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Temporal Assessment of Irrigation Schemes in Çukurova Region of Turkey

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Abstract: Time-series analyses of the comparative performance indicators in irrigation schemes allow us to analyze changes in the schemes due to agricultural and hydrologic interventions. In this study, six comparative performance indicators developed by the International Water Management Institute (IWMI) were applied to 10 irrigation schemes in Çukurova region of Turkey for the period of 1995-2001. Although no significant difference was determined among the means of the schemes for the output per unit land and water, the difference was very significant for irrigation intensity and relative water supply for the same period based on the ANOVA test results. The variation in output per unit land and water was attributed to the cropping pattern and intensity. Although more water than the requirement was applied to the schemes, relatively low output per unit land and water was obtained. This suggest that the schemes are not properly managed possibly due to inappropriate crop pattern and intensity, irrigation infrastructure, reliability of the data, education level of the managers and farmers and structure of the administration.

Key words: Irrigation scheme, comparative indicators, time-series

INTRODUCTION

Scarcity and misuse of water are serious and growing threat to sustainable agricultural production and ultimately to the life. Increasing the yields and sustaining the food production depend mainly on irrigation because water is a limited resource in the most of the world. Therefore, development and protection of irrigation facilities are crucial for a sustainable irrigated agriculture. The performance of many irrigation systems is significantly below their potential due to a number of shortcomings including poor design, construction, operation and maintenance. Anticipated development in irrigation planning, operation and maintenance has not been achieved in Turkey as in the developed countries.

Comparative performance indicators are helpful to see how well irrigated agriculture is performing at the system, basin, or national level. Comparative performance indicators help policy makers and planners to evaluate productive use of land and water resources, irrigation managers to set reasonable objectives and measure progress and researchers to compare irrigation systems (Molden *et al*., 1998).

The accomplishment of irrigation schemes depends on several factors such as infrastructure design, management types, climatic conditions, price, availability of inputs and socioeconomic conditions (Sakthivadivel *et al*., 1999). An appropriate indicator group needs to be set up in order to compare the performance of the irrigation schemes. Using the comparative performance indicators developed by the International Water Management Institute (IWMI), the performances of irrigation schemes of 13 WUAs-operated (Çakmak, 1997) and 213 public-operated in 21 different regions in the city of Konya (Beyribey, 1997), Bursa-Uluabat (Değirmenci, 2001a), 158 WUAs-operated (Değirmenci, 2001b), 7 WUAs-operated in Konya (Çakmak, 2001), Sakarya Basin (Çakmak and Beyribey, 2003) were evaluated in Turkey. Molden *et al.* (1998) assessed the performance of 18 irrigation schemes in 11 different countries using 9 external comparative indicators developed by the IWMI. Sakthivadivel *et al.* (1999) demonstrated four typical applications of these indicators; cross-system comparison, temporal variations in performance at one system, spatial variations within one system and comparing performance by system type to 40 irrigation schemes from 13 countries.

A number of researchers have evaluated the performance of particular irrigation systems with various indicators (Boss and Nugteren, 1974; Levine, 1982; Abernethy, 1986; Seckler *et al*., 1988; Molden and Gates, 1990; Sakthivadivel *et al*., 1993; Boss *et al*., 1994), However, very few of these studies were related to the time-series analysis of the schemes in order to determine changes due to agricultural or hydrologic interventions.

Therefore, the objective of this study is to make cross-system comparison and temporal analysis of 10 irrigation schemes in using the IWMI's Çukurova region

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six performance indicators for the years 1995-2001. To achieve the objectives, we compiled a large data set that compromise of water supply, crop types, crop water requirement and irrigated and command areas from the Evaluation Reports of the irrigation schemes operated by SHW and transferred, whereas the data of crop pattern and unit yield and price was obtained from Product Count Result report of the irrigation schemes operated by SHW and transferred the (Anonymous, 1995-2001a; 1995-2001b). SHW and transferred refer to the state hydraulic works and schemes transferred to the Water User Association (WUAS). This data set was then used to calculate six irrigation performance indicators: Output per unit command, output per cropped area, output per unit water supply, output per unit water consumed, irrigation intensity and relative water supply.

