Agricultural Water Management 275 (2023) 107999

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Examining the perceptions and behaviours of farmers regarding the installation of covers over irrigation ponds: Evidence from South-east Spain

Belén López-Felices [1], Jose A. Aznar-Sánchez [2,*], Juan F. Velasco-Muñoz [3], Ernesto Mesa-Vázquez [4]

Department of Economy and Business, Research Centre on Mediterranean Intensive Agrosystems and Agrifood Biotechnology, University of Almería, 04120 Almería, Spain

ARTICLE INFO

Handling Editor: Dr. B.E. Clothier

Keywords:
Water management
Sustainability
Intensive agriculture
Farmer attitudes
Cluster analysis

ABSTRACT

The installation of covers over ponds for agricultural irrigation is a feasible alternative to reduce evaporative water losses. However, the installation of these systems continues to be very limited. Understanding the factors that influence the behaviour of farmers towards this type of installation is fundamental because they are the individuals making the final decision. This article analyses the perceptions and behaviours of farmers towards the installation of covers in agricultural irrigation ponds in southeastern Spain. A cluster analysis characterized four groups of farmers related to this practice. The results show that these clusters present different perceptions towards the installation of covers, their possible advantages and the different incentives that can be established to promote their implementation. Technical and agronomic aspects play an important role in installation decisions, while economic and environmental aspects are considered secondary. Based on these results, actionable recommendations are proposed for policy-makers. The findings of this study can be very useful in those regions in which it is desired to promote the installation of covers over ponds for agricultural irrigation.

1. Introduction

The use of ponds for agricultural purposes has been a common practice for centuries, as it facilitates managing irrigation water (López-Felices et al., 2020). These systems are particularly important in areas with limited water resources because they can increase and stabilize crop yields (Mushtaq et al., 2009). Ponds have proven to be a viable alternative to combat prolonged droughts, in addition to diversifying production (Chander et al., 2019). Wisser et al. (2010) determined that the construction of small ponds could increase the production of cereals worldwide by 35 %. These data are of great relevance since it is expected that global food production will experience a 70 % increase by 2050 to meet the needs of a growing population (UN, 2012). It is estimated that there are 277,400,000 ponds less than 1 hectare in size and 24,120,000 water bodies between 1 and 10 ha, which represent 90 % of the stagnant water bodies of the world (Céréghino et al., 2013). In addition, since the 1960 s, the construction of ponds has increased by up to 50 % (Davidson and Finlayson, 2018).

One of the main problems posed by ponds is evaporation losses (Maestre-Valero et al., 2011). Specifically, between 30 % and 50 % of the pond capacity is lost due to evaporation (Abdallah et al., 2021). In addition, Althoff et al. (2020) estimated that the evaporation of small ponds will increase between 7.3 % and 18.4 % by 2100 as a result of climate change. Pond function will then be negatively impacted, causing a decrease in the efficiency of water use at a global scale. Wurbs and Ayala (2014) estimate that the evaporated water in Texas reservoirs could meet 61 % of the total water demand for agricultural use. Craig et al. (2005) determined that the annual loss of water to evaporation in the agricultural holdings of Queensland could reach 40 %, with this volume being sufficient to irrigate some 125,000 ha of crop. Maestre-Valero et al. (2013) show that the evaporated water in the agricultural water reservoirs located in the Segura River Basin (Spain) can represent

* Corresponding author.
E-mail addresses: blopezfelices@ual.es (B. López-Felices), jaznar@ual.es (J.A. Aznar-Sánchez), jfvelasco@ual.es (J.F. Velasco-Muñoz), ermeva@ual.es (E. Mesa-Vázquez).
[1] ORCID: 0000-0002-1715-6461
[2] ORCID: 0000-0001-5443-1269
[3] ORCID: 0000-0002-0593-1811
[4] ORCID: 0000-0001-6848-7474

https://doi.org/10.1016/j.agwat.2022.107999
Received 7 July 2022; Received in revised form 25 October 2022; Accepted 26 October 2022
Available online 2 November 2022
0378-3774/

up to 11.7 % of the water available for irrigation in the basin.

Addressing this problem is of great relevance since one of the main obstacles facing agriculture is the growing scarcity of water resources (Velasco-Muñoz et al., 2019). Therefore, different methods have been developed to reduce the evaporation of ponds, which can be classified as biological methods (organic residues, aquatic plants, wind breakers), chemical methods (chemical covers) and physical methods (suspended covers and floating covers) (Craig et al., 2005; Abdallah et al., 2021). Several studies have analysed the effectiveness of these methods to reduce evaporation, varying between 13 % and 90 % (Martínez-Álvarez et al., 2010; Benzaghta et al., 2013; Jiang et al., 2015; Saggaï and Bachi, 2018). The most promising methods seem to be the physical ones since they have the highest efficiency rates (Abdallah et al., 2021; Martínez-Espinosa, 2021).

In addition to reducing evaporation, covering the ponds can have further advantages. Covering ponds improves water quality due to two main reasons (Maestre-Valero et al., 2011; Martínez-Espinosa, 2021): i) preventing the growth of algae and vegetation in the water by minimizing solar radiation and ii) reducing the amount of dust and waste transported by the wind that enters the pond. This is especially relevant in agricultural systems in which drip irrigation is used, since it is composed of narrow conduits and a large number of drip emitters with small openings that can be easily clogged by physical, chemical and/or biological compounds found in water (Maestre-Valero et al., 2011). The increase in suspended particles in the water and clogged drip emitters can affect the distribution and uniformity of irrigation, which impact on water consumption and crop yield (Bonachela et al., 2013). Therefore, farmers can maintain the optimal performance of the irrigation system by cleaning the filters frequently.

On the other hand, covering the ponds can lead to savings in various operating costs such as water consumption or pond maintenance. Traditionally, two practices have been carried out to keep the pond clean and preserve the irrigation water quality. Dredging the pond is usually carried out at the end of the agricultural season to control excess vegetation and sediments. The other practise is applying biocides to prevent algal growth. There are also studies that suggest the economic viability of these types of installations (Martínez-Álvarez et al., 2009; Maestre-Valero et al., 2013; Han et al., 2019). Despite these advantages, the use of covers in ponds is still not a widespread practice (Abdallah et al., 2021).

