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MEASUREMENT AND EVALUATION OF PERFORMANCE OF MANAGEMENT-OPERATION AND MAINTENANCE OF IRRIGATION SCHEMES IN BEFORE-AND-AFTER TURNOVER: A CASE STUDY AT GREAT MENDERES BASIN, TURKEY

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SUMMARY - Management, Operation and Maintenance (MOM) performance is the degree of fulfilment of either a specific quantified output target typified by such thing as yields, water use efficiency and cropping intensification or a specific input target such as discharge, water level or timing of irrigation deliveries. Considering about 1.7 million hectare irrigation areas turned over to Water User Associations in Turkey, shows clearly the importance of the irrigation schemes performance. The purpose of this research was to measure and evaluate the performance of the MOM of Nazilli, Akçay and Aydın irrigation schemes using the WAM (Weighted Average Mark) method in the Great Menders basin in Turkey in before and after turnover. The measurement and the evaluation of the MOM's performance is done by scoring according to an index system consisting of twenty techno-economic performance indicators. The higher WAM value indicates the best performance. Average WAM values in before and after turnover were (71.14, 78.02), (78.93; 82.23) and (82.60, 83.24) for Akçay, Aydın and Nazilli irrigation schemes respectively. Performance of irrigation schemes in basin in periods after turnover was found 'good'. WAM values calculated to index the system of MOM in before and after turnover in the basin schemes didn't vary widely. But after the turnover, the WAM value related to MOM's economical and institutional indicators increased in somewhat than before.

Key words: irrigation, management, operation, performance, indicator, turnover.

INTRODUCTION

A number of specialists thought that taking irrigation and drainage system management out of the direct governmental sphere would inevitably lead to improvements in the sustainability of irrigation and drainage systems and in agricultural production. The philosophy was that users were more likely to operate systems effectively and according to their requirements and also pay for the operation if they were also the owners. The dominant perception was that public irrigation management organizations lacked the incentives and responsiveness to enhance performance whereas water users had a direct interest in cost efficiency, profitability and proper physical condition of the irrigation facilities.

Review of prevailing constraints and existing status of land and water resources gives an idea about availability and utilization pattern of these resources, difference between actual and potential output, and scope for improvements in the performance of system, which is represented by its measured levels of achievement in terms of one or several parameters that are chosen as indicators of system's goals. The basic concept is that irrigation must modernize their operations with the appropriate technical and managerial components. The system managers have to see how the irrigated agriculture is performing within various settings. Several workers have proposed indicators depending on the purpose of the assessment. Major purpose of the assessment is to assist irrigation managers to improve the management, operation, and maintenance (MOM) services to user in irrigation schemes. Some researchers have proposed indicators for performance evaluation of irrigation systems. A brief review of some of the important works related to performance assessment of irrigation systems are mentioned below.

Clemens and Burt (1997) suggest that evaluation of actual irrigation system performance should rely on accurate hydrologic water balance over the area considered. They provided equations, procedures and examples for making these calculations and recommended that confidence interval be included in all reporting of irrigation performance parameters. Molden et al (1988) developed a set for evaluating the performance of the turnover irrigation systems, and compared performance of eighteen irrigation systems located in eleven different countries through various indicators. They presented nine indicators namely output per unit cropped area, output per unit command, output per unit irrigation supply, output per unit water consumed, relative water supply, relative irrigation supply, water delivery capacity, gross return on investment, and financial self-sufficiency. Based on this set, Klozen & Garces-Restrepo (1998) of Alto Rio Lerma WUA in Mexico and Vermillion et al (2000) of small scale irrigation areas, 500 ha in size or below in Indonesia evaluated the performances of irrigation schemes. Koc (2006) evaluated the impact of the water users related to MOM services, carried out by WUAs in Great Menderes basin irrigation schemes in Turkey. Dorsan et al (2004) evaluated some physical, economic and institutional performance criteria of irrigation schemes, operated by WUAs in Lower Gediz basin in Turkey. Akcay et al (2006) assessed some of the economical, institutional and physical performance criteria of irrigation schemes in Menemen, Turkey.

Bastiaanssen and Boss (1999) after reviewing significant works suggested to use remote sensing determinants to evaluate irrigation performance indicators and suggested that it refines the spatial scale as compared to the classically collected flow measurements. Droogers et al (1999) used four performance indicators; yield over transpiration, yield over evapotranspiration, yield over depleted water and they concluded that if irrigation performance indicators are used only at a local scale, a misleading picture can be given on the regional scale. This paves a way for evaluating the management of all water resources in a river basin context. Styles and Marino (2002) utilized and refined a set of evaluation indicators to describe the irrigation projects in less developed countries and found that performance of many projects was poor. The causes behind the poor performance of these projects were due to technical, financial, managerial, social, and institutional causes. They concluded that modernized irrigation delivery service index can be used as a determinant of an economic irrigation project performance indicator.

The purpose of this study is to apply a set of MOM performance indicators that will allow for comparative analysis of MOM performance in irrigation schemes in periods before-and-after turnover.

MATERIALS AND METHODS

A study of three projects in Great Menderes basin, Turkey was done with the purpose of identifying relevant MOM performance indicators and evaluating the performance in periods before and after turnover. The Irrigation schemes researched in the basin are Akcay, Aydın, and Nazilli. These schemes were chosen for study, with total area of 45000 hectares. Irrigation schemes are managed by Water User Associations (WUAs). The main crops grown in the irrigation schemes are cotton, maize, wheat, citrus, and tomato. Two Dams provide surface water for irrigation schemes with a combined storage capacity of 1.496 million cubic meters serving 103951 hectares. The climate is Mediterranean with average yearly precipitation of 558.9 mm and average temperature of 20 °C. The total number of water users was 7070, 2799, and 9358 respectively in Akcay, Aydın, and Nazilli irrigation schemes. The data related to irrigation schemes and WUAs have been obtained, Monitoring and Evaluation Reports of Irrigation Schemes Transferred Water User Association (DSI, 1999, 2000, 2001, 2002, 2003, 2004) and PhD Thesis (Koc, 1998).

