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# Adopting sustainable water management practices in agriculture based on stakeholder preferences

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**Abstract:** Technology has made it possible to achieve the very efficient use of water resources in agriculture. However, there are a set of practices that could increase both the availability and quality of the water resources, but which are not yet widely used. In view of the scarcity situation mainly produced by the consequences of climate change, the objective of this work is to analyse the adoption of sustainable irrigation management practices in agriculture. To this end, the aim is to identify and evaluate the variables involved in adopting sustainable practices in agriculture through the use of different qualitative research tools in successive phases (literature review, in-depth interviews, Delphi method and workshop). The results indicate that the sustainable practices to be adopted to improve water management in the study area are rainwater harvesting (RWH) and pond covering (PC). The main barriers are the costs, some farm characteristics and lack of research, while the facilitators include easy access to technology and the existence of farmer-to-farmer networks. Furthermore, the most influential stakeholders for these practices are the farmers, policymakers and researchers. Proposals for the adoption of sustainable water use practices have also been made consensually with all the involved agents.

**Keywords:** behavioural economics; participatory methodology; qualitative research; stakeholder involvement; sustainability; water resources management

The scarcity and deterioration of water resources are making their management in the agricultural field increasingly complex. Current changes in the state of water resources generate impacts on the development of agricultural activities. Among them, we can mention the increase in the water demand as a result of the increased evapotranspiration of crops, the growing scarcity of water, mainly in areas that already suffer water stress, the deterioration of the water quality, the increased risk of floods, and the sea level rise in coastal areas (Aznar-Sánchez et al. 2019). Therefore, one of the main challenges facing agriculture is to reconcile the satisfaction of the growing demand for food with the use of more sustainable agricultural practices, especially in the management of water resources (Laurett et al. 2021).

Numerous studies have addressed the adoption of sustainable agricultural practices in relation to the

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management of water resources. Some of them have highlighted the difficulty in implementing the adoption of sustainable measures in agriculture due to the existence of several stakeholders pursuing conflicting objectives (Feola et al. 2015). Some studies show that opposition from interest groups is the main constraining factor for the successful adoption of new practices in agriculture (Grover and Gruver 2017). It is, therefore, necessary to design proposals that take the stakeholders' needs into account and that reconcile the diverse views (Aznar-Sánchez et al. 2017). Other studies have highlighted the need for greater knowledge about the reasons that limit the adoption of this type of practice (Long et al. 2016). Understanding the barriers and facilitators involved in the adoption of these practices is another aspect that requires a higher level of research. Similarly, confronting the different approaches of the set of stakeholders can be a very relevant practice when developing effective intervention measures in this field (Wang et al. 2016). The relevance of the collaboration of farmers is also highlighted since it can be considered that these agents are mainly responsible for the introduction of sustainable practices in agriculture, so understanding their perception in this field is also essential (Feola et al. 2015).

This work aims to contribute to filling this research gap through the identification and evaluation of the variables involved in the adoption of sustainable practices in water resource management in agriculture. Specifically, it aims at addressing the following gaps: *i*) what are the best practices to help sustainably manage water resources in intensive agricultural systems; *ii*) who are the main involved actors in such management and what role do they play; and *iii*) what are the main barriers and facilitators for such practices. This study was carried out in south-eastern Spain, where an agricultural model based on the use of greenhouses has been developed. The intensification of agriculture through the use of greenhouses has allowed an increase in the productivity of the land thanks to the increase in the production on the same cultivated surface (Valera et al. 2016). In the field of water resource management, there are agricultural practices that could represent additional progress but that have not yet been widely implemented (Reca et al. 2018). Thus, within this case study, it is intended to identify the possible sustainable practices to be adopted in water management, as well as the main barriers and facilitators and the stakeholders that influence the generalisation of its use the most. Finally, proposals will be developed in agreement with all the parties involved for the adoption of sustainable practices of water use. The results obtained from this case study can make an important contribution to the creation of programmes to achieve improvement in the sustainable management of water resources in agriculture.

