Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. VI, 2017
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

BENCHMARKING PERFORMANCE OF LARGE SCALE IRRIGATION SCHEMES WITH COMPARATIVE INDICATORS IN TURKEY

Hasan DEĞİRMENCİ, Çağatay TANRIVERDİ, Fırat ARSLAN, Engin GÖNEN

Kahramanmaras Sutcu Imam University of Biosystem Engineering, 46100 Kahramanmaras, Turkey

Corresponding author email: ctanriverdi@ksu.edu.tr

Abstract

Irrigation management is one of the key factors for the sustainability of irrigated agriculture. There has been a good number of performance indicators developed for the assessment of irrigation schemes. DSI (State Hydraulic Works) datas for 5 years (2011-2014) were used to calculate indicators of irrigated agricultural output. The most important one among them is the four basic comparative performance indicators related output to unit land and water. These "external" indicators provide the basis for comparison of irrigated agriculture performance. Comparative indicators are the output per cropped area ($/ha), output per unit command ($/ha), output per unit irrigation supply ($/m^3), and output per unit water consumed ($/m^3). In this paper, obtained the data that regarding irrigated cropped area, production, which are the output of the irrigated area in terms of gross or net value of production measured at local prices, command area, diverted irrigation supply, volume of water consumed by ET. This data were used to calculate comparative indicators. This study, in three climatic zones (Continental, Mediterranean and Black Sea) fourteen irrigation schemes, more than 20.000 ha of command area for each scheme, were assessed. Irrigation schemes were classified with regard to crop pattern. As a result of the study, based on the 2011-2014 years output per unit command area, output per cropped irrigated area, output per unit irrigation supply, output per unit water consumed were determined as 1040-7669 US$/ha, 2387-10129 US$/ha, 0.13-1.38 US$/m^3, and 0.60-2.29 US$/m^3, respectively. Calculated comparative indicators compared with each irrigation scheme's crop pattern and climatic zone. In addition, results compared with irrigation schemes in similar climatic zone with similar crop pattern. In conclusion, it was determined that crop pattern is the most effective factor to success of irrigation schemes.

Key words*: comparative indicators, cropping pattern, irrigation scheme, irrigated area, production*

INTRODUCTION

Agriculture is the major source of livelihood and employment in developing and underdeveloped countries. 70% of the water used in the world is used in the irrigation. Irrigated agriculture has vital importance in underdeveloped countries. The use of technology in the transmission and distribution of irrigation water in underdeveloped countries is very low. The main problems are the irrigation ratio and the low irrigation efficiency. Irrigation ratio of irrigation schemes in Turkey is 62%. The irrigation schemes in Turkey have low irrigation efficiency.

The total surface area of Turkey is 78 million hectares (783.577 km^2), 28 million hectares of which are cultivable agricultural lands. In 2014, a total of .6.09 million hectares of land has been put into operation in Turkey. Of the irrigation areas put into operation, approximately 81% of them are irrigated by surface water resources, while the remaining 19% of them by underground water resources. In Turkey, the management of irrigation schemes has been assigned to the water user organizations since 1994. According to this irrigation management assignment scheme, the irrigation areas that were previously run by the state have been assigned to the irrigation associations (89.1%), cooperatives (5.1%), municipalities (3%), legal village entities (1.6%) and the unions of village delivery service (0.9%) (DSI, 2015).

Four basic benchmarking indicators developed by Molden et al. (1998) are used in this study. These indicators are related cropped area, command area, irrigation supply, water consumed and evapotranspiration. Various studies are conducted in the World and Turkey (Kukul et al., 2008; Cakmak et al., 2010; Uysal and Atis, 2010). Senerve Albut (2011) used comparative indicators in 10 irrigation schemes in Trakya region in Turkey. In this study output per unit command area, output per cropped

irrigated area, output per unit irrigation supply and output per unit water consumed were determined as 106-7498 US$/ha, 999-3947 US$/ha, 0.06-1.29 US$/$m^3$, and 0.12-0.63 US$/m^3, respectively.

Djen et al. (2011) used comparative indicators in two irrigation schemes in Ethiopia. In Golgota Irrigation Scheme, output per unit command area, output per cropped area, output per unit irrigation supply and output per unit water consumed were realized 9.212 US$/ha, 12.999 $/ha, 0.48 $/$m^3$ and 0.86 US$/$m^3$, respectively. In Wedecha Irrigation Scheme, output per unit command area, output per cropped irrigated area, output per unit irrigation supply and output per unit water consumed were observed 1.808 $/ha, 4.520 $/ha, 0.25 $/$m^3$ and 0.49 $/$m^3$, respectively. Ingle et al. (2015) were used comparative indicators to assess small scale irrigation schemes in Maharashtra Ratnagiri region in India. Shrestha et al. (2014), were assessed Telegasari Irrigation Scheme in Indonesia with same indicators. Similar research has been done assessing performance of various scale irrigation schemes (Alwis and Wijesekara, 2011; Lakmali et al., 2015; Bareng et al., 2015; Shenkut, 2015; Adongo et al., 2016).

