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Evaluation of some Water, Energy and Financial Indicators: A Case Study of Esenli Water User Association in Yozgat, Türkiye

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ABSTRACT

Energy is one of the most important inputs for pressurized irrigation systems in the world's agriculture sector. As in all areas of life, energy used in irrigation has become an important research subject for researchers. In studies performed with performance indicators in Türkiye, the use of energy indicators is limited. The scarcity of energy resources makes the efficiency of energy used in irrigation schemes extremely important. This study evaluated the performance of a pressurized irrigation scheme with water, energy and financial indicators in Yozgat. The data obtained were compared with other countries in the Mediterranean region. As a result, it was concluded that, on average, the irrigation rate was 39%, annual irrigation water supply per unit irrigated area was 8229 m^3 ha^{-1}, specific energy was 0.33 kWh m^{-3}, energy consumed per unit irrigated was 2671 kWh ha^{-1}, total maintenance, operation and management cost per unit irrigation water supply was 403 € ha^{-1} in the years (2008-2017) when the study was conducted. The finding showed that the specific energy value was about three times lower than in other countries. However, when the energy consumed per unit in the irrigated area was examined, it was found that the irrigation scheme has a high consumption of energy.

Keywords: Financial management, Energy use, Performance evaluation, Water use, Water user associations

1. Introduction

Water is essential for food, energy, poverty reduction, sustainable development and human well-being. Global projections indicate that demand for freshwater, energy and food will significantly increase over the next decades under the pressure of population growth and mobility, economic development, international trade, urbanization, diversifying diets, cultural and technological changes and climate change (Hoff 2011; Endo et al. 2017; Lu et al. 2021).

Irrigated agriculture is extremely important for providing maximum benefit with the scarce resources available. With the widespread use of pressurized irrigation systems, energy use in irrigated agriculture is increasing gradually. Total global water withdrawals for irrigation are projected to increase by 10% by 2050 (FAO 2011).

In Türkiye, rapid and extensive work has been conducted in recent years for the transition to pressurized irrigation systems instead of open channel systems. Furthermore, new irrigation projects are designed and built as pressurized irrigation systems. With these developments, agricultural energy consumption is increasing. In Türkiye, energy is used in approximately 20.5% of the total irrigated area. One of the most important problems faced by water user associations (WUA) is that the energy cost is very high, and they have payment difficulties (DSI 2019).

The data obtained as a result of irrigation performance evaluation can support the planning, implementation and management of similar projects (Bastiaanssen & Bos 1999). Performance indicators such as water, energy and financial management are to evaluate irrigation schemes and benchmark among the others or the years. The indicators help to improve water management in agricultural lands and give key clues to water decision-makers managers, policymakers and scientists. These indicators were created by Molden et al. (1998), Malano & Burton (2001) and Córcoles et al. (2010) and used by many researchers.

In Türkiye, after the transfer of irrigation management (giving the management, operation and maintenance (MOM) rights of the irrigation system from the government to WUA), numerous studies have been performed to evaluate irrigation performance with these indicators and published in national and international journals.

The studies that have been done on water use, agricultural efficiency, environmental efficiency and financial efficiency indicators (Degirmenci et al. 2003; Cakmak et al. 2010; Arslan & Değirmenci 2017) have a growing body in literature (Kartal et al. 2019; Arslan et al. 2020; Çifçi & Değirmenci 2022). The studies showed that there is no energy use indicator. However, Diker (2018) calculated energy use indicators in the master's thesis on the evaluation of 18 irrigation associations in the Lower Seyhan Plain. The calculation results showed that the energy cost per unit irrigation area was between 2.79 and 123.94 \$ ha^{-1}, the energy cost per unit irrigated area was between 2.93 and 132.04 \$ ha^{-1} and the energy cost per unit irrigation water supply was between 0.0002 and 0.0158 \$ m^{-3}, based on the data of 2011-2015. Çifçi and Değirmenci (2022) found that the highest energy cost per unit irrigation areas for five irrigation associations in the Asi Basin was 233.96 \$ ha^{-1}, the energy cost per unit irrigated area was 394.94 \$ ha^{-1} and the energy cost per irrigation water supply was 0-0.03494 \$ m^{-3}. The literature review showed that most studies on the evaluation of the performance of irrigation associations were conducted in Spain, Türkiye, Italy and Greece.

