International Scholars Journals

International Journal of Irrigation and Water Management ISSN 2756-3804 Vol. 12 (1), pp. 001-009, January, 2025. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Evaluating Irrigation Water Management Effectiveness: A Case Study of Karacabey Irrigation Scheme

Hayrettin Kuscu[1*] Filiz Eren Bölüktepe[2] and Ali Osman Demir[3]

[1]Department of Industrial Plants Cultivation and Evaluation, Mustafakemalpasa Vocational School, University of Uludag, 16500 Bursa, Turkey.

[2]Department of Business Management, Mustafakemalpasa Vocational School, University of Uludag, 16500 Bursa, Turkey.

[3]Department of Agricultural Structures and Irrigation, Faculty of Agriculture, University of Uludag, 16059 Gorukle, Bursa, Turkey.

Accepted 23 December, 2024

The objective of this study is to assess the performance of irrigation water management of the Bursa– Karacabey irrigation scheme (KIS) located in the western Turkey. The study was carried out in two stages. In the first stage, performance of irrigation water management was assessed using two physical and three financial performance indicators for six years during the period 2002–2007. According to the results, the physical performance indicators, which are average irrigation ratio and relative water supply, were found to be 61% and 0.77, respectively. Nevertheless, the financial performance indicators, which are the effectiveness of fee collection, the financial self sufficiency of fees collected to cover management, operating and maintenance budgets, and the staffing number per unit area were found as average 103%, 0.94 and 0.003 persons/ha, respectively. In the second stage, the irrigation water management was tested and assessed by the Logit model taking farmers perceptions concerning satisfaction with taking irrigation service. The probability of the satisfaction in irrigation fee policy and maintenance of irrigation and drainage canals was significant at 0.01 and 0.05 levels, respectively. Most of participants (80%) who use water from the KIS have been satisfied with taking service from the Karacabey Water Users' Association. According to the research results, it may be claim that the management with regard to physical performance was negative; on the other hand, the management with regard to financial performance and water user satisfaction was positive.

Key words: Irrigation management, performance indicators, water user association, logit model, farmer satisfaction.

INTRODUCTION

Today, organization structures are rapidly changing under the impact of globalization, large- scale industrial changes and environmental disasters. According to Drucker (1987), in such an environment, managers have to make more efficient decisions in performance manage-ment. Thus, the improvement in performance manage-ment plays a key role in using organization's current resources appropriately and creating competitive advantage (Jeston, 2008) . Performance assessment is an essential component of performance management. The performance assessment system is seen as the information system which enables the performance management process to function effectively and efficiently (Bititci et al., 1997). There is a clear relationship between performance assessment and organizational excellence. The latter can be defined as "organizational excellence is outstanding practice in managing organizations and delivering value for all stakeholders". Performance assessment provides the information needed to assess extend to which an organization delivers value and achieves ex-

[*]Corresponding author: E-mail: kuscu@uludag.edu.tr

cellence (Moullin, 2007). Therefore, recently, academics, practitioners and researchers have debated on development of new approaches looking for better ways of more rapid and reliable measurements and determi-nation of organizational performance.

The literary on performance management and management control system claim that traditional performance indicators such as profits and return on investment, costs are insufficient for decision making, planning and control operations in a dynamic environment. Traditional performance indicators are criticized because they are short-term rather than long term focus, measuring the past rather than future (Jusoh et al., 2008). According to these new approaches, performance assessment systems should reflect all dimensions of organizational perfor-mance in a balanced and integrative framework. Thus, it became main point of performance indicators, such as corporate social responsibility, stakeholder satisfaction and participation, continuous improvement, quality standards and excellence (Carroll, 1979; Lewin and Minton, 1986; Kaplan and Norton, 1992; Lakhal, 2006; Chevalier, 2008) . Furthermore, performance assessment systems should align with organization's peculiarities such as industry type, public enterprise sector and private sector, size, organizational culture and strategic goals, etc. (Bititci et al., 1997; Neely, 2004; Van Aken et al., 2005; Rantanen et al., 2007).

