Issues in Design and Management of Irrigation Systems: The Southeastern Anatolia Project (GAP) Experience

by

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Introduction

Population and economic development have overwhelmed traditional water management practices in the Eastern Mediterranean. Water management issues can conveniently be considered under two major headings: supply management (activities required to locate, develop and manage new sources); and demand management (mechanisms to promote more desirable levels and patterns of water use). Given the constraints on new supplies in the region, far greater emphasis should be placed on demand management. Countries of the region can adapt themselves to limited availability of and growing demand for water by stressing the productive efficiency as a major goal for water-using activity along with the adoption of principles of allocative efficiency. Hence, a realistic approach to the water problem in the region should incorporate policies for improving management and allocation practices, and also upgrading and modernising water delivery structures in major sectors of the economy such as the agriculture. Demand management covers both direct measures to control the use of water such as technical interventions in all sectors to reduce water losses unaccounted for, and the modernisation of both the distribution and on-farm systems, as well as indirect measures that affect voluntary behaviours such as water charges, tariffs, market mechanisms, financial incentives and public education.

Since irrigation accounts for some 75 percent of water withdrawals region-wide, technical interventions to reduce water use have particular potential in irrigation. Hence, the promotion of irrigation water use efficiency is identified by many experts as the essential strategy needed to address the problems of water scarcity and of costly new supplies. There are technological and managerial demand management options to improve irrigation water use efficiency. Traditional irrigation technologies which deliver water to plants by gravity usually result in substantial water losses and poor uniformity in water distribution. Modern technologies such as sprinkler and drip irrigation systems, and/or introduction of low pressure pipes improve water use efficiency as being major water saving techniques. Technological improvements in irrigation systems have expanded production opportunities.

Thus, this study will look into the Turkish experience in improving irrigation water use efficiency through technological and managerial options with special regards to the developments within the Southeastern Anatolia Project (hereafter: GAP-the Turkish acronym of the Project). The GAP constitutes a unique case to be examined, since a transboundary river system, namely the Euphrates and the Tigris rivers are the major

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sources for irrigation in the Project area. Hence, improvements in the patterns and levels of use and management of these water resources will not only contribute to the increasing water use efficiency at national level, but will also support policies to stretch the existing capacity of transboundary water resources to meet the growing demands of co-riparians. More importantly, experiences which are gained in the GAP case in terms of attaining higher levels of productive efficiency through the adoption of advanced technologies and management options in the irrigation sector will represent a standing example which challenges the existing water use and management practices of co-riparians, namely Syria and Iraq.

The agricultural area of Turkey is huge (i.e. around 28 million hectare, m ha) but the productivity is comparatively low because of the aridity along with other factors such as the persistence of traditional on-farm practices. Government policies aim to tackle the problem by expanding the area of irrigation. About 8.5 m ha of land are estimated to be economically irrigable.[1] By the end of the 1990s, half of this potential had been developed (i.e., 4.16 m ha). Although Turkey is often considered as being self-sufficient in water resource endowments, it is not always in the right place and at the right time to meet its present and anticipated (future) needs. Irrigation infrastructure is indispensable because of the uneven distribution of rainfall. For years, governments have pursued a strategy to expand irrigation as rapidly as possible (gross irrigated area doubled within 30 years: from 2.3 m ha in the 1970s to 4.16 m ha in the 1990s) using low cost approaches. The primary aim has been to provide more irrigable land as quickly as possible, although that meant facing problems of modernisation later on.

The GAP being the largest multi-purpose integrated development project of Turkey is envisaged to expand the irrigated area by adding 1.7 m ha to the current 4.16 m ha of irrigated area. Alongside with the initiation of the major irrigations in the GAP in 1995, especially in the renowned Sanliurfa-Harran Plain, different irrigation technologies have been tested to ensure planned development and efficient utilisation of limited water resources in the region. Hence, it has been envisaged in the project to expand the irrigated area concomitant with the adaptation of the modern irrigation technologies. Land and water are the major natural resources which form the driving force of the GAP. Thus, the project aims to achieve economic and social development through the optimum utilisation of these resources along the principle of sustainability. In line with this goal, various projects have been implemented, and are being implemented, with a view to attain appropriate use and management of available resources.

