RESEARCH ARTICLE

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A Survey on Energy Use in Agricultural Irrigation and Determination of Saving Measures in Sanliurfa, Diyarbakir and Mardin Provinces in Turkey

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ABSTRACT

The main objective of this study is to determine the necessary measures to reduce energy consumption and save energy in agricultural irrigation in the Southeastern Anatolia Region of Turkey. The primary data of the survey study consists of the primary data collected through face-to-face surveys with producers in Sanliurfa, Diyarbakir and Mardin provinces. In the survey, the number of questionnaires to be applied to the producers was determined as 300 in total and the farms to be surveyed were determined by using stratified random sampling method. Flood and furrow irrigation methods are commonly used (62%) in the region. About a quarter of the farmers apply sprinkler irrigation. Nearly four-fifths (78%) of the farmers in the region report that there is a loss-leakage in the irrigation system. A very high proportion (95%) of the farmers in the region apply non-pressure irrigation, and approximately three-quarters (76%) report that they do not know whether the pumps and irrigation systems used are working at the recommended flow and pressure. Almost all of the farmers in the region (98%) do not use solar energy systems. A very high proportion (94%) of regional farmers does not use engine drivers in pumps. The responses of the farmers to the survey questions were interpreted and discussed and suggestions were developed based on the responses of the farmers to the survey questions.

Keywords: Agricultural irrigation, energy use, energy saving, Turkey.

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I. Introduction

Agriculture and agro-based industry are in rapid development in the Southeastern Anatolia Region (SAR). With the introduction of the Southeastern Anatolia project (GAP), irrigated agricultural areas have started to increase substantially, areas with cotton farming extended rapidly; all of those developments have caused the cotton gin and textile industry to grow in the SAR, and they have contributed to the economy of the region as well as the national economy. In terms of the size of the share of agriculture in the Regional Gross Product (RGP); Southeast Anatolia Region is in the first place. The agricultural sector in the SAR, which has a country average and higher values in the agricultural sector, maintains its characteristic of being the main sector with its high employment rate. The SAR ranks last in Turkey in terms of agricultural production value per rural population and ranks last in terms of agricultural production value.

Negative effects of climatic conditions cause a low amount of product to be bought. Low rainfall causes that year to be completely dry, especially in the areas where irrigation cannot be done. Dozens of dams built in the region in the context of the GAP are expected to both revitalize the agricultural economy of this area and positively stop the migration phenomenon. The types of agricultural products are changing in the fields irrigated by the canals of Atatürk dam and the economic welfare level of the people has been gradually improved year by year. The main changes observed in these areas are the widespread use of cotton in the Harran Plain and the tendency of greenhouse cultivation in these areas. This shows that an extensive method has started to dominate in field and the effect of traditional factors has started to disappear with the use of machinery in irrigation and agriculture [1].

Agricultural production, in many regions of the world, is strongly affected by global climate change and the drought problems. The amount of water used in agricultural irrigation and energy consumption are of the great importance for sustainable agricultural production. For this reason, extensive researches [2]-[12] have been carried out by different researchers in different regions of the world on irrigation methods, water consumption of agricultural plants, prevention of drought, reduction of water and energy consumption in agricultural irrigation. Therefore, in this study, it is aimed to determine the necessary measures to reduce energy consumption and save energy in agricultural irrigation in the SAR of Turkey.

II. Material and Methods

A. Study Area Description

The Southeastern Anatolia Region covers a total area of 7.628.946 ha and its share is 9.7% of the Turkey's land.

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While 33.9% of the total surface area of Turkey is agricultural lands, 18.7% is meadow pastures, 27% is forest and heathland and 20.4% is other areas; 44.2% of the lands of the TRC Southeastern Anatolia Region are agricultural areas, 13.7% are meadow-pastures, 17.3% are forests and heaths, and 24.8% are other areas. While 90% of Turkey's 26 million hectares of agricultural area is irrigable, the rate of the economically irrigable area is 30% with 8.5 million hectares. According to the latest data, 60% of the economically irrigable area is irrigated. Of the 3,373,188 hectares of agricultural land of the Southeastern Anatolia Region, 50% (1,760,728 ha) is irrigable [1].

