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Mapping performance of irrigation schemes in Turkey

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Abstract. Water is a crucial resource and approximately 70% usage of it in the agriculture sector in Turkey. Water user associations are in charge of irrigation water management. The core aim of this study is to assess water user associations have command area more than 1,000 ha (WUAs) within the districts of DSI (State Hydraulic Works) and to create spatial maps to show the distribution of the performance indicators used constantly by researchers especially around Mediterranean countries during the period from 2011 to 2015. Frequency and panel data analysis are used to figure out the relationship among performance indicators and attributes such as water diversion type, management type, source of water and district no. Panel data analysis was applied to examine statistical assessment over time. As a result, current performance indicators show that excessive irrigation water used due to low technology and management problem. Performance indicators show high differences among districts due to climate, water resources, and crop pattern. Moreover, low irrigation efficiency can be increased with a transition to pressurized irrigation systems, so more are can be irrigated with less water.

Key words: panel data analysis, performance indicators, water management, water user associations.

INTRODUCTION

Effective water management is one of the most important issues since water is a limited source in agriculture (Gündoğdu et al., 2002) especially in semi-arid areas such as Mediterranean region (Lamaddalena et al., 2015). Estimated 65 per cent of global water use is consumed in the agricultural sector (Postel, 2014). Water is scarce and requires sustainable management at WUAs (Water User Associations) level due to water controlled by these organizations. To evaluate WUAs, performance indicators are used (Burt, 2001; Malano & Burton 2001). Performance indicators give general information about WUA evaluated (Molden et al., 1998; Burt 2001; Malano et al., 2004; Renault et al., 2007). The application of performance indicators to improve WUAs performance is a relatively recent phenomenon (Rodríguez-Díaz et al., 2008). The benchmarking technique, which is based on the comparison between different WUAs allow to determine the best practices in each of them (Córcoles et al., 2010). These indicators are also useful for water policies (Alcon et al., 2017) and can be used to measure effects of modernization of irrigation management (Değirmenci et al., 2003; Soto-García et al., 2013), land consolidation (Sönmezyildiz & Çakmak, 2013), water-scarce impact (Alcon et al., 2017), evaluation in years (Córcoles et al., 2010) and differences between management types among WUAs (Tanrıverdi et al., 2011). The methodology is also popular to assess WUAs in Mediterranean Countries (Borgia et al., 2013; Zema et al., 2015 and 2018; Kartal et al., 2019 and 2020).

The studies conducted with performance indicators in Turkey comprise a group of WUAs (Değirmenci et al., 2003; Değirmenci, 2004; Tanrıverdi et al., 2011; Akkuzu & Mengü, 2011) or a WUA (Çakmak et al., 2004; Nalbantoğlu & Çakmak, 2007; Tanrıverdi & Değirmenci, 2011; Sönmezyıldız & Çakmak, 2013; Çakmak et al., 2014; Arslan & Değirmenci, 2018) except Merdun & Değirmenci (2004) studied on 239 irrigation schemes but only for a year 2001. In these studies, WUAs compared in the discussions do not reflect a whole or not give sufficient comparison. Therefore, there is a need overall performance indicators in order to compare them.

The main aim of the present study is to determine reference performance indicators using 5 years of data between 2011 and 2015 from 244 WUAs. In this regard, panel data analysis is applied to analyse the data. This study also investigates the effects of a score of parameters such as water resources (river, lake, underground etc.), water diversion type (gravity, pumped or both), management type on performance. Other purposes of the study include recommendations to improve the performance of WUAs to managers, engineers and policymakers.

MATERIAL AND METHODOLOGY

Case study description

The current study was carried out with 244 irrigation schemes have more than 1,000 ha command area (except 2 of them) in 23 DSI (State Hydraulic Works) of 26 districts based on river basins between 2011 and 2015 irrigation seasons data. The total area of WUAs evaluated covers 20,195.222 km^2 whose sample size presents 89.4% of all WUAs. The sample size was not 100 per cent due to the available data. Fig. 1 shows that spatial distribution of DSI districts. As it is given in Table 1, each district has different features such as precipitation, water potential etc.

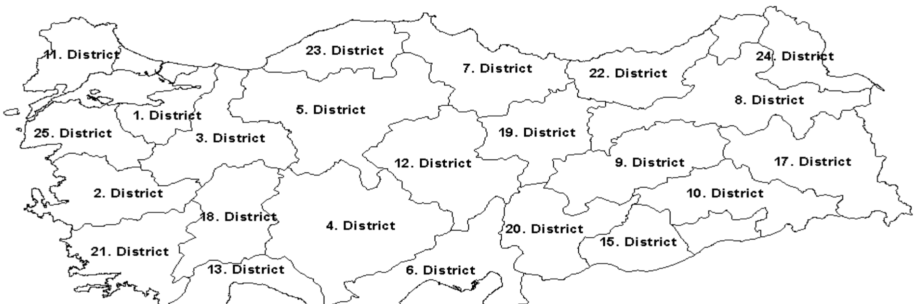

Figure 1. Spatial distribution of DSI districts in Turkey.

