ASSESSMENT OF AGRICULTURAL WATER USE IN TURKEY

CAKMAK Belgin[1], UNVER I.H. Olcay[2], and AKUZUM Turhan[1]

[1]Department of Farm Structures & Irrigation, Faculty of Agriculture, University of Ankara, 06110 Diskapi, Ankara, TURKEY

[2]President, Republic of Turkey Prime Ministry, Southeastern Anatolia Project Regional Development Administration, Willy Brandt Sok. No. 5, 06680 Cankaya, Ankara, TURKEY

Abstract:

Turkey is not a water rich country. A large part of Turkey's water resources is consumed by the agriculture sector. The rapidly increasing population creates a rising demand for water and reduces the amount of water available for agriculture. This situation emphasizes the need for water resources management, and points out the need for the economic use of water resources. Irrigation represents about 75% of all water consumption. Due to a number of difficulties and limitations, irrigation schemes are not operating at full efficiency. Therefore it is imperative to use agricultural water efficiently in Turkey.

***Key words**: water using, agriculture, Turkey*

1 INTRODUCTION

Water use is increasing rapidly in the world. The world's six billion dwellers are already using 54% of all the accessible freshwater contained in rivers, lakes, and underground aquifers. By 2025, humankind's share will be 70%. This estimate shows the impact of population growth alone. If per capita consumption of water resources continues to increase at the current rate, humankind could be using over 90% of all available freshwater within 25 years, leaving just 10% for all other living beings, include livestock, wild animals and plants. Growing water scarcity for irrigated agriculture leads to a need to produce "more crop per drop". Currently, on a global basis, 69% of all water withdrawn for human use on an annual basis is consumed by agriculture (mostly in the form of irrigation); industry accounts for 23%; and domestic use (household, drinking water, sanitation) accounts for about 8%. These figures vary a great deal between regions. In Africa, for instance, agriculture consumes 88% of all water withdrawn for human use, while domestic use accounts for 7% and industry for 5%. In Europe, most of the water is used in industry (54%), while agriculture and domestic use requires 33% and 13% respectively (Anonymous, 2003a).

As populations have steadily become more dispersed over a larger area, and the rates of urbanization started to increase, society had to be protected from the regular ravages of droughts and floods through better water-control systems and management practices. Thus, water became a critical component of the development process for the whole world in the nineteenth and first part of the twentieth century (Biswas and Tortajada, 2001).

The 1992 Dublin Statement on Water and Sustainable Development concludes that "scarcity and misuse of fresh water pose a serious and growing threat to sustainable development" and urges as a principle that "water has an economic value in all its competing uses and should be recognized as an economic good". The Earth Summit Document, Agenda 21, reflects these principles and adds that "sustainability of food production increasingly depends on sound and effective water use, including water management." (Szöllosi-Nagy et al., 1998).

Shiklomanov (1998) and Szöllosi-Nagy et al. (1998) cited that this century has seen a rapid growth in water demand due to increasing use of water in irrigated food production and industry and increased per capita use for domestic purposes. Between 1900 and 1995, water withdrawals increased by a factor of over six, more than double the rate of population growth. Increased demands are causing water stress in many areas of the world, to the extent that nearly 10% of the world's population lives in countries using so much of their water resources that they can be considered to be highly water stressed. Under the current patterns of water use, an estimated two thirds of the total world population may well face water stress by the year 2025.

A study covering 90 developing countries carried out by FAO, shows that a number of water-scarce nations are already withdrawing water supplies faster than they can be renewed. Irrigation water withdrawal was estimated to account for only 8 percent of total renewable water resources for the 90 developing countries. However, there are wide variations between regions, with the Near East / North Africa region using 53 percent of its water resources in irrigation while Latin America barely uses 1 percent of its resources. In the year 2000, taking into account the country level, ten countries are considered to be in a critical state in that agriculture accounts for more than 40% of total withdrawals of renewable water resources. An additional nine countries used more than 20% of their water resources, a threshold that could be used to indicate impending water scarcity. As average for the 90 developing countries, it is estimated that irrigation efficiency was around 38 percent in the reference period of the year 2000, varying from 25% in areas of abundant water resources (Latin America) to 40% in the Near East/North Africa and 44% in South Asia where water scarcity calls for higher efficiencies (Anonymous, 2003b).