MATERIALS AND METHODS

The SHW department divided the entire area of Turkey into 25 main regions. The irrigation schemes evaluated in this study is located in the sixth region which is named as Çukurova and presented on the map of Turkey (Fig. 1). The 4 of the 26 basins of Turkey are in this region and these are: Seyhan, Ceyhan, Asi and Doğu Akdeniz Basins. The Çukurova region is in the south of Turkey and next to the Mediterranean. Therefore, the region has the Mediterranean climate where summer is warm and dry, whereas winter is cold and rainy. The minimum, maximum and mean annual rain is 415, 1164 and 785 mm, respectively. The surface, groundwater and total water potential is 25300, 1104 and 26404 hm^3/yil. The annual mean temperature is 19°C.

Performance indicators: Six external indicators developed by the IWMI were used for the comparative performance analysis of the SHW and WUAs-operated irrigation schemes (Eqs. 1-6). The first four indicators relate the output (crop production) to unit land and water. These indicators allow to comparing the performance of fundamentally different systems by standardizing the gross value of agricultural production. The relative water supply was presented by Levine (1982) and expressed as the ratio of the total water supply to the total crop-water demand. These indicators can be calculated as (Molden *et al*., 1998):

$$\text{Output per cropped area}\left(\frac{\$}{\text{ha}}\right) = \frac{\text{SGVP}}{\text{Irrigated cropped area}} \quad (1)$$

$$\text{Output per unit command}\left(\frac{\$}{\text{ha}}\right) = \frac{\text{SGVP}}{\text{Command area}} \quad (2)$$

$$\text{Output per unit irrigation supply}\left(\frac{\$}{\text{m}^3}\right) = \frac{\text{SGVP}}{\text{Diverted irrigation supply}} \quad (3)$$

$$\text{Output per unit water consumed}\left(\frac{\$}{\text{m}^3}\right) = \frac{\text{SGVP}}{\text{Volume of water consumed by ET}} \quad (4)$$

$$\text{Relative water supply} = \frac{\text{Total water supply}}{\text{Crop-water demand (ET)}} \quad (5)$$

$$\text{Irrigation intesity} = \frac{\text{Irrigated cropped area}}{\text{Command area}} \quad (6)$$

where, SGVP is the Standardized Gross Value of Production which is the output of the irrigated area in terms of gross or net value of production measured at local or world prices, irrigated cropped area is the sum of the areas under crops during the time period of analysis, command area is the nominal or design area to be irrigated, diverted irrigation supply is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater, volume of water

Fig. 1: Çukurova region on the Map of Turkey

consumed by ET is the actual evapotranspiration of crops and total water supply is the surface diversions plus net groundwater draft plus rainfall.

The SGVP was developed for cross-system comparisons regardless where they are or what kind of crops is grown. It can be calculated as (Molden *et al.*, 1998):

$$SGVP = \left(\sum_{crops} A_i Y_i \frac{P_i}{P_b}\right) P_{world} \qquad (7)$$

Where A_i is the area cropped with crop i (ha), Y_i is the yield of crop i (kg/da), P_i is the local price of crop i ($/kg), P_b is the local price of the base crop (the predominant locally grown, internationally-traded crop) ($/kg) and P_{world} is the value of the base crop traded at world prices ($/kg). Wheat was considered as the base crop because it was predominant, locally grown and internationally traded.

The data on water supply, crop types, crop water requirement and irrigated and command areas for the SHW and WUAs-operated irrigation schemes was obtained from the evaluation report of the irrigation schemes operated by SHW and transferred, whereas the data of crop pattern and unit yield and price was obtained from the Product Count Result Reports of the irrigation schemes operated by SHW and transferred (Anonymous, 1995-2001a; Anonymous, 1995-2001b).

Analysis of the data: Descriptive statistical parameters such as minimum, maximum, mean, plus and minus standard deviations were calculated for each of six indicators of the irrigation schemes. In addition, the analysis of variance (ANOVA) test was made using SPSS software (Norusis, 1990) to determine if statistically significant difference existed among the schemes for each and all of six indicators.

RESULTS AND DISCUSSION

SGVP per unit command: The descriptive statistics and ANOVA test results for each indicator of each scheme is displayed in Table 2. The highest (US$4106), lowest ($232) and mean ($1194) values of the SGVP per unit command are observed at Seyhan in 1996 and Haruniye in 1999 irrigation schemes, respectively (Fig. 2). All of the schemes are operated by the WUAs in semi-humid region and 7 of them are irrigated by the system of pumping or diversion and pumping. Therefore, the high variability of the SGVP per unit command might be because of cropping pattern and intensity rather than climatic conditions or system and management types. The high SGVP per unit command in Seyhan scheme is due to the orchards and industrial crops but orchards in Berdan and Mersin Bahçeleri schemes. Molden *et al.* (1998) also investigated that the systems including orchards, industrial crops and some cereals had the high values of the SGVP per unit command. However, ANOVA test results indicate that there is statistically no significant difference among the means of the schemes ($F_{(9,58)} = 0.948$, $P = 0.49$) for the years 1995-2001. Several researchers in parallel studies determined the SGVP per unit command as 6233 US $ ha^{-1} in Bergama-Kestel scheme, 2167 $ ha^{-1} in Lower Seyhan scheme, 105-1800 $ ha^{-1} in Alto-Rio Lerma scheme of Mexico and 195-5391 $ ha^{-1} in Konya irrigation schemes, respectively (Avci *et al.*, 1998, Molden *et al.*, 1998, Kloezen and Garces-Restrepo, 1998 and Çakmak, 2001).