At present, 327,000 ha of land is under irrigation in the GAP region. Irrigation projects of the GAP region constitute the most important part of the integrated development. Considering that water is the most important input for raising agricultural yield, the project aims to utilise this resource in the most efficient way possible. Thus, four different irrigation methods are being tested on a pilot area of 3,000 ha in the Sanliurfa Plain to determine their comparative advantages in water saving. The methods tested are: pressured irrigation; low pressure irrigation; unit area and unit water; and classical canalette network. This study will therefore scrutinise the implementation stages and the impacts of this Project designed to Compare the Advantages of Certain Water-Saving Irrigation Methods and Technologies. However, the analysis will also be supported with the discussion of other primary projects on land-water resources in the region, such as the Project on the Management-Operation-Maintenance (MOM) of GAP Irrigation Systems. Interviews with authorities in the GAP Administration emphasise the very fact that a sound research could only be conducted through a joint evaluation of major projects regarding land-water resources as they are all designed to ensure the use of natural resources in a sustainable manner.

GAP: An Overview

The construction of three major dams on the Euphrates, namely Keban (1974), Karakaya (1987) and Ataturk (1992) which were originally planned to be a part of a Lower Euphrates Project, initiated the most ambitious development scheme in Turkey, namely the Southeastern Anatolia Project (GAP) in 1980 (Ministry of Energy 1966).

GAP was basically designed to harness the waters of the Euphrates and Tigris rivers for hydro-electrical power (HEP) generation and irrigation (Ministry of Energy 1980). However, it was later transformed to a multi-sectoral development project that covers all development-related sectors such as agriculture, industry, transportation, urban and rural infrastructure, health care, education, housing and tourism (Unver 1993).

The GAP project area lies in southeastern Turkey, covering nine provinces, corresponding to approximately 10 percent of Turkey's total population and a surface area of 75,000 square kilometers. The project area includes the watersheds of the lower Euphrates and Tigris rivers and the upper Mesopotamian plains. The water development program of the GAP includes 13 large sub-projects altogether, 7 of which are on the Euphrates river (Lower Euphrates -which is the largest and the most comprehensive project including the Atatürk Dam and the Sanliurfa Tunnels together with five more sub-projects within this framework- Karakaya, Euphrates Border, Suruç-Baziki, Kahta-Adiyaman, Gaziantep, Gaziantep-Araban) and 6 on the Tigris (Dicle, Kralkizi -under construction- Batman, Batman-Silvan, Garzan, Ilisu, Cizre). The GAP involves a total of 21 major dams and 19 HEP generating stations, as well as irrigation networks to irrigate 1.7 million hectares of land. The centerpiece is the Atatürk Dam, which was completed at the beginning of the 1990s, with a total storage capacity of 48.7 billion m3, and an installed electricity-generating capacity of 2,400 MW (Bagis 1989)

Other major works in the GAP are considered to be the Sanliurfa Tunnels, Birecik and Karkamis Dams on the Euphrates and Ilisu on the Tigris. The Sanliurfa Tunnels are the major units of the GAP consisting of two tunnels which discharge water from the reservoir of Atatürk Dam at a rate of 328m3/s. Water reaches the Sanliurfa-Harran plains via Sanliurfa Tunnels system, which consists of two parallel tunnels each being 26.4 km long. One of the tunnels was opened in 1995, and irrigation has been practiced in a 90,000 ha area in 1998. The Sanliurfa-Harran plain has two main canal systems. Sanliurfa main irrigation canal will irrigate 43,000 ha of land by gravity and 5,000 ha by pumping. The Harran main irrigation canal will irrigate 98,500 ha by gravity.