In this study, in order to measure and evaluate the performance of management, operation, and maintenance of irrigation schemes in before and after turnover were used Weight Average Marks (WAM) method (Zhi, 1993). This method is to evaluate the MOM's performance by scoring according to an index system consisting of twenty techno-economic performance indicators (*Table 1*). The higher the WAM, the better performance. The basis for calculating WAM is the values of mark and the weight of each index. The method for determining these values will be introduced in the following;

Determination of the mark and weight of each performance indicator

Based on the results of application of the WAM method to evaluate the performance of a Water User Association, the methods for determining the mark and weight of each index are given (*Table 2*).

Method of calculating the weighted average mark of the index system

For a given WUA, the WAM is calculated by:

$$\mathbf{WAM} = \sum_{i=1}^{20} (ID_i * WT_i) + \Delta MK_1 + \Delta MK_2 + \Delta MK_3 + \Delta MK^1$$

Where:

ID_i and WT_i are the values of i-th index and its weight;
ΔMK_1, ΔMK_2, ΔMK_3 are the additional marks. If the management organization sound and the great majority of peasant management personnel have been trained, $\Delta MK_1 = 4$. If the records, tables and charts of management are complete, $\Delta MK_2 = 2$. If the advanced technique has been applied and proved to be effective, $\Delta MK_3 = 4$.

If it doesn't accord with the above respective demands, ΔMK_1, ΔMK_2, and ΔMK_3 are equal to zero. ΔMK^1 is the deduction of marks due to an accident arising from the negligence of management personnel. The values of ΔMK^1 are as follow;

For ordinary accident; $\Delta MK^1 = 2.0$ (A >100 ha), $\Delta MK^1 = 1.5$ (A =100 -1000 ha), $\Delta MK^1 = 1.0$ (A >1000 ha). For serious accident; $\Delta MK^1 = 10.0$ (A >100 ha), $\Delta MK^1 = 7.5$ (A =100 -1000 ha), $\Delta MK^1 = 5.0$ (A >1000 ha).

In this study, the government has fixed the standards of ordinary and serious accidents. In *Table 2,* the sum of the weight of 20 performance indicators is 0.90. Therefore, in general the full mark of WAM of 20 indices is 90 and the full mark of WAM of a WUA is 100. The standard for evaluating the performance in WUA is:

WAM ≥ 90 Excellent
WAM = 80-89.9 Good
WAM = 70-79.9 Fair
WAM = 60-69.9 Bare
WAM < 60 Poor

In irrigation schemes and WUAs researched, MOM performance indicators, marks (MK), values of weight (WT), and values of WAM relevant indicators were calculated by Software program, Microsoft Office Excell 2003.

Table 1. MOM techno-economic performance indicators, formulation, and data specifications

	MOM PERFORMANCE INDICATORS	FORMULATION	DATA SPECIFICATIONS
I	MOM Physical Indicators		
1	Percentage of actual irrigated area, F, (%) :	**$F = A / Ap$**	Where A is the actual irrigated area in ha in the same year; Ap is the planned irrigated area in ha in the same year (Zhi, 1991).
2	Efficiency of irrigation water supply, S, (%)	**$S = (W / Wr) * 100$**	Where W and Wr are the actual and required annual quantity of irrigation water diverted from the water resources in the same year (m^3/year) (Zhi, 1991).
3	Sustainability of irrigated area, Fs, (%)	**$Fs = (Fc / Fi) *100$**	Where Fc is the curret irrigable area in ha ; Fi is the initial irrigable area in ha (Bos et al., 1994).
4	Distribution network density, DND, (%)	**$DND = (TLD / TCD) * 100$**	Where TLD is the total length of distributor canals in irrigation scheme;TCD is the total legth of conveyance and distributor canals in same irrigation scheme (Frazao and Pereira, 1991).
5	Percentage of irrigation facilities in good conditions, QIP, (%)	**$QIP = QFG / TGN$**	Where TGN is the total number of structues for irrigation scheme in a particular category; QFG is the number of structures in good condition (safe, integrated, functioning normally) (Zhi, 1991).
6	Percentage of drainage facilities in good conditions, QDP, (%)	**$QDP = (SCD / TCD) * 100$**	Where TCD is the total number of structues for drainage scheme in a particular category (main, secondary, tertiary drainge canals); SCD is the number of structues in good conditions (Koc, 1998).
7	Actualize rate of irrigation planning, WSE, (%)	**$WSE = (W / Ws) * 100$**	Ws is the quantity that the managers intended to supply according to irrigation planning (m^3/year) (Koc, 1998).
8	Percentage of change of water used unit area, FD, (%)	**$FD = (FNM / FNH) * 100$**	Where FNM is the water used in unit area (ha) (m^3/ha/year); FNH is the amount of water used in unit area in the historical (m^3/ha/historical year) (Koc, 1998).
9	Project irrigation efficiency, Ep, (%)	**$Ep = (Uc / Wa) * 100$**	Where Uc is the crop irrigation water requirement in project area (m^3/year); Wa is the total inflow into canal system (m^3/year) (Bos et al., 1994).
10	Rate of change of groundwater table, R, (%)	**$R = ((Dl - Dt) / D) * 100$**	Where Dl and Dt are annual average depth of groundwater table last year and this year (m); D is the mean annual depth of groundwater table (m) (Zhi, 1991).
II	MOM Economical Indicators		
11	Percentage of the highest yield per unit quantity of irrigation water, Pyw, (%)	**$Y_W = (Y / W)$** **$P_{YW} = (Y_W / Y_{Wh}) * 100$**	Where Yw is the yield per unit quantity of irrigation (ton/m^3); Y is the total annual yield (ton/year). Ywh is the historical highest annual yield per unit quantity of irrigation water (ton/m^3) (Zhi, 1991).
12	Percentage of the highest total yield, Py, (%)	**$Py = (Y / Yh) * 100$**	Where Y is the total annual yield (ton/year) of crops in project area (ha); Yh is the historical highest total annual yield in the whole irrigation district (ton/year) (Zhi, 1991).
13	Efficiency of collection of irrigation water charges, TE, (%)	**$TE = (MTU / MTG) *100$**	Where MTG is the irrigation charges due in the whole irrigation district; MTU is the irrigation charges collected.
14	Total financial viability, TFC, (%)	**$TFC = (GIBO / TIBOG) *100$**	Where TIBOG is the total MOM requirements for irrigation schemes and WUA; GIBO is the actual MOM allocation (Bos et al., 1994).
15	Financial self-sufficiency, Eyy, (%)	**$Eyy = (TG / S) * 100$**	Where TG is the total MOM revenue actualized in year researched; S is total MOM cost in the year (Koc, 1998).
16	MOM personnel cost, PGO, (%)	**$PGO = (PG / S) *100$**	Where PG is the personnel cost in the year researched, (US$/year); S is the total MOM cost, (US$/year)
17	MOM secondary revenue rate, IG0, (%)	**$IGO = (SDG / TG) * 100$**	Where TG is the total MOM revenue actualized in year (US$/year); SDG is the revenue except for irrigation charges (US$/year)
III	MOM Institutional Indicators		
18	Rate of irrigation groups in irrigation scheme, SGHO, (%)	**$SGHO = (ASG / Ap) * 100$**	Where ASG is the area operated by irrigation groups (ha); Ap is planned irrigation area (ha) (Koc, 1998).
19	Technical knowledge of staff, TPO, (%)	**$TPO = (TPG / TPS) * 100$**	Where TPG is the number of staff with knowledge required to fulfil MOM service; TPS is the total number of staff (Bos et al., 1994).
20	Percentage of change of MOM personnel number, PDY, (%)	**$PDY = (PSB / PSM) * 100$**	Where PSB is the current number of personnel with knowledge required to fulfill MOM services; PSM is the current number of personnel fulfilling MOM services.