SGVP per unit cropped land: The highest (US$6615), lowest ($429) and mean ($1522) values of the SGVP per unit cropped land are observed at Berdan in 2001 and Haruniye in 1998 irrigation schemes, respectively (Fig. 3). Statistical analysis results are given in Table 1. The high SGVP per unit cropped land might be because of cropping pattern and intensity where orchards and industrial crops in Seyhan scheme but orchards in Berdan and Mersin Bahçeleri schemes are dominantly grown. Molden *et al.* (1998) also stated similar results. However, ANOVA test results indicate that there is statistically no significant difference among the means of the schemes ($F_{(9,58)}=0.916$, $P=0.518$) for the years 1995-2001. In similar studies, the SGVP per unit cropped land was found as 676-5430 US $ ha^{-1} for 1999 and 354-8659 $ ha^{-1} for 2000 in the Sakarya Basin irrigation schemes by Çakmak and Beyribey (2003), 2857-4415 $ha^{-1} at the Uluabat irrigation scheme between 1992-1998 by Değirmenci (2001b) and 2900-4000 $ ha^{-1} in 18 irrigation schemes for the year 1998 by Molden *et al.* (1998).

SGVP per unit irrigation supply: The minimum (US$0.05), maximum ($0.58) and mean ($0.14) values of the SGVP per unit irrigation supply are observed at Haruniye in 1999 and Berdan in 2001 irrigation schemes, respectively (Fig. 4). The high SGVP per unit irrigation supply might be because of cropping pattern and intensity where mostly orchards and industrial crops such as cotton, corn and peanuts are grown in Yarseli, Seyhan and Kesiksuyu schemes but orchards in Berdan and Mersin Bahçeleri schemes. However, statistically no significant difference was determined among the means of the schemes based on the ANOVA test results ($F_{(9,58)}=1.050$, $P=0.413$) for the years 1995-2001 (Table 2). The SGVP per unit irrigation supply was calculated as 0.31-0.50 $ m^{-3} in Bursa-Uluabat scheme by Değirmenci (2001b) for the period of 1992-1998; 0.23-0.81 and 0.26-0.77 $ m^{-3} in Karacabey and Mustafakemalpaşa schemes by Değirmenci and Kuşcu (2002) for the year 1996-2000 and 0.63 and 0.04 $ m^{-3} at Samaka in Colombia and Mahi-Kadana in India by Molden *et al.* (1998), respectively.

Table 1: Prominent features of studied irrigation schemes

System name	Type of system	Command area (ha)	Cropping pattern	Climate	Type of management	Water availability
Seyhan	Diversion & pumping	121690	Corn, cotton, fruit,	Semi-humid	WUAs[a]	Water sufficient
Ceyhan	Diversion	85000	Corn, legumes, cotton	Semi-humid	WUAs	Water sufficient
Haruniye	Diversion & pumping	7980	Peanut, corn, cotton	Semi-humid	WUAs	Water sufficient
Kesiksuyu	Diversion	7500	Corn, peanut, fruit	Semi-humid	WUAs	Water sufficient
Kirikhan	Diversion	7300	Cotton, wheat, corn	Semi-humid	WUAs	Water sufficient
Yarseli	Diversion & pumping	7000	Cotton, corn, vegetable	Semi-humid	WUAs	Water sufficient
Kozan	Diversion & pumping	9000	Corn, fruit	Semi-humid	WUAs	Water sufficient
Berdan	Diversion & pumping	14000	Corn, fruit	Semi-humid	WUAs	Water sufficient
Mersin Bah.	Pumping	9000	Fruit, vegetable	Semi-humid	WUAs	Water sufficient
Silifke	Diversion & pumping	5800	Fruit, corn	Semi-humid	WUAs	Water abundant

[a]Schemes operated by the Water User Associations (WUAs)