The total water surface coverage of the Southeastern Anatolia Region is 173.086.59 hectares, 84% of the total water surface is surfaces of dam reservoirs, 10% is stream surfaces, 1% is natural lake surfaces and 5% is pond reservoir surfaces. The total water potential of the SAR is 80,309.95 hm^3/year, and it is seen that 96% of the total water potential consists of surface water resources and 4% is groundwater resources [1].

Climatically, the continental climate preponderates in the SAR, but climax products of the Mediterranean climate grow in certain areas, and the vegetation shows typical Mediterranean characteristics. In addition, the soil formed as a result of the joint effect of the climate and the plant is similar to the soil formed under the Mediterranean climate.

B. Determining the Number of Agricultural Enterprises to be Surveyed

The primary data of the survey study consists of the primary data collected through face-to-face surveys with agricultural producers in Sanliurfa, Diyarbakir and Mardin provinces. The enterprises to be surveyed in Sanliurfa, Diyarbakir and Mardin were determined by using a stratified random sampling method. The information obtained from the applied surveys consists of the data of the 2021 production year. The sampling size was calculated by the *Neyman* method, the formula of which is given below. The permissible error was defined to be 5% for 95% reliability [13].

$$n = \left(\sum N_h S_h\right)^2 / \left(N^2 D^2 + \sum N^h S_h^2\right) \quad (1)$$

where; n is the required sample size, N is the number of farms in the target population, N_h is the number of population in h the stratified, S_h is the variance of h the stratified, and D is the precision where (x-X).

As a result of the calculation, the number of sample enterprises to be studied was found to be 150 in Sanlıurfa, 100 in Diyarbakır and 50 in Mardin. In the survey, the number of questionnaires to be applied to the producers was determined as 300 in total and the farms to be surveyed were determined by using a stratified random sampling method. Some visuals related to face-to-face surveys with farmers in Sanliurfa region are given in Fig. 1.



Fig. 1. Some images of face-to-face surveys with farmers in the Sanliurfa region.

III. Results and Discussions

A. Results, Comments, and Suggestions of Farmer Responds to Survey Questions

The questions asked to the farmers in the surveyed agricultural enterprises and the answers given by the farmers are given in Table I. The responses of the farmers to the survey questions are interpreted and discussed in Table II.

Suggestions developed based on the responses of the farmers to the survey on energy use in agricultural irrigation are given in Table III.

B. Discussion on Sustainable Water Management and Agricultural Irrigation in Study Area

Water management is defined as the development of water resources in a planned way, their distribution and use. Efforts to develop water resources and put them into service to humanity started thousands of years ago and have continued to the present day. However, it has been observed that the physical structures built for the development of water resources were insufficient. In order to strike a balance between water potential and demand, new water management models have been created to include economic, social and institutional issues by ensuring the participation of water users in water management together with physical structures. Problems with water management are generally seen in successive stages, from the development of water resources to the use of water at the field level. The problems that arise with irrigation are explained in the following sections.

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TABLE I: SURVEY QUESTIONS FOR FARMERS AND THEIR RESPONSES

No	Question	Response
1	Have you get any training on irrigation?	No: 89% Yes: 11%
2	Which irrigation method do you prefer?	Flooding : 27% Furrow: 35% Drip: 14% Sprinkler: 24%
3	Which irrigation system is installed in your production area?	Furrow: 42% Flooding: 39% Sprinkler: 18% Drip: 1%
4	How much are irrigation systems operating and maintenance costs on an annual basis?	Do not know: 15% High: 55% Very high: 30%
5	Do you have any information about when plants need more water?	I have: 85% I have not: 15%
6	Is irrigation (life water) done before planting?	Applied: 33% Not applicable: 67%
7	How do you decide when to do the first and last irrigation?	Wilting: 22% Soil moisture: 19% By precipitation: 13% By soil and plant condition: 46%
8	How do you decide how many days interval to irrigate?	Wilting: 22% Soil moisture: 23% By precipitation: 6% By soil and plant condition: 49%
9	Is the amount of irrigation water that should be applied/given in each irrigation calculated?	Yes: 3% No: 97%
10	How is it decided that the water supplied is sufficient?	Eyeball estimate: 47% Soil wetness: 28% Soil moisture: 25%
11	How much flow rate is needed to irrigate?	Do not know: 57% Very high: 18% High: 14 % Little: 9% Very little: 2%
12	Is the amount of water used in each irrigation measured?	Yes: 23% No: 77%
13	How do you decide when to start and when to stop irrigation?	Wilting: 22% Soil moisture: 23% By precipitation: 6% By soil and plant condition: 49%
14	When do you prefer to water?	Morning: 34% Evening: 18% Night: 13% Whenever water comes from mains: 35%
15	How many hours can be irrigated in a day?	5 hours: 15% 8 hours: 27% 10 hours: 43% 24 hours: 15%
16	Is there any loss-leakage in the irrigation system? How is it controlled?	There is a leak: 78% No leaks: 22% Eye control: 46% Hand control: 24% Not controlled: 30%
17	During irrigation, is there any water loss from the lower end of the field by surface flows? If so, how much? Is any action taken regarding this?	There is water loss: 28% No water loss: 72% Very high: 7% High: 18% Little: 48% Very little: 27% There is prevention: 74% No prevention: 26%
18	What is the basis for planting plant preferences?	Habits: 16% Price status: 54% Ecological properties: 9% Neighbor interaction: 2%1
19	Are the pump specifications suitable for the pumping plant?	No pump: 38% Suitable: 59% Not eligible: 13%
20	Are the pipelines suitable for the pumping plant?	No pipes: 38% Suitable: 59% Not eligible: 13%
21	How much electrical energy do water pumps consume?	Don’t know: 56% Too much: 23%