Irrigation is of major importance in many countries. It is important in terms of agricultural production and food supply, the incomes of rural people, public investment for rural development, and often recurrent public expenditures for the agricultural sector. Yet dissatisfaction with the performance of irrigation projects in developing coun-tries is widespread. Despite their promise as engines of agricultural growth, irrigation projects typically perform far below their potential (Small and Svendsen, 1992). Head-tail problems, leaky canals and malfunctioning structures because of delayed maintenance, leading to low water-use efficiency and low yields, are some of the commonly expressed problems. A large part of low performance may be due to inadequate water management at system and field level (Cakmak et al., 2004).

In Turkey, the irrigation ratio and irrigation efficiency have been 65 and 45%, respectively (Anonymous, 2008). Poor distribution and management of irrigation water is a major factor contributing to this situation. Adequate monitoring and evaluation of performance are needed to improve water management practices in order to achieve an increase in overall efficiency (Sarma and Rao, 1997). Low performance, with fiscal pressures from increasing operation and maintenance (O and M) costs, has provi-ded a major stimulus for transferring management of irrigation schemes to user management. Transfer can have positive effects for farmers, including improved irrigation service and maintenance, a sense of ownership of resources, increased accountability and transparency. However, the results of management transfer in improving O and M and water use efficiency are mixed (Vermillion, 1997).

Performance assessment enables verification of the degree to which targets and objectives are being re-alized. It also provides different stakeholders (system managers, farmers, and policy makers) with a better understanding of how a system operates. It can help determine problems and identify ways and means of improving system performance (Cakmak et al., 2004) . In this respect, an irrigation water management system re-quires forms of performance measurement and deter-mines that reflect the differing needs and expectations of the stakeholders involved. Irrigation water managers have to successfully balance the competing demands of various stakeholder groups. Especially, farmers are one of the strategic stakeholders of water business. Paying attention to the farmers' may provide economic and social benefits for irrigation system. More importantly, if an irrigation system committed to farmers satisfaction, it can supply more and better sustainability information.

The performance has been assessed for individual schemes, schemes in a basin, and schemes at national level for specific types such as those public-operated and transferred to users' organizations or cross-system comparison of irrigation systems all over the world. Most of researchers have conducted studies to assess the performance of irrigation management process using financial and physical indicators (Molden and Gates, 1990; Sakthivadivel et al., 1993; Bos et al., 1994; Merdun, 2004, Yercan et al., 2004; Jayatillake, 2004; Diaz et al., 2004; Degirmenci et al., 2006; Yıldırım et al., 2007) . On the other hand, a few researchers have conducted stu-dies to evaluate irrigation water management from the perspective of farmers (Naik and Kalro, 2000; Yercan, 2003; Ghosh et al., 2005; Kuscu et al., 2008).

In this study, the irrigation water management of KIS transferred to farmer management in the southwest of the Susurluk Basin in the west of Turkey was determined and assessed with performance indicators such as farmers' satisfaction as well as physical and financial performance indicators in balanced and integrative perspective.

BACKGROUNDS

In Turkey, irrigation development is the responsibility of State Hydraulic Works (DS). The DS is the main investment agency responsible for planning, development and management of water and soil resources. It is therefore responsible for water supply, large dams for flood control, irrigation, power generation, water supply and also for groundwater development. Transfer of operation, maintenance, and management responsibilities of irrigation systems from DS to Water User Organizations (WUOs) has gained momentum since 1993. While small and isolated projects were transferred before 1993, transfer activities began to include large-scale irrigation systems after 1993. WUOs assume the responsibility for operation rights of the project; they do not take the ownership rights away from DS . Reasons of IMT are to decrease in budget and other assets; the reality that users often perform services more economically, more systematically, and more swiftly; and similar approaches in the world. Nevertheless, targets of IMT are decrease in operation and maintenance expenditures (personnel, energy, maintenance, and repair costs); more equitable, reliable, and adequate water distribution; and solution of problems in each locality.