Table 2: Descriptive statistics and ANOVA test results

	Output/cropped area				Output/unit command				Output/water supplied			
System name	Min.	Max.	Mean	SD±	Min.	Max.	Mean	SD±	Min.	Max.	Mean	SD±
Seyhan	0	4519	1739	374-3103	0	4106	1575	330-2819	0.00	0.40	0.15	0.03-0.27
Ceyhan	637	1412	967	652-1283	565	1302	885	594-1176	0.07	0.11	0.08	0.07-0.10
Haruniye	429	1264	828	549-1107	232	820	450	185-715	0.05	0.24	0.12	0.05-0.19
Kesiksuyu	816	2327	1286	760-1812	519	1968	1105	626-1584	0.10	0.36	0.18	0.09-0.27
Kirikhan	873	2118	1369	933-1805	627	1685	1173	813-1533	0.08	0.16	0.11	0.08-0.14
Yarseli	0	3697	1704	482-2925	0	2641	1128	274-1981	0.00	0.43	0.20	0.07-0.33
Kozan	924	2616	1439	884-1993	524	2413	1154	520-1788	0.07	0.23	0.13	0.07-0.19
Berdan	0	6615	2323	77-4569	0	3970	1511	165-2858	0.00	0.58	0.18	-0.02-0.38
Mersin Bah.	0	4451	1966	60-3873	0	3703	1643	42-3244	0.00	0.40	0.16	0.00-0.32
Silifke	0	2819	1599	445-2752	0	2225	1316	354-2279	0.00	0.14	0.07	0.02-0.13
	$F_{(9,58)}$=0.916, P=0.518				$F_{(9,58)}$=0.948, P=0.492				$F_{(9,58)}$=1.050, P=0.413			

	Output/water consumed				Irrigation intensity				Relative water supply			
System name	Min.	Max.	Mean	SD±	Min.	Max.	Mean	SD±	Min.	Max.	Mean	SD±
Seyhan	0.00	0.40	0.26	0.13-0.39	86	97	90	86-93	1.00	2.43	1.99	1.48-2.49
Ceyhan	0.13	0.30	0.20	0.13-0.27	94	94	91	89-94	1.73	2.81	2.30	1.87-2.72
Haruniye	0.09	0.26	0.17	0.11-0.23	31	83	54	31-78	1.02	2.81	1.61	0.91-2.31
Kesiksuyu	0.19	0.59	0.31	0.17-0.45	59	93	85	73-97	1.51	2.12	1.81	1.61-2.01
Kirikhan	0.13	0.40	0.26	0.17-0.36	54	104	87	70-104	1.00	3.11	2.35	1.69-3.02
Yarseli	0.00	0.79	0.35	0.10-0.60	59	71	66	61-71	1.32	2.03	1.72	1.50-1.95
Kozan	0.17	0.50	0.27	0.16-0.38	55	95	77	58-96	1.57	2.80	2.16	1.70-2.61
Berdan	0.00	1.25	0.44	0.01-0.86	59	78	69	60-77	2.18	5.07	3.06	2.04-4.09
Mersin Bah.	0.00	0.73	0.32	0.01-0.63	66	98	84	74-95	1.82	5.50	2.73	1.45-4.02
Silifke	0.00	0.69	0.38	0.08-0.68	71	115	90	74-107	1.97	7.30	4.48	2.72-6.23
	$F_{(9,58)}$=0.881, P=0.547				$F_{(9,58)}$=5.687, P=0.000				$F_{(9,58)}$=6.685, P=0.000			

Anova test results for the six parameters of the irrigation schemes is $F_{(9,398)}$=0.833, P=0.586