MATERIALS AND METHODS

Two of the irrigation schemes that have been assessed are located in the Central Anatolian region (Çumra and İvriz) and under the influence of continental climate.

The winters are cold and the summers are hot. Two irrigation schemes are located in the eastern Anatolian region (Erzincan and Iğdır) where the summers are short and chilly whereas the winters are cold and longer.

Another irrigation scheme is located in the Southeastern region (Harran) where the summer is very hot and the winter is mild. 5 of the irrigation schemes are located in the Mediterranean and Aegean regions that are under the influence of Mediterranean climate. In those places, the summers are hot and dry whereas the winters are mild and rainy. Another irrigation scheme is located in the Black Sea region where is rainy in all seasons. The summers are chilly and the winters are mild on the coasts, but colder and snowy in the higher areas.

The locations of the irrigation schemes being assessed are provided in the Figure 1, whereas the characteristics of each irrigation scheme are listed in the Table 1 below.

Table 1. Characteristics of Fourteen irrigation schemes (DSİ, 2016)

Code	Irrigation Scheme	Surface (ha)	Water Diversion (% by area)		Main Crops (Percentages by area)		
			Gravity	Pumped			
1	Menemen	22865	91	9	Cotton (56%)	Corn (18%)	Vegetables (8%)
2	Salihli	22797	96	4	Vineyard (44%)	Corn (32%)	Cereals (9%)
3	Ahmetli	50232	100	-	Corn (53%)	Grape (35%)	Fruit trees (4%)
4	Çumra	59560	88	12	Cereals (53%)	Corn (35%)	Sugarbeet (12%)
5	İvriz	36108	81	19	Cereals (46%)	Corn (31%)	Sunflower (10%)
6	Seyhan	142274	99	1	Corn (42%)	Citruses (15%)	Nursery tree (11%)
7	Ceyhan	101726	89	11	Corn (79%)	Peanut (10%)	Cotton (56%)
8	Tokat	20275	82	18	Corn (24%)	Vegetables (20%)	Fruit trees (15%)
9	Erzincan	29112	63	37	Cereals (50%)	Sugar beet (16%)	Bean (15%)
10	Harran	134366	100	-	Cotton (78%)	Cereals (22)	-
11	Kahramanmaraş	20000	97	3	Corn (60%)	Cereals (32%)	-
12	Söke	26000	100	-	Cotton (100%)	-	-
13	Baklan	44072	100	-	Sunflower (54%)	Corn (15%)	Fruit trees (10%)
14	Iğdır	61900	94	6	Forage (50%)	Corn (31%)	Grassland (13%)

Data used are taken from General Directorate of State Hydraulic Works report archive (DSİ, 2016). 14 irrigation schemes in three climatic zones in Turkey are chosen to assess their irrigation performance. These irrigation schemes have more than 20,000 ha command area. The locations of the irrigation schemes are given on Figure 1 below.

Figure 1. Irrigation schemes locations in Turkey

The four basic comparative performance indicators are used to assess irrigation schemes performance (Molden et al., 1998). These indicators:

$$\text{Output per unit command area}\left(\frac{\$}{ha}\right)=\frac{\text{Production}}{\text{Command area }(V_{div})}$$

$$\text{Output per cropped area}\left(\frac{\$}{ha}\right)=\frac{\text{Production}}{\text{Irrigated cropped area }(A_{cropped})}$$

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

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

where:

- *Production* is the output of the irrigated area in terms of gross or net value of production measured at local or world prices (see below);
- *Command area* is the nominal or design area to be irrigated. *Irrigated cropped area* is the sum of the areas under crops during the time period of analysis;
- *Diverted irrigation supply* is the volume of surface irrigation water diverted to the command area, plus net removals from groundwater;
- *Volume of water consumed* by ET is the actual evapotranspiration of crops.

