# Evaluation of Agricultural Water Use: A Case Study for Kizilirmak Basin

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Water is not only a renewable source but also a limited substance. Population growth and development in industry bring about competition among the sectors of water use. Agriculture has the largest rate of water use among the sectors. Most of irrigation schemes cannot be operated efficiently due to management, operation and maintenance problems. Since the farmers irrigate crops based on physical observations of plants, applied irrigation water and irrigation interval are not based on any technical criteria. Also, since water fees cannot be calculated based on amount of water used, it leads excessive water use. A certain land area becomes unavailable for agricultural purposes due to soil salinity and excessive water use. For these reasons, the issues of efficient water use and irrigation performance evaluation are the most critical issues in water use evaluation studies.

In this study, water use performance indicators in Kızılırmak Basin Irrigation Schemes for the years were 2003-2005 were determined; the results were discussed and evaluated. The water use efficiency indicators including output per unit command area, output per unit irrigated area, output per unit irrigation supply and output per unit water consumed, relative water supply and irrigation ratio were determined as 66-5550 \$/ha, 1095-7620 \$/ha, 0.03-1.17 \$/m$^3$, 0.28-2.18 \$/m$^3$, 0.8-9.7, %1-98, respectively.

**Key words:**Kızılırmak Basin, gross production value, relative water supply, irrigation ratio

## Tarımda Su Kullanımının Değerlendirilmesi: Kızılırmak Havzası Örneği

Su, yenilenebilir bir kaynak olmasına ragmen aynı zamanda sınırlı olan temel bir ihtiyac maddesidir. Nufus artısı ve sanayide gorulen gelisme, su kullanımında sektorler arasında rekabete yol acmaktadır. Sektorler arasında su kullanımında en buyuk payı tarım sektoru almaktadır.

Sulama sistemlerinin buyuk bir bolumu isletme ve bakım sorunları nedeniyle verimli calısamamaktadır. Ciftciler sulamayı genellikle fenolojik gozlemlere gore yapmakta, uygulanan sulama suyu miktarı ve sulama aralıgı teknik bir kritere dayanmamaktadır. Su ucretlerinin kullanılan su miktarına gore alınmaması asırı su kullanımına yol acmaktadır. Bilincsiz sulamalar nedeni ile topragın tuzlulasması ve asırı su verilmesi sonucu her yıl belirli bir alan urun alınamaz hale gelmektedir. Bu acıdan toprak ve su kaynaklarının etkin kullanımı ve sulama sistemlerinde performansın degerlendirilmesi buyuk onem tasımaktadır.

Bu calısmada, Kızılırmak Havzası Sulama Sebekelerinde 2003-2005 yıllarına iliskin su kullanım performans gostergeleri belirlenmis ve elde edilen sonuclar degerlendirilmistir. Arastırma alanındaki sulama sebekelerinde birim sulama alanına karsılık elde edilen gelir, sulanan birim alana karsılık elde edilen gelir, sebekeye alınan birim sulama suyuna karsılık elde edilen gelir, tuketilen birim sulama suyuna karsılık elde edilen gelir, su temini oranı ve sulama oranı degerleri sırasıyla 66-5550\$/ha, 1095-7620\$/ha, 0.03-1.17\$/m$^3$, 0.28-2.18\$/m$^3$, 0.8-9.7, %1-98 olarak belirlenmistir.

**Anahtar Kelimeler:** Kızılırmak Havzası, brut uretim degeri, su temin oranı, sulama oranı

## Introduction

Water is not only a renewable source but also a limited substance. Population growth and development in industry bring about competition among the sectors of water use. Agriculture has the largest rate of water use among the sectors. Total water potential of the country from the 26 watersheds is 186 billion m$^3$ and only 95 billion m$^3$ of this potential is used for different purposes. However, based on technical and economical criteria, total available surface and subsurface water potential is 110 billion m$^3$. It is assumed that 95 billion m$^3$ of this potential was supplied from rivers inside the country, 3 billion m$^3$, from the rivers out of country and 12 billion m$^3$ from subsurface water. Annual water potential per watershed exhibits large fluctuations. The total water use was 42 $km^3$ in the year 2000. Of which 75% was used for irrigation, 15% for drinking and utility and 10% for industry (Gundogmus et al., 2001).

Currently, agriculture consumes the largest rate of the total consumed water in Turkey. This situation emphasizes the need for efficient use of water in agriculture. Most of the irrigation schemes cannot be operated efficiently due to some management, operation and maintenance problems. Since the farmers irrigate crops based on physical observations of plants, applied irrigation water and irrigation interval are not based on any technical criteria. Also, since water fees cannot be calculated based on amount of water used, it leads excessive water use (Ucan, 2000). A certain amount of land area becomes unavailable for agricultural purposes due to soil salinity and excessive water use. For these reasons, the issues of efficient water use and irrigation performance evaluation are the most critical issues in water use evaluation studies.

