Water management in Ilgın Irrigation Association, Turkey

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Abstract

The aim of this study is to evaluate water management of period for 2010-2015 in Ilgın Irrigation Association (IIA), Turkey. In this context, in the relevant years, amount of irrigation water determined by our team was compared the amounts of water diverted to the irrigation system. Results show that 2014 and 2015 years except, irrigation water planning was realistic made in IIA. Relative irrigation supply (RIS) varied between 0.64 and 1.75 with a mean value of 1.33. When considered RIS threshold value of 1.5 specified for IIA, it was observed that irrigation water amount required in IIA were not supplied sufficiently in some years.

Keywords: Irrigation association, Irrigation water planning, Irrigation Ratio, Relative irrigation supply, Konya

Introduction

Water resources in Turkey are limited and unequally distributed in space and time. In Turkey, there are approximately 6.5 million ha of irrigated areas in today. Irrigated agriculture is still the largest water user in the country, using about 73% of all water resources (Anonymous, 2019a). However, the average irrigation ratio is 62% and the irrigation efficiency is 42% across Turkey, which is low (Anonymous, 2014; Eldeniz, 2016). Many studies conducted reveal that agriculture use excessive water in Turkey. In evaluation of irrigation performance, relative irrigation supply (RIS) is one of the most important indicators. According to Beyribey (1997), if the total RIS is equal to 1, the water is used as much as required in irrigation, if it is less than 1, irrigation water is provided inadequate and greater than 1, excess water is used in irrigation. For example, Nalbantoğlu and Çakmak (2007) reported that the total RIS for Akıncı Irrigation Association varied between 1.55–1.98 over the years and therefore the water used in the research area was above the requirement. Similarly, Kaya and Çiftçi (2016) reported that the total RIS in the Çumra Irrigation Association was between 2.35–3.42.

RIS is inverse of irrigation efficiency. Akkuzu and Mengü (2011) reported that irrigation efficiency in irrigation networks in operation in Turkey is considered as 50% and hence the RIS value should be at least 2. Akkuzu and Mengü (2011) reported that in Turkey, irrigation efficiency is considered as 50%, and hence RIS value should be at least 2. Akkuzu and Mengü

(2011) determined the average RIS values between 1.2 and 1.72 during the period from 2001-2008 in Alaşehir region. The researchers reported that the RIS values were less than 2 and that the irrigation water was not supplied sufficiently.

Konya basin has low annual precipitation (398 mm) (Anonymous, 2019b), high evaporation amount (1150 mm) (Munsuz *et al*., 1999) and 950–1000 mm reference evapotranspiration (ET_o) (Anonymous, 2019c). Therefore, irrigation is prerequisite necessary for agricultural production in the region. Moreover, most of evapotranspiration, about 80–90%, is compensated by irrigation because of low rainfall. The compensation rate of ET by applied irrigation was determined as at potato 85% (Yavuz *et al*., 2012), at confectionary pumpkin 82% (Yavuz *et al*., 2015), at sugarbeet 88% (Topak *et al*., 2016) and at oil sunflower 88–91% (Yavuz *et al*., 2018; 2019) for full irrigation conditions. In this study, in Ilgın Irrigation Association (IIA), during period from 2010–2015 water management was evaluated by years

Materials and Methods

Konya is located in the Central Anatolia Region, Turkey (Figure 1) and has a surface area of 40 838 km^2. It is the largest city in Turkey in accordance of land size. Konya is located between 36º 41' and 39º 16' northern latitudes and 31º 14' and 34º 26' east longitudes, with an average 1016 m above sea level. Middle Anatolia is the driest region in Turkey. About 50% of the region has rainfall between 250–400 mm. The other 50% of that has rainfall of between 401–500 mm (Çağlayan ve Ayhan, 2018).

There are a total of 338 irrigation organizations in the Konya region, including 16 irrigation associations and 322 irrigation cooperatives. Irrigation associations and irrigation cooperatives carry out the irrigation of 140 thousand hectares (Anonim, 2019d) and 143 thousand hectares (Anonim, 2019e), respectively. One irrigation scheme was selected for this study: Ilgın irrigation scheme, which is located in the Konya. Ilgın irrigation scheme cover an agricultural area of 5214 ha. The irrigation water for the Ilgın Plain scheme is provided by pumping from Cavuşcu dam with a total theoretical storage capacity of 240 million cubic meters. The Ilgın Irrigation Association (IIA) was established in 1995, and IIA serves to Ilgın irrigation scheme area since 1995.