## MATERIALS AND METHODS

**Study site.** This research took place in south-eastern Spain, which has the highest worldwide concentration of greenhouses (Thompson et al. 2020) (Figure 1). In this region, there are 32 554 ha of greenhouses distributed in two main areas: Poniente (Campo de Dalías) with 67% of the total area and Levante (Campo de Níjar and Bajo Andarax) with 28% of the total area (Aznar-Sánchez et al. 2019). The agricultural development of this area is based on the use of plastic greenhouses, which protect crops from wind and low temperatures in winter; and on the 'sanding' technique, the laying of artificial gravel and sand layers on the soil (Valera et al. 2016). The two most characteristic greenhouse structures in the area are the 'flat-top' (29.1%), where the roof has no inclination; and the sloping roof (68.7%), in which the roof is divided into inclined slopes allowing the rainwater evacuation and preventing the crop from getting wet (Carvajal et al. 2016). Drip irrigation is used, and most farms have ponds for water regula-


Figure 1. Location of the study site

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tion and storage (Casas et al. 2015). Production has specialised on six vegetable crops (peppers, tomatoes, zucchinis, cucumbers, eggplants and green beans) and two fruit crops (watermelons and melons).

The climatic conditions of south-eastern Spain, with a large number of sun hours per year and moderate temperatures, are ideal for agricultural production. However, the lack of rainfall, with an annual average of 220 mm per year, provides long periods of drought. Agricultural watering in this area has mainly been based on groundwater. This has caused the overexploitation of aquifers, leading to severe water deficits and progressive salinisation (Casas et al. 2015). This problem is especially relevant in the area of Campo de Níjar and Bajo Andarax, where the water electrical conductivity is quite high and makes it difficult to produce crops sensitive to salinity (Aznar-Sánchez et al. 2017). To address this problem, alternative systems have been developed to provide further sources for agricultural irrigation, such as desalinated water and recycled water (Aznar-Sánchez et al. 2019). However, despite the existence of practices that have improved water management in this area, the farmers' implementation level is still limited. Therefore, it is necessary to analyse the factors that influence the farmers' practices and propose possible strategies to promote their use, which will be agreed upon and accepted by all stakeholders.

In this study, different qualitative research tools were used to collect primary and secondary information based on the requirements of the different phases of the research. In this way, it is intended to obtain detailed exploratory knowledge and validate it at the system level by all the agents involved. The set of tools used includes a review of previous literature, in-depth interviews with academic experts, the Delphi method with experts in the study area, and a workshop with the key stakeholders. This procedure will be referred to as the multistage qualitative exploratory approach involving stakeholders (MSQS) (Figure 2).

First, a literature review was conducted to synthesise the previous general knowledge developed globally for application to the case study and to establish the conceptual framework underpinning the rest of the process (Qu and Dumay 2011; Gardas et al. 2019). The review included scientific literature obtained from the main databases and grey literature published by official sources specialised in the agricultural field. As a result, it was determined that the main limiting factor for the sustainability of the agricultural model in the study area was the scarcity of water resources (Aznar-Sánchez et al. 2017; García-Caparrós et al. 2017). Therefore, the next phases of the research focused on determining the possible practices to be implemented to address this challenge.

Second, in-depth interviews were conducted with academic experts to identify sustainable water management practices in agriculture, as well as the relevant criteria, and with the stakeholders to assess and imple-

