THE POSSIBLE EFFECT OF CLIMATIC CHANGES ON THE IRRIGATED AGRICULTURE OF SEYHAN BASIN
EVALUATION OF LOWER SEYHAN IRRIGATION PROJECT

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INTRODUCTION

Huge irrigation projects play important role in works carried out to diversify and increase agricultural production in Turkish agriculture. These projects also offer enormous possibilities for increasing economic efficiency and incomes in rural areas and undeveloped regions. Lower Seyhan Irrigation Project (LSIP) located in central-south Turkey on Eastern Mediterranean initiated in the late 1950's is a pioneer in Turkey's huge scale irrigation projects. Considered as one of the most progressive and exclusive investments the country has undertaken, LSIP is a multipurpose project put into operation for irrigation, drainage, flood control and hydroelectric energy production.

It is well known that this irrigation project realized in Lower Seyhan Plain has resulted in important achievements in increased yields, employment and economic welfare as well as reduction of social problems. In spite of all the positive achievements, LSIP just like other huge scale irrigation investments also have many shortcomings and deficiencies such as excessive water use, high water table, salinity and insufficient water measurements.

It is also known that climate changes due to global warming will have negative effects on water resources. Important irrigation factors such as temperature, precipitation and evapotranspiration may change and these may adversely affect water resources. Up till now, however, impact of climate change on important irrigation performance factors such as water use, cropping pattern, water table quality and depth, and other general factors have not been studied yet. In this study, therefore, climate changes will be taken into account in evaluating the observed changes in the irrigated areas of Lower Seyhan Plain and these changes will be modeled (presented in Dr. Tananori Nagano's article). This study will also be undertaken to evaluate the performance of irrigation and drainage systems in Lower Seyhan Plain, and to find out problems in the effective use of water and offer solutions.

Determining the strengths, accomplishments as well as degree of realization of the irrigation project's initial objectives, weaknesses, failures, insufficiencies and project's limitations, therefore, are of utmost importance in the planning, implementation and supervision of such intended projects. Such an evaluation may help shed light for future irrigation and drainage investments elsewhere in the country and thus improve the performance of large scale public irrigation projects. With this objective in mind, this study was undertaken to assess the performance of irrigation and drainage systems in LSIP.

DESCRIPTION of LOWER SEYHAN IRRIGATION PROJECT (LSIP)

LSIP area is located on the southern part of Turkey on the eastern Mediterranean (Fig. 1). Seyhan Plain is the largest and the most important deltaic plane in southern Turkey. This important project covers an area of 204,000 ha of which 174,000 ha is irrigable. The area is bordered by the Mediterranean Sea on the south, by the foot hills of the Taurus Mountains on the north and by Berdan River on the west and Ceyhan River on the east. The area is divided in two parts by the Seyhan River which flows from north to south through the plain. The part between Seyhan and Berdan Rivers is known as "Seyhan Right Bank" or "Tarsus Plain" with a completed irrigation network for 64,400 ha, and the other part located between Seyhan and Ceyhan Rivers is called "Seyhan Left Bank" or "Yuregir Plain" with a completed network for 68,200 ha. The average slope varies between 1% and 0.1% from north towards south.

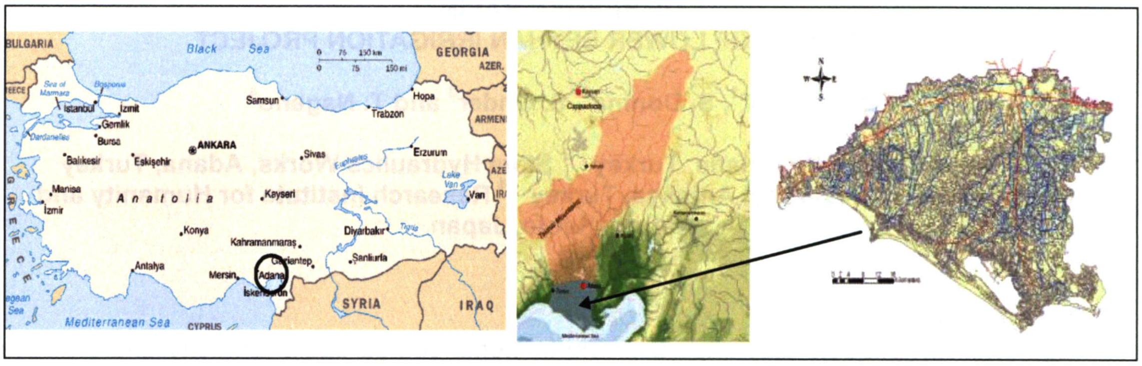


Figure 1. Map of Turkey (Seyhan Basin in box), Seyhan Basin and LSIP

Climate: Typical Mediterranean climate prevails with hot and dry summers, and mild and wet winters. Maximum, minimum and average temperatures are 45.6 °C, 8.1 °C and 18.7 °C, respectively. Mean annual precipitation in LSIP area is 630 mm. Yearly rainfall between 1982 and 2004 is presented in Figure 2. The distribution of rainfall over the year is 21% in fall, 45% in winter, 25% in spring and 5% in summer. Annual average evaporation is 1558 mm of which 64% evaporates between May and October.

