Chapter 8
The Efficient Management of Water User Associations: The Case of Lower Seyhan Irrigation Project in Turkey

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Abstract

During the last decade, many government managed water allocation schemes were transferred to private organizations such as water users' associations (WUAs). The transfer of water management authority from government to WUAs had significant impacts on improving operation and maintenance of irrigation canals as well as increasing water fee collection rate. However, recently some WUAs are having difficulties in management because of their small-scale operation size. This paper tries to address the relative efficiency of WUA management by suggesting alternative composite efficiency index. We observe the case study of WUAs in Lower Seyhan Irrigation Project in Adana, Turkey. We apply data envelopment analysis to compare efficiency levels with management-, engineering- and welfare-focused models. The analysis revealed that some WUAs are suffering from unfavorable management practices and there is a scope for major reorganization. In face of future climate change and water scarcity in the region, the role of WUAs for efficient management of water resources seems important.

Key words: water users' association, irrigation water management, DEA, composite index

1. Introduction

Turkey is considered one of the countries that achieved successful transfer of government water management systems to water user associations (hereafter WUAs). Since 1994, the government accelerated the transfer program and water management of nearly one million hectares of publicly irrigated land was rapidly transferred to local WUAs within three years. By 2002, the transfer of the management authority reached roughly 2 million hectares of irrigated land. If this trend were to continue, what would be the present and future role of WUAs in irrigation water management?

Lower Seyhan Irrigation Project (hereafter LSIP) in Adana was initiated by the Turkish government as one of the important irrigation projects located in southern Turkey. The Seyhan Dam was constructed during the 1950s for the purposes of irrigation, power generation and flood protection and the reservoir can store 1.2 billion cubic meters that supply irrigation water to LSIP. Construction of irrigation and drainage networks of Seyhan Plain has four stages. So far, area only up to stage III have completed and the area for stage IV at the down stream have left without concrete canal infrastructure. The completion of the stage IV is facing a problem of high water table, salinity and insufficient drainage. WUAs were created in LSIP from 1994 and currently there are 18 WUAs managing operations and maintenance of canal networks in the command area. However, recently some WUAs are having difficulties in management because of their small-scale operation size. It has been suggested that some WUAs in LSIP should merge to a larger operation size so as to solve their financial and logistic

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problems.

Water scarcity in the distant future is becoming a concern in this region due to climate change and the increase of water demand by the expansion of irrigated areas as well as domestic and industrial use in urban areas. Already ten years have passed after the transfer of water authority from government to WUAs that started in 1994. It may be worthwhile to assess the current status and the future scenarios for WUAs in LSIP.

The purpose of the paper is to assess the efficiency of WUA management practices in LSIP and suggest possible improvement for reorganization. The paper first describes the overview of WUAs in LSIP. This includes a review of the environment that Turkish government required to transfer water management authority, the objectives and responsibilities of water users associations in irrigation project. Also we compare the impacts of transferring authority to WUAs and the current problems faced by WUAs. The second Section explains the method of analysis and the data sets. The third section shows the results of efficiency analysis for current eighteen WUAs as well as for artificially merged six new WUAs. The fourth section describes the results of the analysis. The last section concludes with some policy implications.

Although the transfer of WUAs played significant role in reducing cost and increasing fee collection, the efficiency analysis revealed that some WUAs are suffering from their small-scale management. It is suggested that a major reorganization is necessary to further improve the management of WUAs for the efficient water use and farmer welfare.

2. The overview of WUAs in Lower Seyhan Irrigation Project

i) Establishment of WUAs in Turkey

During the early 1950s, the Turkish government slowly started transferring the role of irrigation water management to water users. Three laws became the base for transferring authority of water management to water users' associations. Those are 1953 DSI Establishment law[1] (Law number 6200), 1954 Municipality law (Law number 1580), and 1960 Cooperative law (Law number 1163). Until 1993 small-scale irrigation systems were transferred to water users at a pace of about 2,000 hectares per year. DSI encouraged farmers to organize Irrigation Groups (IGs) or Water User Groups (WUGs) with limited responsibility for operation and maintenance. After 1994, large-scale irrigation systems including Lower Seyhan Irrigation Project (LSIP) started to be transferred to WUAs (Tekinel, 2001).

The main reason that Turkish government accelerated the transfer of water management authority is as follows. First, the government budget problem made it difficult to pay overtime salary after 5pm, which became the statewide problem. Thus the cost of operation and maintenance became a huge burden to DSI. Second, since the 1980s small government is preferred and government tried to cut budget and freeze new employment to achieve this goal (Stevenson, M. and G. Nott, 2000). Third, as a result of budget cuts, DSI was not able to provide enough service to beneficiary farmers. Not only O&M of public irrigation systems were costly, water fee collection rate by DSI was quite low (42%) and became unsustainable. Therefore, the establishment of WUAs and the transfer of management authority to WUAs was the policy tool to decentralize water management authority and to perform more economically efficient operation and maintenance services.

During the 1960s-1980s, mainly small projects were transferred to WUAs. During the 1990s, because DSI failed to provide enough service, farmers themselves were willing to take responsibility of water management. One DSI official mentioned that farmers were more ready and eager to take responsibilities while DSI was not yet ready to transfer them officially. The acceleration of transferring water management authority after 1994 proceeded rapidly beyond DSI expectations. During the initial phase, 10,000 hectares were transferred to WUAs compared to annual average of 2,000 hectares before the acceleration program. By 1995, DSI had already transferred 800,000 hectares to WUAs, the level that was expected to reach in 2000. DSI had already achieved the goal of 2000 five years earlier.