Vanino et al. (2015) reported that in WUA in Epirus and Western Greece, Greece and Apulia, Italy, the use of surface water resources accounted for 15% of the total irrigation water consumption cost, while the use of underground water resources accounted for 60-90% of the total irrigation water consumption cost, and the energy cost should be reduced by 13%. Rodríguez-Díaz et al. (2011) used data from 10 irrigation regions in Spain, and reported that the amount of energy consumed per unit of irrigation water varied between 0.15 and 0.85 kWh m^{-3}, while Abadia et al. (2010) reported that the amount of energy supply per unit irrigated area in 22 irrigation associations varied between 92.32 and 6.229.90 kWh ha^{-1}, the energy cost per unit irrigated area was between 10.67 and 543.35 € ha^{-1} and the energy cost per unit of irrigation water varied between 0.009 and 0.264 € m^{-3}. Soto-García et al. (2013) reported that the average energy consumption per unit irrigated area in Campo de Cartagena, Miraflores & Calasparra-Cieza irrigation regions, was 1.891-2.997 kWh ha^{-1} between the years 2002 and 2011, while the energy consumption per unit water supply varied between 0.15 and 0.18 kWh m^{-3}. González et al. (2015) found the average energy consumption per unit area in the Andalusian region was 1003 kWh ha^{-1}, and the average energy consumption per unit water was 0.41 kWh m^{-3}. Alcon et al. (2017) studied 5 WUAs in the Segura River Basin District in Spain. One of these WUAs, Miraflores, which uses only groundwater, the average total MOM cost per unit irrigated area is 1014 € ha^{-1} and the average total MOM cost per irrigation water supply is 0.31 € m^{-3}, while the average values of the four other irrigation communities are 554 € ha^{-1} and 0.22 € m^{-3}, respectively. Playán et al. (2018) evaluated the success of current and future telemetry/remote control applications in the irrigation associations in Spain. They stated that these systems will become widespread in irrigation schemes in the short run.

Energy prices have been increasing dramatically in the world in recent years as well as in Türkiye. For this reason, there is a growing body of literature that recognizes the importance of using energy effectively. Energy use plays a crucial role in modern agricultural irrigation systems to use water efficiently. However, there is no considerable amount of literature that has been published on energy use in irrigation systems in Türkiye. Accordingly, researchers have shown an augmenting interest in the evaluation of irrigation schemes with energy use performance indicators.

This study focused on the analysis of the energy, water use and financial management level of Esenli Water User Association located in the Central Anatolia of Türkiye, where most sugar beet is produced and a sprinkler irrigation system has been commonly used, for over 10 years. The study results will contribute to the successful management of irrigation associations, more efficient use of energy and increased production with less water and energy consumption.

2. Material and Methods

2.1. Study area

The Esenli Water User Association of Yozgat province located in the Central Anatolian region of Türkiye was selected as the study area. A semi-arid continental climate prevails in Yozgat province. In the region, summers are hot and dry; winters are cold and rainy.

The average precipitation amount was determined as 516.7 mm (Central Anatolia Development Agency 2011). The location of Esenli Water User Association is located within the borders of Yozgat province in Türkiye (Figure 1).

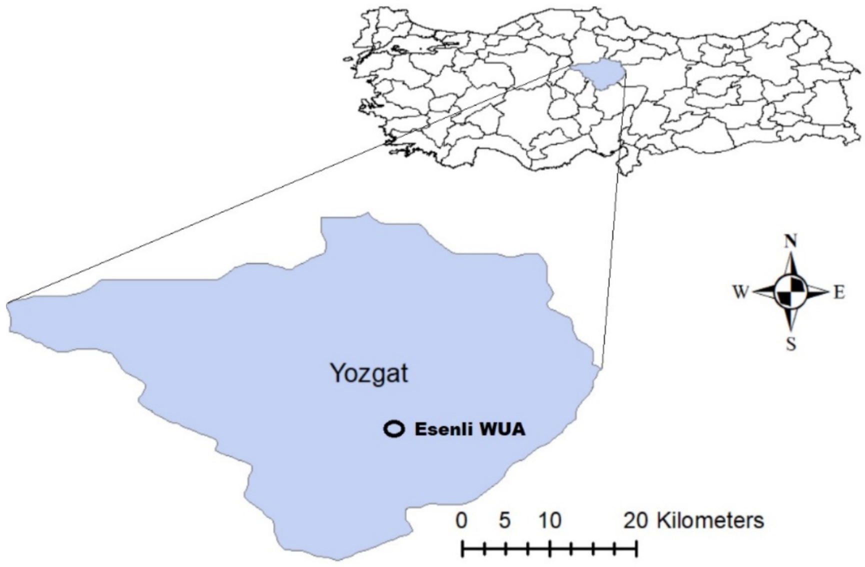

Figure 1- Esenli Water User Association location map

In the Esenli WUA, irrigation is done by pumping, and the information about the irrigation association is given in (Table 1). Sugar beet is cultivated in 98% of the irrigated area, while wheat is cultivated in dry conditions. The pumped irrigation system consists of a pipeline with a total length of 193 km including 40 km of primary pipe and 153 km of secondary pipes. Irrigation water is taken from the Gelingüllü dam, located on the Kanak stream in the Kızılırmak basin through pumping facilities. In the study, the data from 2008-2017 were taken from the irrigation association monitoring and evaluation reports (DSI 2019).