Vermillion and Garces-Restrepo (1996) determined and compared the irrigation system performance of the year 1993 for Coello and Saldana irrigation transferred to irrigation association in 1976 in Colombia. They found the relative water supply ratio as 1.4 and 1.8 for Coello and Saldana, respectively.

Cakmak (2001) applied the performance indicators developed by the Institute of International Water Management (IWMI) to Konya irrigation schemes for the years 1995-1999 and determined the performance indicators of gross production value, gross production value per command area, gross production value per irrigated area, gross production value per unit of diverted water, gross production value per irrigation water requirement, relative water supply and irrigation ratio.

Degirmenci (2001) applied the performance indicators to transferred irrigation schemes for the year 1998 and determined the indicators of gross production value, irrigated area gross production value, gross production value for per unit of diverted water, relative water supply and irrigation ratio.

In this study, agricultural water use in Kızılırmak Basin for the years 2003-2005 was determined, evaluated and recommendations were made for better water use in the basin.

## Material and Method

With a connection to Black Sea, Kızılırmak Basin is located on the eastern Central Anatolia, Turkey, between 37° 58' - 41° 44' north parallels and 32° 48' - 38° 22' east longitudes. It has a uniform climate with arid summers. Average annual precipitation ranges between 300-800 mm and falls during winter and spring months. Basin average precipitation is 446.1 mm and temperature is 13.7 °C. Main river of the basin is Kızılırmak. Cereal farming is the dominating culture in the basin. Beside cereals, vegetables, potato, sugarbeet, sunflower, onion, garlic, beans, vineyards, fruits, chickpeas, lentils, common vetch, alfalafa, tobacco and corn are also grown in the basin.

In this study, the total of thirty DSİ-operated and transferred irrigation schemes were taken as material (Table 1). Irrigation area, irrigated land, diverted water, irrigation water requirement for he years 2003-2005 were taken from evaluation reports of irrigation facilities; and cropping pattern, yield and unit prices were taken from reports of yield count results (Anonymous, 2004a; 2005a; 2006; 2004b; 2005b).

In this study, four comparative indicators developed by International Water Management Institute (IWMI) corresponding to unit area and water were used as performance indicators. These comparative indicators can be used to evaluate the effect of interferences in irrigation schemes, to compare system performance based on time and to compare the systems (Molden et al., 1998). If the limiting factor is water, then income per unit of water may be more important, or if the limiting factor is land, then the income per unit of land may be more important. Gross value of output per unit command area (GVCA), gross value of output per unit of cropped irrigated area (GVIA), gross value of output per unit irrigation delivered (GVID), gross value of output per unit consumed water (GVCW), total water supply ratio (RWS) and irrigation ratio (IR) were calculated by using the following equations and excel spreadsheets.

$$GVCA = \frac{\text{Production value}}{\text{Command area}} (\$/ha) \quad (1)$$

$$GVIA = \frac{\text{Production value}}{\text{Irrigated area}} (\$/ha) \quad (2)$$

