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MONITORING AND ASSESSMENT OF IRRIGATION MANAGEMENT IN A LARGE IRRIGATION PROJECT AREA

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ABSTRACT

This work undertaken is an attempt to quantify water budget elements and determine existing irrigation efficiency in a large irrigated area with plant patterns showing large variability. The study was carried out in the Lower Seyhan Plain irrigation area in the Southern Mediterranean coastal region of Turkey. During the two-year work realized in 2006 and 2007, the existing planting pattern consisted of corn, wheat, cotton, citrus and limited acreages of vegetables. The research findings showed that the irrigation efficiency in the study area was rather low, as 20.1% in 2006. Crop water use efficiency and drainage fraction was 28.7% and 56%, respectively, at the catchment level in 2006. In the second hydrological year (in 2007), crop water use efficiency and drainage fraction were found 42.0% and 46.6%, respectively. Because flow rate in the irrigation channels is based on the principle of continuous availability of water, the farmers are encouraged both day- and night-time irrigation. However, they commonly irrigate during daytime. Therefore, water flow in the channels was wasted as drainage water during night. The results imply that both irrigation management of water user association and irrigation methods adopted by the farmers in the area require urgent improvements if we are to decrease wasteful use of available fresh water resources. To this effect, the use of sprinkler and drip irrigation methods should be promoted by water authorities.

KEYWORDS:
Crop water consumption, drainage fraction, irrigation efficiency, irrigation water requirement.

INTRODUCTION

Irrigation is essential if shortages of rainfall and irregularity of rainfall season coincide with cropping season to ensure of getting high crop yields [1]. It should be noted that the irrigation practices may have some difficulties and problems, either on farmers' actual field-practice level or on management of the irrigation scheme. Lack of knowledge on plant water relations causes to accelerate challenges and difficulties in the agricultural water management at the catchment and field level. As such, farmers may not have the essential experience to decide on proper irrigation timing and quantity irrigation water to be applied, for getting not only good crop yields but also achieving sustainable irrigation practice. The irrigation systems and methods commonly used and/or adopted in irrigation areas have very low irrigation efficiency. Hence, large volume of irrigation water diverted to the irrigation command areas percolates below the plant-rooting zone and thus causes to rise groundwater table. In the areas with lack of proper drainage systems, soil salinization or even alkalinity in long run may develop, at the expense of degrading fertile soils. A field study by Cetin and Kirda [2] showed that excess irrigation water use caused an increase in the level of soil salinity. Irrigated agriculture is the sole area where future water allocation must be decreased to meet future increase of both municipal and industrial water demands.

Because of climate change phenomenon and its likely triggering of water shortages, water conservation and new management innovations for efficient and effective use of what is presently available must be implemented without delay [3]. It is well documented that available water resources per capita are decreasing due to increased temperatures because of global warming and/or climate change. Furthermore, global distribution of water resources is unfortunately not uniform over space and time. Some countries are fortunate for having excess rainfall, but some are faced to long periods of droughts. Hamdy et al. [4] reported that 80 countries with 40% of world's population have serious water shortages, not for irrigation, for drinking and municipal use as well. Groundwater and surface water resources available in Turkey annually add up to 112 km^3, on average, which shows large year-to-year variability [5]. Hydrologic drought experienced in recent years influenced nearly all sectors, from agricultural production to household needs in Turkey. Significant saving of water resources can be achieved if proper irrigation methods as well as rational irrigation water management techniques are developed for effective and efficient use of water resources allotted for agricultural uses [6, 7].

Water demand for agricultural sector, namely irrigation, are getting increased year by year similar to demands by municipal and industrial sectors, and consequently, agricultural sector uses nearly 74% of

available water resources in Turkey [5]. On the other hand, increased demands for municipal and industrial water use have to be met at the expense of decreasing allotment of water to the agricultural sector. Therefore, sustainability of irrigated agriculture is questioned considering pollution of both surface and groundwater resources, wide spread of irrigation practices with no concern of efficiency and effective use of irrigation water, likely development of drainage and soil salinity problems [3]. Although globally World's surface is covered with 71% water, only 0.64% of that is fresh water. There is increased pressure for decreasing amount of water allotted to agricultural sector. Therefore, water allocated for irrigated agriculture must be used very efficiently and effectively in arid and semiarid areas. In areas where groundwater table is close to soil surface, low irrigation efficiency would further worsen the situation and cause to increase groundwater table, and accelerate soil salinity development [8, 9] particularly in the very plain areas located in Mediterranean region.