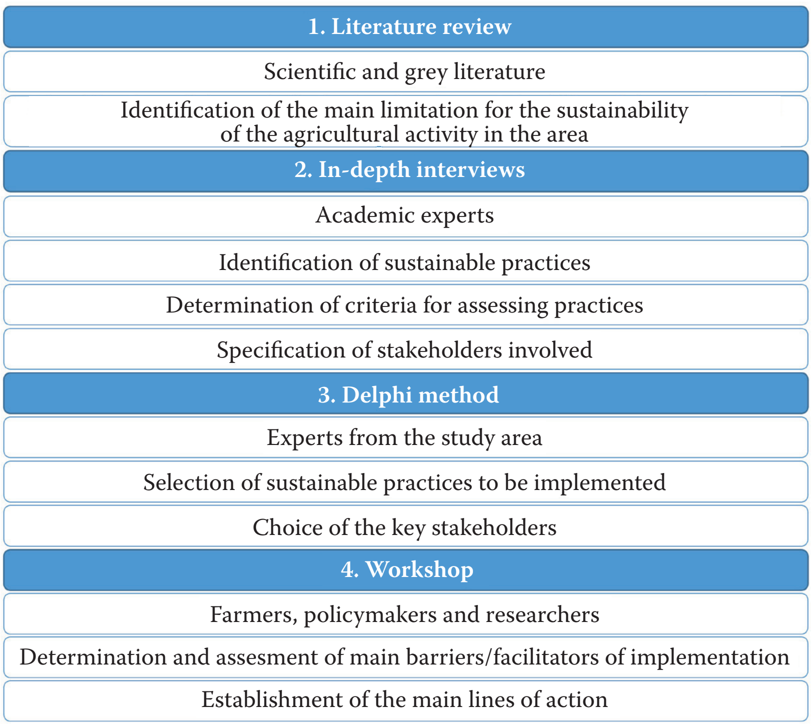


Figure 2. Multistage qualitative exploratory approach involving stakeholders (MSQS)

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ment such practices. In exploratory studies, the initial interviews usually provide a higher level of knowledge, while the subsequent interviews tend to focus on verifying the aspects learned in the previous interviews (Qu and Dumay 2011). Therefore, the number of interviews should be conditioned by the achievement of such verification. In our research, five interviews were necessary [Table S1 in electronic supplementary material (ESM); for the ESM see the electronic version], conducted in February 2021, using a script with a series of open-ended questions (Table S2 in ESM; for the ESM see the electronic version). The interviewees were experts from the fields of soil and agricultural chemistry, plant production, ecology, applied economics and agricultural vocational training.

A Delphi analysis was then carried out to select the most appropriate practices for the case study based on the established criteria and to determine the set of key actors in order to design the strategies that enable their widespread adoption. The Delphi method is a qualitative tool that aims to identify and organise, by relevance, those aspects that influence the processes in which complex decisions are made (Panagea et al. 2016), by means of a panel of experts specialised in areas related to the topic to be investigated (Gardas et al. 2019). A minimum number of thirteen members can guarantee reliability of at least 80% (Qu and Dumay 2011). In this case, the group of participants included a total of fourteen experts (Table S3 in ESM; for the ESM see the electronic version) in different areas of sustainable development and the local agricultural system who were selected using the snowball technique. Delphi participants were representatives of the involved sectors: Delegation of Agriculture of Almería, Organisation of Irrigators of the Poniente, Public Centre for Agricultural Research, Professional Agricultural Organisation, Organisation of Fruit and Vegetable Producers, Department of Agronomy of the University of Almería, Area of Agriculture of the Local Administration of the Poniente, Organisation of Agricultural Technicians, Organisation of Irrigators of the Levante, Private Centre for Agricultural Research, Fruit and Vegetable Cooperative, Area of Agriculture of the Local Administration of the Levante, Organisation of Companies of the Auxiliary Industry of Agriculture, and Organisation of Irrigators of the Province of Almería.

Each participant was given a questionnaire consisting of two parts (Figure S1 in ESM; for the ESM see the electronic version). In the first part, the participants were asked to rate the suitability of each of the practices for implementation in the study area, based on the different criteria identified in the previous phase. In the second part, they were asked to assess the level of influence of each stakeholder group has on the process of adopting water management practices in agriculture in the area. A 5-point Likert scale was used in both cases. Participants could add comments on all aspects included in the questionnaire. Once the results of this first round were obtained, they were analysed and the mean values, mode and standard deviation of the obtained responses were calculated. In the second round, the same questionnaire was sent again to the participants, including the results obtained in the previous round (Figure S2 in ESM; for the ESM see the electronic version). Based on this information, they were asked to re-evaluate each of the items. Following previous studies, the standard deviation criterion (Henning and Jordaan 2016) was used to determine whether a consensus had been reached. According to this criterion, a standard deviation between 0.00 and 1.00 corresponds to a high level of consensus, a standard deviation between 1.01 and 1.49 corresponds to a reasonable level, and a standard deviation between 1.50 and 2.00 corresponds to a low level, and there would be no consensus if it is higher than 2.00 (Henning and Jordaan 2016). After the second round, the level of obtained consensus was reasonable or high for all the items, so the process was terminated. This phase was carried out between March and April 2021.

The last stage of this methodological procedure consisted of a workshop with a selection of key stakeholders, which had the dual objective of identifying and assessing the barriers and the facilitators with regard to the adoption of the selected sustainable practices and of developing a proposal for measures to promote their implementation in the study area. The groups identified as particularly relevant to the adoption of water management practices in the area were farmers, policymakers and researchers. Each stakeholder group was equally represented, with a total of three participants (Table S4 in ESM; for the ESM see the electronic version). The workshop was held in May 2021.