WUOs can be in several forms. If an irrigation network goes through one local authority area, the management of the irrigation network can be transferred to that autho-rity. However, the majorities of irrigation networks go through more than one local authority area or serve more than one administrative unit. So they could be transferred to Water User Associations (WUAs) and Irrigation Coope-ratives (ICs). Irrigation schemes, which serve the area of only one administrative unit, could be transferred to ICs, as well as to the Municipalities and Village Authorities. The transfer ratio of DS has reached 94%, which indi-cates the success of these transfer activities (Anony-mous, 2008).

MATERIAL AND METHODS

Study site

The KIS lies in the southwest of the Susurluk Basin in the west of Turkey (Figure 1). It has a gross command area of 16683 hectares. The average land holding in the irrigation district is 2.5 hectares. The main water source for the system is the Manyas Lake. Water to the scheme is delivered by means of a regulator and an electrical pump station constructed on the Karadere River lain outlet of the lake. The irrigation network comprises 61 km of main canals, 263 km of secondary and 262 km of tertiary canals. Likewise, there is a network of 196 km of drainage canals.

The local climate is temperate, summers are hot and dry, and winters are mild and rainy. According to long-term meteorological data (1929-1991), annual mean rainfall, temperature, and relative humidity are 689 mm, 14^{o}C, and 70%, respectively (Anonymous, 1992) . A sub humid climate prevails in the region according to mean rainfall amount (from 600 to 700 mm of annual precipitation) (Jensen, 1980), but rainfall amounts are extremely low in the summer period. There was limited rainfall during the crop-growing season.

The KIS was constructed in 1989. It was managed by DSI until 1996 and was transferred from the DSI to the Karacabey Water User Association (KWUA) in 1998 with the national transfer pro-gram. This transfer program has included only shifting authority for operation and maintenance (O and M) to the KWUA. In the KIS, water allocations are based on planned cropping patterns of the farmers.

METHODOLOGY AND DATA

The KIS was selected for analysis because of its larger-than-average service area in the Susurluk Basin. The study was carried out in two stages. In the first stage, the KIS was assessed by five performance indicators suggested by Abernethy (1989), Molden and Gates (1990), Bos et al. (1993), the International Irrigation Management Institute (Molden et al., 1998), Vermillion (2000) and Mondal and Saleh (2003) according to irrigation management process. The analysis is based on time series. Time series covering a period of 6 years were collected to measure change in performance over time at the scheme level. Data were obtained from kept by the DSI and the KWUA. Performance of a system is repre-sented by its measured levels of achievements in terms of one or several parameters, which are considered as indicators of system's goals. The process of performance evaluation consists of speci-fically measuring the extent to which the goals are being met at the end of a given time and, thus requires that all the relevant inputs and outputs are evaluated. This evaluation is done through perfor-mance indicators (Mondal and Saleh, 2003). Selected performance indicators are given as follows:

(i) physical performance indicators:

0.1 the rate of irrigation (RI) = irrigated land (ha)/irrigable land (ha)
0.2 relative water supply (RWS) = total water supply (m^3)/crop water demand (m^3)

(ii) financial performance indicators:

0.1 the effectiveness of fee collection (EFC) = collected fee/total fee
0.2 financial self-sufficiency (FSS) = annual fee revenue/total annual expenditures
0.3 staffing number per unit area (SNA) = total number of person-nel engaged in O and M service/total command area serviced by the system.

Irrigated land refers that the portion of the actually irrigated land in any given irrigation season. Irrigable land is that the area of potential scheme command area which the irrigation network has the capacity to irrigate (Yercan et al., 2004). The RI is one of the agricultural indicators and becomes more important where water is a limiting resource towards irrigation development (Kuscu et al., 2008).