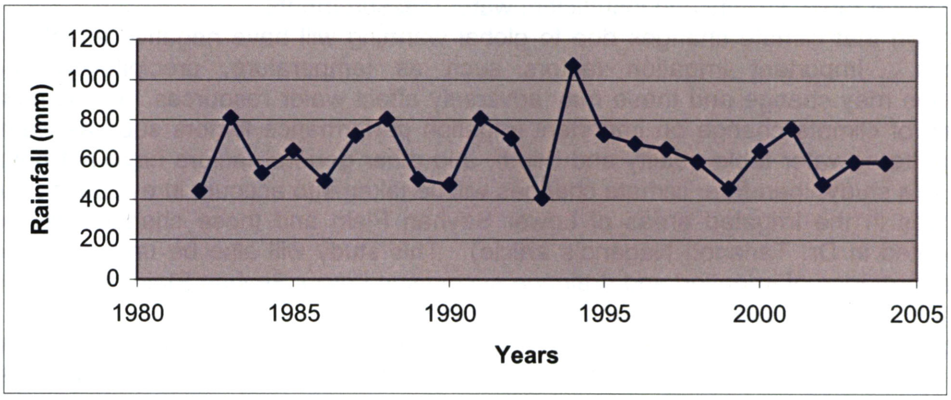


Figure 2. Yearly rainfall between 1982 and 2004

Soils: The delta portion (south) of Seyhan Basin is made of alluvial soils deposited by Seyhan, Ceyhan and Berdan Rivers. These are very fertile and deep soils, varying between 20 to 40m and have very low slopes. But drainage problems rise in the southern part of the area. Generally, the soils have heavy texture and a low permeability.

Water Source: The main irrigation water source is the Seyhan River with a 19,300 km^2 watershed and 6.3x109 m^3 annual flow. Minimum and maximum average water flows per month of the Seyhan River are 51.8 m^3/s and 444 m^3/s, respectively. The water quality is C2S1.

Infrastructure Development: Seyhan Dam and Hydro-Electric Power Plant located 5 km north of the provincial capital city of Adana was completed in 1956 for irrigation, power generation and flood protection purposes. The reservoir volume is 1.2×10^9 m^3 at its normal level.

Irrigation and Drainage Facilities: LSIP has been carried on in four stages since irrigation area is very large (174,000 ha). Irrigation and drainage facilities were completed for 65,000 ha at the first stage, 48,600 ha at the second stage and 19,000 ha at the third stage with a total area of 132,600 ha constituting 77% of the LSIP. The fourth stage which covers an area of 40,657 ha has been delayed since this area has high water table, salinity and alkalinity due to very low hydraulic gradient causing slow groundwater movement and resulting in drainage problems. Pumping is required because there is not sufficient outlet to discharge drainage water to the sea although some pumping facilities are now being installed. Irrigation and drainage tailwater, from 1st, 2nd and 3rd stage network and water from the Seyhan River is diverted into 4th stage earth ditches for irrigation.

MATERIALS AND METHODS

In this project, criteria such as intake and distribution of irrigation water, irrigation methods, crop pattern, production schedules and targets are evaluated in areas served by Lower Seyhan irrigation and drainage network. Studies carried out by ICCAP irrigation subgroup showed that water budget was never established in Lower Seyhan Irrigation Project (LSIP) area.

All Water Users Associations (WUAs) use 'State Hydraulics Works (DSI) Plant Water Use and Requirements" handbook (1988, p.475) in determining irrigation water demand. However, distribution of irrigation water in secondary and tertiary channels are carried out by WUA's distribution technicians, therefore, it is directly related to their experience. In order to determine how results change observations and data collection was continued in selected WUAs. Field observations and measurements were carried out in two WUAs. Two WUAs' tertiary channels are chosen with the following criteria: Eagerness and cooperation of the WUA, protection of measurement devices, and existence of required data and archives, and channel type, soil of the command area, plot sizes distribution and cropping pattern should represent the LSIP. With these purposes in mind tertiary channels from Gazi WUA from the left bank and Yesilova WUA from the right bank were chosen for sampling (Figure 3). The objectives for monitoring water in tertiary canals of the LSIP are as follows.

1) To determine the causes of low irrigation efficiency.
2) To determine how irrigation distribution technicians allocate water.
3) To quantify actual water intake to farmland for different crops.
4) To determine the relationship between irrigation, drainage and fluctuation of shallow groundwater.
5) To determine the reference water budget for constructing the water balance model for the LSIP.

We have selected monitoring canals with the following considerations: a)Canal type, soil of the command area, plot sizes distribution and cropping pattern should be representative of the LSIP. b) WUA of the monitoring canal should be eager to collaborate, for protection of measurement devices, for providing information, for persuading farmers to collaborate and c) There should be no groundwater use or drainage water re-use in the monitored area, to avoid complexity of water budget estimation.