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TABLE I: SURVEY QUESTIONS FOR FARMERS AND THEIR RESPONSES

No	Question	Response
		More: 14%
		Little: 4%
		Very little: 3%
22	What is the energy efficiency of engines?	Don't know: 67%
		Modern engines: 3%3
23	Do the pump and irrigation system used work at the recommended flow and pressure?	Non-pressure irrigation: 95%
		Don't know: 76%
		Yes: 14%
		No: 10%
24	Is technical support required to determine plant water needs?	Yes: 88%
		No: 12%
25	Is soil analysis done?	Yes: 34% No: 66%
26	Is the farmer informed about the water holding capacity in soil analysis?	Yes: 3%
		No: 97%
27	How much is the energy use in irrigation according to the plant type?	Don't know: 54%
		Too much: 25%
		Much: 15%
		Little: 5%
		Very little: 1%
28	How many kWh is the amount of energy used per volume of water pumped?	Don't know: 53%
		Too much: 36%
		Much: 8%
		Little: 2%
		Very little: 1%
29	Is the engine used in accordance with the required load characteristics related to the electrical energy used?	Don't know: 89%
		Yes: 9%
		No: 2%
30	Are solar energy systems used in irrigation?	Yes: 2%
		No: 98%
31	Is it desirable to use solar energy for irrigation?	Yes: 78%
		No: 22%
32	What are the yield and quality differences between irrigated and dry farming on a product basis?	Too much: 73%
		Much: 13%
		Little: 5%
		Very little: 3%
		No difference: 6%
33	How is the amount of fertilization determined in irrigated agriculture?	Soil analysis: 44%
		Neighbor interaction: 28%
		Pharmaceutical dealer: 28%
34	Is the amount of water reduced in the rainy season in wheat and cotton?	Yes: 8%9
		No: 2%
		Don't know: 9%
35	Is it desirable to plant alternative plants instead of corn, wheat and cotton plants?	Yes: 29%
		No: 71%
36	If it is not desired to plant alternative plants instead of corn, wheat and cotton plants, what are the reasons?	Marketing: 26%
		Plant definition unknown: 37%
		Farmer's unwillingness to take risks: 37%
37	Do you use motor driver in pumps?	Yes: 0%
		No: 94%
		Don't: 6%