Table 1. Main features of DSI districts

District No.	Mean annual precipitation (mm)	Total water potential (hm^3 year^{-1})	Irrigable area (ha)	Evaluated area (ha)	Evaluated area (%)
1	738	8,018.5	61,410	54,175	88.2
2	605	4,508	133,258	122,561	91.9
3	548	5,469.29	67,713	64,659	95.5
4	398.4	8,353	188,976	169,866	89.9
5	493.6	11,862	43,540	42,130	96.8
6	812	23,292	347,219	301,814.2	86.9
7	713	10,944	104,877	91,377	87.1
8	438	12,118	83,356	77,634	93.1
9	720	11,202	74,164	60,542	81.6
10	645	20,500	48,928	44,226	90.4
11	621	9,921.9	57,145	54,852	95.9
12	720	11,202	82,161	69,769	84.9
13	1,009	15,907.13	80,046	78,980	98.7
15	425	33,582	226,677	195,187	86.1
17	662.6	13,038.08	71,132	59,214	83.2
18	529.5	4,690.7	93,499	80,929	86.6
19	902	11,202	22,966	18,390	80.1
20	620.6	9,614.8	78,541	54,534	69.4
21	720	11,202	205,482	203,482	99
22	10,180	15,755	15,647	15,647	100
23	713	8,649	20,987	18,987	90.5
24	720	11,202	68,792	68,400	99.4
25	663	5,867	83,107	72,167	86.8

Turkey has 4 types of climate; continental climate (summers are hot and arid, winters are cold and snowy); Mediterranean climate (summers are hot and dry, winters are warm and rainy); transition climate (characteristic between continental, Mediterranean and Black sea climate); Black sea climate (winters are warm and summers are cool) within regions (FL, 2017). These climate types help to interpret performance indicators within districts.

Methodology

Calculation of performance indicators

A set of performance indicators related to water, land and finance are used to evaluate WUAs. The performance indicator is used to improve system operation, better understand the performance determinants and to compare the performance of a system over time with others or the same system (Molden et al., 1998; Malano & Burton, 2001). These assessment methods are also used as a part of the modernization process by FAO (Renault et al., 2007). Available data-limited number of performance indicators to calculate. Selected performance indicators are given in Table 2.

Value of production of Turkish currency (Turkish Lira) are changed into Euro based on the consumer price index of Turkey according to Newbold (2009) and the year 2011 is selected reference year.

To show spatial distribution of performance of the districts, a district map was created using ESRI ArcMAP GIS package program. After calculation of performance indicators of WUAs within each district, the data entry was made to the program. And, the ranges of performance indicators were given in legent.

Table 2. Formulas of calculation irrigation performance indicators selected

Performance indicator	Formula
Irrigation intensity (%)	$\frac{\text{Irrigated area} \cdot 100}{Command\ area}$
Annual irrigation water supplied to users per unit command area (m^3 ha^{-1})	$\frac{\text{Annual volume of irrigation water supplied to users}}{Command\ area\ of\ the\ irrigation\ schemes}$
Annual irrigation water supplied to users per unit irrigated area (m^3 ha^{-1})	$\frac{\text{Annual volume of irrigation water supplied to users}}{Irrigated\ area\ of\ the\ irrigation\ schemes}$
Irrigation efficiency (%)	$\frac{\text{Conveyance efficiency} \cdot \text{field application efficiency}}{100}$
Total MOM cost per unit command area (€ ha^{-1})	$\frac{\text{Total MOM cost}}{Command\ area}$
Total MOM cost per unit irrigated area (€ ha^{-1})	$\frac{\text{Total MOM cost}}{Irrigated\ area}$
Total MOM cost per unit water supplied to users (€ m^{-3})	$\frac{\text{Total MOM cost}}{Annual\ volume\ of\ the\ irrigation\ water\ supplied\ to\ users}$
Output per unit command area (€ ha^{-1})	$\frac{\text{Total annual value of production}}{Command\ area}$
Output per unit irrigated area (€ ha^{-1})	$\frac{\text{Total annual value of production}}{Irrigated\ area}$
Output per unit water supplied to users (€ m^{-3})	$\frac{\text{Total annual value of production}}{\text{Annual volume of irrigation water supplied to users}}$

Data collection

Data used for the study was obtained from irrigation facilities evaluation reports and crop count reports of DSI related years. Data required including irrigated and command area, annual volume of irrigation water supplied to users, total maintenance and operation cost were taken from irrigation facilities reports and the total annual value of production was taken from crop count reports. WUAs have data less than 3 years were not taken into consideration.

Some WUAs' features were selected for consideration effect on performance indicators. Water diversion type (gravity, pumped and both), management type (transferred and non-transferred), crop pattern and source of water (river, lake, underground etc.) are these properties.