Table 1- Characteristics of Esenli Water Users Associations

Attribute	***Definition***
Command area (ha)	3296
Water distribution method	On-demand
On-farm irrigation methods	Sprinkler irrigation
Main crops	Sugar beet
Number of villages	7
Number of farmers	188
Number of parcels	879
Average parcel width (ha)	1.7
Water pricing method	ha x € (different for each crop)
Average water fee (€ ha-1)	400.67
Is water supply measured?	Yes
Is measurement done at distribution points?	No
Is there a water distribution program?	Yes

2.2. Performance indicators

Various methods have been developed and used to evaluate irrigation performance (Alcon et al. 2017; Zema et al. 2015; 2018; Abadia et al. 2010; Elshaikh et al. 2018; Carrillo-Cobo et al. 2010; Rodríguez-Díaz et al. 2011; González et al. 2015; Kukul et al. 2008). The performance indicators and calculation method used in the performance evaluation of the Esenli Water User Association are given in Table 2. In this study, the performance indicators were divided into four groups, including land use, water use, energy use and financial management. In the calculation of performance indicators, irrigation water supply (m^3), command area (ha), irrigated area (ha), energy consumed (kWh), energy cost (€), total MOM cost (the annual MOM cost of providing the irrigation service such as salaries, communication, transportation, repairing, building, etc., €), maintenance cost (€), total revenue (€), staffing cost (€), water fee accrual (€) and water fee collection (€) data of the Esenli Water User Association over 10 years (2008-2017) were used. The changing currency of the Turkish Lira to the Euro, and the values of the year were used according to the Türkiye Central Bank.

Table 2- Description and calculation method of the performance indicators used in this study

Domain	*Indicator name*	*Abrev*	*Unit*	*Calculation*
Land use (Arslan & Değirmenci, 2018)	Irrigation ratio	ICR	%	*(Irrigated area) / (Command area)*
Water use (Córcoles et al. 2010; Zema et al. 2015)	Annual irrigation water supply per unit command area	VsSa	m^3 ha^{-1}	*Irrigation water supply / Command area*
	Annual irrigation water supply per unit irrigated area	VsSr	m^3 ha^{-1}	*Irrigation water supply / Irrigated area*
Energy use (Córcoles et al. 2010)	Specific energy	EacVs	kWh m^{-3}	*Energy consumed / Irrigation water supply*
	Energy consumed per unit irrigated area	EacSr	kWh ha^{-1}	*Energy consumed / Irrigated area*
	Energy cost per unit irrigated area	CENSr	€ ha^{-1}	*Energy cost / Irrigated area*
	Energy cost per irrigation water supply	CENVs	€ m^{-3}	*Energy cost / Irrigation water supply*
	Energy cost to total MOM costs ratio	EacMOMc	%	*Energy cost / Total MOM cost*
Financial management (Córcoles et al. 2010; Zema et al. 2015)	Total MOM cost per irrigation water supply	CMSVs	€ m^{-3}	*Total MOM cost / Irrigation water supply*
	Total MOM cost per unit irrigated area	CMSSr	€ ha^{-1}	*Total MOM cost / Irrigated area*
	Maintenance cost	CM	€ ha^{-1}	*Maintenance cost / Irrigated area*
	Revenue collection performance	RCP	%	*Gross revenue collected / Gross revenue invoiced*

3. Results and Discussion

This study revealed that the performance indicators have varied greatly over the years. The average, range (min-max) and standard deviation values of the indicators selected in the study for the period of 2008-2017 are given in (Table 3).

3.1. Land use

The irrigation rate is an indicator used to evaluate the service area of the irrigation scheme. The irrigation rate needs to increase over the years. The average, min and max values of the irrigation rate of the study area between 2008 and 2017 are 39%, 23% and 51%, respectively. They are among the acceptable values according to the limit values given below. The irrigation rate has exceeded 50% only in 2013, over the 10 years Figure 2. Wheat is cultivated in the irrigation area in dry conditions. Farmers think that the precipitation is sufficient in these areas and do not demand irrigation water. The average ICR in the study region was 50%, 68% on average of Türkiye's WUAs according to DSI (State Hydraulic Works) reports (DSI 2019). Yercan et al. (2009) determined the acceptable limit values of ICR based on the literature and found that the irrigation rate of the irrigation associations in the Gediz river basin in Türkiye was 80%. Where, ICR is poor if in the range <30%, acceptable if 30-40%, satisfactory if between 40 and 50% and good if >50%. Zema et al. (2018) found the average ICR value to be 27.9% in 10 irrigation associations in the Calabria region of Southern Italy and considered this as poor according to the aforementioned literature.