Stevenson and Nott (2000) point out the specific

1) Enacted Dec. 18, 1953; Effective Feb, 28, 1954. DSI is General Directorate of State Hydraulic Works, Ministry of Energy and Natural Resources, Government of Turkey.

characteristic of transfer program in Turkey. First, the transfer program utilized the existing local government organizations and leaders rather than local farmers' grassroots organizations. Local organizations are village and municipality governments and their heads. Second, the scale of transferred units and the number of beneficiary farmers involved is quite large and the average size of WUAs is 6,500 hectares. This average unit size to be transferred is much larger than those in Southeast and South Asia. The staff of regional DSI operation and maintenance division played a major role in implementing the transfer program at the local level.

ii) The role of WUAs in water management

Currently in Turkey about 91% of transferring organizations are WUAs. The remaining 9% include municipalities, cooperatives, water user groups (WUGs) or irrigation groups (IGs). Before 1994, WUGs or IGs, headed by a village head, took responsibility of O&M for tertiary distribution canals and thus considered appropriate intermediate organization for WUAs. The followings are the types of various transferring organizations based on the local government in the irrigation scheme (Tekinel, 2001):

i) An irrigation scheme can be transferred to WUAs where there is more than one local administrative unit (village, legal entities, municipalities) within one irrigation scheme.

ii) An irrigation scheme can be transferred to Municipality where the irrigation scheme serves only single village. Mayor is the natural chairman of this organization.

iii) An irrigation scheme can be transferred to Village organization where the scheme serves only single village. Muhtar (village head) is the natural chairman of this organization.

iv) An irrigation scheme can be transferred to Cooperatives where legal cooperative can be formed with a request of a minimum 15 farmers before a scheme is undertaken.

When WUAs are established, the irrigation facilities were turned over based on the turnover contract and protocols made between DSI and WUAs. While DSI owns the irrigation facilities and is responsible for carrying water through main canals, operation and maintenance is transferred to WUAs and they are responsible from the main canal (Mert, 2003). Water rights, on the other hand, were not transferred to WUAs (Scheumann, 1997). Thus the government still possesses the rights over water resources in irrigation project.

Objectives of the WUAs are as follows (Stevenson and Nott, 2000): a) Providing adequate and timely irrigation water supplies to all farmers in the unit; b) Providing irrigation service in a reliable and sustainable manner; c) Contracting O&M costs; d) Collecting service fees from all benefiting farmers; e) Acquiring mechanical equipment for maintenance and repair.

Responsibilities of WUAs include: a) Scheduling and delivering water within the WUA unit; b) Monitoring deliveries to farms; c) Collecting operational monitoring data; d) Resolving disputes; e) Paying irrigation pumping costs.

iii) The impacts of transferring authority to WUAs

Lower Seyhan Irrigation Project is located in the south of Adana city stretching to the Mediterranean coast (Figure 1). Mediterranean climate prevails in the region with hot and dry summers and mild and rainy winters. The average annual rainfall is approximately 650mm and most precipitation occurs in May and December (Donma, 2004). The average temperature is 18 (C with max 45.6 (C and min -8.1 (C (Mert, 2004). The main crop in LSIP is corn (52%), citrus (14%), cotton (7%), vegetables (6%) in terms area planted, and citrus (39%), corn (33%), melon (10%), vegetables (6%) in terms of production value. The dominant irrigation technology is gravity irrigation.

In Lower Seyhan Irrigation Project (LSIP) area, 18 WUAs were established during 1994-1996 (Figure 2). Although available data is limited, the impacts of transferring authority from DSI to WUAs can be mainly summarized in four points. Those are: i) reduction of O&M costs, ii) reduction of water fee, iii) increased fee collection rate by WUAs, iv) more equitable distribution of water among head and tail farmers compared to DSI regime.

Table 1 Water fee assessed by DSI and WUA in Region IV

crop	Fee by DSI before 1994 (MTL/da)	Fee by WUA 2003 (MTL/da)
corn	10	5.5
soybean	8	4.5
cotton	15.5	5.5
melons	8	5.5

Source: Mert (2003). MTL: million Turkish Lira; da: decare=0.1 hectare.

The assessment of irrigation scheme in Yüreğir Plain during 1994-5 indicated that the total O&M costs by WUA was only 41% of the cost paid by DSI (Scheumann, 1997). In case of LSIP, water fee became less than a fee assessed by DSI (Table 2). Stevenson and Nott (2000) reported, however, that water fee doubled when WUAs were established during the early 1990s. Since water fee is generally not only the cost of water but also a service fee of WUAs to farmers, there is a regional variation depending on the endowment of the WUAs and the above statement of Stevenson and Nott (2000) should be examined carefully. Also water fee for each crop is determined by WUAs before the next irrigation season. A wide range of water fees depending on the WUA may raise a question of equity among farmers in the irrigation project.

Fee collection rate, on the other hand, increased drastically. From 1989 to 1994, average fee collection rate by DSI was 37.6 percent (Yazar, 2002), while average collection rate of assessed fee was 65% in 2002 (Table 2). Also, farmers consider water allocation became more equitable among head and tail farmers compared to the times of DSI regime[2].

iv) The WUAs in Lower Seyhan Irrigation Project: current issues

Table 2 shows the general information of 18 WUAs during the 2002 irrigation season. The Seyhan right bank, Tarsus Plain, has 8 WUAs and the Seyhan left bank, Yüreğir Plain, has 10 WUAs. At the time of transferring authority, the basic concept of making WUA boundary was to assign management responsibility of one main canal to one WUA and also to show concerns for ethnic groups in the command area. However, in reality many right bank WUAs share the same main canal TS-3 and this situation is causing frequent water sharing problems until present. Having learned from the lesson of the right bank, WUAs in the left bank basically do not share main canals. Their total service area ranges from 1,650 hectares for Cumhuriyet WUA to 16,529 hectares for Guney Yüreğir WUA. The service area includes area of uncompleted LSIP project phase IV that does not have canal infrastructure. For example, Ata WUA's total service area is consisted totally without any concrete canal infrastructure. Some portion of the land is irrigated by groundwater for citrus and vegetable cultivation. Groundwater use is high in Çukurova WUA for citrus cultivation. The number of irrigators ranges from 283 for Ata WUA to 4,731 for Toroslar WUA. The number of parcels is also highest in Toroslar. The average water fee ranges from the lowest in Yeni Gök, MTL3.20/da[3] (US\$19.5/ha) to the highest in Cumhuriyet, MTL9.10/da (US\$55.5/ha) and this is due to pumping cost for irrigation. The fee collection rate in Table 2 shows that six WUAs could not collect even 60% of total water fee expected in year 2002. Water fee is based on crop type and each WUAs charge different water fee for each crop. For example, water fee/da for corn in LSIP ranged from MTL3.5 to MTL6.7 in 2002 irrigation season[4]. The highest water fee is assessed for citrus, fruit trees and vegetable cultivation.