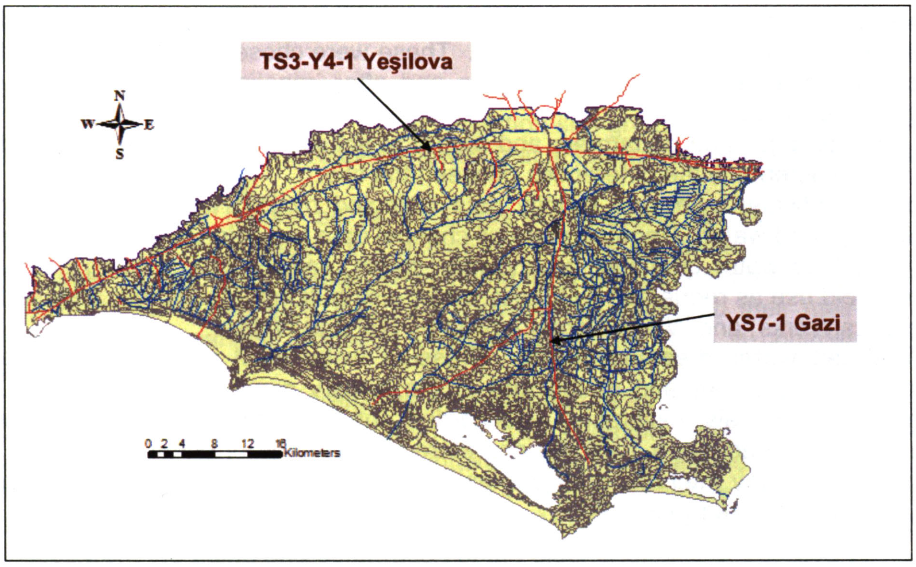


Figure 3. Gazi WUA from the left bank and Yesilova WUA from the right bank

Description of Irrigation Tertiary Channel YS 7-1-1 and Drainage Channel YD4 in Gazi WUA: YS 7-1-1 is a tertiary canal which belongs to Gazi WUA in the left bank of Seyhan River. It is a 'kanalet' type and has no gates for water intakes to farms. Farmers use siphons in order to irrigate. It has a total length of 2157 m and serves 80.6 ha. Main crops are citrus and maize. There is one diversion in the canal, operated exclusively for carrying water for some farm plots. Tail water from the canal flows into drainage ditch, YD4. The command area of YS7-1-1 is not equipped with subsurface drainage.

Technical data:

Inlet	N36°54' 40.1", E35°20' 32.7"
	Capacity: 0.243 m^3s^{-1}
	Kanalet type: 456
Outlet	N36°53' 17.4", E35°20' 29.4"
	Capacity: 0.137 m^3s^{-1}
	Kanalet type: 180
Drainage Mon.1	N36°53' 13.7", E35°20' 28.8"
Drainage Mon.2	N36°52' 35.9", E35°20' 24.6"

Description of Irrigation Tertiary Channel TS3 Y4-1 and Drainage Channel TD7-0-10 and TD7-0-9 in Yeşilova WUA: TS3 Y4-1 is a tertiary channel with concrete lining. It belongs to Yeşilova WUA on the right bank of Seyhan River. It has a total length of 3750 m and serves 109.2 ha. The channel was built in 1974 and concrete lining is very much degraded. Farmers use siphons in order to irrigate their fields and orchards. Rural Services have installed subsurface drainage in the past.

Technical data:

Inlet	N36°58' 40.8", E35°14' 21.7"
	Capacity: 0.380m^3s^{-1}
Outlet	N36°57' 7.9", E35°13' 20.8"
	Capacity: 0.140 m^3s^{-1}
Drainage Mon.1	N36°57' 1.4", E35°13' 5.6" (end of 0-10 to TD7)
Drainage Mon.2	N36°56' 40.1", E35°13' 19.6" (end of 0-9 to TD7)

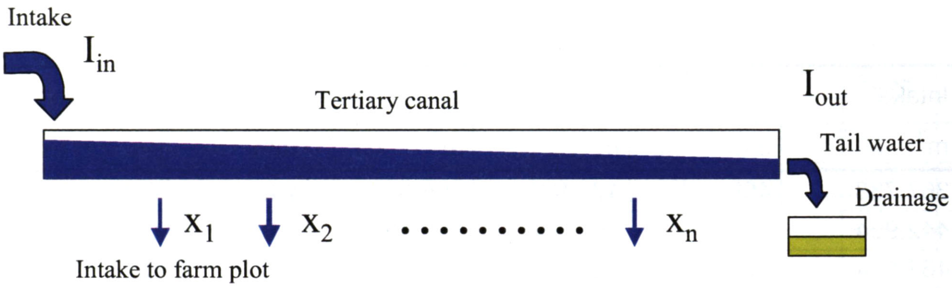
Pressure level sensors were placed in the chosen channels and calibrations were carried out. Pressure water level sensors with data loggers were installed at the intake and at the end of the tertiary channels. According to dimensions of canals, calibration was carried out to relate water level to flow volume.

Access tubes were placed in citrus and maize fields in Gazi WUA and watermelon and maize field in Yeşilova WUA in measuring soil moisture. These were chosen with the criteria of representing the command area. Soil moisture before and after irrigation was continuously measured during the irrigation season.

Water demand form as requested by farmers and record of actual irrigation water allocated were recorded in order to determine the differences between the two.