RWS is the ratio of total water supply to the total demand at scheme level, and can be used both as a measurement of ade-quacy and seasonal timeliness. This variable constitutes a powerful analytical tool as it incorporates the "management" element and farmers' reaction to perceived water availability. It is no dimensional parameter (Levine, 1982). The denominator includes consumptive use, non-beneficial ET, losses to drains, and net flow to groundwater. In the KIS, the water consumption or ET of the all crops planted in the irrigation season is determined by the Blaney- Criddle method. RWS is a physical performance indicator. Physical indicators deal with the lifting, conveyance and delivery of irrigation water from the source to the farmers' fields by management of irrigation facilities (Mondal and Saleh, 2003).

In the second stage of the study, a data set of agricultural hold-ings was collected with the aim of determining social performance in 2005. In order to determine the probability of satisfaction with taking irrigation service, 17 villages in the service area were clas-sified (within themselves) into 3 groups according to the locations along the service area (head, middle and tail). Nine villages, 3 from each group, (Akhisar, Beylik, Hamidiye, Hotanli, Kepekler, Kucukkaraagac, Ortasaribey, Ovaesemen and Eskisultaniye) were selected for study (Figure 1). In these nine villages, 4 land size classes (0–1.0 ha, 1.1–5.0 ha, 5.1–10.0 ha and above 10.0 ha) were created according to the holding size using a stratified random sampling method (Cochran, 1977) the number of respondents in each village was determined. A cross–section survey,questions were asked to 190 farmers out of 1700 water users who belong to the KWUA. Questionnaire is related with satisfaction taking irriga-tion service from the KWUA was tested by Logit model. It is consi-dered regression models in which the dependent and independent variables take a value of 1 or 0 and point out some of the interest

