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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Benchmarking of Irrigation Performance in Karataş and Karaçal Irrigation Associations*

Karataş ve Karaçal Sulama Birliklerinde Performansının Karşılaştırmalı Değerlendirilmesi

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Abstract

This study was carried out to evaluate the system performances of Karataş and Karaçal irrigation associations located in Burdur province. Karataş irrigation association was put into operation in 1982 and Karaçal irrigation association in 2015 with irrigation areas are 5476 and 4975 ha, respectively. The same public personnel were appointed to both irrigation associations as the Head of the Association in 2018, and as of 2019, both irrigation Associations were gathered under the management of Karataş irrigation association. In this study, the performances of Karataş irrigation, which has an old and predominantly open canal system, and Karaçal irrigation systems, which are relatively new and have a pressurized irrigation system, between the years 2015-2019 have been evaluated. In the performance evaluation, a set of indicators under two main headings as water use efficiency, and financial efficiency recommended by the International Technology and Research Program in Irrigation and Drainage (IPTRID) was used. According to the results of the research, when the water use efficiency is examined, especially Annual relative irrigation supply (0.53-0.73 for Karataş; 0.47-0.96 for Karaçal) and irrigation ratio (20-72% for Karataş; 36% for Karaçal) 55) values were not at the desired levels. In terms of Financial Efficiency, cost recovery ratio (119-401% for Karataş; 144-311 for Karaçal) and revenue collection performance (78-442% for Karataş; 10-130 for Karaçal) were found to be high. Although this is a new irrigation, Karaçal irrigation shows that relatively high maintenance costs are incurred. Total operating maintenance and management (MOM) cost per unit area is US$ 9.60-14.98/ha for Karataş and as 1.32-22.92 US$/ha for Karaçal. These values showed that, in general, both irrigations have sufficient financial strength.

Keywords: Water use efficiency, Economic efficiency, Irrigation system performance, Irrigation association, Performance indicators.

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Öz

Bu çalışma, Burdur ilinde yer alan, Karataş ve Karaçal Sulama Birliklerinin sistem performanslarını değerlendirmek amacıyla yapılmıştır. Araştırma alanlarından, Karataş Sulama birliği 1982 yılında, Karaçal sulama birliği ise 2015 yılında işletmeye açılmış ve sırasıyla sulama hizmet alanları 5476 ve 4975 ha'dır. Her iki sulama birliğine 2018 yılında DSI tarafından alınan karara istinaden aynı kamu personeli birlik başkanı olarak atanmıştır. Ayrıca, 2019 yılı itibariyle de her iki sulama, Karataş sulama birliği çatısı altında toplanmışlardır. Bu çalışma ile eski ve ağırlıklı olarak açık kanal sisteme sahip Karataş sulaması ile nispeten yeni ve kapalı sisteme sahip Karaçal sulama sistemlerinin karşılaştırmalı olarak 2015-2019 yılları arası performansları değerlendirilmeye çalışılmıştır. Performans değerlendirmesinde Sulama ve Drenajda Uluslararası Teknoloji ve Araştırma Programı (IPTRID) tarafından tavsiye edilen gösterge setleri kullanılmıştır. Bu amaçla, su kullanım etkinliği ve finansal etkinlik olmak üzere iki ana başlık halinde hazırlanan bir gösterge seti kullanılmıştır. Araştırma sonuçlarına göre, su kullanım etkinliği incelendiğinde özellikle sulama suyu temin oranı (Karataş için 0,53-0,73; Karaçal için 0,47-0,96) ve sulama oranı (Karataş için %20-72; Karaçal için %36-55) değerleri istenen seviyelerde olmadığı görülmüştür. Finansal Etkinlik açısından, masrafların karşılanma oranı (Karataş için %119-401; Karaçal için %144-311) ve Tahsilat oranları (Karataş için %78-442; Karaçal için 10-130) yüksek bulunmuştur. Bakım masrafların gelire oranı Karataş için %7-43; Karaçal için %17-48 bulunmuştur. Bu durum yeni bir sulama olmasına rağmen Karaçal sulamasında nispeten yüksek miktarda bakım masrafı yapıldığını göstermektedir. Birim alana düşen toplam işletme bakım yönetim masrafı Karataş için 9,60-14,98 US$/ha; Karaçal için 1,32-22,92 US$/ha olarak belirlenmiştir. Bu değerler, genel olarak her iki sulamanın finansal açıdan yeterli güce sahip olduklarını göstermiştir.

