12	**Eco Tox Score**
Domain	Environmental
Theme	Biodiversity
Description	It assesses the chemical ecosystem hazard score
Metrics	[The calculation is the sum of the scores assigned to each Risk Phrase (RP) and Toxicity Class (TC) listed on the label of the pesticide used, and depend on the dose used per hectare]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-13	**Fuel Use**
Domain	Environmental
Theme	Energy
Description	It calculates the liters of fuel used for all mechanized operations carried out in the field
Metrics	[It is calculated on the base of fuels consumption estimated, on the base of slope, soil texture and operation depth]
Unit of measurement	l of fuel/ha or l of fuel/t
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-14	**Renewable Fuel**
Domain	Environmental
Theme	Energy
Description	It assesses the farm's use of fuel from renewable sources
Metrics	[This indicator assesses the farm's use of fuel from renewable sources]
Unit of measurement	n.a.
Interpretation	The higher the score, the more positive the evaluation
References	Adam-Blondon et al. (2017)

EN-15	**Waste**
Domain	Environmental
Theme	Energy
Description	It analyses the farm's waste management
Metrics	[The calculation includes phytosanitary treatment residue; pruning waste management; material for tying; sheets and nets; poles for trees]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation.
References	Adam-Blondon et al. (2017)

EN-16	**Water Footprint**
Domain	Environmental
Theme	Water
Description	It assesses the water footprint of the product's life-cyle
Metrics	[The calcuations includes volumes of freshwater that is used, lost to evapotranspiration, and/or polluted, for each activity performed in the field]
Unit of measurement	H2O m3/ha or H2O m3/t
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-17	**Water Supply**
Domain	Environmental
Theme	Water
Description	It evaluates the sustainability of the types of water used for crop irrigation
Metrics	[The calculation takes into consideration the sustainability of the types of water used for crop irrigation (wastewater, rainwater or desalinated water, above-ground reservoirs, water table]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-18	**Water Use Technical Efficiency**
Domain	Environmental
Theme	Water
Description	It assesses the sustainability of the irrigation system used in crop production
Metrics	[The calculation considers the type of watering system used, such as localized drips or sprinklers, flood or furrow methods]
Unit of measurement	n.a.
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-19	**Acidification I**
Domain	Environmental
Theme	Water
Description	It estimates the emissions into the air of acidifying gases due to the production process
Metrics	[The calculation takes into consideration the emissions into the air of acidifying gases, due to the production process (e.g. fossil fuel combustion or fertilizer use). Every acidifying substance is converted in equivalent sulphur dioxide (SO_2)]
Unit of measurement	SO_2 eq t/ha or SO_2 eq t/t
Interpretation	The higher the score, the more negative the evaluation
References	Adam-Blondon et al. (2017)

EN-20	**Eutrophication**
Domain	Environmental
Theme	Water
Description	It evaluates the effect of added phosphoric and nitrogenous compounds on water ecosystems
Metrics	[The calculation takes into consideration the effect of added phosphoric and nitrogenous compounds, derive from fertilizers used during a crop's life cycle. Every molecule responsible for freshwater and seawater eutrophication, are converted in equivalent phosphate (PO_4^{3-}) ions]
Unit of measurement	PO_4 eq t/ha or PO_4 eq t/t
Interpretation	The higher the score, the more negative the evaluation.
References	Adam-Blondon et al. (2017)

EN-21	**Climate Change**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the radiative forcing as global warming potential
Metrics	[The indicator estimates the increase in the average global temperature resulting from greenhouse gas emissions (GHG)]
Unit of measurement	kg CO_2 eq/ha
Interpretation	The higher the score, the more negative the evaluation.
References	Manfredi et al. (2012)

