Irrigation system and improvement in the Lower Seyhan Plain

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1. Natural condition in the Lower Seyhan Plain

1.1 The Location

LSP is one of the important irrigation project located in southern Turkey, the area of the LSP, is bordered in the north by Taurus Mountains, in the east by the river Ceyhan, in the west by river Berdan, and in the south by the Mediterranean Sea. The plain is divided by the River Seyhan into Yureğir and Tarsus Plain. The region is one of the most fertile areas of Turkey.

1.2 Climate

The climate of the plain is Mediterranean, with very hot and dry summers, mild and wet winters. The average rainfall is 630 mm; the distribution of rainfall over the year is 21% in autumn, 45% in winter, 25% in spring and 5% in summer. The humidity is relatively high throughout the year. The average temperature is 18.7 °C. Frosts occur, statistically, once in three years, lasting not more than 3 to 4 days and strong frosts occur in every 20 to 30 years. The frequency of temperatures of minus 5 °C is statistically once every 4, 5 years. Soil temperatures below 0°C were not yet registered.

1.3 Topography

The topography of the delta is very flat, with a maximum elevation of 60 meters above mean sea level in the north, with the minimum ranging from zero to 0.4 meters in the south. The general slope stretches to the southwest, with grades varying from 1% in the north to 0.1% or less in the southern parts bordering on to the Mediterranean Sea.

1.4 Soils

The soil of the higher elevated lands and of the hills is residual, red-colored, and heavy-textured Terrae Rossae. They are mainly shallow, with a depth ranging from 30 cm to 120 cm, and are composed of conglomerate and limestone formations. In the main areas of the central and lower delta, alluvial soils have developed on the deposits of the three main rivers and their tributaries. These are the deepest and most fertile soils, with depths varying up to 20 m. Solonchaks, Solonetzes, Grumosols and Chernozems also can be found in the delta regions.

1.5 Geology and Groundwater

The Taurus Mountains, bordering Çukurova plain in the north, are of Cretaceous limestone which shows superficial fractures due to weathering. The southern foothills of the Taurus consist mainly of limestone, and of marine deposits of the Miocene age which consist of the sandstone, marls and shale, overlaid by Pliocene conglomerates and sandstone. In the south of foothills alluvial deposits from the Quaternary age are found. The delta in south of the city of Adana consists of recent deposits of the three rivers, Seyhan, Ceyhan and Berdan. These deposits are composed of clay, silt, sand and gravel, with the clay components dominating. The plain is surrounded by Miocene and Cretaceous hills to the southeast and east. Continuous sand dunes are found along the eastern seashore of the Yureğir plain, and swamps and lagoons have been preserved along the northern border of the dunes (the Salt Sea, and Akyatan and Agyatan lagoon).

The annual accumulated groundwater volume in the deeper groundwater storey, which reaches to depth of about 300 meters, is estimated to be 30 billion cubic meters. Artesian groundwater is not used for irrigation purposes, because it is not economically feasible. It is exploited for drinking water. The intake area for this water is in the foothills to the north of the plain, and the aquifers are mostly confined. The confining layer is generally 20 to 100 meters thick, slightly permeable, and allows the slow upward seepage of the water. An impermeable soil layers separates these storey from the accumulated groundwater near surface. Seyhan River and Berdan River are water-losing streams. Intrusion of waters from the Seyhan is only significant near the city of Adana, where the gravel river bed intersects a large shallow continuous aquifer which extends to the east of river. The river Ceyhan is a gaining stream and its influence on water tables is negligible

1.6 Water Source

Seyhan River, with its tributaries, supplies irrigation water to the project area. Watershed area of the Seyhan is about 19,300 square kilometers. The annual discharge is 6.3 billion cubic meters. Quality class of Seyhan River water is C_2 S_1, which means that there is a very low sodium hazard and a medium salinity hazard.

2. Facility of Lower Seyhan Irrigation Project

2.1 Seyhan Dam

Irrigation water in the Lower Seyhan Irrigation Project (LSIP) is provided primarily from Seyhan dam (completed in 1956). It is a multi-purpose dam for irrigation, flood control (in the snow-melt season) and hydropower generation. After completion of Çatalan dam in the upstream, the burden of entire flood control by Seyhan dam has eased.

Seyhan dam has two outlets for irrigation canals (YS1 and TS1) and one outlet for hydraulic power generation. YS1 and TS1 provide irrigation water to upper region of the LSP. YS1 has pipeline irrigation system, which is unique in the LSP. During irrigation period, operation of the dam is basically determined by the water demand of YS1, TS1 and demand for hydropower station. Demand for hydropower station is based on water demand at Seyhan Diversion for two main conveyance canals (YS0 and TS0) and releasing amount of 5 m^3s^{-1} for natural waterway. During non-irrigation period, power generation dominates and some water for drainage of LSP is considered too. Sixty one meters is the critical water level for providing TS1 irrigation water with gravity.