Agriculture is the largest user of water, demanding almost 70% of the total amount withdrawn in most of the countries (Table 1). It takes a remarkable amount of water to produce crops. Supplies, however, are already limited. Overpumping of groundwater by the world's farmers exceeds natural replenishment by at least 160 billion cubic meters a year. It takes one to three cubic meters to yield just one kilo of rice, and 1,000 tons of water to produce just one ton of grain (Anonymous, 2003a).

Irrigation plays a major role in the overall agricultural production of the world. Irrigated areas comprise about 250 million hectares worldwide today; nearly five times more than at the beginning of the 20th century. Irrigation contributed to rising yields and production. Poor irrigation management has lead to environmental problems such as water table and soil damage, and water quality deterioration (Rosegrant et al., 2002).

Water is a useful tool for economic and social development and for poverty eradication. However, it is generally agreed that the growing water shortage may lead to serious water crises in many parts of the world in the future. Already, 1.1 billion people do not have access to safe drinking

Table 1. Importance of the consumption in water by sector (Chohin-Kuper et al., 2002)

Country	Year	Agriculture (%)	Domestic use (%)	Industry (%)
Spain	1998*	93	4	3
France	1995*	68	24	8
Greece	1997	87	10	3
Turkey	1997	74	15	11
Israel	1986	79	16	5
Egypt		82	8	10
Tunisia	2001*	83	12	5
Morocco	1991	92	5	3
Italy	1999	50	20	30
Croatia	1996**	1	47	52
Slovenia	1994**	2	68	30
Albania		74		26
Malta	1995	12	87	1
Cyprus		75	19	6

Palestinian Authority		71	26	3
Jordan	1997*	69	4	27
Lebanon	1996	68	5	27
Libya		87		13

Net consumption indicated by (*), total water used excluding hydroelectricity indicated by (**)

water, and almost 2.5 billion do not have access to adequate sanitation. To make the water crisis easier to understand, it is helpful to look at individual countries and regions with special conditions and problems. Every country has its own understanding of these problems, and the challenge of translating global targets into local action differs from country to country. With this aim, water use for all sectors should be assessed for each individual country.

Water is a limiting factor for agriculture throughout much of Turkey. While average annual precipitation is highest in the Black Sea region (1,120 mm), and exceeds 800 mm/year in some of the other coastal areas, Thrace and eastern Anatolia, the remaining 70% of the country receives precipitation averages of less than 500 mm/year. In the vast high land plains of central Anatolia, it averages less than 400 mm (Anonymous, 2003c). Because of this, irrigation is gradually being expanded. Turkey, like many countries today, faces challenges in efficiently developing and managing its agricultural water resources while trying to protect water quality and the environment. Turkey will also need to continue to develop its water resources to support its economic and social development. As a result, water development is urgently needed in order to meet existing demands, and to prepare for future demands by agriculture and other sectors.

2 GENERAL INFORMATION ABOUT TURKEY

The Republic of Turkey lies between 26° and 45° east longitude and 36° and 42° north latitude. It is bordered on three sides by the Mediterranean, Aegean Sea, and Black Sea. The total area of Turkey is 78 km^2. Turkey's climate is semi-arid with extremes in temperatures. Average annual temperatures range from 14°C to 20°C, depending on distance from the sea. The difference in temperature between winter and summer varies from 16°C to 29°C, and is highest in the eastern part of the country.

Its exposure to both maritime and continental weather patterns combines with highly varied topography to produce several distinct climate zones. The Mediterranean region is essentially subtropical, characterized by hot dry summers and mild, rainy winters; citrus fruits, vegetables and rice and cotton are predominant crops. The Black Sea region, which receives rain throughout the year, is where most of the country's tea, hazelnuts, and maize are grown. In the Aegean Region (western Turkey) the mountains run roughly east west (perpendicular to the coast) and is interspersed with grassy flood plains; these plains are among the most fertile in the country. This region produces olives, cotton, tobacco, and a diversity of horticultural crops. Central Anatolia is a vast, high plateau (average altitude of 1,000 meters above sea level) with a semi-arid continental climate. A great part of Turkey's wheat, wine grapes, and sugar beet are grown there.

