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Barriers and Facilitators for Adopting Sustainable Soil Management Practices in Mediterranean Olive Groves

José A. Aznar-Sánchez ^{1,*} , Juan F. Velasco-Muñoz ¹ , Belén López-Felices ¹ and Fernando del Moral-Torres ²

¹ Department of Economy and Business, Research Centre CAESCG and CIAIMBITAL, University of Almería, 04120 Almería, Spain; jfvelasco@ual.es (J.F.V.-M.); blopezfelices@ual.es (B.L.-F.)

² Department of Agronomy and Agrifood Campus of International Excellence ceiA3, University of Almería, 04120 Almería, Spain; fmoral@ual.es

* Correspondence: jaznar@ual.es; Tel.: +34-950-015-192

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Abstract: Soil is a fundamental resource, subject to severe and quick degradation processes because of the pressure of human activities, particularly in many regions of the Mediterranean where agriculture is an important economic activity. It has been proven that the use of sustainable soil management practices can potentially give rise to the creation of a carbon sink, an increase of soil organic matter content, the maintenance of crop productivity and a reduction in erosion. Despite the existence of scientific evidence about the benefits generated by the use of sustainable practices on soil, many farmers are reluctant to adopt them. The objective of this study is to identify and give a hierarchical structure to the factors that condition the adoption of sustainable practices in the management of agricultural soil. The case of olive tree cultivation in Southeast Spain has been studied, using a participatory qualitative methodology. The results show a series of seven principal barriers (information, costs, risk aversion, characteristics of the farm and sustainable practices, macro factors, and cultural barriers) and five facilitators (technology, farmer training, awareness, incentives, and social pressure) for the adoption of the proposed sustainable agricultural practices. The principal political and legislative actions proposed to increase the adoption of sustainable agricultural practices include: administrative control, fostering environmental awareness, technical knowledge, and on-farm demonstrations; and, on the economic and financial level, incorporation of both general incentives and subsidizing specific costs. This study contributes to the development and discussion of intervention proposals that are designed to stimulate the implementation of sustainable practices in agricultural soil management.

Keywords: impact assessment; Delphi; agricultural development; sustainability; Mediterranean basin; participatory qualitative methodology

1. Introduction

Soil is a fundamental resource, given that it forms the basis of human populations and the support of the majority of ecosystems, and the services that they provide [1]. Among these services, we can find the production of basic goods, such as food, animal feed, fiber, and fuel, and critical services including soil water infiltration and storage, and carbon sequestration. Furthermore, it provides the habitat of billions of organisms [2]. In spite of its acknowledged importance in maintaining the functions of the ecosystems, human life and economic activities, soil is suffering from a severe transformation and degradation process [3]. As a result, currently 75% of the surface of the planet has been modified by human activity, with agriculture being one of the dominant uses, occupying more than a third of the total available land [3,4].

In many regions of the Mediterranean, the quality of the agricultural soil has experienced a continual deterioration over the last few decades due to processes of erosion, loss of organic matter, loss of biodiversity, salinization, etc. [5]. This deterioration of agricultural soils has been mainly due to overexploitation and the widespread implementation of inappropriate crop production techniques such as incorrect irrigation methods, the application of low quality water, excessive tillage, a reduction in organic inputs, and the excessive use of agrochemicals. The perpetuation of these conducts constitutes a serious threat to the sustainability of the agricultural sector in large areas of the Mediterranean basin [6]. In this region, the soils, in general, have low organic carbon content, so, in order to maintain fertility levels the use of chemical fertilizers is common. These last have a positive impact on crop yields in the short term but do not improve the physical properties of the soil [7]. Furthermore, over the last century, these soils, which are already degraded, have suffered a severe loss of carbon, which has partly contributed to the growing trend of global warming [8]. However, Mediterranean agricultural soils have considerable potential as carbon sinks which help to mitigate the high emissions of fossil CO₂ [9]. In this sense, it is important to increase organic matter content to maintain soil productivity and reduce erosion and desertification [10]. Therefore, the adoption of sustainable practices in soil management is essential in the Mediterranean basin [11].

There are different agricultural practices that can contribute to improving the quality of the soil. However, these sustainable practices are expanding very slowly in Mediterranean countries. In view of this situation, it is important to consider why the adoption of these practices by the farmers in these regions continues to be considerably weak [12,13]. Understanding the barriers and facilitators for adopting sustainable practices in agricultural soil management is an important prerequisite for designing appropriate and efficient intervention measures that encourage farmers to adopt them.

This study had a double objective: on the one hand, to identify barriers and facilitators experienced by farmers in adopting sustainable practices in soil use; on the other hand, to contribute to a better understanding of how the intervention measures, aimed at stimulating farmers to adopt these sustainable practices, should be designed. To achieve these objectives, the case of olive tree cultivation has been analyzed in a Mediterranean region. A qualitative methodology has been used, comprising a literature review and the collection of primary information obtained from different stakeholders through interviews, surveys, and workshops. The data collected contributes to the development and discussion of intervention proposals that are designed to stimulate the implementation of sustainable practices in agricultural soil management.

2. Materials and Methods

2.1. Delphi Method

The Delphi method can be defined as a structured methodology for systematically bringing together the judgement of experts in a specific topic related to a problem that is the object of analysis, to process the information and, through statistical resources, to construct a general group agreement [14]. It is a qualitative methodology used to identify and give a hierarchical structure to factors that influence complex decision processes [15]. It attempts to find evidence in order to generalize arguments instead of statistical proof [16]. In situations where the solution to a problem is not easy to find through an empirical analysis and the opinion of the experts is the best available resource, the Delphi method is an appropriate tool given its suitability for collecting and aggregating these expert opinions in conclusions [17,18].

