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Sustainable Irrigation and Importance of Technological Irrigation Systems for Konya Basin

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Abstract

In this study, available water potential, excess water use in agriculture was briefly analyzed first and then sustainability of irrigation and importance of pressurized irrigation methods for efficient water resources use were discussed in Konya basin of Turkey. Basin water resources are scant with 2.5% of total available water potential of Turkey. Present agriculture has resulted excess surface and groundwater uses in basin. The main reasons of this are unplanned increase of the irrigated areas and current crop patterns. This has caused 1.4 billion m^3 excess water extractions from basin groundwater resources. There is almost 70 000 unplanned open illegal wells resulted excess water extraction. Portable sprinkler irrigation system is widely used for field crops so average irrigation efficiency is high. Excess water use has not resulted from the farmers irrigation applications. In summary, to irrigate all areas open for the irrigation by present available water resources, new irrigation techniques and water resources development works are needed.

Key words: Konya basin, water resources potential, irrigation, sustainable water use.

INTRODUCTION

Drought is one of the common environmental stresses restricted agricultural productions in the world. On the other hand, the use of irrigation water from basin water resources has gradually declined due to the environmental pollution and global climate changes. Thus, development of new water saving techniques and intensively their uses are necessary. Since, agriculture is the single highest fresh water user as 70% in the world [17] and has reached up 90% in some cases [3]. Water resources are declining worldwide [25] and are scant in nearly 80 countries with more than 40% population of the world [24]. By projections of 2030 water withdrawal for irrigation will increase by about 14% [5].

Konya Closed Basin, KCB, one of the important water basins of Turkey with average annual 378 mm rainfall [6], has almost arid climate. Therefore, total semi-arid lands of the world are 14.2% and Konya basin is within these areas [2]. In the near past (10-15 year), the annual water potential of basin was 950 m^3/person, but it has reduced up to 750 m^3/ person. This resulted reduction of water resources in Konya that is known as water poor basin. Under present conditions, 88% available water potential has allocated for agriculture [6] and currently agriculture has 90% of total water consumption in basin [29]. Current irrigated agriculture has resulted excess uses of basin water resources [6, 18, 29, 30].

In this study, water resources of Konya basin, irrigation and excess water use in basin agriculture were analyzed with detail. In addition, some suggestions were given for sustainable irrigation, reducing excess water uses and also importance of pressurized irrigation systems were also discussed.

DROUGHT, WATER POTENTIAL AND USE IN IRRIGATION IN KONYA BASIN

Agricultural drought in Konya basin

Semi-arid climate is common and annual precipitation varies from 280 mm to 350 mm (almost arid climate) in most parts of the Konya Basin. The 20-25% of total rainfall has observed in crop growth period. This situation, geographical position, has led to semi-arid climate conditions as well as agricultural drought.

Agricultural drought can be defined as the condition of insufficient water status within the soil to meet crop water requirement. It has associated by moisture loss and shortage of water resources. In agricultural drought, water amount within the crop root zone depth is considered. It can not be defined as low rainfall event in any place. In other word, low rainfall may not mean agricultural drought. In some cases, sufficient amount of water could be within the crop root zone depth under low rainfall conditions.

Agricultural drought is more harmful especially for high water consuming crops. Konya basin has arid climate due to lack of rainfall amount and ununiform distributions throughout the year. According to recent report, it is not a new history. Increase of high water consuming cropped lands, adding new crops and rapid increase of irrigated areas has resulted intensive pressure on water resources of basin. This has led to over water extraction from basin groundwater resources [30].

Konya basin has almost little agricultural drought for some crops such as barley, wheat and high agricultural drought for crops such as sugar beet, corn, bean, potato, tomato, water melon, soy bean. To reduce the harmful drought effects, irrigation applications have been performed in basin.

Water resources of basin and availability

The surface and groundwater resources of basin and finally available water resources by transferring water from Göksu River in near future are presented in Table 1.

In Table 1, available water potential of basin is 2.74 billion m^3 and safely available water potential of 2.618 billion m^3 with accessed water of 2.308 billion m^3 for agriculture in basin [6]. By transferring 417 million m^3 water from Göksu basin, total available water potential of basin will be 3.18 billion m^3 /year. Available and finally available water resources of basin are 2.5% and 2.9% of total Turkey, respectively [29].

Total arable land potential of basin is 2.75 million hectare (ha) and accounts of 10.8% of total arable land of Turkey [6]. The 80% of this arable land can not be irrigated. Almost all land potential of basin is irrigable by considering new developments in irrigation technologies. Average irrigation water requirement of crops reported as 683.5 mm (499 mm net water requirement/0.73 irrigation efficiency) by Topak et al. [30]. By considering this crop water requirement value, Konya Plain Projects (KOP) and basin general water requirement are determined (Table 2).