In this context, understanding the factors that influence the behaviour of farmers towards this type of practice is fundamental because they make the final decision about adopting it. In this way, approaches and tools that encourage their implementation can be formulated and applied, allowing for the more efficient management of water resources (Liu et al., 2018). This is even more relevant in arid and semiarid areas where water availability can act as a limiting factor for agricultural production (Abdallah et al., 2021). However, to date, no research has analysed the perceptions and behaviours of farmers towards this type of installation. The objective of this work is to fill this knowledge gap by studying the attitudes and behaviours of farmers towards the installation of covers in ponds, aiming to improve the management of water resources. To achieve this, a study was carried out in southeastern Spain, where an intensive agricultural model based on the use of greenhouses was developed (Aznar-Sánchez et al., 2011). The specific objectives of this study include 1) determining the existing profiles of farmers in relation to the installation of covers in the ponds, 2) knowing their perception towards adopting this practice and 3) examining the degree of acceptance of the different measures intended to promote their installation.

2. Material and methods

2.1. Study area

This research was developed in the region of Campo de Dalías located in Almería (southeastern Spain) (Fig. 1). Almería has 32,554 ha of greenhouses, of which 67.7 % are located in Campo de Dalías (Junta de Andalucía, 2020). This area has a Mediterranean climate characterized by mild temperatures in winter, with an average of 18 °C, and low rainfall, averaging 220 mm annually (Mendoza-Fernández et al., 2021). In addition, the high solar radiation, with more than 3000 h of sun per year, leads to high evaporation and evapotranspiration rates (Sánchez et al., 2015). Production has been specialized in a range of eight fruit and vegetable crops (pepper, cucumber, zucchini, tomato, eggplant, green bean, melon and watermelon).

Water consumption for agricultural irrigation in the region amounts to 168.3 hm^3 per year (García-Caparrós et al., 2017). The scarcity of surface water resources has necessitated groundwater-based agricultural development of this region, leading to the overexploitation of aquifers (Caparrós-Martínez et al., 2020). The Horticultural Water Exploitation Index of the region is 1.1 (García-Caparrós et al., 2017). Therefore, technologies have been implemented to improve water use efficiency, such as drip irrigation and the use of tensiometers. Desalinated water has also been incorporated as an alternative source for agricultural irrigation, with 7.5 hm^3 coming from the Campo de Dalías desalination plant (Mendoza-Fernández et al., 2021). In addition, in recent years, the percentage of holdings that harvest rainwater has increased to 50% (García-García et al., 2016) However, the savings generated by these technologies and the use of other alternative sources of water are not enough to meet the high demand of the region, so it is necessary to continue improving water use efficiency. Water resources for agricultural irrigation in this region are managed through irrigation communities, which provide water to member farmers at an average price of 0.30€/m^3 (Caparrós-Martínez et al., 2020). However, the increases in the cost of electrical energy mean that irrigation communities have higher water prices, reaching as high as 0.50 €/m^3.

Almería has more than 10,000 ponds for agricultural purposes (Casas et al., 2011). In Campo de Dalías, 80 % of the holdings have an irrigation pond to store water and flow regulation purposes (Junta de Andalucía, 2015). To cover the ponds of the study area, physical methods are used,

Fig. 1. Location of Campo de Dalías.

specifically concrete covers or suspended covers of shade cloth. Carvajal et al. (2016) determined that covering agricultural ponds in Almería with shade cloth could reduce evaporation losses by up to 83 %. In addition, it is estimated that the evaporation losses of the Campo de Dalías ponds account for approximately 15 % of the total water destined for agricultural use (Mendoza-Fernández et al., 2021). Despite these significant figures, in this region, only approximately 40% of the ponds are covered (García-García et al., 2016). For this reason, Campo de Dalías is an ideal 'laboratory' to carry out this research.

2.2. Questionnaire development

The collection of information for preparing the questionnaire was carried out through interviews with experts and a focus group. The presidents of two of the most important irrigation communities in the region were interviewed, as well as the president of an agricultural cooperative and two farmers with extensive experience. By conducting these interviews, the most relevant information was obtained in relation to the practice of covering the ponds in the study area. To validate the information obtained, a focus group was developed with six farmers in the region, of which three had their pond covered and another three did not. Once the questionnaire was completed, a pilot survey was carried out to test it with a group of eight farmers; four of them had their pond covered, and another four did not. Finally, the questionnaire was divided into four sections:

1. Characteristics of farmers and their holdings. This section had four groups of questions related to a) traits of farmers (age, experience as a farmer and educational level), b) characterization of the holding (type of soil and greenhouse, size, year of construction, climate conditioning systems, irrigation systems, tensiometers, computerized irrigation and rainwater harvesting systems), c) characterization of the irrigation pond (capacity, type, shape, volume at which it is maintained, methods to keep it clean, and type of cover), and d) data on crops and inputs (number of crop cycles, organic production, monoculture, income, expenses, trading channel, number of total workers and family members, electrical conductivity level, methods to deal with pests, percentage of phytosanitary treatments and biological control, methods used for pollination, and type of technical advice).
2. Environmental attitude. In this section of the questionnaire, farmers had to indicate the frequency with which they performed six behaviours in their daily life using a five-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always). The selection of the items was based on previous studies (Paço and Lavrador, 2017; Karasmanaki et al., 2021; Musova et al., 2021). The items included in our study were recycling, turning off the faucet while brushing teeth, limiting showering time, using energy-saving light bulbs, using energy-efficient appliances, and turning off lights and electrical appliances when not in use.
3. Perceptions of installing covers in the ponds. This section of the questionnaire had two parts. In the first part, the farmers had to assess the importance of a series of aspects in their decision to install or not install covers on the ponds using a 5-point Likert scale (1 = not important, 2 = less important, 3 = moderately important, 4 = very important, 5 = extremely important). In the case of the farmers with the covered pond, they had to establish the relevance of the following reasons for doing so: algae and vegetation growth prevention, aquatic animals prevention, dust and waste reduction, evaporation prevention, cost reduction, aquifer conservation, affordable installation cost, and use of space. Covering the pond can prevent the growth of algae and vegetation and the presence of aquatic animals by preventing solar radiation, as well as the entry of dust and waste, which can positively impact water quality. By minimizing the evaporation of water, the aquifer can be conserved since less groundwater needs to be extracted. The reduction of costs can be derived from water savings and the reduction of the maintenance costs of the pond. If the farmers feel that the installation cost is acceptable this can incentivize covers being installed on the ponds. Finally, in the case of covering using concrete, the surface of the pond can be used for other purposes, such as building a warehouse for the irrigation system. Those farmers who did not have covered ponds had to assess the following reasons for not doing so: installation cost, difficulty, algae improves water quality, ecosystem services loss, and biodiversity loss. The difficulty in installing the covers may be due, for example, to the fact that the necessary infrastructure is not available around the pond or that the ponds are large and require the installation of beams in the centre. This can increase the cost if a roof needs to be constructed. On the other hand, the presence of algae can lead to better water quality by generating an ecosystem that allows controlling various water parameters. Thus, if it remains uncovered, the pond can provide ecosystem services by allowing various animals to use them. Therefore, covering it can lead to a loss of biodiversity in the area.
   In the second part, both farmers with covered ponds and uncovered ponds had to select from a series of options, the advantages and disadvantages about covering the ponds. The advantages included the following: evaporation reduction, water quality improvement, reduces the need for filtering and risk of clogging of the irrigation system, reduces the use of additional methods to keep the pond clean, cost reduction, use of space, and aquifer conservation and recovery. By improving the quality of the water and reducing the presence of solids, the filtration of the irrigation system is minimized, and the chances of its clogging are reduced. In addition, by keeping the water cleaner, it is necessary to use fewer additional methods of pond management, such as dredging or biocide treatment. On the other hand, the disadvantages considered were prevents vegetation growth, prevents animals from using the pond, biodiversity loss, installation cost, and difficulty of installation.
4. Measures to promote the installation of covers on the ponds. In the last section of the questionnaire, farmers were asked about four possible measures to encourage the installation of covers in the ponds: training sessions, further information available, aid to cover the cost of installation and regulatory measures. The training sessions include training courses in which the possibilities offered by covering the pond are shown and holdings that already have this installation can be visited as a demonstration. The availability of more information refers to the possibility that farmers can access data on the possible advantages and disadvantages of covering the pond, as well as that the technicians advise them on this practice. With the item of aid to cover the cost of installation, we want to determine the opinion of farmers regarding the need to establish economic aid. In addition, through the item of regulatory measures, it is intended to know if farmers consider it appropriate to establish a regulation that requires covering the ponds in the region. The scoring of these measures was performed with a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree; 5 = strongly agree).