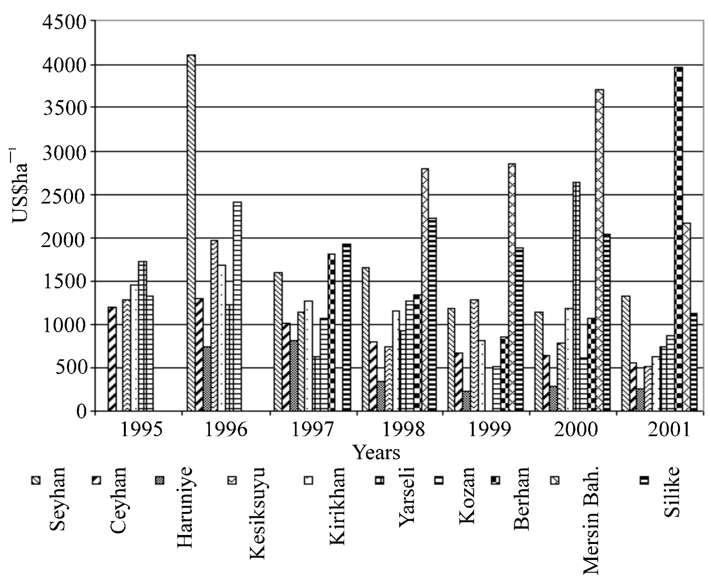

Fig. 2: Standardized gross value of production per unit command area

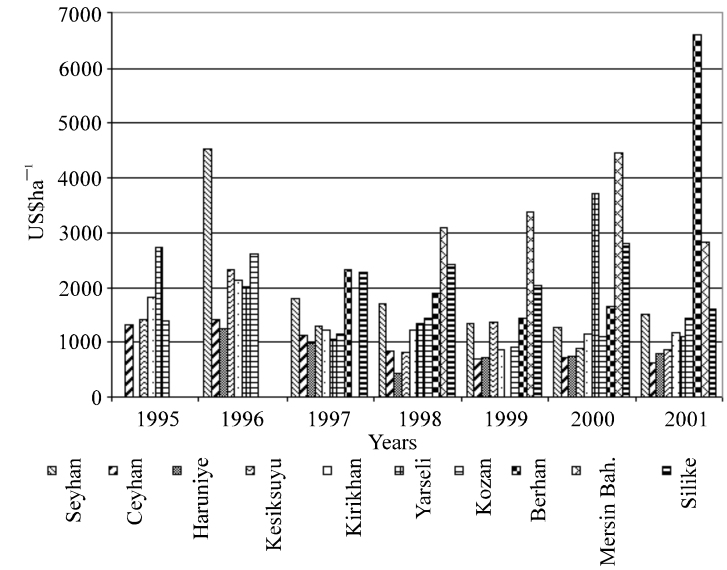

Fig. 3: Standardized gross value of production per unit cropped area

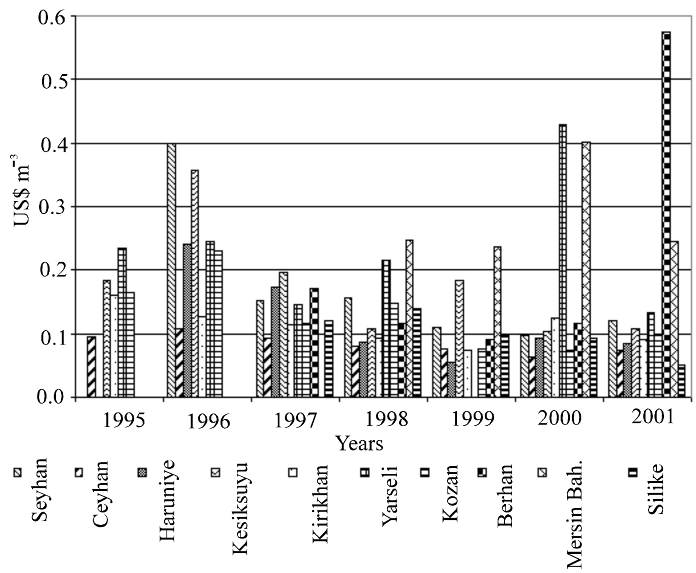

Fig. 4: Standardized gross value of production per unit irrigation supplied

SGVP per unit water consumed: The minimum (US$0.09), maximum ($1.25) and mean ($0.30) values of the SGVP per unit water consumed are observed at Haruniye in 1998 and Berdan in 2001 irrigation schemes, respectively (Fig. 5). The high SGVP per unit water consumed might be because of diverted water supply and cropping pattern and intensity where mostly orchards and industrial crops such as cotton are grown in Yarseli but orchards in Berdan, Mersin Bahçeleri and Silifke schemes. However, statistically no significant difference was determined among the means of the schemes based on the ANOVA test results ($F_{(9,58)}$=0.881, P=0.547) for the years 1995-2001 (Table 2). The output per unit water consumed was found as 0.15-1.55 \$m^{-3} at Kizilirmak Basin irrigation schemes for the year 1999-2000, as 0.18-0.41 \$m^{-3} by Girgin *et al.* (1999) at Salihli scheme. Kloezen and Garces-Restrepo (1998) have calculated output per unit water consumed as 0.38, 0.41 and 0.41 \$m^{-3} for Alto-Rio Lerma, Cortazar and Salvatierra schemes in Mexico, respectively.