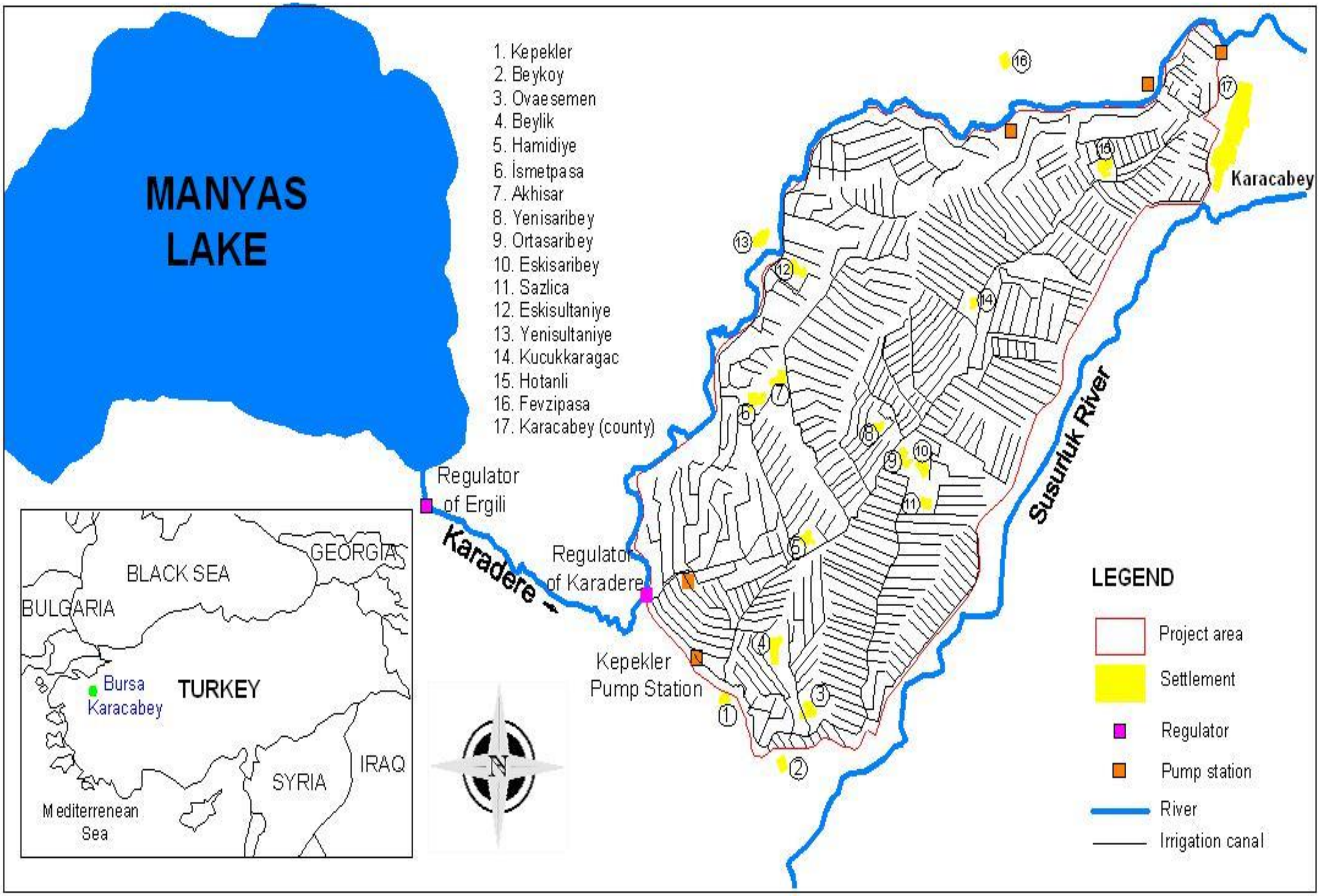

Figure 1. The Karacabey Irrigation Scheme.

Table 1. Definition of variables in the satisfaction with the taking irrigation service

	Dependent variable
Y	Satisfaction (1) and dissatisfaction (0) with the taking irrigation service
	Independent variable
X_1	Positive (1) and negative (0) satisfaction in adequacy of irrigation water supplied to the farm
X_2	Positive (1) and negative (0) satisfaction in fairness of water distribution within the system
X_3	Positive (1) and negative (0) satisfaction in timeliness of water delivery to the farm
X_4	Positive (1) and negative (0) satisfaction in irrigation fee policy
X_5	Positive (1) and negative (0) satisfaction in maintenance of irrigation and drainage canals

resting estimation problems associated with such models (Gujarati, 1995; Greene, 2000). The basic ideas underlying the Logit model are given in the below items:

$$\frac{1}{X_i} = {}_1 + {}_2X_i \qquad (1)$$

where Y and X_i are given in Table 1. Consider the following representation of Y:

$$P_i = E\ Y = \frac{1}{X_i} = \frac{1}{1+e^{-({}_1 + {}_2 X_i)}} \qquad (2)$$

for ease of exposition, we write as:

$$P_i = \frac{1}{1+e^{-Z_i}} \qquad (3)$$

where $Z_i = {}_1 + {}_2X_i$ … *Eq. (4)* represent what is known as the logistic distribution function. It is easy to verify that as Z_i ranges from - to + , P_i ranges between 0 and 1 that P_i is nonlinearly related to Z_i (i.e. X_i). That P_i is non-linear not only in X_i but also in 's can be seen clearly from (2).

If P_i, the probability of being in satisfaction with the taking service is given by (3), then (1 - P_i), the probability of not being in satisfaction with the taking service, is:

$$1 - P_i = \frac{1}{1+e^{Z_i}} \qquad (4)$$

therefore, it can be written:

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} \qquad (5)$$

P_i / (1 – P_i) is simply odds ratio in favour of satisfaction, a ratio of probability that a farmer will be in satisfaction with the taking service to the probability that he will not be in satisfaction.

If it is taken the natural log of (5), we obtain a result, namely:

$$\frac{P_i}{1-P_i} = Z_i = {}_1 + {}_2X_i \qquad (6)$$

L is called the Logit, and hence the name Logit model for the models like (6).

RESULTS AND DISCUSSION

Physical performance indicators

Data used to calculate the measures of physical performance are detailed in Table 2 analyzing the performance of irrigation water management. Average IR for the period 2002-2007 was found to be 61%. Beyribey (1997) determined IR as lower than 30% in 74 schemes, between 30 and 60% in 72 schemes, as and higher than 60% in 53 schemes from a total of the irrigation schemes in Turkey. This indicates that average IR values of KIS are some on of the national average.