For each year, General Directorate of DSI in Ankara makes calculation and sends the principal water level plan to the DSI 6th, to respect for that year (for Seyhan and Çatalan dams). Principal method of calculation for the plan is not known at the 6th directorate. It may be obtainable from Ankara.

2.2 Çatalan dam

Çatalan dam (completed in 1992) is again a multi-purpose dam for flood control, irrigation, hydropower generation and domestic water supply. It is controlled in set with Seyhan Dam. Its releasing amount is decided primarily by desired water level of Seyhan dam. If water level in Seyhan dam is below projected value, they release water from Çatalan dam, with consideration for natural water supply from the stream between two dams.

In 2002, Adana city started to take domestic water directly from Çatalan dam. It is 2m^3s^{-1} at the moment, and provisioned amount in future is 10 m^3s^{-1}. Çatalan dam has a spillway for the dead volume. It has never been opened since its operation. After initiating uptake of domestic water, spillway would have to be closed permanently.

2.3 Seyhan Barrage and main conveyance canals

Seyhan Barrage (completed in 1942) is a diversion built on the main stream of Seyhan River. It is situated in the upper part of Adana city and it releases water to TS0 and YS0. For both canals, released amount is monitored using automatic flow gauge. The facility and responsibility of operation belongs to DSI.

2.4 Main canals

From main conveyance canals TS0 and YS0, each water user assciation take in water to their main canals. There are watchhouses built at the inlet and gatekeepers stay 24hrs during irrigation period. Beyound this inlet, small gates for secondary and tertiary canals are operated by irrigation technitians of each WUA.

2.5 Secondary and tertiary canals

In the LSP, secondary and tertiary canals are lined by concrete. In the large part of the irrigation area, tertiary canals are 'canalette' types, which are upraised from the ground. Canalett is less affected by undulation of the ground thus easier to construct, and also it is easier to detect leakage and to carry out maintenance. Irrigation technicians of WUAs, depending on irrigation schedule and their experience, decide release amount of irrigation to secondary and tertiary canals. Farmers use siphons or cranes for drawing water to their farmland. Drawing amount can be easily calculated, by multiplying the capacity and number of siphons to irrigation time.

3. Agriculture in the Lower Seyhan Plain before the irrigation project

Until the middle of the 19th century the Yureğir and Tarsus Plains were of little agricultural importance. From the 110,000 ha which were agriculturally utilizable in the Yureğir Plain, 6,250 ha were used to grow rice in areas near towns and villages. Yureğir Plain was mainly covered by oak trees, which spread from the southern district town of Karataş to Adana city. In Tarsus Plain, marshland and steppe dominated.

In 1858, new land legislation was introduced which brought radical changes to the development of settlements and agricultural land use. Before that time, there was only a traditional right to own house plots. The farmland became land with a possessor title. Then tax had to be paid, but it could also be sold, bequeathed or mortgaged.

The purchase of land by each other, led to formation of the so-called ´Ciftliks´, which are prominent feature in a number of villages. Ciftlik is the name given to a large private or state-owned farming enterprise in which land accumulation has resulted from prudent management of existing land, labor, and capital, rather than by inheritance. The Ciftliks concentrated on the cultivation of cotton, sesame and rice, which generally brought higher returns on the market, and they invested in the agricultural as well as in the urban sector. Up to 1940, short staple cotton was grown in rotation with wheat. In some areas rice plantation dominated.

A great chance was brought about by introduction of a new cotton variety in 1943, the medium staple ´ Akala´ which increased yields of cotton from 500 to 1000 kg /ha. Wheat growing disappeared completely, and in some areas crop rotation was abandoned. The output increased due to the expansion of the area cropped, and, at that time, the gross income per hectare of cotton was estimated to be three times higher than that of cereals.

In 1961, prior to the irrigation project, 75% of the arable land had planted with cotton in rain-fed farming, and, in some parts of the project area, cotton and other crops were irrigated by withdrawing water from the natural water bodies and from the rivers. It was estimated by the project planner (World Bank) that a result of the project would be a more diversified pattern of summer crops, and the area of the cotton would decline to 35%. The areas under fruits, vegetables and oilseeds would increase, and fodder crops and legumes would be new crops needed in the rotation for intensifying livestock production and for improving soil fertility. It was further expected that about 45% of the area would be used for producing winter crops (, i.e. legumes, winter vegetables, melons and cabbage).