3 LAND AND WATER RESOURCES

Twenty-eight million ha of the land in Turkey is considered arable, 21.5 million ha is pasture and meadow, and 23 million ha is woodland. The irrigable land totals 26 million ha, and, of this, 8.5 million ha is considered economically irrigable; 0.6 million ha by groundwater.

Although Turkey generally has sufficient water resources, it is not always in the right place at the right time to meet actual needs. Hydrologically, Turkey is divided into 26 drainage basins. The river flow regimes are irregular and cannot be considered as usable resources in their natural states. Average annual precipitation, evaporation, and surface runoff vary greatly. The annual average precipitation in Turkey is estimated at 643 mm, corresponding to a volume of 500 km^3. The average runoff coefficient is 0.37, and the annual runoff is 186 km^3 (2400 m^3/ha). The annual exploitable water resources potential of Turkey is estimated at 91 km^3 as shown in Table 2. When the annual amount of water that enters Turkey from neighboring countries is added, the technical and economically exploitable water potential is increased to 110 km^3 (Kulga, 1994; Kulga, 1997).

According to DSI, the primary government institution responsible for water resources development in Turkey, the average annual surface flow in all 26 river basins is 186 km^3. The largest river basins, in terms of exploitable water potential, are the Euphrates (31.61 km^3), the Tigris (21.33 km^3), the Eastern Black Sea (14.90 km^3), the Eastern Mediterranean (11.07 km^3), and Antalya basins (11.06 km^3).

Table 2. Annual Water Potential of Turkey (Bilen 1997, Kulga 1997)

Contribution	Water potential (km^3)
Total runoff	186
Of which exploitable surface runoff	95
Safe yield of groundwater	+12
Water that enters Turkey from neighboring countries	+19
Water allocated to Syria and Iraq	-16
Total exploitable potential	110

The three major objectives of water resources development in Turkey are to provide sufficient quantities of water for domestic and industrial use; to generate sufficient hydropower; and to irrigate its farmland (Cakmak,1997). According to IWMI indicators of water scarcity, Turkey has little or no water scarcity. The current water withdrawals are only 43% of the renewable water supply and the expected water demand in 2025 is about 183% of the present consumption (Seckler et al., 1998). But local water scarcities do occur in Turkey. Some parts of the country such as European, Central Anatolia, and Western Anatolia are subject to serious water shortages, both for irrigation and domestic water supply (Bilen, 1997). Therefore it is necessary to use Turkey's limited water resources efficiently.

Irrigation development potential in Turkey is estimated at about 8.5 million hectares (Uskay, 2001). Development of irrigated areas is shown in Table 3 which shows that 3.77 million ha is irrigated by surface water and the remaining 0.51 million ha by ground water according to data from the year 2000. At present, particular attention is being paid to the Southeastern Anatolia Project (GAP) under which 1.7 million ha will be irrigated by waters from the Euphrates and Tigris basins. The Euphrates and Tigris rivers represent over 28% of the nation's water supply from rivers. The economically irrigable areas in the GAP region make up 29% of the irrigable land in the entire country (Unver, 1997). GAP has provided Turkey with valuable experience in integrating human and economic development with the management of its water resources (Kibaroglu, 2003).

The annual per capita water potential is currently 1,700 m^3 but is expected to be reduced to 1,000 m^3 by the year 2020. Thus Turkey cannot be considered a "water-rich" country, and its per capita potential is nearly the same as those of its neighbors Iraq (2,000 m^3/yr) and Syria (1,400 m^3 /yr) (Bayazıt and Avcı, 1997).

4 IRRIGATION DEVELOPMENT

Irrigation development in Turkey is carried out by the public sector, represented by DSI (State Hydraulic Works) and GDRS (General Directorate of Rural Services) and by the private sector (farmers and groups of farmers). DSI is responsible for almost all aspects of water resources development of Turkey. They build dams, flood control structures, irrigation and surface drainage systems; supply drinking water and water for domestic and industrial purposes for cities with a population larger than 100,000; and also develop surface and groundwater resources (Akuzum et al., 1997). By the end of the year 2001, DSI completed 571 storage facilities (203 large dams and 368 low dams) and developed 2,297,000 hectares of irrigation schemes (Ozlu et al., 2002a).