Anahtar Kelimeler: Su kullanım etkinliği, Ekonomik etkinlik, Sulama performans, Sulama birliği, Performans göstergesi.

1. Introduction

Water is a crucial resource for agricultural production. Water scarcity and overuse pose a severe and growing hazard to human life and development. Because water is a scarce resource in most parts of the world, irrigation is essential for improving yields and sustaining food production.

Poor performance in irrigation schemes; It can lead to losses in crop production and reduction in sustainable irrigation areas. The indicators of whether the expected benefit from irrigation investments aimed at transforming limited water resources into economic benefits by increasing crop production is achieved are the monitoring and evaluation parameters of the performance of irrigation schemes.

Performance assessment is an essential component of irrigation management. With performance evaluation, it is assessed whether the system's performance is satisfactory and whether there is chance for improvement. Irrigation management will determine which areas of performance need to be addressed at the conclusion of the performance evaluation. Monitoring and evaluation are two essential elements of how performance evaluations are carried out. Monitoring determines whether project operations were accomplished on time, within the set budget, and according to project specifications. Assessment, on the other hand, is done on projects that have already been completed and is used to determine whether or not the project activities were accomplished satisfactorily. Performance is measured using performance indicators derived from obtained and recorded data. Indicator analysis provides information on performance levels. Performance evaluations frequently result in recommendations for redefinition of objectives, re-identification of operation objectives, personnel training, rehabilitation measures, new infrastructure construction, maintenance work, new management plans, alternative irrigation methods, and system rehabilitation (Burton, 2010). Malano and Burton, (2001) defined comparative evaluation as periodic assessments of irrigation scheme activities using internal and external indicators. In this sense, the major goal of monitoring and assessment activities is to improve irrigation scheme performance.

According to the 2016 data of Suruç Plain, Akçakale, Şanlıurfa-Harran, Yaylak and Upper Harran irrigation networks, which are SHW XVth Region irrigation networks; water use in agriculture was evaluated with water use efficiency indicators. As a result of the research, Annual relative water supply (RWS); 0.46-1.79 and irrigation ratio (IR) values; It was calculated to be between 58 and 116% (Çolak and Çakmak, 2018). Şener (2011) examined the water use performances of 10 existing irrigation systems in SHW XIth regional directorate. The research stated that the values of RWS 0.45-6.28 and Annual Relative irrigation supply (RIS) varied between 0.0-7.07. Akçay (2016), evaluated 25 irrigation cooperatives in Aydın province between 2006 and 2014 in terms of water use efficiency and RWS was determined between 0.89-1.58, and RIS was between 0.64-1.20. Tekiner and Çakmak (2010) found Total cost per person employed on water delivery (CTp) in Çanakkale-Kepez Cooperative to be 1,100-16,680 TL/person for the years 2002-2008. According to the 2016 data of Suruç Plain, Akçakale, Şanlıurfa-Harran, Yaylak and Upper Harran irrigation schemes, which are SHW XVth Region irrigation schemes; water use in agriculture was evaluated with water use efficiency indicators. At the end of the research, RWS were calculated as 0.46-1.79 and IR as 58-116% (Çolak and Çakmak, 2018). Şener and Kurç (2012), stated that cost recovery ratio (CRR), revenue collection performance (RCP), and maintenance cost to revenue ratio (MCR) were determined as 20-205%, 16-100% and 10-223%, respectively in 22 small irrigation schemes in Thrace region.