Table 2. Methods of calculating the marks and weights of MOM performance indicators

No	Names, symbols and units of MOM performance indicators	Methods of calculating marks (MK=Marks)	Values of weight (WT=Weight)	
1	Percentage of actual irrigated area (F), (%)	MK=2F–100	0,07	
2	Efficiency of irrigation water supply (S), (%)	S≥100; MK=100 S<100; MK=S	0,05	
3	Sustainability of irrigated area (F_S), (%)	F_S<100; MK=F_S F_S≥100; MK=100	0,02	
4	Distribution network density (DND), (%)	MK=DND	0,02	
5	Percentage of irrigation facilities in good conditions (QIP), (%)	MK= 2QIP–100	0,05	
6	Percentage of drainage facilities in good condition (QDP), (%)	MK= 2QDP–100	0,04	
7	Actualize rate of irrigation planning (WSE), (%)	WSE≤100; MK=50+0,5WSE WSE>100; MK=150–0,5WSE	0,02	0,4
8	Percentage of change of water used unit area (FD), (%)	FD≤100; MK=50+0,5FD FD>100; MK=150–0,5FD	0,03	
9	Project irrigation efficiency (E_P), (%)	E_P≤25 MK=50; 26≤E_P≤35 MK=70; 36≤E_P≤45 MK=80; 46≤E_P≤55 MK=90; 56≤E_P≤65 MK=100 (Border and furrow irrigation method)	0,06	
10	Rate of change of groundwater table (R) (%)	MK=2,5*(40- |R|)	0,04	
11	Percentage of highest yield per unit quantity of irrigation water (Pyw), (%)	MK= 2Pyw-100	0,05	
12	Percentage of the highest total yield (P_Y), (%)	MK=2P_Y-100	0,1	
13	Efficiency of collection of irrigation water charges (TE), (%)	MK=TE	0,07	
14	Total financial viability (TFC), (%)	TFC≥100; MK=100 TFC<100; MK=FC	0,06	0,4
15	Financial self sufficiency (E_{YY}), (%)	E_{YY}<100; MK=E_{YY} E_{YY}≥100; MK=100	0,08	
16	MOM personnel cost (PGO), (%)	PGO≤35; MK=100; 35<PGO≤50; MK=50; 50<PGO≤100; MK=25	0,02	
17	MOM secondary revenue rate (IGO), (%)	MK=IGO	0,02	
18	Rate of irrigation groups in irrigation scheme (SGHO), (%)	MK=SGHO	0,02	
19	Technical knowledge of staff (TPO), (%)	TPO≤100; MK=50+0,5TPO TPO>100; MK=150-0,5TPO	0,03	0,1
20	Percentage of change of MOM personnel numbers (PDY), (%)	PDY≤100; MK=50+0,5PDY PDY>100; MK=150-0,5PDY	0,05	

RESULTS AND DISCUSSION

Measurement and evaluation of performance of the irrigation schemes and the WUAs in periods of before and after turnover are urgently required to improve their performance and to raise their performance and their management level. The performance of WUA can be measured and evaluated by a method of quantitative analysis with the weighted average mark of an index system, which consists of twelve techno-economical indicators of a WUA. The present level of performance of WUA, the major problems and their main causes can be clarified and the main measures for resolving the problems and improving the performance can be identified by applying this method.

The performance of irrigation schemes researched in periods before and after turnover was evaluated by the method of WAM. The process and results of WAM values calculated relevant MOM physical, economical, and institutional indicators are presented (*Tables 3 and 4*). Average WAM value of MOM physical indicators in period before turnover was 31.60, 36.02, and 37.30 for Akcay, Aydın and Nazilli irrigation schemes, respectively. Average WAM values of MOM physical indicators in after-turnover were 33.83, 35.93, and 36.73 (Figs 1, 2, and 3). Average WAM value relating to MOM economical indicators in periods before turnover was 26.47, 28.99, and 27.11 for Akcay, Aydın, and Nazilli schemes. In after-turnover, average WAM value for the irrigation schemes was 33.47, 33.48, and 36.61 (Figs 4, 5, and 6). WAM value of MOM institutional indicators in before turnover was 6.79, 7.00, and 8.61; after-turnover, 8.93, 7.20, and 8.74 for Akcay, Aydın, and Nazilli schemes (Figs 7, 8, and 9). Total WAM value of MOM indicators in the period before turnover was 71.14, 78.02, and 78.93; after turnover: 82.23, 82.61, and 83.24 for Akcay, Aydın, and Nazilli schemes respectively (Figs 10, 11, and 12).