The GAP is considered to be a very expensive project: 32 billion dollars is the estimated cost, and 13.9 billion dollars have been spent so far. Due to the "transboundary flows" involved, except for the German and Swiss credits obtained for equipment purchases and some others, it has not been possible to secure international finance.[2] The GAP is very critical for the Turkish economy: the installed capacity to be created is approximately 7,500 MW with an annual hydro-power generating capacity of 27 GWh which will significantly increase the country's existing energy output. There is a huge demand for hydro-power in Turkey due to its population growth (2,2 % per annum) along with urbanization (3,6% for 1985-90) and impetus for industrialization. Moreover, with the irrigation systems envisaged, Turkey is determined to develop agriculture and agro-industrial production for export and to raise the standard of living of the people of the region. The importance of the GAP for Turkey can be summed up by these two sentences: GAP will add 70 per cent to Turkey's existing hydro-electric output, and 1.7 million ha. to the current 4.16 million hectares of irrigated land in Turkey. At present, 327,000 ha of land is under irrigation in the GAP region. While 211,000 ha of this total has been irrigated by the state, 116,000 ha are irrigated privately.

Starting by the late 1970s and early 1980s numerous studies had been conducted by researchers on the characteristics of the water and land resources in the GAP region, in general and in Harran Plain, in particular.[3] These studies classified the soils in the GAP region into eight capability classes. The classes are defined according to soil texture, soil depth, water holding capacity, alkalinity, salinity, topography, stoniness, and drainage. Over 90 percent of the land was said to belong to Class II which were highly suitable for agricultural use. However, these studies emphasized that soils in the region comprise mainly silty clays. Hence, they pointed to the danger of applying excessive water to that type of soil that might end up cracks in the soil and extensive waterlogging in the region. Besides, these surveys showed that salinity and alkalinity were not widespread problems. Stoniness was indicated as a major problem in the region and stone clearing has been a major operation in farming areas. Wind erosion has been limited primarily by low wind speeds in the region. On the other hand, these studies indicated that soil erosion by running water has been serious in the GAP region. This has been particularly the case on sloping ground where vegetation cover has been reduced.

Given the underdevelopment of the southeastern Anatolia region and the government's desire to raising the population's standard of living the importance of the GAP to Turkey is obvious. The GAP region faces many of the problems that are typical for underdeveloped regions in the world. Compared with the rest of Turkey, the region has had higher fertility rates, higher infant mortality, and lower literacy rates because of the less access to health care and education. The region also experienced a net outmigration -both seasonal agricultural migration and permanent rural-to-urban outmigration as a response to high unemployment in the region. The region’s economy is based largely on agriculture, but productivity historically has been low. In 1985, per capita income in the region was half of the national average, and the region, which has 10 percent of the country’s area and population, accounted for only 4 percent of the GNP (Unver 2000).

A Master Plan study was carried out to determine the region’s potential and bottlenecks for development, as well as to set the development objectives and strategies in general, and in development related sectors. Thus, among the development objectives of the GAP there are "to raise the income levels in the GAP region by improving the economic structure in order to narrow the income disparity between the region and the other regions"; "to increase the productivity and employment opportunities in rural areas"; "to enhance the assimilative capacity of larger cities in the region"; "to contribute to the national objective sustained economic growth, export promotion, and social stability by efficient utilisation of the region's sources" (Nipon Koei 1989). It is planned that the development of the region’s soil and water resources will provide a basis for agricultural development, with substantial increases in production output, diversity, and productivity, which, in turn, will stimulate the growth of agro-related industries.