RESULTS AND DISCUSSIONS

Output per unit command area

Evaluated irrigation scheme's output per unit command area varies 1040-7669 $/ha with a variation ratio of 1 to 7.40 between years 2011 and 2014 (Figure 2). The most important factors affecting per unit command area are irrigation ratio and crop pattern. The lowest value occurred in Ivriz Irrigation Scheme in 2014. The rate of irrigation ratio in Ivriz irrigation scheme was 42% in 2014. Otherwise, cereals which economic value is lower than the other plants were cultivated 58% of the command area. Seyhan Irrigation Scheme had the highest output per unit command area in 2014. Seyhan Irrigation Scheme irrigation ratio was 75% in 2014; in addition it is observed that industrial plants with high economic value (39% corn, 14% citrus and 13% cotton) were heavily cultivated.

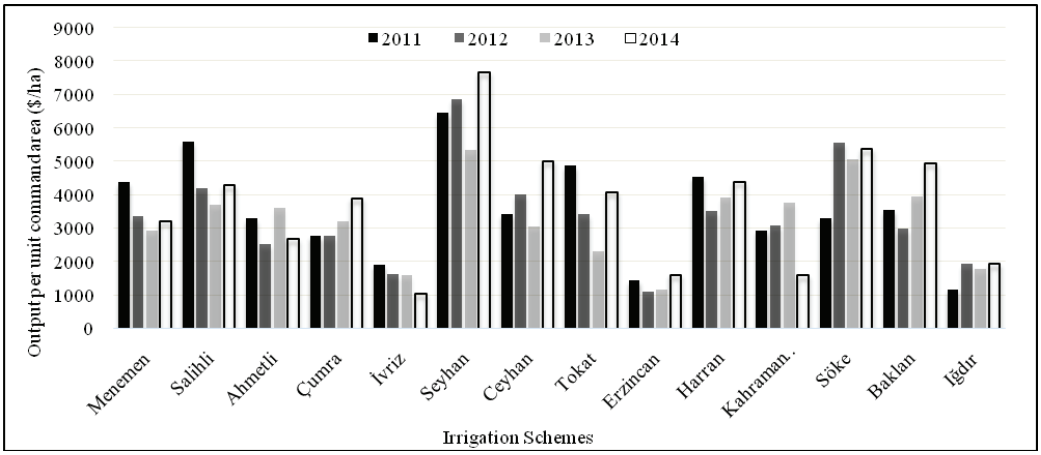

Figure 2. Output per unit command area

Output per cropped area

Evaluated irrigation scheme's output per unit cropped area varies between $2387 and $10129 per ha (Figure 3). The lowest value was realized in Cumra Irrigation Schemes in 2011 while the highest value was observed in Tokat Irrigation Scheme in 2011. Variation ratio of the irrigation schemes evolve between 1 and 4.20. Irrigation ration in Cumra Irrigation Schemes which had the lowest value was 85% in 2011. Whereas cereals with low economic value cultivated 70% of the cropped area in 2011. Irrigation ratio was 46% in Tokat Irrigation Schemes having the highest value in 2011. Crop pattern, yield and market price of the product affect output. 24% vegetable, 21% sugar beet and 21% fruit of the cropped area cultivated heavily in Tokat Irrigation Scheme in 2011.

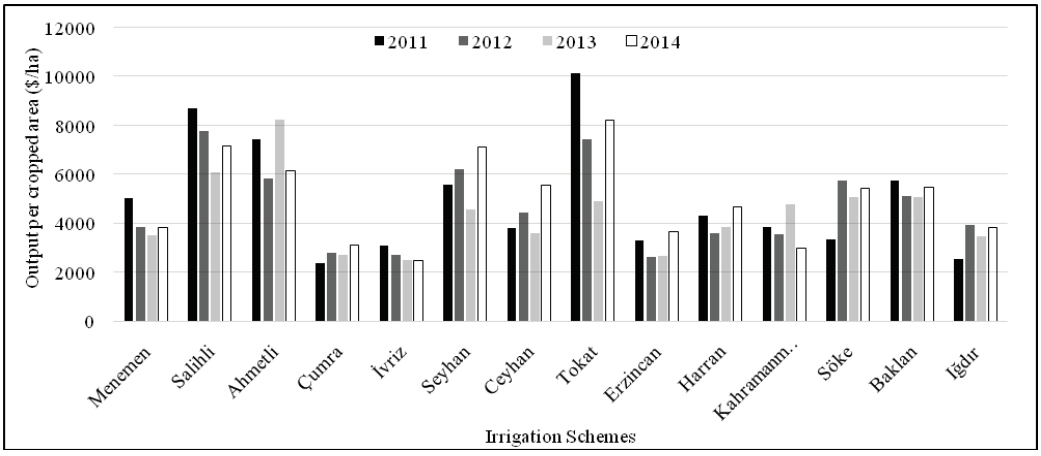

Figure 3. Output per cropped area

Output per unit irrigation supply

Values of output per unit irrigation supply are given in Figure 4, output per unit irrigation supply varies between 0.13 $/m^3 and 1.38 $/m^3. The lowest value is observed Igdir Irrigation Scheme in 2011. Output per unit irrigation scheme values varies between 1 and 10. The most cultivated plants in Igdir Irrigation Scheme feed crop with 40% and cereals with 21% of the cropped area. The highest value is

realized Baklan Irrigation Scheme in 2014. Sunflower with 48%, fruit with 16% and corn 12% of the cropped area were cultivated in Baklan Irrigation Scheme. Industrial plants and fruits are the most productive value for output per unit irrigation supply.