An RWS value of 1 or higher indicates adequate and less than 1 indicates inadequate supply of irrigation (Beyribey, 1997; Degirmenci et al., 2003; Kuscu et al., 2008). Average RWS was found to be 0.77 for the period 2002-2007. As is shown in Table 2, RWS values were lower than what can be considered an ideal level of 1. In 2007 year, water diverted to the irrigation scheme was very lower than crop water demand. This indicates that crops are not getting enough water. Also, the lowest value of IR (46%) was determined in 2007 year. Proba-bly, this is the reason creating from the out of KWUA. In that time there was less rainfall, less treatment on the canal system, organization deficiency, cropping intensity, type of crop grown, etc. In a similar study, Cakmak et al. (2004) determined the RWS values as average 1.65-4.51 for five irrigation schemes of the State Hydrualic Works (DS) 10th Region in Turkey for 1997-2001 periods. The highest and the lowest values for relative water supply were found in the Malaysia-Sg. Manik (4.9) and Malaysia-Mada (0.37) irrigation schemes (Ghazalli, 2004).

According to the physical performance indicators, water for irrigation in the KIS was not at ideal levels. All of the service area cannot be irrigated because of lack of irrigation infrastructure, water scarcity, cropping intensity, less rainfall, fallow and socio-economic reasons. Since climatic conditions and soil structures are favourable, it has done generally vegetables and corn growing (86%) in the service area. Despite economic values of this crops are high; crop water demands are high, too. In order to raise irrigation ratio and relative water supply, crop pattern should be carefully planned. Training and extension of farmers and irrigation mangers in technical and economic respects are also vital to the augmentation of the irriga-tion ratio and relative water supply. Furrow is the most common method of irrigation in the study region. Farm efficiency in surface irrigation methods such as in border

Table 2. Physical performance indicators.

Years	Irrigable land (ha)	Irrigated land (ha)	Total water supply (m^3/ha/season)	Crop water demand (ET) (m^3/ha/season)	The rate of irrigation (RI) (%)	Relative water supply (RWS) (no dimension)
2002	16683	9739	66480	78500	58	0.85
2003	16683	10115	77160	100310	60	0.77
2004	16683	10763	78770	94630	65	0.83
2005	16683	11358	87040	104560	68	0.83
2006	16683	11750	93980	111050	70	0.85
2007	16683	7664	24440	66160	46	0.37

Table 3. Financial performance indicators.

Years	Collected fee (TL)	Total fee (TL)	Annual fee revenue (TL)	Total annual expenditures (TL)	EFC (%)	FSS	SNA (persons/ha)
2002	802835	1101984	802835	705380	73	1.14	0.003
2003	1277087	1709997	1277087	2032226	75	0.62	0.003
2004	1653662	2074770	1653662	2621227	80	0.63	0.003
2005	2249506	2581057	2249506	2048231	87	1.10	0.003
2006	2638807	2561223	2638807	2326967	103	1.13	0.003
2007	2116790	1051404	2116790	2068894	201	1.02	0.004
Average	1789781	1846739	1789781	1967154	103	0.94	0.003

or furrow irrigations is about 60%. If leakage, evapora-tion, and operational losses are included, efficiency be-comes 50%. In other words, to provide the necessary 1 cubic meter of water for a crop, 2 cubic meters of water are consumed, resulting in waste of limited water resources, thus increasing costs, and additional power consumption. Drip and sprinkler irrigation methods should be used due to numerous advantages such as higher irrigation efficiency over furrow methods in the irrigation service area. In order to use the water effectively, it should be shifted from classic open-channel distribution networks to closed pipeline distribution network. Water savings increase in pressurized pipe networks. The closed pipelines may be encouraged in modern irrigation systems. Furthermore, on- farm water losses constitute the major proportion of total water losses in irrigation, and the main source of losses are farming practices. There-fore, the most important factor is to increase farm effi-ciency. When sprinkler and drip irrigation methods are utilized instead of traditional methods, efficiency increases from 60% to 80 - 90% respectively. It means 20–30% water saving at on-farm level alone.