2.3. Sample size and selection

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, α = confidence level, Z_α = statistical parameter that depends on the confidence level (e.g., 1.96 for 95% confidence level), e_α = maximum accepted estimation error, p = probability of occurrence of the event under study. A confidence level of 95% and a maximum error of 5% were established. The study area has an area of 22,054 ha of greenhouses (Junta de Andalucía, 2020), so it was necessary to survey a minimum of 378 ha. Finally, 182 farmers with a total of 395 ha were surveyed. Taking these data into account, the margin of error is approximately 4.89%. To select the sample, simple random sampling without replacement was carried out as all individuals had the same probability of being chosen in each of the extractions. Farmers were contacted with the collaboration of different irrigation communities in the area. The surveys were conducted in person and lasted between 15 and 20 min, from August to November 2021.

2.4. Data analysis

SPSS software (version 27) was used to perform the data analysis. First, descriptive statistics were obtained, the interoperative relationships of the variables were studied, and the outliers and data distribution were observed. Subsequently, a cluster analysis was carried out with the objective of determining the characteristics of the different groups of farmers in relation to the installation of covers in the ponds of the study area. It is an exploratory technique that allows the classification of observations with similar properties through a multivariate statistical procedure (Hennig et al., 2015). In our case, a hierarchical cluster analysis was developed in which the clustering of clusters was performed using the Ward or "minimum variance" method. The application of this method allows obtaining homogeneous clusters in an objective way (Hennig et al., 2015). The homogeneity of the clusters is measured by the sum of the squared distances of each element with respect to the centroid or vector of means (Murtagh and Contreras, 2017). To prevent possible problems derived from obtaining the data

Table 1
Variables and descriptive statistical data.

Area	Variable	Description	Min.	Max.	Average	Standard deviation	Variation coefficient
Farmers' characteristics	V_1	Farmer's age (years old)	27	67	47.66	8.45	17.7 %
	V_2	Years of farming experience	9	50	27.93	9.74	32.42 %
	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	*	*	*
Holding characteristics	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 multi-tunnel, 4 asymmetric	1	4	*	*	*
	V_6	Holding size (ha)	0.55	7	2.11	1.35	64.08 %
	V_7	Construction year. Four-digit year	1985	2021	2004.22	10.01	0.50 %
	V_8	Number of climate systems	1	3	1.33	0.56	41.91 %
	V_9	Irrigation programmer. 0 no, 1 yes	0	1	0.84	0.37	44.55 %
	V_{10}	Use of tensiometers. 0 no, 1 yes	0	1	0.66	0.48	72.08 %
	V_{11}	Fully computerised irrigation with tensiometers. 0 no, 1 yes	0	1	0.18	0.38	217.10 %
	V_{12}	Rainwater harvesting. 0 no, 1 greenhouse surface, 2 other elements of the holding	0	2	*	*	*
	V_{13}	Destination of harvested rainwater. 1 exclusive rainwater pond, 2 pond for different types of water, 3 filter well	1	3	*	*	*
Irrigation pond characteristics	V_{14}	Pond capacity (m^3)	100	20000	1666.04	1925.53	115.57 %
	V_{15}	Type of pond. 1 concrete, 2 polyethylene-lined, 3 others	1	2	*	*	*
	V_{16}	Shape of the pond. 1 square, 2 rectangular, 3 others	1	3	*	*	*
	V_{17}	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%)	2	4	*	*	*
	V_{18}	Method to keep the pond clean. 1 dredging, 2 biocide treatment, 3 covering	1	3	*	*	*
	V_{19}	Covering pond. 0 no, 1 yes	0	1	0.59	0.49	83.00 %
	V_{20}	Type of cover. 1 concrete, 2 shade cloth, 3 others	0	2	*	*	*
Crop and inputs data	V_{21}	Number of crop cycles per year	1	3	1.38	0.51	36.89 %
	V_{22}	Organic farming. 0 no, 1 yes	0	1	0.37	0.48	131.37 %
	V_{23}	Monoculture. − 1 no, 0 depends, 1 yes	-1	1	0.81	0.42	51.42 %
	V_{24}	Season income (€/m^2)	5	13	8.03	1.78	22.16 %
	V_{25}	Season expenses (€/m^2)	2,5	8	4.49	1.12	24.83 %
	V_{26}	Trading channel. 1 cooperative, 2 exchange, 3 direct sale, 4 private distributor, 5 SAT, 6 others	1	5	*	*	*
	V_{27}	Number of labours per year	2	40	6.91	5.81	84.12 %
	V_{28}	Percentage of farmer family-bounded labour	0	39.21	10.29	11.82	114.88 %
	V_{29}	Level of electrical conductivity in irrigation water (dS/m)	0.53	2.10	1.22	0.31	25.13 %
	V_{30}	Number of methods used to deal with pests	3	7	5.55	1.01	18.22 %
	V_{31}	Phytosanitary treatments (%)	0	100	32.02	31.50	98.37 %
	V_{32}	Biological control (%)	0	100	67.98	31.50	46.34 %
	V_{33}	Method for pollination. 0 no, 1 yes	0	1	0.62	0.49	79.28 %
	V_{34}	Type of advice. 1 independent technicians, 2 supply providers, 3 trading company, 4 others	1	3	*	*	*
Environmental attitude	V_{35}	Recycling. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	3.87	1.08	28.03 %
	V_{36}	Turning off the faucet while brushing teeth. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.59	1.02	22.18 %
	V_{37}	Limiting showering time. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	3.05	2.06	67.49 %
	V_{38}	Using energy-saving light bulbs. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.73	0.82	17.25 %
	V_{39}	Using energy-efficient appliances. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	1	5	4.43	0.83	18.73 %
	V_{40}	Turning off lights and electrical appliances when not in use. 1 never, 2 rarely, 3 sometimes, 4 often, 5 always	3	5	3.86	1.46	37.69 %