Lower Seyhan Plain is among the most important irrigated area, in Southern Turkey, along the Mediterranean coast. The area was first opened to irrigation following the construction of Seyhan Regulator in 1942. The irrigated area increased further following the construction of the Seyhan Dam in 1956 [10]. Soon after the area was opened to irrigation, problems such as drainage, soil salinity and alkalinity were observed not only in the irrigated parts, but also in non-irrigated areas located in downstream. Seepage water coming from upland irrigated sites increased groundwater table and caused salinity, even in non-irrigated areas. It is widely accepted that irrigation efficiency nearly in all irrigated areas in Turkey is low and irrigation methods and management must be critically evaluated to improve the unwanted situation. This work was undertaken to: a) evaluate the existing irrigation management status causing low irrigation efficiency in a large area, b) attempt to identify problem areas to focus for improving existing irrigation management practice.

MATERIALS AND METHODS

The research work was conducted in the area of Akarsu Irrigation District (AID) in Adana, Turkey, along the Mediterranean coastal area (Figure 1). Total area of the irrigation district, located in the Seyhan Lower Seyhan Plain, was about 9 495 hectares, of highly fertile agricultural soils. Agricultural practices in the area with mostly two even tree crops annually is very intense. Geographically it lies within 36º 57′ 32″ – 36º 50′ 43″ north latitudes and 35º 40′ 22″ – 35º 28′ 42″ east longitudes. The research area has been under irrigation over 60 years. The irrigation management task, which was initially administered by State Hydraulic Works, was transferred to AID in 1994.

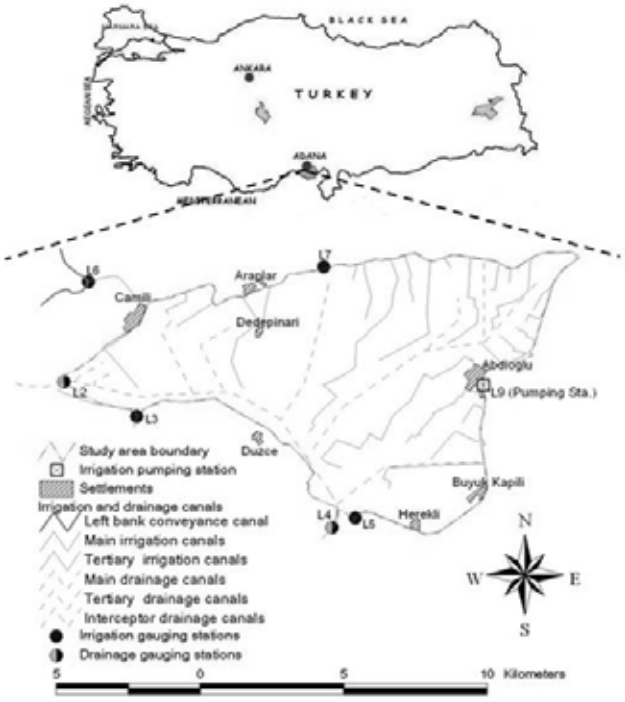


FIGURE 1
Location of the study area in Turkey; irrigation and drainage gauging stations in the study area.

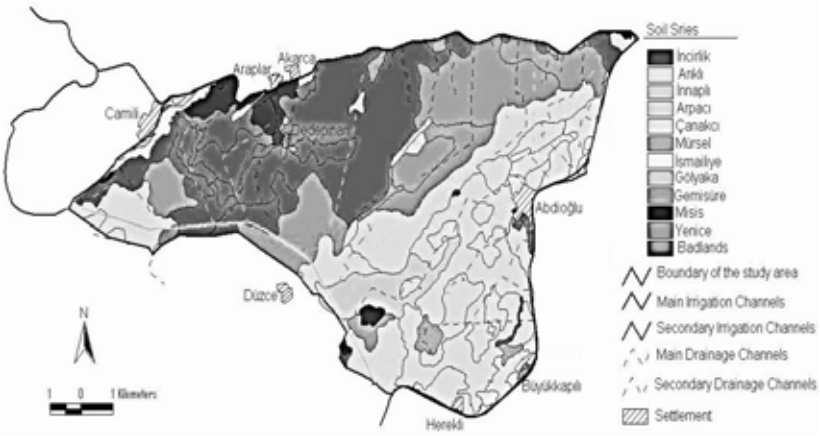


FIGURE 2
Spatial distribution of the soil series in the Akarsu Irrigation District (AID).

The major soil series present in the area (Figure 2) was Arikli (30%), Incirlik (27%) and Yenice series (14%) [11]. Others were Ismaliye (0.9%), Golyaka (0.5%) and Innapli series (0.4%).