GDRS deals with on-farm development and minor irrigation works such as land leveling, land consolidation, sub-surface drainage works, and irrigation networks for minor irrigation projects. GDRS also works together with DSI on large irrigation projects and groundwater irrigation cooperatives in small size projects.

According to comprehensive studies carried out by DSI, 8.5 million hectares of land could be economically irrigated. Development achieved as of end of 2001 is shown in Table 4. By 2030, when all irrigation networks are constructed, 8.5 million hectares of economically irrigable land in Turkey will be opened for irrigation. It is estimated that water consumption for irrigation will be 71.5 billion m^3 and the rate of water consumption in irrigation will decline to 65% through the use of modern irrigation techniques.

Table 3. Development of Irrigated Area for the Years 1995-2000 (Uskay, 2001)

Years	Irrigated areas (million ha)		
	Surface water	Ground water	Total
1995	3.30	0.42	3.72
1996	3.38	0.44	3.82
1997	3.45	0.46	3.91
1998	3.54	0.48	4.02
1999	3.73	0.50	4.23
2000	3.77	0.51	4.28

Table 4. Irrigation Development in Turkey (Ozlu et al., 2002a)

Institutions	Area (ha)
Potential for irrigation projects	8.500.000
Projects in operation	4.358.000
DSI	2.297.000
GDRS	981.000
Farmers	1.080.000
Projects under construction	753.000

In Turkey, as in most other countries, there are two types of irrigation schemes developed by the State. One is irrigation management by the Government; the other is irrigation management by local authorities and Water Users' Associations (WUAs).

DSI was established in 1954 by an exclusive Act No. 6200 (Özlü et al., 2002a). Article 2.g of the Turkish Act No. 6200 authorizes DSI to manage operate, maintain and repair the irrigation structures it has constructed. DSI is also empowered under article 2.k of the same law to transfer irrigation structures it has constructed to a range of other organizations. Since 1954, Turkey has had a legal framework allowing the transfer of management responsibility for public constructed irrigation schemes to local government control of irrigation management. In the early 1960s, some small scale irrigation schemes which were isolated and far from the administrative units of DSI were transferred to water users in a very different approach which eventually led to the Participatory Irrigation Management (PIM) concept of today. Additionally, water user groups (WUGs) made a major contribution and have actively participated in irrigation management since that time.

As of 1993, a total of 62,000 ha of small schemes were gradually transferred to users. DSI's policy shifted from transferring only small and isolated schemes to an accelerated approach of transferring large schemes as well. The main underlying reason for accelerating the transfer program has been the financial burden of operation and maintenance for DSI and the Government, which was getting unsustainable (Svendsen and Murray-Rust, 2001). The operation and maintenance cost recovery (rate of collection of water fees), has been unsatisfactory (about 41%) (Ozlu et al., 2002b).

The present Government's general policy of promoting privatization was also a contributing factor. Positive results from generally satisfactory operation and maintenance of transferred schemes were another important contributing factor, which substantially alleviated the concern that the systems would rapidly deteriorate after transfer. As of end of 2001, DSI had transferred areas totaling about 1,663,730 ha, which corresponds to 87.2% of the total area developed by DSI (Figure 1).

5 WATER USE IN AGRICULTURE

Currently, agriculture consumes 75% of the total water in Turkey. The growing demand for water by its rapidly increasing population is reducing the amount of water available for use in agriculture. This situation emphasizes the need for optimal water resource management, and the economic use of water in agriculture. Consumptive use of water in irrigated agriculture is defined as the

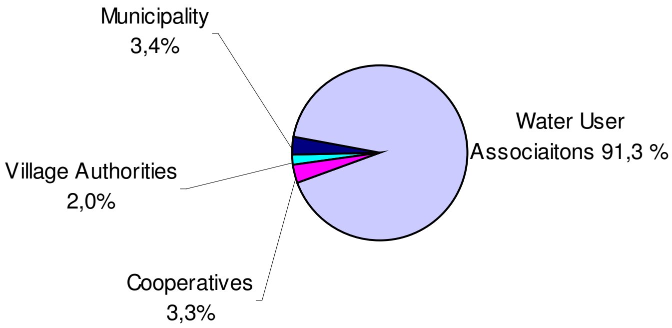

Figure 1. Distribution of Transferred Irrigation

water required in addition to water from precipitation (soil moisture) for optimal plant growth during the growing season. Optimal plant growth occurs when actual evapotranspiration of a crop is equal to its potential evapotranspiration. Irrigation water withdrawal normally far exceeds the consumptive use of irrigation because of water lost in its distribution from its source to the crops. Table 5 shows the water consumption for irrigation by years. The ratio between the estimated irrigation water requirements and the actual irrigation water withdrawal is usually referred to as "irrigation efficiency".