TABLE II: INTERPRETATION OF THE RESPONSES OF THE FARMERS

No	Question	Comment
1	Have you get any training on irrigation?	Almost 90% of the farmers in the region have not received any training on irrigation.
2	Which irrigation method do you prefer?	Flood and furrow irrigation methods are commonly used (62%) in the region. About a quarter of the farmers apply sprinkler irrigation.
3	Which irrigation system is installed in your production area?	A large part of the region's farmers, approximately 80%, use the flood and furrow irrigation methods. The application rate of high (sprinkling) and low pressure (drip) irrigation systems is very low (19%).
4	How much are irrigation systems operating and maintenance costs on an annual basis?	More than half of the regional farmers (55%) report that the annual operating and maintenance costs of irrigation systems are high.
5	Do you have any information about when plants need more water?	A significant portion of the farmers in the region (85%) do not have information about which periods the plants need more water.
6	Is irrigation (life water) done before planting?	Pre-planting irrigation (life water) is not applied by approximately two-thirds (67%) of the regional farmers.
7	How do you decide when to do the first and last irrigation?	Nearly half (46%) of the regional farmers decide when the first and last irrigation will be done, taking into account the conditions of the soil and the plant.
8	How do you decide how many days interval to irrigate?	Nearly half (49%) of the farmers in the region decide how many days to irrigate, taking into account the condition of the soil and plant.
9	Is the amount of irrigation water that should be applied/given in each irrigation calculated?	A very high proportion (97%) of the regional farmers do not calculate the amount of irrigation water that should be applied/given in each irrigation.

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TABLE II: INTERPRETATION OF THE RESPONSES OF THE FARMERS

No	Question	Comment
10	How is it decided that the water supplied is sufficient?	Nearly half (47%) of the regional farmers decide subjectively that the water supplied is sufficient, by eye decision.
11	How much flow rate is needed to irrigate?	More than half of the regional farmers do not know how much flowrate they need to irrigate.
12	Is the amount of water used in each irrigation measured?	More than three-quarters (77%) of regional farmers do not measure the amount of water used in each irrigation.
13	How do you decide when to start and when to stop irrigation?	Nearly half of the regional farmers (49%) decide when to start and when to stop irrigation, taking into account the conditions of the soil and plant.
14	When do you prefer to water?	A high proportion of the regional farmers (69%) prefer to irrigate in the morning and when water is supplied from the mains.
15	How many hours can be irrigated in a day?	A significant portion of the regional farmers (43%) think that irrigation can be done for 10 hours a day.
16	Is there any loss-leakage in the irrigation system? How is it controlled?	Nearly four-fifths (78%) of the farmers in the region report that there is a loss-leakage in the irrigation system. Approximately one third (30%) of the regional farmers do not know how to control the losses and leakages in the irrigation system.
17	During irrigation, is there any water loss from the lower end of the field by surface flows? If so, how much? Is any action taken regarding this?	More than 70% (72%) of the farmers in the region report that there is no water loss by surface runoff from the lower end of the field during irrigation and that a related measure is taken (74%).
18	What is the basis for planting plant preferences?	More than half (54%) of the regional farmers consider the price situation in determining the plant species planted.
19	Are the pump specifications suitable for the pumping plant?	More than half (59%) of the regional farmers report that the pump specifications are suitable for the pumping facility.
20	Are the pipelines suitable for the pumping plant?	More than half (59%) of the regional farmers report that the pipelines are suitable for the pumping plant.
21	How much electrical energy do water pumps consume?	More than half (56%) of the regional farmers do not have information about the electricity consumption of water pumps.
22	What is the energy efficiency of engines?	Two-thirds (67%) of regional farmers report that they do not know about the energy efficiency of engines.
23	Do the pump and irrigation system used work at the recommended flow and pressure?	A very high proportion (95%) of the farmers in the region apply non-pressure irrigation, and approximately three-quarters (76%) report that they do not know whether the pumps and irrigation systems used are working at the recommended flow and pressure.
24	Is technical support required to determine plant water needs?	A very high proportion (88%) of the regional farmers seeks technical support to determine their crop water needs.
25	Is soil analysis done?	Two-thirds (66%) of the regional farmers do not have a soil analysis.
26	Is the farmer informed about the water holding capacity in soil analysis?	A very high proportion of the regional farmers (97%) report that the farmers are not informed about the water holding capacity in the soil analysis.
27	How much is the energy use in irrigation according to the plant type?	More than half of the regional farmers (54%) do not know the use of energy in irrigation according to the plant variety.
28	How many kWh is the amount of energy used per volume of water pumped?	More than half (53%) of regional farmers do not know the amount of energy used per volume of water pumped.
29	Is the engine used in accordance with the required load characteristics related to the electrical energy used?	A very high proportion (89%) of the farmers in the region does not know whether or not a engine suitable for the required load characteristics is used regarding the electrical energy used.
30	Are solar energy systems used in irrigation?	Almost all of the farmers in the region (98%) do not use solar energy systems.
31	Is it desirable to use solar energy for irrigation?	About four-fifths (78%) of the regional farmers want to use solar energy systems for irrigation.
32	What are the yield and quality differences between irrigated and dry farming on a product basis?	A significant portion (73%) of the regional farmers is aware of the yield and quality differences between irrigated and dry farming on a product basis.
33	How is the amount of fertilization determined in irrigated agriculture?	Nearly half of the regional farmers (44%) report that the amount of fertilizer in irrigated agriculture is determined based on soil analysis. About 28% of the farmers get information from their neighbors and drug dealers about determining the amount of fertilizer.
34	Is the amount of water reduced in the rainy season in wheat and cotton?	A significant portion of the farmers in the region (89%) reduce the amount of water in the rainy season for wheat and cotton.
35	Is it desirable to plant alternative plants instead of corn, wheat and cotton plants?	A significant portion of the regional farmers (71%) do not want to plant alternative crops instead of corn, wheat and cotton crops. However, about one third of the farmers (29%) want to plant alternative crops instead of wheat and cotton crops.
36	If it is not desired to plant alternative plants instead of corn, wheat and cotton plants, what are the reasons?	More than one third (37%) of the regional farmers reported that they did not know about alternative crops and did not want to take risks as reasons for not wanting to plant alternative crops instead of corn, wheat and cotton crops. However, about a quarter (26%) of farmers report marketing problems as the reason for not planting alternative crops instead of wheat and cotton crops.
37	Do you use motor driver in pumps?	A very high proportion (94%) of farmers don't use engine drivers in pumps.