Sustainability of Irrigation in the GAP

The holistic approach adopted by the GAP is based upon an expanded principle of sustainability whose definition has been developed by the GAP Regional Development Administration (RDA)[4] which covers several aspects of sustainability:

-sustainability of irrigation
-sustainability of the agricultural system
-economic sustainability, or economic viability
-environmental sustainability
-spatial sustainability (i.e., sustainability of land use & transportation)
-societal sustainability[5]

In accordance with the sustainable development approach and strategies of the GAP, special programs and projects have been initiated in the GAP region with a view to emphasize the human dimension of development through project implementations concerned with basic social services. The design, construction, management, operation and maintenance of irrigation facilities constitute the essential component of these social services. Irrigated agriculture is the basis for the sustained development of the GAP region. The Master Plan and the subsequent studies of the GAP RDA stress the principle that irrigation system should be sustainable. Land and water are major natural resources which form the driving force of the Southeastern Anatolia Project. The project aims at economic, spatial and social development through the optimum and efficient utilisation of these resources along the principle of sustainability.

Four major projects have been implemented to ensure planned development and effective utilisation of water resources in the irrigation sub-sector. These on-going projects as a whole serve the primary aim of the Southeastern Anatolia Project concerning the surface (Tigris and Euphrates rivers) and groundwater resources, that is introduction of technological and managerial measures to improve efficiency in the irrigation sub-sector. The GAP Master Plan was drafted to ensure efficiency and integration in the utilisation of land and water resources existing in the region. Hence, the basic development scenario envisaged by the Plan is to transform the region into an ‘agriculture based export centre.’ In the event, these four projects have been planned and are being implemented as essential component of package of agricultural development projects and activities:

Agricultural Development Projects in the GAP region
(Projects on Land-Water Resources)

1.Land Consolidation
2.GAP Agricultural R&D Project Package
3.Project for Agricultural Marketing, Crop Design Planning and Integration of Marketing Planning Works
4.Study on Agricultural Mechanisation Needs in the GAP region
5.Economic Analysis of Enterprises in the GAP Region; Short, Medium and Long-Term Credit Needs

6.GAP Region, Fresh Vegetable-Fruit Post Harvest Technologies
7.Project for Raising the Income Level of People in Non-Irrigated Areas
8.Afforestation and Erosion Control
9.Sanliurfa-Harran Plains On-farm and Village Development project
10.Feasibility Study on Ceylanpinar Ground Water Reserves

(Projects in the Irrigation Sub-sector)
11.Improvement of Irrigation Canal Regulation Techniques in the GAP region;
12.Comparative Advantage Study for Various Irrigation Methods and Techniques;
13.Introduction of and Demonstration for New Irrigation Technologies;
14.Management-Operation-Maintenance of Irrigation Systems in the GAP region.

Source: *GAP Review*, GAP-RDA, No. 11, 1999.

Projects to Improve Design, Operation, Management and Maintenance of Conveyance, Distribution and On-farm Irrigation Systems in the GAP Region

Improvement of Canal Regulation Techniques

The overall aim of the Project has been to improve the conveyance, distribution and on-farm irrigation facilities to achieve efficient patterns and levels of water use in the GAP region. Research was conducted jointly by the GAP-RDA and the French Water Management Department to design and to compare different regulation techniques in the main irrigation (feeder) canal of the GAP, namely the Harran Main Canal, so as to select the appropriate solution which fulfils the following objectives:

-preventing water loss or temporary shortages which are the likely outcomes of uncertainties in water demand at the heads of secondary networks;
-to take into account the progress of the canal construction work of which the first 56 km length had already been completed and where only the type and characteristics of the regulators could be modified,
-to pay special attention to criteria related to the operation and maintenance of the system;
-to consider the present state of local technical capabilities and their potential evaluation (Unver&Voron 1993).

Various regulation methods were tested on the Harran Main Irrigation Canal, the largest and longest (118 km) of its kind in Turkey. The Harran Main Canal is fed from the Ataturk Dam reservoir through Sanliurfa Tunnels, is designed, with a capacity of 80 m3/sec, to provide irrigation water to an area of 141,000 hectares. Certain options were analysed to design a regulation system with minimal water losses, ease of operation, and economy. The most appropriate method located was a mixed regulation system with an upstream control section (first 56 km), a transition section with in-canal storage (mid-18 km) and a downstream control section (last 44 km).