This work aims at obtaining qualitative information that will serve both to draw valid results and conclusions and as a foundation for further quantitative studies. It can be pointed out that the lack of statistical analysis at this stage could be a current work limitation. However, this does not diminish the validity of the obtained results due to the varied research tools employed. On the other hand, a future line of research in the field could fill this gap through a quantitative study on specific variables.

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## RESULTS AND DISCUSSION

**Selection of sustainable water resource management practices.** Based on the results of the literature review and the in-depth interviews, the focus was placed on the sustainable management of water resources in the study area. To this end, a set of practices was identified and criteria were established to assess their suitability for the study area (Figure 3). In the next phase of the research, the experts consulted in Delphi used these criteria to select the practices to be applied from the proposed set (Table S5 in ESM; for the ESM see the electronic version). The results obtained for each of the practices analysed can be found in the supplementary material (Tables S6–S10 in ESM; for the ESM see the electronic version). Considering the mean value for the set of items for each of the practices, it can be determined that rainwater harvesting (RWH) and pond covering (PC) are the most suitable to be developed in the study area, as they present the highest values. Furthermore, the level of consensus on these practices is high, as their standard deviation is less than 1, which shows that there are no significant differences in the scores given by the respondents on the different items.

RWH consists of the collection of water from precipitation and condensation from the greenhouse roof through gutters installed to conduct the water to a system of downpipes for storage or evacuation to a pond (Leong et al. 2018). This system can only be incorporated into greenhouses with sloping roofs. Approximately 50% of the farms in the study area have RWH systems, but there are no data on how many of them use water for agricultural irrigation (García-Caparrós et al. 2017). The most valued variables of this practice are related to the cost savings and protection against torrential rains, 'which cause damage to roads and other forms of infrastructure' according to Participant 11. Thus, the respondents indicate that these systems help to save costs for the maintenance of the installations because they minimise serious damage, both on the farms and in the vicinity and on roads, which results in an improvement in the occupational safety on the farm (score of 4.1 points) and in the protection of the environment (4.0 points). In addition, this practice helps to reduce costs as the resource obtained is free of charge (4.4 points). Compared to the other practices, the respondents identified RWH as having the lowest environmental impact (4.4 points). Contrary to previous studies, the respondents do not consider the contributions of RWH in terms of water autonomy (2.3 points), increased production (3.4 points) and diversification of production (3.3 points) to be relevant (Redwood et al. 2014; Panagea et al. 2016). According to Panagea et al. (2016), the respondents think that one of the weaknesses of this practice is that it may increase the input use because the water has a lower concentration of nutrients, which may require higher fertiliser use (2.9 points).

PC consists of the installation of a concrete cover or polyfibre or polyethylene shade cloth that covers the pond, limiting the loss of stored water by evaporation (Juan et al. 2012). In the case of the performance with a shade cloth, the efficiency of this system can vary between 70% and 95% (Juan et al. 2012). It has been estimated that 40% of the ponds are covered in the study area (García-Caparrós et al. 2017). With respect to the rest of the practices, it is the one that allows a greater level of autonomy to the farmer in terms of its management (4.9 points), requires less investment (4.6 points) and requires less training for its use (4.2 points). Participant 2 indicated that 'covering the ponds using a shade

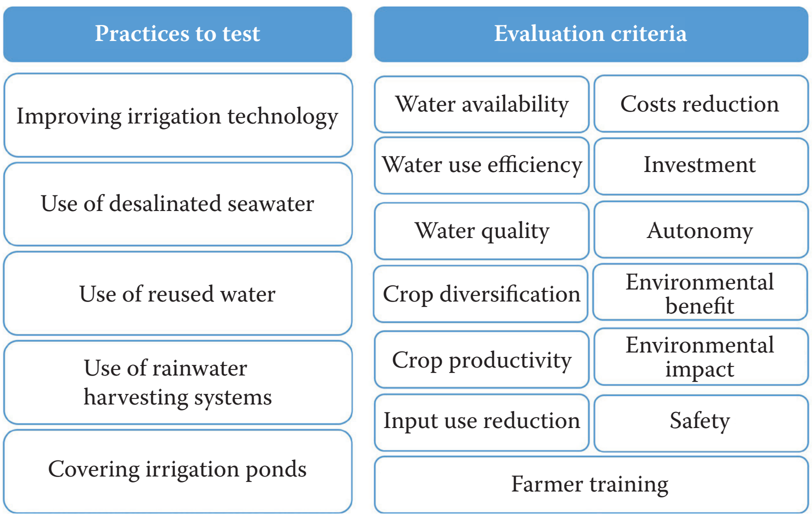


Figure 3. Proposed practices and criteria to consider for the selection of final practices