Irrigation intensity: The range and mean of the irrigation intensity are 31-115 and 79%, respectively (Fig. 6). The important reasons of low irrigation intensity might be factors such as the lack of infrastructure and national agricultural policy, increase in input prices, landownership situation, poor farmer training, irrigation water fees and insufficient water resources. However, in general,

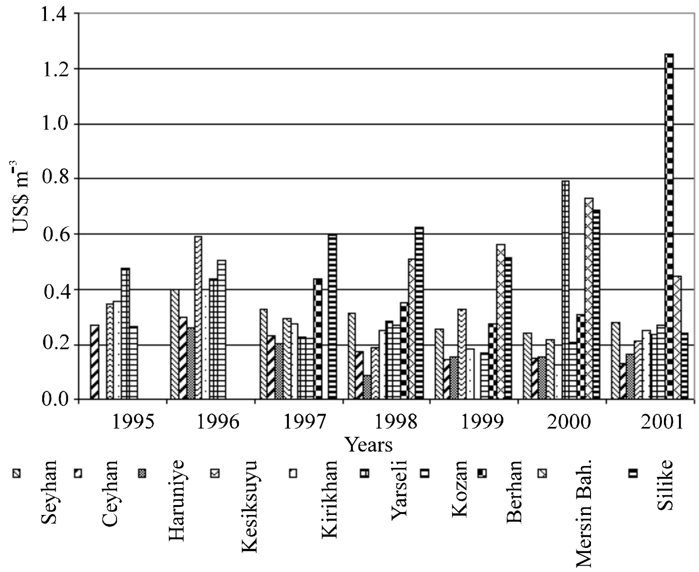

Fig. 5: Standardized gross value of production per unit water consumed

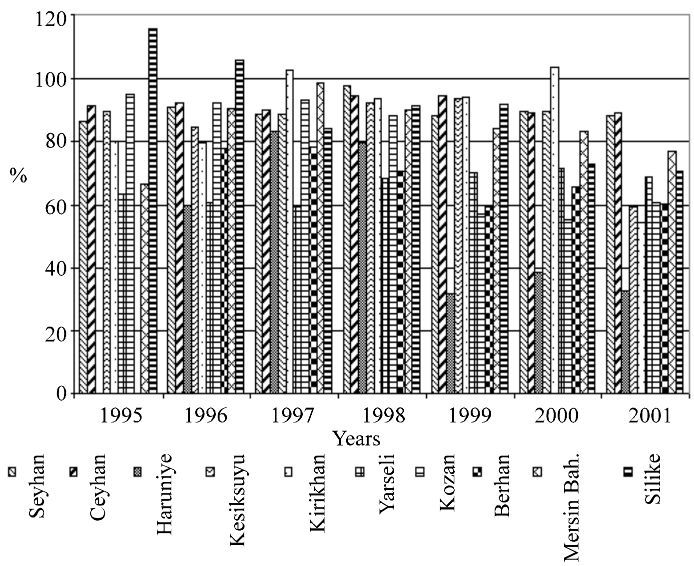

Fig. 6: Irrigation intensity

irrigation intensity is relatively high possibly due to the operation of the schemes by the WUAs. Significant difference was determined among the means of the schemes based on the ANOVA test results ($F_{(9,58)}$=5.687, P=0.000) for the years 1995-2001 (Table 2). The irrigation intensity was 32-117, 4-100, 44-100, 24-105, 57-81, 15-94, 36-104 and 25-96% in the studies of Erozel and Alibiglouei (1991), Değirmenci (2001b), Beyribey *et al.* (1997a), Beyribey *et al.* (1997b), Yazgan and Değirmenci (2002), Çakmak and Beyribey (2003) and Çakmak (2001) and Değirmenci and Yazgan (2002), respectively.

Relative water supply: The range and mean of the relative water supply are 1.00-7.30 and 2.42, respectively (Fig. 7). The relative water supply indicates how well irrigation supply and demand are matched; a value over one would suggest too much water is being supplied, possibly causing water-logging and negatively impacting yields; a value less than one indicates that crops are not getting enough water. The optimum value of the relative water supply is one.