The growing period for most crops in Turkey are the summer months of June, July, and August during which there is almost no rain and rivers have their lowest base flows. Therefore, water storage is essential. DSI projects are generally based on surface irrigation methods, using either classical open channel systems or raised canalets. Sprinkler irrigation has been used in certain projects under specific conditions. Almost 90% or the total areas use surface irrigation methods (furrow, basin and flooding). The remaining area of an estimated 200,000 ha use pressurized irrigation which is common among farmers throughout the country. On DSI schemes, more than 108,000 ha are irrigated by sprinklers, mainly for sugar beet, cereals, alfalfa, sunflower, watermelons and vegetables. Micro irrigation is practiced on about 5,800 ha of DSI schemes, mainly for citrus, vineyard, strawberries, and vegetables.

Cultivated land is mainly covered in field crops, fallow, orchards, vegetable and flower gardens. Crop pattern in DSI-managed and transferred irrigation schemes are shown in Table 6. Delivered water per hectare is much more than needed because of high water losses (Table 7). There is a large amount of water loss at both scheme and field levels. Current irrigation water pricing is also not enough to meet O&M costs. The irrigation water price is too low which leads to excessive water use in agriculture. Inefficient use of irrigation water not only makes it necessary to divert and/or pump large amounts of water, but it also results in environmental degradation by such phenomena as water logging, salinization and pollution, and it causes health risks such as the increased incidence of vector-borne diseases.

Due to a number of difficulties and limitations, irrigation schemes operated and transferred by DSI are not operated at full efficiency. Table 8 summarizes the factors which limited the operation of the command area. In DSI-managed and transferred irrigation schemes, total irrigated areas were 198,718 ha and 1,583,543 ha and total non-irrigated areas were 125,889 ha and 570,657 ha for the reference year 2001 respectively. Efficiency indicators of agricultural water use are very low, for both irrigation ratio and irrigation efficiency.

Table 5. Water Consumption for Irrigation During 1990-2000 (Anonymous, 2003c)

Irrigation Year	Total water consumption (million m^3)	Development (%)	Amount (million m^3)	Share (%)
1990	30,600	28	22,016	72
1992	31,600	29	22,939	73
1998	38,900	35	29,200	75
2000	42,000	38	31,500	75
2030*	110,000	na	71,500	na

*Estimation

Table 6. Crop Pattern in DSI-managed and Transferred Irrigation Schemes for The Year 1997-2001 (Anonymous, 1998; Anonymous, 1999; Anonymous, 2000; Anonymous, 2001; Anonymous, 2002)

Crops	Crop pattern (%)				
	1997	1998	1999	2000	2001
Cereals	18.6	15.1	18.6	18.9	14.3
Legumes	3.7	3.9	3.3	2.6	2.7
Sugar beet	9.6	10.9	9.0	9.8	8.0
Cotton	23.0	23.1	21.6	19.5	24.6
Maize	14.2	15.4	15.1	16.3	15.7
Sunflower	1.1	1.2	1.8	2.3	0.2
Fruits	4.2	4.6	4.6	5.0	5.4
Vegetables	5.6	6.0	6.0	5.6	5.3
Forage crops	2.8	2.7	2.7	2.8	3.2
Other	17.2	17.1	17.3	17.2	20.6

Table 7. Total of Water Inflow, Irrigation Water Requirement and Delivered Water per Hectare in DSI-managed and Transferred Schemes (Anonymous, 1996; Anonymous, 1997; Anonymous, 1998; Anonymous, 1999; Anonymous, 2000; Anonymous, 2001; Anonymous, 2002)