Table 3- Average, range and standard deviation of the performance indicators

Domain	***Indicator name***	***Abrev***	***Unit***	***Average***	***Range***	***Std dev.***
Land use	Irrigation ratio	ICR	%	39	23-51	8
Water use	Annual irrigation water supply per unit command area	VsSa	$m^3\ ha^{-1}$	3251	2355-4656	799
	Annual irrigation water supply per unit irrigated area	VsSr	$m^3\ ha^{-1}$	8229	6458-10208	1286
Energy use	Specific energy	EacVs	$kWh\ m^{-3}$	0.33	0.12-0.48	0.09
	Energy consumed per unit irrigated area	EacSr	$kWh\ ha^{-1}$	2671	1157-3563	670
	Energy cost per unit irrigated area	CENSr	$€\ ha^{-1}$	259	66-344	104
	Energy cost per irrigation water supply	CENVs	$€\ m^{-3}$	0.033	0.01-0.05	0.01
	Energy cost to total MOM costs ratio	EacMOMc	%	64	15-94	26
Financial management	Total MOM cost per irrigation water supply	CMSVs	$€\ m^{-3}$	0.05	0.03-0.07	0.01
	Total MOM cost per unit irrigated area	CMSSr	$€\ ha^{-1}$	403	266-549	79
	Maintenance cost	CM	$€\ ha^{-1}$	21.6	3.6-57.4	17.5
	Revenue collection performance	RCP	%	76	42-88	17

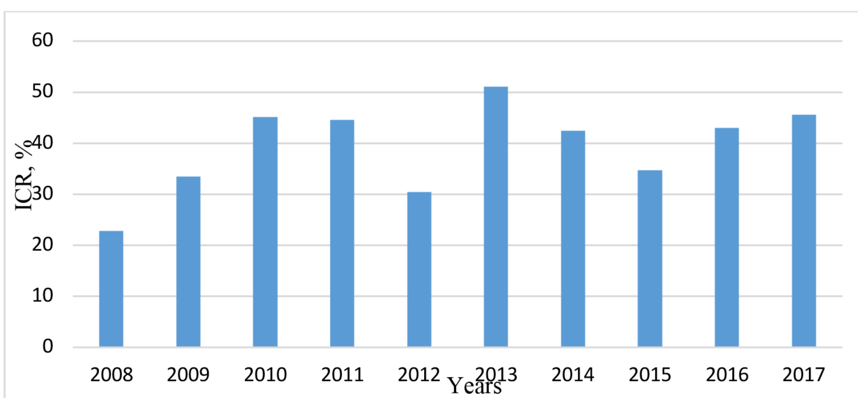

Figure 2- Irrigation ratio (ICR)

3.2 Water use

The VsSa value was 3251 $m^3\ ha^{-1}$ on average and in the range of 2355-4656 $m^3\ ha^{-1}$. The VsSr value was 8229 $m^3\ ha^{-1}$ on average and in the range of 6458-10208 $m^3\ ha^{-1}$ Table 3. The change of VsSa and VsSr indicators over the period of 2008-2017 is given in Figure 3. As seen in Figure 3, both VsSa and VsSr values have changed considerably on a yearly basis. This shows that the irrigation association has been unable to fully apply the planned water distribution. Moreno et al. (2010) found the VsSa value in 15 irrigation associations in Spain to be in the range of 739.7 (Drip irrigation method) and 7,189.5 (sprinkler irrigation method) $m^3\ ha^{-1}$. Alcon et al. (2017) reported that the average VsSr was 2889 $m^3\ ha^{-1}$ and the maximum amount delivered reached 4255 $m^3\ ha^{-1}$.

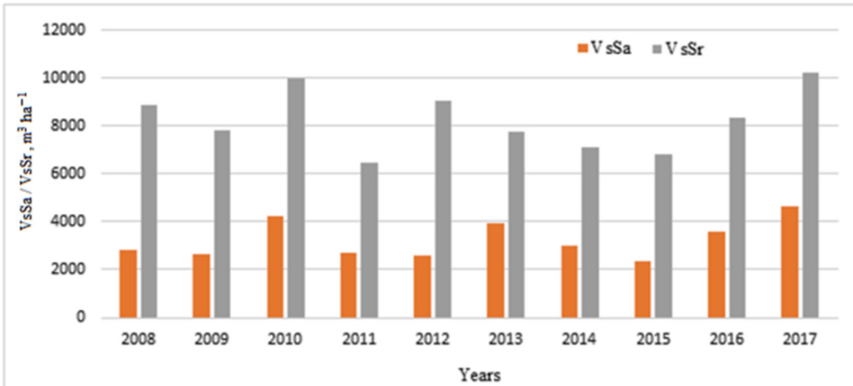

Figure 3- Annual irrigation water supply per unit command/irrigated area (VsSa/VsSr)