Statistical evaluation

Panel data analysis is used to assess relation performance indicators and WUAs facilities over time. The data is evaluated over time and the same individuals with panel data analysis and then a regression is run over these two dimensions. A panel dataset is one in which each of $N > 1$ units (sometimes called 'individuals' or 'groups') is observed over time. In a balanced panel, there are $T > 1$ observations on each unit; more generally the number of observations may differ by the unit. In the following, we index units by i and time by t. To allow for imbalance in a panel we use the notation T_i to refer to the number of observations for unit or individual i. In this context, effects of attributes (performance indicators, management type, source of water etc.) and time (2011–2015) are allowed to determine effects on performance indicators by the analysis. In this study, two techniques are used to analyse panel data: random and fixed effects. In general, a linear panel data model may be written as

$$Y_{it} = \beta_{0it} + \beta_{1it}X_{1it} + \beta_{2it}X_{2it} \dots \dots + \beta_{kit}X_{kit} + \upsilon_{it}$$

where $i = 1, 2, ...$, N is the cross-sectional unit and $t = 1,2, ..., T$ is time, Y_{it} is a dependent variable, X_{it} is explanatory variable for i^{th} observation at the period t, and υ_{it} is the error term is assumed to be independent and normally distributed $N =\sim (0, \sigma_i^2)$. When 1_{it} mean the first observation and the first time period and *kit* means the latest observation and the latest time period (Torres-Reyna, 2007).

RESULTS AND DISCUSSION

Table 3 shows the mean and standard deviation values of performance indicators for the districts. When we examine average values of indicators, irrigation intensity (IRRINT) was 45.3%, annual irrigation water supplied to users per unit command area (WATCOM) was 4,966.55 m^3 ha^{-1}, annual irrigation water supplied to users per unit irrigated area (WATIRR) was 12,907 m^3 ha^{-1}, and irrigation efficiency (IRREFF) was 43.4%for overall water delivery performance indicators. For financial indicators, mean values of total MOM (maintenance, operation and management) cost per unit command area (MOMCOM) was found as 81.4 € ha^{-1}, total MOM cost per unit irrigated area (MOMIRR) was 262.9 € ha^{-1}, total MOM cost per unit water supplied to users (MOMWAT) was 0.1 € m^{-3}. Production indicators are output per unit command area (outputCOM), output per unit irrigated area (outputIRR) and output per unit per unit water supplied to users (outputWAT) were found as 2,468.3 € ha^{-1}, 6,486.8 € ha^{-1} and 1.6 € m^{-3}, respectively.

Irrigation intensity was calculated considering all area irrigated including aftercrop areas. Fig. 2 shows average irrigation intensity (IRRINT) of irrigation schemes within 23 districts ranges from 7.4 to 86.7% and the mean was 43.3% during the experimental period. When it comes to irrigation schemes, mean IRINT was found 48.82%. Over irrigated areas (more than 100%) found because of after crops and irrigated areas out of command area of the WUAs. Irrigation schemes in 22th District had lowest IRRINT due to farmers who thought precipitation was adequate and no demand for water (20%), the inadequacy of irrigation facilities (11%), fallow (24%) and social and economic reasons (45%). Only irrigation intensity does not indicate the success of a WUA because of distinction diverted from the reservoir. Even though WUAs irrigate whole command area, they may use overabundance amount of water. For example, even if the highest rate of IRRINT was found in 15th District, the highest amount of water was used by WUAs in the district. Average IRRINT of 15th District was 86.7% and 451.10 million cubic meter water used 775.86% much more than average (58.14 million cubic meters) of DSI Districts. The lowest IRINT was seen in 22th District due to high rate of precipitation (10,180 mm) which was adequate and no irrigation water demand from WUAs according to farmers.