All schemes except Seyhan in 1996 and Kirikhan in 2000 get water over the requirement. This indicates that irrigation water is not used uniformly and effectively. Levine (1982) stated that water supplied more than 2.5 times of the net requirement was an indication of inappropriate water management. Since planned water delivery is not available in the irrigation schemes, the

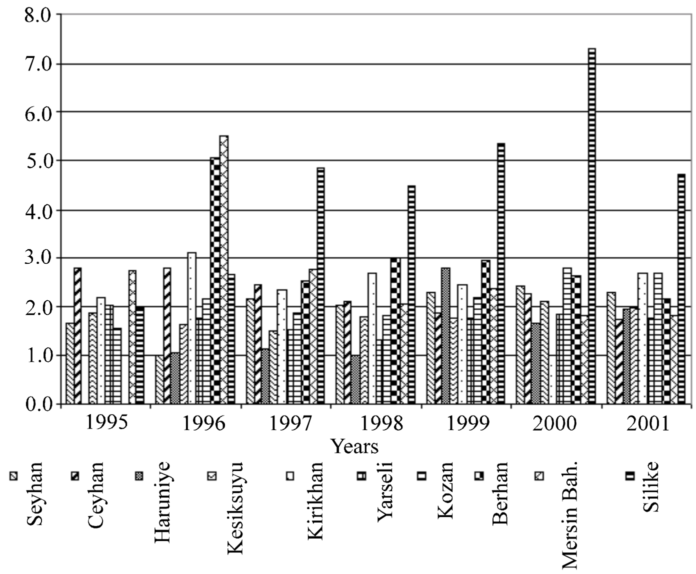

Fig. 7: Relative water supply

large amount of water in the canal is wasted; as a result, this increases the relative water supply. Significant difference was determined among the means of the schemes based on the ANOVA test results ($F_{(9,58)}$=6.685, P=0.000) for the years 1995-2001 (Table 2). The relative water supply was determined as 1.20-1.48, 0.91-7.15, 0.60-1.79, 0.58-2.41, 0.80-4.10, 0.60-1.09, 1.30-8.40, 1.40-1.80, 0.30-7.83 and 1.88 in the studies of Değirmenci (2001a) and (2001b), Beyribey *et al.* (1997a) and (1997b), Molden *et al.* (1998), Yazgan and Değiemenci (2002), Çakmak and Beyribey (2003), Vermillion and Garces-Restrepo (1996), Çakmak (2001) and Bandara (2003), respectively.

Six comparative performance indicators developed by the IWMI were applied to 10 irrigation schemes in Çukurova region of Turkey for the period of 1995-2001. Although more water than the requirement is used for all schemes, water is not used efficiently because output or production per unit land and water is relatively low. This might be due to the lack of infrastructure and the lack of the knowledge and experience of the farmers for an appropriate irrigation practice.

The systems that mostly grow orchards, industrial crops and some cereals have higher output per land and water than the cereal-producing systems. The application of inappropriate crop pattern and intensity to the project areas might be another common management problem for low output per unit land and water.

In addition, the irrigation schemes should be grouped based on their regions, climatic conditions, crop patterns and growth-time, irrigation systems and methods, marketing situation and management types and then similar schemes should be compared or evaluated among themselves to develop a topology that allows comparison of irrigation schemes with similar settings.

REFERENCES

Abernethy, C.L., 1986. Performance measurement in canal water management. ODI-IIMI Irrigation Management Network Paper 86/2d.

Anonymous, 1995-2001a. Evaluation Report of the Irrigation Schemes Operated by the SHW and Transferred for the years 1995-2001. General Directorate of State Hydraulic Works, Operation and Maintenance Unit, Ankara, Turkey (in Turkish).

Anonymous, 1995-2001b. Product Count Result Reports of the Irrigation schemes operated by the SHW for the years 1995-2001. General Directorate of State Hydraulic Works, Operation and Maintenance Unit, Ankara, Turkey (in Turkish).

Avci, M., E. Akkuzu, H.B. Ünal and Ş. Aşik, 1998. Performance evaluation of the Bergama-Kestel Dam irrigation scheme. Aegean Region 1. Agricultural Convention, 2: 62-70.

Bandara, K.M.P.S., 2003. Monitoring irrigation performance in Sri Lanka with high-frequency satellite measurements during the dry season. Agric. Wat. Manag., 58: 159-170.

Beyribey, M., 1997. Performance evaluation of the Government-operated schemes. A.Ü., Faculty of Agriculture, Publication No: 1480, Scientific Research and Studies, Ankara, pp: 813, 88 (in Turkish).

Beyribey, M., F.K. Sönmez, B. Çakmak and M. Oğuz. 1997a. Determination of monthly relative water supply in the Government-operated schemes. J. of Agricultural Sciences, Ankara, Turkey, 3: 33-37 (in Turkish).