Sustainable irrigation is at risk due to excessive flood-ing of lands with inappropriate irrigation methods. There-fore, cultivation plans and patterns should be followed and water must be supplied to the root zone after efficient measurement on a volume basis. Since crop water requirements cannot be reduced to any great extent during irrigations, water–saving can only be achieved during water conveyance, water distribution, system operation and field water application.

Financial performance indicators

Temporal variations of the financial performance indicators for the period 2002-2004 are shown in Table 3. The effectiveness of fee collection is one of the most impor-tant indicators for water user associations because of the only source of income and contribution to sustainability of associations. The effectiveness of fee collection was found as average 103%. As it can be seen from Table 3, the EFC values have been at a satisfactory level.

The ratio of financial self-sufficiency is the annual revenue from water user fees divided by total annual expenditures. The FSS of fees collected to cover management, operating and maintenance budgets was found as average 0.94 that it is a reasonable level. As it can be seen from the Table 3, the cost of irrigation was paid by stakeholders (water users). Yercan et al. (2004) determined EFC and FSS values as 90 to 98% and 1 to 2.6 for eight irrigation schemes in Gediz River Basin in Western Turkey, respectively.

Temporal variations for staffing number per unit area (SNA) are presented in Table 3. Average SNA was about 0.003 persons/ha. According to Bekisoglu (1994), optimal command area serviced by the system of one

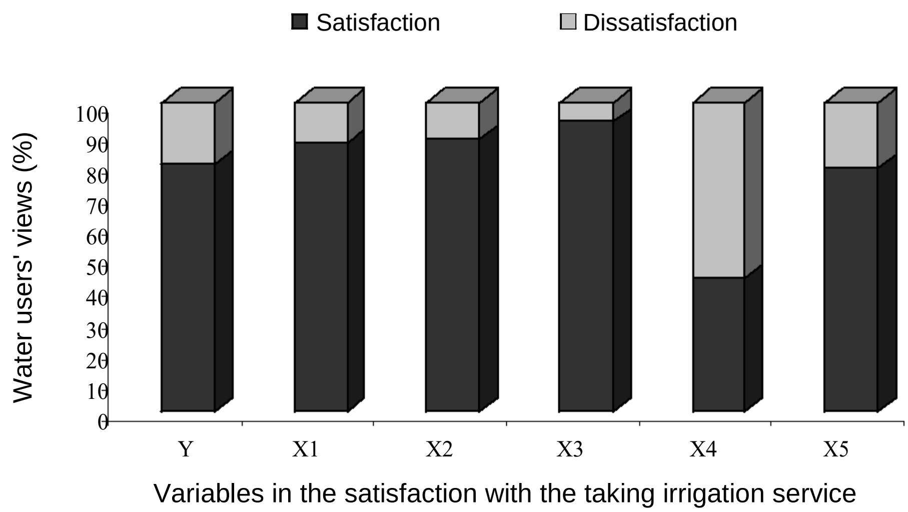

Figure 2. Perceived the taking irrigation service by stakeholders. (see Table 1 for Y, X1, X2, X3, X4, X5).

Table 4. The parameter estimates of the Logit model on satisfaction or dissatisfaction from the taking irrigation service.