Total value of weight for MOM physical indicators was considered as 0.40 (or 40%). MOM physical indicators consist of indicators related to irrigation area, irrigation water used and drainage facilities. WAM value of MOM physical indicators for Akcay scheme in periods before turnover the range found is from 30.15 to 32.80 and after the turnover ranges between 33.33 and 34.50. In Akcay scheme, the actualized rate of average WAM value for MOM physical indicators in before turnover was 79% (31.6/40). This value in after turnover was 85%. Actualized rates of WAM for MOM physical indicators in Aydın and Nazilli schemes were 90 and 93% in period of before turnover, 90 and 92% in after turnover. Percentage of irrigated area and sustainability of irrigated area haven’t varied too much in periods before and after turnover. Percentage of irrigation and drainage facilities in good conditions and distribution network density were actualized the close values in before and after turnover. In order to increase WAM value related to MOM physical indicators of irrigation schemes in the basin, percentage of actual irrigated area, percentage of water used in unit area, and percentage of drainage facilities in good conditions should be improved.

Total value aimed of weight for MOM economical indicators is 0.40 or (40%). WAM value of MOM economical indicators in periods before turnover varied between 26.12 and 27.23 in Akcay; 27.94 and 29.62 in Aydın; 26.06 and 27.91 in Nazilli schemes. In periods after turnover were: (32.40 and 34.60), (30.48 and 35.23), and (28.90 and 33.38) respectively in for Akcay, Aydın, and Nazilli schemes (Figs 4, 5, and 6). However, actualized rates of value aimed to relevant WAM value of MOM economical indicators in before turnover were: 66.80%, 72.40%, and 67.70% then in after turnover were: 83.60%, 83.70%, and 91.50% respectively in Akcay, Aydın, and Nazilli schemes. WAM values of MOM economical indicators in period of after turnover increased in 17.60% than before turnover. Percentage of the highest yield per unit area and percentage of the highest total yield haven’t varied significantly in periods of before and after turnover. Efficiency of the irrigation water collection decreased in periods after turnover in Akcay, and Aydın schemes more than before turnover. However, Nazilli schemes increased with 1% in the period of after turnover. Financial self-sufficiency increased with 104.8, 42.8, and 30% for respectively Akcay, Aydın, and Nazilli schemes in periods of after turnover. Total WAM values of MOM economical indicators in after-turnover increased 25, 15, and 16.5% respectively in Akcay, Aydın, and Nazilli schemes.

MOM institutional indicators consist of group irrigation rate in irrigation scheme and MOM personnel. Total WAM value of MOM institutional indicators in after turnover increased with 31.5, 2.85, and 1.5% respectively in Akcay, Aydın, and Nazilli schemes more than before turnover. The Variation of MOM personnel numbers affected significantly WAM value of MOM institutional indicators. The number of MOM personnel in Aydın and Nazilli schemes was higher than what is required. In order to increase WAM value of MOM institutional indicators quality, the number of MOM personnel should be considered.

Table 3. MOM physical, economical, and institutional indicators and WAM values, before-turnover

No	Names, symbols and units of MOM performance indicators	Before-turnover																	
		Akçay Scheme						Aydın Scheme						Nazilli Scheme					
		1990	1991	1992	1993	1994	1995	1992	1993	1994	1995	1996	1997	1990	1991	1992	1993	1994	1995
1	Percentage of actual irrigated area (F), (%)	2,66	3,36	2,10	3,22	3,22	3,43	3,36	4,90	6,72	6,30	6,58	6,16	7,00	7,00	7,00	7,00	7,00	7,00
2	Efficiency of irrigation water supply (S), (%)	4,20	4,50	3,95	4,50	4,90	3,85	4,77	4,10	3,90	4,90	4,70	3,75	4,15	4,20	4,40	4,59	4,86	4,01
3	Sustainability of irrigated area (Fs), (%)	2,00	2,00	2,00	2,00	1,94	1,94	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
4	Distribution network density (DND), (%)	1,52	1,52	1,52	1,52	1,52	1,52	1,70	1,70	1,70	1,70	1,70	1,70	1,62	1,62	1,62	1,62	1,62	1,62
5	Percentage of irrigation facilities in good conditions (QIP), (%)	4,25	4,30	4,20	4,10	4,30	4,30	4,50	4,40	4,63	4,60	4,80	4,90	4,60	4,60	4,50	4,50	4,45	4,70
6	Percentage of drainage facilities in good condition(QDP), (%)	2,35	2,42	2,25	2,56	2,24	2,24	3,05	3,15	3,00	2,96	3,20	3,44	2,85	2,92	2,92	2,80	2,96	2,96
7	Actualize rate of irrigation planning (WSE), (%)	1,78	1,92	1,87	1,93	1,12	1,76	1,65	1,72	1,66	1,63	1,78	1,62	1,93	1,93	1,94	1,91	1,95	1,78
8	Percentage of change of water used unit area (FD), (%)	2,90	2,80	2,90	2,99	2,94	2,88	3,10	3,12	2,98	3,00	2,90	2,78	3,00	2,95	2,95	3,00	2,99	2,99
9	Project irrigation efficiency(Ep), (%)	6,00	6,00	5,40	6,00	4,80	5,40	6,00	6,00	6,00	6,00	6,00	5,40	6,00	6,00	6,00	6,00	6,00	5,40
10	Rate of change of groundwater table (R) (%)	3,94	3,98	3,96	3,98	3,96	3,97	3,96	3,98	3,98	3,97	3,97	3,98	3,96	3,98	3,99	3,98	3,97	3,97
	MOM Physical Indicators	31,60	32,80	30,15	32,80	30,94	31,29	34,09	35,07	36,57	37,06	37,63	35,73	37,11	37,20	37,32	37,40	37,80	36,43
11	Percentage of highest yield per unit quantity of water (Pyw),(%)	4,40	4,55	4,60	4,50	4,70	4,50	4,73	4,68	4,65	4,70	4,80	4,50	4,65	4,75	4,50	4,73	4,83	4,84
12	Percentage of the highest total yield (Py), (%)	9,00	9,15	9,40	9,40	9,40	9,00	8,15	8,70	8,50	8,80	9,20	8,40	8,57	9,02	8,13	9,00	8,94	9,24
13	Efficiency of collection of irrigation water charges (TE), (%)	4,35	4,39	4,53	4,55	3,78	3,92	5,75	5,80	5,85	5,81	6,44	5,95	3,00	3,43	3,13	3,50	3,01	3,15
14	Total financial viability (TFC), (%)	3,87	3,78	3,83	3,96	3,78	3,78	3,77	3,68	3,54	3,78	3,72	3,54	4,05	3,97	3,95	4,08	3,86	3,97
15	Financial self sufficiency (E_{YY}), (%)	3,92	3,82	3,87	4,00	3,84	3,92	5,40	5,76	4,40	5,76	3,76	5,44	5,40	5,21	5,35	5,60	5,28	5,52
16	MOM personnel cost (PGO), (%)	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
17	MOM secondary revenue rate (IGO), (%)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	MOM Economical Indicators	26,54	26,69	27,23	27,41	26,50	26,12	28,80	29,62	27,94	29,85	28,92	28,83	26,67	27,38	26,06	27,91	26,92	27,72
18	Rate of irrigation grops in irrigation scheme (SGHO), (%)	0,85	0,90	1,00	0,86	1,00	1,12	0,00	0,00	0,00	0,00	1,52	1,52	1,77	1,81	1,91	1,88	1,76	1,92
19	Technical knowledge of staff (TPO), (%)	2,10	2,07	1,98	1,92	2,07	2,04	1,15	1,95	1,95	2,07	2,06	2,03	2,61	2,65	2,65	2,63	2,60	2,54
20	Percentage of change of MOM personnel numbers (PDY), (%)	3,83	3,85	3,75	3,88	3,80	3,75	4,70	4,73	3,95	4,78	4,80	4,80	4,12	4,15	4,15	4,05	4,25	4,25
	MOM Institutional Indicators	6,78	6,82	6,73	6,66	6,87	6,91	5,85	6,68	5,90	6,85	8,38	8,35	8,50	8,61	8,71	8,56	8,61	8,71
WAM=20∑(MK*WT)		64,92	66,31	64,11	66,87	64,31	64,32	68,74	71,37	70,41	73,76	74,93	72,91	72,28	73,19	72,09	73,87	73,33	72,86
$MK_1+MK_2+MK_3$		6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
	Total WAM	70,92	72,31	70,11	72,87	70,31	70,32	74,74	77,37	76,41	79,76	80,93	78,91	78,28	79,19	78,09	79,87	79,33	78,86
	STANDART FOR EVALUATION THE PERFORMANCE	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair	Fair	Fair	Fair