Figure 1. Konya Province and study area in Turkey

Farmers have received irrigation water from the open channels. Cereals and sugar beets are main field crops in the study region. In addition to those two crops, corn and opium poppy are also common crops.

In this study, in IIA, irrigation water planning and management were evaluated for 2010-2015 period. In this context, taking into account the crop pattern, crop water consumptions and irrigation water requirements by years were determined with Cropwat8.0 software. The meteorological data used in the calculations were obtained from the General Directorate of Meteorology and given in Table 1. Irrigation water requirement determined by Cropwat software was compared with irrigation water requirement values planned by IIA. Additionally, amounts of irrigation water determined by our team was compared the amounts of water diverted to the irrigation system. For this purpose, relative irrigation supply (RIS) index was used as indicator (Levine, 1982).

$$RIS = \frac{\text{Irrigation supply (m3)}}{\text{Irrigation demand(m3)}}$$

The irrigation supply data are provided from State Hydraulic Works IV Regional Directorate and Ilgın Irrigation Association.

Table 1. Climate data used in the calculation of crop irrigation water requirement (Anonymous, 2017a)

Year/Month	Monthly Total Precipitation (mm)											
	1	2	3	4	5	6	7	8	9	10	11	12
2010	69,4	35,9	16,9	40,0	8,4	114,0	3,7	11,9	4,8	47,8	4,0	84,3
2011	57,6	41,4	44,1	32,7	73,0	52,2	0,3	2,1	0,9	67,4	13,6	37,0
2012	67,1	13,8	15,4	9,8	54,0	18,6	0,4	0,0	0,0	16,0	40,6	62,2
2013	65,6	39,8	31,0	42,2	50,0	2,2	29,4	11,4	7,2	28,0	27,6	4,8
2014	50,2	5,6	33,6	31,0	63,8	92,4	38,0	12,0	121,2	48,4	25,8	23,8
2015	34,4	61,0	75,2	36,0	76,8	77,6	7,2	30,0	6,4	8,0	11,2	0,7
Monthly Average Temperature (°C)												
2010	3,9	6,3	8,3	10,5	16,6	19,7	24,6	25,5	20,2	12,0	10,6	6,3
2011	1,1	1,5	5,3	9,4	13,5	18,4	24,9	22,4	18,0	9,7	1,6	2,4
2012	-2,1	-	3,7	13,7	15,1	22,0	25,2	22,1	19,7	14,4	8,3	4,5
2013	2,3	5,6	7,9	11,4	17,7	-	23,0	22,9	17,6	9,2	7,5	-2,5
2014	3,5	6,0	7,4	13,2	15,8	19,2	24,8	24,5	18,1	12,1	6,0	6,0
2015	1,0	2,6	6,4	8,4	16,4	17,8	23,0	23,0	21,00	13,6	6,9	-1,5
Monthly Average Maximum Temperature (°C)												
2010	8,5	11,6	15,3	17,6	24,4	26,7	31,9	34,5	29,1	18,6	19,5	11,3
2011	5,1	7,1	11,0	15,3	19,8	25,0	31,8	30,0	26,8	16,8	7,8	8,1
2012	2,5	-	9,9	20,7	21,1	28,7	32,7	29,6	28,4	22,2	12,8	8,8
2013	6,2	11,2	14,2	17,8	24,8	-	29,9	30,6	25,5	18,1	14,9	2,3
2014	8,3	13,2	14,0	20,0	22,5	25,9	31,8	32,7	25,5	18,7	12,0	10,7
2015	5,6	7,0	11,9	14,8	22,8	24,0	30,1	30,7	29,9	20,7	15,2	3,4
Monthly Average Minimum Temperature (°C)												
2010	0,1	2,1	1,9	3,7	8,1	12,7	16,2	16,6	12,2	7,0	4,4	2,5
2011	-1,9	-2,9	0,5	4,4	7,9	11,3	15,4	13,4	8,8	3,9	-2,9	-1,6
2012	-5,5	-5,8	-1,9	6,6	9,2	12,4	15,7	13,1	10,8	8,6	4,8	1,0
2013	-0,8	1,0	2,7	5,2	10,0	13,5	14,0	13,6	9,2	2,9	2,6	-5,4
2014	-0,3	-0,3	1,8	5,9	9,4	11,8	16,1	16,0	12,1	6,8	1,9	2,4
2015	-2,7	-1,2	1,5	2,6	9,8	12,0	13,9	15,3	12,8	8,1	1,4	-5,2
Monthly Average Relative Humidity (%)												
2010	72	65	58	64	53	57	51	43	50	67	55	68
2011	85	78	72	67	69	60	39	40	42	65	73	71
2012	84	70	60	46	62	44	37	41	41	62	76	78
2013	78	67	56	62	51	55	40	39	45	57	66	76
2014	78	61	61	49	54	53	39	39	58	72	74	77
2015	78	74	68	60	55	65	42	48	44	62	59	73
Monthly Average Wind Speed (m/s)												
2010	72	65	58	64	53	57	51	43	50	67	55	68
2011	85	78	72	67	69	60	39	40	42	65	73	71
2012	84	70	60	46	62	44	37	41	41	62	76	78
2013	78	67	56	62	51	55	40	39	45	57	66	76
2014	78	61	61	49	54	53	39	39	58	72	74	77
2015	78	74	68	60	55	65	42	48	44	62	59	73