Table 3 shows financial information of WUAs in LSIP. The major revenue of WUAs comes from water fee collected from irrigators. The total expected WUA fee is estimated by WUAs based on the actual cropping pattern of their irrigated land. However, the WUA revenue is short of the expected amount because of the following reason. First, collection rate is in average 65% and there is a substantial amount of delayed payment. Six WUAs had more than 40% share of delayed payment in expected fee revenue. Therefore, the actual amount of fee collected is the sum of collected fee for this year and collected fee from the past years as shown in the column (d) of Table 3. Collection rate of many WUAs exceeds 80 % only when the fees from the past years are included as shown in column (f). Staff salary indicates that a share of personnel cost is overwhelming exceeding 60 % of its actual budget in case of Cumhuriyet and Kadıkoy. Comparing to staff salary, O & M costs provided by WUAs ranged from 9% (Altınova, Yeni Gök) to 86% (Güney Yüreğir). According to the regulation, WUAs are supposed to allocate 30% of its annual budget to staff salary and 40% for repair and maintenance. However, small scale of operation

2) From authors' interview survey in summer 2003.

3) Million Turkish Lira per da. da (decare)=0.1ha. 1US\$ = 1.64MTL (October 2002)

4) In normal years, irrigation season starts from April and ends in October.

and high staff salary are causing financial difficulties in some WUAs, thus making it difficult to meet the regulation.

Table 4 shows the water demand and irrigation efficiency of 18 WUAs. Claimed demand indicates that this amount of water is requested to DSI in March by each WUA before the irrigation season. DSI plans the annual water allocation based on this request from WUAs. Net demand is estimated based on the actual cropping pattern during the irrigation season. Gross demand is estimated by multiplying around the factor of 1.8 to take into account conveyance and other physical losses of the irrigation system. Theoretically this gross demand suffice the water demand at the farm level, however, the actual water release by DSI is shown in the last column which is larger than the amount of claimed demand. Irrigation efficiency, i.e., percentage of net demand out of actual release of water, indicates that Çotlu has the highest efficiency (63%) while Kuzey Yüreğir has the lowest (31%) efficiency. It is a customary practice for WUAs to overestimate the cultivation area at the time of aggregating farmers' water request and report larger amount of claimed water to DSI office compared to gross demand.

The current issues of WUAs in LSIP can be summarized as follow: a) large amount of delayed fee payments; b) low fee collection rate; c) high staff salary; d) low operation and maintenance expenditure ; e) water demand being claimed so high by WUAs ; and f) small operation scale.

Following the management difficulties reported by some WUAs, it has been suggested that 18 WUAs in LSIP should reorganize into smaller number of WUAs with larger command area. We tentatively merged current eight WUAs in the right bank into three and ten WUAs in the left bank into three, six WUAs in total, for our further analysis. Before the transfer in 1994, right bank and left bank of the Seyhan River had four and three DSI field offices respectively. This suggested that this aggregation level of six newly merged WUAs is similar to the previous operation scale under DSI administration before the transfer in early 1990s. Table 5 shows the characteristics of newly merged WUAs named tentatively R-1 (1 WUA), R-2 (5 WUAs), R-3 (2 WUAs) for the right bank and L-1 (3 WUAs), L-2 (3 WUAs), L-3 (4 WUAs) for the left bank. The main advantage of this merger is that none of the new WUAs shares the same main canal within its command area. Thus in the following section, we try to consider efficiency analysis for both current and newly merged WUAs.

3. Method and data

i) Method of analysis

The input-oriented CCR (Charnes, Cooper and Rhodes, 1978) efficiency is the radial measure of technical efficiency in which the efficiency is obtained by radially reducing the level of inputs relative to the frontier technology holding the level of output constant. The input-oriented model implicitly assumes cost-minimizing behavior and the output-oriented DEA model, on the other hand, assumes revenue-maximizing behavior of organizations. It is more reasonable to assume that organizations have a budget constraint and thus minimize costs. In general, DEA efficiency measure requires input and output quantity information and is independent of input prices as well as behavioral assumptions on producers. Also CCR efficiency measure assumes constant returns to scale. Fig 3 illustrates the input-oriented CCR measure and distance function for a two-input case. The frontier technology is given by the piecewise linear isoquant, ABCDE. Efficient production activity occurs at the extreme point of the convex hull of this frontier (BCD). Line segments extending from B and D, AB and DE, indicate strong disposability of inputs i.e., disposal of surplus inputs is free. Production activity F is inside of the input requirement set and thus inefficient. In terms of distance, the CCR technical efficiency at period t is given by 0C/0F. The CCR efficiency measure varies between zero and one and equals to one when the observation is efficient, i.e., the observed Decision Making Unit (DMU) is on the frontier technology (C).