Table 3. Mean and standard deviation values of performance indicators

District no	IRRINT*	WATCOM	WATIRR	IRREFF	MOMCOM	MOMIRR	MOMWAT	outputCOM	outputIRR	outputWAT
1	46.77	3,299.35	8,051.37	59.47	178.80	424.81	0.09	3,190.90	6,822.49	1.52
	(23.79)	(1,679.52)	(3,715.09)	(0.26)	(147.22)	(369.79)	(0.08)	(2,215.63)	(3,418.92)	(0.83)
2	42.33	3,811.11	9,771.10	55.84	166.05	548.43	0.10	2,967.09	7,610.98	1.59
	(21.37)	(1,712.14)	3,542.22	(0.19)	(210.44)	(809.18)	(0.14)	(2,032.95)	(4,831.75)	(1.13)
3	37.27	4,048.96	14,250.97	34.70	72.11	270.28	0.06	1,819.62	7,056.75	1.44
	(27.58)	(2,916.42)	(14,592.40)	(0.18)	(73.90)	(273.88)	(0.07)	(1,321.77)	(8,018.65)	(1.26)
4	54.85	4,032.96	10,394.89	54.22	52.99	144.78	0.04	1,947.52	4,178.97	0.85
	(38.75)	(2,831.69)	(12,120.36)	(0.26)	(35.21)	(114.47)	(0.03)	(1,338.38)	(2,966.46)	(0.43)
5	24.25	3,971.62	17,922.50	30.74	33.71	428.93	0.11	1,653.98	6,652.34	1.67
	(15.31)	(3,012.28)	(8,739.43)	(0.18)	(24.97)	(1,107.7)	(0.29)	(1,272.88)	(6,122.31)	(1.50)
6	59.05	7,747.92	18,286.94	43.77	140.02	583.64	0.05	4041.16	13,735.46	1.19
	(29.62)	(4,746.67)	(22,468.84)	(0.21)	(208.81)	(1,443.5)	(0.07)	(2,859.52)	(2,2101.9)	(0.80)
7	45.67	2,881.02	7,022.72	57.43	43.62	102.85	0.03	1,984.66	4,771.50	1.17
	(23.91)	(1,863.02)	(3,770.20)	(0.27)	(29.08)	(66.98)	(0.02)	(1,164.31)	(2,352.66)	(0.58)
8	31.39	2,480.06	8,559.02	32.63	35.89	138.25	0.06	697.19	2,149.29	1.15
	(14.44)	(1,510.86)	(4,330.43)	(0.12)	(22.56)	(93.68)	(0.05)	(465.77)	(807.19)	(1.37)
9	48.53	5,624.54	13,399.19	40.29	133.56	360.63	0.37	4,128.14	7,748.83	6.35
	(27.87)	(4,571.89)	(9,699.78)	(0.20)	(314.20)	(646.83)	(1.57)	(4,341.64)	(5,658.86)	(21.16)
10	58.85	7,903.21	13,974.04	36.61	63.18	108.93	0.02	1,648.81	2,829.66	0.62
	(22.89)	(4,238.02)	(6,782.70)	(0.15)	(64.83)	(98.02)	(0.02)	(856.77)	(1,289.60)	(0.26)
11	58.26	8,197.54	11,957.48	52.45	129.42	193.47	0.03	3035.63	3,021.54	0.79
	(34.31)	(8,761.55)	(5,170.11)	(0.21)	(126.59)	(141.67)	(0.02)	(2,401.54)	(3,260.13)	(0.45)
12	45.58	4,044.23	9,923.92	41.21	59.06	145.36	0.04	2263.17	4,725.61	1.38
	(24.08)	(2,189.97)	(6,193.99)	(0.20)	(50.34)	(145.34)	(0.03)	(2,327.18)	(2,952.08)	(0.80)
13	54.17	5,534.37	10,001.85	55.07	128.71	265.86	0.06	7692.71	1,5005.64	3.10
	(19.46)	(3,137.69)	(4,271.38)	(0.23)	(95.69)	(218.50)	(0.05)	(5,593.48)	(1,3278.0)	(3.60)
15	86.66	10,570.20	11,548.18	50.73	131.09	176.66	0.03	2,925.94	3,498.49	0.60
	(30.16)	(6,682.49)	(4,889.91)	(0.22)	(98.61)	(162.42)	(0.03)	(838.51)	(839.26)	(0.22)
17	29.97	3,826.20	15,669.61	32.40	56.32	192.67	0.05	962.56	3,535.66	0.94
	(20.39)	(2,677.75)	(10,491.32)	(0.17)	(65.04)	(189.09)	(0.05)	(934.95)	(2,507.66)	(0.84)
18	47.14	4,194.41	11,024.16	45.54	77.11	176.53	0.04	3,059.39	5,752.88	1.30
	(28.72)	(3,313.47)	(7,781.65)	(0.23)	(72.45)	(160.61)	(0.04)	(3,700.81)	(4,049.91)	(0.91)
19	34.75	4,121.01	13,699.83	32.06	34.95	106.53	0.03	1,850.85	4,972.19	1.46
	(17.94)	(2,090.07)	(9,171.95)	(0.15)	(23.73)	(68.12)	(0.02)	(1627.60)	(2,787.78)	(0.78)
20	54.78	5,718.24	11,266.92	41.71	61.08	131.18	0.03	1,522.64	2,967.36	0.70
	(27.11)	(2,723.39)	(4,954.51)	(0.17)	(35.16)	(83.04)	(0.02)	(839.04)	(1,129.96)	(0.24)
21	68.73	7,618.15	26,870.80	48.37	92.67	305.40	0.03	3,279.78	15,124.52	0.93
	(33.68)	(4,690.02)	(71,897.28)	(0.22)	(50.09)	(701.66)	(0.02)	(1717.44)	(51,161.8)	(0.51)
22	7.40	773.67	11,985.18	42.70	10.03	151.09	0.06	442.47	6,106.35	2.17
	(1.69)	(585.46)	(11,058.82)	(0.29)	(6.91)	(122.33)	(0.05)	(499.41)	(6,475.63)	(2.21)
23	21.64	2,001.57	1,1307.73	30.04	30.91	139.72	0.05	1,529.11	7,080.85	2.60
	(11.62)	(951.67)	(7,484.01)	(0.14)	(21.78)	(76.44)	(0.03)	(1,080.94)	(4,166.51)	(1.53)
24	27.93	4,985.02	15,456.65	35.82	42.53	700.76	0.07	1,050.05	4,924.44	1.30
	(19.00)	(4,107.49)	(11,653.42)	(0.24)	(30.55)	(933.52)	(0.12)	(623.62)	(2,495.48)	(1.05)
25	56.79	6,844.38	14,226.21	45.38	109.73	180.20	0.04	3,076.55	5,460.36	1.07
	(23.02)	(2,380.49)	(8,175.09)	(0.20)	(175.32)	(190.07)	(0.04)	(1,790.88)	(2,224.10)	(0.52)
Av	45.3	4,966.5	12,937.0	43.4	81.9	262.9	0.1	2,468.3	6,486.8	1.6

*IRRINT:irrigation intensity; WATCOM: annual irrigation water supplied to users per unit command area; WATIRR: annual irrigation water supplied to users per unit irrigated area; IRREFF: irrigation efficiency; MOMCOM: total MOM cost per unit command area; MOMIRR: total MOM cost per unit irrigated area; MOMWAT: total MOM cost per unit water supplied to users; outputCOM: output per unit command area; outputIRR: output per unit irrigated area; outputWAT: output per unit per unit water supplied to users.