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cloth is not a very high cost and, in addition, in many cases, farmers save on labour by installing it themselves'. In addition, this practice is of great importance to prevent accidents resulting from falls into the ponds, thus contributing to occupational safety on the farm (4.6 points). On the other hand, the participants value that keeping the pond covered improves the water quality (4.0 points), and reduces the need for supplies to clean the pond and for pond maintenance (4.2 points). Moreover, the reduction of evaporation by covering the ponds decreases the salinity of the water stored in the ponds, which is perceived as an improvement in the water use efficiency by the respondents (3.9 points). Carvajal et al. (2016) quantified this reduction in water losses by evaporation in the agricultural ponds of Almería by up to 83%. However, given the small average size of the ponds in the study area, the participants understand that the impact of this practice is lower in terms of increasing the available water (1.1 points) and improving productivity (1.8 points) compared to the other practices.

**Identification and selection of key stakeholders for the adoption of sustainable water resource management practices.** The literature review and in-depth interviews allowed the identification of the different stakeholder groups involved in the adoption of sustainable water resource management practices in the study area. A total of thirteen groups related to the adoption of these practices were differentiated: academia, auxiliary industry, credit institutions, employees, farmers, farmers' organisations, local residents, non-governmental organisations, other economic sectors, policymakers, researchers, supply chain and technicians. In the next phase of the research, the experts consulted in Delphi were asked to assess the ability of the different stakeholder groups to influence the process of adopting sustainable practices of water resource management in the agriculture of the study area. The objective was to identify the most influential groups, called 'key', to involve them in the design of strategies to facilitate the widespread adoption of the proposed practices. The stakeholders considered 'key' according to the group of experts consulted are the farmers, policymakers and researchers since they obtain an average score higher than 4 points (Table S11 in ESM; for the ESM see the electronic version). In general, the rest of the stakeholder groups show a secondary level of influence compared to the first three. The stakeholders that obtained a lower average score are the supply chain, employees and other sectors. Finally, the level of consensus regarding the valuation of each of the stakeholder groups is high or reasonable.

**Determination and evaluation of the barriers and facilitators for the adoption of sustainable water resource management practices.** The first objective of this phase was to identify and evaluate the main barriers and facilitators in order to consider how to design the strategies for the adoption of the proposed practices. The results collected a total of 6 barriers and 6 facilitators. Regarding the barriers, some cultural aspects related to the farmers were highlighted, such as their advanced age, the lack of generational change, and the reluctance to change their usual way of managing the farm and incorporate new practices. Other studies show that these types of factors tend to be an obstacle when implementing any type of innovation in the agricultural sector (Wang et al. 2016). The lack of research on these practices and their effects generates doubts among the stakeholders that may limit their implementation. In addition, the disconnection between farmers and researchers accentuates this aspect (Perry-Hill and Prokopy 2014). Another limiting factor is the local characteristics of the study area and the farms, such as 'limited space for pond construction or expansion' (Participant 1), and 'the age of many farms which affects the investment needed to adopt these practices' (Participant 3). This poses a barrier to the implementation of the proposed measures due to the need for additional investment (Wang et al. 2016; Liu et al. 2018). On the other hand, in the study area, there is a lack of regulation on some aspects of agricultural activity, and the level of compliance is limited, as indicated by Participant 9, 'due to the authorities' failure to supervise the facilities and their proper use by farmers'.