The mixed regulation system of the Harran Main Irrigation Canal introduced for the first time in the entire Turkish irrigation system the ‘downstream control’ (partially) with special emphasis on ‘water on request’ system. In Turkey common regulation systems in irrigation facilities are constant upstream level which is maintained by regulators. All main canals are operated by the concerned state agency whereas at the secondary and tertiary levels irrigation management organizations, namely the irrigation unions undertake operation and maintenance of the existing systems. In general, under the upstream control a rotation system based on the prior scheduling of watering to enable the continuous use of flows 24 hours a day is required. However, in most cases the rotation system on the tertiary canal is not steadily used, and when there is a lack of accurate schedule of water requirements for the following weeks, the operator is obliged to allow an extra discharge to ensure that demand is met. This method of regulation and distribution system leads to overuse of water resources which in turn results in improper irrigation of fields with excess water and direct flow into the drainage network where the direct and indirect return flow is increased.

Moreover, for the specific case of the GAP, rational and optimal use of water resources is a prerequisite for sustainable development. Water resources of the GAP region will soon become a limiting factor as larger areas are opened to irrigation along with the rapid and large-scale development of the hydropower schemes. Furthermore, as provinces grow with higher standards of living and as factories flourish, municipalities and industries will ask more water from the existing supply of water resources. Mixed regulation system was also applied to limit effluent water downstream of the perimeters. Control of pollution through improved canal regulation would not only protect water and land resources through the GAP region, but minimize the negative impacts of usage beyond the national borders all through the Euphrates-Tigris river basin which constitute a system of transboundary surface water resources draining from Turkey and flowing through Syria and Iraq. Improvement in the regulation of water resources in the Main Irrigation Canal will serve this very end of efficient patterns and levels of water use in the most thirsty sector of irrigation.

O. Unver and B. Voron indicate that:

> … the mixed regulation used for the Harran Main Canal brings together the advantages of operation flexibility, water economy, and relatively low incremental construction costs. First of all, the downstream control of the last section prevents wastage of water; the entirely automatic operation of the mixed gates makes use of the storage volume extremely easy and reliable. Secondly, the flexibility of operation given to the system by the mixed regulation solution makes it possible to handle the variation in demand for water from the perimeters. Thirdly, the evolution of techniques and the advantage of easier use of water for irrigators may lead to the evolution of distribution network operation toward a 'water on request' system. Fourth, the solution used for the Main Canal makes it possible to integrate this evolution of equipment and the method of water use in the secondary canals without having to modify the main infrastructure. Finally, the operator can master this technical compromise with minimal technical training (Unver&Voron 1993).

Comparative Advantage Study for Various Irrigation Methods and Techniques

Four different irrigation methods are being tested on a pilot area of 3,131 hectares in the Sanliurfa Plain to determine their comparative advantages in water saving. The methods tested are: classic canalette (flumes) network, unit area unit water[6], low pressure irrigation and pressurised irrigation. The implementation (pilot) area was selected in the Sanliurfa

Plain with an aim of presenting the technical characteristics of each solution studied, and examining the differences in perimeter management (Unver, Voron and Akuzum 1993). The soil and topographical characteristics of pilot area are similar to the average of GAP irrigation schemes. The technical solutions developed for the pilot zone have been, therefore, applied to other schemes in the GAP region. Through this implementation in the pilot zone, technical, economic, and operational merits of various irrigation water management practices have been studied in the actual farmers' environment. Comparisons among these four major irrigation methods/technologies based on the following criteria:

-Reduction of water losses both at distribution and on-farm levels: The irrigation technique selected for application for the rest of the GAP irrigation schemes should serve the end of optimum and efficient use of existing water resources so that water saved through this technique can be reallocated to other emerging water thirsty sectors of the region when needed.
-These four methods should be compared according to their technical characteristics (based on their individual components and on their overall efficiency).
-These techniques should also be compared according to their maintenance properties: ease of management, that is, any method adapted should both leave sufficient freedom for farmers and reduce need for intervention by operating agencies.
-Best solution should also be decided according to the acceptance by farmers: any solution adapted to farmers' prevailing technological levels by reducing constraints at field distribution level will meet with the approval of users.
-Moreover, the technique chosen should also be suitable for the evolving patterns of crop design in the region.

