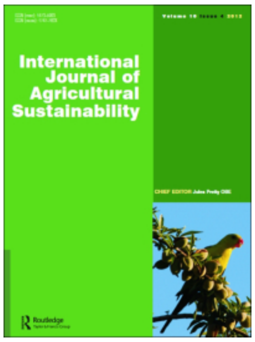

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Farmers' profiles and attitudes towards the implementation of rainwater harvesting systems in intensive agriculture

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ABSTRACT

Rainwater harvesting (RWH) systems are presented as a feasible alternative to increase water resources for agricultural use. However, the installation of these systems in farmers' holdings is very limited. It is necessary to know the opinions and attitudes of farmers towards these systems to develop specific measures that respond to their needs. This study analyses the case of intensive agriculture in southeastern Spain. The objective is to understand the attitudes of farmers in relation to the installation of RWH systems. A profile of farmers regarding RWH usage was developed through cluster analysis techniques. The results show that the detected farmer groups have different preferences and attitudes regarding RWH and the incentives that could be implemented to encourage its use. The most important obstacles to implementing RWH are not only economic but also technical and agronomic. Additionally, the degree of environmental awareness a farmer has plays a key role in their decision to install RWH systems. Recommendations based on the findings of this study are provided for policy-makers. The results of this research may be useful for those regions that are considering RWH, especially in areas where water availability is a limiting factor for agricultural development or compromises its sustainability.

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KEYWORDS
Water harvesting; water management; sustainability; intensive agriculture; farmer attitudes; cluster analysis

1. Introduction

Meeting the growing demand for food is one of the main challenges facing humanity (FAO, 2018). It is estimated that the world population will increase from 7.7 billion in 2019 to 9.7 billion in 2050 (UN DESA, 2019). As this population increases, it will be necessary to increase world food production by 70% (UN, 2012). Agriculture itself however, also faces various issues, such as the depletion of resources, soil degradation or the loss of biodiversity (Singh et al., 2017). Among the limiting factors of agricultural development is the growing scarcity of water (Hanjra & Qureshi, 2010).

The global demand for fresh water has multiplied by six in the last century, growing steadily approximately 1% per year since the 1980s (UN & UNESCO, 2021). In addition, it is estimated that global water demand will increase between 20% and 33% by 2050 (Burek et al., 2016). Currently, in many areas around the planet, groundwater extraction exceeds its recharge capacity, which is progressively depleting these resources and deteriorating their quality (Richey et al., 2015; Shamsudduha & Taylor, 2020; UN DESA, 2021). As water scarcity becomes worse, the growing competition between the different productive sectors for this limited resource becomes more evident. Many regions around the world will face conditions of constant or seasonal water scarcity as a result of increased demand in agriculture and other productive sectors

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and the uncertain availability of water resources induced by climate change (Greve et al., 2018; UNICEF, 2021). Agriculture is the largest consumer of fresh water worldwide, with irrigation representing approximately 70% of total water use (Knox et al., 2012). In addition, 40% of the land surface dedicated to irrigated agriculture uses water that comes from underground sources (Siebert et al., 2010). Therefore, it is essential that water resources are efficiently and sustainably used for agricultural activities.

One of the practices that can help improve the availability of water resources for agricultural use is rainwater harvesting (RWH). It is an ancient technique that consists of collecting and storing surface runoff for later use (Bafdal et al., 2017; Islam et al., 2013). Rainwater can be collected from the surface of the soil or from the roofs of different structures, such as buildings or greenhouses (Lye, 2009). Despite the existence of water distribution systems, people continue to collect rainwater due to water shortages (Eslamian & Eslamian, 2021a). These systems are presented as an effective way to expand the supply of water for agricultural use and are widely used during periods of drought (Liang & van Dijk, 2011b). RWH is one of the most efficient and simplest ways to reduce water consumption from external sources to meet crop water requirements (Eslamian & Eslamian, 2021b). In this way, these systems increase the resilience of farmers to the changes caused by climate change (Milhorance et al., 2022; Nyberg et al., 2021). Oweis and Hachum (2006) showed that up to 50% of rainwater could be used for agricultural purposes in the driest regions of Asia and Africa as long as appropriate collection techniques were implemented. Rahaman et al. (2019) concluded that rainwater and runoff could satisfy 71% of the total water demand for households and agriculture in a region of Bangladesh. In a study carried out in Australia, using harvested rainwater reduces the reliance on outside water by 30% in a hectare of greenhouse growing tomatoes and cucumbers (Jewell, 2016). Boyaci and Kartal (2020) determined that RWH could meet 48% of the water needs of a greenhouse tomato crop in Turkey. Singh et al. (2019) concluded that this percentage was 60% for a sweet pepper crop in India. Additionally, RWH can help in artificially recharging groundwater. For example, in the city of Lahore in Pakistan, Hussain et al. (2019) concluded that the groundwater level could be raised to 3.54 ft (feet) after each monsoon period once recharge wells are installed. Soni et al. (2020) showed that a recharge of up to 176 m^3 per well could be achieved in the Dharta watershed (Rajasthan, India).

In southeastern Spain, water management for agricultural irrigation has become an urgent matter because the intensive agriculture model developed in this region has traditionally been based on the use of groundwater (Aznar-Sánchez & Sánchez-Picón, 2010; Aznar-Sánchez et al., 2011). The availability and quality of water in this area is being seriously compromised due to the overexploitation of aquifers (Casas et al., 2015). Although there are other sources of water available in the area, such as desalinated water, this only represents a small percentage of the total water resources used (less than 5%) (Caparrós-Martínez et al., 2020). The use of this source involves an extra cost in the price of water for farmers, which represents an important limiting factor for its use, along with agronomic problems (Aznar-Sánchez et al., 2019). In this sense, RWH systems are presented as a feasible alternative to increase the availability of water in the area and, in this way, reduce the extraction of underground water resources (Carvajal et al., 2014). It could also be used to recharge these underground water bodies. Despite these advantages, less than 50% of holdings in the region have RWH systems (García-García et al., 2016).

Numerous studies have analysed the socioeconomic factors that affect the implementation of RWH systems (Arunrat et al., 2017; Mango et al., 2017; Recha et al., 2015; Rozaki et al., 2017; Shadeed et al., 2020; Tessema et al., 2018). The factors analysed are usually age, level of experience, educational level, family size, income, group affiliation, availability of income from other activities, contact with extension groups, participation in government projects, access to credit or the availability of advice. However, most of these studies have been carried out in developing countries and focus on subsistence and rainfed agricultural models. Along these lines, in his review of the research on RWH, Velasco-Muñoz et al. (2019) indicated that it is necessary to delve into the factors that determine whether these systems are adopted by farmers in developed countries and in intensive agricultural systems such as greenhouse agriculture. In addition, existing studies do not usually differentiate between the different types of farmers and, those that do, are limited to showing the differences between adopters and nonadopters (Mango et al., 2017). However, this differentiation is of great relevance since it allows policy-makers to establish measures based on the characteristics and needs of the different groups identified (Aznar-Sánchez et al., 2021).

The objective of this article is to cover the gaps mentioned in the research through the study of farmers attitudes towards the installation of RWH systems to cover part of their water needs for irrigation. To achieve this objective, the case of intensive agriculture in southeastern Spain is analysed, and the following aspects are examined: (1) farmers profiles in relation to the installation of RWH systems, (2) farmers attitudes towards the installation of these systems and (3) the extent of farmers agreement with a series of measures that are intended to encourage their installation. It should be borne in mind that this study also has limitations derived mainly from the possibility of extending the results to other geographical areas or agricultural models, since it has analysed the most relevant variables for the case of intensive agriculture in southeastern Spain, in addition to the fact that the attitudes and opinions of farmers may be conditioned by the characteristics of the study area. Nevertheless, the results obtained may constitute a starting point for designing and carrying out similar research in those areas where water availability is a limiting factor for maintaining or developing agricultural activity.

2. Material and methods

2.1. Study area

The development of this research has been carried out in the Campo de Dalías region, which is located in the province of Almería in southeastern Spain (Figure 1). This area has a Mediterranean climate with an average annual temperature of 19°C and annual rainfall of approximately 200 mm. In addition, it receives more than 3000 h of sunlight per year (Mendoza-Fernández et al., 2021). This area has the largest concentration of greenhouses in Spain, with 22,054 hectares (Junta de Andalucía, 2020), and small family holdings of approximately 2.5 hectares are distributed throughout (Junta de Andalucía, 2015). The production is concentrated in six vegetables (pepper, cucumber, zucchini, eggplant, green bean, and tomato) and in two fruits (watermelon and melon).

In the Campo de Dalías basin, 168.3 hm^3 of water is consumed per year for agricultural irrigation, which mostly comes from underground sources (Garcia-Caparros et al., 2017). In particular, the water comes from the Campo de Dalías–Sierra de Gádor aquifer. This aquifer was declared overexploited in the 1980s (Caparrós-Martínez et al., 2020) and currently the amount of water extracted from its aquifer continues to exceed its regeneration capacity, so its Horticultural Water Exploitation Index is 1.1 (Castro et al., 2019). The 2022–2027 Hydrological Plan of the Andalusian Mediterranean basin recognizes that this aquifer is one of the most deficient in the area and that it is overexploited, endangering the socio-economic development model implemented in the area (Tortajada & González-Gómez, 2022). However, no studies have been found that model the capacity of this aquifer and establish, taking into account current abstraction and recharge rates, the period of time that it will be able to continue to supply water to the area. The amount of water extracted from its aquifer exceeds its regeneration capacity, so its Horticultural Water Exploitation Index is 1.1 (Castro et al., 2019). Therefore, one of the main problems facing the agriculture of the Campo de Dalías is the limitation in the availability of water resources and the overexploitation of its aquifer. Faced with this situation, the use of technological improvements such as drip irrigation, automatic fertigation or the use of digital tensiometers to increase water efficiency has been applied (Valera et al., 2016). Additionally, the use of another source of alternative water supply for agricultural irrigation has been introduced, such as desalinated water. The Campo de Dalías desalination plant was commissioned in 2015 and has a capacity of 30 hm^3 per year, of which 7.50 hm^3 is used for agricultural irrigation (Mendoza-Fernández et al., 2021).