Table 4. MOM physical, economical, and institutional indicators and WAM values, after-turnover

No	Names, symbols and units of MOM performance indicators	After-Turnover																	
		Akçay Scheme						Aydın Scheme						Nazilli Scheme					
		1999	2000	2001	2002	2003	2004	1999	2000	2001	2002	2003	2004	1999	2000	2001	2002	2003	2004
1	Percentage of actual irrigated area (F), (%)	3,64	3,78	3,57	3,57	3,35	3,57	3,78	5,04	5,74	5,18	6,02	7,00	6,93	6,51	6,51	6,51	7,00	7,00
2	Efficiency of irrigation water supply (S), (%)	5,00	4,93	4,90	4,87	4,91	5,00	4,04	5,00	4,06	4,10	4,10	4,12	5,00	5,00	4,88	5,00	4,95	5,00
3	Sustainability of irrigated area (Fs), (%)	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
4	Distribution network density (DND), (%)	1,52	1,52	1,52	1,52	1,52	1,52	1,70	1,70	1,70	1,70	1,70	1,70	1,62	1,62	1,62	1,62	1,62	1,62
5	Percentage of irrigation facilities in good conditions (QIP), (%)	4,85	4,90	4,90	4,85	4,85	4,90	5,00	5,00	5,00	5,00	5,00	5,00	4,85	4,85	4,90	4,90	4,90	4,90
6	Percentage of drainage facilities in ggod condition(QDP), (%)	2,72	2,76	2,91	2,78	2,80	2,90	2,80	2,96	3,20	3,20	3,00	3,05	2,72	2,64	2,64	2,61	2,75	2,66
7	Actualize rate of irrigation planning (WSE), (%)	1,96	1,76	1,93	1,95	1,92	1,92	1,88	1,99	1,84	1,87	1,83	1,85	1,89	1,90	2,00	1,80	1,92	1,98
8	Percentage of change of water used unit area (FD), (%)	2,84	2,91	2,96	2,96	2,90	2,90	2,82	2,98	2,98	2,95	2,87	2,93	2,55	2,78	2,99	2,65	2,98	2,81
9	Project irrigation efficiency (Ep), (%)	5,40	4,80	5,40	6,00	5,40	4,80	5,40	5,40	6,00	6,00	6,00	5,40	4,80	5,40	6,00	6,00	4,80	4,80
10	Rate of change of groundwater table (R) (%)	3,97	3,97	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	3,98	3,97	4,00	4,00	4,00	3,98
	MOM Physical Indicators	33,90	33,33	34,09	34,50	33,65	33,51	33,42	36,07	36,52	36,00	36,52	37,05	36,34	36,67	37,54	37,09	36,92	36,75
11	Percentage of highest yield per unit quantitiy of water (Pyw)	4,70	4,76	4,83	4,80	4,77	4,81	4,81	4,73	4,69	4,77	4,57	4,92	4,32	4,40	4,62	4,65	4,33	4,43
12	Percentage of the highest total yield (Py), (%)	9,40	9,60	9,86	9,65	9,77	9,81	9,15	9,20	9,20	9,27	9,38	9,23	9,20	9,14	9,46	9,48	9,47	9,44
13	Efficiency of collection of irrigation water charges (TE), (%)	2,01	2,40	2,50	3,84	3,62	2,78	5,35	4,89	4,84	4,90	5,11	4,76	3,54	4,01	2,89	4,49	3,89	3,58
14	Total financial viability (TFC), (%)	5,54	5,62	5,57	5,55	5,60	5,63	6,00	4,66	6,00	6,00	5,25	6,00	5,60	5,22	5,36	5,40	5,33	5,61
15	Financial self-sufficiency (Eyy), (%)	8,00	7,92	8,00	8,00	8,00	8,00	8,00	4,76	6,96	8,00	7,68	8,00	5,12	7,12	6,00	8,00	8,00	8,00
16	MOM personnel cost (PGO), (%)	2,00	1,00	2,00	2,00	2,00	1,00	1,00	2,00	1,00	1,00	1,00	2,00	0,80	2,00	1,00	1,00	1,00	2,00
17	MOM secondary revenue rate (IGO), (%)	1,43	1,10	1,06	0,76	0,69	0,47	0,32	0,24	0,31	0,32	0,33	0,32	0,32	0,24	0,36	0,36	0,25	0,24
	MOM Economical Indicators	33,08	32,40	33,82	34,60	34,45	32,50	34,63	30,48	33,00	34,26	33,32	35,23	28,90	32,13	29,69	33,38	32,27	33,30
18	Rate of irrigation grops in irrigation scheme (SGHO), (%)	1,20	1,20	1,20	1,20	1,20	1,20	0,00	1,52	1,52	1,56	1,56	1,56	1,85	1,85	1,85	1,85	1,85	1,85
19	Technical knowledge of staff (TPO), (%)	2,84	2,75	2,66	2,73	2,68	2,73	2,48	2,55	2,48	2,51	2,50	2,52	2,85	2,78	2,78	2,78	2,80	2,78
20	Percentage of change of MOM personnel numbers (PDY), (%)	5,00	5,00	5,00	5,00	5,00	5,00	3,50	3,43	3,38	3,38	3,38	3,38	4,28	4,00	4,00	4,10	4,10	4,13
	MOM Institutional Indicators	9,04	8,95	8,86	8,93	8,88	8,93	5,98	7,50	7,38	7,45	7,44	7,46	8,98	8,63	8,63	8,73	8,75	8,76
WAM=(MK*WT)		76,02	74,68	76,77	78,03	76,98	74,94	74,03	74,05	76,90	77,71	77,28	79,74	74,22	77,43	75,86	79,20	77,94	78,81
$MK_1+MK_2+MK_3$		6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
	Total WAM	82,02	80,68	82,77	84,03	82,98	80,94	80,03	80,05	82,90	83,71	83,28	85,74	80,22	83,43	81,86	85,20	83,94	84,81
	STANDART FOR EVALUATION THE PERFORMANCE	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