Table 1. The data used related to Kızılırmak Basin Irrigation Schemes

| Scheme name | Years | Command area (ha) | Irrigated area (ha) | Irrigation supply ($m^3$/yıl) $10^6$ | Irrigation water requirement ($m^3$/ha) |
|---|---|---|---|---|---|
| Guldurcek | 2003 | 6200 | 124 | 7.200 | 3363 |
| | 2004 | 6200 | 109 | 7.214 | 3182 |
| | 2005 | 6200 | 57 | 9.614 | 3769 |
| Tashan | 2003 | 500 | 52 | 0.883 | 4447 |
| | 2004 | - | - | - | - |
| | 2005 | - | - | - | - |
| Zamantı | 2003 | 2618 | 1012 | 8.750 | 2844 |
| | 2004 | 2618 | 767 | 6.360 | 3132 |
| | 2005 | 2618 | 653 | 6.755 | 3240 |
| Tahtakopru | 2003 | 493 | 56 | 0.660 | 3500 |
| | 2004 | 493 | 42 | 0.320 | 3500 |
| | 2005 | 493 | - | - | - |
| Suksun | 2003 | 885 | 388 | 1.700 | 2577 |
| | 2004 | 885 | 355 | 3.420 | 3286 |
| | 2005 | 885 | 227 | 1.150 | 2343 |
| Gemerek | 2003 | 2150 | 829 | 6.714 | 3172 |
| | 2004 | 2150 | 676 | 4.820 | 2908 |
| | 2005 | 2150 | 460 | 3.692 | 3693 |
| Karacomak | 2003 | 1670 | 610 | 5.749 | 2773 |
| | 2004 | 1670 | 529 | 4.619 | 2798 |
| | 2005 | 1670 | 453 | 5.203 | 2865 |
| Koprukoy | 2003 | 6600 | 2811 | 89.074 | 3980 |
| | 2004 | 6600 | 2262 | 73.120 | 4018 |
| | 2005 | 6600 | 1614 | 72.058 | 4626 |
| Kızılırmak | 2003 | 4840 | 1805 | 86.200 | 7738 |
| | 2004 | 4840 | 1640 | 90.850 | 8170 |
| | 2005 | 4840 | 1747 | 50.950 | 8170 |
| Gokceoren | 2003 | 1850 | 202 | 1.325 | 4578 |
| | 2004 | 1850 | 88 | 0.521 | 4548 |
| | 2005 | 1850 | 151 | 0.705 | 4432 |
| Bafra | 2003 | 6650 | 3116 | - | - |
| | 2004 | - | - | - | - |
| | 2005 | 6650 | 3600 | 26.250 | 4303 |
| Sarımsaklı | 2003 | 7900 | 7569 | 51.319 | 2656 |
| | 2004 | 8300 | 8100 | 53.003 | 3016 |
| | 2005 | 8300 | 8149 | 46.454 | 3404 |
| Sarız | 2003 | 1040 | 530 | 2.300 | 2497 |
| | 2004 | 1040 | 590 | 2.310 | 2401 |
| | 2005 | 1040 | 580 | 2.310 | 2685 |
| Agcasar | 2003 | 12720 | 7623 | 39.862 | 3303 |
| | 2004 | 12720 | 7704 | 36.367 | 3763 |
| | 2005 | 12720 | 7254 | 22.060 | 3519 |
| Yesilhisar-T.Arkı | 2003 | 1000 | 0 | - | - |
| | 2004 | 1000 | 0 | - | - |
| | 2005 | 1000 | - | - | - |

Table 1. The data used related to Kızılırmak Basin Irrigation Schemes (continue)

| Scheme name | Years | Command area (ha) | Irrigated area (ha) | Irrigation supply ($m^3$/yıl) $10^6$ | Irrigation water requirement ($m^3$/ha) |
|---|---|---|---|---|---|
| Kovalı | 2003 | 2860 | 2523 | 26.365 | 3783 |
| | 2004 | 2860 | 2650 | 24.756 | 3911 |
| | 2005 | 2680 | 2681 | 24.993 | 3794 |
| Cogun-Guzler | 2003 | 3755 | 2016 | 16.117 | 2714 |
| | 2004 | 3755 | 1743 | 13.134 | 2648 |
| | 2005 | 3755 | 1643 | 11.377 | 2815 |
| Kultepe | 2003 | 2350 | 0 | - | - |
| | 2004 | 2350 | 0 | - | - |
| | 2005 | 2350 | - | - | - |
| Yalıntas | 2003 | 1097 | 240 | 3.150 | 3393 |
| | 2004 | 1097 | 28 | 0.282 | 5420 |
| | 2005 | 1097 | - | - | - |
| Sekili | 2003 | 1500 | 900 | 9.250 | 2107 |
| | 2004 | 1670 | 765 | 10.713 | 1863 |
| | 2005 | 1850 | 740 | 9.200 | 1881 |
| Fehimli | 2003 | 1210 | 345 | 3.928 | 4260 |
| | 2004 | 1210 | 0 | - | - |
| | 2005 | 1210 | - | - | - |
| Uzunlu | 2003 | 7222 | 2307 | 8.318 | 4260 |
| | 2004 | 7222 | 960 | - | 4260 |
| | 2005 | 7222 | 1019 | 16.800 | 4260 |
| Yahyasaray | 2003 | 3436 | 1182 | 8.112 | 3950 |
| | 2004 | 3436 | 746 | 7.911 | 4211 |
| | 2005 | 3436 | 963 | 8.408 | 4217 |
| Pasakoy | 2003 | 4072 | 1700 | 27.280 | 3402 |
| | 2004 | 4072 | 1755 | 21.640 | 1809 |
| | 2005 | 4072 | 1629 | 19.100 | 3963 |
| Yerkoy | 2003 | 4000 | 2272 | 20.500 | 2794 |
| | 2004 | 4000 | 2104 | 33.197 | 2501 |
| | 2005 | 4500 | 2358 | 40.375 | 2380 |
| Karaova | 2003 | 1800 | 1008 | 7.276 | 2726 |
| | 2004 | 2285 | 1330 | 6.610 | 2505 |
| | 2005 | 2500 | 1135 | 10.352 | 3007 |
| Yıldızırmagı | 2003 | 2426 | 925 | 9.350 | 2273 |
| | 2004 | 2426 | 1005 | 11.270 | 2421 |
| | 2005 | 2426 | 1060 | 9.240 | 2607 |
| Yapıaltın | 2003 | 1880 | 783 | 7.553 | 3485 |
| | 2004 | 1880 | 831 | 7.298 | 3467 |
| | 2005 | 1880 | 874 | 6.095 | 3588 |
| Gazibey | 2003 | 2385 | 391 | 7.680 | 3562 |
| | 2004 | 2385 | 447 | 8.080 | 3635 |
| | 2005 | 2385 | 485 | 8.000 | 3870 |
| Kırcalar | 2003 | 1450 | 331 | - | - |
| | 2004 | 1450 | 307 | 2.316 | - |
| | 2005 | 1450 | - | 3.428 | 3037 |