The climate in the area was typically Mediterranean with hot and dry summers and cool and rainy winters. Long-years average temperature (60 years) was 18.8 °C. August is the hottest with 28.1 °C and January was coolest with 9.9 °C in the study area. Almost fifty percent of total annual rainfall occurs in winter months. Annual average rainfall is 649.5 mm in the area. However, rainfall distribution over the year shows wide variability. Humidity increases up to 96% in summer months. However, the humidity in winter is low. Due to the lack of precipitation and increasing temperature in summer months, irrigation generally starts in early April and ends in late October in the region.

Data sources and collection. The research work and data collection were carried out in 2006 and 2007 hydrological years.

The sides of irrigation water intake, and drainage inflows and outflows were determined by using topographical maps and detailed field works. Flow measuring stations (FMS) were constructed for both determining water volume diverted for irrigation and drainage inflows and outflows (Figure 1). Volume of irrigation water diverted into the area was measured at FMS of L3, L6, L7 and L9. Drainage inflows and outflows were measured at L2 and L4, respectively. The FMS at L5 was for measuring irrigation flows leaving the study area. In summary, the data collected from FMS provided the basis for calculating actual or net volume of irrigation water used in the study area. Additionally, groundwater depths collected from 107 drainage observation wells in 2006 and 2007, distributed more or less homogeneously over the study area, were used for assessing changes in water table in a hydrological year, starting 1st of October and ending 30th of September in the following year.

Water balance. The reference evapotranspiration (ETo) needed for estimation of crop evapotranspiration (ETc) was calculated using FAO Penman-Monteith model [12]. Basic hydrologic water balance equation, given below, was applied in this study. Graphical presentation of water balance elements was given in Figure 3.

$$P + (I_{in} - I_{out}) - (D_{out} - D_{in}) - ETc = \frac{\pm \eta \Delta h}{10^4} \times A(ha) \quad (1)$$

Where; P is rainfall (m^3), (I_{in}-I_{out}) is the net irrigation water (m^3) diverted into the area, (D_{out}-D_{in}) is net drainage water (m^3) generated solely by the hydrologic catchment, ETc is crop water use (m^3), Δh is the change in groundwater table depth (cm), η *is* average porosity (%) of the soils in the study area, and A is the area (ha) considered. In this study, it was assumed that deep percolation (G_r) is equal to capillary rise (G_c), i.e. equilibrium in the hydrological year.

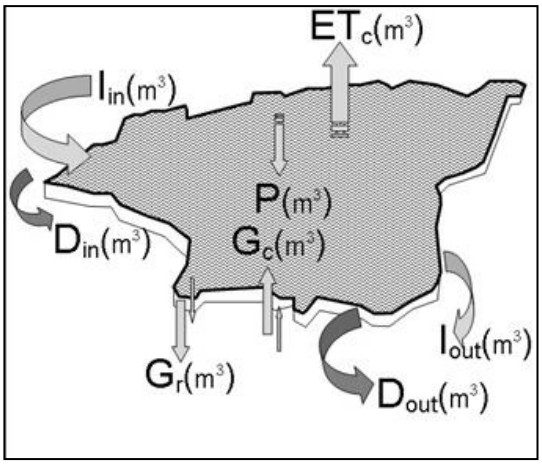


FIGURE 3
Elements of water balance study in the Akarsu Irrigation District (AID).

District irrigation efficiency. The following equation was used for calculation of irrigation efficiency at the district level.

TABLE 1
Temporal changes in cropping pattern (%) in Lower Seyhan Plain (1964-2000).

Crops	Projected	1964	1974	1985	1995	2000
Wheat	13	-	0.6	2.9	1.0	0.04
Vegetable	15	-	0.3	1.1	2.0	2.82
Melon and W. Melon	1	-	0.6	7.4	5.0	4.66
Cotton	35	94	96.5	50.3	35.0	9.98
First Crop Maize	-	-	0.1	9.0	40.0	56.43
Second Crop Maize	-	-	-	-	-	5.22
Citrus	8	1.0	1.0	2.7	10.0	11.28
Fruits	-	2.0	0.4-	5.9	6.0	4.58
Legumes (soybeans)	-	-	-	17.6	-	1.44
Peanut	3	-	-	-	-	0.85
Onion and Garlic						0.59
Alfalfa	20	-	-	-	-	0.04
Rice	5	1.0	0.4	1.4	-	
Others		2.0		1.7	1.0	2.07
TOTAL	100	100	100	100	100	100

$$DIE = \frac{(ETc - P)}{I} \times 100 \qquad (2)$$

Where, *DIE* is irrigation efficiency (%) at the district level; ETc, crop water consumption (mm); P, rainfall (mm), and I, total irrigation water diverted into the area (mm).