As seen from Table 2, water requirements for only Konya Plain Projects areas and basin are almost 12-13 billion m^3 and 19 billion m^3, respectively. Available water resources of basin are poor for irrigation of all irrigated areas.

Irrigation in basin and evaluation of present case

The total areas of basin with or without (public irrigation) projects are 542 118 ha [6]. The 370 000 ha of this amount is in Konya plain. The current irrigated land of basin is 10% of total irrigated land of Turkey. High water consumption summer crops and low water consuming winter cereals have produced as 60% and 40%, respectively in irrigation areas. Thus, average net crop water and irrigation efficiency reported as 499 mm and 73%, respectively [30]. In basin, by considering the crop pattern and irrigation efficiency, 340 000 ha areas can be irrigated by accessed 2.308 billion m^3 water. It

Table 1. Available water potential of basin at Present and at near future

Water Resources	Available water potential (billion m^3)								
	Basin General			Open for use			Basin+Göksu (Finally)		
	Agriculture	Residential	Total	Agriculture	Residential	Total	Agriculture	Residential	Total
Surface	1.025	0.064	1.089	0.900	0.047	0.947	1.390	0.119	1.509
Groundwater	1.408	0.263	1.671	1.408	0.263	1.671	1.360	0.311	1.671
Total	2.433	0.327	2.760	2.308	0.310	2.618	2.750	0.430	3.180

Table 2. Water requirements for irrigable lands

Land, ha	Area, ha	Irrigation water requirement (m^3/ha)*	Required irrigation water (billion m^3)
Irrigated-area (542118)	542 118	6835	3.705
Konya Plain Projects (KOP)**	1 500 000	6835	12.986
Total Basin (2754243)***	3 150 000	6835	18.825

*Topak et. al. (2008) **Kara et al. (1992) ***Anonymous (2007)

Table 3. Available Water Potential of Basin, Net Water Requirement of Irrigated Lands and Water Uses in Irrigation (Topak et al. 2008).

Finally Available Water Potential * (billion m^3)		Present Available Water Potential* (billion m^3)		Net Water Requirement in Present Irrigated Area ** (billion m^3)	Present Water Uses in Agriculture** (billion m^3)
Total	Agriculture	Total	Agriculture		
3.180	2.750	2.618	2.308	2.707	3.690

* Anonymous, (2007) ** Topak, (2008)

indicates that there is 542 000 ha area opened for the irrigation and 200 000 ha excess areas has opened to irrigation. This excess area has resulted use of unsafely 1.4 billion m^3 water from the groundwater resources of basin. Available water potential of basin, net water requirement of irrigated lands and water uses in irrigation are given in Table 3.

Topak et al. [30] reported that net annual water requirement for crop pattern in irrigated lands of basin has estimated as 2.7 billion m^3. However, total annual water extracted from basin resources for irrigation has estimated as 3.69 billion m^3 (Table 3). Although total safely available water allocated from basin resources is 2.308 billion m^3 at present, 3.69 billion m^3 water has been used. The water used in irrigation of basin is 3.69 billion m^3; 2.790 billion m^3 (3.690-0.9) from groundwater resources and 0.90 billion m^3 from surface water resources. It is obvious seen that excess water used in basin agriculture is 1.382 billion m^3 (3.690-2.308) and all is obtained from groundwater resources.

As seen Table 3, available water potential of basin is not enough for irrigation of all arable lands. Water use in agriculture is higher than safely available water potential of basin and irrigation is seen not sustainable with present form. The main reasons of excess water use in agriculture are increases in area opened for irrigation and high water consuming cropped lands. By considering land size or potential, ending excess water use in agriculture, sustainable water resources and agricultural production are necessarily prerequisites.

SOLUTION APPROCHES FOR SUSTAINABLE IRRIGATION

To conserve, develop and sustain irrigated agriculture of basin, following radical precautions are needed;

- Efficient use of water resources
- Studies for developments in obtaining new water resources.

Efficient use of water resources

It is clearly seen that excess water use has observed in basin agriculture and this has resulted rapid reduction in groundwater resources. This problem will be more serious in near future. To sustain the present water resources, irrigation of areas by safely available water resources are necessarily prerequisites. To use basin water resources efficiently;

- Water use in basin should be limited by allocated safely available water potential
- The excess water use in agriculture should be analyzed or determined correctly
- Crop pattern should be reorganized
- New irrigation techniques resulted high efficiency or water savings should be developed and applied.

Making irrigation plans according to safely water reservoir

The safely available surface and groundwater potential of basin agriculture reported as 2.308 billion m^3 [6]. Irrigation plans should be performed higher than that value. Since, annual available water potential has restricted by this value. In this case, irrigated area of basin will be reduced as 30% and has reached 350 000 ha. If it is impossible to reduce the irrigation area, low water consuming cropped lands should be increased and conventional irrigation techniques are never applied.