The Delphi method was developed in 1948 by the Rand Corporation for the USA intelligence services and was published years later by Dalkey and Helmer [19]. This method is used with a double objective. First, it seeks to use the experience of the participants to predict or forecast how a phenomenon will behave in the future [20]. Second, it is applied in transversal studies to describe an object, phenomenon, or situation in order to define it or delimit it. This is especially useful when it is very complicated to describe the question, or when evidence is insufficient, not published, excessive

or controversial, requiring the interpretation of experts in the subject [21]. In both cases, the Delphi method compares and combines individual opinions and arguments gathered from experts and enables decisions to be taken [22].

The Delphi method involves several phases [18,23]: The formation of a panel of experts to consult; a first round of individual interviews; the elaboration of a report of the results; the communication of the results to the participants and a new round of consultations; the comparison of the results of the different rounds; and once a consensus has been reached, the conclusion of the process. With respect to the formation of the panel, the participants should ideally come from a diverse variety of fields closely related to the research topic [24]. The appropriate size of a panel will depend on the degree of heterogeneity of the group of experts. It should have a minimum of ten participants and can reach very high numbers in the case of international panels [25]. According to Sharghi et al. [26], when conducting the interviewing processes among the experts using the Delphi method, a minimum number of thirteen participants is able to ensure a reliability of the results of at least 80%.

This methodology has been widely used to identify factors related to the adoption of measures and decisions to be taken in agriculture to guarantee its sustainability. McFarlane et al. [27] used this methodology to identify the features of crops that could be feasibly introduced to benefit farmers and society, as a whole, in the member states of the European Union. Shi et al. [28] used it to analyze spatial and temporal differences and factors influencing intensive cropland use in the Huang-Huai-Hai Plain. Singh et al. [29] focused on prioritizing different types of vegetables for their cultivation in greenhouses in Saudi Arabia based on comprehensive criteria related to sustainable agricultural practices. Gardas et al. [24] applied the Delphi method to analyze the challenges faced by the supply chain in the case of the agricultural sector. Other studies that have applied this methodology to the sector of Mediterranean olive growing are those of Karray and Kanoun [30], and Ozden and Dios-Palomares [31,32]. Karray and Kanoun used the Delphi method to provide an estimate of the production and export of Tunisian olive oil to the European market in 2016, for two scenarios of total and partial liberalization of EU imports from third countries. Ozden and Dios-Palomares used the Delphi method to determine the relative importance of factors influencing environmental, quality, and technical efficiency in olive oil industry in different countries.

2.2. Study Site

In order to fulfil the objective proposed, olive tree has been selected as it is the most important perennial crop in the Mediterranean region [33,34]. The study site is located in the municipality of Tabernas, Southeast of Spain ($37^{\circ}6'14.85''-2^{\circ}17'29.32''$ W) (Figure 1). In the Filabres-Tabernas region olive groves account for 29% of the agricultural surface [35] and in this area the intensive olive grove occupies about 4000 ha [36]. The studied farm has an area of 81,871 m², and the main crop is olive tree (*Olea europea* L.) Rainfall is scarce (240 mm per year) and the potential evapotranspiration (800 mm per year) is several times higher than precipitation, although it varies from year to year, generating a permanent water deficit. The dominant soils, with a loamy-sandy texture, belong to the calcareous Regosols group [37]. They have a basic pH, a low content of organic matter and nutrients and a limited depth due to a hard and continuous crust. There is evidence of slight water sheet erosion [38] and superficial crusting. The twenty-year-old olive trees are planted in 7 m × 7 m with drip irrigation. Each tree is provided with three emitters (8 L/h per emitter). The soil is subjected to a very superficial tillage regime (5 cm), before the autumn rainy period, aimed at breaking the superficial crust and burying the organic fertilizers and possible adventitious weeds. The annual irrigation is 150 mm, distributed homogeneously through the crop cycle, which is insufficient to cover the water needs of the crop).

The scarce rainfall, together with the low availability of water for irrigation in the study site subjects olive growing to a water stress because in every month of the year, the evapotranspiration significantly exceeds the sum of water from rainfall and irrigation. Therefore, a regulated deficit irrigation model is used. It has the objective of stabilizing the crop yields and obtaining maximum productivity of the water with the available resources, increasing the water stress in those phases of

the cultivation when the tree is more tolerant to drought and maximizing water input in the phases that most affect its final yield [39–41].

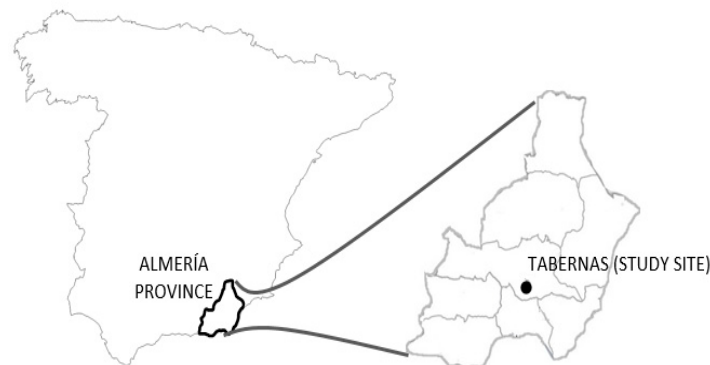


Figure 1. Location of Tabernas (Almería) in the Southeast of Spain.