The production possibility set P is defined by the set of feasible activities as follows:

$$P = \{(x, y) \mid x \geq X\lambda, y \geq Y\lambda, \lambda \geq 0\}. \quad (1)$$

CCR model is estimated as a linear programming model as follows (Cooper, Seiford and Tone, 2000).

$$\max \quad \boldsymbol{u}\boldsymbol{y}_0 \qquad (2)$$
$$\text{subject to} \quad \boldsymbol{v}\boldsymbol{x}_0 = 1$$
$$-\boldsymbol{v}X + \boldsymbol{u}Y \leq 0$$
$$\boldsymbol{v} \geq 0,\ \boldsymbol{u} \geq 0$$

where row vector $\boldsymbol{v}$ is input multipliers and row vector $\boldsymbol{u}$ is output multipliers. The dual problem of the above equations (2) can be expressed as the following linear programming problem where θ is a real variable, and $\lambda = (\lambda_1, \ldots, \lambda_2)$ (2) is a non-negative vector of variables.

$$\min \quad \theta \qquad (3)$$
$$\text{subject to} \quad \theta \boldsymbol{x}_0 - X\boldsymbol{\lambda} \geq 0$$
$$Y\boldsymbol{\lambda} \geq \boldsymbol{y}_0$$
$$\boldsymbol{\lambda} \geq 0$$

The dual LP problem has a feasible solution $\theta = 1$, $\lambda_0 = 1$, $\lambda_j = 1 (j \neq 1)$. Hence the optimal θ^* is not greater than 1. Also the nonnegative constraint for the data forces λ to be nonzero. Thus θ must be greater than zero. Thus 0< θ^* (1. The constraints of dual LP (3) requires the activity (θ x_0, y_0) to remain in the production possibility set P, while the LP minimizes (that contracts the input vector x_0 radially to (x_0. Dual LP problem seeks the activity in P that maintains at least the output level y_0 while reducing the input level x_0 radially at a minimum level.

ii) Data sets

For performing efficiency analysis of WUAs, we consider three models for different focus[5]. First model focuses on *management efficiency*. Management efficiency model has two outputs, WUA fee, total irrigated area served, and five inputs, actual water supply (gross water), operation and maintenance costs, staff salary, a number of technical staff and delayed water fee payment. Second model focuses on *engineering* efficiency that tried to capture water distribution efficiency. Engineering efficiency has two outputs, total irrigated area and net water demand and three inputs, actual water demand, maintenance and repair costs and a number of technical staff. The third model considers *farmer welfare* by including value of agricultural production. Thus welfare oriented model has three outputs, WUA fee, total irrigated area served, gross revenue from production, and five inputs, actual water supply, operation and maintenance costs, staff salary, a number of technical staff and delayed water fee payment. Detailed data description follows. Various cost and operation information of WUAs for 2002 irrigation season are taken from Transferred Irrigation Association Year 2002 Observation and Evaluation Report supplemented by the information collected from authors' interview survey.

Total irrigated area (ha) is the sum of area with canal infrastructure and without canal infrastructure that were irrigated by WUAs and subject to water charge. This total irrigated area of WUAs changes every year because there are some farmers who decide not to irrigate in a particular year. The *WUA fee* (Million Turkish Lira: MTL) is the annual total water charge actually collected in 2002 by each WUA. This amount includes fee collected from past years and fee collected for 2002. The fee not collected for year 2002 is *delayed payment* that causes WUAs difficulty in planning their annual budget. *Operation and maintenance costs* (MTL) include electricity charges, machinery cost, other operation expenses such as communication, office rental fee and utility charges, and maintenance and repair expenses. Maintenance costs (MTL) done in that year includes concrete repair works for canals, canal cleaning, kanalet repairs, painting, maintenance of underground structure, service roads, building, and others. *Number of technical staff* is the sum of irrigation engineer, operation and maintenance technician, water distribution technician, pump operator, electric technician and machine operator. *Staff salary* (MTL) includes staff expenses, president's salary and travel expenses and money paid to the committee members for meetings.

Gross revenue from production (Billion Turkish Lira : BTL) for each WUA is calculated by area cultivated in year 2002 reported by WUAs (DSI, 2003b) and the average gross revenue/da in 2002 for each crop

5) For performance evaluation focused on engineering criteria are often found. For example, Kanber (2004) analyzed the irrigation system performance of various water basins in Turkey using the following criteria: (1) hydraulic performance indicators, (2) economic performance indicators, (3) agricultural performance in dicators.

in Lower Seyhan region (DSI, 2003a). WUAs keep a record of irrigated area by crops for charging purpose, however, non-irrigated crops such as wheat and other agricultural revenue such as livestock are not considered in our analysis. Information reported in *Briefing of WUA and Year 2002 Management Activity Report (DSI, 2003b) were used for actual water supply, net water demand*, and claimed water demand (million cubic meters) for each WUA.

4. Estimation results

i) Efficiency scores of 18 WUAs

We performed the efficiency analysis by estimating CCR efficiency scores for three models, management efficiency, engineering efficiency and welfare focused models as mentioned in the previous section. The efficiency score shows the efficiency level of each WUA relative to the efficient frontier.

Table 6 indicates the result of efficiency scores for these three models with different focus. For management efficiency (ME), 10 WUAs are on the efficient frontier. The one of the least efficient DMUs in this category includes Cumhuriyet (0.709) and Kuzey Yüreğir (0.764). Cumhuriyet is the one of WUAs that has financial difficulties because of its small operation size. On average, the right bank management efficiency (0.968) is slightly better than the left bank (0.929).

The second column shows the engineering efficiency (EE) scores. Eight WUAs scored 1 and are on the frontier, and Cumhuriyet (0.700) and Kuzey Y. (0.744) again showed low performance in engineering efficiency because of large number of technical staff employed by WUAs. Onköy's low performance in engineering efficiency (0.753) is largely due to the fact that they employ the largest number of technical staff for water distribution among all WUAs. On average, the right bank engineering efficiency (0.917) is slightly better than the left bank (0.903) in spite of the old canal infrastructure.

The third column shows the welfare focused efficiency scores that take into account agricultural revenue from the command area. Thirteen WUAs formed a frontier and Cumhuriyet (0.719) and Kuzey Y. (0.768) are low performers. Cumhuriyet WUA has a command area in proximity to the city of Adana and the average parcel size is 1.3 ha and the smallest among all WUAs after Toroslar (1.2 ha). Again on average, the right bank welfare score (0.968) is higher than the left bank (0.942). This may be the fact that right bank includes Toroslar that specializes high value crops such as vegetables and citrus.