Regarding the facilitators that can encourage the adoption of these practices, first, the existence of a wide network of contacts of farmers in the study area stands out, since most of them are affiliated with some entity, be it for the commercialisation of their products, the acquisition of inputs or the water supply. The workshop participants indicated that these entities can facilitate the transfer of knowledge, training of farmers, and access to finance. Wang et al. (2016) stated that the transmission of knowledge based on the experience of farmers is the most effective for the adoption of new practices. Another relevant factor is the high efficiency of water use, so that six times less water is used in the study area than in the rest of Spain (Reca et al. 2018), which has reduced the importance of irrigation in the cost structure (Valera et al. 2016). Despite this, 'farmers are opposed to any increase in the price of water' (Participant 7), so the use of the proposed practices would help to balance the price increase due to the

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use of more expensive water sources, such as desalination or regeneration (García-Caparrós et al. 2017; Reca et al. 2018). In the study area, access to credit for the installation of improvements on farms is very affordable since financial entities, as well as trading companies, offer the possibility of fast and low-cost financing. Regarding environmental awareness, the participants considered that the level of perception about the consequences of climate change is increasing, especially in the rainfall patterns and the increase in the occurrence of extreme phenomena, such as droughts or floods, which can encourage the adoption of these practices. Finally, at the political level, there are instruments to promote the adoption of practices that can improve the situation of aquifers in the form of regulation and economic aid, which constitutes fundamental financial support (Aznar-Sánchez et al. 2019).

Figure 4 shows the opinion of each of the key stakeholder groups consulted on the degree of the intensity with which each of the aforementioned barriers affects the adoption of the proposed practices. In the case of RWH, the barrier due to the characteristics of the study area was rated as the most relevant (score of 5 points) by all three groups, as the high concentration of greenhouses leads to a significant limitation of space to extend or install a catchment basin. This limits the capacity of the collection systems to provide water for irrigation due to a lack of storage. Researchers and farmers agree that the characteristics of the farms make RWH difficult (4 points) because some farms still have flat greenhouses. On other farms, the problem stems from the fact that the irrigation pond is located at the top of the farm, making it necessary to have a reservoir at the bottom and pump the water to the pond, which increases the costs of this system. This result is consistent with those of García-Caparrós et al. (2017) and Reca et al. (2018). As in numerous previous studies, farmers perceive the cost as one of the main barriers (5 points), being one of the main limiting factors in implementing better management practices at a farm level (Liu et al. 2018; Prokopy et al. 2019). Researchers and policymakers consider cultural barriers to be the main obstacle for farmers to adopt this practice (5 points), as many farmers are reluctant to change their usual way of managing farms. In the case of the PC, the limitations derived from the characteristics of the study area and the farms are of lesser importance, although the strong winds in some areas and the location of the pond may influence the possibility of installing them. Stakeholders agree that the main barrier to the use of covers for ponds is the lack of research on the real benefits provided by this practice (5 points). This result is in line with Long et al. (2016). Cultural aspects, in this case, also act as an important barrier for policymakers and researchers (4 points). Researchers point out that the lack of regulation and protocols on the proper use of covers is a very important limiting factor (5 points). For farmers, the costs remain a major constraint (5 points), especially given the uncertainty about the expected returns on the investment.

Figure 5 shows the opinion of the surveyed stakeholders on the facilitators affecting the adoption of sustainable practices. In the case of RWH, farmers highlight social networks as the most important enabler (5 points), as they allow them to get first-hand information and demonstrations through verifiable experiences. Researchers and policymakers consider the main driver to be the cost of water (5 points), as opposed to the ex-