Unfortunately, these improvements in water use efficiency and the new source of water supply are still insufficient to meet the demand for agricultural water in this region. On the other hand, overexploitation of aquifers has led to a deterioration of water quality due to the elevated salinity from marine intrusion (Castro et al., 2019). This increase in the level of groundwater salinity could generate immediate problems because most of the crops grown in the region are not tolerant to high levels of salinity (Garcia-Caparros et al., 2017). Water use in this region is managed through irrigation communities, who are responsible for supplying water to member farmers (Caparrós-Martínez et al., 2020). The average price of water is € 0.30/m^3. However, this price has increased dramatically in recent years due to the

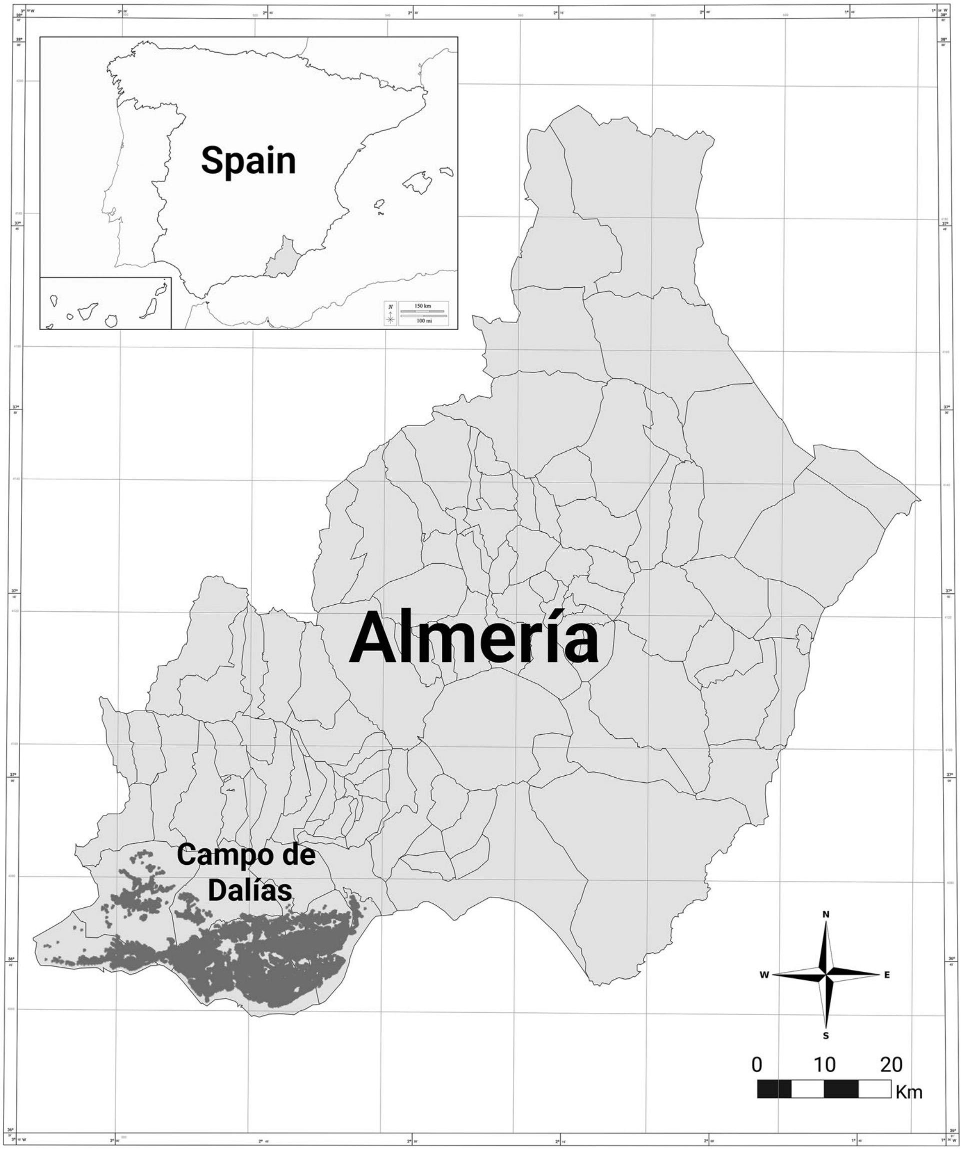

Figure 1. Location of Campo de Dalías in southeastern Spain.

need to extract it from a greater depth in wells and the consequent increase in electricity consumption. The average water consumption of the greenhouses in this area is 5000 m^3/ha per season (Garcia-Caparros et al., 2017; Piedra-Muñoz et al., 2017).

In this context of scarcity and overexploitation, RWH can be a feasible alternative to augment water availability for agricultural irrigation. This region is ideal for implementing this rainwater harvesting practice for two reasons: practically all greenhouses have a roof slope that sheds rainwater, and almost all holdings have ponds to store irrigation water and to regulate the flow of rainwater collected (Figure 2). Taking into account these two characteristics and the climatic conditions of the region, the storage of rainwater that falls on the roof of the greenhouses could reduce the external water needs of the holdings by more than 50% (Carvajal et al., 2014; Mendoza-Fernández et al., 2021). Despite these advantages, the actual implementation of this practice in the region is very low (BOP, 2017). For this reason, the Campo de Dalías region constitutes

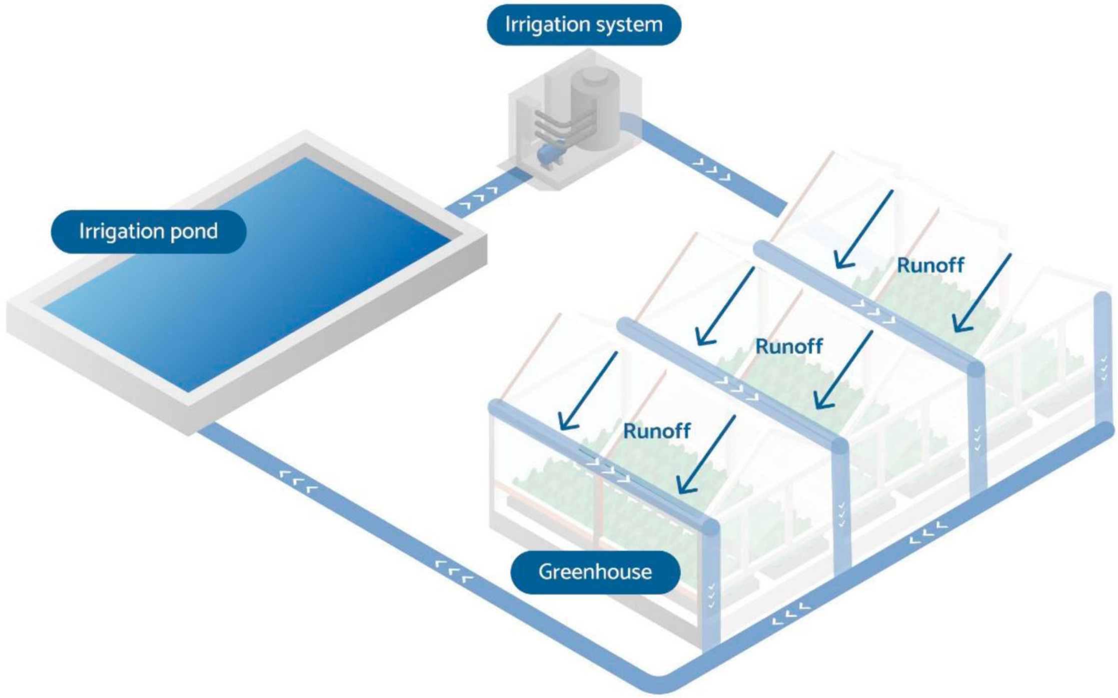

Figure 2. RWH system.

an ideal 'laboratory' in which to develop the proposed research.

2.2. Questionnaire development

To collect the information necessary to develop the questionnaire, a qualitative study was conducted with interviews with experts and a focus group (Figure 3). Interviews were conducted with experts in intensive agriculture in Almería with the objective of learning their point of view on RWH systems and compiling the key aspects of this practice. The number of interviews to be conducted should be based on the achievement of verification of the aspects learned in the course of the preceding interviews (Velasco-Muñoz et al., 2022). In this research, a total of six interviews were necessary to obtain such verification. Specifically, the presidents of the three most important irrigation communities in the region and three farmers with extensive experience in intensive agriculture were interviewed. Subsequently, a focus group with eight farmers from the study area was formed; four of them did not have RWH systems, and the other four did. For the selection of these farmers, the snowball technique was used,

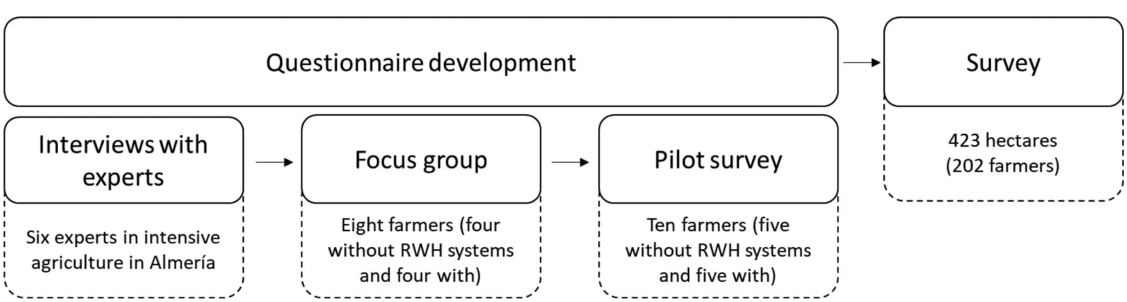

Figure 3. Phases of the qualitative study to develop the questionnaire.

whereby the interviewed experts recommended potential participants for this phase based on their experience and the research topic in order to try to capture all possible points of view. This technique is useful for selecting the right people in relation to the research objective (Ochoa-Noriega et al., 2022). In the first contact with the recommended persons, the objective of the research was explained to them and whether they were interested in participating. If they were interested, they were given a brief questionnaire to find out some of their main characteristics (Nyumba et al., 2018). Specifically, they were asked about their age, experience in the sector, level of education, farm size, type of crop, channel used to market their harvest and whether they had RWH systems. These questions were asked with the aim of including a group of farmers with differentiated profiles that would reflect all possible points of view.

