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Assessment of Irrigation Performance in Başören Irrigation Cooperative Area of Beypazarı, Ankara

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Abstract: This research has been carried out to assess the irrigation performance of the year 2015 in Ankara Beypazarı Başören Irrigation Cooperative, where the irrigation is made by ground water. With this aim, performance indicators related to water utilization efficiency, agricultural efficiency, social and economic efficiency were determined in the research area.
Irrigation water delivery to the research area was 738.000 m^3, water supply per irrigation area was 10542,8 m^3/ha, water supply per irrigated area was 14760 m^3/ha, the annual water supply ratio was 1,72, the cost recovery ratio was 500 %, the ratio of the maintenance cost to revenue was 0,14 %, the total management, operation and maintenance cost per unit area was 700 TL/ha and water fee collection performance was 100 %. With regard to economic performance; the total agricultural production value, the revenue per unit command area, the revenue per unit irrigated area, the revenue per unit irrigation supply, the revenue per unit water consumed were determined as 2378953 TL, 33985,04 TL, 47579,06 TL, 3,22 TL/ha, 6,88 TL as respectively.

Keywords: Irrigation performance, performance indicator, irrigation cooperative, pressurized irrigation

Ankara Beypazarı Başören Sulama Kooperatifi'nde Sulama Performansının Değerlendirilmesi

Öz: Bu çalışmanın amacı, yeraltı suyu ile sulama yapılan Ankara Beypazarı Başören Sulama Kooperatifi'nde sulama performansını değerlendirmektir. Bu amaçla, araştırma alanında su kullanım etkinliği, tarımsal etkinlik, sosyal ve ekonomik etkinliği belirlemeye yönelik performans göstergeleri saptanmıştır. Proje alanında dağıtılan sulama suyu 738.000 m^3/ha, birim alana dağıtılan yıllık sulama suyu miktarı 10542,8 m^3/ha, birim sulanan alana dağıtılan yıllık sulama suyu miktarı 14760 m^3/ha, yıllık su temini oranı 1,72, yatırımın geri dönüşüm oranı % 500, bakım m asrafının gelire oranı % 0,14, birim alana düşen toplam işletme, bakım, yönetim masrafı 700 TL/ha, su ücreti toplama performansı % 100, toplam tarımsal üretim değeri 2378953 TL, birim sulama alanına karşılık elde edilen gelir 33985,04 TL sulanan birim alana karşılık elde edilen gelir 47579,06 TL, şebekeye alınan birim sulama suyuna karşılık elde edilen gelir 3,22TL/ha, tüketilen birim sulama suyuna karşılık elde edilen gelir 6,88 TL, olarak belirlenmiştir.

Anahtar Kelimeler: Sulama performansı, performans göstergesi, sulama kooperatifi, basınçlı sulama.

1. Introduction

Together with ever increasing world population, food demands are also increasing. To meet these increasing demands, agricultural sector spends great efforts to increase productions and yields in irrigated lands. Therefore, soil and water resources development is a significant issue to achieve this goal in agricultural sector.

Economically available water potential of Turkey is 112 billion m^3 and all of this resource is planned to be developed until the year 2023. The principle target of Turkey is to use modern irrigation techniques and to reduce water use ratios in agriculture, which is the greatest water user, down to 65 %. Economically irrigable lands of Turkey are 8.5 million hectares and all of this

land is planned to be irrigated by the year 2023. Currently, 6,225 million hectares are being irrigated. Of this amount, 3,935 million hectares are opened for irrigation by State Hydraulic Works (DSI). In this case, about 27 % of potentially irrigable lands of 8,5 million hectares are not irrigated (DSI 2015).