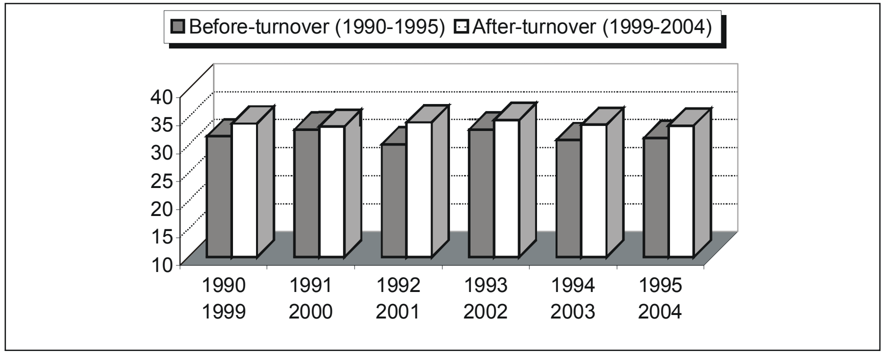

Fig. 1. WAM values of MOM physical performance indicators, Akcay scheme

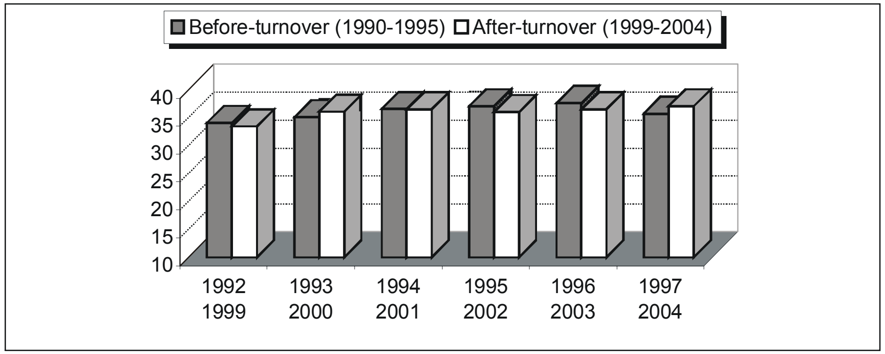

Fig. 2. WAM values of MOM physical performance indicators, Aydin scheme

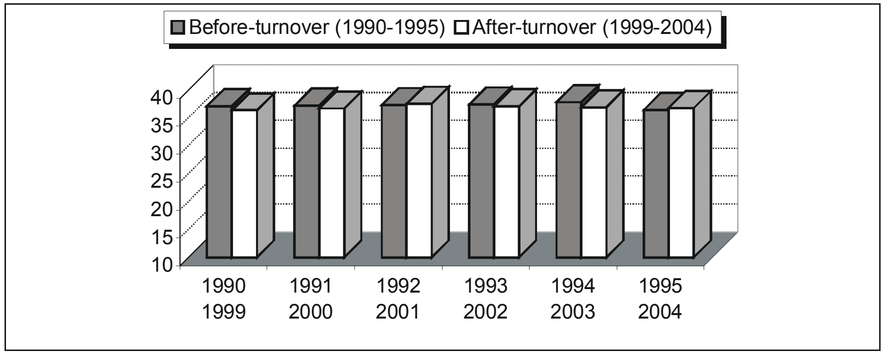

Fig. 3. WAM values of MOM physical performance indicators, Nazilli scheme

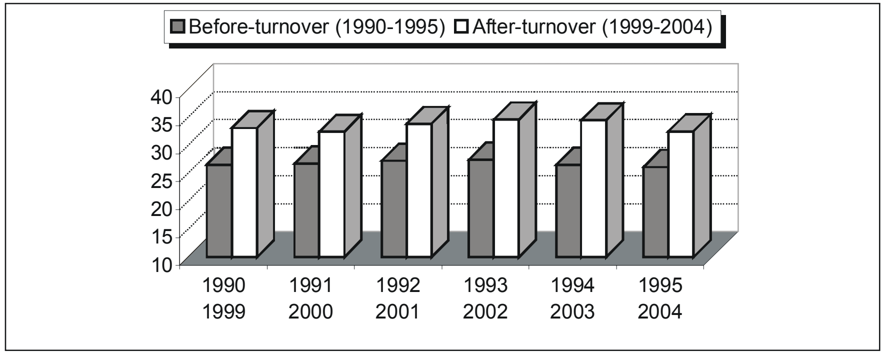

Fig. 4. WAM values of MOM economical performance indicators, Akcay scheme

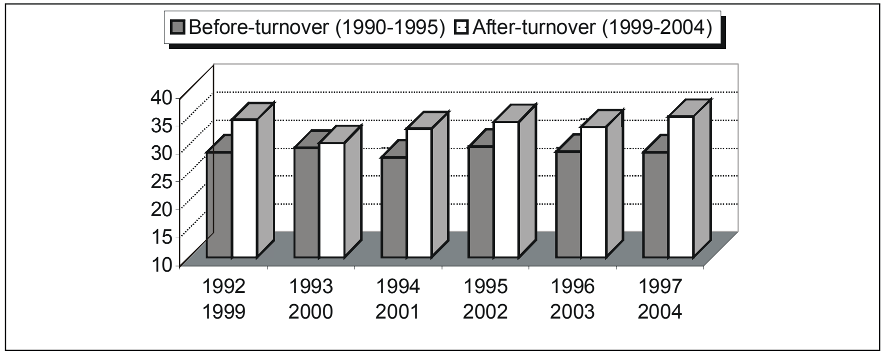

Fig. 5. WAM values of MOM economical performance indicators, Aydin scheme

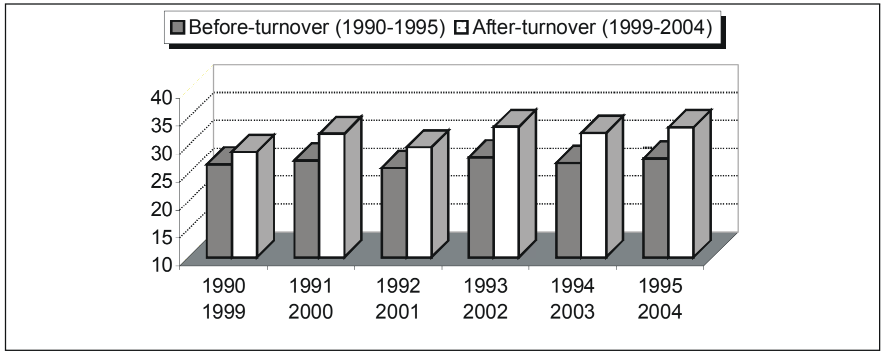

Fig. 6. WAM values of MOM economical performance indicators, Nazilli scheme

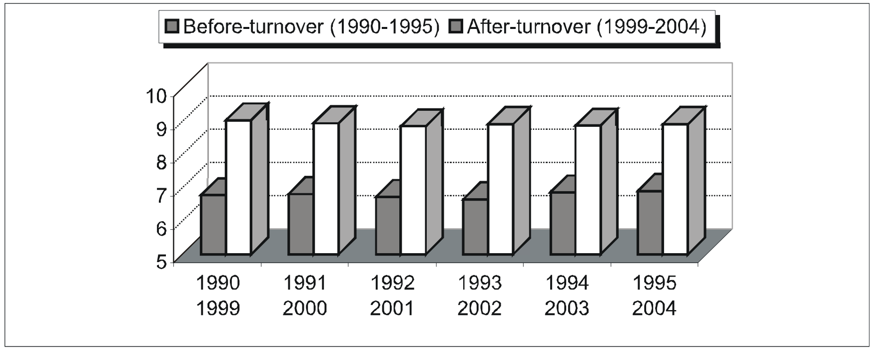

Fig. 7. WAM values of MOM institutional performance indicators, Akcay scheme

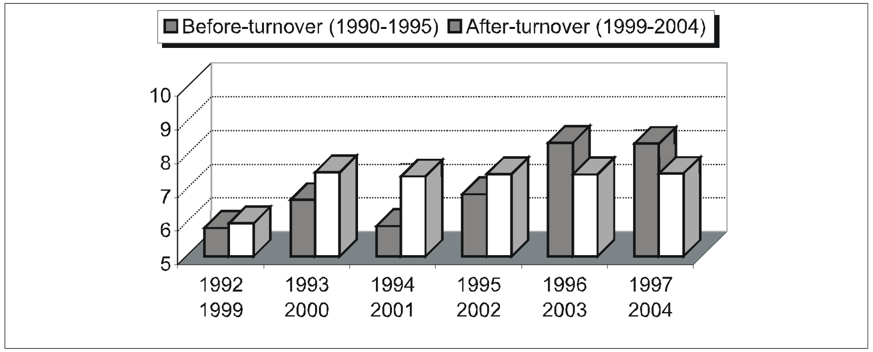

Fig. 8. WAM values of MOM institutional performance indicators, Aydin scheme

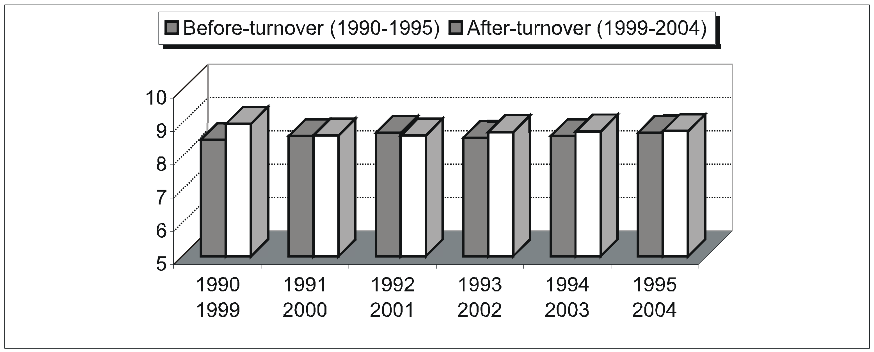

Fig. 9. WAM values of MOM institutional performance indicators, Nazilli scheme

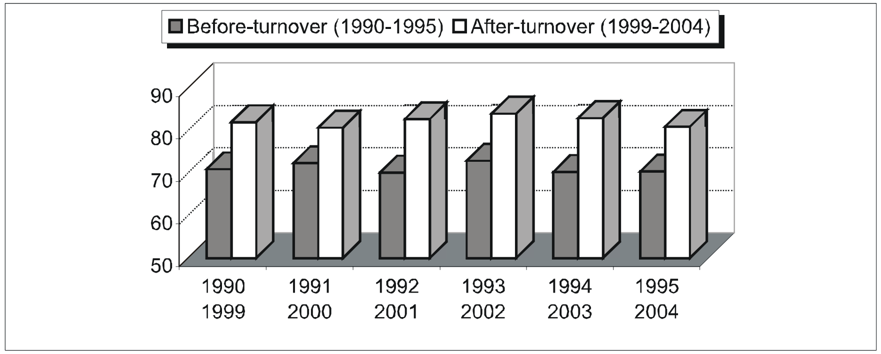

Fig. 10. Total WAM values of MOMI performance indicators, Akcay scheme

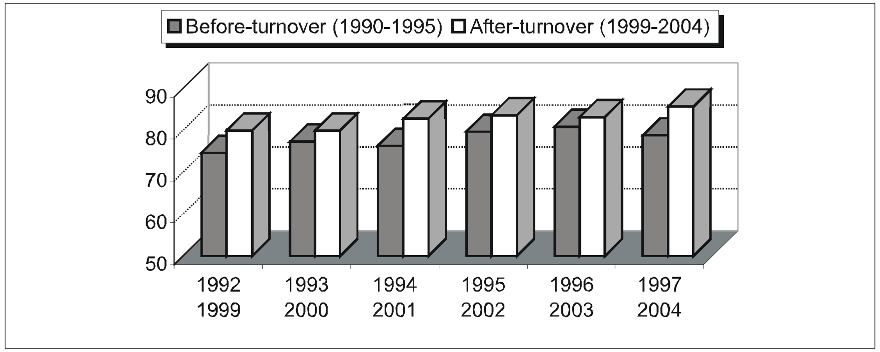

Fig. 11. Total WAM values of MOMI performance indicators, Aydin scheme

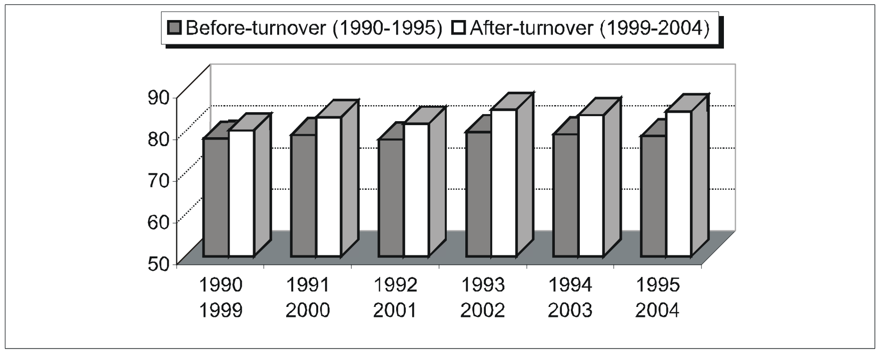

Fig. 12. Total WAM values of MOMI performance indicators, Nazilli scheme

Total WAM values related to MOM physical, economical, and institutional indicators increased in period of after turnover. Increasing rate of total WAM values in after turnover was 15.5, 5.8, and 5.46% respectively in Akcay, Aydın, and Nazilli schemes (Figs 10, 11, and 12). Standard for the performance evaluation in periods of before turnover was ‘fair’ in the schemes researched in basin. But after turnover, standard was ‘good’ in all the schemes.