A pilot survey was conducted to test the questionnaire. A total of ten farmers participated; five of them had RWH systems on their holdings, and the other five did not. The sample was selected randomly using the database of the most important irrigation community in the area. Once the questionnaire had been completed with these farmers, it was verified that they were representative of the study area by comparing their characteristics with those obtained in other studies carried out in the area (Junta de Andalucía, 2015; Valera et al., 2016). Based on their feedback, small changes were made in the wording of some questions. The final questionnaire contained 38 common questions that were asked to all participants and 4 conditional questions depending on whether they had a RWH system and the destination of the harvested water. The questionnaire was divided into four sections:

2.2.1. Characterization of farmers and their holdings

In this part of the questionnaire, three groups of questions were asked: (a) characteristics of the farmers (age, years of experience, and level of education), (b) characteristics of the holding (type of soil, type and size of greenhouse, year of construction, climate conditioning systems, water storage capacity in the farm, characteristics of the irrigation ponds, availability of irrigation programmer and use of tensiometers), (c) data related to the crop and seasonal inputs (number of crop cycles, organic farming, monoculture, income, expenses, trading channels and technical advice, number of workers, pest management strategies, and methods for pollination) and (d) use of RWH systems (source of collected water and its destination).

2.2.2. Environmental behaviour

In this section of the questionnaire, the level of environmental awareness of farmers was assessed. To do this, respondents were asked to indicate the frequency with which they performed a series of actions in their daily life using a five-point Likert scale where the value 1 corresponds to 'Never' and the value 5 to 'Always'. The choice of items was based on those used in previous studies (Karasmanaki et al., 2021; Karasmanaki & Tsantopoulos, 2019; Musova et al., 2021; Paço & Lavrador, 2017; Petkou et al., 2021). The items included recycling, turning off the faucet while brushing teeth, limiting showering time, using energy-saving light bulbs, using energy-efficient appliances, turning off lights and electrical appliances when not in use.

2.2.3. Attitudes related to the installation of RWH systems

This section has two groups of questions. In the first group, farmers were asked to assess the importance of a series of reasons for installing or not installing the system using a 5-point Likert scale, where the value 1 corresponds to 'Not important' and 5 to 'Very important'. Specifically, farmers who had RWH systems valued the importance of the following reasons in the decision to install it: increased water availability, higher quality water, crop diversification, preventing damage in the holding or other elements, cost savings, environmental benefits, affordable installation cost, and regulations. The RWH in the pond increases the availability of water resources in the holding for its later use. Water quality can be improved because the level of electrical conductivity (EC) of rainwater is very low and can balance the high levels of conductivity of underground water resources. This, in turn, can support continuing to grow the typical horticultural products of the area, which do not tolerate high levels of conductivity, or expand the range of current crops. Reducing damage refers to the episodes of torrential rains that can cause flooding and damage to the infrastructure of the agricultural holding. The cost savings are derived from the possibility of having water without having to pay for it, as well as reducing the investment necessary to fix the damage after torrential rains. RWH can have environmental benefits because it allows the recharge of aquifers and/or reduces the extraction of groundwater. The perception of farmers about the affordability of the installation cost of this type of system can incentivize their installation. Finally, in the study area, a regulation exists that requires farmers to manage the rainwater that falls on their holdings.

In the case of not having RWH systems, farmers provided the following reasons for not doing so: space limitation, limitations due to the characteristics of the holding, installation cost, water availability, regulations, avoiding problems, and rainfall variability. The high concentration of greenhouses in the study area means that there is limited space to build an additional pond for the RWH or expand the existing pond, as this would mean giving up cultivating part of the farm. The limitations associated with the characteristics of the holding may be due to flat-roofed greenhouses from which water cannot be collected and having the pond on the highest part of the farm, which would necessitate a downstream tank and pumping the water to the pond. The concern of higher costs and the availability of water resources from other sources can limit the installation of these systems by farmers. Through the regulation, possible exceptions or lack of control over compliance are represented. The use of rainwater can generate some problems, such as the alteration of the EC, the need to use more fertilizers or to manage the first flow of water that carries surface dirt from the greenhouse. Rainfall in the study area is highly variable, which generates uncertainty about the amount and time for which rainwater will be available.

In the second group of questions, both farmers who have the system and those who do not are asked to select from a group of options the advantages and disadvantages of RWH. The advantages evaluated were increased water availability, higher quality water, crop diversification, aquifer conservation and recovery, preventing damage in holding or other elements, and cost saving. Among the disadvantages were the following: difficulty in adapting the system to the holding, increases the use of fertilizer, alteration of water conductivity, management of the first flow of water, rainfall variability, and installation cost.

2.2.4. Incentives to increase the installation of RWH systems

In this part of the questionnaire, farmers had to indicate how much they agreed with four measures that could promote the installation of these systems: aid to cover the cost of installation, aid for adapting the holding, training sessions and regulatory measures. Taking into account that there are various limitations inherent to the characteristics of the holding itself, the possibility of having economic aid to install the system and aid directed to modifying the necessary elements to be able to implement them were differentiated. The training sessions can include various actions, such as courses or demonstration days in holdings that currently have these systems. Finally, through regulatory measures, the aim is to determine whether it is necessary to modify existing regulations or increase control over their compliance. These measures were scored with a Likert scale of 5 points, where the value 1 corresponds to 'Totally disagree' and 5 to 'Totally agree'.

2.3. Sample size and selection

As in other previous studies (Aznar-Sánchez et al., 2021; López-Felices et al., 2022), the number of hectares was used to determine the size of the sample that needed to be surveyed to be representative, given that the exact number of farmers operating in the study area is not known. The study area has an area of 22,054 hectares of greenhouses (Junta de Andalucía, 2020). The determination of the sample size necessary in this research was performed by establishing a confidence level of 95% and a maximum error of 5%. The following formula was used to determine the sample size:

$$n = \frac{Z_\alpha^2 p(1-p)N}{e_\alpha^2(N-1) + Z_\alpha^2 p(1-p)}$$

where: n = sample size, N = population (22,054 ha), α = confidence level (95%), Z_α = statistical parameter that depends on the confidence level (e.g. 1.96 for 95% confidence level), e_α = maximum accepted estimation error (5%), p = probability of occurrence of the event under study (50%). Taking into account this formula, to meet the statistical requirements, it was necessary to survey a minimum of 378 hectares. Finally, 423 hectares were surveyed, distributed among 202 farmers. The margin of error amounts to approximately 4.72%. Taking into account the characteristics of the study, it was decided to carry out a simple random sampling without replacement because each selected unit has the same probability of being chosen in each extraction (Singh & Masuku, 2014). To reach the necessary sample of farmers, collaboration was carried out with the irrigation communities in the study area. The farmers were randomly selected using the databases that the irrigation communities have on their members. The first contact with the randomly selected farmers was made through the irrigation communities themselves, who explained the objective of the study and asked them about their willingness to participate. Once the farmer agreed to participate in the study, a member of the research team contacted the farmer to arrange a face-to-face appointment to carry out the survey. The surveys were conducted between August and November 2021. Each survey lasted between 15 and 20 min.

2.4. Data analysis

Once the information was collected and refined, SPSS software (version 27) was used to perform the data analysis. After obtaining the main descriptive statistics and studying the interoperative relationships of the variables, as well as the identification of outliers and the distribution of the data, a cluster analysis was performed to characterize the main groups of farmers in relation to the RWH in the area. Cluster analysis is an exploratory analysis technique consisting of a multivariate statistical procedure that allows the characterization of groups of observations that share similar characteristics (Hennig et al., 2015). It is a very useful technique that has been used in different fields, including agriculture (Aznar-Sánchez et al., 2021; Tiwari & Misra, 2011). Specifically, a hierarchical cluster analysis was performed using the Ward or 'minimum variance' method to group the clusters. Ward's method was used because it allows to obtain compact clusters more accurately than other methods (Di Vita et al., 2021; Reiff et al., 2018). Therefore, Ward's method has been widely used in the literature (Kebede et al., 2019; Telles et al., 2019). This method results in an objective classification since it seeks to obtain the greatest homogeneity between the clusters formed, which is measured through the sum of the squared distances of each element with respect to the centroid or vector of means in each cluster (Murtagh & Contreras, 2017). Given the nature of the data obtained, the squared Euclidean distance was used as a measure, and the standardization of the data was determined to avoid problems associated with the different scales or units in which the variables of interest were obtained.