Results and Discussions

Irrigation Ratio

In Ilgın Irrigation Association (IIA), the irrigated areas between 2010 and 2015 are given in Table 2. As seen Table 2, irrigation ratio occurred between 21.5% and 63.6%, average irrigation ratio was about 48.1%. When the Turkey's average irrigation ratio of 62% (Anonymous, 2014; Eldeniz, 2016) is taken into consideration, it is seen that the irrigation ratio

is lower in IIA. The reason for low irrigation ratios in IIA is the lack of sufficient water at the water source. Therefore during the period from 2010-2015, a large part of the Ilgın irrigation scheme area could not be irrigated due to lack of water.

Table 2. Irrigation ratios of the area (Anonymous, 2017b)

Years	Irrigation Area (ha)	Irrigated Area (ha)	Irrigation Ratio (%)
2010	5214	2837	54,4
2011	5214	1121	21,5
2012	5214	3193	61,2
2013	5214	2666	51,1
2014	5214	3316	63,6
2015	5214	1921	36,8
Average	5214		48.1

Irrigation water planning

In IIA, the crop pattern realized during the period from 2010–2015 is given in Table 3. The highest share in the crop pattern belongs to cereal and sugar beet, and the shares of these two plants varied between 73.2% and 91.6% by years. It is seen that there is no significant change in the plant pattern in the 6-year period.

Table 3. Crop pattern of irrigation association during the period from 2010–2015 (Anonymous, 2017b)

Crops	2010		2011		2012		2013		2014		2015	
	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)	Area (ha)	Ratio (%)
Cereals	1755	61.9	263.4	23.5	1813.5	56.8	885.6	33.2	2135.5	64.4	655.6	34.1
Legumes	18.3	0.6	3.7	0.3	2.0	0.1	4.4	0.2	4.6	0.1	11.8	0.6
Sugar Beet	841.4	29.7	675.9	60.3	1101.2	34.5	1180.0	44.3	721.8	21.8	750.2	39.1
Opium Poppy	1 40.4	4.9	16.1	1.4	65.0	3.9	2 15.3	8.1	180.3	5.4	195.0	10.2
Corn	29.1	1.0	95.8	8.5	124.4	0.3	2 36.3	8.9	145.5	4.4	174.7	9.1
Sunflower	-	-	-	-	3.0	2	36.9	1.4	21.9	0.7	3.3	0.2
Fruits	7	0.2	5.8	0.5	9.3	0.1	8.9	0.3	6.7	0.2	7.6	0.4
Vegetables	10.8	0.4	8.3	0.8	5.4	0.3	-	-	-	-	4.0	0.2
Potato	7.2	0.3	7.7	0.7	7.9	0.2	3.7	0.1	-	-	16.9	0.9
Forage Crops	27.8	1.0	44	3.9	60.8	1.9	92.9	3.5	97.7	2.9	99.4	5.2
Total	2837	100	1121	100	3192	100	2666.	100	3316	100	1920	100