3.3. Energy use

The EacVs was found to be 0.33 kWh m^{-3} on average and in the range of 0.12-0.48 kWh m^{-3} and the standard deviation was found as 0.09 kWh m^{-3}. Rocamora et al. (2013) found the EacVs to be 1.71 and 1.69 kWh m^{-3} in the 2-year irrigation season (2009-2011) in Spain. The EacSr was found to be 2671 kWh ha^{-1} on average and in the range of 1157-3563 kWh ha^{-1}, and the standard deviation was found as 670. Abadia et al. (2010) defined the Esenli Water User Association as 'very large' consumer based on the scale for evaluating the energy amount consumed per irrigated area. When the change of EacVs and EacSr values between 2008 and 2017 is examined, it is seen that energy use was similarly based on area and volume, and in 2012, 2016 and 2017, EacVs decreased while the EacSr increased as seen in Figure 4. The situation resulted in lower irrigated area and higher irrigation water use can be considered as management and operation problem in the years. In Türkiye, value of average energy use is 14% (DSI 2019). The value was found that the EacVs in irrigated agriculture in Spain was between the range of 0.03 kWh m^{-3} and 0.17 kWh m^{-3} between 1950 and 2017, and the energy use increased by 2.9% between 1950 and 1979 and by 4.5% between 2014 and 2017 (Espinosa-Tasón et al. 2020). González et al. (2015) found that the EacSr in 10 irrigation associations in the Andalusian irrigation region was 1003 kWh ha^{-1} on average and in the range of 455-1901 kWh ha^{-1}, and the standard deviation was 418.1 kWh ha^{-1}.

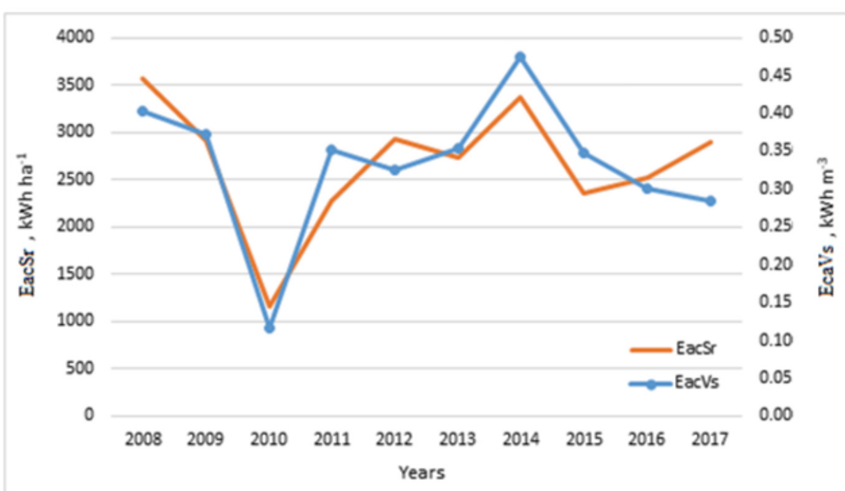

Figure 4- Specific energy (EacVs) and energy consumed per unit irrigated area (EcaSr)

The CENSr was 259 € ha^{-1} on average and in the range of 66-344 € ha^{-1}, and the standard deviation was 104. The CENVs was 0.03 on average and in the range of 0.01-0.05 € m^{-3}, and the standard deviation was 0.015 Table 3. The CENSr and CENVs rapidly increased between 2010 and 2011 as seen in Figure 5. In Asi River basin, the indicator value was found 0.007 \$ m^{-3} on average which is very low comparing with the study area due to the technological backwardness used in the irrigation area (Çifçi & Değirmenci 2022). Studies on WUAs installed by only pressurized irrigation system are more suitable for benchmarking such as Spain and Italia' experience. García et al. (2014) found that the CENSr in five irrigation schemes in the Andalusian irrigation region of Southern Spain was in the range of 48.9-147.6 € ha^{-1} after the modernization of the irrigation schemes. The energy cost increased by 149% compared to before the irrigation modernization. Carrillo-Cobo et al. (2010) determined the average CENVs as 0.05 € m^{-3} in their study with monthly data in the Fuente Palmera irrigation district in Spain in 2007. They determined that there was a significant change in energy cost in the year.

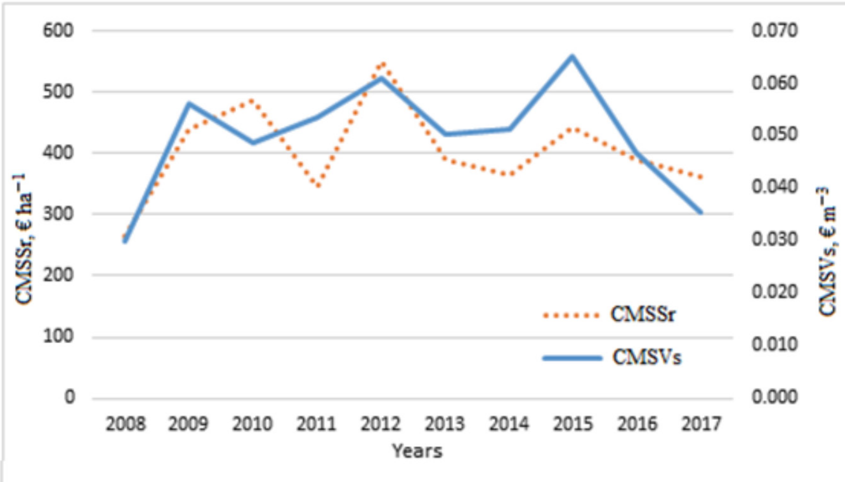

Figure 5- Energy cost per irrigation water supply (CENVs) and the energy cost per unit irrigation area CENSr