In this study; Irrigation performances of Karataş and Karaçal irrigations, which were put into operation in Burdur in 1982, and 2015, for the years 2015-2019 were investigated. Performance evaluation of irrigations was carried out using a selected set of performance indicators for water distribution, and financial performance was evaluated by the indicators recommended by the International Technology and Research Program in Irrigation and Drainage (IPTRID).

2. Materials and Methods

2.1. Material

As the research area, Karataş and Karaçal irrigation systems in Burdur province were chosen as material. Karataş and Karaçal irrigation systems selected as the research area are located in the Burdur Lakes Basin, 51 km from Burdur to the west (*Figure 1*).

The basin is geographically between 290 38' and 300 37' east longitudes and 370 08' and 370 42' north latitudes (SHW, 2009). The climate of the research area is in the transition zone between the Mediterranean climate and the continental climate (SHW, 2019). The average temperature of the research area is 11.8 °C, the average precipitation is

310.7 mm, the month with the lowest precipitation is July with 2.6 mm, and the month with the highest precipitation is January with 78.6 mm. Average relative humidity is 49%; the lowest average value is 40% in July and the highest average value is 78% in January (SHW, 2019).

The soil type in the research area is generally alluvial soil, and most of it has a clayey and calcareous composition, the irrigation area soils are generally soils with high natural fertility. Plain soils, most of which have medium and medium-heavy texture, and heavy textured character is observed towards the west (SHW, 2019).

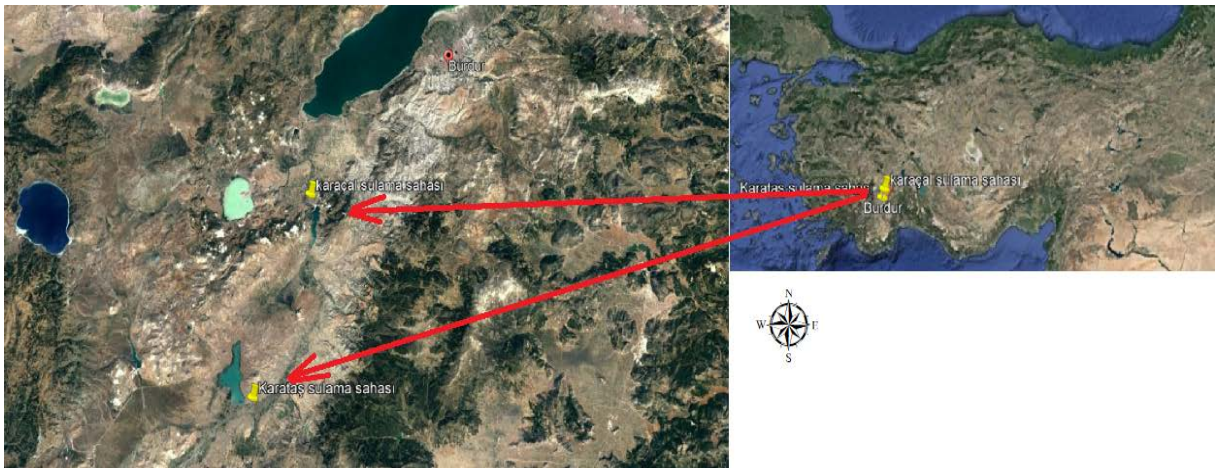

Figure 1. Location of the study

2.2. Method

In this study, the approach recommended by the International Technology and Research Program in Irrigation and Drainage (IPTRID) for the comparative evaluation of the performance of irrigation and drainage systems was used (Malano and Burton, 2001). Performance evaluation of irrigations was carried out using a selected set of performance indicators for water distribution, financial and agricultural production recommended by the IPTRID.

The performance indicators were calculated using information from the Karataş and Karaçal irrigation associations (Anonymous, 2015-2019a; Anonymous, 2015-2019b) and SHW (SHW, 2015-2019a; SHW, 2015-2019b). The US Dollar (USD) was used as the currency to compare the outcomes.