Together with increasing water demands of rapidly increasing population, there is an aggravating competition among water-user sectors. To meet food demands of increasing population, maximum gain should be achieved from each drop of water used in agriculture. Competition of agricultural sectors for water with the other sectors, expectations of farmer families to improve their life standards require higher performance of irrigation systems (Yıldırım et al. 2007). Therefore, performance assessment has been performed in several countries to check if the irrigation systems are operated at targeted performance expectations (Nalbantoğlu and Çakmak 2007, Çakmak et al. 2014).

Performance assessment is an integral component of irrigation management. With performance assessment, whether or not the performance of the system is satisfactory and if there is a chance to improve it is determined. At the end of performance assessment, irrigation management will decide the area of which the performance is to be improved. Monitoring and assessment are two inherent components of performance assessment works. With monitoring, it is determined whether or not the project activities were completed on time, within the specified budget and as described in project specifications. On the other hand, assessment is carried out on already completed projects and used to assess whether or not the project activities were successfully implemented. Performance is assessed through performance indicators calculated by using the gathered and recorded data. Analysis of indicators provides information about performance levels. Performance assessment commonly ends up with recommendations about redefinition of objective/targets, re-identification of operation objective/targets, stuff training, implementation of rehabilitating measures, construction of new infrastructure, performance of maintenance works, development of new management plans, changing alternative irrigation methods, system rehabilitation/modernization (Burton 2010).

For an efficient use of soil and water resources, it is necessary to determine current utilization levels, to identify the problems and produce solutions for these problems. Therefore, monitoring and assessment is a critical issue in irrigation systems (Bulut and Çakmak 2001, Sönmezyıldız and Çakmak 2013). Malano and Burton (2001) defined periodical assessments of the activities of irrigation schemes with internal and external indicators as comparative assessment. In this sense, the primary objective in monitoring and assessment works is to improve performance of irrigation schemes.

In Turkey, irrigation schemes are usually operated by irrigation associations, municipalities, irrigation cooperatives, village judicial personalities and DSI (Çakmak and Tekiner 2010). The 1163-numbered cooperatives law was issued in 1969. Irrigation cooperatives operate according to this law and the success is depend on well irrigation planning, preparation and implementation of proper water distribution programs.

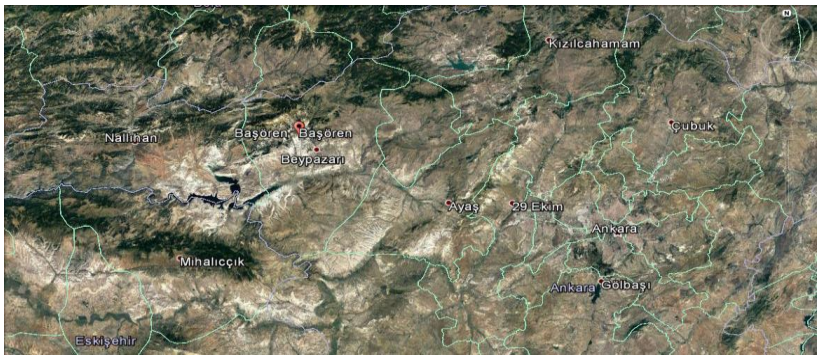
The present study was conducted to assess the performance of Başören Irrigation Cooperative operating in Beypazarı town of Ankara province.

2. Material and Method

Başören Irrigation Cooperative operating in Beypazarı town of Ankara province constituted the material of this study. The cooperative performs irrigations with groundwaters. Surface irrigation methods are used in majority of irrigation district, but sprinkler irrigation is applied in some parts and drip irrigation is used in vineyard irrigation. Over the irrigation district, there are 4 groundwater wells and each well discharge is 20 L/s. Electricity is the primary energy source in irrigations. Beypazarı town is located within upper Sakarya Basin and 100 km northwest of Ankara province. Project area is located 5 km northwest of Beypazarı town center between Başören village and Yukarı Başağaç district and covers the lands on the east of Arısekisi hill (Figure 1). Commonly carrot is produced within the research site. Spinach, fresh onion, lettuce and radish are among the other vegetables within the research site.