Irrigation intensity was 32.2% in Daphan plain in 24th District in 2013 (Demir et al., 2014), 62.43% in Aydın province in 2th District between the years 2006–2014 (Akçay, 2016), 27.33% in Gevrekli WUA in 4th District between the period 2008–2013 (Eliçabuk & Toprak, 2017).

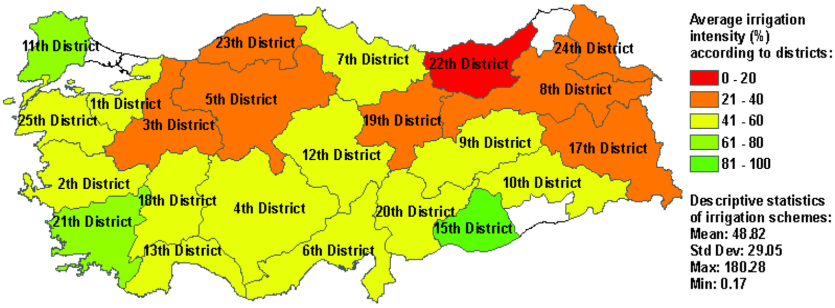

Figure 2. Irrigation intensity.

Values of WCOM changed between 10,570.20 and 773.70 m^3 ha^{-1} and the average value was found 4,966.50 m^3 ha^{-1} within the districts while WIRR was 7,022.70, 26,870.80 and 12,937.00 m^3 ha^{-1}, respectively. WUAs' WCOM values changed between 33.25 and 49,958.78 m^3 ha^{-1} while mean value was 5,185.88 m^3 ha^{-1}. WIRR values of irrigation schemes changed between 224.86 and 416,459.18, and the mean of the value was 13,403.47 m^3 ha^{-1}. WIRR is highly effected by water diversion type to users. The average WIRR was 1,173.74 m^3 ha^{-1} for WUAs with gravity water diversion type, 523.34 m^3 ha^{-1} for WUAs with pumped water diversion type, and 430.63 m^3 ha^{-1} for WUAs with both diversion types. The indicator also affected dramatically by management type. Mean WIRR of WUAs managed by DSI was 708.64 m^3 ha^{-1} while managed by WUAs their self has an average value of 1,570.94 m^3 ha^{-1} (Fig. 3). Besides that, the resource of water effects on WIRR, mean values of the indicator according to river, lake, underground, river and lake, river and underground, other were 1,085.52, 756.43, 258.26, 858.14, 725.26 and 535.03 m^3 ha^{-1}, respectively. Statistically significant correlation was found between WIRR and crop pattern ($P < 0.05$) except some crops (cereals, citrus, sunflower, sugar beet, strawberry, banana, forage crops and arboriculture). To be able to prepare a water distribution plan more realistically, the amount of water required for the crop pattern should be calculated as accurately as possible. The water distribution system also should be suitable to distribute water to users with pumped irrigation systems instead of gravity.

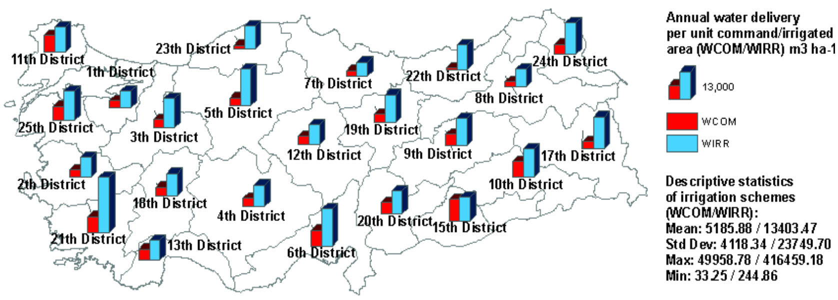

Figure 3. Annual irrigation water delivery per unit command area and irrigated area.

Financial indicators

These financial indicators show expenses in the field of irrigation schemes. This indicator does not tell us MOM requirement. A high value of MOM does not mean sustainable system. MOM expenditures may be low to encounter current MOM necessity. This indicator highly changed from 10.00 to 178.80 € ha^{-1} for MOMCOM, and 102.90 to 700.80 € ha^{-1} for MOMIRR within the districts. Average of MOMCOM and MOMIRR values of WUAS were 89.96 and 264.57 € ha^{-1}, respectively. Average, maximum and minimum values of the indicator were 89.96, 2,429.72 and 0.45 for MOMCOM, 254.57, 10,679.01 and 0.47 for MOMIRR within irrigation schemes (Fig. 4). Average MOMCOM of irrigation schemes with pumped distribution system was 265% more than gravity distribution systems. Non-transferred irrigation schemes have 177% more MOM expenditure than transferred irrigation schemes. The highest value of MOMCOM was found irrigation schemes getting water from underground. Energy bill and water tariff of these irrigation schemes highly likely increased MOM expenditure.