2.2.1. Water use efficiency

In the determination of water use efficiency in Karataş and Karaçal irrigation system a set of 6 indicators was used namely; Total annual volume of irrigation supply (IWS), Annual irrigation water delivery per unit command area area (IWSCA), Annual irrigation water supply per unit irrigated area (IWSIA), annual relative water supply (RWS), annual relative irrigation water supply (RIS) and irrigation ratio (IR). Formulas for indicators used to determine water use efficiency are given in equations 1, 2, 3, 4 and 5 (Malano and Burton, 2001).

Annual irrigation water supply per unit command area (IWSCA) ($m^3\,ha^{-1}$),

$$\text{IWSCA} = \frac{\text{Total annual volume of irrigation supply (IWS)}}{\text{command area}} \quad \text{(Eq.1)}$$

Annual irrigation water supply per unit irrigated area (IWSIA) ($m^3\,ha^{-1}$),

$$\text{IWSIA} = \frac{\text{Total annual volume of irrigation supply (IWS)}}{\text{irrigated area}} \quad \text{(Eq.2)}$$

Annual relative water supply (RWS),

$$\text{RWS} = \frac{\text{Total annual volume of water supply}}{\text{Total annual volume of crop water demand}} \quad \text{(Eq.3)}$$

Annual relative irrigation water supply (RIS),

$$\text{RIS} = \frac{\text{Total annual volume of irrigation supply}}{\text{Total annual volume of crop irrigation demand}} \quad \text{(Eq.4)}$$

Irrigation ratio (IR), (%)

$$IR = \frac{\text{irrigated area}}{\text{irrigable area}} \quad \text{(Eq.5)}$$

In equations; irrigated area (ha) refers to the portion of the area actually irrigated during one irrigation season. Amount of irrigation water delivery to the irrigation network (m^3) represents water delivery for irrigation, total plant water consumption (m^3), potential plant water consumption (ET_p) or actual evapotranspiration (ET_c) when the full crop water demand is met.

Evapotranspiration and irrigation requirement were calculated with the help of the CROPWAT software, taking into account the Burdur meteorological station records for each year. The reference evapotranspiration (ET_0) was calculated according to the Penman-Monteith method, and then the evapotranspiration was calculated with the help of the crop coefficients (FAO, 1992). The effective precipitation values (P_e) were determined according to the US Soil Conservation Service method and the irrigation water requirements of the crops were determined. RWS and RIS values show whether there is sufficient supply to meet the need. Values of 1 or higher RWS and RIS indicate adequate irrigation, while values less than 1 indicate insufficient irrigation supply (Şener, 2004).

2.2.2. Financial Efficiency

In determining the financial efficiency of irrigation systems 7 indicators were examined including; cost recovery ratio (CRR), maintenance costs to revenue ratio (MCR), Total MOM cost per unit area (MOMPUA), Total cost per person employed on water delivery (TCPWD), Revenue collection performance (RCP), Staffing numbers per unit area (SNPUA) and Total MOM cost per unit volume supplied (MOMPUWS) (Malano and Burton, 2001). The equations for the indicators used in the study are given in 6, 7, 8, 9, 10, 11 and 12.

Cost recovery ratio, (CRR), (%),

$$\text{Cost recovery ratio} = \frac{\text{Gross revenue collected}}{\text{Total MOM cost}} \quad \text{(Eq.6)}$$

Cost recovery ratio represents the ratio of the expenses incurred for the operation, maintenance and management of the irrigation system with the water service fee paid by the water users. Cost recovery ratio indicates when less than or equal to 30% is poor, 40-60% acceptable, 60-75% satisfactory condition, and more than 75% good condition (Vermillion, 2000).