These expectations were not met because of farmers' decisions. From 1964 to 1981 cotton remained to be the dominant crop in irrigated agriculture (94 and 77% respectively), and the cotton-wheat crop rotation was widespread. In the 1980s, cotton was still being planted in more than 50% of the project area, and only since 1987 has percentage declined to the estimated level of approximately 35%. Since the mid-1980s expenditure for cotton increased significantly because application of pesticides had to be increased to control pest and disease and because labor cost for cotton-pickers became higher, after GAP project initiated since most of labors came from that region. This low net income, together with second crop promotion policies for soybean and maize, caused the farmers to give up cotton plantation. On contrary, maize and soybean become profitable. In 2002 Maize was the first crop (54%) and citrus was the second (13%).

4. The planning and implementation process of the project

The planning of water resource development on the River Seyhan started in 1939. In the 1940s, a diversion dam, flood control barriers, and two main conveyance channels were constructed from which 18,500 ha could be irrigated. In 1956, the Seyhan Dam was completed and the hydroelectric power plant started its operation with an installed capacity of 54 megawatts, generating an average of 350 Gwh annually.

Seyhan Dam also serves as a flood control reservoir for 24,500 ha of agricultural land and the city of Adana, and the area surrounding the reservoir is used for recreation. The available volume of surface water from the river Seyhan, damned in the Seyhan reservoir, is sufficient to irrigate the project area of 175,000 ha, and water quality is most suitable for irrigation purposes

The LSIP area comprises 175,000 ha which were to be installed with irrigation and drainage facilities and with on-farm development work. The LSIP was planned to be developed in three stages at first, but after some time due to high investment costs incurred, the area of stage III was reduced,

Table 1 Implementation schedule for the subproject and their size

Stage I	65,000 ha	1963-1968
Stage II	48,600 ha	1969-1974
Stage III	19,831 ha	1976-1985
Stage IV	40,657 ha	

and the most problematic part of the plain was designated for the stage IV project.

In 1987 with the completion of the stage III project, irrigation and drainage facilities had been constructed on approximately 133,000 ha, or about 70% of the total project area, with 69,031 ha in the Tarsus Plain and 64,400 ha in the Yureğir Plain. Surface drains were installed on 120,000 ha, subsurface drains on 62,000 ha, and land leveling had been completed on 95,400 ha. According to DSI (SHW) and TOPRAKSU (GDRS) estimation, the stage II and the stage III projects were completed with delays of 10 years and 18 years respectively. The service area was not significantly extended until the 1990s.

With the completion of stage I project at the end of the 1960s, the General Directorate of State Hydraulic Works initiated the establishment of Irrigation Cooperatives and Irrigation Associations, which were in operation until 1981. The Irrigation Cooperatives were weak in settling matters of conflict, the farmers did not pay O&M costs and irregularities appeared with the administration of the collected water charges. After 1981 another type of water user organizations, named Water User Groups were established on village bases.

One branch of Regional Directorate of DSI named 'Operation and maintenance Directory of LSIP' operated 133,431ha service area of the LSIP, with two operational field units in Tarsus and the Yureğir Plains. The units were further divided into subunits, with engineers and technicians executing water distribution, maintenance, and repair work together with the WUGs. The field operation unit of the Tarsus Plain water district was located in Yenice village with four subunits, and served 69,031 ha. The operation unit of the Yureğir Plain water district, with its office in Dogankent, had three field units serving area of 64,400 ha.

The DSI was able to manage many distribution problems, because the water supply in the project area was favored by natural, technical and institutional conditions. Water was usually abundant. In 1988 and 1989, for the first time since the operation started, the LSIP experienced water shortage. With the fact that the fourth stage of the project area, or about 40,000 ha not yet connected and supplied with water, all available water could be used in the three stages already operating. A legally bound decision has been made that irrigation needs had priority whenever water deficit has occurred due to the energy generation.

The Water User Groups had shown some disadvantages within the publicly run projects. The main disadvantage was that there was a lack of direct farmer involvement, and that the irrigators had no institutionalized control over the WUGs' operation and maintenance activities. As a result of their institutional setting, they had not been successful in enforcing the water allocation rules, and they could not prevent excess water withdrawals by the farmers.

In 1986, a rehabilitation program for the stage I, II and III project areas was negotiated between the World Bank and Turkish Government, and a commitment was set by the World Bank that capital and recurrent cost recovery had to be achieved by the beneficiaries. The DSI stressed the point that cost recovery would be impossible to attain under the prominent institutional setting, and it proposed that operation and maintenance responsibilities in the DSI-managed large-scale irrigation projects should be, whenever possible, transferred to water user organizations. This initiative was encouraged by the World Banks policy. In 1993, the accelerated irrigation transfer program has started, beside others, in the Lower Seyhan Irrigation Project.