After turnover periods of six years were not enough to assess whether these rates are enough to guarantee long-term sustainability of irrigation schemes and WUAs researched. None of the WUA has established effective mechanisms to cope with high annual inflation rates and potential financial shortfalls. This could put at risk the sustainability of WUAs.

Farmers’ increased control has not led major improvements in WAM values of MOM physical indicators in period of after turnover. Although the Hydraulic State Works (DSI) has become an important institution in which user participate in planning the use of and control over the water service, there is no evidence that turnover has resulted in significant improvements in the way water is allocated and distributed. Generally, schemes have so far followed the same allocation and distribution principles and practices as used by DSI. Similarly, no chances in the area irrigated or cropping patterns can be attributed to turnover.

Another apparent improvement that resulted from the turnover is the increase in financial self-sufficiency from around 45 percent in the period of before turnover to around 100 percent in the after turnover. This is mainly due to the ability of the WUAs to achieve fee collection rates of about 70 percent and to decrease in MOM expenditures in schemes. Moreover, all WUAs used computer software to handle daily financial administration, this has resulted in improving the financial transparency of the WUAs in basin.

For further analysis, comprehensive assessment of WUAs management in Great Menderes 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, environment factors, such as soil and water 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 available. WUA’s contribution on improving water efficiency and their basin wide 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.