Beypazarı is a transition zone between Central Anatolia Region and Western Black Sea Region. Therefore, the town bears the characteristics of the climate of both regions.

Northern sections of the town are covered with forests and Western Black Sea climate is dominant over these sections; southern parts are steppe and Central Anatolian climate is dominant over these sections.Annual total precipitation of Beypazarı is 423 mm.



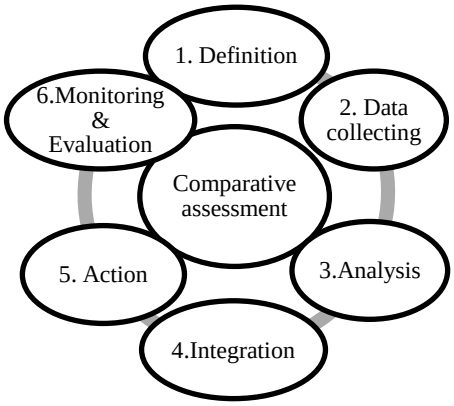
Şekil 1. Araştırma alanı konumu (NetCAD 2016)
Figure 1. *Location of research area (NetCAD 2016)*

About 67 % of population deals with agricultural activities. Total agricultural lands are 636,345 decares. Of this amount, 67 % is non-tilled barren lands, 13 % is irrigated fields. Mostly carrot is grown in vegetables production lands. The distribution of agricultural fields of Başören Irrigation Cooperative is presented in Table 1.

Çizelge 1. Başören sulama kooperatifi'nde tarım arazilerinin dağılımı (BSK 2015)
Table 1. *Distribution of agricultural land in Basoren irrigation cooperative (BSK 2015)*

Using area	**Area (da)**	**Ratio (%)**
Vineyard	200	40,00
Fruits	150	30,00
Vegetables	120	24,00
Field crops	30	6,00
Total	500	100

Irrigation performance of Başören irrigation cooperative was determined by comparative indicators (Malano and Burton 2001). The stage of comparative assessment is given in Figure 2. The performance indicators and relevant data used in this study are provided in Table 2.



Şekil 2. Karşılaştırmalı değerlendirme işleminin aşamaları (Malano ve Burton 2001)
Figure 2. *Phases of comparative assessment process (Malano and Burton 2001)*

Çizelge 2. Çalışmada kullanılan performans göstergeleri ve gerekli veriler (Burton ve ark. 2000, Cakmak ve ark. 2004)
Table 2. *Performance indicators and data requested for research ((Burton et al. 2000, Cakmak et al. 2004)*

Domain	Performance Indicators	Data required
Water use efficiency	Total annual volume of irrigation water delivery (m^3 /year)	Total water delivery to water users
	Annual irrigation water delivery per unit command area (m^3/ha) = Total water inflow to the irrigation system / Total command area	Total water inflow to the irrigation system Total command area
	Annual irrigation water delivery per unit irrigated area (m^3/ha) = Total water inflow to the irrigation system / Total irrigated area	Total water inflow to the irrigation system Total irrigated area
	Annual relative water supply = Total annual of water supply / Total annual volume of crop water requirement	Total annual of water supply Total annual volume of crop water requirement
	Irrigation ratio = Irrigated area (ha) x 100 / Command area (ha)	Irrigated area Command area
Social and economic efficiency	Cost recovery ratio = Total water fee collected from users / Total MOM costs	Total water fee collected from water users Total management, operation and maintenance (MOM) costs
	Maintenance cost to revenue ratio = Total maintenance costs / Total water fee collected from users	Total maintenance costs Total water fee collected from users
	Total MOM cost per unit area (TL/ha) = Total MOM costs / Command area	Total MOM costs Total command area
	Water fee collection performance = Total water fee collected from users / Total water fee invoiced	Total water fee collected from users Total water fee invoiced
Agricultural efficiency	Total annual value of agricultural production (TL) = Total annual tonnage of each crop x Crop market price	Total annual tonnage of each crop Crop market price
	The revenue per unit command area (TL/ha) = Total production value / Command area	Total annual tonnage of each crop Crop market price Total command area
	The revenue per unit irrigated area ((TL/ha) = Total production value / Irrigated area	Total annual tonnage of each crop Crop market price Total annual irrigated crop area
	The revenue per unit irrigation supply (TL/m^3) = Total production value / Total water inflow to the irrigation system	Total annual tonnage of each crop Crop market price Total water inflow to the irrigation system
	The revenue per unit water consumed (TL/m^3) = Total production value / Total volume of water consumed by the crops	Total annual tonnage of each crop Crop market price Total volume of water consumed by the crops (ETc)