During the period from 2010–2015, the irrigation water requirements of the crops cultivated in IIA was estimated using cropwat software by our team according to years and is given in Table 4. As it can be seen from Table 4, sugar beet is crop to be highest irrigation water

requirement and its irrigation water requirement change between 547 and 594 mm according to years. Irrigation water requirement is lowest for cereal

Table 4. Seasonal crop irrigation water requirements determined by Cropwat software (mm)

Crops	2010	2011	2012	2013	2014	2015
Cereals	202	72.4	188.5	162.5	158.2	123.9
Legumes	252.4	276.9	339.3	310.9	219.5	222.8
Sugar Beet	426.3	436.1	504.4	464	302.4	385.4
Opium Poppy	203.1	78.9	191.8	167.2	165.8	112.1
Corn	298.7	327.2	386.8	355.8	262.7	266.5
Sunflower	-	-	385.7	355.8	258.6	269.3
Fruits	318.9	267.9	400.4	325.0	195.7	256.2
Vegetables	419.9	401.7	471.7	-	-	341.8
Potato	353.4	360.3	425.8	395.1	-	297.6
Forage Crops	246.4	180.3	301	222.4	145.3	194.9

During the period from 2010–2015, net irrigation water requirements of the crop pattern was calculated according to years with cropwat software by our team and is given in Table 5. As it can be seen from the Table 5, it is seen that the net irrigation water requirements for crop pattern change between 208.9 and 323.8 mm by years.

Table 5. Net irrigation water requirements of the crop pattern in irrigation area (mm)

Crops	2010	2011	2012	2013	2014	2015
Cereals	125.04	17.01	107.07	53.95	101.88	42.25
Legumes	1.51	0.83	0.34	0.62	0.22	1.34
Sugar Beet	126.61	262.97	174.02	204.16	65.92	150.69
Opium Poppy	9.95	1.10	7.48	13.54	8.95	11.43
Corn	2.99	27.81	1.16	31.67	11.55	24.25
Sunflower	-	-	7.71	4.98	15.81	0.54
Fruits	0.64	1.34	0.40	0.98	0.39	1.02
Vegetables	1.68	3.21	1.41	-	-	0.68
Potato	1.06	2.52	0.85	0.40	-	2.68
Forage Crops	2.46	7.03	5.72	7.78	4.21	10.13
Total	271.94	323.82	306.16	318.08	208.93	245.01
Planned by IPIA	265.9	377.2	285.5	325.2	254.5	419.5

During the period from 2010–2015, the amounts of irrigation water planned in IIA and determined by our team are given in Figure 2 by years. As it can be seen from Figure 2, it is seen that irrigation water amounts determined by IIA and our team are about equal in 2010,

2011, 2012 and 2013 years. But, amounts of irrigation water planned by IIA are higher than the water values determined by our team in 2014 and 2015 years.

