The Efficiency of WUA Management in the Lower Seyhan Irrigation Project

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1. Introduction*

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.

2. The overview of WUAs in Lower Seyhan Irrigation Project

Lower Seyhan Irrigation Project (hereafter LSIP) in Adana was initiated by the Turkish government as one of the important irrigation project 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 have four stages. So far, only up to stage III has completed and the area for stage IV at the down stream has left without concrete canal infrastructure. The completion of the stage IV is facing a problem of high water table, salinity and insufficient drainage (Mert, 2003).

In LSIP area, 18 WUAs were established during 1994-1996. 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. WUAs manage 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 problems. 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 left bank into three, six WUAs in total, for our further analysis. Before the transfer in 1994, right bank and left bank of 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. Newly merged WUAs were named tentatively R-1, R-2, R-3 for the right bank and L-1, L-2, L-3 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

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to consider efficiency analysis for both current and newly merged WUAs.

3. Method and data

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.

For performing efficiency analysis of WUAs, we consider three models for different focus[1]. 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.

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 in Lower Seyhan region (DSI, 2003a). 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. The efficiency score shows the efficiency level of each WUA relative to the

[1] 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 indicators.

Table 1. 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.

efficient frontier.

Table 1 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 have 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

Table 2. 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

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 2 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 3 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 4 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.

Table 3. 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 4. 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

5. Conclusion

This paper tries to address the relative efficiency of WUA management by suggesting alternative composite efficiency index. 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 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 WUAs 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 limited data, 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. In face of future climate change and water scarcity in the region, the role WUAs for efficient management of water resources seems important.

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