Maintenance cost to revenue ratio, (%), (MCR),

$$MCR = \frac{\text{Maintenance cost}}{\text{Gross revenue collected}} \quad \text{(Eq.7)}$$

Total MOM cost per unit area (US$ ha^{-1}), (MOMPUA),

$$\text{MOMPUA (US\$ ha}^{-1}) = \frac{\text{Total MOM cost}}{\text{Total irrigated area serviced by the system}} \quad \text{(Eq. 8)}$$

Total cost per person employed on water delivery (TCPWD),

$$\text{TCPWD (US\$ personel}^{-1}) = \frac{\text{Total cost of personnel engaged in I\&D service}}{\text{Total number of personnel engaged in I\&D service}} \quad \text{(Eq. 9)}$$

Revenue collection performance (RCP),

$$RCP\ (\%) = \frac{Gross\ revenue\ collected}{\text{Gross revenue invoiced}} \quad \text{(Eq. 10)}$$

Revenue collection performance of less than 30% is poor, 40-60% is acceptable, 60-75 percent is satisfactory, and more than 75 percent is excellent (Vermillion, 2000)

Staffing numbers per unit area (SNPUA)

$$\text{SNPUA (personnel 1000 ha}^{-1}) = \frac{\text{Total number of personnel engaged in I\&D service} * 1000}{\text{Total annual irrigated area serviced by the system}} \quad \text{(Eq. 11)}$$

The number of personnel per 1000 hectares irrigated is referred to as staffing numbers per unit area. If the number of staffing numbers per unit area is greater than 3 persons per 1000 ha, it is considered weak; if the number is less than 3 persons per 1000 ha, it is considered good (Vermillion, 2000).

Total MOM cost per unit volume supplied (MOMPUWS)

$$\text{MOMPUWS (US\$ } m^{-3}) = \frac{\text{Total MOM cost}}{\text{Total annual volume of irrigation water delivery}} \quad \text{(Eq. 12)}$$

3. Results and Discussion

3.1. Water use efficiency

In this section, water use efficiency was calculated using 6 performance indicators. *Table 1* and *Table 2* shows Total annual volume of irrigation supply (IWS), Annual irrigation water supply per unit command area (IWSCA), Annual irrigation water supply per unit irrigated area (IWSIA) in Karataş and Karaçal irrigation systems.

Table 1. IWS, IWDCA and IWDIA in Karataş irrigation association

Years	Irrigated area (ha)	Command area (ha)	(IWS) (m^3)	(IWSCA) (m^3 ha^{-1})	(IWSIA) (m^3 ha^{-1})
2015	2343.0	5476	11223000	2049	4790
2016	3926.3	5476	23250000	4246	5922
2017	2326.4	5476	9687000	1769	4163
2018	1084.8	5476	3490000	637	3217
2019	3705	10.451	11520000	1102	3109

Table 2. IWS, IWSCA and IWSIA in Karaçal irrigation association

Years	Irrigated area(ha)	Command area (ha)	(IWD) (m^3)	(IWDCA) (m^3ha^{-1})	(IWDIA) (m^3ha^{-1})
2015	2723.0	4975	9624000	1934	3534
2016	2733.2	4975	21277000	4276	7778
2017	2323.4	4975	17140000	3445	7377
2018	1868	4975	6730000	1353	3603

As seen in *Tables 1* and *2* IWSCA was found to be the lowest 637 m^3 ha^{-1} in 2018 and the highest 4246 m^3 ha^{-1} in 2016 in Karataş irrigation system. In Karaçal irrigation system it is seen that IWSCA varies between 1353-4276 m^3 ha^{-1}. In Karataş irrigation association IWSIA calculated lowest 3217 m^3 ha^{-1} in 2018 and the highest is 5922 m^3 ha^{-1} in 2016 while in Karaçal irrigation association the lowest is 3534 m^3 ha^{-1} in 2015 and the highest is 7778 m^3ha^{-1} in 2016. IWSCA and IWSIA were 1102 and 3109 in 2019, respectively, after Karaçal irrigation association joined Karataş irrigation association. Eliçabuk and Topak (2017) determined IWSCA as 665–1301 m^3 ha^{-1} and IWSIA as 2577–5273 m^3 ha^{-1} in Gevrekli Irrigation Association. Total amount of diverted irrigation water was $6.054x10^6$-$10.747x10^6$ m^3 $year^{-1}$ IWSCA 7.23-10.54 m^3 ha^{-1} and IWSIA 7.68-16.15 m^3 ha^{-1} in Akıncılar irrigation system (Nalbantoğlu and Çakmak, 2007). The other indicators used in evaluation water use performance are RWS RIS and IR and were calculated and the result are shown *Table 3* and *Table 4*.