(*) No data are provided because these are qualitative variables.

using different scales or units, we standardized the data set, and the squared Euclidean distance was used as a measure.

Finally, the analysis of variance of a factor (ANOVA) was used, which carries out a generalization of the contrast of equal means for independent samples (Cardinal and Aitken, 2013). This analysis, frequently used to establish experimental designs, allows studying the clusters and determining the behaviour of the groups within the same variable of interest (Tabachnick and Fidell, 2007). With the use of this type of analysis, the means of each population group are obtained, and their variances (intragroup variance) are studied with respect to the average variance within each group (between-group variance) (Cardinal and Aitken, 2013). If it is taken into account that the groups have been obtained from the same population universe, both the mean and the variances should be equal.

3. Results

This section presents the main results of this research. Firstly, the farmers' profile and main characteristics are shown. Then, the perceptions of different groups in relation to the installation of covers on the ponds are presented. Finally, the farmers' assessment of the different measures to promote the adoption of this practice is reported. The descriptive statistics of the variables studied in this research are shown in Table 1.

3.1. Profile of farmers

Through the application of cluster analysis, the 182 farmers who participated in this research were classified into four homogeneous groups. Of the 40 variables studied, 32 have been found to be relevant to establish this classification (Table 2). Next, the main characteristics of these groups are shown, taking into account the average values obtained in these variables (Table 3).

Cluster 1. *Space optimizers* (N = 54, 30%). These are younger farmers than those of the rest of the clusters who have less experience in the agricultural field. They have a medium level of education. Their holdings are newer, with a medium size and grow mainly in sloping-roof greenhouses using sanding. Eighty-seven percent of their holdings have an irrigation programmer, and 67 % use tensiometers, although both systems are automatically connected in only 19 % of holdings. They collect rainwater from the surface of the greenhouse and from other elements of the holding, directing the harvested water to a reservoir in which water from different sources or a filter well is stored. The ponds of this cluster have an average capacity of 1850 m^3 and are made of concrete. The main method used to keep the pond clean is to cover it with a concrete cover, although it is also drained. It is the cluster that carries out the greatest number of crop cycles per season. Twenty-six percent of the holdings in this cluster grow organically. They obtain an average income of 8.22 €/m^2, while the average cost is 4.68 €/m^2. The main trading channels for the harvest are cooperatives or SAT, from which they also receive technical advice. They have an average of 7 workers per year, of which 7 % are family members. Biological control is mainly

Table 2
ANOVA analysis.

Variable	Description	Conglomerate Root mean square	df	Error Root mean square	df	F	p-value (*)
V_1	Farmer's age	16.840	3	8.232	178	4.185	0.007
V_2	Years of farming experience	18.888	3	8.794	178	4.613	0.004
V_3	Level of education	6.256	3	1.475	178	17.992	0.000
V_4	Type of soil	0.674	3	0.431	178	2.448	0.065
V_5	Type of greenhouse	1.168	3	0.554	178	4.442	0.005
V_6	Holding size (ha)	41.488	3	12.507	178	11.003	0.000
V_7	Construction year	22.613	3	9.662	178	5.478	0.001
V_8	Number of climate systems	0.660	3	0.555	178	1.411	0.241
V_9	Irrigation programmer	0.836	3	0.359	178	5.416	0.001
V_{10}	Use of tensiometers	0.757	3	0.469	178	2.601	0.054
V_{11}	Fully computerised irrigation with tensiometers	0.791	3	0.371	178	4.549	0.004
V_{12}	Rainwater harvesting	1.745	3	0.582	178	8.986	0.000
V_{13}	Destination of harvested rainwater	3.660	3	1.121	178	10.652	0.000
V_{14}	Pond capacity (m^3)	3796.268	3	1878.100	178	4.086	0.008
V_{15}	Type of pond	1.315	3	0.374	178	12.365	0.000
V_{16}	Shape of the pond	0.652	3	0.520	178	1.573	0.198
V_{17}	Quantity of water in the pond	0.749	3	0.577	178	1.685	0.172
V_{18}	Method to keep the pond clean	7.087	3	0.401	178	311.800	0.000
V_{19}	Covering pond	3.739	3	0.105	178	1268.453	0.000
V_{20}	Type of cover	2.944	3	0.056	104	2809.000	0.000
V_{21}	Number of crop cycles per year	0.925	3	0.499	178	3.440	0.018
V_{22}	Organic farming	1.957	3	0.416	178	22.090	0.000
V_{23}	Monoculture	0.514	3	0.416	178	1.523	0.210
V_{24}	Season income (€/m^2)	8.972	3	1.364	178	43.237	0.000
V_{25}	Season expenses (€/m^2)	2.244	3	1.086	178	4.266	0.006
V_{26}	Trading channel	2.549	3	1.609	178	2.511	0.060
V_{27}	Number of labours per year	11.319	3	5.676	178	3.977	0.009
V_{28}	Percentage of farmer family-bounded labour	34.102	3	11.070	178	9.490	0.000
V_{29}	Level of electrical conductivity in irrigation water (dS/m)	0.540	3	0.300	178	3.246	0.023
V_{30}	Number of methods used to deal with pests	0.834	3	1.014	178	0.676	0.568
V_{31}	Phytosanitary treatments (%)	64.263	3	30.649	178	4.396	0.005
V_{32}	Biological control (%)	64.263	3	30.649	178	4.396	0.005
V_{33}	Method for pollination	1.358	3	0.459	178	8.750	0.000
V_{34}	Type of advice	1.127	3	0.680	178	2.748	0.044
V_{35}	Recycling	1.481	3	1.076	178	1.894	0.132
V_{36}	Turning off the faucet while brushing teeth	0.875	3	1.021	178	0.735	0.533
V_{37}	Limiting showering time	3.308	3	2.034	178	2.645	0.051
V_{38}	Using energy-saving light bulbs	1.155	3	0.808	178	2.043	0.110
V_{39}	Using energy-efficient appliances	1.541	3	0.812	178	3.600	0.015
V_{40}	Turning off lights and electrical appliances when not in use	3.446	3	1.398	178	6.075	0.001

(*) With a 90%-reliability, all variables are significant except for V_8, V_{16}, V_{17}, V_{23}, V_{30}, V_{35}, V_{36}, and V_{38}.