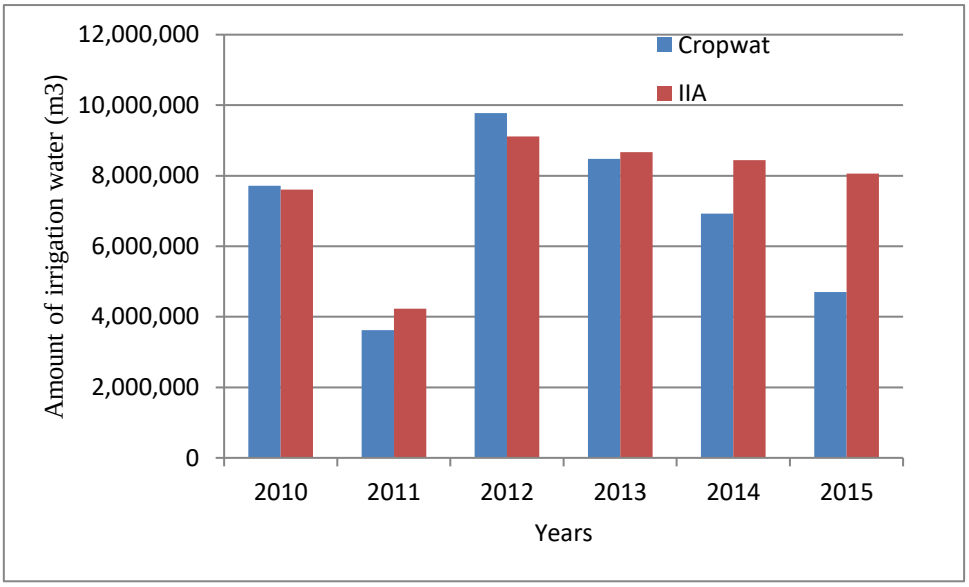

Figure 2. Net irrigation water amounts for irrigation area

In the irrigation association, volumetric values of net irrigation water amount planned by IIA in 2010–2015 period and the amount of irrigation water determined by Cropwat software are given in Table 6. According to Table 6, there is no significant difference between the amounts of irrigation water for 2010 and 2013. However, in 2011, 2014 and 2015 years, respectively 600 000, 1 500 000 and 3 350 000 m^3 more irrigation water was planned in IIA, while in 2012, 600 000 m^3 less irrigation water was planned.

Table 6. Net irrigation water amounts of irrigation area (m^3/year)

Years	Cropwat	IIA	Cropwat - IIA
2010	7 711 497	7 608 834	103000
2011	3 622 735	4 228 412	–606000
2012	9 774 464	9 116 015	658000
2013	8 480 330	8 669 832	–189000
2014	6 928 954	8 439 220	–1 511000
2015	4 705 417	8 058 595	–3 353000

Evaluation of irrigation adequacy

The amount of irrigation water supplied from the source for the period 2010–2015 in the IIA and the amount of net irrigation water requirement of the irrigation area estimated by

our team are given in Table 7. Taking into account the irrigation efficiency data of State Hydraulic Works Regional Directorate, the RIS threshold value for IIA was determined as 1.5 by our team.

Table 7. Relative irrigation supply according to Cropwat software

Years	Amount of Water Diverted to Irrigation System (m^3/yıl)*	Net irrigation water determined by our team (m^3/yıl)	RIS
2010	4900 000	7 711 497	0.64
2011	7100 000	3 622 735	1.96
2012	13100 000	9 774 464	1.34
2013	14800 000	8 480 330	1.75
2014	8225 000	6 928 954	1.19
2015	5040 000	4 705 417	1.07
Average			**1.33**

***:**Anonymous (2017b)

According to the table, the amount of water supplied from the source in 2010 and 2015 years is less than the net irrigation water requirement determined by our team (Cropwat software). In other years, the amount of water supplied to the irrigation system is higher than the net irrigation water requirement. As it can be seen from Table 7, RIS values ranged from 0.64 to 1.75 by years. When the RIS threshold value (1.5) is taken into consideration, it is seen that irrigation requirements were met in 2011 and 2013, but could not be sufficiently met in other years. Akkuzu and Mengü (2012) reported that RIS values vary between 0.91 and 1.72 in the Gediz Basin irrigation associations, and that there is insufficient irrigation in these irrigation associations because RIS is less than 2. In two different studies conducted in the Konya region, Eliçabuk and Topak (2017) determined that the RIS for the Gevrekli Irrigation Association varied between 0.46–1.0. The researchers reported that the RIS values were less than 1.4 and that the irrigation water was not supplied sufficiently. Yürekli and Topak (2018) reported that the RIS value for Ereğli Right Coast Irrigation Association was between 1.28–1.80, and when the RIS threshold value 1.0 was taken into consideration, excessive water was used in the irrigation association.

Conclusions

In this study, the water management of Ilgın Irrigation Association (IIA) was evaluated for 2010-2015 period. The following conclusions can be drawn from this study:

- Crop pattern is no sustainable.

- Irrigation ratio is about 48.1%. Therefore, 50% of IIA area could not be irrigated.
- RIS values ranged from 0.64 to 1.75 by years. When the RIS threshold value (1.5) is taken into consideration, it is concluded that irrigation requirements were not be sufficiently met in some years.

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