The result of RWS and RIS shown in *Table 3* and *4* were calculated as 0.79-0.95; and 0.47-0.96 at Karataş and Karaçal respectively it is seen that inadequate water distribution is supplied in both irrigation systems. However, it should not be forgotten that values of 0.9-1.1 are considered to be equivalent to each other in the evaluation. Also, the results of RIS shows that inadequate irrigation water is supplied both the irrigation systems. Vermillion and Vermillion and Garces-Resrepo (1996) determined RWS in Coello and Saldana to be 1.4 and 1.8 respectively in 1993. Uçar and Yardımcı (2003) determined Irrigation ratio as 15-83% and RWS as 1.66-5.72 in the irrigations of SHW in Isparta province.

Table 3. RWS RIS and IR in Karataş irrigation association

Years	IWD + Effective rainfall (m^3)	Total Irrigation water requirement (m^3)	RWS	RIS	IR (%)
2015	20735580	22926688	0.90	0.61	43
2016	36985271	40092861	0.92	0.73	72
2017	16419602	21446196	0.77	0.56	42
2018	8244678	9046585	0.91	0.53	20
2019	23742135	22242595	1.07	0.39	35

Table 4. RWS RIS and IR in Karaçal irrigation association

Years	IWD + Effective rainfall (m^3)	Total Irrigation water requirement (m^3)	RWS	RIS	IR (%)
2015	20680192	26179046	0.79	0.50	55
2016	30823197	27734119	1.11	0.96	55
2017	23865920	24998915	0.95	0.80	47
2018	14915253	18356155	0.79	0.47	37

3.2 Financial efficiency

Cost recovery ratio of Karataş and Karaçal irrigation association research area is shown in *Table 5*.

Table 5. Cost recovery ratio (%)

Years	Karataş irrigation association			Karaçal irrigation association		
	Gross revenue collected (US$)	Total MOM cost (US$)	CRR (%)	Gross revenue collected (US$)	Total MOM cost (US$)	CRR (%)
2015	186473	79252	235	11672	6573	178
2016	223624	82034	272	182378	114044	160
2017	210819	52591	401	225621	72641	311
2018	92599	77848	119	77390	53766	144
2019	311214	117503	265			

Cost recovery ratio for Karataş and Karaçal irrigation associations was found as 119-401% and 144-311% respectively. The value was calculated as the ratio of total irrigation fee collected from the users to total operation-maintenance-management costs. The Asartepe Irrigation Association stated a cost recovery ratio of 52-170% for the years 2001-2004 whereas state irrigation schemes recorded a ratio of 21-91% and the country average was 65% (Beyribey, 1997). Maintenance cost to revenue ratio is given in *Table 6*.