Once the cluster analysis was configured, the clusters were studied with one-way analysis of variance (ANOVA), which allowed us to observe the behaviour of the groups within the same variable of interest. This technique is defined as a generalization of the comparison of equal means for independent samples (Cardinal & Aitken, 2013). It is a technique with which direct and easy to interpret results are obtained, in addition to having been widely used for the establishment of experimental designs and in research fields where behaviour is studied (Tabachnick & Fidell, 2007). The literature supports that adequate results can be obtained using this technique with a sample size greater than 30 (Cardinal & Aitken, 2013). Therefore, the results obtained with the application of ANOVA in this study are sufficiently robust. Through the use of ANOVA, the aim is to obtain the means of each population group and study their variances (intra-group variance) with respect to the average variance within each group (inter-group variance) (Tabachnick & Fidell, 2007). In this way, assuming that the groups have been obtained from the same population universe, both their mean and variances should be identical.

3. Results

3.1. Characterization of farmers and their holdings and environmental behaviour

Table 1 shows the descriptive statistics of the variables that have been analysed in this research. The most relevant aspects are highlighted below.

(A) Characterization of the farmer. The average age was 47 years, with the youngest being 27 years old and the oldest being 68 years old. More than 88% of the sample is over 40 years old, so the working age of the sample is high. The average number of years of experience is 25, with a minimum of 1 and a maximum of 50. Most farmers (47%) have a basic level of education, while only 14% have level higher and 10% have university studies.

(B) Characteristics of the holding. The most common type of soil is sandy (80%), where farmers cover the soil surface with a layer of sand to retain moisture. Most of the greenhouses are a sloping roof design (84%). The average area dedicated to cultivation is 2.34 ha. This variable has a high coefficient of variation since the smallest

Table 1. Variables and descriptive statistical data.

Area	Variable	Description	Min.	Max.	Average	Standard deviation	Variation coefficient
Personal farmer data	V_1	Farmer's age (years old)	27	68	47.32	9.19	19.43%
	V_2	Years of farming experience	1	50	25.25	10.22	40.50%
	V_3	Level of education. 0 no schooling, 1 compulsory education, 2 upper secondary school, 3 intermediate training course, 4 higher training course, 5 university degree	0	5	*	*	*
Agricultural holding data	V_4	Type of soil. 1 local ground, 2 sanded soil, 3 hydroponic soil	1	3	*	*	*
	V_5	Type of greenhouse. 1 flat-top, 2 sloping roof, 3 multitunnel, 4 asymmetric	1	4	*	*	*
	V_6	Greenhouse size (ha)	0.35	11	2.34	1.84	78.64%
	V_7	Construction year. Four-digit year	1985	2020	2005	8.96	0.45%
	V_8	Number of climate systems	1	3	1.30	0.54	41.58%
	V_9	Holding water storage capacity (m^3)	0	20,000	1164.37	2174.11	186.72%
	V_{10}	Type of pond. 1 concrete, 2 polyethylene-lined, 3 others	1	2	*	*	*
	V_{11}	Shape of the pond. 1 square, 2 rectangular, 3 others	1	3	*	*	*
	V_{12}	Quantity of water in the pond. 0 empty (0%), 1 less than 25%, 2 between 25 and 50%, 3 between 50 and 75%, 4 between 76 and 99%, 5 full (100%)	3	5	*	*	*
	V_{13}	Method to keep the pond clean. 1 dredging, 2 biocide treatment, 3 covering	1	3	*	*	*
	V_{14}	Irrigation programmer. 0 no, 1 yes	0	1	0.83	0.38	45.10%
	V_{15}	Use of tensiometers. 0 no, 1 yes	0	1	0.68	0.47	68.27%
	V_{16}	Fully computerized irrigation with tensiometers. 0 no, 1 yes	0	1	0.23	0.42	184.61%
Crop and inputs data	V_{17}	Number of crop cycles per year	1	3	1.40	0.51	36.36%
	V_{18}	Organic farming. 0 no, 1 yes	0	1	0.30	0.46	154.22%
	V_{19}	Monoculture. −1 no, 0 depends, 1 yes	−1	1	0.83	0.40	48.18%
	V_{20}	Season income (€/m^2)	5	13	8.24	1.34	16.33%
	V_{21}	Season expenses (€/m^2)	2.5	8	4.53	1.16	25.62%
	V_{22}	Trading channel. 1 cooperative, 2 exchange, 3 direct sale, 4 private distributor, 5 SAT, 6 others	1	5	*	*	*
	V_{23}	Number of labours per year	2	40	5.37	5.20	96.86%
	V_{24}	Percentage of farmer family-bounded labour	0	66.67	9.27	15.91	171.66%
	V_{25}	Level of electrical conductivity in irrigation water (dS/m)	0	2.10	1.21	0.34	27.98%
	V_{26}	Number of methods used to deal with pests	3	7	5.48	1.07	19.55%
	V_{27}	Phytosanitary treatments (%)	0	100	31.08	32.25	103.77%
	V_{28}	Biological control (%)	0	100	68.82	32.20	46.79%
	V_{29}	Method for pollination. 0 no, 1 yes	0	1	0.62	0.49	77.86%
	V_{30}	Type of advice. 1 independent technicians, 2 supply providers, 3 trading company, 4 others	1	3	*	*	*
Rainwater harvesting system	V_{31}	Rainwater harvesting. 0 no, 1 greenhouse surface, 2 other elements of the holding	0	2	*	*	*
	V_{32}	Destination of harvested rainwater. 1 exclusive rainwater pond, 2 pond for different types of water, 3 filter well	1	3	*	*	*
Environmental behaviour	V_{33}	Recycling. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	3.92	1.08	27.56%
	V_{34}	Turning off the faucet while brushing teeth. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.62	0.98	21.10%
	V_{35}	Limiting showering time. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.12	1.38	33.43%
	V_{36}	Using energy-saving light bulbs. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	2	5	4.82	0.57	11.85%

(*Continued*)

Table 1. Continued.

Area	Variable	Description	Min.	Max.	Average	Standard deviation	Variation coefficient
	V_{37}	Using energy-efficient appliances. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.43	0.80	18.13%
	V_{38}	Turning off lights and electrical appliances when not in use. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	2	5	4.74	0.61	12.85%

(*) In qualitative variables no data are provided.

greenhouse is only 0.35 ha, while the largest reaches 11 ha. The oldest greenhouse was built in 1985, and the newest was built in 2020. The holdings usually have at least one climate conditioning system. The average water storage capacity on the holding is 1164.37 m^3, with a minimum of 0 m^3 and a maximum of 20,000 m^3. The percentage of holdings that cannot store water is small (9%). Most of the ponds are made of concrete (71%) and have a rectangular (48%) or square (44%) shape. Sixty-six percent of the ponds are usually at between 75% and 99% of their capacity, while none are at less than 25% or at 100% of their capacity. The most commonly used methods to keep the pond clean are covering it (55%) and dredging (48%). Eighty-three percent of holdings have an irrigation programmer, and 68% use tensiometers. However, irrigation and fertigation are only fully computerized in 23% of cases.

(C) Seasonal data related to the crop and inputs. Although a maximum of three crop cycles are performed per year, the most common is to perform one (59.91%) or two (39.11%). Thirty percent of holdings cultivate organically. The majority of farmers (84%) repeat crops from one season to another. The average income amounts to € 8.24/m^2, while the average cost is € 4.53/m^2. Farmers sell their harvest through different channels, but most do so through cooperative (49%) or Agrarian Transformation Company (SAT) (20%). The average number of workers per year is approximately five, although this variable has a fairly high coefficient of variation, as it changes depending on various factors, such as the size of the holding or the type of crop. The average EC for water is 1.21 dS/m. An average of five methods are used to address pests. Biological control was used in 68.82% of cases, while phytosanitary treatments were used in 31.08%. In 62% of the holdings, an additional method is used for pollination. In most cases, the agronomic advice comes from the trading company with which the farmer works (75%), although a fairly high percentage of the farmers surveyed (45%) receive advice from supply providers.

(D) Use of RWH systems. Eighty percent of holdings have RWH systems. In these holdings, rainwater is collected from the surface of the greenhouse, and in some cases (22%), it is also collected from other elements of the farm, such as roads. The collected water is directed to filter wells in 52% of cases, to ponds where different types of water are stored in 23%, to dedicated rainwater ponds in 7%, and to ponds and wells together in 17% of cases.

(E) Environmental behaviour. To determine the level of environmental awareness of farmers, a series of environmental behaviours were analysed (Table 1). The most frequent behaviour is using energy-saving light bulbs with an average value of 4.82. This is followed by turning off lights and electrical appliances when not in use (4.74). On the other hand, the least frequent behaviour is recycling with an average value of 3.92.

3.2. Profile of farmers

Through the application of cluster analysis, the 202 farmers who participated in this research were classified into three homogeneous groups. These groups have been named: 'aware farmers' (Cluster 1), 'regulation-compliant farmers' (Cluster 2), and 'reluctant-to-adopt farmers' (Cluster 3). As shown in Table 2, of the 38 variables studied, 31 were found to bestatistically different between the groups.

With the application of this methodology, the characteristics of each cluster, as well as their quantitative and qualitative importance, were identified. A characterization of each cluster was performed taking into account the variables that were found to

Table 2. ANOVA.