Table 3
Farmer group clusters.

Variable	Description	Cluster 1	Cluster 2	Cluster 3	Cluster 4
V_1	Farmer's age	45.35	46.76	48.09	50.81
V_2	Years of farming experience	24.94	27.31	29.28	31.13
V_3	Level of education	Upper secondary education	Upper secondary education/ Compulsory education	Compulsory education	Compulsory education
V_4	Type of soil	Sanded	Sanded	Sanded	Sanded/Local
V_5	Type of greenhouse	Sloping roof	Sloping roof	Sloping roof	Sloping roof/Flat-top
V_6	Holding size (ha)	2.35	2.67	1.87	1.35
V_7	Construction year	2008	2006	2003	2000
V_9	Irrigation programmer	0.87	0.96	0.77	0.69
V_{10}	Use of tensiometers	0.67	0.69	0.86	0.54
V_{11}	Fully computerised irrigation with tensiometers	0.19	0.22	0.36	0.04
V_{12}	Rainwater harvesting	Greenhouse Surface/Other elements of the holding	Greenhouse Surface/Other elements of the holding	Greenhouse Surface/Other elements of the holding	No
V_{13}	Destination of harvested rainwater	Pond for different types of water/Filter well	Pond for different types of water/Filter well	Exclusive rainwater pond/ Pond for different types of water	–
V_{14}	Pond capacity (m^3)	1850.00	2236.85	1324.09	1026.92
V_{15}	Type of pond	Concrete	Concrete/Polyethylene-lined	Concrete/Polyethylene-lined	Concrete
V_{18}	Method to keep the pond clean	Covering/Dredging	Covering/Dredging	Dredging	Dredging/Biocide treatment
V_{19}	Covering pond	Yes	Yes	No	No
V_{20}	Type of cover	Concrete	Shade-cloth	–	–
V_{21}	Number of crop cycles per year	1.56	1.33	1.23	1.31
V_{22}	Organic farming	0.26	0.41	1.00	0.17
V_{24}	Season income (€/m^2)	8.22	8.43	10.23	6.48
V_{25}	Season expenses (€/m^2)	4.68	4.78	4.09	4.17
V_{26}	Trading channel	Cooperative/SAT	Cooperative/SAT	Cooperative	Exchange/Private distributor
V_{27}	Number of labours per year	7.76	8.35	6.18	4.85
V_{28}	Percentage of farmer family-bounded labour	7.73	6.02	12.12	16.61
V_{29}	Level of electrical conductivity in irrigation water (dS/m)	1.22	1.14	1.38	1.22
V_{31}	Phytosanitary treatments (%)	34.67	23.63	21.36	42.50
V_{32}	Biological control (%)	65.33	76.37	78.64	57.50
V_{33}	Method for pollination	0.59	0.67	0.18	0.77
V_{34}	Type of advice	Trading company	Trading company	Trading company	Trading company/ Supply providers
V_{37}	Limiting showering time	3.30	2.87	3.95	2.62
V_{39}	Using energy-efficient appliances	4.30	4.63	4.73	4.23
V_{40}	Turning off lights and electrical appliances when not in use	4.06	4.02	4.55	3.21
	Agricultural holdings total:	54	54	22	52

used to deal with pests (65%). This cluster presents high average values in environmental awareness.

Cluster 2. *Irrigation optimizers using physical methods* (N = 54, 30 %). Farmers in this cluster have extensive experience in the agricultural sector and low/medium education levels. They have the holdings with the largest average size of all clusters. They use sloping-roof greenhouses and sanding for cultivation. It is the cluster with the largest number of irrigation programmers (96%), and 69% of cases also use tensiometers. They collect rainwater from the surface of the greenhouse and from other elements of the holding, with the destination of the harvested water being a pond in which water from different sources or a filter well is stored. Their ponds have the greatest storage capacity, which are concrete or polyethylene-lined. All ponds in this cluster were covered using shade cloth. Dredging is also used as an additional method of cleaning the pond. A high number of these holdings cultivate organically (41 %) and mostly use biological control to deal with pests (76%). This cluster has the highest expenses and the largest number of workers per year. They have the lowest level of electrical conductivity of water of all clusters. They sell the harvest and receive advice from the cooperative or SAT. They reach values higher than 4 points in all items related to environmental awareness, except for limiting showering time.

Cluster 3. *Irrigation optimizers by natural methods* (N = 22, 12 %). This group has extensive experience as farmers and have a basic level of education. Holdings have an average size of 1.87 ha, and greenhouse type is the sloping-roof. Seventy-seven percent of their holdings have an irrigation programmer. This is the cluster that most uses tensiometers (86%) and as well as fully computerized irrigation system through the use of tensiometers (36%). They collect rainwater both from the surface of the greenhouse and from other elements, and the destination of the water harvested in all cases is the pond. They have concrete and polyethylene-lined ponds with an average capacity of 1324 m^3. They use dredging as the only method of cleaning the pond. All farmers in this cluster grow organically. They have the highest average income and lowest expenses of the cluster set. The trading channel used for their harvest is the cooperative, and they receive technical advice through this same route. The average number of workers per year is six. They have the highest average water conductivity of all clusters. It is the cluster that uses biological control the most to deal with pests (78%), and it is the one uses additional methods for pollination the least (18%). This cluster reaches the highest values of all clusters in relation to environmental awareness.

Cluster 4. *Reluctant to adopt* (N = 52, 28 %). It is made up of older farmers with more experience in the sector and a low educational level. Their holdings are the oldest and have the smallest average size. Their greenhouses are sloping-roof and flat-top and they cultivate both in sanded and in local soil. Only 69% of their holdings have an irrigation programmer, and 54% use tensiometers. This cluster does not harvest rainwater. Their ponds have the lowest storage capacity of all the clusters and are all made of concrete. The methods used to keep the pond clean are dredging and biocide treatment. It is the cluster with the lowest organic cultivation (17 %). They gain a lower average income than the rest of the clusters. The main trading channels for their harvest are exchanges and private distributors. They receive technical advice from the exchanges and the companies that provide them with supplies. They have the lowest average number of workers in all clusters and the highest percentage of family workers (16 %). It is the cluster that uses a greater proportion of phytosanitary products to deal with pests and a greater percentage of methods for pollination. It is the one that presents the lowest average values in environmental awareness.