Total irrigation water requirement was calculated by using CROPWAT irrigation software. Soil and plant data to be used in this software were taken from irrigation cooperative and Beypazarı Town Directorate of Agriculture and climate data were supplied from General Directorate of Meteorology. Currency unit was taken as TL.

3. Results and Discussion

3.1 Water use efficiency

The classification criteria for some performance indicators used in assessment of water use efficiency of Beypazarı Başören Irrigation are provided in Table 3.

3.1.2. Total irrigation water delivery per unit command area

The amount of annual irrigation water delivered to per unit command area was calculated as the ratio of annual irrigation water supplied to the system to the total irrigation area and the value was identified as 10542.8 m^3/ha. The value was reported as between 8,11-10,51 m^3/ha for the years 1998-2004 in Akıncı Irrigation Association by Nalbantoğlu and Cakmak (2007); as 4311,02 m^3/ha for Beyazaltın village of Eskişehir by Sönmezyıldız and Çakmak (2013). As sugar beet generally was being grown, much water was supplied in Beyazaltın village of Eskişehir.

Çizelge 3. Sulama oranı, su ücreti toplama performansı ve yatırımın geri dönüşüm oranının sınıflandırılması (Sönmezyıldız ve Çakmak 2013)

Table 3. *Classification of irrigation ratio, water fee collection performance and cost recovery ratio (Sönmezyıldız and Çakmak 2013)*

Indicators	Poor	Acceptable	Satisfactory	Good	Definition
Irrigation ratio	<30	30–40	40–50	>50	The ratio of irrigated area to command area.
Water fee collection performance	<40	40–60	60–75	>75	Total revenues collected as percentage of total service revenue due.
Cost recovery ratio	<40	40–60	60–75	>75	Total revenues collected as percentage of total management, operation and maintenance costs.

3.1.3. Total irrigation water delivery per unit irrigated land

The amount of annual irrigation water delivered to per unit of irrigated land for the year 2015 was calculated as the ratio of annual amount of irrigation water supplied to irrigation system to amount of irrigated lands and the value was identified as 14760 m^3/ha. The value was reported by Sönmezyıldız and Çakmak (2013) same as the amount of annual irrigation water distributed to per unit irrigation area since irrigation ratio was 100 % in Beyazaltın village of Eskişehir. Nalbantoğlu and Cakmak (2007) reported the value as between 7,68-16,15 m^3/ha for the years 1998-2004 in Akıncı Irrigation Association.

3.1.4. Annual water supply ratio

Annual water supply ratio was calculated as the ratio of total amount of irrigation water supplied to the system in a certain year to the total irrigation water requirement of that year. A total water supply ratio of 1 indicates that amount of water diverted to the system was equal to the requirement, a value less than 1 indicate insufficient water supply and a value over 1 indicates excessive water supply (Beyribey 1997). Total plant water consumption of the research site was calculated with CROPWAT software as 345540 mm and total irrigation water requirement was calculated as 745 mm/500 da. The amount of water diverted to irrigation system on Başören irrigation cooperative in 2015 was 738000 m^3, total irrigation water requirement was 372500 m^3, and thus annual water supply ratio was calculated as 1,98. Such a value indicates that almost twice as much of irrigation water requirement was diverted to the system.