The indicators' values sharply increased due to sharp increase in energy prices after the year 2009. The EacMOMc was 64% on average and in the range of 15-94% as seen in Table 3. The energy cost has had a very high share in the total MOM cost since 2010 as depicted in Figure 6. González et al. 2015 found the EacMOMc in 10 irrigation associations in Southern Spain to be 36.4% on average. The EacMOMc is 23% on average in Türkiye according to DSI reports (DSI 2019). The higher EacMOMc may show modernization works have been continued in the irrigation area and more investment is needed to give better service to farmers. Carrillo-Cobo et al. (2010) stated that total energy cost accounts for 28% of MOM costs. Rodríguez-Díaz et al. (2011) found that the energy cost in 10 irrigation regions in the Andalusian region of Spain increased approximately ten times compared to pre-modernization, and that the post-modernization energy cost accounted for 30% of the total MOM cost. They found that the EacMOMc was 36.40% on average and in the range of 16.1-65.3% and the standard deviation value was 15.1%. Córcoles et al. (2010) found out in their study in seven irrigation associations in the Castilla-La Mancha region of Spain based on the data of 2006-2008 that the energy cost accounted for ~45% of the total MOM cost in the case of drip irrigation, while it accounted for 70% in case of sprinkler irrigation. It is seen that the 10-year average EacMOMc of the Esenli Irrigation Association, where the sprinkler irrigation method is applied, is very high.

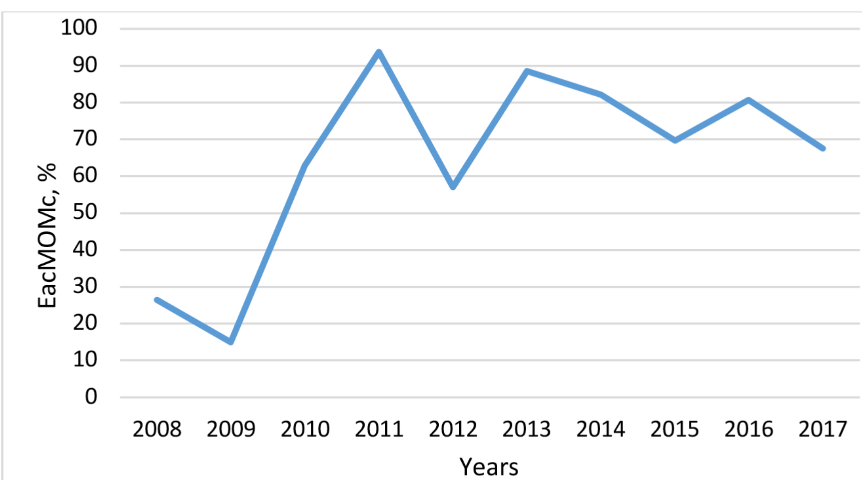

Figure 6- Energy cost to total MOM cost ratio (EacMOMc)

3.4. Financial management

Financial indicators measure how efficiently an irrigation association uses economic resources (Córcoles et al. 2010). It is essential to measure financial management performance for a sustainable irrigation association.

The CMSVs was 0.05 € m^{-3} on average and in the range of 0.03-0 between 2008 and 2017. The CMSSr was 403 € ha^{-1} on average and in the range of 266-549 € ha^{-1} (Table 3). The change of CMSVs and CMSSr over the period of 2008-2017 is given in Figure 7. González et al. (2015) found that the CMSVs in 10 irrigation Associations in Southern Spain was 0.10 € m^{-3} on average and in the range of 0.18-0.04 € m^{-3}. In sprinkler irrigation systems, energy costs account for 60-78% of total MOM costs, and in drip irrigation systems, they account for approximately 45% of total costs. Zema et al. (2018) found the CMSSr to be 1445 € ha^{-1} on average in 10 irrigation associations and stated that this variability can occur, considering that the MOM costs vary depending on different factors. The MOM cost is affected by changes in energy prices, maintenance and repair requirements, annual climate factors, water fee collection rate, the characteristics of the pumping facility, and management performance.