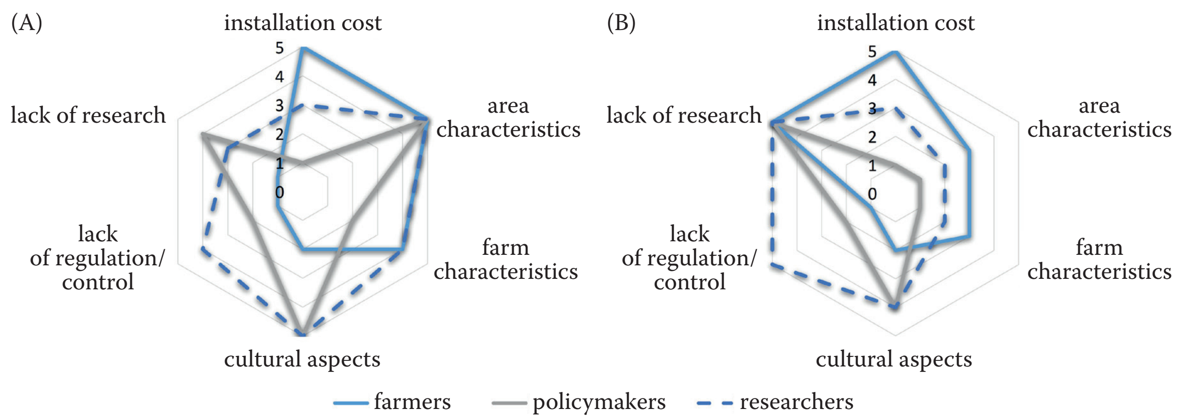


Figure 4. Main barriers to the adoption of sustainable practices by group: (A) rainwater harvesting (RWH) and (B) pond covering (PC)

Source: Authors' own elaboration

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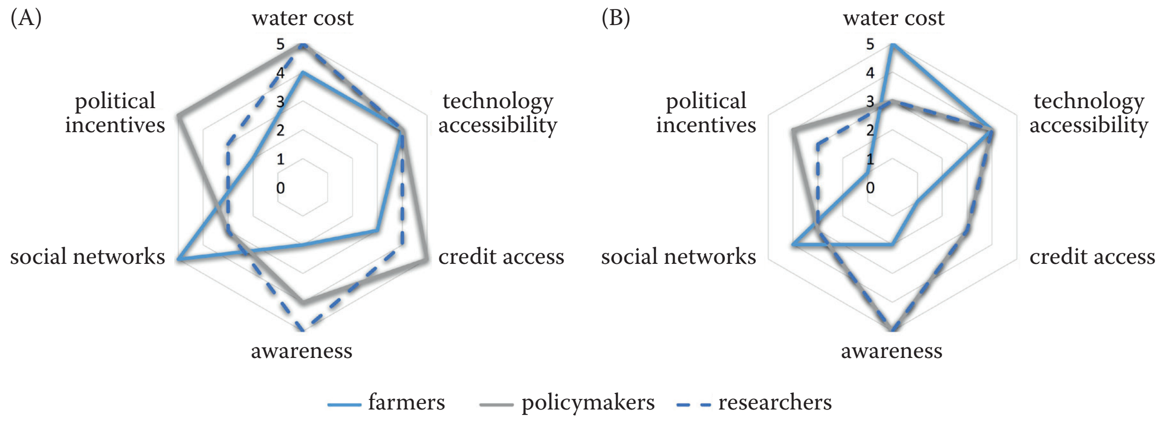


Figure 5. Main facilitators of the adoption of sustainable practices by group: (A) rainwater harvesting (RWH) and (B) pond covering (PC)

Source: Authors' own elaboration

pected increase in the use of more expensive alternative water sources, due to the declining quality of the groundwater due to overexploitation. All three groups consider access to technology as a very important enabler (4 points). Policy makers argue that the administration has put sufficient incentives in place for farmers to adopt these sustainable practices through regulation (5 points) and providing funding facilities (5 points). However, they consider that more could be done in this respect (3 points) because there are different regulations and degrees of control depending on the area, which leads to confusion among farmers. The results obtained for the PC show that farmers consider that the most important drivers are the price of water (5 points), social networks (4 points), and access to technology (4 points). The three groups consulted agree on this last point. Likewise, farmers consider that access to credit only has medium importance (3 points) given that the cost of investment is lower. Both policymakers and researchers believe that the level of environmental awareness is presented as an important facilitator, valuing it with 5 points. However, although farmers in this area have a high level of environmental awareness, they do not consider this factor especially relevant when incorporating this practice and value it with 2 points.

**Proposal of the actions for the adoption of sustainable water management practices.** After debating and clarifying the main points of support and obstacles to the adoption of the proposed practices based on the points of view of each of the main groups involved, the next step in the research was to design a consensual strategy for their implementation in the study area. First, a greater effort on the part of the administration is necessary, both in the development of specific regulations and in the control of compliance with those already in force. The existence of different municipal regulations for the installation and use of RWH systems in greenhouses generates a comparative feeling of injury among the farmers in neighbouring municipalities. Therefore, the development of a regulatory proposal or general regulatory framework is recommended where the action protocol for the farmer is collected and adopted by all the municipal administrations of the study area. On the other hand, the aquifers that provide the groundwater of the study area exceed the municipal scope, so the practices carried out in a municipality have an impact on the resources available in the area as a whole. Therefore, the homogenisation in the regulation and the level of demand for agricultural holdings throughout the study area improves the level of equity, as well as the state of the common resource.