Water use efficiency. Overall crop water use efficiency in the study area is estimated using the equation:

$$WUE = \frac{ETc}{(I + P)} \times 100 \qquad (3)$$

Where; WUE is crop water efficiency (%), ETc is crop water consumption (mm), P is rainfall (mm) and I is defined above.

Drainage fraction. The following equation was employed to define drainage fraction (DF, %) for a given period under the existing irrigation management.

$$DF = \frac{Q}{(I + P)} \times 100 \qquad (4)$$

Where; Q is net drainage ($Q=D_{out}-D_{in}$ in Equation 1, mm) generated by the irrigation catchment; I and P are net irrigation ($I=I_{int}-I_{out}$ in Equation 1) and precipitation, respectively, in the unit of mm.

RESULTS

Changes in cropping pattern in previous years were summarized in Table 1. Cotton crop (*Gossypium hirsutum L.*) covered the largest area (Table 1) in early years when the area was opened to irrigation. However, cotton planted areas diminished by the years. On the other hand, first and second crop corn (*Zea mays L.*) grown areas increased remarkably in 1990s. In 2006 hydrological year, based on the acreages, corn was the preponderant crop in AID, with first crop being 41.9% and the second crop corn was 6% (Figure 4). Following corn, the areal coverage of orchards was 21%, wheat 18.9 % and cotton was only 8%. In 2007 hydrological year, the largest acreage of plant in the Akarsu Irrigation District was winter wheat, covering a total area of 3 238 ha (34.1%) (Figure 5). As seen in Figure 5, corn was the dominant irrigated crop in summer, planted either as a first crop (29%) or as a second crop (5%) following winter wheat (34.1%). Cotton was planted only 9% as one of the major irrigated crops, although it was nearly the only crop, covering more than 90% of Lower Seyhan Plain in 1980s and in low 1990s. The coverage of citrus orchards (26%) follows the 1st crop corn. Minor crops which were dubbed as "others" consisted of garlic, onion, potatoes, etc.

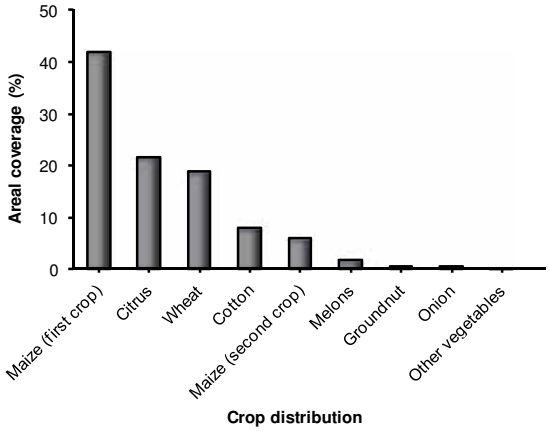


FIGURE 4
Areal distribution of crops grown in Akarsu Irrigation District in 2006.

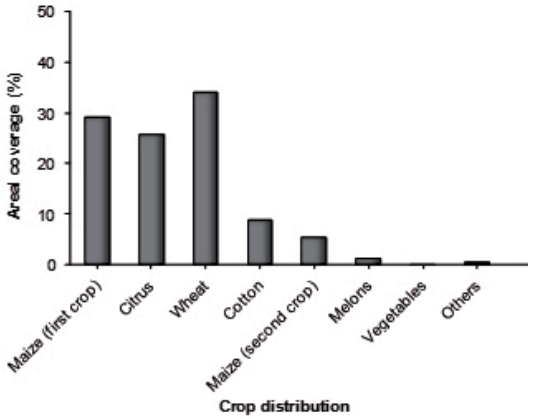


FIGURE 5
Areal distribution of crops grown in Akarsu Irrigation District in 2007.

Water depths in the canal cross-sections at the gauging stations were recorded every ten minutes and hourly averages were calculated. Then, data of water depth measurements were converted to flow rates (m^3 s^{-1}) through using rating curves [i.e., Q=f(h)] developed for each gauging station. As expected, every flow gauging station has its own specific rating curve. Figure 6 shows an example of such a rating curve developed for L6 in Figure 1.