Monthly data of groundwater level and salinity data collected by DSI were recorded for monitoring fluctuations ground water. Regulator and all channel data (equation development for transforming water depth to water quantity), groundwater depth, salinity, crop sowing dates, irrigation programme, field use as requested by WUAs, water distribution methods that are used by DSI (State Hydraulics Works) and WUAs were supplied by DSI and WUAs.

Water intake and tail water measurements: Pressure water level sensors with data loggers were installed at the intake and at the end of the tertiary canal (Figure 4, below). According to dimensions of canals, calibration was carried out to relate water level to flow volume. The data was measured every 1 minute and stored as average of every 10 minutes. Data was downloaded in 15 day intervals during irrigation season. At the same time siphon capacities as used by farmers were measured.



$$I_{in} - I_{out} = \sum_{1}^{n} x_i + leakage$$

n: number of farm plots

Fig. 4 . Water intake and tail water measurements

Intake into farm plots: Capacities of siphons and intake gates in the canal were quantified in the beginning of season. Leakage from the canal will be measure before the irrigation season, by measuring difference between intake and tail water. Actual intake into farm plots was calculated, using capacities of siphons and intakes gates and duration time recorded by distribution technicians. This revealed mean water intake of different land use in the command area of the tertiary canal.

Monitoring of actual infiltration in the fields (soil moisture): Farm plots that represent land use in the command area of each canal were chosen. Actual infiltration was measured by comparing soil moisture profile down to 1m depth before and after each event of irrigation. Soil Profile Probe (Delta device PR-1, Great Britain) which employs ADR method for soil moisture measurement was used. Access tubes were installed during the entire irrigation. Comparison of soil moisture profile between the points near the canal and points at far end of the farm would revealed the degree of over irrigation, if it existed.

Monitoring of drainage flow: Drainage flow was measured automatically using the same technique as described above. Electrical conductivity and pH were manually measured in biweekly intervals with portable devices.

RESULTS AND DISCUSSION

Results from the sampled Water Users Associations

The primary work that the ICCAP irrigation sub-group was to to quantify water budget in the Lower Seyhan Plain. Our results showed that actual water budget of the project area was never measured in the past.

As mentioned before all Water Users Associations (WUAs) use "Plant Water Use and Requirements" handbook for calculation of irrigation water demand. Depending on the cultivation area of crops, total water demand at main canal basis is calculated. WUAs strictly monitor water intake from the main conveyance canal into their main canals. And after the intake to main canals, allocation of water within the WUA is controlled by water distribution technicians.

Tertiary channel measurements were carried out as shown in Figure 4 above. Tables 1 and 2, below shows measurements from the 2004 irrigation season in both of the WUAs as typical examples. As seen in Gazi WUA, intake rate and tailwater loss is much than expected. This results in tailwater loss rates as high as 0.47 which is unacceptable. Although, the tailloss rates at Yeşilova WUA look a lot less than Gazi WUA's values, this is simply due to high spilling losses from the aging and deteriration of the older channels at Yeşilova WUA.

Table 1. Measurements from the 2004 irrigation season at Gazi WUA's YS7-1-1 tertiary channel

Months	Intake		Tailwater	Water Use		Tail Loss Rate
	m^3	mm	m^3	m^3	mm	
May	367,733	456	171,866	195,867	243	0.47
June	442,964	550	162,534	280,431	348	0.37
July	462,514	574	122,036	340,478	422	0.26
August	422,220	524				
September	267,096	331				
Total	1,962,528	2,435				

Table 2. Measurements from the 2004 irrigation season at Yeşilova WUA's TS3-Y4-1 tertiary channel

Months	Intake		Tailwater	Water Use		Tail Loss Rate
	m^3	mm	m^3	m^3	mm	
May	295,211	270				
June	615,284	563	49,725	565,559	518	0.08
July	727,712	666	44,265	683,446	626	0.06
August	430,623	394	50,642	379,982	348	0.12
September	245,397	225	48,531	196,865	180	0.20
Total	2,314,226	2,119	193,163	1,825,852		

CROP PATTERN

LSIP area with its fertile lands and abundant water resources plays a foremost role in Turkish agriculture. It produces, for example, 55% of total maize, 60% of total citrus and 25% of total watermelon production of Turkey. Favorable climate conditions permit cropping year around allowing both single (wheat, corn, cotton, soybeans, onions, potatoes, melons, etc.) and double cropping (usually corn or soybeans after wheat harvest in late May or after onion harvest in April). Note that wheat is seldom irrigated, it is mainly rainfed.

A variety of crops are grown in the region, from cereals, citrus to vegetables. The crop pattern has changed radically from the early 60's and 70's (the years irrigation commenced) to present (Table 3 and Figure 5). Table 3 clearly shows proposed crop pattern at the commencement of the project was never realized. For example, cotton acreage with an initial planning of 35% jumped to almost 85% in 1970's due to demands of strong Turkish textiles industry and sound governmental incentives until white fly infestation and labor shortages forced it to decline. Although cotton constitute only 7% of the total cultivated area in 2004, it is coming back due to availability of mechanized harvesters, better governmental support policies and declining revenues in maize. Figure 6 shows the Landsat image of crop pattern in August 2003. It is clear that cotton is only prominent in the fourth stage area of LSIP (southern reaches of the plain) where irrigation and drainage infrastructure is less than desired.