Reasons of excess water use in agriculture

By considering information mentioned above, reasons of excess water use in agriculture are; unplanned increase of irrigation areas, current crop patterns, senseless of society and farmer irrigation applications.

Although total safely available water allocated from basin resources is 2.308 billion m^3, net annual water requirement of crop pattern in irrigated lands of basin has estimated as 2.7 billion m^3. It means that net water requirement of basin crop pattern is higher than available water resources. There are two main reasons of this. The first is some high water consumption crops such as grain corn have added to the crop pattern and those cropped lands have been increased. The second, the most important, is that high water consumption crops have increased two fold in a short period. In summary, irrigated lands has increased for the favor of high water consumption crops within 5-6 years.

In addition, almost none efforts have been done about danger of drought in most rural societies and almost none demonstration works related to importance of water have been performed. Like Turkey general, especially in Konya with other basins, civil societies have governed by monopole authorities. Thus, they can not perform their responsibilities properly. Due to the senseless of local managers and producer organizations about basin problems, producers have the rights of water resources usage. Thus, none owners are present for water resources.

Reorganization of crop pattern

The areas of winter cereals, summer fodder crops and fruit gardens - fodder crops are 40%, 50% and 10%, respectively in irrigation lands of basin. The summer crops in general are high water consuming crops. In this group, sugar beet is the highest production area as 21% followed by potato as 8%, vegetable (including carrot) as 7.5%, dry bean as 6%, maize as 5% and sunflower as 2.5% [30]. To reduce the excess water use by changing the crop pattern such as shortening planting areas of high water consuming crops or adding new crops that are low water consuming, radical decisions are needed in basin. The highest water consuming crops in basin are sugar beet, maize and potato and they accounts of 60% in summer crops. Sugar beet is the most water consumption

with a value of 1.167 billion m^3 followed by potato of 0.298 billion m^3 and maize of 0.227 billion m^3 [30]. The 50% reduction in sugar beet planting area, completely ignoring of maize production and conserving of present potato production areas will be beneficial solution for sustainability of basin water resources.

The irrigation of cereals is the other cause of excess water use in basin. The previous studies [4, 16] showed that especially water requirement of wheat is 200-250 mm in basin. In reality, two fold of water has been applied and 0.85 billion m^3 water has used for winter cereals [30]. This shows that almost excess 200-250 mm water has been applied for winter sowing cereals.

Application of new irrigation techniques

Beside use of conventional irrigation techniques, application of full crop water requirement, new deficit irrigation techniques, not resulted significant yield reduction, may be applied and new irrigation systems can be designed in accordance of deficit irrigation. In this study, individual deficit irrigation widely used in public irrigations was evaluated. Deficit irrigation may be suggested in areas where water resources are scant whereas irrigation lands are great. However, it is more difficult in practice than the full irrigation. Many studies showed that these are suitable for some crops such as sugar, potato, maize, wheat, sunflower, dry bean as well as some vegetables. By development of these techniques that are suitable those crops, both present crop pattern and irrigation areas will be remain and also extracted water from the basin groundwater resources will be restricted by allocated amount.

For instance, if we make a 25% deficit in present consuming water of basin, consumable water amount will be 2.75 billion m^3 instead of 3.69 billion m^3. It means that there is a 0.925 billion m^3 more low water use from ground water resources. Irrigated land also will still remain as 542 000 ha.

Finding new irrigation water resources

In this issue, unconventional water resources uses and rainwater harvesting are advisable for Konya basin. These application are met only very little amount of water deficiency. These are two new water resources. The contribution of this for water problem of basin is very little. There is debate in Turkey about the marginal waste water use (residential waste and drainage water) in agriculture recently [11, 20]. Usage of this source is necessary for Konya basin agriculture due to the water shortage. A new refine unit has built by Konya Municipality for refining and reuses residential waste water in agriculture. The Konya basin covers Konya, Karaman, Niğde and Aksaray, and Konya has 80 million m^3 residential waste water potential, but refine unit of Konya Municipality has the refine capacity of 50 million m^3 [10]. The improved 50 million m^3 waste water will be stored in Hotamış storage where it is close to Çumra region. By considering the current crop pattern of basin, additional 7 500 ha land will be irrigated by this 50 million m^3 water. This value is quite important amount. The residential waste water of other cities should be refined and used for sustainable agriculture and water resources.

Farming by rainwater harvesting covers three major components: rain water harvesting system, irrigation system with water saving, and crops with high yields**.** In recently, there are many efforts about rainwater harvesting, storage and usages techniques of harvested water in irrigation especially in arid and semi arid regions of the Africa, Middle East, South Eastern Asia and India [12, 13, 23, 27]. Most of these studies are about small-scale rainwater harvesting and storages works. Rainwater harvesting techniques can be successfully done for irrigation of vineyards and fruit gardens, and those plants use less water comparison to the field crops in basin. In hilly sides of basin, rainwater harvesting systems are occasionally constructed. Therefore, for rainwater harvesting works and their applications, subsidizing by government are necessary.