Variable	Description	Conglomerate Root mean square	*df*	Error Root mean square	*df*	*F*	*p*-value (*)
V_1	Farmer's age (years old)	36.182	2	8.496	199	18.138	0.000
V_2	Years of farming experience	31.408	2	9.781	199	10.311	0.000
V_3	Level of education	4.852	2	1.420	199	11.682	0.000
V_4	Type of soil	1.240	2	0.467	199	7.063	0.001
V_5	Type of greenhouse	2.398	2	0.472	199	25.768	0.000
V_6	Greenhouse size (ha)	57939.286	2	17561.249	199	10.885	0.000
V_7	Construction year	21.277	2	8.745	199	5.920	0.003
V_8	Number of climate systems	0.734	2	0.536	199	1.880	0.155
V_9	Holding water storage capacity (m^3)	3518.598	2	2156.348	199	2.663	0.072
V_{10}	Type of pond	1.850	2	0.602	199	9.458	0.000
V_{11}	Shape of the pond	1.805	2	0.615	199	8.616	0.000
V_{12}	Quantity of water in the pond	1.728	2	0.897	199	3.709	0.026
V_{13}	Method to keep the pond clean	4.183	2	1.059	199	15.609	0.000
V_{14}	Irrigation programmer	1.160	2	0.359	199	10.462	0.000
V_{15}	Use of tensiometers	1.731	2	0.435	199	15.804	0.000
V_{16}	Fully computerized irrigation with tensiometers	1.156	2	0.406	199	8.090	0.000
V_{17}	Number of crop cycles per year	1.177	2	0.502	199	5.495	0.005
V_{18}	Organic farming	0.992	2	0.450	199	4.871	0.009
V_{19}	Monoculture	0.490	2	0.400	199	1.504	0.225
V_{20}	Season income (€/m^2)	4.914	2	1.259	199	15.240	0.000
V_{21}	Season expenses (€/m^2)	3.695	2	1.107	199	11.153	0.000
V_{22}	Trading channel	3.381	2	1.621	199	4.351	0.014
V_{23}	Number of labours per year	10.958	2	5.107	199	4.604	0.011
V_{24}	Percentage of farmer family-bounded labour	17.362	2	15.898	199	1.193	0.306
V_{25}	Level of electrical conductivity in irrigation water (dS/m)	1.263	2	0.316	199	16.012	0.000
V_{26}	Number of methods used to deal with pests	0.960	2	1.072	199	0.803	0.449
V_{27}	Phytosanitary treatments (%)	72.966	2	31.576	199	5.340	0.006
V_{28}	Biological control (%)	71.775	2	31.552	199	5.175	0.006
V_{29}	Method for pollination	0.825	2	0.481	199	2.968	0.054
V_{30}	Type of advice	1.050	2	0.680	199	2.383	0.095
V_{31}	Rainwater harvesting	5.170	2	0.404	199	163.509	0.000
V_{32}	Destination of harvested rainwater	11.075	2	0.430	199	664.730	0.000
V_{33}	Recycling	1.410	2	1.077	199	1.715	0.183
V_{34}	Turning off the faucet while brushing teeth	0.696	2	0.978	199	0.506	0.604
V_{35}	Limiting showering time	1.775	2	1.372	199	1.673	0.190
V_{36}	Using energy-saving light bulbs	1.179	2	0.562	199	4.403	0.013
V_{37}	Using energy-efficient appliances	1.878	2	0.784	199	5.735	0.004
V_{38}	Turning off lights and electrical appliances when not in use	1.777	2	0.586	199	9.203	0.000

(*) With a 90%-reliability, all variables are significant except for V_8, V_{19}, V_{24}, V_{26}, V_{33}, V_{34}, and V_{35}.

be significant when classifying these three groups of farmers (Table 3). Next, the main characteristics of each cluster are developed as a function of the average values obtained in the 31 representative variables.

(A) Cluster 1. *Aware farmers* ($N = 78$, 38.6% of sample). These are younger farmers than those in the other two clusters (43 years old). They have less experience in the agricultural field but a higher level of education (upper secondary education). They own the largest greenhouses on average (2.95 ha). They have the newest greenhouses (built in 2007), most of which have sloping roofs. Their holdings are more technologically advanced because practically all of them (97%) have an irrigation scheduling system and in majority use tensiometers. In addition, they have the highest percentage of computerization of their irrigation system (31%) and tensiometers (82%). The holdings in this cluster have greater water storage capacity (1578.76 m^3). The ponds are made of concrete and polyethylene-lined and are usually maintained with a lower volume of water than the rest of the clusters (50%–75%). The main method to pond cleaning in this cluster is covering it, although dredging is also frequent. They are farmers specializing in higher value-added products and earn a higher income than the

Table 3. Farmer group clusters.

Variable	Description	Cluster 1	Cluster 2	Cluster 3
V_{1}	Farmer's age (years old)	43.62	47.81	53.50
V_{2}	Years of farming experience	22.22	25.48	30.95
V_{3}	Level of education	Upper secondary education	Compulsory education	Compulsory education
V_{4}	Type of soil	Sanded	Sanded	Sanded/Local
V_{5}	Type of greenhouse	Sloping roof	Sloping roof	Sloping roof/Flat-top
V_{6}	Greenhouse size (ha)	2.95	2.22	1.38
V_{7}	Construction year	2007	2005	2001
V_{9}	Holding water storage capacity (m^3)	1578.76	1010.00	680.50
V_{10}	Type of pond	Concrete/Polyethylene-lined	Concrete/Polyethylene-lined	Concrete
V_{11}	Shape of the pond	Rectangular	Rectangular	Square
V_{12}	Quantity of water in the pond	50%–75%	75%–99%	75%–99%
V_{13}	Method to keep the pond clean	Covering/Dredging	Covering/Dredging	Dredging/Biocide treatment
V_{14}	Irrigation programmer	0.97	0.76	0.70
V_{15}	Use of tensiometers	0.82	0.71	0.35
V_{16}	Fully computerized irrigation with tensiometers	0.31	0.26	0.00
V_{17}	Number of crop cycles per year	1.29	1.55	1.35
V_{18}	Organic farming	0.41	0.26	0.15
V_{20}	Season income (€/m^2)	8.64	8.31	7.30
V_{21}	Season expenses (€/m^2)	4.65	4.77	3.80
V_{22}	Trading channel	Cooperative	Cooperative/SAT	Exchange/Private distributor
V_{23}	Number of labours per year	6.10	5.71	3.20
V_{25}	Level of electrical conductivity in irrigation water (dS/m)	1.11	1.18	1.46
V_{27}	Phytosanitary treatments (%)	22.28	34.52	40.75
V_{28}	Biological control (%)	77.36	65.45	59.25
V_{29}	Method for pollination	0.72	0.60	0.50
V_{30}	Type of advice	Trading company	Trading company	Trading company/Supply providers
V_{31}	Rainwater harvesting	Greenhouse Surface/Other elements of the holding	Greenhouse Surface/Other elements of the holding	No
V_{32}	Destination of harvested rainwater	Exclusive rainwater pond/ Pond for different types of water/Filter well	Filter well	–
V_{36}	Using energy-saving light bulbs	4.92	4.83	4.60
V_{37}	Using energy-efficient appliances	4.64	4.36	4.15
V_{38}	Turning off lights and electrical appliances when not in use	4.82	4.55	4.03
	Agricultural holdings total:	78	84	40

rest of the clusters (8.64 €/m^2). The main trading channel for their harvest is through the cooperative, from which they also receive technical advice. They have the largest average number of workers (6 workers). In this cluster, more holdings cultivate organically (41%) and mainly use biological control to manage pests (77%). It is the cluster that most uses additional pollination methods (72%). All holdings in this cluster collect rainwater from both the greenhouse surface and other elements of the farm. The destination of the rainwater collected is the pond that can be exclusively for rainwater storage or for storing different types of water. Some of these farmers also have filter wells to direct the water from some areas of the holding or if the maximum storage volume of the pond is reached. This cluster presents the highest average values in environmental awareness.

(B) Cluster 2. *Regulation-compliant farmers* ($N = 84$, 41.6% of sample). These are farmers with extensive experience in the agricultural sector (25 years) and with a basic level of education (compulsory education). Their greenhouses are somewhat greater than 2 hectares; they are mainly of the sloping roof type, and they use sanding for cultivation. The water storage capacity in the holding is medium (1010.00 m^3). The ponds are usually both concrete and polyethylene-lined maintaining a water volume of between 75% and 99% capacity. The main methods to keep the pond clean are covering it and dredging. Most holdings have an irrigation programmer (76%), and a high percentage use tensiometers (71%). Twenty-six percent of holdings cultivate organically. They have the highest number of growing cycles per season of all clusters, with an average of 1.5. They have intermediate income (8.31€/m^2) and costs (4.77 €/m^2) between those of the other two clusters. The selling of their harvest is done mainly through cooperative or SAT, from which they also receive technical advice. To manage pests, they mainly use biological control (65%), although the use of phytosanitary products is relatively high (34%). In this cluster, all the rainwater that is collected goes to a filter well. This cluster presents average values of environmental awareness.

(C) Cluster 3. *Reluctant-to-adopt farmers* ($N = 40$, 19.8% of sample). Includes older farmers (53 years old) with more experience in the sector (30 years). They have a low level of education (compulsory education). They own the oldest greenhouses (built in 2001) with the smallest average size (1.38 ha). Half of the greenhouses are flat-top and they grow both in sanded and in local soil. The holdings have the lowest average water storage capacity (680.50 m^3), and their ponds are made of concrete and are usually maintained at a volume of between 75% and 99%. The main methods to keep the pond clean are dredging and the application of biocide treatment. Only 70% of the holdings have an irrigation scheduling system, and 35% use manual tensiometers. This is the cluster with the lowest percentage of organic crops (15%). These farmers earn a smaller income than the rest of the clusters (7.30 €/m^2). The main channel of selling their harvest is through exchanges and private distributors. Technical advice is received from exchanges and companies that provide supplies. They have the lowest average number of workers of all clusters with an average of 3. The average EC of the water in this cluster is the highest (1.46 dS/m). They are those that use a greater proportion of phytosanitary products to manage pests (40%). It is the cluster that uses the fewest pollination methods. It does not have RWH systems and is the cluster with the lowest level of environmental awareness.