Table 3. Percentage of cultivated land for major crops in the LSIP area.

Crop	Crop Pattern from 1970 to 2004 (%)							
	Proposed	**1970**	**1975**	**1980**	**1985**	**1989**	**1999**	**2004**
Cotton	35	88.7	84	82	51.6	35	6	7
Maize		1.1	3	2	8.7	23	64	46
Wheat	13				2.6	16	16	16
Citrus	8	2.2	2	4	4.5	7	12	14
Vegetables	15	0.4	1		1	1		
Rice	5	4.9	5	2	4.8	1		
Melons		0.6	2	8	8.5	6	7	5
Soybeans					16.6	9	1	1
Alfalfa	20							
Other	4	2	3	2	2.1	15	5	8

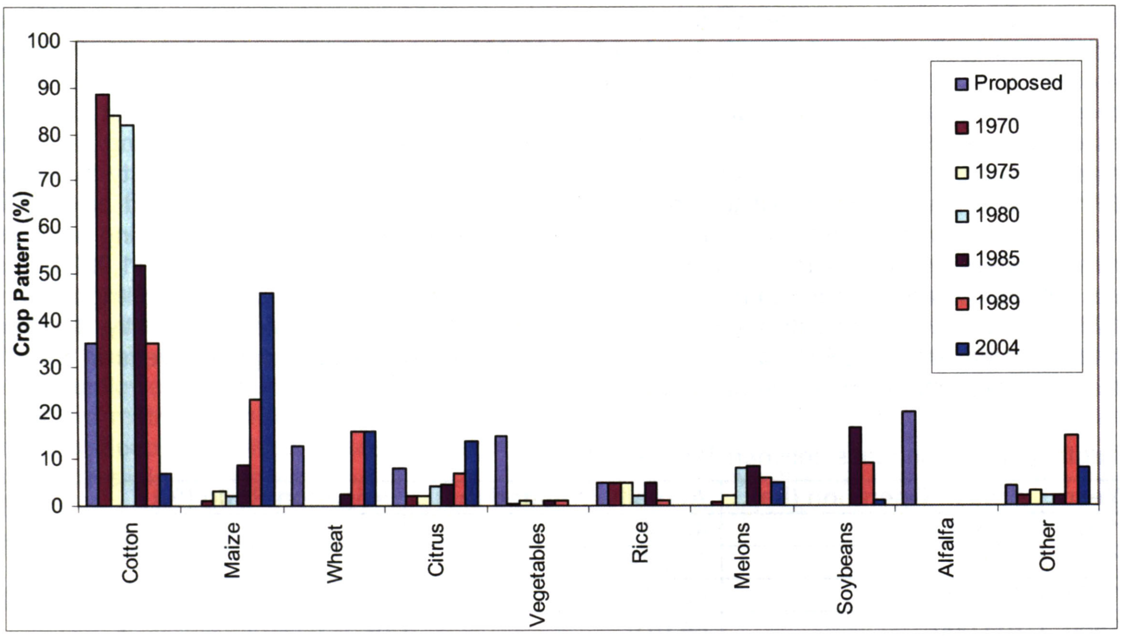


Figure 5. Proposed and actual crop pattern between 1970 and 2004

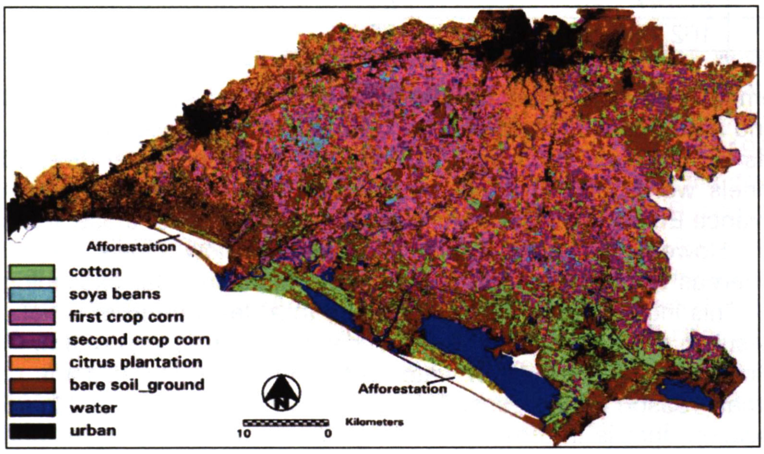


Figure 6. Landsat image of crop pattern in August 2003 (by Dr. Süha Berberoğlu, Çukurova Univ., Turkey)

Maize either as a first crop or a second crop after wheat has become one of the major crops (Table 3, and Figures 5 and 6) due to its less labor requirement and governmental support. Government policies encouraged the farmers to expand their acreage by favorable prices since Turkey had a huge maize deficiency. In a period of few years Turkey became self sufficient in maize mainly thanks to farmers in LSIP area. However prices fell sharply and farmers were very disappointed and bewildered (Özekici, 2006) and they switched to other crops. All these changes in the crop pattern prove a simple point; farmers are quick to adapt to market conditions. A similar finding was also observed by Umetsu et al. (2006) who stated that high value crops such as citrus and vegetable production are gradually increasing in LSIP area since the early 2000s.