2.3. Conducting the Data Collection

In order to carry out the data collection, a multiple survey was conducted in two phases (Figure 2). In the first phase, a group of ten experts in the research field were consulted. This first consultation provided us with knowledge on a theoretical-academic level. This first phase had a double objective: (i) To select the sustainable practices to test in the study site, based on their possible advantages and disadvantages; and (ii) to identify the possible barriers and facilitators for their implementation.

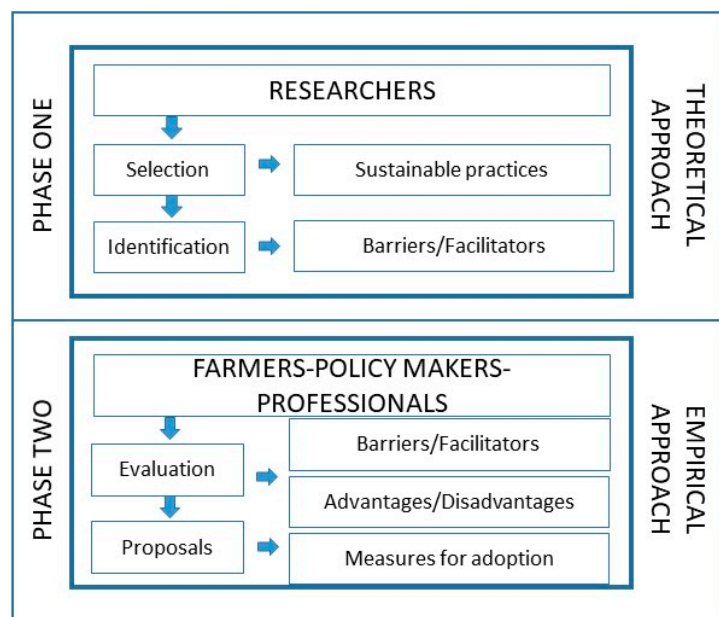


Figure 2. Conceptual framework.

Given that one of the objectives of the methodology used was to reach consensus among the participants, this first phase had two rounds. The first contact was made by telephone. In this first communication the project was presented to the experts and they were invited to participate. After the agreement to participate in the project, a questionnaire was sent to the experts by email in which they had to include the practices that they considered the most appropriate and the possible impacts that may be derived from their adoption. Furthermore, they were asked to list a series of barriers and facilitators for those practices implementation in the area of study. In the second round, the experts were invited to participate in a workshop. The objective of this meeting was to present the results

of the first round of surveys in order to reach a consensus after a debate between the participants. This variation in the traditional Delphi method, which consisted of a face-to-face meeting, had the advantage of generating a debate in which the participants coming from different disciplinary fields can consider different aspects [42,43]. In order to guarantee that the consensus is not directed by one of the parties, the meeting was appropriately moderated, following the indications of Campos-Climent and Chaves-Avila [44]. In a conventional Delphi application, participants never know the identity of the others experts. Combining different data collection qualitative methodologies provides a new contribution since a consensus can be reached taking into account the involved stakeholders' points of view regarding the analyzed reality.

In the second data collection phase, a group of experts made up of farmers, professionals, and policy makers were consulted (Figure 2). This consultation provided us with knowledge on an empirical-practical level. This second phase also had a double objective. On the one hand, it sought to compare the information relating to the barriers and facilitators provided by the experts from the research sphere. At this point, practices were already established. The participants identified the most relevant facilitators and barriers of those proposed by the researchers in the previous round; and subsequently they established a hierarchical structure of each of them. To do this, each of the factors was rated on a 4-point Likert scale (1 = not important, 2 = less important, 3 = important and 4 = very important). On the other hand, the participants were asked to provide action proposals for implementing these measures. In the second phase, a two-round process was also used, similar to the first phase, in order to ensure consensus. The total number of participants was 28.

2.4. Conditioning Factors of Adopting Soil Sustainable Practices

A theoretical framework of reference was established based on the classification by Liu et al. [45] of factors influencing the adoption of sustainable practices by farmers. This classification was provided to the researchers surveyed in the first phase, serving as a starting point and facilitating their responses. Below is a brief description of each group of variables included in Table 1.

1. Information and awareness. It has been shown that the level of training and awareness of the farmers is one of the principal factors determining the adoption of sustainable practices. This knowledge includes the familiarity with the existence, implementation and benefits of adopting the different sustainable practices and the level of environmental awareness of the farmers and their attitude towards agricultural sustainability [46]. This section is concerned with gathering some of the principal variables related to this knowledge, the means through which it is produced, the influence of relations and communication networks, etc. Among them, we can find the information about conservation programs or specific practices and the information sources; the creation of networks; the interpersonal contact between conservation agencies and farmers, other fundamental interested parties; the exposure to conservation networks; the families, traders of agricultural chemical products, vendors of seeds and crop consultants; gender, given that women farmers have a higher probability of learning and adopting the sustainable techniques; the means of communication, particularly internet-based social networks; etc. [47].
2. Financial incentives. There is extensive literature on the capacity of financial incentives to influence the adoption of agricultural practices, specifically government subsidies and credit or loans [48]. It was revealed that the subsidies and finance facilities can be important facilitators, able to stimulate the adoption of sustainable practices. However, the financial aspects can also represent a barrier in the form of a lack of cash or credit for cost sharing and a limited cashflow while waiting for the payment from the government. We should also consider the role of the different types of costs associated to the adoption of sustainable practices [49]. These include opportunity costs, capital costs, implementation costs, and maintenance costs.
3. Social norms. Social norms and group pressure can have a great impact on the perceptions and attitudes of agricultural producers and play fundamental roles in the process of adoption [50]. Within each community, there is usually a farmer who has a greater influence. These types

of people can serve as a reference when adopting sustainable measures if their experience is successfully shared. Other groups that usually exert pressure on the decision-making of the farmer are family, friends, and neighbors as well as professionals related to the activity, such as vendors and technicians [51].