Independent Variables (X_n)	Estimated coefficient	Standard deviation	Z-statistic	Odds Ratio	P-value
X_1	0.4371	0.6706	0.65	1.55	0.515
X_2	-0.9102	0.6859	-1.33	0.40	0.185
X_3	1.4589	0.8106	1.80	4.30	0.072
X_4	2.1234	0.5744	3.70	8.36	0.000**
X_5	1.1065	0.4594	2.41	3.02	0.016*
Constant	-0.9002	0.7494	-1.20	-	0.230

Dependent variable (*Y*): observed 1 = 152 (satisfaction with the taking irrigation service), 0 = 38 (dissatisfaction with the taking irrigation service), total = 190. Log likelihood = - 76.277. Based on surveyed data.
** Significant at 0.01, * Significant at 0.05.

personnel engaged in O and M service was approximately 333 ha (0.003 persons/ha). In similar studies, Cakmak et al. (2004) determined the staffing level per hectare as 0.002-0.009 for irrigation schemes of DS 10th Region. In another study, staffing level per hectare was observed as 0.007-0.012 by Nalbantoglu and Cakmak (2007) in Akıncı Irrigation District. According to the above data, SNA values were in adequate level.

Perceived the taking irrigation service by farmers

The water users' (stakeholders') point of view about the irrigation water management was designated according to satisfaction or dissatisfaction on the base of taking some services from the KWUA. Parameters are given in Table 4 and Figure 2 according to the data of Table 1. The probability of the satisfaction in irrigation fee policy and maintenance of irrigation and drainage canals is highly significant at 0.01 and 0.05 levels, respectively. Satisfaction in fairness of water distribution within the system has negative effect on the satisfaction taking irrigation service, but is not significant at the 0.05 level (Table 4). In a similar study, Kuscu et al. (2008) determined the probability of changes after management transfer in adequacy of irrigation water supplied to the farm, in fairness of water distribution within the system, in timeliness of water delivery to the farm, in irrigation fee policy, and in maintenance of drainage canals as signifycant at the 0.01 level. In another study, the probability of the changes in irrigation timing, in the water volume and in the maintenance activities was observed as significant at 0.05 (Yercan, 2003).

According to the research results, more than 80 per-cent of participants (water users) who use water from the KIS have been satisfied with taking service from the Karacabey Water Users' Association. Also, stakeholders' views in point of adequacy of irrigation water supplied to the farm, fairness of water distribution within the system, timeliness of water delivery to the farm and maintenance of irrigation and drainage canals are positive (more than

79%). On the other hand, stakeholders' views in point of irrigation fee policy are negative by a ratio of 43% (Figure 2). This is also proved by the statistical data in Table 4. The water users generally declared instalments (fixed term), high interest and expensive irrigation fees to be inappropriate. In the district, contract farming is dominant. The farmers take prices of products at the determined term because of these contracts. This term does not fit in with the payment plans of the KWUA and the water users pay interest on their irrigation fees. Nevertheless, the cost of irrigation was paid by stakeholders (Table 3). So, the participation of the users has been achieved. And some profit was created, too. This is important for the new investments. The profit from the cost recovery was used for infrastructure investment costs such as excavator, digger and other machinery and equipment. The satisfac-tion in maintenance of irrigation and drainage canal is confirmation of this idea.

Conclusions

This study determined and assessed with performance indicators based on farmers' satisfaction as a social performance indicator as well as physical and financial performance indicates the performance of irrigation water management of the Bursa–Karacabey irrigation scheme, which is located western Turkey. Therefore, this study provides support for literature claiming that performance measurement systems should be designed to take into consideration of both physical performance indicators and financial performance indicators, social performance indicators in a balanced and integrative perspective. Few researches used logit model to examine determinants of farmers' satisfaction as a social performance indicator in literature. This study is one of the first to use logit model on examining determinants of farmer satisfaction and expectation with water user association. In conclusion, for efficient water management, all activities in the irrigation network should be monitored and checked, technical requirements should be met, training and extension should be enhanced, evaluations should be performed on a daily and seasonal basis and the results should be delivered to the relevant individual and institutions with an efficient monitoring and evaluation system. The vitality of the monitoring and evaluation system should be well understood by all relevant individuals, from water users to managers. When this is achieved, problems and solu-tions in project management can be easily and rapidly defined. One of the most important reasons for not reaching the targeted performance level in irrigation sys-tems is that it emphasizes the physical infrastructure, neglecting the social dimension on the other hand. Therefore participation irrigation management is put on the agenda in operation of irrigation systems.

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