IRRIGATION

Even though actual crop pattern is considerably different nowadays than the proposed, water shortage in the LSIP area should not pose a problem since water stored in the Seyhan reservoir is capable of supplying water to the whole plain as long as sound irrigation principles are applied. Irrigation network was completed for 132,600 ha but irrigation ratio (actually irrigated area/area in operation) is less than desired. DSI (State Hydraulic Works - the main body responsible for irrigation and drainage network) records (DSI, 2006) below shows that irrigation ratio between 1966 and 2001 varied between 63% and 99% (Table 4). Decreasing irrigation ratios indicate that many areas are not irrigated even though they have the capacity to do so. Either much land is either lost to urbanization or simply not irrigated. This could be due to increasing population and some farmers switching to less profitable dryland farming such as rainfed wheat. A huge portion of the LSIP potential in the last few years (around 11,000 ha) is not utilized. Water intended to irrigate 132,600 ha with infrastructure is diverted to irrigate only 121,690 ha, of which only 85% (102,728 ha with infrastructure) is irrigated. Recently, average total irrigated area in LSIP has been around 134,000 ha (including irrigated areas in the 4^{th} stage) corresponding to 77% irrigation ratio.

Table 4. Irrigation ratios between 1966 and 2001.

Year	Area in Operation (ha)	Actually Irrigated (ha)	Irrigation Ratio (%)
1966	41,512	40,145	97
1970	58,400	36,929	63
1974	83,550	82,517	99
1980	103,000	84,670	82
1985	125,300	114,134	91
1989	137,039	120,200	88
1997	121,690	100,834	84
1999	121,690	97,747	81
2001	121,690	102,728	85

Net irrigation water requirement was calculated by considering crop water requirements using Blaney-Criddle method and area planted for each crop. In a earlier study (Tekinel et al., 1988) net irrigation requirements for 1984 and 1985 were 525 and 481 mm, and water diverted from the regulator to the channels were 1060 and 960 mm, respectively. Overall irrigation efficiency of the system (Conveyance Efficiency x On-farm Application Efficiency) at those years were 48 and 53%, respectively. However, in recent years, as Figure 7 below shows, overall efficiency has been declining whereas water diverted to channels for irrigation is far exceeding the planned value of 1150 mm. This increasing trend could be due to a) leakage from canals, b) bad design of canals which result in much loss of tail water, c) diversified cropping pattern, d) inexperience of irrigation technicians and e) overuse of water in the farmland, etc. (Donma et al., 2004). However, note that main reason for increased irrigation water use in 2004 and 2005 is due to prolonged irrigation season, that is in these years irrigation commenced earlier and ended later than usual due to unusually dry conditions in late spring and early fall. As shown before, studies in two Water Users Associations (WUAs) tertiary channels' have shown that tailwater losses (intake minus water use- i.e. the water that discharges to open drainage channels) were as high as 47% in some months (Donma et al., 2004). These results suggest that farmers have ample water in the canals and they are not conscious on water savings, they get more than what they actually need. Farmers are not charged by volume basis for water, they are simply charged by acreage and type of crop, and therefore they have no incentive to save water.

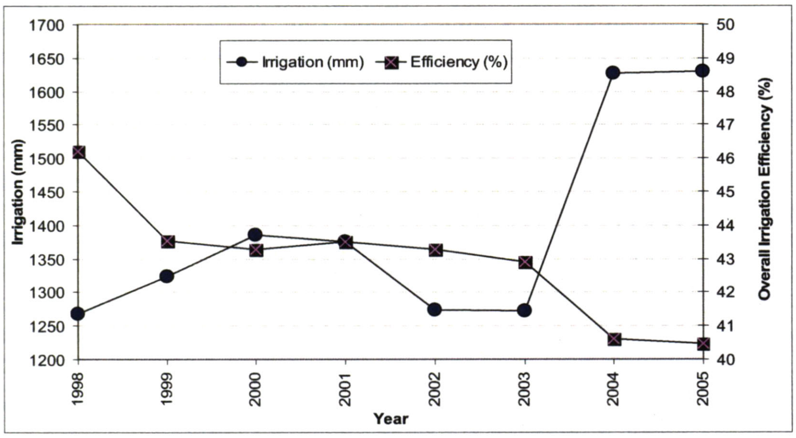


Figure 7. Overall irrigation efficiency and water diverted to irrigation network (1998-2005)

Much water is wasted by inefficient irrigation network (leakage from aging channels) and irrigation methods. This is especially true for farmers who use surface irrigation methods, mainly basin irrigation used on orchards and furrow irrigation used in cotton, maize, soybeans and sunflower (Özekici, 2006). Most vegetables and fruits are irrigated by either drip or sprinkler methods which have higher application efficiencies. Önder et al. (2004) have found out that deep percolation losses and runoff percentage account as high as 38.6% and 27.6%, respectively in surface irrigation of maize. They also have shown that application efficiency was 87.7% in watermelon when sprinkler irrigation was used as opposed to 53.8% in maize when surface irrigation was used.