4. Macro factors. The factors on a macro scale are the series of circumstances that directly or indirectly affect the agricultural activity but do not fall within the capacity of influence of the individual farmer [52]. These circumstances include the consequences of global climate change and the legislative proposals implemented to mitigate them and which may affect agriculture, the fluctuations in the markets due to variations in crops, the changes in consumer preferences, etc. They also include agrosystemic factors such as the type of soil, rain distribution, and soil fertility; the political viewpoints; the participation of agricultural production in the generation of wealth and the creation of employment, etc.
5. Farmers' demographics, knowledge, and attitudes. Factors that influence the adoption of sustainable practices are the level of income and capital, the diversity of the operations carried out, the level of access to labor, the level of gross agricultural sales, social class or the family involvement in the farm [53]. Another aspect to consider is the vocational factor and the preference for the agricultural way of life, referring to people who value country life, those who consider agriculture as enjoyable or those who contemplate the farm as a legacy. Another series of variables is formed by characteristics such as age, sex, level of education, and experience. Finally, beliefs, religious and political ideology, or the level of social commitment can condition the adoption of sustainable measures.
6. Farmers' risk and time preferences and uncertainty. Risk and time preferences of agricultural producers are also factors that influence the adoption of sustainable practices [54]. The risk of a loss of crop yield is one of the principal barriers for farmers. Some studies indicate that risk aversion is usually linked to lower levels of training and income. Similarly, evidence has been found that indicates that the effect of uncertainty is unequivocally negative for sustainable practices.
7. Farmer's environmental awareness. The level of environmental awareness is directly related to the adoption of sustainable agricultural practices. Among the variables used to evaluate the level of environmental awareness, we can find the awareness of the water quality, soil erosion, and the impact of the sustainable practices on the environment [55].
8. Characteristics of farms. The geophysical and socio-political characteristics and those related to farm management such as the size of the farm, the soil fertility, the gradient of the land, the altitude of the farm, the proximity to the urban area, the type of ownership, the communication between tenants and landowners, the inscription in conservation programs and different operations such as the type of crop and livestock are some of the variables to consider in this section [56]. Another influential factor is the access to labor, including that of family members or hired workers.
9. Characteristics of sustainable practices. The characteristics of the different applicable sustainable practices include being observable, the location, user friendliness, time requirement, profitability, or flexibility of the conservation standards are highly influential factors in the adoption decision [57]. The practices that are particularly valued are those whose results are easily observable in the short term, such as the use of terraces, waterways with grass, and conservation tillage to reduce soil erosion, instead of less observable practices. Other issues to consider are that farmers will be more prone to adopt practices that increase the aesthetic value of the land and respect the useful surface area for farming [53].
10. Interactions between sustainable practices. The adoption of sustainable practices can offer a series of synergistic benefits; therefore, grouping different types of practices together can make the adoption more profitable [58]. It has also been shown that the effects of sustainable practices exceed the physical limits of farming and that there is a higher probability of adopting practices in cases in which others have been previously adopted.

Table 1. Summary of findings on factors influencing the adoption of sustainable practices by farmers.

Factor Category	Factor
1. Information and awareness	Timely access to tailored and credible technical information on sustainable practices In-person information dissemination Networking (conservation agencies, extension services, and farm organizations) Inadequate access to information Positive opinions of family, farm chemical dealers, seed dealers, and crop consultants Conservation education programs Facilitating infrastructures (internet access) Information shared via social media
2. Financial incentives	Financial incentives (not further differentiated) Government subsidies Credits or loans Lack of cash or credit for cost sharing and limited cash flow Capital cost associated with sustainable practices adoption Maintenance cost Time and other expenses (e.g., price of herbicide, commodities markets, land values and rental rates)
3. Social norms	Social conformity and neighbor's acceptance Adoption by neighbor (s) Encouragement of family, friends and neighbors, as well as support from active conservation districts, sales people, and local information offices
4. Macro factors	Geographic regions Share of agricultural production in total GDP of a state Climate change and extreme weather conditions N Uncertainties regarding market price and conservation regulations Roles of policies, markets, business or agencies
5. Farmers' demographics, knowledge, and attitudes	Age Gender (being female) Income and capital, and level of gross farm sales The household life stage, history of family ownership of a landholding, family size and structure Family member planning to take over the farm Farmers' experience and education Political views and socio-political beliefs Risk aversion
6. Farmers' risk and time preferences and uncertainty	Conservation risk tolerance Positive time preference Uncertainties with the installation and adaptation and management skills Awareness of water quality, soil erosion, and impact of sustainable practices on the environment
7. Farmer's environmental awareness	Environmental stewardship or steward intentions Land tenure
8. Characteristics of farms	Communication between tenants and landowners Crop types, livestock types and diversity and livestock holding Enrolment in conservation programs (e.g., EQIP) Geophysical characteristics (soil fertility, slope, altitude, etc.) Proximity to urban area Resource endowment Access to labor (family or hired) Diverse operation Farm size Observability, location, ease of use, smaller time requirement, cost-effectiveness, and flexibility of conservation standards
9. Characteristics of sustainable practices	Profitability of the practices Increase of aesthetic value of the land Regulatory requirement associated with nutrient management Location of the practice (e.g., remove valuable land from production) Crowding-in effects
10. Interactions among sustainable practices	Crowding-out effects Spatial spillover effect Temporal spillover effect

Source: Adapted from Liu et al. [45].