The last column shows the composite index, which is estimated by taking geometric mean of three efficiency scores. The results indicate that eight WUAs scored composite index of 1, namely Altınova, Çukurova, Yukari Seyhan, Pamukova, Çotlu, Kadıkoy, Yeni Gök and Ata. It is surprising to see that Ata which entire command area does not have concrete canal infrastructure is on the efficiency frontier indicating that they are utilizing their limited resources most efficiently.

Table 7 shows the projected input levels to reach efficient frontier of welfare model for Cumhuriyet and Kuzey Y. WUAs that resulted in lowest performance in all categories. The projection shows the level of input that are can be reduced to reach the same level of output by comparing other efficient DMUs. For example, the delayed payments of Cumhuriyet can be reduced by 46% or by 34,003 MTL, thus the efficient level of delayed payments are 39,763 MTL. Similarly, actual water supply, O & M costs, staff salary and the number of technical staff can be reduced by 28%, 28%, 28%, and 53% respectively. In case of Kuzey Y., the major reduction of input should come from O & M costs (41%), technical staff (66 %) and delayed payments (41%). Thus DEA analysis provides the target input for major reorganization.

ii) Efficiency scores of merged WUAs

In the second stage, we performed efficiency analysis of welfare model for artificially merged WUAs for R-1, R-2, R-3, L-1, L-2 and L-3. First, data sets of all 18 WUAs were merged into 6 WUAs. Newly created 6 WUAs (DMUs) were included in estimating the efficiency scores together with current 18 WUAs. Thus we have 24 DMUs altogether and could estimate the efficiency scores of new DMUs in reference to the existing DMUs. Table 8 shows the results of efficiency scores of merged WUAs with current WUAs. R-1, L-2 and L-3 scored 1 because they are consisted of originally efficient WUAs as show above. On the other hand, L-1 showed lowest scores among new WUAs, 0.867, because it consists of originally inefficient Cumhuriyet and Kuzey Y. It is obvious that simply merging inefficient WUAs will result in inefficient WUA.

Table 9 shows the projected input levels to reach frontier for L-1. The reduction level required is more moderate compared to the reduction revel in Table 7. However, L-1 needs to reduce technical staff and delayed payments by 34% and 22% respectively. By merging WUAs, the average efficiency score improved slightly from 0.954 to 0.966. However, by simply merging to less number of WUAs does not improve the efficient level significantly. In order for new WUAs to reach frontier, significant reorganization, i. e., reduction of some inputs, is required.

5. Conclusion

The WUAs that were established rapidly after 1994 became the major actor of water management in Turkey. The benefits of reducing the O&M costs and alleviating inequality of water distribution are considered large. However, recently some WUAs are having difficulties in management because of their small-scale operation size. This paper tries to address the relative efficiency of WUA management by suggesting alternative composite efficiency index. We observe the case study of WUAs in Lower Seyhan Irrigation Project in Adana, Turkey. We apply data envelopment analysis to compare efficiency levels with management-, engineering- and welfare-focused models. The composite index was estimated by geometric mean of three efficiency indices. The analysis revealed that some WUAs are suffering from unfavorable management practices and there is a scope for major reorganization. Particularly the reorganization should come from the reduction of technical staff and delayed payments of water fee. The current 18 WUAs are grouped into artificially created 6 WUAs to see the effect of merger. Merging results show that the average efficiency score improved slightly from 0.954 to 0.966. However, by simply reducing the number of WUAs does not automatically improve the efficiency of DMU significantly. In order for new WUAs to reach frontier, significant reorganization, i.e., reduction of some inputs, is required.

For further analysis, comprehensive assessment of WUAs management and productivity in Seyhan River Basin in reference to other regions of Turkey may be necessary to understand and predict future scenarios for WUAs. Also due to data availability, environmental factors, such as soil quality, gradient, salinity conditions in each WUA were not considered. It may be worthwhile to separate the external environment that may be affecting management practices when data set is available. WUA's contribution on improving water efficiency and their basinwide impact of water use and allocation are still need to be investigated further. In face of future climate change and water scarcity in the region, the role of WUAs for efficient management of water resources seems important.

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Figure 1. Location of Lower Seyhan Irrigation Project, Adana, Turkey