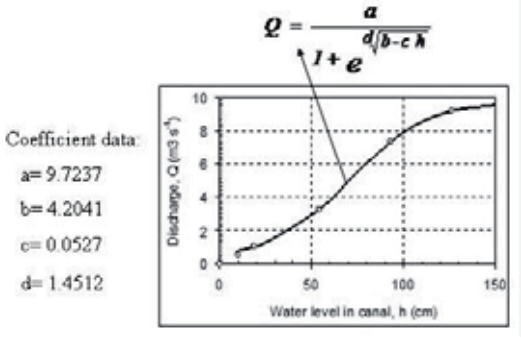


FIGURE 6
The best fitted calibration (rating) curve developed for the cross-section of L6 in the Akarsu Irrigation District.

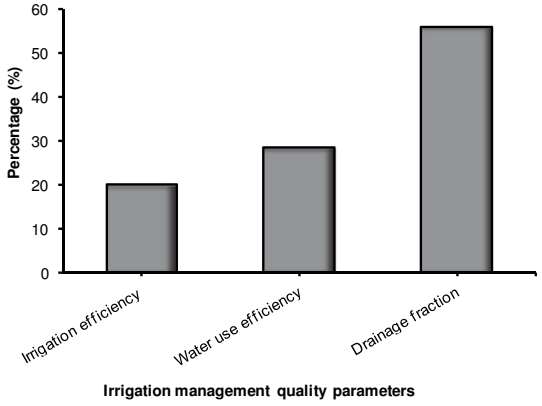


FIGURE 7
Irrigation system management parameters in the Akarsu Irrigation District (AID) in 2006 hydrologic year.

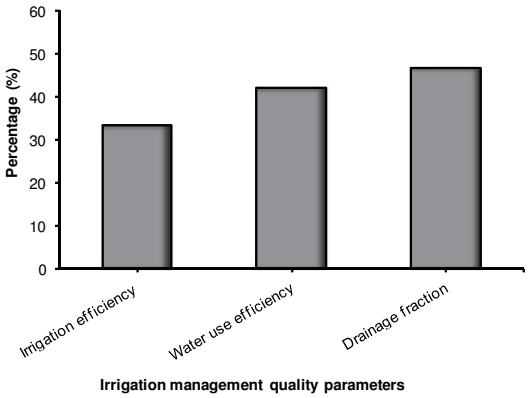


FIGURE 8
Irrigation system management parameters in the Akarsu Irrigation District (AID) in 2007 hydrologic year.

Based on the actual measurements at the flow rate gauging stations, net irrigation water amount diverted into the AID area was 996 mm, net drainage outflow was 625 mm in the hydrological year of 2006. However, crop evapotranspiration, ETc, was estimated as 320.7 mm, and the rainfall measured was 120 mm in the same period. These figures indicate clearly that diverted net irrigation water is rather high in comparison with the crop evapotranspiration, in 2006.

Assessment of the existing irrigation management in the area might be done by using district irrigation efficiency (DIE), crop water use efficiency (WUE) and the drainage fraction (DF) during irrigation season as well as hydrological year. As seen in Figure 7, irrigation efficiency was surprisingly and disappointingly low (20.1%) in the 2006 hydrological year. Similarly, crop WUE was extremely low and only 28.7%. On the other hand, drainage fraction DF, showing percentage of irrigation water flowing out of the area, was as high as 56% (Figure 7). High DF in the irrigation season implies that 56% of available water (net irrigation water plus rainfall amount in the catchment) was simply wasted as drainage in the catchment. Meteorological data showed that the amount of rainfall was almost nil in the irrigation season. This means that DF during the irrigation season is directly percentage of irrigation water wasted in the drainage canals in the catchment. The high DF is an indication of poor irrigation management in the district.

In the 2007 hydrological year, the district irrigation efficiency was only 33.4% during the hydrological year. However, DIE, to some extent, increased during the irrigation season (Figure 8). It implies that the net irrigation water diverted to the Akarsu ID was wasted as drainage outflows during irrigation season, giving a drainage fraction (DF) as high as 46.7%. DF remained constant during irrigation season (IS) and non-IS, indicating that there is a room for improving DIE in the IS due to the fact that rainfall in wet season cannot be