EN-22	**Climate Change, Fossil**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the radiative forcing as global warming potential
Metrics	[The indicator covers GHG emissions to any media originating from the oxidation and/or reduction of fossil fuels by means of their transformation or degradation (e.g. combustion, digestion, landfilling, etc.)]
Unit of measurement	kg CO_2 eq/ha or kg CO_2 eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-23	Climate Change, Biogenic
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the radiative forcing as global warming potential
Metrics	[The indicator covers carbon emissions to air (CO2, CO and CH4) originating from the oxidation and/or reduction of aboveground biomass by mean of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO2 uptake from the atmosphere through photosynthesis during biomass growth]
Unit of measurement	kg CO_2 eq/ha or kg CO_2 eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-24	Climate Change, Land Use and Transformation
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the radiative forcing as global warming potential
Metrics	[The indicator accounts for carbon uptakes and emissions (CO2, CO and CH4) originating from carbon stock changes caused by land use change and land use]
Unit of measurement	kg CO_2 eq/ha or kg CO_2 eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-25	Ozone Depletion
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the Ozone Depletion Potential – ODP
Metrics	[The indicator considers the depletion of the stratospheric ozone layer protecting from hazardous ultraviolet radiation]
Unit of measurement	kg CFC-11 eq/ha or kg CFC-11 eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-26	**Human Toxicity, Non-Cancer Effects**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It evaluates the Comparative Toxic Unit for humans
Metrics	[The indicator considers the impact on human health caused by absorbing substances through the air, water, and soil. Direct effects of products on humans are not measured]
Unit of measurement	CTUh/ha or CTUh/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-27	**Human Toxicity, Cancer Effects**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It evaluates the Comparative Toxic Unit for humans
Metrics	[The indicator considers the impact on human health caused by absorbing substances through the air, water, and soil. Direct effects of products on humans are not measured]
Unit of measurement	CTUh/ha or CTUh/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-28	**Respiratory Inorganics**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the impact on human health (disease incidence)
Metrics	[The indicator considers the impact on human health caused by particulate matter emissions and its precursors (e.g. sulfur and nitrogen oxides)]
Unit of measurement	disease inc./ha or disease inc./t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-29	**Ionizing Radiation HH**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the human exposure efficiency relative to U-235
Metrics	[The indicator considers the impact of exposure to ionising radiations on human health]
Unit of measurement	kBq U235 eq/ha or kBq U235 eq/t
Interpretation	The higher the score, the more negative the evaluation.
References	Manfredi et al. (2012)

EN-30	**Photochemical Ozone Formation**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It evaluates the tropospheric ozone concentration increase
Metrics	[The indicator considers the potential of harmful tropospheric ozone formation (“summer smog”) from air emissions]
Unit of measurement	kg NMVOC eq/ha or kg NMVOC eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-31	**Acidification II**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the Accumulated Exceedance – AE
Metrics	[The indicator considers the acidification from air, water, and soil emissions (primarily sulfur compounds) mainly due to combustion processes in electricity generation, heating, and transport]
Unit of measurement	molc H+ eq/ha or molc H+ eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-32	**Terrestrial Eutrophication**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the Accumulated Exceedance – AE
Metrics	[The indicator considers the eutrophication and potential impact on ecosystems caused by nitrogen and phosphorous emissions mainly due to fertilizers, combustion, sewage systems]
Unit of measurement	molc N eq/ha or molc N eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-33	**Freshwater Eutrophication**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It evaluates the fraction of nutrients reaching freshwater end compartment
Metrics	[The indicator considers the eutrophication and potential impact on ecosystems caused by nitrogen and phosphorous emissions mainly due to fertilizers, combustion, sewage systems]
Unit of measurement	CTUe/ha or CTUe/t
Interpretation	The higher the score, the more negative the evaluation.
References	Manfredi et al. (2012)

EN-34	**Marine Eutrophication**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It evaluates the fraction of nutrients reaching marine end compartment
Metrics	[The indicator considers the eutrophication and potential impact on ecosystems caused by nitrogen and phosphorous emissions mainly due to fertilizers, combustion, sewage systems]
Unit of measurement	kg N eq/ha or kg N eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-35	**Freshwater Ecotoxicity**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the Comparative Toxic Unit for ecosystems
Metrics	[The indicator considers the impact of toxic substances on freshwater ecosystems]
Unit of measurement	CTUe/ha or CTUe/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-36	**Land Use**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the soil quality index, representing the aggregated impact of land use on: Biotic production; Erosion resistance; Mechanical filtration; Groundwater replenishment
Metrics	[The indicator considers the transformation and use of land for agriculture, roads, housing, mining or other purposes. The impact can include loss of species, organic matter, soil, filtration capacity, permeability]
Unit of measurement	kg C deficit/ha or kg C deficit/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-37	**Water Scarcity**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the weighted user deprivation potential
Metrics	[The indicator considers the depletion of available water depending on local water scarcity and water needs for human activities and ecosystem integrity]
Unit of measurement	m3 depriv./ha or m3 depriv./t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-38	**Resource Use, Energy Carriers**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the abiotic resource depletion – ADP ultimate reserves
Metrics	[The indicator considers the depletion of non-renewable resources and deprivation for future generations]
Unit of measurement	MJ/ha or MJ/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

EN-39	**Resource Use, Mineral and Metals**
Domain	Environmental
Theme	PEF (Product Environmental Footprint)
Description	It assesses the abiotic resource depletion, fossil fuels – ADP-fossil
Metrics	[The indicator considers the depletion of non-renewable resources and deprivation for future generations]
Unit of measurement	kg Sb eq/ha or kg Sb eq/t
Interpretation	The higher the score, the more negative the evaluation
References	Manfredi et al. (2012)

List of Figures

List of Tables