In Turkey gravity irrigation through standard canalette networks is the most extensively used irrigation method in large schemes, ranging from several thousands to several tens of thousands of hectares. This method has been used in the GAP region in 211,080 hectares (Table 1) of state irrigations in operation as well. In gravity irrigation systems the supply and distribution networks are typically operated by upstream control through embanked lined canals or canalettes. Furrow or classic basin irrigation methods are practiced on-farm level. These open channels or canalettes with upstream control often result in wasteful water use. Moreover there is a certain amount of difficulty involved in the management of water distribution in these installations. In this system careful planning is required to match farmers' water demand and the discharge delivered from the main canal. Upstream control usually requires the preparation of delivery schedules, which optimally are based on field observations and crop data, though in many cases they are repetitions of outdated manuals or design reports. Upstream control requires estimates of distribution and conveyance efficiency as well as of the transmission time to determine the flow and the time of release at the headwork.

However, in line with the interim results obtained in the pilot project area, State Hydraulic Works (SHW), the government agency responsible for, among others, the design and construction of the irrigation facilities has started to build low pressurised irrigation network with downstream control through buried pipes in about 125 000 ha of land in the GAP region. Hence, in Table 2 all irrigation schemes indicated hold closed distribution networks with downstream control. This will not only reduce water losses in comparison with the open gravity installations but reduce the physical obstacle created by long canal or canalette networks since after the main canal all distribution networks under construction are built as underground systems. Moreover, pipe discharges are not determined by release at the head of the network but by the demand of the farmers. The networks remain under constant (low) pressure, making water available at all times. Note that, when irrigation projects in the GAP are fully realised (i.e. 1.7 millions of hectares of land will be fully equipped with irrigation infrastructure), 35 percent of these irrigation areas in the region could be irrigated by pressurised schemes. This rate compares favourably to the 15 percent and 30 percent rates for France and the United States, respectively. Moreover, approximately 50 percent of the irrigation from the Ataturk Reservoir will be through pressurised perimeters. Pressurised irrigation systems are under construction in Kralkizi-Dicle (75880 ha), Batman (9184 ha), Bozova (860 ha) , Belkis-Nizip (11925 ha), and Samsat (2450 ha) irrigation project areas. Sprinkler methods have been applied at only limited ground water schemes in Ceylanpinar (27000 ha) and at some minor schemes between Viransehir and Kiziltepe. High evaporation rates and existing wind conditions as well as financial and institutional difficulties in the region constitute major impediments for expanding the areas under sprinkler systems.

Hence, by using the possible advantages of widespread pressurised system in the whole GAP region, SHW has started to implement low pressure irrigation (California system) systems for the irrigation schemes under construction. It has been planned that California system will be initially applied in Mardin-Ceylanpinar (15376 ha), and Gaziantep-Kayacik irrigation projects areas (13680 ha). Even though in this system field irrigation is by conventional gravity flow, as the farmers operate the flow limiter valves themselves this system offers higher water use flexibility and enhances water saving in the perimeter. Low pressure pipe irrigation is technically viable in the GAP region. Systems using low-pressure buried pipes have water conveyance and distribution efficiencies as high as 90 percent, compared to 50-60 percent for earth canals. Such systems successfully prevent unnecessary losses from both seepage and evaporation.