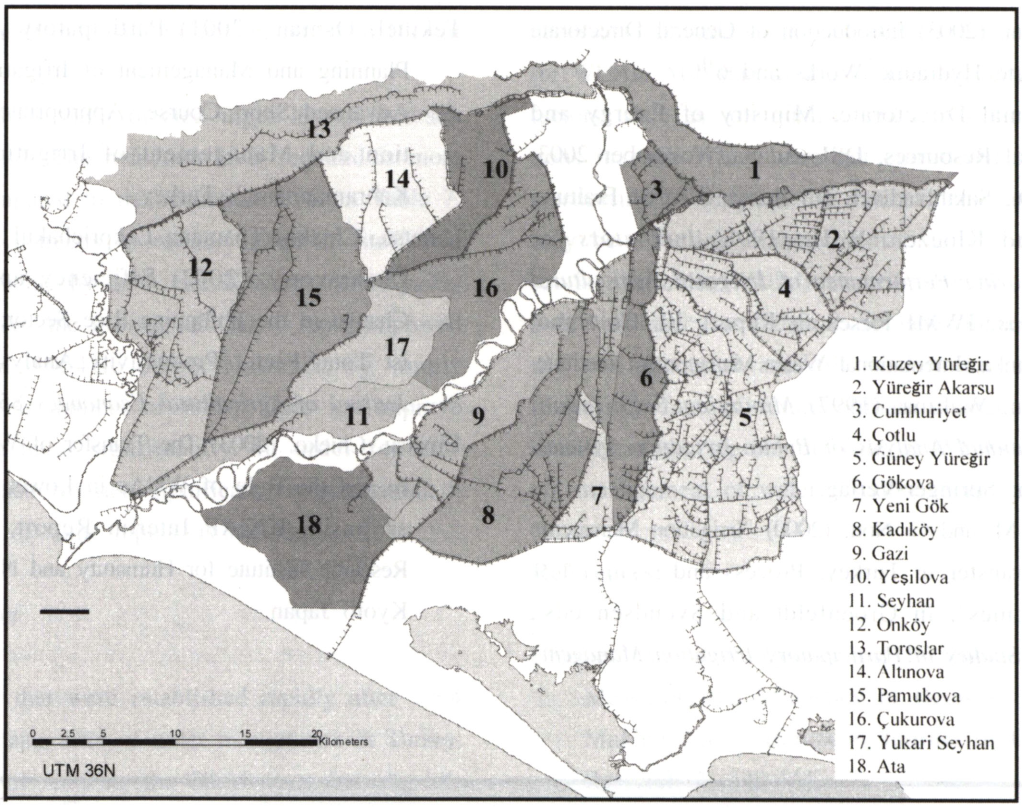

Figure 2. WUAs in Lower Seyhan Irrigation Project

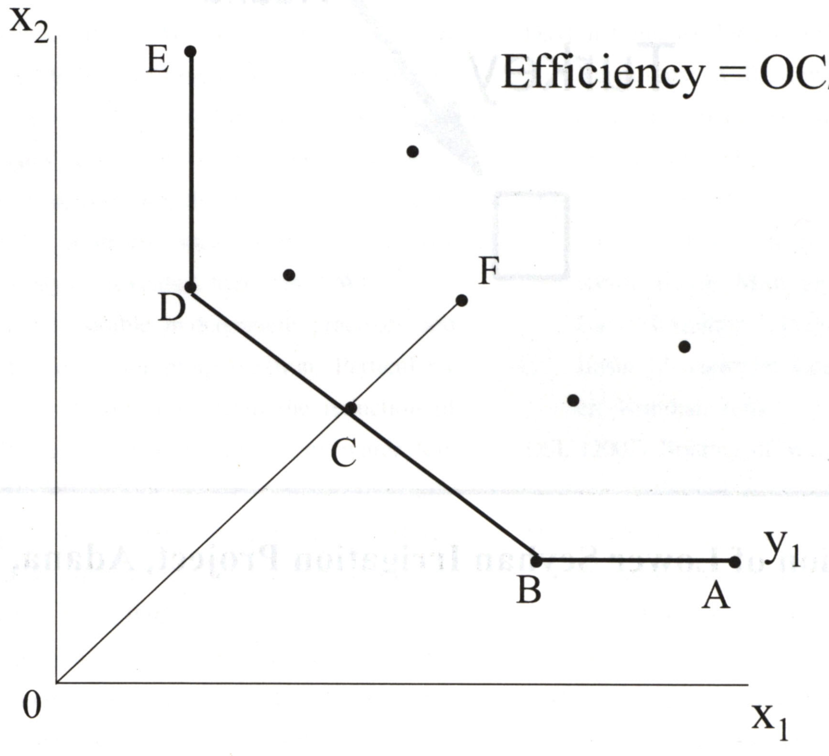

Figure 3. Production frontier and Farrell efficiency

Table 2. General Information of 18 WUAs in Lower Seyhan Irrigation Project (2002)

map no.	WUA name	established year	main canal	total service area (ha)	irrigated area with infrastructure (ha)	irrigated area without infrastructure (ha)	tatal irrigated area (ha)	non-irrigated area (ha)	groundwater irrigated area (ha)	number of irrigators	number of irrigated parcels	average water fee (MTL/da)	fee collection rate %
13	Toroslar	1995	TS1, 2	13700	15695	0	13719	1891	190	4731	9795	7.20	49.69
10	Yeşilova	1994	TS3	3740	5734	0	2577	853	310	413	881	6.20	56.90
14	Altınova	1995	TS5	5379	7373.8	0	5478	252	420	694	1465	5.40	72.83
16	Çukurova	1995	TS3	6847	8842	0	6133	920	799	1757	3123	6.10	78.45
17	Yukari Seyhan	1996	TS3	4150	6146.3	0	4001	960	74	734	1578	5.80	93.57
11	Seyhan	1994	TS3	3400	5394	0	3060	540	120	651	1288	6.50	74.63
12	Onköy	1994	TS8,9,10	8887	10881	0	8697	3096	190	1589	4044	6.90	74.73
15	Pamukova	1995	TS6,7	11982	13977	0	10688	1194	155	2070	4956	6.10	64.41
2	Yüreğir Akarsu	1995	YS2	7523	9518.2	0	7523	1812	0	918	1666	5.50	64.80
3	Cumhuriyet	1994	YS0	1650	3644	0	1651	934	160	602	1161	9.10	50.53
1	Kuzey Yüreğir	1994	YS1	3610	5603.5	539	3606	1971	0	1141	1133	5.00	46.85
4	Çotlu	1994	YS4	3215	5209	790	2640	607	0	310	971	5.00	59.40
6	Gökova	1994	YS6	3315	5309	0	4139	974	0	435	734	5.60	71.95
5	Güney Yüreğir	1994	YS5,3	16529	18523	2175	16528	4965	0	1620	3419	4.40	66.48
8	Kadıköy	1994	YS8	11568	13562.4	1570	10409	898	332	1275	1640	3.90	72.61
7	Yeni Gök	1994	(YS8) YS9	4731	6725	2867	4688	42	44	519	735	3.20	59.64
9	Gazi	1994	YS7	7097	9091	1470	6985	1328	278	569	1270	3.50	84.43
18	Ata	1996	(YS7)	4360	0	4360	4360	5700	300	283	996	4.50	64.23

Source: DSI. (2003) Transferred Irrigation Association Year 2002 Observation and Evaluation Report
Main canal in bracket indicates that this canal is shared with other WUA.
Total irrigated area does not include the area irrigated by groundwater.
Fee collection rate is the collected 2002 fee out of expected fee in 2002.