Cakmak et al. (2010) reported annual water supply ratio of 8 irrigation schemes transferred by DSİ 5th Regional Directorate as between 1,5-8,4 for the years 2000-2003. Cakmak et al. (2014) assessed the performance of irrigation schemes in trans boundary river basins and reported annual water supply ratio as between 1,70-4,01 for Asi

basin, as 2,83 for Çoruh basin, as between 0,43-35,01 for Aras basin, as between 0,72-2,31 for Meric basin, as between 0,95-9,77 for Fırat basin and as between 2,78-9,87 for Dicle basin. Akkuzu and Mengü (2012) reported annual water supply ratio of 10 irrigation associations in Lower Gediz basin as between 1,42-2,05 for the years 2002-2008. The value of 1,98 for Beypazarı Başören Irrigation Cooperative complies with the results of earlier studies carried out in Turkey. Such a value can be considered as the success of irrigation cooperative.

3.1.5. Irrigation ratio

The irrigation ratio for the research site in 2015 was identified as 71,4%. According to data of the year 2015, general average in Turkey is 73 % (DSİ 2015). The value for the research site is close to general average of Turkey. About 73 % of 8,5 million hectares irrigable lands are currently irrigated in Turkey. Irrigation of remaining 2,275 million hectares is a significant issue in meeting food demands of increasing population.

3.2. Social and Economic Efficiency

3.2.1. Cost recovery ratio

Cost recovery ratio for Beypazarı Başören Irrigation Cooperative was calculated as 500 %. The value was calculated as the ratio of total irrigation fee collected from the users to total operation-maintenance-management costs. Costs recovery ratio was reported as between 52-170 % for the years 2001-2004 in Asartepe Irrigation Association (Çakmak et al. 2009), as between 0,3-80 % in Çanakkale Kepez Irrigation Cooperative (Çakmak and Tekiner 2010), as 530 % for Eskişehir Beyazaltın village (Sönmezyıldız and Çakmak 2013). As it was indicated in Table 3, costs recovery ratios of less than 75 % are not suitable for irrigation projects. Current value of 500 % is way above 75 %, therefore it is considered as a reliable value. The value is almost 7 folds of acceptable value. Such a high value probable resulted from ground waters use and thus on-time fee collection from the users and timely performance of operation-maintenance services.

3.2.2. Maintenance cost to revenue ratio

The ratio of maintenance costs to revenues is defined as the ratio of total maintenance cost of irrigation scheme to total collected irrigation fees from the users. It is also defined as the coverage ratio of collected fees to maintenance costs. The value was calculated as 14 % in present study. Nalbantoğlu and Çakmak (2007) reported this value as between 2,51-10,82 % for the years 1998-2005 in Akıncı Irrigation Association and Sönmezyıldız and Çakmak (2013) reported the value as 8 % in Eskişehir Beyazaltın village. The value of 14 % for Beypazarı Başören Irrigation Cooperative is a quite well value. This value indicates that maintenance costs of irrigation cooperative corresponded only 14 % of collected irrigation water fees, thus maintenance services were easily performed.

3.2.3. Total operation-maintenance-management costs per unit area

Operation-maintenance-management costs per unit area are calculated as the ratio of total operation-maintenance-management cost to irrigation area. The total operation-maintenance-management cost per hectare was calculated as 10 TL. This value was reported as between 22,53-108,61 $/ha for Akıncı Irrigation Association by Nalbantoğlu and Çakmak (2007), as between 0,4-192,5 TL/ha for Kepez Irrigation Cooperative by Çakmak and Tekiner (2010), as 51,98 TL/ha for Eskişehir Beyazaltın village by Sönmezyıldız and Çakmak (2013). Current value of 10TL/ha is a quite low value and such a low value probably resulted from lower size of irrigation district and regular performance of operation and maintenance services.