3. Results and Discussion

3.1. Soil Sustainable Practices Tested in the Area of Study

Two soil sustainable practices were tested in the study site:

- The use of chopped pruning residues (SSP1): the pruning residues are laid on the surface of the soil acting as a mulch to protect the soil from the direct impact of the raindrops and to reduce water loss through evaporation [59]. Once incorporated into the soil, with the agronomical practices in the olive grove, its high content of lignin provides the soil with a large amount of highly persistent humic precursors, which are expected to increase the total soil organic carbon and contribute to stabilizing soil meso and microaggregates, improving the water retention capacity of the soil and therefore the water available for the olive grove, reducing the risk of crusting [60,61]. It also reinforces the development and diversity of the microorganisms of the soil and replaces part of the nutrients extracted by the cultivation back into the soil [62].
- Use of vegetation cover (SSP2): The mild temperatures, together with the minimum tillage practices during periods of greater water availability, favor the mineralization processes and the subsequent loss of organic matter, which is not sufficiently replaced by the scarce natural biomass that exists, giving rise to the low levels of organic matter in the soils in these climates. This low level of organic matter in coarse textured soils such as those in our case, affects the structural stability of the aggregates which, in response to the impact of the raindrops or as a consequence of the mechanized tillage, tend to disintegrate on the surface, leading to a crusting of the upper surface which hinders the infiltration of new rainfall and increases the surface runoff and risk of erosion. The use of sown vegetal covers, specifically selected for these soil and climate conditions in periods of lower water deficit, along with spontaneous herbaceous cover, contribute to protecting the soil against the direct impact of the raindrops, slowing down the surface runoff and improving infiltration through its root system, contributing to increasing the value of the effective rain [63], and stabilizing the macroaggregates of the soil as a direct consequence of its root system and indirectly fostering the development of mycorrhizal fungi [64]; the biological diversity increases on both a plot scale and in the soil itself and the nutrient balance is modified [65,66]; its incorporation in the soil will have a temporary effect on the total organic carbon content due to the labile nature of the material incorporated, but it will affect the balance of the soil organic carbon fractions, which have a high ecosystem value [67]. The contribution of sown covers is due to the need to increase biomass contributions over those made by spontaneous vegetation, which is not sufficient in itself. Its value as a sustainable practice depends on the efficiency in improving the water balance of the soil, as it should prosper without competing for water with the olive growing [68].

3.2. Principal Impacts of Adopting Soil Sustainable Practices

The principal impacts expected from adopting sustainable practices have been classified as economic, productivity and environmental (Table 2). The economic impacts, in turn, can be related to the costs derived from the consumption of inputs (water, fertilizers, herbicides, etc.) and the undertaking of different activities necessary for production (tillage, pruning, sowing, etc.); and the income obtained through the sale of production. All of these economic impacts can be considered as being positive or negative depending on the sign presented. That is, an increase in the costs would constitute a negative impact, while an increase in income implies a positive impact. The opposite would be the case if the costs or income had the opposite sign. The impacts on productivity reflect variations in the quantity and/or quality of the crop, derived from the implementation of the sustainable practices. In this case, the consideration of an impact as either negative or positive will also depend on whether the variation is an increase or a decrease. Finally, the adoption of sustainable practices is also expected to have environmental effects, mainly positive.

Table 2. Main impacts of adopting the Soil Sustainable Practice (SSP) in the study site.

Component	Positive Impact		Negative Impact	
	SSP1	SSP2	SSP1	SSP2
COST				
Collection	*			
Transport	*			
Processing			*	*
Compost production		*	*	
Fertilization	*		*	*
Seeds				*
Workforce				*
Water				*
INCOME				
Prize	*	*		
Quantity	*	*		*
YIELD				
Quantity	*	*		*
Quality	*	*		
ENVIRONMENTAL BENEFIT				
Soil organic matter	*	*		
Soil erosion	*	*		
Soil compaction	*	*		
Soil crusting	*	*		
Occurrence of pests	*	*		
Biological control of pests	*	*		*
Desertification	*	*		
Pollution (water/soil)	*	*		
Soil salinization	*	*		
Biodiversity	*	*		
Nutrient imbalance	*	*		

In the case of the SSP1, the positive economic impacts include a reduction in the costs of the collection and transport operations of the pruning residues and a reduction in the need for fertilizers in the medium term, 3–5 years approximately [6]. In the case of the SSP2, there is a positive impact on costs due to the availability of raw material for making compost based on pruning residues. With respect to the negative impacts on costs, the implementation of these practices represents an increase in the number of operations [66]. In the first case, it is due to the processing of pruning residues for their subsequent use. In the second case, it is due to the pre-sowing, sowing, mowing operations, etc. In the SSP2 there is also an increase in costs due to the acquisition of the seeds, necessary to increase biomass inputs over those made by spontaneous vegetation, not sufficient in itself, the increase in water consumption and the increase in the number of hours of labor for its management. Furthermore, in both practices an increase in costs can occur derived from the short-medium term fertilization.