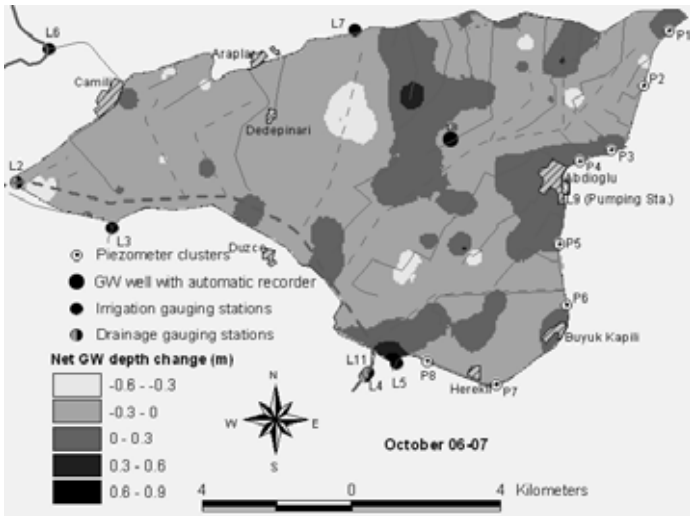


FIGURE 9
Spatial distribution of net GW depth change in 2006 and 2007.

TABLE 2
The terms of the water balance calculations in 2007

The terms of the water balance	Hydrologic Year	Irrigation Season (IS)	Non-IS
Irrigation (I, mm)	1014.0	941	73
Precipitation (P, mm)	675.8	180	495.8
Crop's ET (ETc, mm)	709.8*	532.6	177.2
Surface drainage (Q, mm)	788.3	523.2	265.1
Change in groundwater depth (ΔGWD, mm)	-67.4	-	-
Change in soil water storage in 0.90 m (ΔSWD, mm)	-4.0	-	-
Net subsurface lateral flows (D or SLF, mm)	+1.6	-	-
Water balance [ΔW=I+P+LSF-ETc-Q]	193.3 (12%)[a]	65.2 (6%)[a]	126.5 (22%)[a]

*Based on reference evapotranspiration (ETo) estimated with FAO Penman Monteith method and adjusted with relevant crop coefficients [12].
[a]Percentage based on inflows for the period considered

controlled by irrigation management, i.e. Akarsu Water User Association, but net diverted irrigation water. DF was improved to some extent in 2007, compared to DF of 56% obtained in 2006. The irrigation scheme in the Akarsu ID is managed based on "continuous flow system" under which there is always water flow existing in secondary and tertiary irrigation channels, and the growers and/or irrigators are supposed to continue irrigating crops by day and night. Unfortunately, the growers generally irrigate their fields during daytime and therefore irrigation water in the system is simply lost as drainage outflows, i.e. irrigation return flows, during the night. As a matter of fact, drainage flows generated by night are direct by-pass flows in the district. On the other hand, there is endless complain from the growers that their shareof irrigation water is not enough. Because of low water use efficiency and high drainage fraction, irrigation management authorities should undertake some measures immediately. At least, irrigation technicians may continually check tail waters at the end of secondary and tertiary canalette system for the sake of saving irrigation water for the farmers in downstream parts of the district.

The irrigation management pursued in the AID area was based on continues availability of water in the irrigation channels, including all seconder and the tertiary channels. Because irrigation water is available all the time, the growers are encouraged irrigation during both day and night time to increase irrigation efficiency. However, growers prefer day time irrigation for convenience, and thus water in the irrigation channels simply is wasted as drainage water during night. High DF in IS indicates low DIE at the catchment level. Therefore, growers continuously complain of low flow rates in the channels and inadequacy of irrigation water allotted to them. Research results reveal clearly that DIE can be improved through taking logical measures by irrigation management authority.

Water depth equivalent (areal GW depth change multiplied by soil porosity) of net GW depth change (ΔGWD, groundwater depth in 2006 minus groundwater depth in 2007) in 2007 was found to be ΔGWD=-67.4 mm, indicating a decrease in GW table level. Spatial distribution of net GW depth change in 2007 was depicted in Figure 9. It could be concluded that availability of main and secondary

drainage canals and drainage network density had played a major role in decreasing GW reserve. As seen in Figure 9, change in GW depth is subject to spatial variability, indicating the effects of cropping pattern and anthropogenic intervention over the agricultural catchment.

Similarly, net change in soil water storage (ΔSWD, soil water storage in 2007 minus soil water storage in 2006) was -4.0 mm per 0.9 m soil depth, indicating a decrease of stored water in plant rooting depth during the hydrological year 2007. It should be kept in mind that the changes in soil water storage between GW table level and plant rooting depth, i.e. in the capillary fringe zone, could not be considered in this study. At the end of hydrological year 2007, the areal average of GW table depth was about 1.55 m. However, GW table was within the rooting zone in winter and summer months, indicating that GW is recharged by rainfall in winter and irrigation water applications in summer.