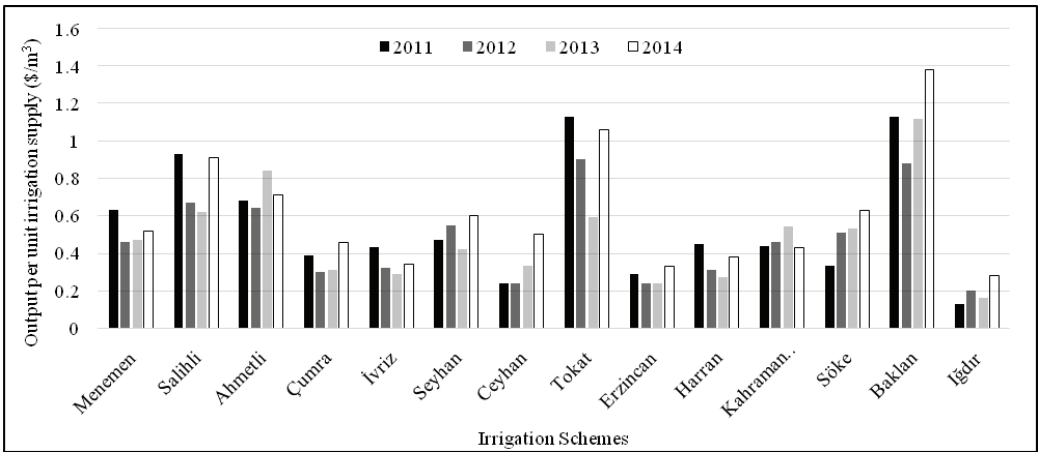

Figure 4. Output per unit irrigation supply

Output per unit water consumed

Output per unit water consumed values varies between 0.60 $/m^3 and 2.29 $/m^3 per unit water consumed (Figure 5). Output per unit water consumed varies proportionally between 1 and 4 in Figure 5 below. The lowest values are observed in Igdir Irrigation Scheme in 2011 while the highest value is realized in Tokat Irrigation Scheme in 2011.

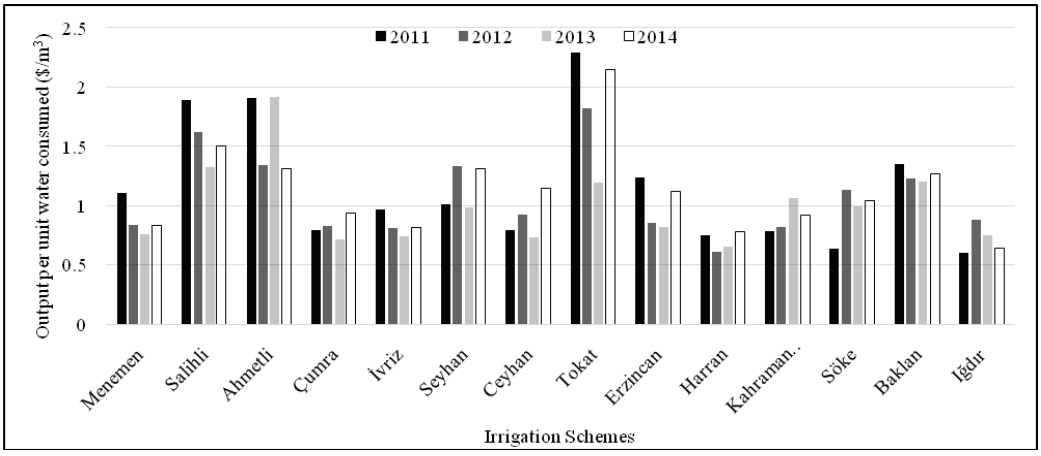

Figure 5. Output per unit water consumed

CONCLUSIONS

Comparative indicators, which relate to land, water and production, demonstrate the differences in performance of irrigation schemes over the years.

The different results in performance indicates shows the analysis is correct. In study, variation ratio is higher than 2:1 suggests that there are significant differences between the assessed irrigation schemes (Molden et al., 1998).