Establishment of water users associations in the lower levels of large-scale systems is viewed as a positive step towards ensuring participation and towards development of a sense of cooperation and organized management skills. The political emphasis on the transfer of O&M responsibility to WUAs primarily stems from the political wish to lift the financial burden from the national budget. It has been estimated that transfer would reduce the annual O&M expenditures per hectare by about 100 USD, and that the Turkish Government could save about 10 to 16 ´million USD each year. In addition, there were also national restrictions on agency growth, and there was a complete stop of new assignments to the O&M departments.

Water rights were not transferred, and the hydraulic infrastructures remained to be the property of the DSI who, therefore, exercise control over the WUAs O&M activities. The O&M responsibility for the irrigation networks were turned over by the contracts negotiated between the WUAs, on behalf of their members, and the Regional Directorate of the DSI. The DSI handed over water supply planning, scheduling, monitoring and conflict settlement.

The WUAs are fully responsible for O&M works and they issue actual water requirement for the planning of the water supply, and distribution schedule, and they are responsible for their own enforcement, and for the maintenance of their delivery networks.

5. Present problems and conclusion

The uncoordinated efforts of the two state agencies (DSI and GDRS) caused the levels of the project and the on-farm drainage systems to be unadjusted, which had to be corrected entailing high costs. The heavy delays in the installation of on-farm drainage networks were directly related to the investment strategy of on-farm works. The present investment strategy completely subsidizes the installation of the on-farm drainage system. However, this state financed drainage is not sufficient unless the farmers install additional subsurface drains in between. These additionally required investments were also omitted by the farmers. Irrespective of the investment strategy, cooperation between the constructions units, i.e. the public agency, and/or the private company, and the farmers was poor. Therefore the engineering works could not be organized in a rational way, causing delays and the overrun of the estimated project costs

Despite deficiencies in investments in O&M, groundwater and soil conditions improved within the service area. But in the stage IV project area, high groundwater levels and saline/alkaline soils are concentrated. The difference is apparent between the upstream and downstream farmers: while the upstream farmers have enjoyed high net incomes from irrigated agriculture, the downstream farmers bear the costs from in adequate groundwater control means, and from the postponed investments in the not yet completed delivery networks.

At the farm level where water is used as an input factor in agricultural production, water savings have not been considered. Policies encouraged irrigation for certain crops by setting low water charges per crop and area, which is not effective. The O&M charges have been area-crop based which has provided no incentive for water savings. For the farmers, the dominant decision-making factor has been the profitability of the crops; decisions on water have been secondary.

The maintenance of the deliveries and the water supply, including enforcement of scheduling, improved with the transfer of O&M tasks to WUAs. The main reasons are increase in labor productivity, heavier sanctions on non-payers and rule-breakers, adequate budgeting constituted by the beneficiaries´ payment, and better repayment mode fitting with the farmers ability to pay. It cannot yet be judged whether improvements have been made, or will be made with the state agency being responsible for the project's drainage system. These services are completely subsidized and they depend on central budget allocations, and the state-provided services are not part of the contract between the WUAs and the state agency (DSI). Under the present transfer program the WUAs have no control over the publicly subsidized services, in particular the maintenance of the entire project drainage networks. DSI still carries out the maintenance works of drainage networks but it is not sufficient enough because of shortage of budget.

Maintenance of secondary and tertiary drainages could be the task for WUAs, but for the main drainage it is difficult because WUAs' service areas are designed around a main delivery channel which does not coincide with the drainage area of the agricultural effluents. The main drainage system can only be subject to a transfer if all WUAs are represented in an upper-level decision making body which is authorized to make decisions on drainage basin issues.

The WUAs have only recently contributed, at least partly, towards groundwater and salinization control, they are operating and maintaining the shallow groundwater well which are located in their responsible area, but these contributions are still minimal, and they are better characterized as a by-product of the activities which guarantee adequate and reliable water supplies i.e., the proper maintenance and repair of the delivery system.

A new investment strategy is required with active farmer participation, covering the whole process from the project identification to the maintenance of the on-farm drainage development works. Some part of the investment costs could be subsidized by the government, and some parts to be paid by beneficiaries, including realistic interest rates. The farmers should commit themselves to sharing a substantial part of the on farm development costs in real terms before any government support is given. The basic assumption of this investment approach is that farmers who participate in actual decision-making, and who share in the costs, will also have a positive attitude and feel responsible for the maintenance of the on-farm drainage infrastructure.

References

Scheumann, W., 1997: Managing Salinization. Institutional analysis of public irrigation systems. Springer Verlag, p.274