TABLE III: SUGGESTIONS DEVELOPED BASED ON THE RESPONSES OF THE FARMERS

Question No	Suggestion
1	It should be ensured that the farmers of the region receive training on irrigation.
2	Water loss is very high and irrigation efficiency is very low in flood and furrow irrigation methods. Necessary measures should be taken to promote the use of low-pressure irrigation systems such as drip irrigation, which save water and energy among farmers.
3	Regional farmers should be discouraged from flood and furrow irrigation methods, and especially low pressure (drip) irrigation systems should be applied.
4	Regional farmers should be informed about the reduction of annual operating and maintenance costs of irrigation systems and awareness should be raised about related technologies.
5	The farmers of the region should be informed about the periods when the plants need more water.
6	It should be ensured that the farmers of the region are informed about the pre-planting irrigation (life water) application by providing training.
7	Practical training on irrigation timing should be given to regional farmers and awareness should be raised by showing practical examples.
8	Practical training should be given to regional farmers on how many days to irrigate, and awareness should be raised by showing practical examples.
9	Practical training should be given to the regional farmers about calculating the amount of irrigation water to be applied/given in each irrigation, and awareness should be created by showing applied case studies.
10	Practical training on the application of objective methods should be given to regional farmers in order to decide that the water provided is sufficient, and awareness should be created by showing practical case studies.
11	Practical training should be given to regional farmers to determine plant water consumption. Awareness should be created by showing applied case studies.
12	Practical training should be given to regional farmers to determine the amount of water used in each irrigation, in order to save water and energy in irrigation and awareness should be created by showing practical case studies.
13	Practical training should be given to the farmers of the region about when to start and when irrigation will stop, and awareness should be created by showing practical examples.
14	In order to save water and energy in irrigation, farmers in the region should be taken practical training on irrigation timing,
15	especially night irrigation, and awareness should be created by showing practical examples.
16	Practical training should be given to the farmers of the region about losses and leakages in irrigation systems and their control and awareness should be created by showing practical examples.
17	Regional farmers should be informed about losses during irrigation.
18	Practical training should be given to the farmers of the region about the factors that they should consider in determining the plant species to be planted and awareness should be created by showing applied case studies.
19	Practical training should be given to the farmers of the region about the factors they should consider regarding pump selection,
20	pipelines and pumping facilities, and awareness should be created by showing practical case studies.
21	Training should be given to regional farmers on electricity consumption of water pumps, selection of pumps and engines and
22	high efficiency pumps and engines.
23	Practical training should be given to the farmers of the region about the factors they should consider regarding pump selection, pipelines and pumping facilities, and awareness should be created by showing practical case studies.
24	Practical training should be given to the farmers of the region on the determination of plant water consumption and awareness should be created by showing applied case studies. Incentive practices should be developed for consultancy procurement.
25	Practical training should be given to regional farmers on the benefits of soil analysis, fertilizer and water use. Applications to
26	promote soil analysis should be developed.
27	Practical training should be given to regional farmers on the use of energy per plant variety and per water volume, and the use
28	of engines suitable for the required load characteristics. To expand the use of water and energy saving irrigation systems,
29	premium payments etc. incentive practices should be developed.
30	Practical training on the use of solar energy in irrigation should be given to the farmers of the region and awareness should be
31	created by showing practical examples. In order to expand the use of solar energy in irrigation, premium payment etc. incentives should be developed.
32	In order to expand irrigated agriculture and water saving, premium payment etc. incentives should be developed.
33	Practical training should be given to regional farmers on determining the amount of fertilizer to be used, and awareness should be raised by showing applied case studies. Incentive practices should be developed for consultancy procurement.
34	Incentives such as premium payment should be developed in order to expand irrigated agriculture and water saving.
35	There is a significant potential for alternative crop production in the region, although it is not sufficient. In order to expand the
36	cultivation of alternative plants instead of corn, wheat and cotton plants in the region, field and product-based incentive practices should be designed.
37	In order to expand irrigated agriculture and water saving, incentive practices such as paying premiums for energy efficient technological applications should be developed.