Table 3. Financial information of 18 WUAs in Lower Seyhan Irrigation Project (2002)

map no.	WUA name	(a) WUA fee revenue expected	(b) WUA fee revenue from past years	(c) WUA fee revenue collected	(d)=(b)+(c) WUA fee revenue actual	(e) delayed payment 2002	(f)=(d)/(a) actual/ expected %	(g)=(e)/(a) delayed/ expected %	(h) staff salary (MTL)	(i)=(h)/(d) % of WUA staff salary in (d)	(j) O&M cost (MTL)	(k)=(h)/(d) % of WUA O&M expenditure
13	Toroslar	1082591	341878	537943	879821	544648	81.27	50.31	336389	38	231800	26
10	Yeşilova	209133	20163	119003	139166	90130	66.54	43.10	91459	66	20560	15
14	Altınova	330820	14686	240946	255632	89874	77.27	27.17	101017	40	22456	9
16	Çukurova	368111	35792	288794	324586	79317	88.18	21.55	166247	51	60512	19
17	Yukari Seyhan	115636	9840	108202	118042	7434	102.08	6.43	74902	63	73363	62
11	Seyhan	188581	16597	140735	157332	47846	83.43	25.37	79399	50	51712	33
12	Onköy	638100	67899	476832	544731	161268	85.37	25.27	336205	62	279908	51
15	Pamukova	708000	40805	456050	496855	251950	70.18	35.59	372141	75	385260	78
2	Yüreğir Akarsu	366538	47514	237499	285013	129039	77.76	35.20	148284	52	69178	24
3	Cumhuriyet	149127	20255	75361	95616	73766	64.12	49.47	58394	61	29812	31
1	Kuzey Yüreğir	178469	31855	83620	115475	94849	64.70	53.15	47703	41	60883	53
4	Çotlu	128281	54792	76198	130990	52083	102.11	40.60	50730	39	36113	28
6	Gökova	213412	32258	153543	185801	59869	87.06	28.05	97560	53	41055	22
5	Güney Yüreğir	662199	95375	440224	535599	221975	80.88	33.52	161766	30	460234	86
8	Kadıköy	382408	38697	277651	316348	104757	82.73	27.39	203348	64	84870	27
7	Yeni Gök	143765	198182	85748	283930	58017	197.50	40.36	61106	22	26398	9
9	Gazi	230056	27481	194245	221726	35811	96.38	15.57	125567	57	106240	48
18	Ata	182536	23067	117244	140311	65292	76.87	35.77	37531	27	41587	30

Source: DSI. (2003) Transferred Irrigation Association Year 2002 Observation and Evaluation Report
Unit: million Turkish Lira; (i) and (k) does not sum to one because of other incomes and shortfalls.

Table 4. Water demand and irrigation efficiency of 18 WUAs in Lower Seyhan Irrigation Project (2002)

map no.	WUA name	(a) claimed demand (MIL m3)	(b) net demand (MIL m3)	(c) gross demand (MIL m3)	(d) actural water (MIL m3)	(d)/(c) water use efficiency	(b)/(d)*100 irrigatgion efficiency (%)	(a)/(c) claimed demand/ gross	net (b)/ irrigated area (m3/ha)	actual (d)/ irrigated area (m3/ha)	gross revenue (MTL/m3)
13	Toroslar	129.51	71.16	128.79	156.39	1.21	45.50	1.01	5187	11400	0.452
10	Yeşilova	31.40	13.86	25.08	35.89	1.43	38.62	1.25	5378	13927	0.263
14	Altınova	62.57	30.20	54.65	70.46	1.29	42.86	1.14	5513	12862	0.257
16	Çukurova	60.29	32.71	59.20	66.29	1.12	49.34	1.02	5333	10809	0.356
17	Yukari Seyhan	40.22	21.70	39.28	46.73	1.19	46.44	1.02	5424	11680	0.333
11	Seyhan	33.25	16.27	29.44	38.05	1.29	42.76	1.13	5317	12435	0.233
12	Onköy	105.47	44.95	81.35	114.21	1.40	39.36	1.30	5168	13132	0.213
15	Pamukova	100.92	57.61	104.27	114.54	1.10	50.30	0.97	5390	10717	0.284
2	Yüreğir Akarsu	89.61	41.99	76.00	80.04	1.05	52.46	1.18	5582	10640	0.435
3	Cumhuriyet	22.52	8.77	15.87	25.44	1.60	34.48	1.42	5311	15406	0.273
1	Kuzey Yüreğir	43.15	17.58	33.05	55.96	1.69	31.41	1.31	4874	15518	0.187
4	Çotlu	23.51	13.20	23.89	21.01	0.88	62.84	0.98	5001	7958	0.284
6	Gökova	44.00	21.94	39.70	49.38	1.24	44.42	1.11	5300	11930	0.397
5	Güney Yüreğir	159.39	87.40	158.20	212.60	1.34	41.11	1.01	5288	12863	0.265
8	Kadıköy	107.69	54.28	98.24	117.63	1.20	46.14	1.10	5214	11301	0.335
7	Yeni Gök	81.77	25.01	45.26	77.41	1.71	32.31	1.81	5334	16512	0.103
9	Gazi	79.10	37.83	68.47	87.99	1.29	42.99	1.16	5416	12597	0.314
18	Ata	46.76	20.09	36.35	54.50	1.50	36.85	1.29	4607	12500	0.235

Source: DSI. (2003) Transferred Irrigation Association Year 2002 Observation and Evaluation Report
MIL m3: Million cubic meters; MTL: Million Turkish Lira