With respect to the impacts on production, in the case of the SSP1, there may be an increase in the amount harvested; while in the case of the SSP2 there may be an increase or decrease in the quantity depending on the volume and distribution of the rain during the campaign [34]. Therefore, variations in income cannot be estimated. With respect to the environmental effects, we can expect positive impacts derived from the adoption of the two sustainable practices related to the improvement in organic matter, the control of erosion, compaction and the formation of crusts, the salinity of the soil and the nutrient balance [69]. Furthermore, they contribute to the fight against desertification and reducing the pollution of the soil and water resources [70]. Finally, adopting these practices implies the recovery of habitats capable of increasing the biodiversity, a lower occurrence of pests and a better biological control of them. This positive effect will depend on the selection of the covers, with a negative result occurring if the cover chosen gives rise to the development of plagues of the principal crop.

3.3. Identification and Hierarchically Structuring the Barriers and Facilitators for Adopting Sustainable Practices

As a result of the survey and pooling process, the participants in the first phase selected those factors that can be applied to the case study. Specifically, they identified a total of seven principal barriers and five facilitators for implementing the different sustainable practices (Figure 3). The principal barriers are the lack of information on the practices, macro factors such as the absence of a system to control the fulfilment of the legal regulations, the implementation and maintenance costs, cultural aspects, uncertainty with regard to risk, disadvantages related to the size of the farm and certain characteristics of the proposed sustainable practices. Among the facilitators, we found the existence and accessibility to the necessary technology, the improvement of farmers training, the level of awareness of the different interested parties, the influence of the social norms and the existence of incentives for adopting sustainable practices.

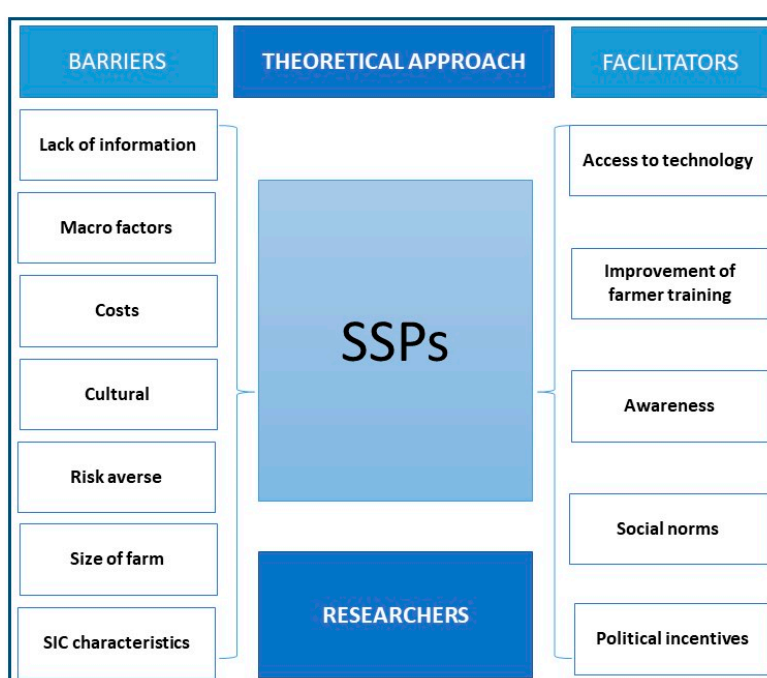


Figure 3. Main barriers and facilitators identified during the first process of interviews.

These factors condition the adoption of the sustainable practices differently. In general, the profile of the farmers has evolved in recent decades. On the one hand, the overall level of training of farmers has improved. However, there is a high level of disconnection between farmers and researchers, which leads to a serious lack of knowledge among farmers of the existence of those practices, of their implementation and benefits [33]. The average age of farmers is usually high and in general there is no generational replacement. Therefore, certain prejudices are prevalent regarding the abandoning of traditional practices, even though they are inadvisable or even restricted today, such as the burning of pruning residues or frequent tilling. A generational replacement is necessary for the generalization of the adoption of sustainable practices in the Mediterranean olive growing sector [33].

In the countries of the European Union, there are regulations aimed at ensuring that the agricultural sector fulfils a minimum level of respect for the environment. Some of the specific limitations are related to the use of pesticides, fertilizers, and chemical products, waste management or the pollution of water bodies. However, in many cases the competent authorities fail to undertake an appropriate follow-up of the level of compliance as stipulated in the requirements of the European Commission [71]. This is the case of Spain, where certain practices that have been prohibited are still carried out due to the absence of administrative control and an environmental awareness among farmers [72]. On the

other hand, the European Union provides incentives for the adoption of sustainable practices, for example, agro-environmental schemes.

The Mediterranean basin has a series of advantages for developing agricultural activities, such as mild temperatures and plenty of hours of sunshine. However, the poor soils, the scarcity of rainfall and the consequences of climate change are determining factors, with water being the principal limiting factor [73]. The rivalry of cover crops versus olive groves for available water is one of the principal factors to consider among the adverse characteristics of the proposed sustainable practices. The water consumption of cover crops in the driest periods can prevent resource availability for olive trees. This could lead to a decline in the olive crop yield, so that the timing of cover crop mowing is critical for the SSPs success. On the other hand, the selection of herbaceous covers implies a risk in terms of the occurrence of pests and diseases. Furthermore, we should consider that, in some areas, the characteristics of the farms are fundamental due to their small size or the orography of the land [74]. Technology has provided solutions for the different limitations of the agricultural activity in recent decades. For example, there are now specific tools and machinery available for practically all of the tasks which can be adapted to the characteristics and circumstances of the different types of farms [75,76]. Similarly, the search for alternative water sources has contributed to ensuring the supply of water for irrigation in certain areas of the Mediterranean [77–80]. Even so, the characteristics of the agricultural sector, the volatility of prices and their dependence on external conditions such as climate imply that many farmers could have a very small profit margin, which limits them in accessing this technology. Furthermore, we should also consider other costs related to the consequences derived from the lack of action, such as, for example, the costs of soil erosion, estimated at €48/ha per year in the European agricultural areas [81].