The development of water resources and the efficient use of irrigated agricultural lands remarkably contribute to an increase in agricultural production and are also important in terms of food supply. The bottlenecks to be experienced due to population growth and pressures from climate change necessitate more efficient use of water resources in irrigated agriculture. Particularly, it is necessary to create the required infrastructure and technology to provide the desired quantity and quality of water at the desired time and place, to allocate it on a sectoral basis, to improve it after use, to reuse it, to protect the environment, to ensure social justice, to support economic development and to operate water-related structures pursuant to international law.

In successful irrigation management, firstly the water resource should be developed accordingly, and secondly, the irrigation water should be delivered from the source to irrigation fields. In addition, strategies should be developed to guide producers in irrigation areas, to adopt proper irrigation practices, to optimize the cropping pattern according to the water potential, and to make the production plans that guarantee the income of farmers.

1) Cropping pattern suitable for water potential and agricultural subsidy programs

It is essential that the irrigation water used in agricultural production should be supplied from sustainable water sources and be used effectively, and that the cropping pattern is congruous with the available water potential, particularly in the water-limited basins. Achieving the desired success in irrigation management can be achieved largely with the right production planning which is in agreement with the available water potential and incentives that will ensure a proper cropping pattern. However, while strategies to determine support and incentive policies are developed, it is necessary to carry out complete monitoring studies in irrigated areas and use appropriate information systems, as such data will be expected to be instantaneous, accurate, and questionable in addition to the generation of the required data.

Product support conditions in irrigated agriculture should be related to the sustainability of irrigation water resources and the availability of water rights. Seasonal irrigation water requirements on a parcel basis should be known, and the relationship of each irrigated parcel with the water source should be documented accordingly. Agricultural subsidies in irrigated areas should not be available to the on-site producers who do not have the certificate to be taken from the operating organizations and to the off-site producers not having the certificate to be determined with in-situ checks.

In addition, incentive practices should be made applicable in order to prevent excessive irrigation water use. The support payment should be conditioned on the use of appropriate irrigation methods in a way that saves the maximum amount of irrigation water, especially in water-scarce basins, and low tariffs should be applied to producers who use appropriate irrigation methods when accruing water usage service fees. Consequently, since all these issues are included in sectoral water allocation plans while encouraging the cropping pattern in the catchments where sectoral water allocation plans were completed, the recommended crop types should be given priority.

2) Non-compliance with the planned cropping pattern

Irrigation schemes are planned and put into operation according to the likely cropping pattern to be grown in the irrigation project area. However, while the cotton crop was planned to have approximately 35% share in the GAP area or region, this rate still varies between 60-95% in the GAP area and different irrigation networks. Growing plants with high irrigation water demands may result in both excessive uses of irrigation water and inadequacies in the irrigation network structures during the peak irrigation season.

3) Excessive irrigation application

Excessive irrigation application practice, i.e., overirrigation, is common in the region and leads to water loss. This practice, on the other hand, results in scouring the fertile upper part of the soil by creating excessive surface runoff, thus causing soil productivity to reduce and erosion of the soils. Furthermore, high groundwater table and desertification in irrigation areas over time are major causes of overirrigation.