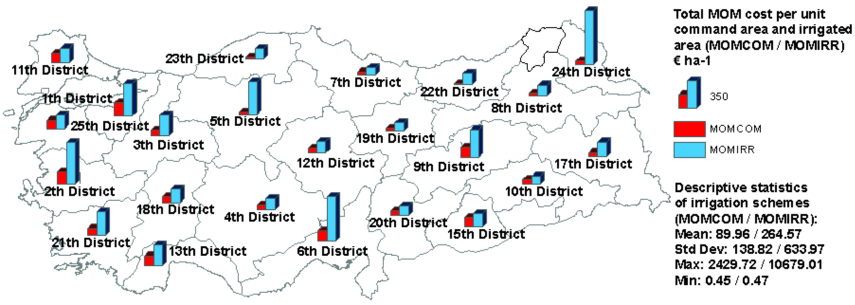

Figure 4. Total MOM cost per unit command and irrigated area.

Fig. 5 shows spatial distribution of MOMWAT within the districts. Average MOMWAT value is 0.06 when the maximum is 0.37 and minimum is 0.02 € m^{-3} within the districts. Mean MOMWAT value of irrigation schemes was 0.07, max was 12.18 and min was 0.0001 € m^{-3}. MOMWAT values were not affected highly by water diversion type but management type affected the indicator. Transferred irrigation schemes had a mean value of 0.045 while non-transferred irrigation schemes had a value of 0.081 € m^{-3}. The highest value was seen WUAs pumping water from underground.

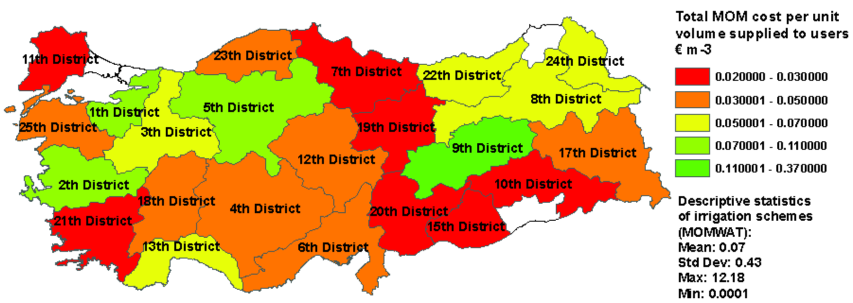

Figure 5. Total MOMWAT cost per unit volume supplied to users.

Production

Production indicators show the efficiency of farmer economic activity (Alcon et al., 2017). The average value of outputCOM and outputIRR were 2,468.30 and 6,486.80 € ha^{-1} within the districts. The values of the indicator changed from 442.50 to 7,692.70 € ha^{-1} for outputCOM, from 2,149.30 to 15,124.50 € ha^{-1} for outputIRR within the districts. The highest value of outputCOM was 28,019.33 while the lowest value was 2.18 € ha^{-1} and mean was 2,868.85 € ha^{-1} among irrigation schemes (Fig. 6). The highest and lowest values of outputIRR were 37,6536.75 and 48.46 € ha^{-1} (mean 7,384.79 € ha^{-1}). Seferihisar irrigation scheme had the highest value of over 16,000 € ha^{-1} in 2013. The indicators related to output had fluctuation because the situation seen among farmers planning crop pattern according to crops made money more last year (DSI 2016). Mean value of outputIRR according to water diversion type; gravity, pumped and both were found 7,587.39, 9,718.37 and 5,532.63 € ha^{-1}, respectively. There were big differences between transferred irrigation schemes and non-transferred irrigation schemes for the indicator. Mean of the indicator of transferred irrigation schemes was 2,909.49 € ha^{-1} while non-transferred irrigation schemes had value 677.37 € ha^{-1}.

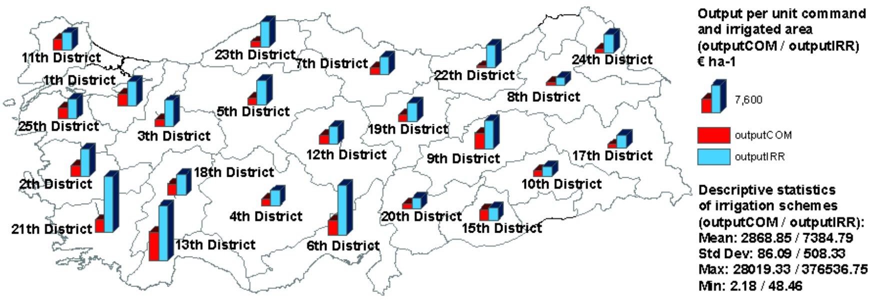

Figure 6. Output per unit command and irrigated area.