DRAINAGE and GROUNDWATER LEVELS

High winter rainfall, flatness of the plain, excessive irrigation, and leakage from irrigation network cause high ground water tables resulting in drainage problems. Weed infestation and sediment buildup are two major problems of drainage canals. Delays in cleanup due to insufficient personnel and machinery, and confusion as to who is in charge of maintenance (DSI vs. WUAs) often cause drainage systems to work under submerged conditions, resulting in high water table levels especially during winters when rainfall is very high, and in peak irrigation season (summer). Figure 8 shows areas with critical groundwater levels between 0-1 m, 1-2 m, 2-3 m and above. Percentage of the area with critical groundwater level between 0-1 m has increased from 45% of the total area in 1976 to 57% in 1989 (DSI, 2006). Another main problem associated with drainage is that subsurface clay tile drains installed at a depth of 1.8 m at wide spacings (100 m) in the early 60's by General Directorate of Village Affairs often work under submerged conditions. These wide spacings are inadequate for effective drainage. Farmers were expected to install a drain tile between the ones installed by the General Directorate of Village Affairs thereby resulting in the desired spacing around 50 m. However, only few farmers took the initiative to invest in this much needed investment.

Although drainage systems are not very effective in lowering water tables, they have however, been effective in decreasing salinity levels compared to pre-LSIP period. Salinity of groundwater during the peak irrigation season show positive improvement since mid 1960s. Area with groundwater salt content greater than 2000 micromhos/cm in 1976 has decreased from 35% of the total area in 1976 to 15% in 1989 and areas with groundwater salt content less than 1000 micromhos/cm in 1976 has increased from 35% of the total area in 1976 to 55% in 1989 (DSI, 2006). Studies by Donma et al., (2006) also indicate that the groundwater salinity has continuously decreased in the past 20 years in the upper and middle parts of the plain and that the salts were most probably leached out of the system through the drainage. Most of the salinity affected areas are in the low lying southern reaches of the Seyhan Left Bank in the 4th stage area where drainage infrastructure is insufficient even though some works are carried out now to discharge drainage to the Mediterranean Sea.

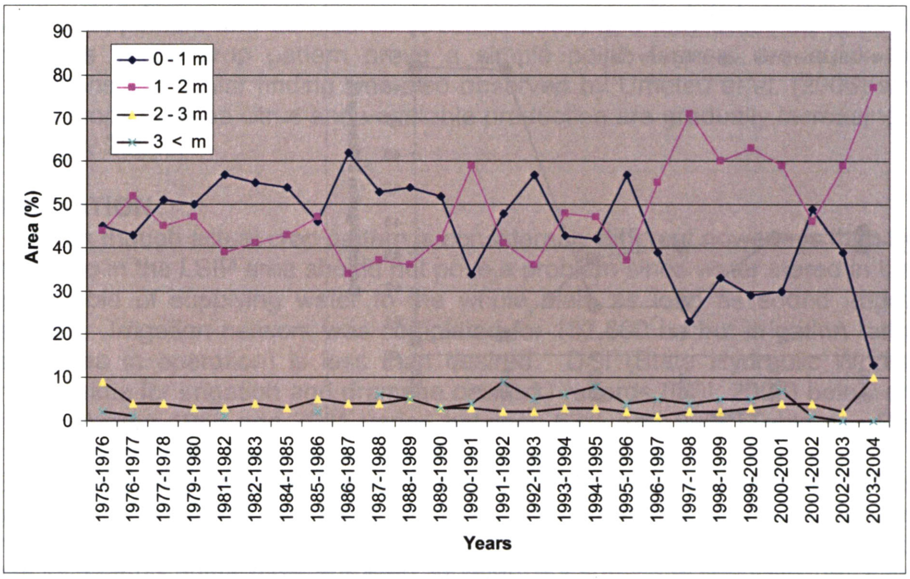


Figure 8. The highest groundwater level in a year

When groundwater levels (above sea level) and depth were studied similar results as above were found. The figure below shows ground water levels and depths at the left bank of the LSIP at three different elevations for 1993 and 2003. Most of the groundwater depths are at between 1-2 m. Same results are also obtained for the right bank of the LSIP.