In the second phase, the degree to which the different factors identified in the previous phase influenced the decision to adopt the sustainable practices in the area of study was analyzed. To do this, different types of stakeholders were consulted, as farmers, professionals and policy makers (28 participants). Figures 4 and 5 show the results of both rounds in the second phase.

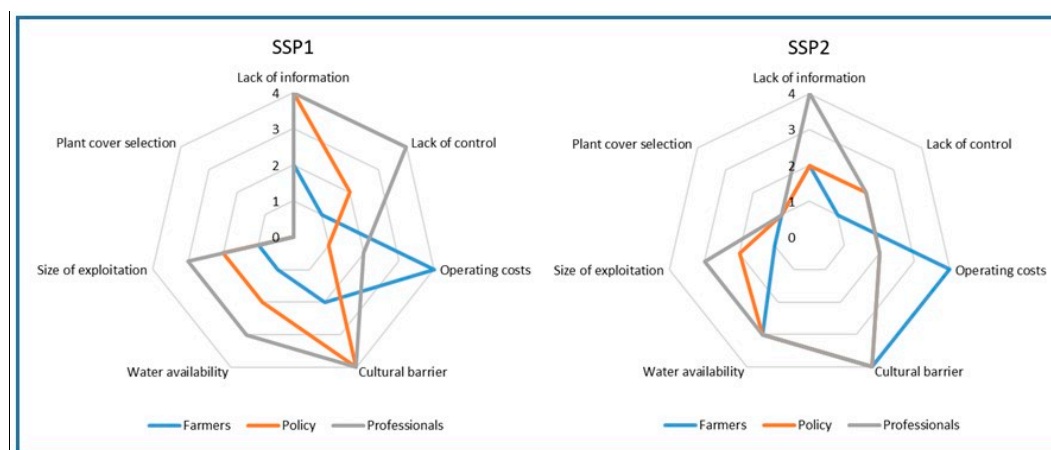


Figure 4. Main barriers assessed during the second process of interviews of SSPs.

Figure 4 shows the degree of intensity to which each of the barriers identified affects the adoption of the SSPs tested in the area of study based on the opinion of the different groups surveyed. The higher the score of this variable, measured from one to four, the higher the intensity with which it affects its level of adoption by farmers. In the case of SSP1, we can observe a high level of disparity in the opinions in general; with a greater agreement among professionals and policy makers. We should indicate that in this case, the limitation referring to the selection of cover plants is not applicable. Policy makers agree with the professionals that the principal difficulties for adopting this practice are the lack of information that the farmers have, together with the cultural barrier that makes them reticent to modify their behavioral patterns. These patterns include the belief that the best practice for their

crops is to leave the soil bare and continue engaging in traditional practices such as the burning of stubble and pruning residues. However, the professionals also find that the failure of the authorities to regulate the compliance with the established norms is equally problematic and they give great importance to the shortage of water in the area. Meanwhile, the farmers consider that the principal and almost only difficulty resides in the costs derived from implementing the new practice. This result is consistent with that of de Sastre et al. [69], which establishes that, after tradition, soil management is based on the economic profit, the quality of the product and finally, environmental reasons. In this study, only 7% of the farmers mention subsidies as an important factor to stimulate the adoption of a specific agricultural decision.

With respect to the SSP2, there is consensus among the three groups in that the principal barrier is cultural, given that it is difficult for farmers to understand that the soil should not remain bare, particularly due to the rivalry in the consumption of the available water. Regarding this last aspect, the availability of water, there is also unanimity, placing it in second place. However, the professionals find that once again there is a severe lack of knowledge among the farmers that should be solved. The farmers, meanwhile, reveal that the other main inconvenience is, again, the high costs. These results coincide with those obtained by Gómez [68], analyzing the use of the cover crops in Mediterranean olive growing.

Figure 5 shows the degree of intensity to which each of the facilitators identified affects the adoption of the sustainable practices tested, based on the opinion of the different groups surveyed. With respect to the SSP1, there is practically unanimity among the three groups regarding the determining factors, although this is not the case for the degree of intensity of those that condition this practice. First, it should be pointed out that the farmers were less confident about adopting this practice than the rest of the stakeholders. The main reason is that the results of this practice are more difficult to observe and measure and are obtained in the medium term. Both farmers and professionals hope that a successful experience by one of the reference farmers would serve as an example for the rest and facilitate the widespread adoption. Meanwhile, the policy makers understand that there are sufficient incentives provided by the authorities for the access to the technology and its widespread adoption.

With respect to SSP2, there is a higher level of confidence in all three groups, but for different reasons. The farmers believe that the level of training is sufficient for this practice to be easily adopted and are less reticent. Furthermore, they believe that the aesthetic aspect is also relevant but a priori this is not contemplated. The policy makers understand that the level of environmental awareness is widespread, even among the farmers, and the contributions of this practice are sufficiently visible for it to be easily adopted. They also believe that the incentives that exist constitute another sufficient reason. On the other hand, the professionals reveal a medium-high level of positive influence of all of the factors, except for the access to technology. In this respect, all of the groups agree that the access to technology is not decisive in this case.