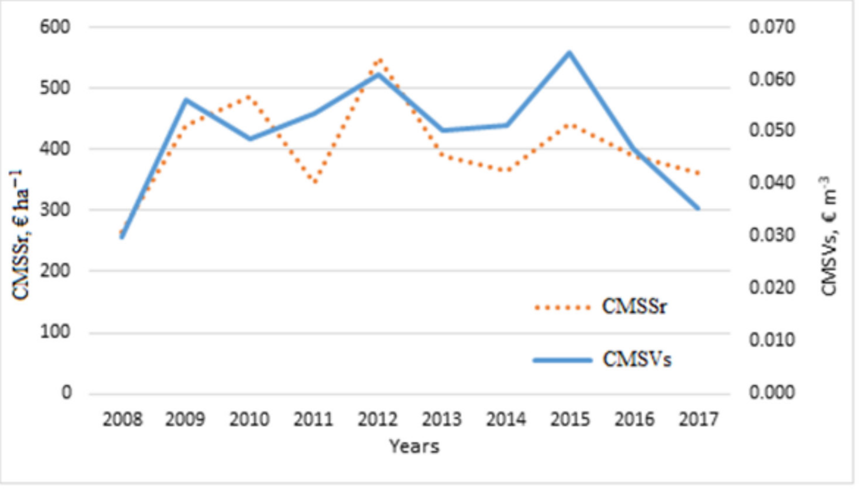

Figure 7- Total MOM cost per unit irrigated area (CMSSr) and total MOM cost per irrigation water supply

Maintenance cost is an indicator that measures the maintenance costs spent per unit area. The CM was found to be 21.6 € ha^{-1} on average and in the range of 3.6-57.4 € ha^{-1}. It is seen that the maintenance costs spent per unit area decreased from 2008 to 2013 (Figure 8). García et al. (2014) found that in five irrigation schemes in the Andalusian region of Spain, the CM was between 42.9 and 80.1 € ha^{-1} before the modernization and 76.5 and 106.4 € ha^{-1} after the modernization. It was found that the water distribution capacity was insufficient in 1/3 of irrigation schemes and deteriorated due to poor maintenance (García-Bolanos et al. 2011).

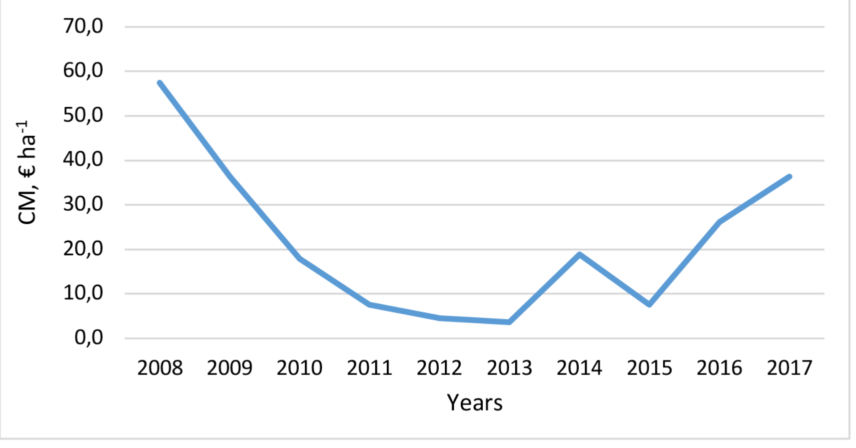

Figure 8- Maintenance cost (CM)

In the study, the RCP varied between 42% and 88% and was 76% on average. Yercan et al. (2009), based on some literature, determined the acceptable RCP value as follows; poor if <40%, acceptable if in the range 40-60%, satisfactory if between 60% and 75% and good if >75%. Based on these limit values, Esenli WUA can be considered as satisfactory. Since 2010, the RCP can be considered as very good (Figure 9). Svendsen & Murray-Rust (2001) reported that after the irrigation management transfer of irrigation schemes in Türkiye, the RCP has increased.

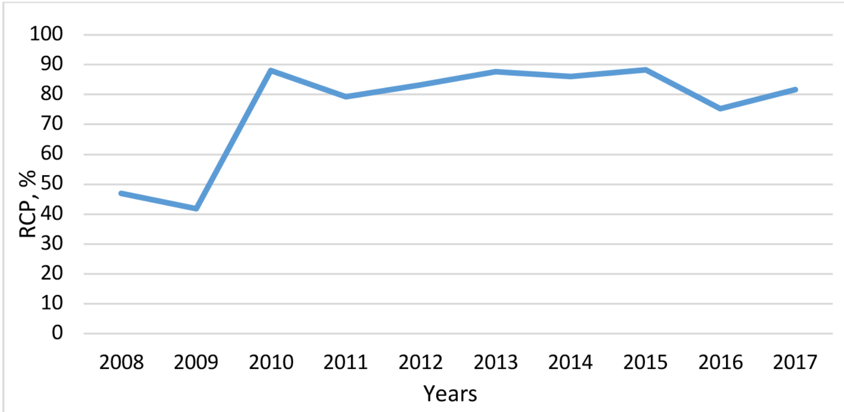

Figure 9- Revenue collection performance (RCP)

The correlation between CENSr and ICR is high and positive ($p<0.05$; $r=0.668$). In this case, it is seen that as the energy consumption per unit irrigated area increases, the irrigated area also increases (Table 4). A very high positive correlation ($p<0.01$; $r=0.862$) was found between CENSr and CENVs. Similarly, also very high positive correlation was found between CENSr and EacMOMc ($p<0.01$; $r=0.915$). In this context, as the energy consumption per unit irrigated area increases, the total MOM costs also increase. A very high negative correlation was found between CENSr and CM ($p<0.01$; $r=-0.850$). The correlation between CENSr and RCP is high and positive ($p<0.01$; $r=0.943$). It is seen that as the energy cost per unit irrigated area increases, the water fee collection rate also increases.