As seen from Table 2, water balance calculations resulted in 193.3 mm error of closure in 2007 hydrological year. One third of this value occurred during irrigation season (IS) while the remaining portion (2/3 of the error term) was during the non-irrigation season (NIS). Although this error balance term might be attributed to various unknown and/or unmeasured losses including year-round evapotranspiration of intensively growing crops in drainage canals and also evaporation from water surfaces along the irrigation and drainage canals during the hydrological year. Due to the difficulties and uncertainties in partitioning of water budget elements, the shares of water consumption of the crops growing in the drainage canals and free water surface evaporation from the irrigation scheme could not be determined in this study. It is also worth noting that the share of cultivated area was only about 60% of the Akarsu ID during fall and winter seasons, indicating that almost 40% of the arable areas were uncultivated in the dormant season. Evaporation from the uncultivated areas was also calculated and considered within bare soil evaporation. Furthermore, we were able to establish only one meteorological station in the center of the Akarsu ID with the expectation that the measured rainfall amount in the station fully represents the areal rainfall over the entire district. However, during the fieldwork, we often noticed localized precipitation events within a few kilometers neighborhood. The water stored in the 65 cm soil depth -which was calculated as the soil layer thickness between 90 cm root zone and 1.55 m average GW depth- which was overlooked in water balance calculations, might also be contributed to the some major parts of that error balance term of water balance in 2007 (Table 2). Additionally, water use in urban areas, as well as dairy farms which may be potential contributors of the error term in the water balance, were not considered in this study.

DISCUSSION

During the early period when the area was opened to irrigation, cotton was the preponderant crop (Table 1) in the region. Çetin and Özcan [10] showed that up until 1978, cotton was the only crop in the area, indicating mono cropping system adaptation. However, planting of corn crop, soybean and sesame was after 1980s. In the 2006 hydrological year, the largest acreage was devoted to corn crop (Figure 4). Fifty six percent of irrigation water and rainfall received in the area was wasted as drainage water in the catchment. A similar work carried out by Isidora et al. [13] in Spain showed that over 70% of irrigation water and rainfall received in an irrigated area was wasted as drainage water. Rather high drainage fraction as was the case in this work showed that irrigation efficiency was very low and thus new irrigation methods and irrigation systems modernization must be adopted to increase DIE. An earlier work by Çetin and Özcan [10] also showed that irrigation efficiency under the existing management was 35-40% in the region. Crop water use efficiency (WUE) was only 28.7% in the 2006 hydrological year (Figure 7) showing that irrigation water was applied more than actual crop water requirement. Low values of district irrigation efficiency show that excess irrigation water applied and methods of irrigation must be improved [14]. Additionally, irrigation management should overview existing management regime to improve WUE and DIE against high DF. A study by Çakmak and Aküzüm [15] showed that nearly all irrigation projects in Turkey have low irrigation efficiency, which suggests that excess irrigation practice in Turkey is a common problem. The reason may be the policy of irrigation water pricing. In most of the irrigation project areas, the pricing is based on the crop type and area of irrigation not based actual volume of used. In early season the agency managing the irrigation scheme simply records the areas planted to different crops. Unit area of each crop irrigated has a different water price in Turkey due to the fact that water user associations have large flexibility to determine water prices. On the other hand, total irrigation cost is calculated by simply multiplying total area with the unit price attributed to the specific crop. It is up to the growers how much water they apply and how many times they irrigate. It constitutes a contradiction that cost does not change by irrigation volume applied, but the crop type.

Although all the terms of the water balance equation was directly measured, zero error in the balance could not be achieved owing to the large size of the study area and the inheritance stochastic behavior in the water balance elements, i.e. rainfall and evapotranspiration. Isidoro et al. [13] also offered similar argument for the errors observed in water balance work.

CONCLUSION

This study was carried out in Akarsu Irrigation District with 9 495 hectares of irrigated area having both irrigation and drainage systems over 60 years. The district is on the delta plain of the Seyhan River in Adana, Turkey. The irrigation methods used in the area are commonly surface irrigation methods of low irrigation efficiency. Because of problems in irrigation management, low irrigation efficiency, excess irrigation water application, heavy clay soil texture and inadequate field drainage endanger sustainability of irrigation practice in the area. Groundwater table in the area has increased soil salinity which may cause loss of soil fertility irreversibly. Therefore, this work undertaken here aims at assessing irrigation management for identifying the areas of focus for improving irrigation practice in the area. The results showed that both district irrigation efficiency (DIE) and crop water use efficiency (WUE) achieved under the existing irrigation practice was extremely low. The major cause of the problem was excess irrigation water application due to the fact that irrigation water pricing was based on crop type and area, but not the volume. Furthermore, technical sufficiency of irrigation management was not enough to improve efficiencies at the district level. In order to overcome low DIE and WUE against high DFs, surface irrigation methods must be replaced with sprinkler or drip irrigation systems of high irrigation application efficiency. It was noted that nearly 60% of irrigation water diverted into the area was wasted in the drainage system and flowing out of the area as tail and/or bypass water in the channels. This can be minimized with promoting night irrigation. Alternatively, the continuous irrigation water supply in the channels might be modified so that during nights, when actual field irrigations are discontinued, the flow rates may be reduced. In order to sustain soil fertility, renovating field drainage systems is urgently needed to control water table at the catchment level.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Zou, W., Lu, X. and Han, X. (2017). Effect of irrigation regime on soybean biomass, yield, water use efficiency in a semi-arid and semi-humid region in northeast China. Fresen. Environ. Bull., 26 (3), 1865-1875.