$$GVID = \frac{\text{Production value}}{\text{Irrigation water delivered}} (\$/m^3) \quad (3)$$

$$GVCW = \frac{\text{Production value}}{\text{Irrigation water requirement}} (\$/m^3) \quad (4)$$

$$IR = \frac{\text{Irrigated area}}{\text{Command area}} (\%) \quad (5)$$

$$RWS = \frac{\text{Total water diverted } (m^3)}{\text{Total irrigation water requirement } (m^3)} \quad (6)$$

## Results and Discussions

Among the irrigation performance indicators, for comparative indicators (GVCA, GVIA, GVID and GVCW) are the measures corresponding to the unit land area and unit irrigation water and the values of them calculated based on the local prices were given in Table 2 for the year 2003 and Table 3 for the year 2004.

Calculations couldn't be done for the year 2005 due to lack of reliable data. The lowest GVCA as 67 $/ha and 66 $/ha in Guldurcek Irrigation, the highest GVCA as 4902 $/ha and 5550 $/ha in Kovalı Irrigation were obtained for the years 2003-2004 (Table 2 and Table 3). Irrigation ratio was realized as 2% in Guldurcek Irrigation for the years 2003-2004. However, these ratios were 88% and 93% in Kovalı Irrigation.

Table 2. Gross production value in the study area for 2003

| Scheme name | GVCA ($ /ha) | GVIA ($/ha) | GVID ($ /m$^3$) | GVCW ($ /m$^3$) |
|---|---|---|---|---|
| Guldurcek | 67 | 3369 | 0.06 | 1.00 |
| Tashan | 523 | 5031 | 0.30 | |
| Zamantı | 1672 | 4326 | 0.50 | 1.52 |
| Tahtakopru | 839 | 7385 | 0.63 | 2.11 |
| Suksun | 930 | 2122 | 0.48 | 0.82 |
| Gemerek | 957 | 2482 | 0.31 | 0.78 |
| Karacomak | 2206 | 6038 | 0.64 | 2.18 |
| Koprukoy | 466 | 1095 | 0.03 | 0.28 |
| Kızılırmak | 1156 | 3100 | 0.06 | 0.40 |
| Gokceoren | 284 | 2603 | 0.40 | 0.57 |
| Bafra | 1338 | 2855 | - | - |
| Sarımsaklı | 2453 | 2560 | 0.38 | 0.96 |
| Sarız | 1540 | 3021 | 0.70 | 1.21 |
| Agcasar | 1426 | 2380 | 0.46 | 0.72 |
| Yesilhisar-T.Arkı | - | - | - | - |
| Kovalı | 4902 | 5557 | 0.53 | 1.47 |
| Cogun-Guzler | 1488 | 2772 | 0.35 | 1.02 |
| Kultepe | - | - | - | - |
| Yalıntas | 1066 | 4873 | 0.37 | 1.44 |
| Sekili | 997 | 1662 | 0.16 | 0.79 |
| Fehimli | 1005 | 3523 | 0.31 | 0.83 |
| Uzunlu | 1351 | 4229 | 1.17 | 0.99 |
| Yahyasaray | 851 | 2474 | 0.36 | 0.63 |
| Pasakoy | 1438 | 3446 | 0.21 | 1.01 |
| Yerkoy | 1027 | 1810 | 0.20 | 0.65 |
| Karaova | 744 | 1328 | 0.18 | 0.49 |
| Yıldızırmagı | 642 | 1684 | 0.17 | 0.74 |
| Yapıaltın | 2329 | 5591 | 0.58 | 1.60 |
| Gazibey | 417 | 2541 | 0.13 | 0.71 |
| Kırcalar | 656 | 2872 | - | - |