The observed correlation between energy and irrigated area, water consumption in this study was significant ($p<0.01$). This finding supports the findings of other studies in this field linking energy with irrigated area and water consumption (Diker 2018). The findings confirm that agricultural lands can be irrigated with less energy use when compared to the results of other studies (González et al. 2015; García et al. 2014; Carrillo-Cobo et al. 2010).

Table 4. Correlation between indicators

	ICR	*VsSa*	*VsSr*	*EacVs*	*EacSr*	*CENSr*	*CENVs*	*EacMOMc*	*CMSVs*	*CMSr*	*CM*	*RCP*
ICR	1	0.67*	-0.04	-0.31	-0.46	0.66*	0.51	0.76**	0.02	0.01	-0.48	0.644*
VsSa		1	0.66*	-0.58	-0.32	0.24	-0.12	0.28	-0.45	-0.07	0.10	0.35
VsSr			1	-0.64*	-0.157	-0.17	-0.60	-0.32	-0.44	0.19	0.41	-0.03
EacVs				1	0.844**	-0.25	0.03	-0.05	-0.02	-0.46	0.12	-0.29
EacSr					1	-0.46	-0.372	-0.30	-0.32	-0.47	0.43	-0.44
CENSr						1	0.862**	0.91**	0.34	0.35	-0.85**	0.94**
CENVs							1	0.87**	0.46	0.13	-0.80**	0.75*
EacMOMc								1	0.11	-0.03	-0.69*	0.83**
CMSVs									1	0.73*	-.67*	.29
CMSr										1	-.57	.34
CM											1	-.77**
RCP												1

*The correlation is statistically significant with the value of $p<0.10$, **$p<0.05$ and (coma) represents "0." ICR: Irrigation ratio, VsSa: Annual irrigation water supply per unit command area, VsSr: Annual irrigation water supply per unit irrigated area, EacVs: Specific energy, EacSr: Energy consumed per unit irrigated area, CENSr: Energy cost per unit irrigated area, CENVs: Energy cost per irrigation water supply, EacMOMc: Energy cost to total MOM costs ratio, CMSVs: Total MOM cost per irrigation water supply, CMSSr: Total MOM cost per unit irrigated area, CM: Maintenance cost, RCP: Revenue collection performance

4. Conclusions

It is important to evaluate the annual performance of WUAs with acceptable indicators for a sustainable irrigated agriculture. The results to be obtained can be used to improve the existing and similar irrigation schemes.

The energy consumption per unit irrigated area fluctuates. An average of 2671 kWh of energy was consumed per ha area. An average of 0.33 kWh of energy was consumed per m^3 water supplied as irrigation water. According to these values, WUA was considered a 'very large' energy consumer. The unit irrigated water supply and the energy cost per unit irrigated area have increased rapidly since 2010. The most important factor affecting energy cost is the rapid increase in energy prices. A discount should be made on the applied agricultural energy prices. Furthermore, legal arrangements should be made to allow irrigation associations to meet their energy needs from renewable energy sources (solar energy, wind energy, etc.) to reduce energy costs.

In pressurized irrigation systems, energy costs have an important place among the total MOM costs. The average EacMOMc value was found as 64%. This rate is quite high. To reduce the energy cost, necessary measures, such as reducing reactive energy costs, choosing the right pump and making pump maintenance repairs in time, should be taken. The MOM costs varied against the unit irrigated area and the supplied irrigation water. An effective monitoring and evaluation system should be established to reduce MOM costs. The irrigation system performance is mostly affected by factors in the operational phase rather than those in the planning and designing phases. Dissemination of decision support systems in irrigation associations, establishment of GIS (geographic information systems) infrastructure and establishment of a traceable management infrastructure will be effective in reducing MOM costs. The maintenance cost per unit irrigated area decreased from 2008 to 2013. It is observed that the required maintenance was performed in the irrigation system during this period. The sustainability of an irrigation system depends on the fulfilment of maintenance. A lack of maintenance for one year will create more maintenance and energy needs in the following years. Collection of irrigation water fee on time and spending it effectively for MOM activities is one of the important criteria in determining the performance of the irrigation association. In the study, the irrigation water fee collection rate was found to be 'high'. Necessary care should be taken for the efficient use of collected irrigation water fees.

In conclusion, determination of the performance levels of irrigation associations is very important for drawing lessons from the previous results and for contributing to the improvement of other irrigation associations with low performance. To increase irrigation efficiency in an efficient and successful manner, emphasis should be placed on the modernization of irrigation systems. Reducing energy costs and regular maintenance of irrigation systems emerged as the most important task in the sustainability of the irrigation system.

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