4) Using improper irrigation method

Especially in areas where surface irrigation methods are adopted, irrigation practices are done regardless of land leveling and slope of the land. Under normal conditions, if the slope of the land exceeds 2%, surface irrigation should not be applied, or irrigation direction should be perpendicular to the slope, i.e. parallel to the contour lines. Both surface irrigation applications on these sloping lands and the formation of furrows or borders in the direction of the slope cause excessive erosion in the lands and accelerate soil loss.

5) Lack of education and awareness of water users (Farmers)

Lack of education and awareness of farmers are of great importance in irrigation water management at the large irrigation schemes. This issue directly or indirectly impairs the proper and effective use of water and soil resources.

6) Lack of Irrigation Infrastructure

Land consolidation is an issue in irrigation schemes. In this regard, fragmentation of the lands in the areas opened for irrigation, insufficient leveling and lack of drainage networks can be counted as staple issues which is a hindrance to carrying out agricultural activities economically for various reasons, in accordance with the principles of modern agricultural management and for the development of irrigation services.

7) Inactive irrigation management

This can be stated as the failure of irrigation water user associations or irrigation cooperatives to adequately fulfill their technical and managerial effectiveness in irrigation water management.

8) Problems with lack of physical infrastructure

- Sustainable water management can not be realized in the irrigation areas because on-farm development services such as land consolidation, land leveling and drainage cannot be completed.
- Since irrigation canals, flumes, engineering structures and measurement facilities are exposed to external conditions (flood, precipitation, wind, icing, air temperature) and improper use, they are devastated in a short time and require maintenance and repair.
- In surface irrigation methods, since all facilities are on the soil surface, turnout gates, check structures, measurement facilities and other facilities are interfered with by farmers, in turn, facilities are damaged and operational services are interrupted.
- In some irrigation networks, since the engineering structures are built according to the maximum capacity to meet the demand in peak irrigation season, the channels are operated at full capacity during the irrigation season, which causes waste of water and energy in irrigation.
- Irrigation schemes of insufficient water supply may cause farmers to use groundwater wells that are not allowed officially. This is the cause of a decrease in irrigation.
- Since most of the channel networks do not have intermediate storage facilities and is no nighttime irrigation practice is not adopted in peak irrigation

season, water diverted to the irrigation scheme goes directly to the drainage system.

- Excessive sedimentation accumulation or destruction of structures occurs in the channels due to the lack or non-functionality of water control structures such as sediment-retaining structures (sedimentation pool, grid, filter, etc.), head ditches, lower and upper flood passages. This situation causes substantially funds to be spent on sediment cleaning, maintenance, and repair works.