3.3. Attitudes related to the installation of RWH systems

In the questionnaire, two groups of questions were included in relation to attitudes towards RWH system installation. First, farmers were asked to assess a series of reasons for installing or not installing RWH systems. The farmers of Cluster 1 consider the increase in water availability to be very relevant when opting for the installation of these systems (5 points) (Figure 4). The reasons related to reducing possible damages in the holdings and other related elements, the possibility of reducing costs, and the environmental benefits were also rated highly (4 points). However, availability of higher quality water and the possibility of diversifying crops was not considered that important (3 and 2 points respectively). They also give a medium score regarding the cost of installation of these systems (3 points), that is,

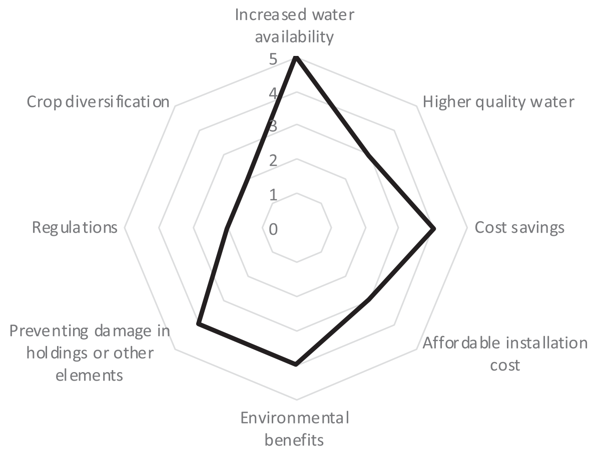

Figure 4. Reasons for installing RWH systems (Cluster 1).

they consider it an affordable investment. Finally, regulatory measures are not an important reason (2 points).

In the case of Cluster 2 (Figure 5), the reasons related to greater water availability, water quality improvements and crop diversification are not important for these farmers since they do not take advantage of rainwater (1 point). For this same reason, cost savings when installing these systems are considered less important (2 points). As in Cluster 1, these farmers greatly value the reasons related to damage reduction (4 points). However, in this case, the possible environmental benefits are not taken into consideration (2 points), while compliance with the regulations is the main reason for installing them (5 points). Finally, this cluster feels affordability is an important factor (4 points).

The farmers of this cluster were also asked to assess the reasons against implementing rainwater management (Figure 6). The main reasons for not taking advantage of rainwater are the availability of water resources from other sources and avoiding potential problems associated with using this type of water (5 points). The cost of installation is also a prominent aspect when deciding not to harvest rainwater, which is related to space limitation in the holding and the limitations derived from the holding characteristics (4 points). The variability of rainfall is a moderate consideration (3 points). Regulation is not an important factor in the decision to not use rainwater (1 point), since the regulation only pertains to its management not its destination (pond or well).

Finally, farmers who did not perform any type of rainwater management (Cluster 3) were asked to

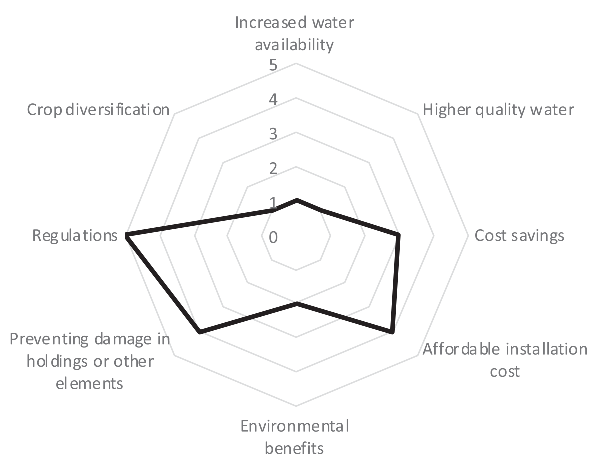

Figure 5. Reasons for installing RWH systems (Cluster 2).

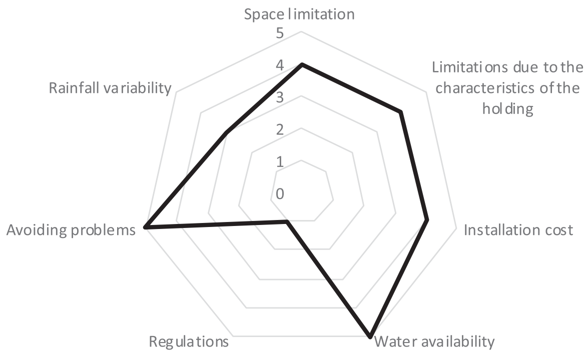

Figure 6. Reasons for not taking advantage of rainwater (Cluster 2).

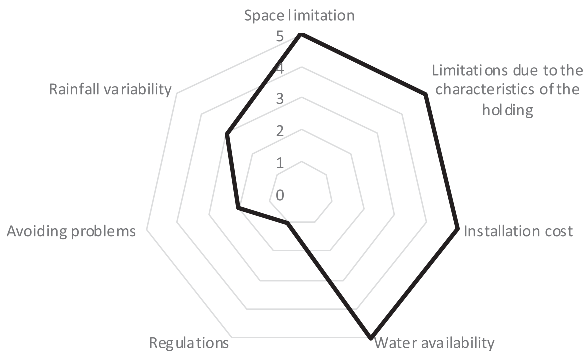

Figure 7. Reasons for not installing RWH systems (Cluster 3).

assess the above reasons for not doing so (Figure 7). In this case, the availability of other water sources is also very important (5 points). Thus, the cost of installation, space limitations in the holding and the limitations derived from the characteristics of holding itself are also key factors (5 points). In the case of this cluster, rainfall variability was moderately considered (3 points), while avoiding possible problems was not considered very important (2 points). The existing regulation is not an important reason when deciding not to manage rainwater (1 point).

In the second group of questions in this section, farmers were asked to select, from a series of options, the advantages and disadvantages of RWH systems. Regarding advantages (Figure 8), the three clusters are in agreement that RWH improves the conservation and recovery of the aquifer, in addition to preventing damage in the holdings. The advantages related to the availability and quality of water have the greatest weight in Cluster 1. Cost savings have a medium value, being highest also in Cluster 1. Crop diversification is the least valued advantage for the farmers.

In the case of the disadvantages (Figure 9), the three clusters agree that rainfall variability is a very important consideration. In general, the rest of the disadvantages are most notable in Clusters 2 and 3. For Cluster 2, the main disadvantages are the change in water EC and the need to increase fertilizer to compensate for these changes. For Cluster 3, the difficulty of adapting the system to the holding and the cost of installation are of great importance.

3.4. Incentives to increase the installation of RWH systems

Finally, farmers were asked to evaluate four measures that could incentivize the installation of these systems. As shown in Figure 10, there are differences in the opinions of farmers depending on the cluster to which they belong. All clusters agree with the provision of aid to help cover the cost of adapting holdings (4 points). Clusters 2 and 3 agree that there should be direct aid to cover the cost of installation (5 points). Cluster 1 feels that training sessions can

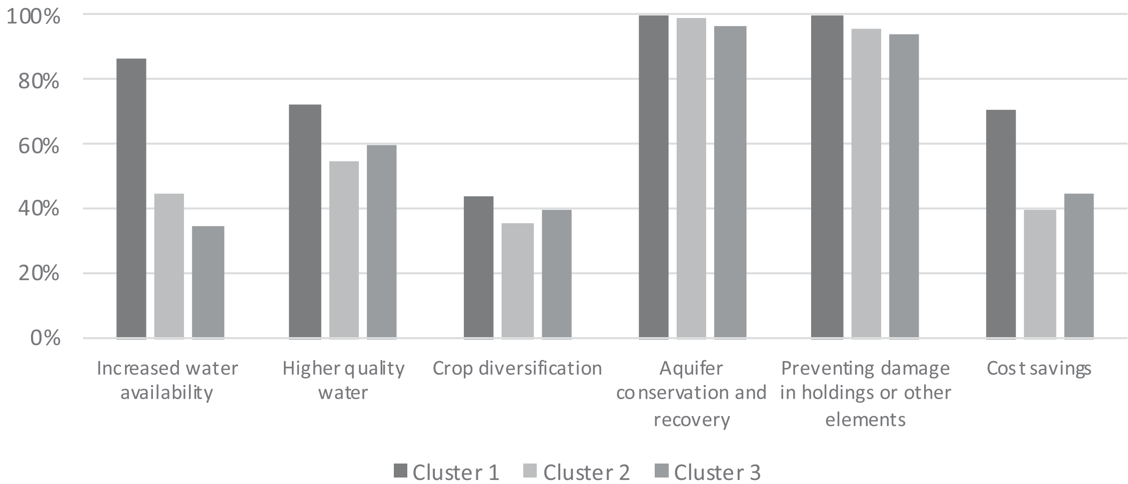

Figure 8. Advantages of RWH systems.