Table 6. Maintenance cost to revenue ratio (MCR)

Years	Karataş irrigation association			Karaçal irrigation association		
	Maintenance cost (US$)	Gross revenue collected (US$)	MCR (%)	Maintenance cost (US$)	Gross revenue collected (US$)	MCR (%)
2015	55237	186473	30	1356	11671	12
2016	48100	223624	22	71308	182378	39
2017	15774	210819	7	39323	225621	17
2018	40259	92599	43	37067	77390	48
2019	156658	311214	50			

MCR was determined as the lowest at 7% in 2017 and the highest at 43% in 2018 for the Karataş irrigation. In Karaçal irrigation association the lowest was 12% in 2015 and the highest was 48% in 2018. MCR was determined as 50% for 2019 after the merger of Karataş and Karaçal irrigation associations. When *Table 6* is examined, it is seen that more maintenance was carried out in Karaçal irrigation association than in Karataş irrigation association in 2016 and 2017 excluding the year 2015 when irrigation was opened. Although it is a relatively new irrigation scheme it was determined that relatively high maintenance costs were incurred in Karaçal irrigation before the transfer. Total MOM per unit area is given in *Table 7*.

Table 7. Total MOM cost per unit area (MOMPUA) (US$/ha)

Years	Karataş irrigation association			Karaçal irrigation association		
	Total MOM cost (US$)	Irrigated area (ha)	MOMPUA (US$ ha^{-1})	Total MOM cost (US$)	Irrigated area-(ha)	MOMPA (US$ ha^{-1})
2015	79252	2343	33.83	6573	2723	2.41
2016	82034	3926	20.90	114044	2735	41.70
2017	52590	2326	22.61	72640	2323	31.27
2018	77848	1085	71.75	53765	1868	28.78
2019	117502	3705	31.71			

Lowest MOMPUA was 20.90 US$ ha^{-1} in 2016 and the highest MOMPUA was 71.75 US$ ha^{-1} in 2018 in Karataş irrigation system (*Table 7*). Lowest MOMPUA in Karaçal irrigation system was 2.41 US$ ha^{-1} in 2015 highest was 41.70 US$ ha^{-1} in 2016. Diker (2018) stated that MOMPUA were calculated between 6.73 and 321 US$ ha^{-1} for the years 2011 and 2015 in the Lower Seyhan Plain. The total cost per person employed in water delivery is given in *Table 8*.

Table 8. Total cost per person employed on water delivery (TCPWD)

Years	Karataş irrigation association			Karaçal irrigation association		
	Total cost of personnel engaged in I&D service (US$)	Total number of personnel engaged in I&D service	(TCPWD) (US$ person^{-1})	Total cost of personnel engaged in I&D service (US$)	Total number of personnel engaged in I&D service	(TCPWD) (US$ person^{-1})
2015	51073	7	7296	56841	8	7105
2016	55061	7	7866	21950	4	5488
2017	49174	7	7025	57872	7	8267
2018	29039	7	4148	28251	9	3139
2019	82700	15	5513			

As seen in *Table 8* the lowest cost for each person employed in water delivery was 4148 US$ person^{-1}in 2018 and the highest cost was 7866 US$ person^{-1} in 2016 for Karataş irrigation. The lowest cost for Karaçal irrigation was 3139 US$ person^{-1} in 2018; the highest cost was 8267 US$ person^{-1} in 2017. After the Karataş and Karaçal irrigation were combined the total cost per person employed in water distribution was 5513 US$ person^{-1}. When TCPWD values are examined, it is seen that much more expenses were incurred in Karaçal irrigation system which is a pressurized system.

Table 9. Revenue collection performance (RCP)

Years	Karataş irrigation association			Karaçal irrigation association		
	Gross revenue collected (US$)	Gross revenue invoiced (US$)	RCP (%)	Gross revenue collected (US$)	Gross revenue invoiced (US$)	RCP (%)
2015	186473	153674	121	11671	112174	10
2016	223624	268676	83	182378	265733	69
2017	210819	271358	78	225621	240173	94
2018	92599	20944	442	77390	59621	130
2019	311214	340528	91			

Revenue collection performance (RCP) of Karataş and Karaçal irrigation systems is given in *Table 9*. Revenue collection performance for Karataş irrigation association was determined as 442% in 2018 and the lowest as 78% in 2016. It is seen that the highest is 130% in 2018 and the lowest is 10% in 2015 in Karaçal irrigation association. On the other hand, after the merger the collection rate was 91%.