3.2. Perceptions of the installation of covers in the ponds

The two clusters that covered the ponds had similar assessments for their reasons for installing them (Fig. 2). The most notable difference is in relation to the use of the space occupied by the pond, which for Cluster 1 is the main reason to cover it, while for Cluster 2, it is not relevant. The reasons related to the prevention of algae, animals and waste in the pond are slightly more important for Cluster 2, as well as the fact that the investment necessary to install the cover is affordable and there is the possibility of reducing costs. On the other hand, preventing evaporation and conserving the aquifer are two reasons with little relevance in the decision to install covers in the ponds for both clusters.

The two clusters that do not cover the ponds decided on this for different reasons (Fig. 3). In the case of Cluster 3, the reasons related to the presence of algae improving water quality, as well as the loss of biodiversity and ecosystem services as a result of covering it, are of great importance. However, for Cluster 4, these reasons are not relevant, with the difficulty and cost of installation being the main reasons for not covering it.

Fig. 4 shows the percentage of farmers in each cluster who selected each of the advantages of covering the proposed ponds. In general, Clusters 1 and 2 better appreciate the advantages of installing covers on the ponds. For these two clusters, the improvement of water quality, reduced filtering and risk of clogging the irrigation systems and the use of additional methods to keep the pond clean are especially noteworthy. Likewise, Cluster 1 also highly values the possibility of using the surface of the pond for other purposes, while the rest of the clusters do not view this as such a prominent advantage. The least relevant advantages for Clusters 1 and 2 are cost reductions and recovery and conservation of the aquifer. In the case of Cluster 3, the main advantages they see for covering the ponds are reducing evaporation and the conservation and recovery of the aquifer. However, the farmers of this cluster do not consider that covering the ponds improves water quality. Cluster 4 mainly values reducing filtering and the risk of clogging the irrigation

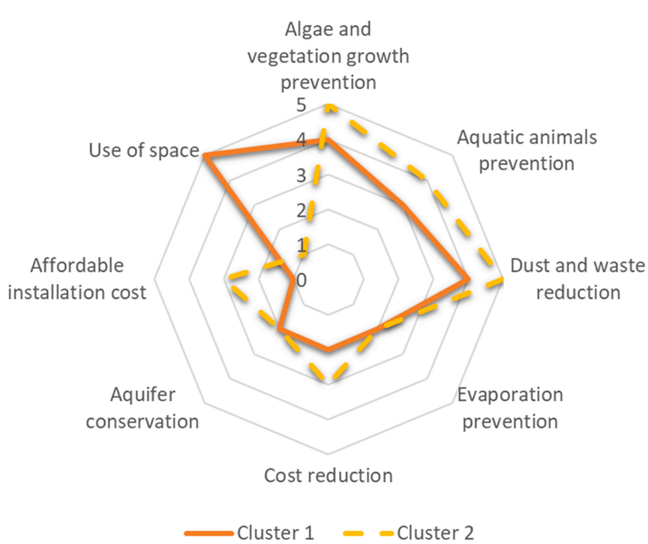

Fig. 2. Assessment of the reasons for covering the pond.

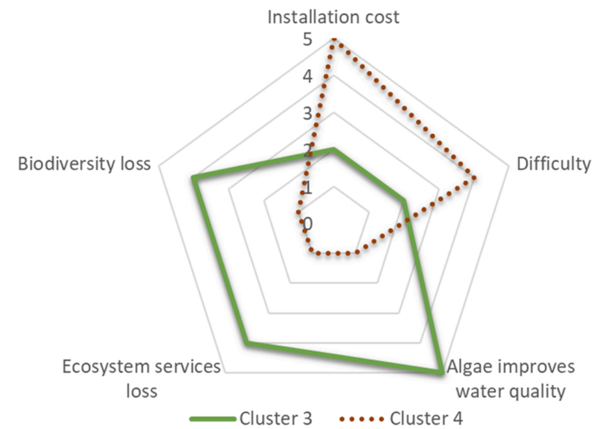

Fig. 3. Assessment of the reasons for not covering the pond.

systems and improving water quality, while the recovery and conservation of the aquifer is the advantaged they least select.

The percentage of farmers in each cluster that selected each of the disadvantages is shown in Fig. 5. For Clusters 1 and 2, the disadvantages of covering the ponds are not considered very relevant, with the most prominent being the cost of installation. In the case of Cluster 3, the main disadvantages are the inhibition of algae and the loss of biodiversity that occurs when covering it. On the other hand, for Cluster 4, the difficulty of installing the system and the cost necessary to do so are particularly relevant.

3.3. Measures to promote the installation of covers on ponds

Fig. 6 shows the level of agreement of the different clusters with the measures to promote the installation of covers on the ponds. All clusters disagree with the training sessions. Clusters 3 and 4 also disagree with establishing a regulation that requires covering the ponds, while Clusters 1 and 2 are indifferent to this measure. Cluster 4 feels that financial aid to meet the cost of installation is absolutely necessary. Finally, all clusters – except cluster 4 – consider that the availability of more information on this practice is important.

4. Discussion

The results of the cluster analysis show that farmers can be grouped into four clusters related to the installation of pond covers. The 'space optimizers' (Cluster 1) decide to install concrete covers in their ponds with the objective of taking advantage of the space that this occupies to make a warehouse for the irrigation system or other tools, as well as for other purposes such as parking for vehicles. The 'optimizers of irrigation by physical methods' (Cluster 2) install suspended shade covers with the aim of preventing the growth of algae and vegetation and reducing the amount of dust and waste entering the pond. The 'optimizers of irrigation by natural methods' (Cluster 3) opt for not covering their ponds because they feel that ecological management favours biodiversity and allows improving the quality of irrigation water. Finally, the 'reluctant to adopt' group (Cluster 4) is formed by older farmers with 'traditional' behaviours who are not willing to make the necessary investment to cover the pond because they are not clear about the benefits that this practice can generate.