Beyribey, M., F.K. Sönmez, B. Çakmak and M. Oğuz. 1997b. Assesment of system performances in irrigation schemes. 6. Kulturtechnique Convention, Kirazliyayla, Bursa, Turkey, pp: 162-171. (in Turkish).

Bos, M.G. and J. Nugteren, 1974. On irrigation efficiencies. International Institute for Land Reclamation and Improvement (ILRI) Publication 19, Wageningen. Revised 1990.

Bos, M.G., D.H. Murrray-Rust, D.J. Merrey, H.G. Johnson and W.S. Snellen, 1994. Methodologies for assessing performance of irrigation and drainage management. Irrig. and Drainage Systems, 7: 231-261.

Çakmak, B., 1997. Assessment of transferred irrigation schemes: A case study in Konya. A.Ü., Faculty of Agriculture, J. Agric. Sci., 3: 79-86 (in Turkish).

Çakmak, B., 2001. Performance evaluation of the transferred irrigation schemes in Konya. J. Agril. Sci., 7: 111-117 (in Turkish).

Çakmak, B. and M. Beyribey, 2003. Performance evaluation of the systems in the Sakarya Basin. J. Agric. Sci., 9: 116-124 (in Turkish).

Değirmenci, H., 2001a. Assessment of Bursa-Uluabat irrigation scheme. Atatürk Üniv., J. Agric. Faculty, 32: 277-283 (in Turkish).

Değirmenci, H., 2001b. Assessment of the transferred irrigation schemes with the comparative performance indicators. U. Ü., J. Agric. Faculty, 15: 31-41 (in Turkish).

Değirmenci, H. and H. Kuşcu, 2002. Assessment of the Karacabey and Mustafakemalpaşa irrigation schemes with comparative performance indicators. Symposium on conservation, development and administration of soil and water resources in watersheds, Hatay, Turkey, pp: 18-20 (in Turkish).

Değirmenci, H. and S. Yazgan, 2002. Assessment of irrigation performance with comparative performance indicators in Turkey. 2002 ASAE/CIGR Annual International Meeting, Chicago, Illinois, USA., pp: 18-31.

Erözel, Z. and H. Alibiglouei, 1991. Irrigation intensities in the Goverment-operated schemes. A.Ü., Faculty of Agriculture: 1219, Scientific Research and Studies: 668, Ankara, Turkey (in Turkish).

Girgin, A., G. Geçgel and S. Gül, 1999. Introduction of the IWMI indicators set, which is used for the comparison of the irrigated agricultural systems and the application of them to the Salihli (Adala) irrigation scheme. Water Convention Proceedings. TMMOB İzmir State Coordination Committee, İzmir, Turkey, pp: 351-365, (in Turkish).

Kloezen, W.H. and C. Garces-Restrepo, 1998. Assessing irrigation performance with comparative indicators: The case of Alto Rio Lerma District, Mexico. Int. Wat. Manag. Inst., Research Report 20, Colombo, Sri Lanka.

Levine, G., 1982. Relative water supply: An explanatory variable for irrigation system. Technical Report No:6, Cornell University, Ithaca, New York, USA.

Molden, D.J. and T.K. Gates, 1990. Performance measures for evaluation of irrigation water delivery systems. J. of Irrig. and Drainage Eng., 116: 804-823.

Molden, D.J., R. Sakthivadivel, C.J. Perry and C. Fraiture, 1998. Indicators for comparing performance irrigation agricultural system. Research Report 20. Colombo, Sri Lanka: IWMI.

Norusis, M.J., 1990. SPSS statistical data analysis. Base system user's guide.

Sakthivadivel, R., D. J. Merrey and N. Fernando. 1993. Cumulative relative water supply: A methodology for assessing irrigation system performance. Irrig. and Drainage Systems, 7: 43-67.

Sakthivadivel, R., C. De. Fraiture, D.J. Molden, C. Perry and W. Kloezen, 1999. Indicators of land and water productivity in irrigated agriculture. Int. J. of Wat. Res. Dev., 15: 161-179.

Seckler, D., R.K. Sampath and S.K. Raheja, 1988. An index for measuring the performance of irrigation management systems with an application. Water Resources Bulletin, 24: 855-860.

Vermillion, D.L. and C. Garces-Restrepo, 1996. Results of management turnover in two irrigation districts in Colombia. International Water Management Institute, Research Report 4, Colombo, Sri Lanka.

Yazgan, S. and H. Değirmenci, 2002. Effectiveness indicators used for the evaluation of irrigation schemes: A case study in the Bursa Groundwater Irrigation. Turkish J. Agric. Forestry, 26: 93-99.