Table 3. Gross production value in the study area for 2004

| Scheme name | GVCA ($ /ha) | GVIA ($/ha) | GVID ($ /m$^3$) | GVCW ($ /m$^3$) |
|---|---|---|---|---|
| Guldurcek | 66 | 3758 | 0.06 | 1.18 |
| Tashan | - | - | - | - |
| Zamantı | 1665 | 2336 | 0.69 | 1.81 |
| Tahtakopru | 649 | 7620 | 1.00 | 2.18 |
| Suksun | 1066 | 2657 | 0.28 | 0.81 |
| Gemerek | - | - | - | - |
| Karacomak | 1858 | 5865 | 0.67 | 2.10 |
| Koprukoy | 402 | 1173 | 0.04 | 0.29 |
| Kızılırmak | 1397 | 4123 | 0.07 | 0.50 |
| Gokceoren | 225 | 4726 | 0.08 | 1.04 |
| Bafra | - | - | - | - |
| Sarımsaklı | 2845 | 2915 | 0.45 | 0.97 |
| Sarız | 1679 | 2959 | 0.76 | 1.23 |
| Agcasar | 1592 | 2628 | 0.56 | 0.70 |
| Yesilhisar-T.Arkı | - | - | - | - |
| Kovalı | 5550 | 5990 | 0.64 | 1.53 |
| Cogun-Guzler | 1467 | 3160 | 0.42 | 1.19 |
| Kultepe | - | - | - | - |
| Yalıntas | 119 | 4654 | 0.46 | 0.86 |
| Sekili | 743 | 1621 | 0.12 | 0.87 |
| Fehimli | - | - | - | - |
| Uzunlu | 587 | 4417 | - | 1.04 |
| Yahyasaray | 797 | 3671 | 0.35 | 0.87 |
| Pasakoy | 1472 | 3415 | 0.28 | 1.89 |
| Yerkoy | 962 | 1849 | 0.12 | 0.73 |
| Karaova | 718 | 1234 | 0.25 | 0.49 |
| Yıldızırmagı | 917 | 2213 | 0.20 | 0.91 |
| Yapıaltın | 2500 | 5655 | 0.64 | 1.63 |
| Gazibey | 454 | 2425 | 0.13 | 0.67 |
| Kırcalar | 762 | 3600 | 0.48 | - |

GVCA in Konya Irrigation Associations for the years 1995-1999, Ceylanpınar Irrigation Associations for the years 1995-2000, Sakarya Basin Irrigation Schemes for the years 1999-2000, K.Maras Irrigation Schemes for the years for the years 1996-2001 werefound out as 279-2860 $/ha, 771-1711 $/ha, 474-3520 $/ha, 430-2573 $/ha, respectively (Cakmak, 2001; Cakmak, 2003; Cakmak and Beyribey 2003; Degirmenci, 2004).

GVIA ranges between 1095-7385 $/ha for 2003 and 1173-7620 $/ha for 2004 in the research area. The lowest GVIA was observed in Koprukoy Irrigation and the highest was observed in Tahtakopru Irrigation for both years. GVIA were found out as 859-3061 $/ha in K.Maras Irrigation Schemes for the years 1996-2001, and as 1181-8900 $/ha for the years 1999-2000 in Sakarya Basin Irrigation Schemes (Degirmenci, 2004; Cakmak and Beyribey 2003). Degirmenci (2001) calculated it as 190-14843 $/ha in 158 irrigation schemes considering the results of the year 1998. The highest GVIA was determined as 1800 $/ha and the lowest as 105 $/ha in Mexico-Alto-Rio Lerma Irrigation Scheme (Kloezen and Garces–Restrepo, 1998).

GVID ranges 0.03-1.17 $/m$^3$ for the year 2003 and 0.04-1.00 $/m$^3$ for the year 2004, with the highest value in Uzunlu and Tahtakopru Irrigations and the lowest value in Koprukoy Irrigation, in the research area. Considering the whole irrigated area, sugarbeet was grown in Uzunlu Irrigation and fodder crops was grown in Tahtakopru Irrigation for the years 2003-2004. Cereals and legumes were grown over

79.8% of irrigated area for the year 2003 and 43.5% of irrigated area for the year 2004 in Koprukoy Irrigation. GVID in Ceylanpınar Irrigation Association for 1995-2000, K.Maras ırrigation Schemes for 1996-2001, Konya Irrigation Associations for 1995-1999 were determined as 0.13-0.23 $/m$^3$, 0.07-3.45 $/m$^3$ and 0.02-2.16 $/m$^3$, respectively (Cakmak, 2003; Degirmenci, 2004; Cakmak, 2001). Degirmenci (2001) found out GVID as 1.86 $/m$^3$ as the highest in Antalya-Gazipasa Irrigation, and however 0.03 $/m$^3$ as the lowest in Sucatı Irrigation.