9) Problems with the operation of irrigation systems

- Low irrigation water prices in Turkey cause excessive water use in agriculture. Existing irrigation water charges are not sufficient to cover full operating and maintenance costs. The fact that irrigation water charges, i.e., water prices, are lower than their real value. This causes excessive water use and environmental problems in the irrigation sector. In Turkey, the price of water in irrigation is generally based on the area irrigated and plant type. However, the collection is usually lower than the accrued revenues. This is due to the inadequacy of the delay penalty in the national water authority State Hydraulic Works (DSI) law, especially in irrigations operated by DSI.
- Unconscious irrigation practices and aged irrigation systems are the primary causes of excessive water use in agriculture. Excessive use of water reduces irrigation efficiency and increase drainage fraction. This causes environmental problems such as soil salinization, water logging, and irrigation induced pollution. Due to the problems such as insufficiency in water resources, high water table, topographical factors, improper design and defects in the construction of irrigation facilities, fallow areas, socio-economic factors in irrigation networks, irrigation project area can not be irrigated fully.
- Irrigation ratio and irrigation efficiency are the basic indicators to determine how irrigation water is used in an efficient way, and these indicators are substantially low in irrigation areas of Turkey. Irrigation efficiency can be defined as the ratio of irrigation water consumed actually by the crops to the water diverted from the source to the irrigation scheme.
- In order to ensure optimal development of the crops, irrigation water should be applied to the plants in the right amount and time when they need. Due to the losses in the distribution system, the water that is diverted to the system is much more than the plant water requirements. The ratio between diverted and required water is, therefore, greater than one. Applied irrigation water is approximately two or three times higher than the required one. This is due to a large amount of water losses at both the network and field levels.
- In conventional irrigation systems, the small parcel size and the improper choice of furrow and/or border dimensions render water management difficult, decrease the irrigation efficiency and cause high losses in farm fields. When border or furrow irrigation methods are used, the field water application efficiency is conventionally around 60%, and if the leakage, evaporation and operating losses in the network are taken into consideration, the efficiency drops below 50% level. In this case, 2 m^3 of water should be diverted to the network to meet 1 m^3 of water required by the crop.
- This situation causes the waste of limited water resources and the construction of storage, distribution, and drainage networks having a larger capacity. Therefore, an increase in the construction costs and additional energy use if there is pumping in the system is inevitable in practice. Additionally, if all this is added to the fact that the water to be used is expensive, the importance of water saving in irrigation becomes even clearer.
- If sprinkler and drip irrigation methods are preferred to surface irrigation methods, irrigation efficiency will increase from 60% to 80% for sprinkler irrigation and 90% for drip irrigation. This means substantial water saving by adopting modern irrigation techniques, i.e. 25% and 33% water saving for sprinkler and drip irrigation methods, respectively.
- Due to the lack of land use plans and the increase in non-agricultural land use types, agricultural areas are decreasing day by day. The misuse of agricultural lands has reached significant proportions in Turkey. To make agriculture attractive for farmers, some measures should be taken to increase the income level of farmers, and investments related to the development of water and soil resources should be given importance and priority.
- The misuse of agricultural land has reached significant dimensions in Turkey. In order to make agriculture attractive to farmers, measures that raise the income level should be taken and investments related to the development of water and soil resources should be given importance and priority.
- Realized cropping pattern in the irrigated areas shows great differences when compared to the planned ones. Mostly, the irrigation ratios, as well as irrigation efficiencies are far below the projected values. Such that the profitability of the projects is adversely affected; producers in the project area have tended to switch from irrigated to dry farming. This is generally due to market conditions, farmer traditions, diseases and pests, fluctuations in prices of agricultural inputs, and especially the inability to implement production planning in Turkey.
- Since there is no adequate and effective farmer training service in Turkey, the training of farmers is a challenging issue in order to ensure sustainable irrigation management. In turn, farmers tend to use excessive water, and water losses such as surface runoff, deep percolation and infiltration are increasing day by day. This situation reduces the irrigation efficiency and creates several problems such as poor preparation of the lands for irrigation, drainage, waterlogging, high groundwater table, and salinity.
- Irrigation performance values may be assessed in order to determine on-farm irrigation management practices and irrigation efficiencies in the farmyards. It has been determined that the irrigation performances in many

irrigation schemes are quite low. An efficient irrigation program has not been achieved in almost all irrigation systems. Therefore, irrigation application efficiency is low and water losses are high at the district level.

IV. Conclusion

Among the water demanding sectors in Turkey, the agricultural sector ranks first as the most water user. Therefore, the use of tools and techniques that enable effective water use in agriculture should be among the priority targets of Turkey. With advanced irrigation technologies, it is possible to produce the same amount or more products with less irrigation water as well as labor without harming the environment. In Turkey, choosing the most suitable irrigation method for the crops to be selected according to the characteristics of the land and climate, projecting and implementing a suitable irrigation program will ensure that our natural resources will be transferred to the next generations in the best way. The application of pressurized irrigation systems will reduce water losses, and minimize the likely detrimental effects of excessive irrigation on the environment.

In Turkey, unconscious irrigation practices and the fact that most of the irrigation networks are old and dilapidated channels cause excessive water usage in agriculture. Excessive use of water reduces irrigation efficiency and causes environmental problems such as salinization, waterlogging and pollution. In order to provide the expected benefit from irrigation and for sustainable agricultural production, on-farm development services as land leveling, land consolidation and drainage systems should be handled together with irrigation systems, built parallel to each other and put into operation together. In order to enhance the knowledge on the productivity of water and water management skills of the producers, an effective farmer education extension system should be established to create a modern irrigation awareness. Farmer education should be given importance to prevent excessive irrigation habits.

The protection and development of the soil and water resources of the SAR and their use in accordance with national and international policies are of great importance. Consequently, planning purposes should take not only the needs of today but also the welfare and happiness of future generations into consideration. For this, the resources of the SAR, which has a unique climate, soil, water resources and biological diversity should be protected and used by considering human and natural resource planning together.

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