3.2.4. Water fee collection performance

Water fee collection performance was calculated as the ratio of total water fees collected in a certain year to water fees to be collected in that year. The value was calculated as 100 % for Beypazarı Başören Irrigation Cooperative. This

value is an ideal value and can be considered as the success of irrigation cooperative. Water fee collection ratio was reported as between 18-88 % for Çanakkale - Kepez Cooperative between the years 2001-2008 by Tekiner and Çakmak (2011), as 100 % for Eskişehir Beyazaltın village by Sönmezyıldız and Çakmak (2013). Since card system is used in Beyazaltın village, farmers were able to pay in advance for the amount they need.

3.3. Agricultural Efficiency

3.3.1. Annual total agricultural production value

Annual total agricultural production value was determined by multiplying total production of each crop with the market price of them. The results for production values of Başören Irrigation Cooperative for the year 2015 are provided in Table 4.

Çizelge 4.Yıllık toplam tarımsal üretim değeri (BSK 2015)
Table 4. *Annual total agricultural production value (BSK 2015)*

Crop type	Planted area (da)	Yield (kg)	Production amount (kg)	Market price (TL/kg)	Production value (TL)
Pear	42	50	161.100	3,00	483.300
Apple	18	40	48.160	2,00	96.320
Cherry	15	18	18.972	2,95	55.967
Peach	10	25	27.450	2,16	59.292
Apricot	10	30	30.000	3,27	98.100
Plum	5	40	80.000	4,00	320.000
Vineyard	200	925	185.000	2,50	462.500
Walnut	50	18	17.334	11,65	201.941
Wheat	30	334	10.020	0,83	8.317
Radishes	8	3.500	28.000	0,80	22.400
Carrots	55	6.000	330.000	1,30	429.000
Spinach	24	2.000	48.000	1,50	72.000
Lettuce	18	3.200	57.600	1,16	66.816
Parsley	15	400	6.000	0,50	3.000
Total	**500**				**2.378.953**

3.3.2. The revenue per unit of command area

The revenue per unit command area was calculated as 33985,04 TL/ha. The revenue per hectare was reported as between 3290-4829 $ for Lower Gediz basin by Akkuzu and Mengü (2012), as between 771-1711 $ for the years 1995-2000 in Ceylanpınar Irrigation Association by Çakmak (2002) and as 9.030.000TL for Eskişehir Beyazaltın village by Sönmezyıldız and Çakmak (2013). The present value is a quite well value and indicates profitability of the system.

3.3.3. The revenue per unit of irrigated area

The revenue per unit of irrigated area was calculated as the ratio of total agricultural production value to the irrigated area. The value was calculated as 47579,06 TL/ha. The revenue per unit of irrigated area for 12 irrigation schemes of GAP region for the years 1997-2001 was reported as between 1223-9436 $/ha (Değirmenci et al. 2003). Yıldırım et al. (2007) assessed the performance of DSI-operated and transferred irrigation schemes and reported the revenue per unit of irrigated area for the years 1995-2002 as between 1937-3550 $/ha for DSI-operated schemes and as between 1635-3120 $/ha for

transferred schemes. The value per unit of irrigated area was reported as 9386,69 TL/ha for Eskişehir Beyazaltın village by Sönmezyıldız and Cakmak (2013). Since the irrigated lands are quite low, high-cash value crops are produced and yields are high in Beypazarı Başören Irrigation Cooperative, the revenue per unit if irrigated area was also quite high (47579,06 TL/ha).

3.3.4. The revenue per unit of irrigation water supply

The revenue per unit of irrigation water diverted to the system was calculated as the ratio of total production value to total amount of water diverted to the system. The value was calculated as 3,22 TL/m^3. The outcome per unit of irrigation water diverted to the system was reported as between 0,48-0,68 \$/m^3 for Lower Gediz basin (Akkuzu and Mengü 2012). Cakmak et al. (2009) reported the value as between 0,28-0,55 \$/m^3 for the years 2001-2004 in Asartepe Irrigation Association. The value was reported as 2,18 TL/m^3 for Eskişehir Beyazaltın village (Sönmezyıldız and Çakmak 2013). The present value of 3,22 TL/m^3 for Beypazarı Başören Irrigation Cooperative was considered as a quite well value for irrigation systems.