GVCW ranges 0.28-2.18 $/m$^3$ for 2003 and 0.29-2.18 $/m$^3$ for 2004. The lowest values were observed in Koprukoy and the highest values were in Karacomak and Tahtakopru Irrigations. The difference among the calculated gross value of productions was due to change in cropping pattern and irrigated area. GVCW were found out as 0.39-2.77 $/m$^3$ in Sakarya Basin Irrigations for 1999-2000, and 0.02-1.88 $/m$^3$ in Kızılırmak Basin Irrigation Associations for 1999-2000 (Cakmak and Beyribey 2003; Cakmak 2002). Burt and Styles (1998) in Meksika-Rio Mayo Irrigation Scheme, Molden et al. (1998) in Burkina Faso-Gorgo Irrigation Scheme and Degirmenci (2001) in Gazipasa and Uluborlu Irrigation Schemes were obtained 0.17 $/m$^3$, 0.91 $/m$^3$, 3.02 $/m$^3$ and 2.23 $/m$^3$, respectively. Gross value of productions changes as regard to cropping pattern. Based on the studies carried out by IWMI on 18 Irrigation Systems in 11 countries in the world since 1992, it was determined that the income obtained was found to be higher in irrigation schemes with higher rates of fruit, vegetable and industrial crops (Molden et al., 1998).

RWS was calculated based on total irrigation water requirement in the study area for 2003-2005 and given in Figure 1. Although Guldurcek irrigation had the highest RWS values for the years 2003-2005, these values were not taken into consideration in evaluations since most of the diverted water in this scheme is allocated to local irrigations (rice cultivation areas in Ilgaz, Tosya and Kargı Districts) outside the DSI-operated area.

RWS ranges 0.8-8.0 for 2003, 1.3-8.0 for 2004 and 0.9-9.7 for 2005. The lowest RWS and the highest RWS were obtained in Uzunlu Irrigation with 0.8 and Koprukoy Irrigation with 9.7, respectively. More water than requirement was diverted to the study area and RWS was realized over one. Beyribey et al. (1997a) found out RWS as 0.58-2.41 for 1984-1993 in 21 irrigation schemes from 21 DSİ regions. Bandara (2003) calculated RWS in Sri Lanka Polonnaruwa, Krindi Oya ve Gal Oya Irrigations as 1.88, 1.27 and 2.71, respectively. A total water supply ratio of 1 indicates that sufficient water was diverted to the scheme, a value lower than 1 indicates that insufficient amount of water was supplied and a value higher than 1 indicates that excessive water was supplied to the scheme. Cakmak (20019 determined the RWS as 0.70-7.83 in Konya Irrigation Associations between the years 1995-1999. Cakmak (2003) found out RWS values as 2.05-3.81 in Ceylanpınar Irrigation Associations for 1995-2000. Degirmenci (2001) determined the value as 0.91-7.15 for the irrigation schemes transferred to irrigation associations for 1998. Sener et al. (2007), detected RWS as 1.91 for 2002 in Hayrabolu Irrigation Scheme.

Irrigation ratios were given for 2003-2005 in Figure 2. IR were realized with highest value as 96% in Sarımsaklı Irrigation, with lowest value as 2% in Guldurcek Irrigation for 2003; however, with highest as 98% in Sarımsaklı Irrigation and with lowest value as 1% in Guldurcek Irrigation for 2004-2005. While irrigated area was 7569 ha for 2003, it increased to 8100 ha for 2004 in Sarımsaklı Irrigation. The total unirrigated area was 6076 ha; of which 2936 ha rainfed agriculture, 3000 ha uncultivated area with socio-economic factors and 140 ha with other causes for 2003 in Guldurcek Irrigation (Anonymous, 2004a). For the year 2004, the total unirrigated area was 6091 ha; of which 2041 ha rainfed agriculture, 2050 ha fallow area and 2000 ha uncultivated area with socio-economic factors in Guldurcek Irrigation (Anonymous, 2005a). The total unirrigated area was 6143 ha; of which 2041 ha rainfed agriculture, 2050 ha fallow area 2052 ha uncultivated area with socio-economic factors for 2005 in Guldurcek Irrigation (Anonymous, 2006). Irrigation supply is more than irrigation water requirement in Guldurcek Irrigation.