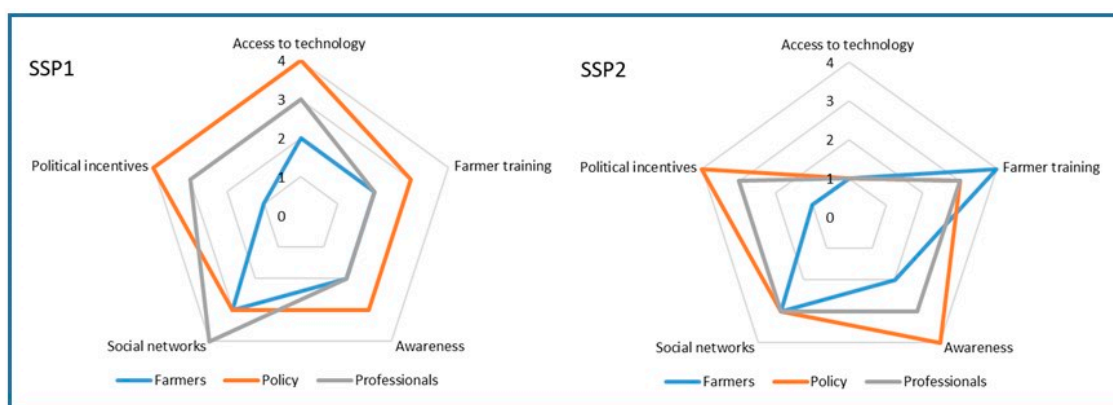


Figure 5. Main facilitators assessed during the second process of interviews of SSPs.

3.4. Proposal of Possible Actions for the Adoption of Soil Sustainable Practices

In this part of the workshop we proceeded in the same way as in the previous one. In this case, the objective was to establish possible actions to promote the adoption of sustainable practices based on previously identified barriers and facilitators. Finally, a consensus was reached and those actions that the group considered most relevant for adopting each of the practices were selected. The results are shown in Table 3.

Table 3. Actions to promote the adoption of sustainable practices by farmers.

1. Administrative Control	
2. Knowledge and awareness	environmental awareness technical knowledge on-farm demonstrations
3. Economic incentives	general incentives subsidizing specific costs

In general, one of the priority actions would be to call for a more exhaustive control by the authorities of the current regulations on water, nitrate pollution, waste management, etc. It has been revealed that the permissiveness of the authorities with respect to uncivil behavior, such as the burning of stubble and pruning residues, incites the rest of the farmers to engage in the same harmful practices. This is the case when the farmer adopts a specific practice that has been imposed by law and not out of conviction. When other farmers are observed to engage in banned practices with total impunity, a contagion effect can occur.

On the other hand, it has been shown that environmental awareness is a determining factor. In the area of study, the level of awareness is high with respect to the water resource, but not with respect to the soil. Small farmers of the area of study perceive agriculture as a way of life to bequeath to their offspring, which is a factor to be considered as an important facilitator. Although the overall level of training has increased, the degree of knowledge regarding sustainable practices is still low. Furthermore, although there is a certain level of knowledge of the sustainable practices, the belief that the traditional method is the best holds significant weight. It has been revealed that one of the best ways to change this situation is through direct observation. In view of all of this, one of the most urgent actions to be developed is the design of communication campaigns in three directions:

- To reinforce environmental awareness so as to create a need in the farmers to take action if they wish to maintain their way of life for future generations;
- to provide adequate technical knowledge in order to overcome the prejudices regarding the use of traditional practices; and
- to develop case studies that are used as examples of successful trials in the area with the same characteristics as the other farms.

Finally, we should not forget that the economic-financial aspect is highly relevant for the sustainability of the agricultural activity. In this respect, the stakeholders consulted considered that there are two priority lines of action. First, to reinforce the economic and financial incentives for adopting sustainable practices in the use of agricultural soil, but developing specific instruments for the local problems and carrying out an effective control of the level of compliance. Second, to subsidize those elements that may represent a direct barrier to the adoption of the sustainable practice, for example the purchase of seeds, access to machinery, etc.

4. Conclusions

The results of this study have revealed the usefulness of the participatory qualitative methodologies for clarifying complex problems in which a diverse range of factors are at play and in which different

groups with opposing interests and opinions participate. Furthermore, the joint use of different complementary tools, depending on their appropriateness for each phase of the research, such as surveys, the Delphi method or workshops, has revealed synergies that enable us to reach consensus conclusions.

The results also reveal the different approaches to adopting sustainable agricultural practices depending on the type of stakeholder considered. Farmers now have a higher level of training and environmental awareness than in previous decades. However, economic interests continue to have a greater weight in their decision-making than any other factor. Furthermore, there is a certain feeling of “impunity” with respect to the non-compliance of the regulations prohibiting the use of harmful traditional practices, justified by the absence of any kind of penalization. On the political level, we can observe the existence of a certain degree of self-satisfaction for a job well done due to the availability of regulations providing farmers with training and resources to act in a sustainable way. However, the politicians are reluctant to assume any responsibility for the mal praxis of the farmers. Meanwhile, the technicians and professionals constitute a good communication link between the previous two groups given that they have an intermediate position with respect to the issues presented. These stakeholders have a more objective criterion, based on empirical experience and their direct contact with the reality of the farmer, their problems and their options for improvement.

Finally, it has been confirmed that in recent years, in the area of study a great deal of progress has been made with respect to training, raising awareness and in agriculture in general; but there is still a great opportunity for improvement thanks to the possibilities that the technology and scientific knowledge have to offer. The results of this study can be applied to the rest of the Mediterranean agricultural regions, particularly in marginal areas with a long tradition in woody crops and impoverished soils.

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