Table 5. Information of merged WUAs in Lower Seyhan Irrigation Project based on year 2002 data

merged WUA	main canal	total service area (ha)	irrigated area with infrastructure (ha)	irrigated area without infrastructure (ha)	total irrigated area (ha)	non-irrigated area (ha)	groundwater irrigated area (ha)	number of irrigators	number of irrigated parcels	average water fee (MTL/da)	fee collection rate (%)
R-1	TS1, 2	13700	13719	0	13719	1891	190	4731	9795	7.20	49.69
R-2	TS3, 5	23516	21249	0	21249	3525	1723	4249	8335	5.93	74.05
R-3	TS6,7,8,9,10	20869	19385	0	19385	4290	345	3659	9000	6.46	69.30
L-1	YS0,1,2	12783	12241	539	12780	4717	160	2661	3960	5.82	57.12
L-2	YS3,4,5,6	23059	20343	2965	23307	6546	0	2365	5124	4.68	66.74
L-3	YS7,8,9	27756	16177	10267	26442	7968	954	2646	4641	3.77	71.89

Source: DSI. (2003) Transferred Irrigation Association Year 2002 Observation and Evaluation Report
ici irrigated area: area with canal infrastructure; disi irrigated area: area without canal infrastructure. Total irrigated area does not include the area irrigatec by groundwater. Fee collection rate is the fee collected 2002 fee out of expected fee in 2002.

Table 6. Efficiency scores of 18 WUAs in Lower Seyhan Irrigation Project

No.	DMU	ME Score	EE Score	W Score	Composite Index
1	Toroslar (R)	1	0.973	1	0.991
2	Yesilova (R)	0.930	0.786	0.930	0.879
3	Altinova (R)	1	1	1	1
4	Cukurova (R)	1	1	1	1
5	Yukari Seyhan (R)	1	1	1	1
6	Seyhan (R)	0.877	0.869	0.877	0.875
7	Onkoy (R)	0.945	0.753	0.945	0.876
8	Pamukova (R)	1	1	1	1
9	Y. Akarsu (L)	0.980	0.861	1	0.945
10	Cumhuriyet (L)	0.709	0.700	0.719	0.709
11	Kuzey Y. (L)	0.764	0.744	0.768	0.759
12	Cotlu (L)	1	1	1	1
13	Gokova (L)	0.924	0.888	1	0.936
14	Guney Y. (L)	1	0.966	1	0.989
15	Kadikoy (L)	1	1	1	1
16	Yeni Gok (L)	1	1	1	1
17	Gazi (L)	0.977	0.939	1	0.971
18	Ata (L)	1	1	1	1
	Right Bank average	0.968	0.917	0.968	0.951
	Left Bank average	0.929	0.903	0.942	0.925
	18 WUAs average	0.946	0.909	0.954	0.936

Key: ME: management efficiency; EE: engineering efficiency; W: welfare; R: right bank; L: left bank.

Table 7. Projected input levels to reach efficient frontier for Cumhuriyet and Kuzey Y. WUAs

DMU Input/Output	Score Data	Projection	Difference	% change
Cumhuriyet (L)	0.719			
Gross water/WUA (M m3)	25.44	18.28	-7.16	-28.13%
O&M costs (MTL)	29812	21425.72	-8386.28	-28.13%
Staff salary (MTL)	58394	41967.44	-16426.56	-28.13%
Technical staff	5	2.36	-2.64	-52.74%
Delayed payments (MTL)	73766	39762.81	-34003.19	-46.10%
Gross revenue from production (BTL)	6941.30	6941.30	0	0.00%
WUA fee revenue (MTL)	95616	95616	0	0.00%
Total irrigated area (ha)	1651	1675.26	24.26	1.47%
Kuzey Y. (L)	0.768			
Gross water/WUA (M m3)	55.959	42.98	-12.98	-23.19%
O&M costs (MTL)	60883	36090.13	-24792.87	-40.72%
Staff salary (MTL)	47703	36639.74	-11063.26	-23.19%
Technical staff	6	2.03	-3.97	-66.19%
Delayed payments	94849	56216.06	-38632.94	-40.73%
Gross revenue from production (BTL)	10479.05	10479.05	0	0.00%
WUA fee revenue (MTL)	115475	123933.31	8458.31	7.32%
Total irrigated area (ha)	3606	3606	0	0.00%

Key: M m3: milliion cubic meters; MTL: million Turkish Lira; BTL: billion Turkish Lira

Table 8. Efficiency scores of merged WUAs

No.	DMU	W Score	Rank
1	Toroslar (R-1)	1	1
2	Yesilova (R-2)	0.930	19
3	Altinova (R-2)	1	1
4	Cukurova (R-2)	1	1
5	Yukari Seyhan (R-2)	1	1
6	Seyhan (R-2)	0.877	21
7	Onkoy (R-3)	0.945	17
8	Pamukova (R-3)	1	1
9	Y. Akarsu (L-1)	1	1
10	Cumhuriyet (L-1)	0.719	24
11	Kuzey Y. (L-1)	0.768	23
12	Cotlu (L-2)	1	1
13	Gokova (L-2)	1	1
14	Guney Y. (L-2)	1	1
15	Kadikoy (L-3)	1	1
16	Yeni Gok (L-3)	1	1
17	Gazi (L-3)	1	1
18	Ata (L-3)	1	1
19	R-1	1	1
20	R-2	0.916	20
21	R-3	0.939	18
22	L-1	0.867	22
23	L-2	1	16
24	L-3	1	1

Key: W: welfare; R: right bank; L: left bank.

Table 9. Projected input levels to reach efficient frontier for L-1 WUA

DMU Input/Output	Score Data	Projection	Difference	% change
L-1	0.867			
Gross water/WUA (M m3)	161.44	140.00	-21.44	-13.28%
O&M costs (MTL)	159873	128172.85	-31700.15	-19.83%
Staff salary (MTL)	254381	220601.85	-33779.15	-13.28%
Technical staff	21	13.89	-7.11	-33.85%
Delayed payments (MTL)	297654	231434.39	-66219.61	-22.25%
Gross revenue from production (BTL)	52205.07	52205.07	0	0.00%
WUA fee revenue (MTL)	496104	496104	0	0.00%
Total irrigated area (ha)	12780	12780	0	0.00%

Key: M m3: milliion cubic meters; MTL: million Turkish Lira; BTL: billion Turkish Lira