The installation of covers in ponds can increase the efficiency of water use in agriculture since it considerably reduces evaporation (Martínez-Álvarez et al., 2009). Despite this, the results of this research show that farmers decide not to cover the ponds to prevent evaporation and, in addition, consider this aspect as a secondary advantage. The farmers of Cluster 1 install concrete covers in their ponds to take advantage of the surface because in the study area, space is limited to

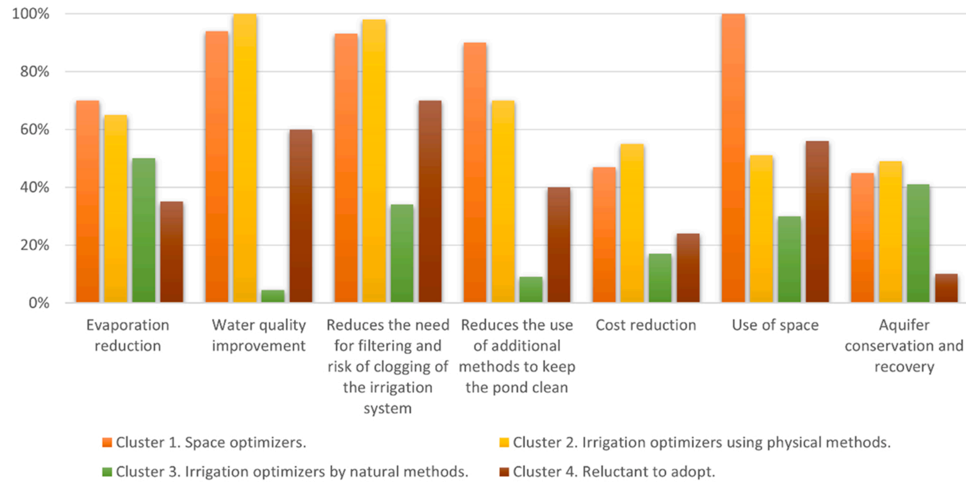

Fig. 4. Assessment of the advantages of covering the pond.

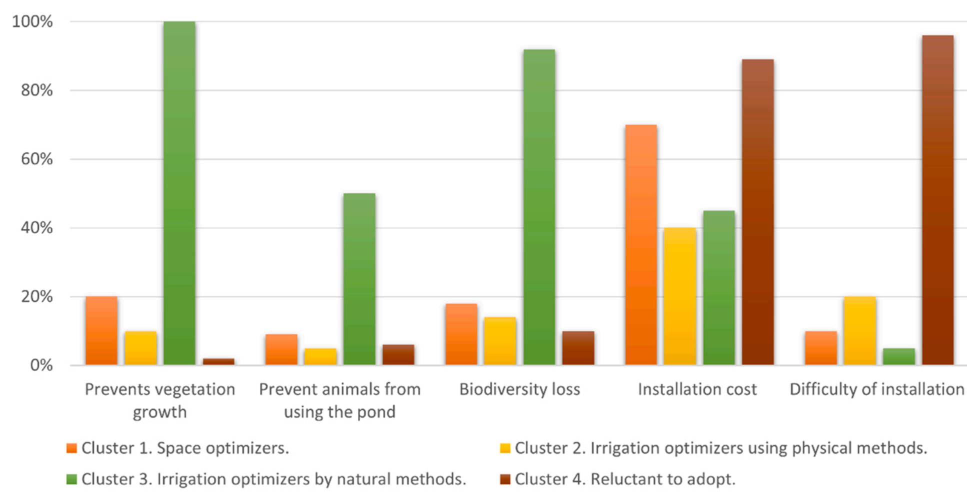

Fig. 5. Assessment of the disadvantages of covering the pond.

Fig. 6. Assessment of the measures to promote the installation of covers on the ponds.

due the high concentration of greenhouses, so taking advantage of the space of the pond allows them to expand the area dedicated to cultivation. For their part, the farmers of Cluster 2 install suspended shade covers with the main objective of preserving the quality of water for agricultural irrigation.

Traditional practices used to keep the pond clean such as dredging and applying biocides are not effective in improving water quality for irrigation (Juan et al., 2012). However, farmers continue to use them, particularly dredging. Most farmers, especially those in Clusters 1 and 2, believe that covering the pond is the best way to maintain water conditions and avoid uniformity problems with irrigation. However, the farmers of Cluster 3 consider that what truly improves water quality is to manage it in an ecological way by developing an aquatic ecosystem which includes algae. In this sense, different studies indicate that the development of algae positively impacts water quality for drip irrigation since it reduces the concentrations of planktonic chlorophyll and total suspended solids (Bonachela et al., 2013; Juan et al., 2013). In addition, uncovered ponds can provide ecosystem services, for example, allowing their use by birds.

The decrease in evaporation reduces the need to use external water sources and, therefore, can reduce the cost of water resources. Although evaporation depends on various factors such as the surface area of the pond or climatic conditions, it is estimated that covering the ponds in the area could save between 400 m^3 and 800 m^3 per season according to the covering method (Carvajal et al., 2016). Taking into account that the price of water ranges from 0.30 to 0.50 €/m^3, savings could amount to 120–400 euros per season. The water needs of the crops in the area range between 6000 m^3/ha and 8000 m^3/ha per season, so that around 6 %13 % of the irrigation water could be covered with evaporated water. In addition, the average water costs per hectare amount approximately to 1800 euros, with the savings achieved by reducing evaporation through the cover installation which represents from 6 % to 22 % of this amount.

The experts commented that covering the ponds in the study area can range from 7 €/m^2 to 14 €/m^2 if it is done with shade cloth, and up to 60 €/m^2 if it is done with concrete. For a typical 200 m^2 pond, in the case of covering with shade cloth, it would be necessary to save from 2800 m^3 to 5000 m^3 water to cover the investment cost, while in the case of covering with concrete it would be necessary to save up to 40,000 m^3 water. Thus, in the case of covering the pond with concrete, this space can be used for other purposes such as building a warehouse for the irrigation system, without the need to invest in the extension of the farm, which has a high cost as the land is valued at 24 euros/m^2. Taking this into account, the water amount to be saved to cover the investment would be 24,000 m^3. Furthermore, it should be borne in mind that covering the ponds can lead to cost savings derived from further aspects such as the following. The need to use additional methods to keep the pond clean is reduced, its average annual cost is estimated at 100 euros for dredging and 141 euros for biocide treatments (Juan et al., 2012). In fact, in our study, 88 % of farmers who do not cover the pond use an additional method for managing it, while this percentage is 41 % for those who do cover it. As well, maintenance needs of the irrigation system can be reduced. Martínez-Álvarez et al. (2009) determined that by covering the pond, the amount of water and electricity needed to clean the filtering systems was reduced by 90 %. Despite this, in our study, cost reduction is not one of the main reasons for installing covers, and it is not one of the most prominent advantages for all farmers.