On the other hand, it has been shown that social relations in the agricultural field, mainly among the farmers themselves, but also with the rest of the parties involved, are a fundamental factor. However, the level of communication between the different stakeholders differs in intensity. On the one hand, the level of associations of farmers is very high. In addition, knowledge based on the experience of other farmers is highly valued. These two factors can facilitate the transmission of knowledge and the formation of this group. On the other hand, it has been found that there is a disconnect between the level of technical-scientific knowledge and the perceptions of the different stakeholder groups. Therefore, the communication channels between the groups should be strengthened. Thus, an action plan is proposed that aims to *i*) strengthen the current communication channels of the sector as a whole

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as well as to establish new ones, where the different stakeholders meet periodically to debate the relevant issues; *ii*) achieve greater collaboration between the researchers, technical personnel and farmers that allows the continuous improvement of the sector, based on the needs of the producers and in regards to fulfilling the environmental objectives; and *iii*) use farms owned by the farmers themselves to evaluate the viability of the proposed sustainable practices and disseminate the success stories as an example for the rest of the farmers.

Finally, concerning the economic-financial sphere, the participants showed that it is necessary to provide farmers with more attractive economic incentives to adopt the proposed sustainable practices. On the other hand, the granting of subsidies that allow farmers to access the existing technology without affecting their level of indebtedness can also be a great boost for its adoption.

## CONCLUSION

The current agricultural systems must face the challenge of increasing their production to meet the demand of a growing population in the context marked by the consequences of climate change, especially in terms of the availability of water resources. To face up this challenge, technology provides a set of solutions that must be adapted to the specific circumstances of each productive area. In addition, when designing an adaptation plan to the new circumstances, it is essential to consider the stakeholders' objectives and interests. This work constitutes a significant contribution to this field of study. On the one hand, the methodological development used, based on the successive use of different qualitative research tools, can be replicated in any other agricultural context to design strategies for the sustainable management of water resources. On the other hand, the varied research tools made it possible to design a proposal for the introduction of management measures that improve agricultural water sustainability in the studied area. This proposal is not generally applicable to other agricultural systems. The results can be applied to greenhouse systems in arid or semi-arid environments with scarce water resources.

The results have identified the best practices for the sustainable management of water resources in agriculture: the installation of RWH systems in the greenhouses of the study area; and the covering of agricultural ponds. The use of these two selected practices could reduce the farm water demand by up to 40%, which, in economic terms, could mean savings of over EUR 700 per ha and a season of the total water costs. Thus, in the case of covering ponds, further expenses can also be reduced as it is not necessary to use additional methods to keep them in good condition, such as drainage or biocide products, which amounts to EUR 100 and EUR 141 yearly per pond. On the other hand, it is also necessary to take the avoided costs derived from the reduction of farm damages as a consequence of torrential rains into account, although these are difficult to quantify. In any case, the savings generated by these practices may be even greater due to the general increase in prices that is taking place globally, especially in the case of energy. This can help to ensure the sustainability of a sector that generates EUR 1 800 million per year and is the livelihood of more than 15 000 farmers, as well as potentially generating 40 000 new jobs.

The various stakeholder groups identified include auxiliary industry, credit institutions, employees, farmers, farmers' organisations, local residents, non-governmental organisations, other economic sectors, policymakers, researchers, supply chain and technicians. Among all of them, the groups considered decisive for the introduction of sustainable water management practices in agriculture are the farmers, as they are ultimately responsible for this. Further key actors are policymakers, such as those in charge of establishing the corresponding regulations, and researchers, as the main providers of knowledge about the procedures and results of effective water management practices.

The main drivers for these practices are the availability of the needed technology, access to credit, the water cost, the level of the farmers' awareness, existing contact networks and the political impetus. The main barriers derive from the characteristics of the farms in the study area, the lack of regulation or control over it, the research scarcity, various cultural aspects and the installation costs. Based on the main identified drivers and barriers, the development of a common regulatory framework for the whole study area is proposed, based on a deeper understanding of the implementation of sustainable practices. In addition, greater collaboration is required between the involved groups and improvement in the communication channels is also necessary. Finally, the establishment of economic and financial measures would provide an added boost as farmers value them very positively.

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