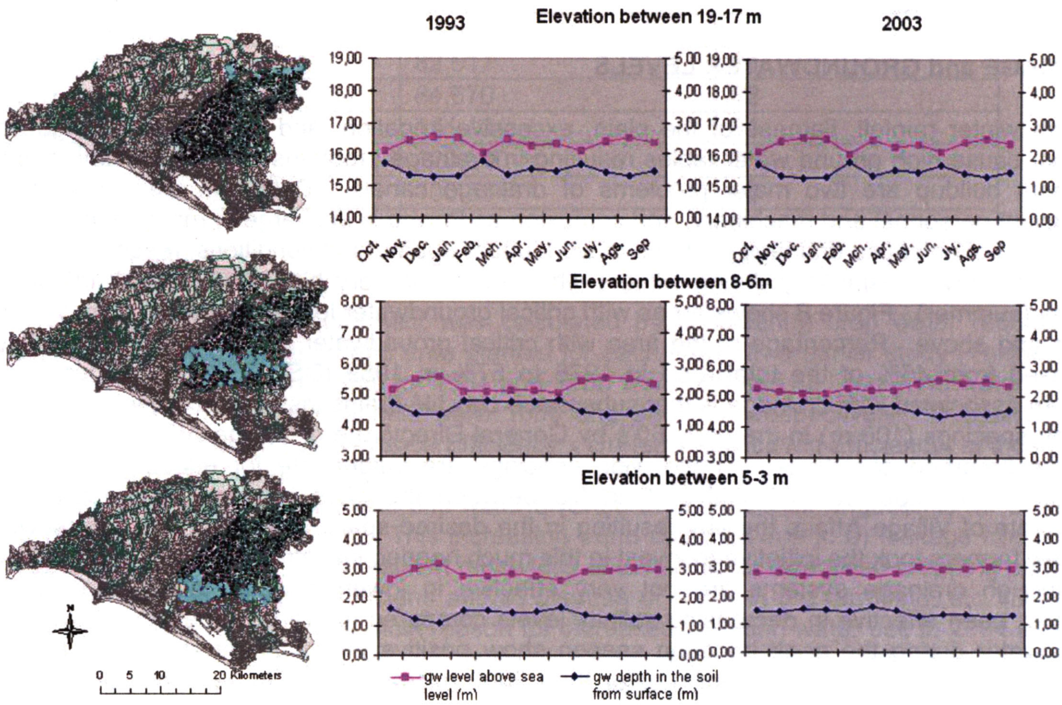


Figure 9. Ground water levels (above sea level) and depths at the left bank of the LSIP at three different elevations for 1993 and 2003

CONCLUSIONS

Countries invest in large irrigation projects to increase welfare and to alleviate economic disparities within regions. Lower Seyhan Irrigation Project (LSIP) in southern Turkey is such a project initiated for hydro-energy, irrigation, and drainage and flood control. Increased agricultural production and employment have benefited the whole region. Despite all the achievements of the project, there are also many shortcomings typical of an introduction of irrigated agriculture to dryland farming.

Implementation of Lower Seyhan Irrigation Project has increased agricultural production considerably, thereby affecting the livelihood of many people in a positive way. However, introduction of irrigated agriculture has also brought problems related to irrigation, drainage and high water tables due to inadequate management and excess water use. Excess water use is the biggest problem and probably the most important reason for other problems encountered today. Most farmers, with a mistaken belief, think more water translates into higher yields. Low conveyance efficiencies coupled with low on-farm application efficiencies have resulted in unacceptable overall irrigation efficiencies as low as 40%. Poor maintenance of irrigation and drainage channels, and underrated water charges have resulted in water wastage and elevated groundwater levels. However, on the positive side, studies have showed that salinity levels in the plain have steadily declined since the initiation of LSIP.

Evaluation of LSIP revealed that expected full productivity has not been realized yet and that this huge investment has many shortcomings which should be monitored carefully and closely in order to shed light for similar future investments. Water should be considered as an important and valuable input through effective measures and should be efficiently utilized by the users. Volume based water charges should be preferred over area-crop basis for conserving this valuable commodity.

REFERENCES

DSI. 2006. Devlet Su Isleri. 6. Bölge Müdürlügü, Adana, Turkey.

Donma, S., T. Nagano, S. Önder and B. Özekici,. 2004. Water Use Efficiency of the Selected Tertiary Canals in the Lower Seyhan Irrigation Project Area. pp. 81-88. Proceedings of the International Workshop for the Research Project on the Impact of Climate Change on Agricultural Production System (ICCAP). November 21-23, 2004. Cappacodia, Turkey.

Donma, S., T. Nagano, T. Kume, S.Kapur, E. Akça and T. Watanabe. 2006. The Shallow Groundwater Level Fluctuations and Salinity Problems in Lower Seyhan Plain. International Symposium on Water and Land Management for Sustainable Irrigated Agriculture. April 4-8, 2006. Adana, Turkey.

Önder, S., S. Donma, T. Nagano, and B. Özekici. 2004. Irrigation Efficiency in Selected Field Plots Under Lower Seyhan Irrigation Project. pp. 89-92. Proceedings of the International Workshop for the Research Project on the Impact of Climate Change on Agricultural Production System (ICCAP). November 21-23, 2004. Cappacodia, Turkey.

Özekici, Bülent. 2006. Farmers' Adaptability to Climatic Changes. pp. 131-134. Proceedings of the International Workshop for the Research Project on the Impact of Climate Changes on Agricultural Production System (ICCAP). March 9-10, 2006. Kyoto, Japan.

Tekinel, O., E. Benli, B. Çevik, A. Yazar and R. Kanber. 1988. Türkiye'de Büyük Sulama Projelerinin Izlenmesi ve Degerlendirilmesi. DSI Genel Müdürlügü Isletme ve Bakim Seminerleri. Sept, 1988.

Umetsu, C., K. Palanisami, Z. Coskun, S. Donma and T. Nagano. 2006. Water Scarcity and Alternative Cropping Patterns in Lower Seyhan Irrigation Project: A Simulation Analysis. pp. 135-143. Proceedings of the International Workshop for the Research Project on the Impact of Climate Changes on Agricultural Production System (ICCAP). March 9-10, 2006. Kyoto, Japan.