IMPORTANCE OF PRESSURIZED IRRIGATION METHODS FOR WATER RESOURCES

The low irrigation efficiency is an indicator of excess water losses. Those losses have observed during the conveyance, distributions and field applications. The water used in irrigation of basin is 3.7 billion m^3; 2.7 billion m^3 from groundwater resources and 0.90 billion m^3 from surface water resources. This shows that 75% (2.8/3.7x100) of total irrigation water has obtained from groundwater resources [30]. The other 25% water obtained from surface resources has conveyed and distributed by open canal systems. The some part of 75% groundwater has conveyed and distributed by pipe lines with a plan and other (most parts) of this has used directly

Table 4. Number of wells managed by irrigation organizations and public

Management Type	Number of Registered Well	Number of Unregistered Well	Total
Public irrigations	27140*	66808*	93948*
irrigation organizations	4749**	-	4749

*İşçioğlu, (2008) **Anonymous, (2008a)

in irrigation by individual farmers wells. The number of wells managed by groundwater irrigation organizations and public are presented in Table 4.

In Table 4, there are almost 100 000 wells in basin. The 94 000 of them belongs to public and 67 000 of this were constructed by without permission.

It is possible to make a conclusion like this by use of information mentioned above. The 2.7 billion m^3 water has extracted from groundwater resources and most of this has been used for irrigation directly from public wells. Thus, none water has been lost throughout the conveyance and distribution due to the direct applications of water to the crops. By considering the wells managed by irrigation organizations, conveyance and distribution of water have made by pipe line systems so that very little amount of water has been lost. In this case, water lost can be as field irrigation lost, and irrigation efficiency is affected by only field irrigation lost or farmer applications. Thus, ***irrigation efficiency*** is equal to the ***field water application efficiency*** for basin.

The effect of farmer applications on excess water consumption were analyzed and evaluated. Irrigation efficiency of basin is 73% (2.707/3.69x100=73%) [30]. By considering the averages of those values are 45% [8, 15] in Turkey and 37% in the world [24], it can be concluded that farmers in basin have great experiences about irrigation applications. There are two reasons of this. The first is that farmers have almost 100 years irrigation experience in basin and second is that sprinkler irrigation has been very widely and properly used. In properly managed portable sprinkler system, water application efficiency reported as 75-80% [14, 22, 26]. It was reported as 77–83% for basin in some previous studies [28, 30, 31]. The estimated value of basin as 73% is within the literature values. Since, sprinkler irrigation is more common in basin. The studies conducted in 1990's showed that, use of sprinkler irrigation system was 75% of total irrigated areas of basin [1, 28].

According to Anonymous [9], 55 207 (25.1%) of total 219 868 sprinkler systems of Turkey is in Konya basin. There are almost 95 000 wells and water has directly applied to the crops. By allocation of credits and subsidize to the sprinkler irrigation systems, the number of the wells have almost reached up to the number of sprinkler system.

It is possible to say that farmers in basin have well adapted to the sprinkler irrigation system and they have used all technological innovation in irrigation very well. As a result of this, water application efficiency is the highest value. Thus, farmers are not responsible for excess water applications. The main reason of excess water use is increment in planting areas of high water consuming crops.

CONCLUSION

Water resources of basin are insufficient to meet the crop water requirement. The available water potential is lower than 1000 m^3/ person. The current agriculture has used almost 90% of annual consuming water. The present agriculture has resulted excess water extraction from groundwater resources. The excess water extraction from groundwater reservoir is 1.4 billion m^3. Farmer irrigation applications have very little effect on excess water use. The reasons of excess water use are present crop pattern and the area opened for irrigation is almost two fold by considering available water potential. This is very big problem inhibited sustainable water resources use in basin. Up to near past, although farmers obtained enough water from groundwater resources, currently most farmers have not obtained right amount of water during irrigation season. By considering those evaluations, the precautions for sustainable irrigation are follows;

· Irrigation area should be replanned by considering available water potential and present crop pattern of basin.

· Present available water resources should be used efficiently. For this, highly efficient irrigation techniques are highly recommended. New irrigation water resources must be developed in basin. Rapid works about obtaining drainage water, residential waste water and rainwater harvesting should be started. Farmers have used water from drainage canals for many years. The studies related to the reuses residential waste completed and 50 million m^3 new water resource will be used within very small period. The similar applications may be performed in other residential places of basin. In proper places, rainwater harvesting must be supported and subsidized.

· In long term, water transfer projects for obtaining water from neighbor basins should be continued.

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