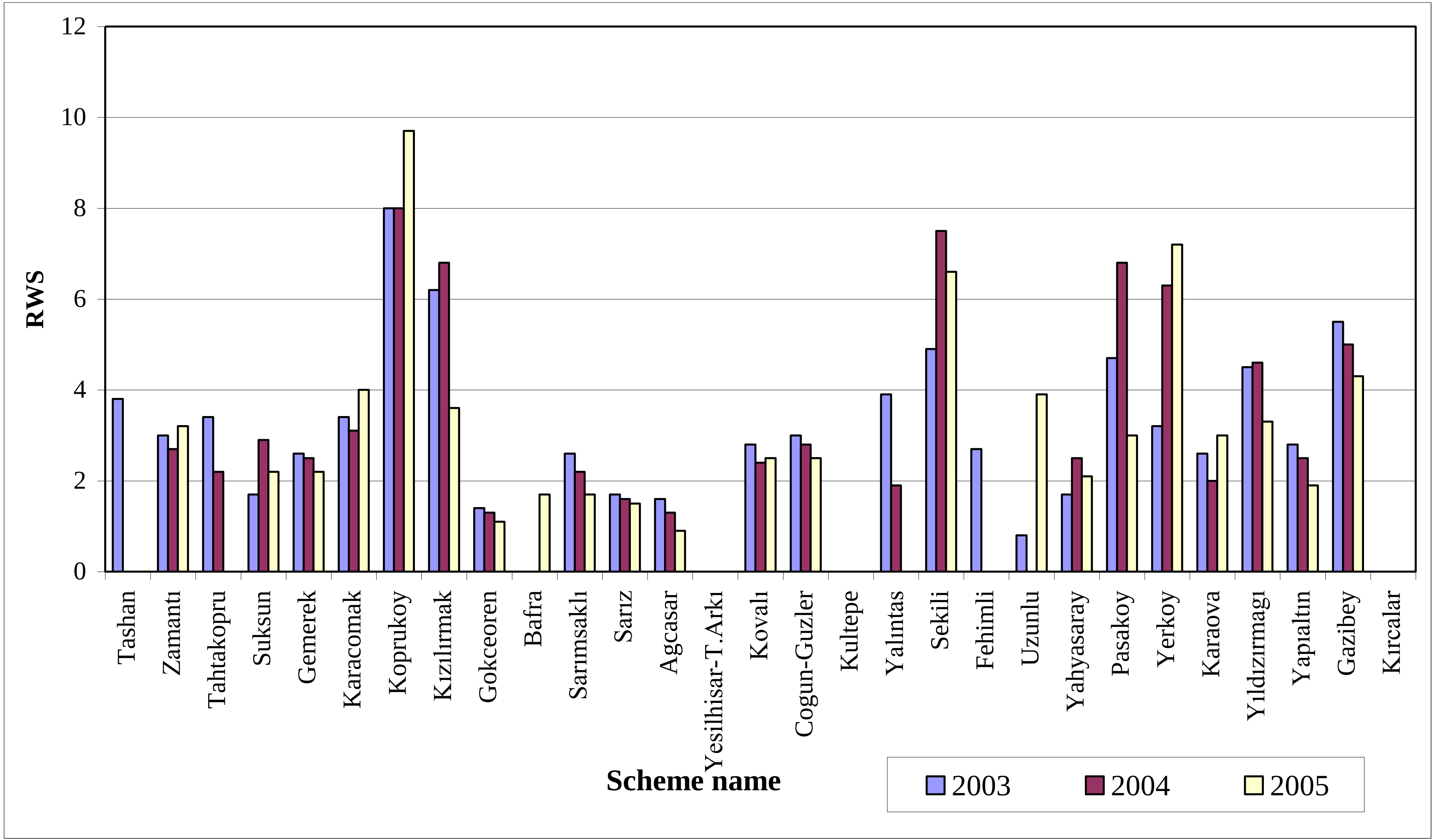


Figure 1. Relative Water Supply in the Study Area

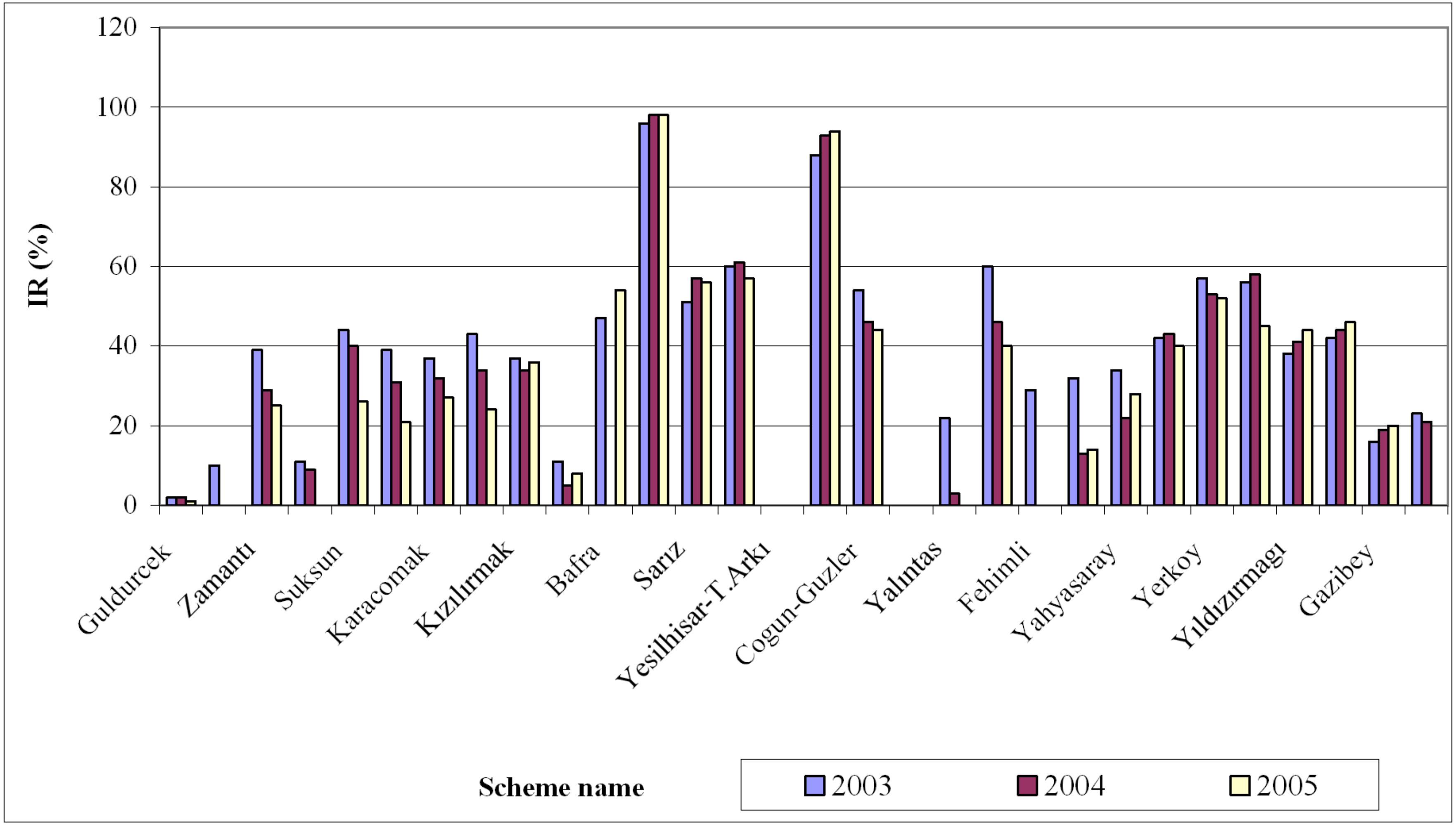


Figure 2. Irrigation ratios in the study area

Beyribey et al. (1997b) determined IR as 24-105% based on a study for 21 irrigation schemes in 21 irrigation region for the years 1984-1993. Degirmenci (2001) determined the IR for irrigation associations for 1998 as ranging between 4-100%. IR were found out in Kızılırmak Irrigation Associations for 1999-2000 and in K.Maras irrigation schemes for 1996-2001 12-96% and 40-90%, respectively (Cakmak, 2002; Degirmenci, 2004). However, IR was calculated as 23% in irrigation schemes by DSİ and 59% in transferred schemes (Anonymous 2006).

## Recommendations

The gross production values per unit area obtained from Kızılırmak Basin Irrigation Schemes are consistent with the results of several other studies carried out at different locations of Turkey. The large part of irrigation area of some irrigation schemes cannot be irrigated in the Basin. Utilization of comparative indicators in performance evaluation has provided an opportunity to compare different irrigation systems. Looking over the GVCA, GVIA, GVID and GVCW values from this study, it was shown that the GVIA was found to be higher in irrigation schemes with higher rates of sugarbeet. GVCA, GVIA, GVID and GVCW values obtained for thirty schemes in this study are in good agreement with the results obtained by Molden et al. (1998) in 18 irrigation systems in 11 countries.