Year	Water inflow (10^6 m^3)		Irrigation water requirement per hectare (m^3/ha)		Delivered water per hectare (m^3/ha)	
	DSI	Transferred	DSI	Transferred	DSI	Transferred
1995	3316	6488	3915	4342	10642	8885
1996	2690	7535	4736	4540	11022	10206
1997	2392	8680	4535	4469	12852	9921
1998	1279	11018	3754	4683	13084	10958
1999	1243	11536	4071	4511	13182	11154
2000	976	11734	3979	4529	11936	10849

2001	705	10184	3507	4705	9281	10849

Table 8. Factors preventing the full operation of DSI-managed and transferred irrigation schemes for the year 2001 (Anonymous, 2002)

Limiting factors	DSI		Transferred	
	Area that could not be irrigated (ha)	Relative importance (%)	Area that could not be irrigated (ha)	Relative importance (%)
Inadequacy of water resources	9,617	8	75,267	13
Insufficiency of irrigation facilities	5,054	4	31,388	6
High water table	1,662	1	11,626	2
Salinity and alkalinity	700	1	11,600	2
Inadequate maintenance-repair	1,584	1	5,472	1
Irrelevant topography	4,797	4	18,684	3
Adequacy of rainfall	45,048	36	129,523	23
Fallow	19,676	16	68,092	12
Social-economic factors	26,404	21	117,345	21
Other factors*	11,347	9	101,660	18

**Water pollution, marketing problems, agricultural areas which converted from agriculture to industrial and settlement areas and graze lands*

Irrigation ratio, the actual rates of irrigated area as a percentage of the command area, and irrigation efficiency are shown in Figure 2 and Figure 3 respectively. In Turkey, the main problem, which reduces irrigation efficiency, is using excessive water for agriculture. For instance, irrigation ratios in transferred and DSI-managed schemes were 62.4% and 38.2% respectively in 2001. Irrigation efficiency was also higher in users-managed projects (48%) than that of DSI-managed ones (less than 38%) (Ozlu et al., 2002b).

The main causes of the current low irrigation efficiencies are due to several factors such as leakage, percolation, and evaporation. (Anonymous 1994) These factors are linked to the deterioration of the irrigation network systems as a result of inadequate maintenance. In such cases, rehabilitation might be the most feasible technical and economic alternative. Irrigation management should give sufficient attention to adequate operation and maintenance of the facilities.

Ignoring the economic value of water has led to waste and environmental problems. The most effective way to achieve efficient use of water resources is to manage water as an economic commodity (Hamdy, 2001). On average, only about 45% of water diverted for irrigation actually reached the crop. Losses vary between 5 and 50 percent.