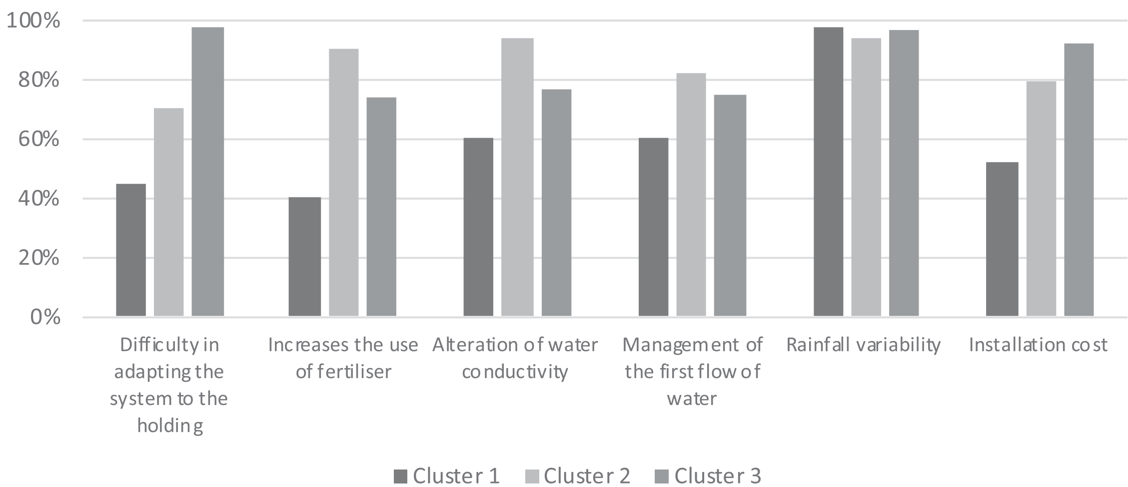

Figure 9. Disadvantages of RWH systems.

encourage the installation and use of RWH systems (5 points). In the case of regulatory measures, Cluster 1 feels that greater control over the degree of compliance with regulation would be necessary (4 points).

4. Discussion

The first objective of this work was to identify the different types of farmers in relation to the installation of RWH systems. The results of the cluster analysis show that there are three types of farmers. The 'aware farmers' (Cluster 1) choose to harvest rainwater for agricultural irrigation because they consider that this practice contributes to ensuring the long-term economic and environmental sustainability of their holdings. The 'regulation-compliant farmers' (Cluster 2), in most cases, are able to direct the rainwater to the pond, but decide to use filter wells for recharging the aquifer because they do not perceive the economic and environmental advantages of this practice, and think that it is the simplest way to comply with the existing regulation. Finally, the 'reluctant-to-adopt farmers' (Cluster 3) are older, more traditional, in many cases do not have the necessary means to install RWH systems and are not willing to carry out all the tasks involved with using alternative sources of water supply.

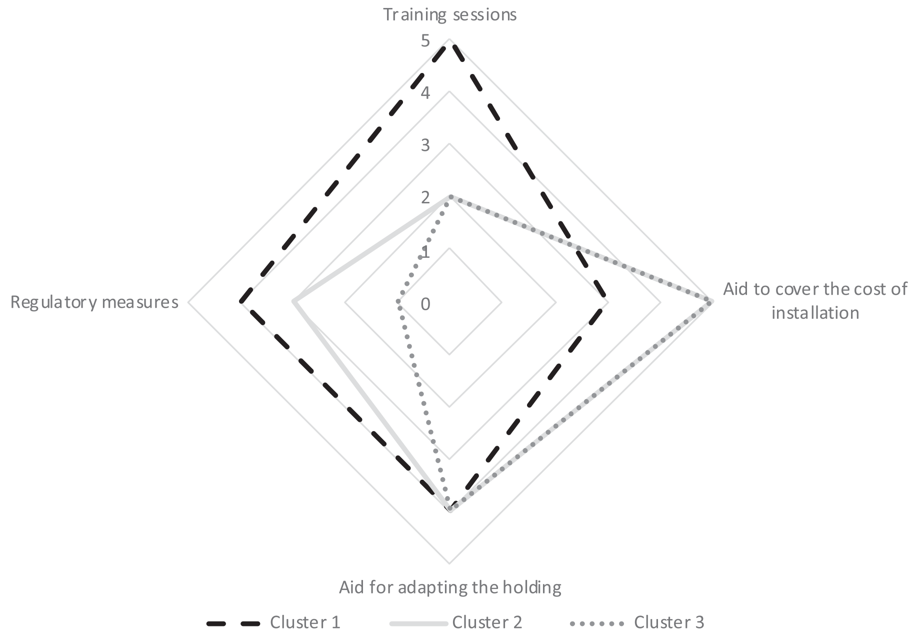

Figure 10. Measures to promote the installation of RWH systems.

The second objective of this work was to determine the attitudes of the different types of farmers in relation to the installation of RWH systems. In general, it can be confirmed that those farmers who have RWH systems and have experience using it for agricultural irrigation feel that limitations for its implementation are few and value its advantages more. Similar results have been obtained in studies applied to other types of water or irrigation technologies. For example, Aznar-Sánchez et al. (2021) determined that experience using desalinated water for irrigation positively impacted how farmers in southeastern Spain valued it, while Lanza-Castillo et al. (2021) established that farmers in Chile who have previous experience with pressurized irrigation have higher adoption rates and greater intention to adopt these systems. One of the main stimuli for taking advantage of rainwater for agricultural irrigation is the increase in water availability. In that sense, Panagea et al. (2016) suggest that RWH systems offer water autonomy to farmers in Crete (Greece), thus ensuring their security when optimizing production. In our case study, farmers who do not harvest rainwater have doubts about the ability of these systems to increase the availability of water resources. Thus, although some of these farmers agree that an increase in the availability of water resources is an advantage of these systems, they still decide not to collect it in the pond due to different limitations and drawbacks. Many holdings have limitations derived from the lack of space or the characteristics of the holding itself, such as flat-top greenhouses or the pond being located in the higher part of the farm. In these cases, it would be necessary to build a tank in the lower part of the holding in which to collect the water and, later, pump this water to the pond, which in addition to a greater investment would mean an increase in electricity costs. These limitations are especially relevant for Cluster 3 since it has the smallest holdings, in some cases without the capacity to store water, and many of the greenhouses are flat-top, which makes it difficult to collect rainwater. In a study conducted in India, Kumar et al. (2016) also conclude that farmers with smaller farms are less willing to install farm ponds for RWH.

Farmers highlighted two main problems in relation to RWH in the pond, which have also been indicated in other studies conducted in Australia (Jewell, 2016), Greece (Panagea et al., 2016) and Indonesia (Bafdal et al., 2017). First, the electrical conductivity (EC) is altered when using the same pond to mix water from different sources since the EC of rainwater is practically zero (Lekouch et al., 2010; Zdeb et al., 2020). EC is a measure of water salinity, which is one of the most important factors affecting irrigation water quality (Zaman et al., 2018). Conductivity tolerance varies depending on the type of crop (Ourimbah et al., 2011). For this reason, it is important to use water with appropriate conductivity levels depending on the crop type to avoid yield losses. Irrigation with water with high levels of EC can affect the nutrient uptake capacity of plants (Rameshwaran et al., 2016). On the other hand, if the conductivity of irrigation water is very low, it may not be sufficient to meet the nutrient needs of plants (Zaman et al., 2018). In this case, nutrients can be supplied through the use of fertilizers. Therefore, farmers in the study area say that RWH can alter the water parameters, making it necessary to use a greater amount of fertilizer to counteract this fact. In this sense, the majority of the farmers surveyed state that for the correct use of rainwater, it would be necessary to collect it in a dedicated pond and, subsequently, mix it with the aquifer water, taking into account the EC requirement for the specific type of crop. However, this implies an extra investment, and taking into account the space limitation in the holdings, it would mean having to use part of the area currently dedicated to cultivation to construct an additional pond. The second outstanding problem is the need to manage the initial flow of water to prevent all the surface dirt from greenhouse from entering the pond. Preventing the entry of dirt into the pond is very important because otherwise, it can clog the irrigation system, preventing a uniform and adequate irrigation of the crop (Bonachela et al., 2013). Farmers who harvest water indicate that there are solutions such as installing filters to prevent most of the dirt from reaching the pond. Despite these solutions, these are significant problems for farmers in Cluster 2, so they consider it easier to direct the water directly to wells.

In general, these limitations and drawbacks, together with the availability of underground water resources in the area, mean that many farmers choose not to harvest rainwater. Liang and van Dijk (2016) and Lee et al. (2016) also noted that one of the main reasons for not collecting rainwater was the existence of sufficient water resources. Though, many of the farmers surveyed state that they would start harvesting rainwater if the cost they currently pay for groundwater increases. In this same sense, Liang and van Dijk (2011a) suggested that the low groundwater prices in China make the installation of these systems unappealing to farmers since it is not profitable for them. Another aspect highlighted by all farmers in relation to the drawbacks of RWH systems is the variability of rainfall, although it is not one of the main reasons for not installing these systems. However, the fact of not knowing when it will rain and in what amount prevents them from knowing to what extent installing the equipment can be recouped. This uncertainty regarding rainfall has also been considered a limiting factor when adopting RWH systems in other studies (Eslamian & Eslamian, 2021b; Gadanakis et al., 2015; Willy & Kuhn, 2016).

The potentially high initial investment has been pointed out as a factor that limits the installation of water conservation technologies (Abdulai & Huffman, 2014; Bogdan & Kulshreshtha, 2021; Liu et al., 2018; Shapiro-Garza et al., 2020). In our case study, for farmers in Cluster 1, the installation cost is less important than for the other two clusters. This may be because they have larger holdings and greater economic resources. In this same sense, Liang and van Dijk (2011a) established that in China, the financial viability of RWH systems depends on their size, and it is only feasible to incorporate them for owners of large holdings. Likewise, it must be taken into account that farmers with smaller holdings are less likely to incorporate technologies that require giving up part of their holdings, since this option implies a loss of income (Gachango et al., 2015). Another reason why farmer in Cluster 1 may consider installation costs less important is because they are more educated and environmentally aware. Several studies show that education presents a positive relationship with the adoption of RWH systems (Arunrat et al., 2017; Rozaki et al., 2017; Tessema et al., 2018). Therefore, Yaghoubi Farani et al. (2019) state that greater awareness and commitment to environmental preservation leads to the development of a certain degree of responsibility among farmers towards its conservation, which favours the incorporation of practices and technologies that allow them to achieve it.