Several studies have established that the environmental awareness of farmers promotes implementing better management practices (Liu et al., 2018; Prokopy et al., 2019). In our research, although farmers generally have a positive environmental attitude, the conservation and recovery of the aquifer is not one of the main reasons to opt for installing covers on the ponds. This may be because farmers believe installing covers does not save a large amount of water due to the small average size of the ponds and, therefore, will not significantly reduce the amount of water extracted from underground sources. For this same reason, the farmers of Cluster 3, who are the ones with the greatest environmental awareness, feel that favouring biodiversity leads to greater benefits. However, the widespread extension of pond covers can have a positive impact on the recharge of groundwater bodies as evaporation losses account for 15 % out of the total irrigation water in the area and 80% of irrigation water comes from groundwater sources. Furthermore, the covering has no negative effects on the environment. In this sense, Casas et al. (2012) concluded that the ponds in the area cannot perform the same function as natural wetlands. Farmers are therefore not aware of the actual amount of water that can be saved with covers, as well as the further cover benefits.

One of the main disadvantages considered by the group of farmers regarding the practice of covering the ponds is the cost of installation. This aspect is especially relevant for farmers in Cluster 4, who indicate this as the main reason for not covering it. In addition, these farmers also mention the difficulty of covering it, which in turn impacts the cost of doing so. Some of the aspects discussed in relation to this issue are the unavailability of the necessary infrastructure around the pond to properly anchor the cloth, requiring beams in the centre of the pond or the incidence of strong winds. Other studies have also indicated that these aspects make the investment necessary to install the ponds more expensive (Craig et al., 2005; Martínez-Álvarez et al., 2010). Martínez-Álvarez et al. (2009) determined that the installation of covers was not economically viable in the Segura River Basin (Murcia, Spain) considering a water price of 0.3 €/m^3. However, in our study area with an equivalent average water price, 59 % of the ponds are covered because this practice presents additional benefits for farmers. This perception shows that the aspects related to the investment are considered secondary when deciding to install covers in the ponds of the study area. This differs from that indicated in other studies on the incorporation or use of better water resource management practices (Abdulai and Huffman, 2014; Bogdan and Kulshreshtha, 2021).

The assessment of the measures to promote the installation of covers on the ponds indicates that farmers require more information about this practice. However, this information should be based on research conducted in the study area that demonstrates the effectiveness of this practice both to reduce evaporation and to improve water quality. Once conclusive scientific results are obtained, they should be disseminated among farmers. In this particular context, training sessions do not seem the most appropriate way to convey information about this practice. This may be because the installation of the cover is carried out by a specialized company and, in addition, does not imply changes in the method of managing irrigation (Juan et al., 2012). These results differ from those obtained in other studies in which training and demonstration sessions are presented as one of the most effective methods to encourage farmers to incorporate sustainable practices into their management of water resources (Adamsone-Fiskovica and Grivins, 2021; Aznar-Sánchez et al., 2021). One way for this information to reach farmers can be through the field technicians who advise them or through the cooperatives or irrigation communities of which the farmers are members. Galdeano-Gómez et al. (2017) point out that farmers' associations in Almería play a key role in resource management and in promoting more environmentally friendly production systems.

The literature indicates that regulation could be an ideal measure to encourage the adoption of practices that positively impact sustainability (Aubert et al., 2012; Aznar-Sánchez et al., 2020). However, in our study, the two clusters that do not have covered ponds disagree with regulatory measures that make it mandatory, although their reasons are different. Therefore, regulations in this regard must take into account the attitude of the different profiles of farmers to avoid rejection or noncompliance. Regarding economic aid, most farmers agree with its effectiveness in encouraging the implementation of this practice. In fact, farmers in the study area who belong to a producer organization (cooperative or SAT) can receive aid from operational funds for the installation of covers on the ponds. However, the farmers of Cluster 4, who are the most in need of such aid, cannot access them because they do not belong to these organizations.

The results obtained in this research are of great relevance for stakeholders, especially for researchers and policy-makers. As has been demonstrated, the existing disparity in research on the best way to maintain and/or improve water quality for irrigation can be confusing among farmers, who end up making decisions based on their own experience. Therefore, it is necessary to expand the research in the study area in relation to the management methods of the ponds to determine which is most beneficial, taking into account both the economic and environmental aspects. In this sense, considering the results of this research, the cover of the ponds is a beneficial alternative as it improves efficiency in water management resources by reducing evaporation. Intermediate solutions could also be considered, such as the installation of partial covers or the use of materials that allow solar radiation and prevent dirt from entering into the pond (Abdallah et al., 2021). The public administration should promote the implementation of this practice by expanding research on it, developing information dissemination programs and incentives adapted to the farmers' needs.

5. Conclusions

Through the application of the cluster analysis, four groups of farmers were characterized in relation to the installation of covers in the irrigation ponds. The 'space optimizers' opt to cover the concrete pond to use its surface for other purposes, while the 'irrigation optimizers by physical methods' seek to maintain water quality to ensure irrigation uniformity. Those farmers who do not cover the pond do so for conflicting reasons. The 'optimizers of irrigation by natural methods' feel that biodiversity improves the quality of water for irrigation, while the 'reluctant to adopt' feel that covering the pond does not provide them a sufficient benefit to make such investment. In general, farmers who do not have their ponds covered are not opposed to implementing this practice, but it is necessary to incorporate the proposed measures to promote such introduction. In this sense, the need to make information on this practice more available among farmers is key due to the fact that there are opposing forms of pond management that have the same purpose. On the other hand, economic incentives to cover the installation cost the system should be promoted, especially among farmers who do not belong to a producer organization.

Future lines of research on this practice in the study area should focus on demonstrating the efficiency of this system to guarantee and/or improve water quality for agricultural irrigation, as well as to reduce evaporation and the demand for additional water resources. On the other hand, it would be necessary to determine the financial viability of the installation of the covers, taking into account all the benefits that this provides to be able to design the necessary economic measures to incentivize their implementation. Finally, it must be taken into account that the characteristics of the study area can influence the perceptions of farmers about the implementation of this practice. Despite this, the results obtained in this study can be extrapolated to those areas with small and medium-sized farms with greenhouses, similar climatic conditions and problems related to water availability, especially those in the Mediterranean basin as it is highly vulnerable to climate change. On the other hand, these results may also be useful in other countries such as Mexico, Egypt or China where large areas of greenhouse vegetable production take place.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

No data was used for the research described in the article.

Acknowledgements

This research was partially supported by the Spanish Ministry of Science and Innovation and the European Regional Development Fund by means of the research project ECO 2017-82347-P. And by the FPU19/04549 Predoctoral Contract to Belén López-Felices and by the regional Government of Andalusia by means of the POSTDOC_21_00281 Posdoctoral Contract to Ernesto Mesa-Vázquez.

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