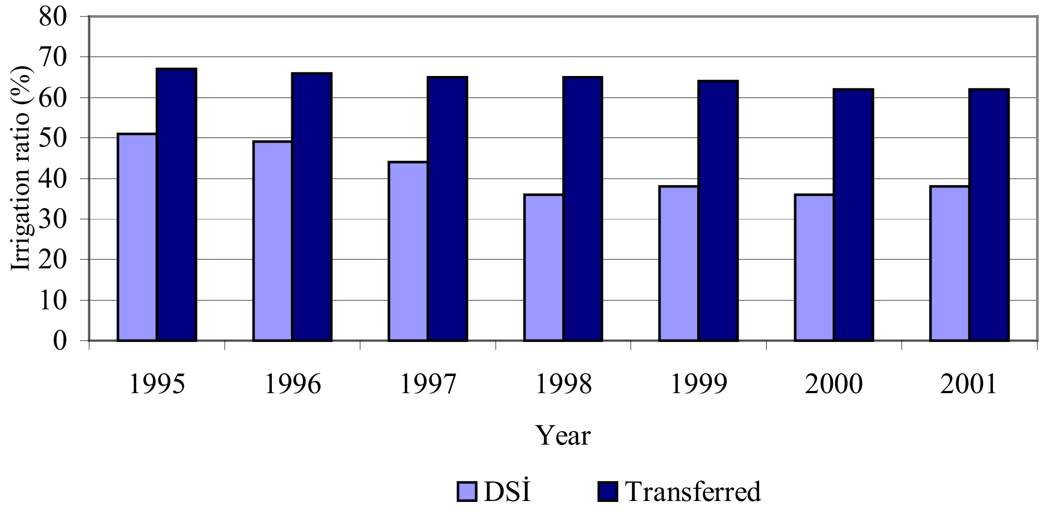

Figure 2. Irrigation Ratio for Schemes Operated by DSI and Transferred

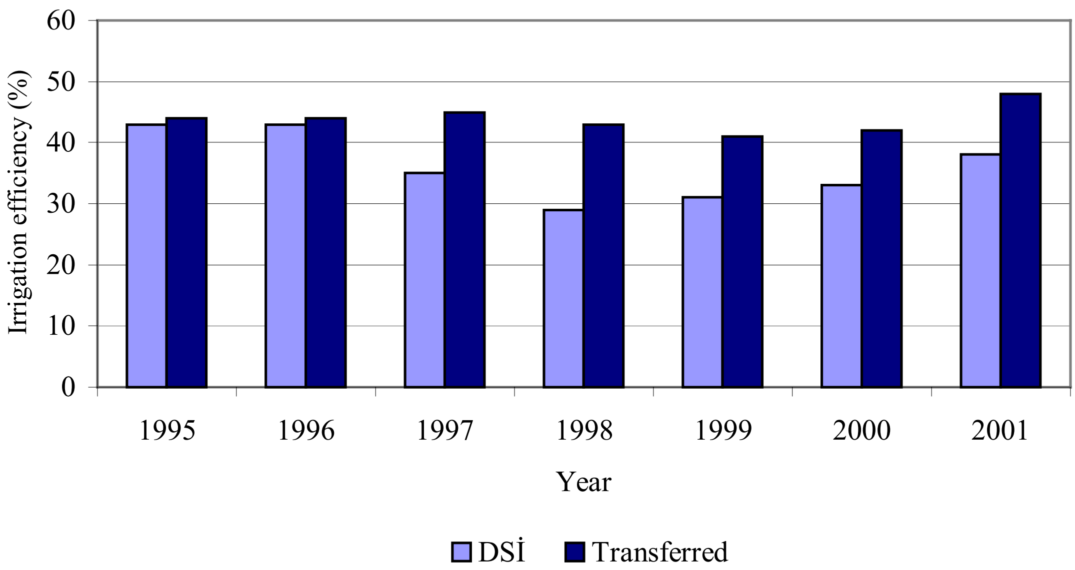

Figure 3. Irrigation Efficiency for DSI Schemes and Transferred schemes.

6 CONCLUSIONS AND RECOMMENDATIONS

Irrigation efficiency and irrigation ratio are low in Turkey, although a large amount of water is consumed by agriculture. Low irrigation efficiency results from seepage losses, tail escapes, unleveled field conditions, and poor water management. Efficiency should be increased by the improvement of existing irrigation technology.

Advanced irrigation methods such as sprinkler and drip irrigation should be used. High water losses and insufficient irrigation water price causes users to waste water. If rapid and appropriate measures are not taken, serious water problems will result in threats to the environment in the near future. Appropriate pricing will prevent excessive water use for irrigation.

Water pricing has proved to be an efficient regulating tool which is better than quantitative regulation. The Dublin Principle of 1992 states that water has an economic value in all its competing uses, and should be considered as an economic good. Water pricing pays for O&M costs, discourages water wastage, and improves quality of services. Appropriate methods of pricing encourage water saving in agriculture. Also, they are essential for the economic sustainability of the irrigation sector, and are an investment in increasing water-use efficiency.

On-farm water management should be improved in order to achieve the maximum possible water use efficiency in Turkey. Thus, it will ensure maximum productivity per unit of water and land, and also reduce the considerable gap between irrigation potential and that which is developed and utilized.

It is possible to improve water productivity in terms of the following options:

- Applying a rational water tariff in irrigation with the involvement of water users,
- Improving of operation and maintenance services,
- Enhancing pressure irrigation systems such as drip and micro irrigation, instead of gravity irrigation to cut evaporation and wind-drift losses,
- Providing of water delivery planning and irrigation scheduling,
- Training WUAs on modern technology,
- M&E of irrigation systems to maximize performance,
- Considering the socio-economic impacts of irrigated agriculture on targeted groups.

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