Whole irrigation area cannot be irrigated due to fallow area, technical and socio-economic factors in irrigation schemes. Irrigation area and crop pattern can be changed by year to year. The result of indicators from the same irrigation scheme can be different as regard to years for this reason. If the unirrigated area can be irrigated in the study area, gross value of production per unit-irrigated area will be ranged between 1095-7620 $/ha. Precautions should be taken to decrease fallow area, and farmer training can be provided on this subject in the study area.

Comparative indicators showing the water use efficiency in agriculture lead planners for an efficient land and water use. Besides, it provides determination of irrigated agriculture investments and monitoring of performance of irrigation schemes. Different irrigation schemes can be compared with these indicators from the point of water, soil and agricultural production. It is also a useful tool in time-domain comparison for irrigation systems or different parts of an irrigation scheme among themselves.

RWS for all irrigation schemes was found to be higher than 1 since the diverted water was more than the need, unproper application of a planned water delivery, water losses in scheme, unconscious irrigation applications, and land-based water pricing. For more effective water utilization in the country, irrigation water pricing approach should be reconstructed at basin level. Since the infrastructure to measure utilized water in a field base is not sufficient, water fees are calculated based on irrigated land area and crop types; and in a few irrigation associations "duration of irrigation-hour (TL/hour)" was used for water fees. The pricing based in volumetric use should be initiated and application has to be speed up. Effective water utilization policies should be developed and basin-scale irrigation performance evaluations should be carried out.

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