RCP were calculated for the Ilgın plain pumped irrigation in the Konya region is between 83.5% and 147% (Kalender, 2017). It has been reported as 75% for the Çumra Plain irrigation association (Cihan, 2017). Vermillion and Garces-Restrepo (1996) reported that RCP in Coello and Saldana irrigation in 1993 was 102% and 109%. Regarding the research area staffing numbers per unit area is given in *Table 10*.

Accordingly, it is seen that SNPUA for Karataş irrigation association between 2015-2018 varies between 3.06-10.14 personnel 1000ha^{-1}. In Karaçal irrigation association it is seen that SNPUA varies between 1.83-5.35 personnel 1000 ha^{-1}. This indicator was realized as 6.48 personnel 1000ha^{-1} after merging of irrigation associations. According to Vermillion (2000) it was determined that staffing numbers per unit area in both irrigation areas was weak. Total MOM cost per unit volume supplied in Karataş and Karaçal irrigation areas are given in *Table 11*.

When *Table 11* is analyzed the highest total MOM cost per unit volume supplied in Karataş irrigation is 0.022 US$/m^3 in 2018 and the lowest cost is 0.004 US$/m^3 in 2016. In Karaçal irrigation association the highest total MOM cost per unit volume supplied was 0.008 US$/m^3 in 2018 and the lowest was 0.001 US$/m^3 in 2015.

Table 10. Staffing numbers per unit area (personnel 1000ha^{-1}) (SNPUA)

Years	Karataş irrigation association			Karaçal irrigation association		
	Total number of personnel engaged in I&D service	Total annual irrigated area serviced by the system	(SNPUA)	Total number of personnel engaged in I&D service	Total annual irrigated area serviced by the system	(SNPUA)
2015	13	2.343	5,55	11	2.723	4,04
2016	12	3.926	3,06	5	2.735	1,83
2017	12	2.326	5,16	8	2.323	3,44
2018	11	1.085	10,14	10	1.868	5,35
2019	24	3.705	6,48			

Table 11. Total MOM cost per unit volume supplied (MOMPUVS)

Years	Karataş irrigation association			Karaçal irrigation association		
	Total MOM cost (US$)	Total annual volume of irrigation water delivery (m3)	(MOMPUVS) (US$ m^{-3})	Total MOM cost (US$)	Total annual volume of irrigation water delivery (m^3)	(MOMPUVS) (US$ m^{-3})
2015	79252	11223000	0.007	6573	9624000	0.001
2016	82034	23255000	0.004	114044	21277000	0.005
2017	52590	9687000	0.005	72640	17142000	0.004
2018	77848	3490000	0.022	53765	6730000	0.008
2019	117502	11520000	0.010			

4. Conclusions

In this study the water use efficiency and financial efficiency performance of Karataş and Karaçal irrigation system were assessed using comparative indicators.

In Karaçal irrigation area it is seen that low irrigation ratio is realized despite the newly established completely pressurized system. The main reason inadequate irrigation in the Karaçal irrigation area is the Karaçal dam's inability to store enough water due to the low precipitation regime. When the water use efficiency is examined a very low level of insufficient distribution was observed in the water supply in the Karaçal System.

It is seen that sufficient irrigation water distribution could not be realized to meet the irrigation water requirement in Karaçal irrigation association. This situation is also stated in the planned water distribution reports of the irrigation areas. In periods when the water supply is insufficient the plants that grow under rainfed agricultural conditions in the irrigation area should be supported in the cultivation of vegetables fruits and industrial plants with high economic value in the areas where irrigation is planned.

When the financial efficiency is examined, it is seen that the water fee collection rate in the Karaçal irrigation area is higher than the Turkey average. Due to this situation, it has been determined that there is no problem in meeting MOM costs in both systems. In order to create a stronger sustainable financial structure in the irrigation association it is necessary to increase the collection rate of irrigation water fees higher.

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