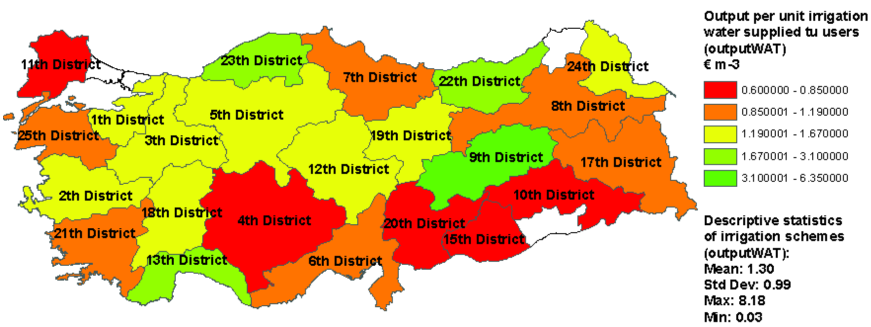

Figure 7. Output per unit irrigation water supplied to users.

Output per unit irrigation supplied to users can be seen as a measure of whether farmers are using the water efficiently or not. Average outputWAT was 1.60 € ha^{-1} within the districts. The highest value was seen in 9th District on average thanks to planting 42.93% of fruits. Average, maximum and minimum values were 1.30, 8.18 and 0.03 € ha^{-1} among irrigation schemes (Fig. 7). The maximum value was seen in Sarıgöl has crop pattern consist of almost 100% of the vineyard. When inputs (water) decrease and production increase the indicator go up. Irrigation efficiency and crop pattern play an important role in delivering water to users.

Average, IRREFF of the districts was 40%, the highest value was seen in 1th and 2td Districts and the lowest value was seen in 24th District. Mean value of IRREFF found in the current study was 0.45% same as the long term data according to reports (DSI, 2011), the highest value was 97 and min value was 0.04% according to calculations. Main system water delivers efficiency was 45% on average of all irrigation schemes between the study years (Fig. 8).

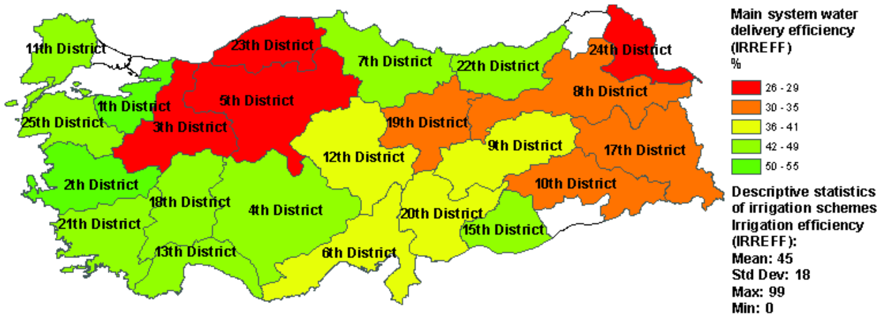

Figure 8. Main system water deliver efficiency.

Low irrigation efficiency was seen in the figure below for most of the irrigation schemes. Earth lined delivery system mainly used to deliver water. This causes that losing a lot of water before farmers get it. Average main system delivery efficiency is 55.84% for all irrigation schemes between the years (2011–2015). To improve water delivery efficiency, more pipe delivery system should be used by associations and farmers should courage to use drip, sprinkler etc. systems on their fields.

General view of water usage for the study period was given in Fig. 9. While water demand indicates (blue line) the total volume of water needed, water diverted (red line) demonstrate the total volume of water diverted or pumped from the source (dam, river, underground etc.) and water delivered (green line) point the total volume of water delivered to farmers. The graph shows WUAs consume water excessively which is about 2 times more than the water needed for irrigation.

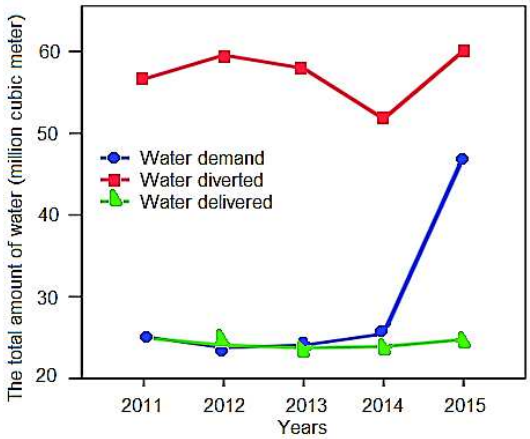

Figure 9. General view of water usage of the current study.

Statically assessment

Which panel method should be used such as fixed effects or random effects? One way of answering this question is concerning the nature of the data set. If the panel comprises observations on a fixed and relatively small set of units of interest, there is a presumption of fixed effects. If it comprises observations on a large number of randomly selected individuals, there is a presumption of random effects (Cottrell & Lucchetti, 2012).