Irrigation schemes can be further screened based on water resources, conveyance system, and the extent of delivery system in the farm, marketing situation, the number of personnel, education level and the age of the scheme. Then similar schemes can be compared or evaluated among them in order to emphasize key issues relative to performance and to better understand key factors affecting the performance.

Most information on the impacts of management turnover to WUAs is based on general assertions rather than on systematic qualitative and quantitative data. Since management turnover has the potential to make major impacts on the performance of irrigated agriculture, it is important that future research includes an improved impact assessment studies. Improvements needed in irrigation management turnover assessment studies should include; comparative use of a standard set of performance indicators, reduction in excessive dependence on data collected from secondary sources, use of before and after turnover interrupted time series, observations of the physical condition and functionality of irrigation infrastructure.

The management of WUAs must be sensitive to potential variations in the nature and structure of the weak WUAs. Therefore, weak WUAs should be identified, strengthened technically and financially to upgrade their management abilities. An effective WUA and its knowledge are needed to take maximum advantage on sustainable, efficient and economic water use. Therefore, farmers need to be trained on the irrigation management, in particular about appropriate layout of the field canals, the application of water in right quantity and at right time so that the wastage of water could be minimized. Land and water degradation constrain efforts to improve water productivity. Therefore, interdisciplinary training and incentives are needed to make long term investment in soil conservation and soil fertility management. Further, environmental performance has not yet been addressed adequately. These are important areas of research that will be useful for future policy planning.

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