[2] Cetin, M. and Kirda, C. (2003). Spatial and temporal changes of soil salinity in a cotton field irrigated with low-quality water. Journal of Hydrology, 272, 238–249.

[3] Büyükcangaz, H., Değirmenci, H. (2002). Drenaj sularının sulamada yeniden kullanılması. (in Turkish), Su Havzalarında Toprak ve Su Kaynaklarının Korunması, Geliştirilmesi ve Yönetimi Sempozyumu 18-20 Eylül 2002, Antakya/Hatay, 614-617.

[4] Hamdy, A., Ragap, R. and Scarascia-Mugnozza, E. (2003). Coping with water scarcity: Water saving and increasing water productivity. Irrigation and Drainage, 52, 3-20.

[5] Çetin, M., Kırda, C., İbrikçi, H., Topçu, S., Karaca, Ö.F., Karnez, E., Efe, H., Sesveren, S., Öztekin, E., Dingil, M. and Kaman, H. (2008). Using geographic information systems (GIS) media to determine water, salt and nitrate budget elements in areas of irrigated agriculture: A case study in the lower seyhan plain. (in Turkish with English Abstract), 5. Dünya Su Forumu Bölgesel Hazırlık Süreci DSİ Yurtiçi Bölgesel Su Toplantıları Sulama-Drenaj Konferansı Bildiri Kitabı, 10–11 Nisan 2008. Adana, (2008) 173–183.

[6] FAO (2001). Drainage and sustainability. IPTRID Issues Paper No. 3, Food and Agriculture Organization of the United Nations, Rome, Italy.

[7] FAO (2002). Crops and drops: Making the best use of water for agriculture. Food and Agriculture Organization of the United Nations. Rome, Italy.

[8] DSİ (1982). ASO IV. Merhale Projesi Planlama Drenaj Raporu. (in Turkish), Ankara.

[9] Cetin, M. and Diker, K. (2003). Assessing drainage problem areas by GIS: a case study in the Eastern Mediterranean Region of Turkey. Irrigation and Drainage, 52, 343–353.

[10] Çetin, M. and Özcan, H. (1999). Problems encountered in the irrigated and non-irrigated areas of the Lower Seyhan Plain and recommendations for solution: A case study. (in Turkish with English Abstract) Turkish Journal of Agriculture and Forestry, 23 (Suppl. 1), 207–217.

[11] Dinç, U., Sarı, M., Şenol, S., Kapur, S., Sayın, M., Derici, M., Çavuşgil, V., Gök, M., Aydın, M., Ekinci, H., Ağca, N. and Schlichting, E. (1995). Çukurova Bölgesi Toprakları. (in Turkish) Çukurova Üniversitesi Ziraat Fakültesi Yardımcı Ders Kitabı, No 26, Adana.

[12] Allen, R.G., Pereira, L.S., Raes, D and Smith, M. (1998). Crop evapotranspiration. Guidelines for computing crop water requirements. Food and Agricultural Organization of the United Nations, Irrigation and Drainage Paper 56, FAO, Rome, pp.300.

[13] Isidoro, D., Quilez, D. and Aragues, R. (2004).

Water balance and irrigation performance analysis: La Violada Irrigation District (Spain) as a case study. Agricultural Water Management 64, 123–142.
[14] Denli, H.H. and Denli, G.O. (2017). The use of soil and water resources at the Mediterranean region in Turkey. Fresen. Environ. Bull., 26 (1), 520-526.
[15] Çakmak, B. and Aküzüm, T. (2006). Problems and solution proposals for water management issues in agriculture, Turkey. (in Turkish with English Abstract), TMMOB İnşaat Mühendisleri Odası Su Politikaları Kongresi, Ankara, 2, 349-359.

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