Performance differences between irrigation networks depend on the management scheme, infrastructure, water distribution and distribution planning, climatic conditions of the region and socio-economic conditions of farmers.

Assessment of irrigation schemes with comparative indicators is important appliance to decision makers. It is also useful in responding to the question "Do I do the right thing?" for irrigation managers (Murray-Rust and Snellen, 1993). Performance indicators can be used to identify long-term plans, to identify and confirm long-term strategic goals.

As a result of this study, it is seen that command area are not used completely. This causes the decrease of the production value. As a result, it is seen that the amount of water used is very high compared to the production value obtained from the unit area. It is necessary to work on raising the irrigation ratio and irrigation efficiency in the irrigation schemes of Turkey without losing time. In this regard, the production and support policies should be reassessed by the relevant ministries. In addition, agricultural publishing services for farmers need to be increased by authority.

REFERENCES

Adongo, T. A., Abagale, F. K., Kranjac-Berisavljevic, G., 2016. Performance Assessment of Irrigation Schemes in Northern Ghana Using Comparative Performance Indicators. International Journal of Scientific Engineering and Technology, ISSN: 2277-1581,Volume No.5 Issue No.4, pp: 217-224.

Bareng, J. L. R., Balderama, O. F., Alejo, L. A., 2015. Analysis of Irrigation Systems Employing Comparative Performance Indicators: A Benchmark Study for National Irrigation and Communal Irrigation Systems in Cagayan River Basin. Journal of Agricultural Science and Technology A, 325.

Cakmak, B., Kibaroglu, A., Kendirli, B., Gokalp, Z., 2010. Assessment of the irrigation performance of transferred schemes in Turkey: a case study analysis. Irrigation and Drainage, 59(2), 138-149.

De Alwis, S. M. D. L. K., Wijesekera, N. T. S., 2016. Comparison of performance assessment indicators for evaluation of irrigation scheme performances in Sri Lanka. Engineer: Journal of the Institution of Engineers, Sri Lanka, 44(3).

Dejen, Z. A., Schultz, B., Hayde, L. G., 2011. Irrigation performance in community-managed schemes: Assessment using comparative indicators and utility analysis. In Proceedings of the ICID 21st International Congress on Irrigation and Drainage, Tehran, Iran, 15-23 October, 2011 (pp. 17-17).

DSI, 2015. Devlet Su İşleri Genel Müdürlüğü 2015 Faaliyet Raporu. General Directorate of State Hydraulic Works. http://www.dsi.gov.tr/docs/stratejik-plan/dsi-2015-faaliyet-raporu.pdf?sfvrsn=2#page=71. (Last access date: 20.01.2017).

DSİ, 2016. 2015 Yılı DSİ'ce İşletilen ve Devredilen Sulama Tesisleri Değerlendirme Raporu. General Directorate of State Hydraulic Works.

Ingle, P. M., Shinde, S. E., Mane, M. S., Thokal, R. T., Ayare, B. L., 2015. Performance Evaluation of a Minor Irrigation Scheme. Research Journal of Recent Sciences, ISSN 2277-2502, Vol.4 (ISC-2014), 19-24.

Kukul, Y. S., Akçay, S., Anaç, S., Yeşilırmak, E., 2008. Temporal irrigation performance assessment in Turkey: Menemen case study. Agricultural water management, 95(9), 1090-1098.

Lakmali, W. A. S., Gunawardena, E. R. N., Dayawansa, N. D. K., 2015. Comparative performance assessment of major irrigation systems in Upper Deduru Oya Basin. Tropical Agricultural Research, 26(2).

Molden, D. J., Sakthivadivel, R., Perry, C. J., De Fraiture, C., 1998. Indicators for comparing performance of irrigated agricultural systems (Vol. 20). IWMI.

Sener, M., Albut, S., 2011. Irrigation performance assessment in Turkey: Thrace region case study. Bulgarian Journal of Agricultural Science, 17(4), 521-530.

Shenkut, A., 2015. Performance Assessment Irrigation Schemes According to Comparative Indicators: A Case Study of Shina-Hamusit and Selamko, Ethiopia. International Journal of Scientific and Research Publications, 451.

Shrestha, S., Aquino, F. Y., Pandey, V. P., 2014. Performance evaluation of the Telagasari Irrigation Scheme (TIS) of Karawang Regency, Indonesia. Journal of Food, Agriculture & Environment, 12(3&4), 187-197.

Uysal, Ö. K., Atış, E., 2010. Assessing the performance of participatory irrigation management over time: A case study from Turkey. Agricultural water management, 97(7), 1017-102.