To decide between fixed or random effects, a hausman test is run where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects. It tests whether the unique errors are correlated with the regressors, the null hypothesis is they are not (Torres-Reyna, 2007). According to the hausman test, fixed effect method is chosen if p-value smaller than 0.05, otherwise random effect method is chosen which is given in Table 4 and Table 5. P is an important value to choose which method should be used.

Table 4. Panel data analysis between performance indicators and attributes

Indicator		Water diversion	Management type	Source of water	District no	Hausman test P-value (model)
IRRINT	p-value	0.67	0.06*	0.39	0.27	0.10
	Coef	(0.81)	(11.35)	(0.73)	(0.27)	(Random)
IRREFF	p-value	0.44	0.02**	0.01**	0.03**	0.08
	Coef	(0.01)	(0.11)	(0.01)	(-0.003)	(Random)
WATIRR	p-value	0.51	0.65	0.30	0.23	0.87
	Coef	(-998.70)	(-2,455.65)	(-716.35)	(248.24)	(Random)
MOMCOM	p-value	0.03**	0.17	0.82	0.06	0.92
	Coef	(6.97)	(40.84)	(0.71)	(-1.69)	(Random)
outputIRR	p-value	0.09*	0.31	0.01**	0.90	0.39
	Coef	(-0.48)	(1.18)	(0.29)	(-0.004)	(Random)

IRRINT:irrigation intensity; WATCOM: annual irrigation water supplied to users per unit command area; WATIRR: annual irrigation water supplied to users per unit irrigated area; IRREFF: irrigation efficiency; MOMCOM: total MOM cost per unit command area; MOMIRR: total MOM cost per unit irrigated area; MOMWAT: total MOM cost per unit water supplied to users; outputCOM: output per unit command area; outputIRR: output per unit irrigated area; outputWAT: output per unit per unit water supplied to users; Significant level at *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$.

IRRINT is affected by WATIRR significantly negatively according to analysis but IRRINT increases 1%, WATIRR decrease just 0.0002 m^3 ha^{-1} which is very few. But the relation may be explained by using modern irrigation techniques decrease the usage of water and more area can be irrigated considering it may increase IRRINT. A similar situation was seen with IRREFF. Positive relation between IRREFF and outputIRR may explain where production more, water delivery systems are more improved. WATIRR is affected negatively by IRREFF and IRRINT, positively by MOMCOM and outputIRR. There is a positive significant relation between MOMCOM and IRREFF, WATIRR and negative significant relation with outputIRR. And IRREFF and WATIRR increase outputIRR considerably but MOMCOM expenditures decrease outputIRR.

Table 5. Panel data analysis among performance indicators

Indicator		IRREFF	WATIRR	MOMCOM	outputIRR	IRRINT	Hausman test *P*-value (model)
IRRINT	*p*-value Coef.	0.22 (5.00)	0.03** (-0.0002)	0.14 (0.006)	0.73 (-3.21e-05)	-	3.06e-006 (Fixed)
IRREFF	*p*-value Coef.	-	1.45-030*** (-8.60e-06)	0.56 (2.16e-05)	7.46e-05*** (3.72e-06)	0.22 (0.0005)	1.84e-05 (Fixed)
WATIRR	*p*-value Coef.	1.45e-030*** (-22,579.8)	-	0.01** (4.73)	7.93e-012*** (0.33)	0.03** (-46.19)	1.22e-077 (Fixed)
MOMCOM	*p*-value Coef.	0.056* (25.97)	0.01** (0.002)	-	0.052* (-0.002)	0.14 (-0.0002)	0.0003 (Fixed)
outputIRR	p-value Coef.	7.46e-05*** (6,807.86)	7.93e-012*** (0.23)	0.05* (-3.05)	-	0.73 (-5.85)	6.07e-025 (Fixed)

IRRINT: irrigation intensity, WATCOM: annual irrigation water supplied to users per unit command area; WATIRR: annual irrigation water supplied to users per unit irrigated area; IRREFF: irrigation efficiency; MOMCOM: total MOM cost per unit command area; MOMIRR: total MOM cost per unit irrigated area; MOMWAT: total MOM cost per unit water supplied to users; outputCOM: output per unit command area; outputIRR: output per unit irrigated area; outputWAT: output per unit per unit water supplied to users; Significant level at *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$.

CONCLUSION

According to this experimental study, the performance of WUAs during the period notably range among the districts due to climatic, social, economic, crop pattern, management type, source of water. Water delivered to crops is overused since low technology is used both management level and farm level. WUAs managed by DSI show low performance according to results. Irrigation management transfer may increase the performance of the WUAs. Modern delivery of water technology ought to be used to enhance irrigation efficiency and not to lose water. And another important view of the current study, data management and collection are very important for decision-makers and researchers to evaluate WUAs. Main water delivers efficiency can be increased by using pressurized irrigation systems. Policies, improvements and innovations show that Turkey will eventually handle the transition to these systems to do not waste water even a drop in the future. Finally, it would be advisable to more focus on the transition of irrigation schemes into pressurized irrigation schemes with help policy and organizational works such as interdigitate of water management, land consolidation, energy production and climate change precautions. Without a systematic process, inefficient management and data collection, convenient irrigation methods, irrigation schemes of Turkey will proceed slightly.

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