3.3.5. The revenue per unit of water consumption

The revenue per unit of water consumption was calculated as the ratio of total production value to total plant water consumption (Table 5).

Çizelge 5. Tüketilen birim sulama suyuna karşılık elde edilen gelir
Table 5. *The revenue per unit of water consumption*

Crop type	Crop water consumption (mm)	Average crop water consumption (mm)	Total tonnage (kg)	Market price (TL/kg)	Annual total production value (TL)
Pear	760.5	63.88	161100	3	483.300
Apple	778.2	28.01	48160	2	96.320
Cherry	791	7.91	18972	2,95	55.967
Peach	554.3	60.97	27450	2,16	59.292
Apricot	136.5	6.54	30000	3,27	98.100
Plum	737.8	22.13	80000	4	320.000
Vineyard	143.9	5.18	185000	2,5	462.500
Walnut	98.9	2.96	17.334	11,65	201.941
Wheat	728.1	291.24	10.020	0,83	8.317
Radishes	773.3	15.46	28.000	0,8	22.400
Carrots	123.5	1.97	330.000	1,3	429.000
Spinach	809.5	16.19	48.000	1,5	72.000
Lettuce	649.6	38.97	57.600	1,16	66.816
Parsley	920.1	92.01	6.000	0,5	3.000
Total		**653.42**			**2.378.953**

The outcome per m^3 irrigation water consumption was calculated as 7.28 TL. The value was reported as between 2,79-3,37 \$ for the years 2001-2004 in Asartepe Irrigation Association (Çakmak et al. 2009). Şener and Hurç (2012) reported the value as between 0,34-2,54 \$/ m^3 for 22 irrigation schemes in Tracee region. The present value of 7.28 TL/m^3 is a quite high value. High sale prices and yield levels of crops produced over the research site resulted to have

such a high value. The value is usually small in irrigation schemes with low sale prices and high water consumptions.

4. Conclusion

As it was in various parts of the world, more than 70 % of available water resources are used in agriculture in Turkey. Increasing water demands of the other sectors force the agricultural sector to use water efficiently. Researches have been conducted to improve water use efficiency in agriculture. Performance assessments of irrigation schemes are among the most important ones of these studies. With performance assessment, potential problems are identified and solutions are proposed for these problems to bring the irrigation schemes to desired performance levels. In performance assessment studies, especially the problems related to excessive water use or high water losses are identified and tried to be eliminated. The target in performance assessment is to gain more from every drop of water.

In present study, performance assessment was made for Beypazarı Başören Irrigation Cooperative. Water use efficiency, agricultural efficiency, social and economic performance indicators were evaluated. Resultant values were mostly within usual limits and some were quite higher than the acceptable values.

Among the water use efficiency indicators, amount of irrigation water distributed to per unit of irrigation area and to per unit of irrigated area was almost twice as much of water requirement. Such findings comply with the results of earlier studies. It was recommended that cooperative stuff responsible water distribution should be trained about irrigation. Among the social and economic efficiency indicators, investment return ratio, ratio of maintenance costs to revenues and water fee collection performance were quite above the targeted values. Therefore, it was concluded that Başören Irrigation Cooperative had high performance with regard to social and economic aspects. On-time collection of water fees and regular performance of operation-maintenance services might have resulted to have such high performance values. It was also concluded based on current findings that irrigation management of the cooperative was successful. Despite the small size of research site, high production values were observed since pear, plum, apple, cherry, apricot, walnut, grape, radish, spinach and parsley are also produced in research site.

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