In relation to water quality, one of the factors that can affect it is salinity, which is measured through EC (Ourimbah et al., 2011). The use of rainwater can be an ideal alternative in those cases in which salinity is a problem (Phogat et al., 2020; Redwood et al., 2014). The EC of water in Almería can vary between 0.6 and 4 dS/m depending on the water source, geographical area, season of the year, etc. (Bonachela et al., 2022). High levels of conductivity, higher than 2 dS/m in the case of most horticultural crops, can lead to losses in crop yield (Ourimbah et al., 2011).

In the case of the study area, the possibility of having higher quality water and crop diversification are not highly valued reasons or advantages because the EC levels of the irrigation water are within the limits to produce the usual crops in the area. These results differ from those obtained in other regions where rainfed agriculture predominates or where water quality compromises production (Aznar-Sánchez et al., 2021; Subedi et al., 2020). However, this could change in the near future as the increasing extraction of water from aquifers is leading to marine intrusion and increasing conductivity levels. On the other hand, in the study area, RWH systems are of great importance in reducing possible damage to holdings, since torrential rains tend to cause flooding and damage to infrastructure (Martín et al., 2014; Molina-Sánchez et al., 2015). As such, the installation of RWH systems can mean cost savings derived from not needing to invest as much in the repair of elements of the holding damaged after the rains. Farmers who use rainwater for irrigation emphasize that the possibility of reducing costs is an important factor in deciding to install RWH systems, since the more water collected and used, the lower dependency on outside water resources. In addition, the need to pump groundwater at increasing depths, together with higher costs associated with electrical energy needed for this, makes cost savings increasingly attractive. However, farmers who do not harvest rainwater do not fully appreciate the cost reductions that RWH systems can generate.

In the case of the regulation, the results obtained in this research show that the 'aware farmers' (Cluster 1) do not collect rainwater because they are obligated to do so by the administration but rather because of its advantages and benefits. The farmers who manage rainwater to recharge the aquifer (Cluster 2) do so mainly to comply with regulations. It is noteworthy that the farmers of Cluster 3 do not give much regard to the regulations, possibly because their holdings have not had to adapt to these regulations since they were built before they came into effect. Finally, although in general, farmers on average have a high sense of environmental awareness and believe that RWH systems can help in recovering and conserving the aquifer, in many cases, this is not enough to install them, especially in the case of the farmers of Cluster 3, who represent the lowest scores. These results are in line with those obtained in other studies in which environmental awareness or attitude have a positive impact on the implementation of sustainable practices by farmers (Liu et al., 2018; Prokopy et al., 2019).

The third objective of this work was to determine the level of agreement of farmers with a series of measures intended to encourage the installation of RWH systems. The results show that farmers require economic support not only to carry out the installation of RWH systems but also to adapt their holdings. In the study area, there is financial aid to help with the installation of these systems. However, these come mainly from operational funds for members of producer organizations (cooperatives or SAT). Therefore, the farmers of Cluster 3, who do not belong to these organizations, cannot access this aid. Thus, although the majority of farmers agree with economic aid being available, many feel that it should be more accessible and better adapted to the needs of farmers. In fact, the percentage of farmers in the study area who incorporate technologies to improve water efficiency benefiting from economic aid is very low (Piedra-Muñoz et al., 2017). Several studies indicate that regulation can be an efficient mechanism to promote the adoption of more sustainable technology or practices by farmers (Aubert et al., 2012; Aznar-Sánchez et al., 2020; Long et al., 2016). However, in our study, farmers show conflicting opinions regarding regulation which are based on their personal situations. Therefore, the development of regulatory measures should be carried out taking into account the reality of farmers to avoid rejection or noncompliance. In this same sense, Dessart et al. (2019) believe that programmes to encourage the use of more sustainable practices should not be based only on regulatory or financial aspects but should take into account the behaviours of farmers to encourage their voluntary installation and use.

Finally, although farmers who do not harvest rainwater do not consider training sessions an important measure for encouraging the installation of these systems, training sessions could still be very useful for demonstrating how to manage the problems indicated regarding the use of this type of water. Bringing research closer to farmers and offering them suitable and affordable solutions can be an impetus for implementing these practices. In this sense, it should be noted that the lack of training on the operation of RWH systems as well as water management in general limits their installation (Demeke et al., 2021; Muriu-Ng'ang'a et al., 2017). In addition, Kumar et al. (2016) find that farmers' access to technical support leads to better performance and higher returns from

RWH systems. Therefore, the content that farmers receive in terms of advice should be expanded, since it is currently limited to agronomic aspects. Velasco-Muñoz et al. (2022) conclude that improving farmers' awareness through the availability of better information can be a turning point in the adoption of sustainable practices. Likewise, demonstration sessions that showcase the experience of other farmers are usually a very effective method to encourage the incorporation of new technologies or more sustainable practices (Adamsone-Fiskovica & Grivins, 2022; Aznar-Sánchez et al., 2020).

4.1. Recommendations for policy-makers

These results are of high interest to policy-makers since the interventions targeted towards installing RWH systems and using collected water must recognize the heterogeneity existing between the groups of farmers and the specific characteristics of their holdings. With these in mind, the following recommendations for policy-makers are proposed to encourage the adoption of RWH systems for agricultural irrigation. Firstly, it is necessary to design financial aid accessible to all farmers and not only to those who are members of an agricultural production organization, in addition to prioritizing its availability for farms that have greater difficulties in installing these systems due to different reasons such as having flat greenhouses or smaller farms. In conclusion, aid must be adapted to the needs of different types of farmers and made more accessible to them.

Nevertheless, the results of this study show that farmers do not just consider economic aspects when deciding to install RWH systems, since in many cases, there are noneconomic barriers that hinder the installation of this type of system such as the lack of knowledge when dealing with the problems that RHW in the pond can generate or the lack of space on some farms. For this reason, policy-makers are recommended to create easily accessible programmes to train farmers, especially for farmers who are reluctant to adopt RWH systems.

Finally, it is recommended to improve the environmental behaviour of farmers, as it is the most aware farmers who use rainwater for agricultural irrigation. Farmers who have a good understanding of environmental concerns are more likely to appreciate the advantages of RWH, such as aquifer conservation and recovery or higher quality water. Furthermore, environmentally conscious farmers are more likely to comprehend the long-term benefits of RWH, such as enhanced crop yields and reduced irrigation costs. There are various approaches to increase farmers' awareness of these aspects, such as organizing educational programmes like workshops, seminars, and training sessions, conducting publicity campaigns, or arranging field demonstrations. Additionally, efforts can be made to raise public awareness about the benefits of RWH so that farmers can gain commercial benefits from using environmentally friendly techniques.

In general, in those cases in which it is possible, it is necessary to encourage the collection and use of rainwater to avoid problems resulting from the overexploitation of aquifers, as this can endanger the survival of the agricultural sector of the region. To maximize the rainwater collected it would be necessary to build additional ponds, however this is not possible in most cases because farmers, in addition to having to make a large investment, will fear their income being reduced when having to dedicate part of their holding to RWH rather than crop production. In these cases, it is necessary to ensure farmers are well-versed in the measures to be carried out to avoid the possible issues associated with water collection, while in smaller holdings, it is necessary to encourage the construction of wells that contribute to recharging the aquifer.

5. Conclusions

In this study, extensive field work has been developed with farmers who have greenhouses in southeastern Spain with the objective of obtaining information on (1) the profile of farmers in relation to the installation of RWH systems and (2) the attitudes of farmers towards the installation of such systems and (3) the level of agreement of farmers with a series of measures intended to encourage their installation. The cluster analysis classified farmers into three groups: (1) 'aware farmers', (2) 'regulation-compliant farmers', and (3) 'reluctant-to-adopt farmers'. The results of this research show that there are differences in the attitudes of these three groups in relation to RWH systems. Farmers who harvest rainwater for agricultural irrigation are noted for having experience using it, a greater appreciation of the advantages of RWH systems, and a higher level of awareness. In general, the aspects they value most are the recovery and conservation of the aquifer and avoiding possible damage to the holding and related elements. On the other hand, the main obstacles to installing RWH systems are related to the limitations of the holdings and the problems that this can generate. Likewise, the rainfall variability and the groundwater availability are also presented as aspects that limit its installation and use. The assessment of the different measures to encourage the installation of RWH systems shows that economic aid is necessary to cover the cost of adapting the holdings to be able to collect water. On the other hand, expanding farmer's training on the use of these collection systems could be positive. It would also be necessary to how the existing regulation regarding the collection of rainwater is managed.

As future lines of research, the analysis in relation to the RWH in the study area should be expanded to analyse the financial viability of the installation of these systems and their ability to reduce the demand for additional water resources, taking into account the pattern of rainfall and the volume of water that can be stored in the holdings, as well as the possibilities of recharging the aquifers through filter wells. In addition, the capacity of the aquifer in the area to meet water needs should be studied from a temporal point of view, taking into account the current withdrawal and recharge rates, as this would allow a better determination of the potential of RWH in the area. Finally, it must be kept in mind that this study was carried out in southeastern Spain, so the attitude and perception of farmers about RWH may be influenced by the specific characteristics of the study area. However, the results of this research can be useful for those regions in which the installation of RWH systems is to be promoted, especially in areas where water availability is a limiting factor for agricultural development or compromises its sustainability.

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