Table 1

IRRIGATIONS IN OPERATION **(hectares)**

1.	Hancagiz Irrigation	7 330
2.	Sanliurfa-Harran Irrigation (Partial)	117 000
3.	Hacihidir Irrigation	2 080
4.	Derik-Dumluca Irrigation	1 860
5.	Silvan I & II Irrigation	8 790
6.	Nusaybin Cag-Cag Irrigation	7 500
7.	Silopi-Nerdus Irrigation	2 740
8.	Akcakale Groundwater Irrigation	15 000
9.	Ceylanpinar Groundwater Irrigation	27 000
10.	Devegecidi Irrigation	7 500
11.	Suruc Groundwater Irrrigation	7 000
12.	Cinar-Goksu Irrigation	3 580
13.	Garzan-Kozluk Irrigation	3 700
14.	Adiyaman-Camgazi Irrigation	1 000
	TOTAL	**211 080**

Source: State Hydraulic Works (DSI), *GAP 2000.*

Table 2

IRRIGATIONS UNDER CONSTRUCTION **(hectares)**

1.	Sanliurfa-Harran Irrigation (Partial)	50 000
2.	Kralkizi-Dicle Irrigation	24 421
3.	Batman Left Bank	18 750
4.	Batman Right Bank	18 600
5.	Belkis-Nizip	11 915
6.	Adiyaman-Camgazi Irrigation (Partial)	6 430
7.	Kayacik Plain Irrigation	14 740
8.	Bozova Pumped Irrigation	860
9.	Samsat Pumped Irrigation	2 806
	TOTAL	**149 317**

Source: State Hydraulic Works (DSI), *GAP 2000*.

Introduction of and Demonstration for New Irrigation Technologies to Farmers

In virtually all cases, farmers adopt the technology that produces the greatest net income within acceptable levels of risk and complexity. What is essential to rapid adoption of a new technology is farmer exposure to it through neighbours, demonstration farms, and sound support from private-sector suppliers. Hence, with this project GAP-RDA aims at the establishment of demonstrative farming enterprises and widespread use of water saving irrigation methods and technologies in the region. By giving special priority to the farmers who depend largely on ground water resources, under two year contracts GAP-RDA let the farmers the necessary equipment for practising sprinkler and drip methods including special methods of surface irrigation, namely gated pipe.[7] For instance, at some plots where gated pipes were used, water saving of 20-25 percent was achieved. Those equipment are all donated to the GAP-RDA by private domestic or foreign companies. Hence, in collaboration with other concerned state agencies like authorities from SHW, Provincial Agricultural Directorate and the Regional Department of Agrarian Reform, GAP-RDA regional personnel select ‘leader’ farmers who are deemed most capable and interested in applying these technologies at his farm, and install either of these technologies in a designated plot near other plots under traditional gravity irrigation. Moreover GAP-RDA supply the farmers with necessary agricultural inputs such as fertilisers as well. Furthermore, all technical and managerial assistance and other extension activities are provided to the farmers. In this context, eleven demonstration units have been installed in various parts of the region like Nusaybin, Batman, Silopi, Sanliurfa, Akcakale, Bozova (sprinkler irrigation will be constructed with credits from Spain), Bismil, Derik, Kiziltepe and Dicle University. Operation and maintenance of these demonstrative units are constantly monitored by the GAP-RDA. All in all, this Project enables farmers to build capacity to apply water saving (pressurised) irrigation methods and technologies. And as noted earlier, when completed, 35 percent of the irrigations in the GAP region carry the unique advantage of being irrigated under pressurised perimeters. Meanwhile, by the initiatives of the GAP-RDA, farmers are acquainted with necessary technical knowledge and experience to practice pressurised irrigation methods. Yet, for the time being, these technologies are applied in limited areas all through the region. This is largely due to the lack of necessary capacity and financial capability on the farmers side.

Management-Operation-Maintenance of Irrigation Systems in the GAP region

The Projects discussed above indicate that notable progress has been achieved with the planning, design and construction of major infrastructure and distribution works to deliver irrigation water to the GAP region. However, according to the GAP-RDA the management, operation and maintenance of these large-scale irrigation systems in an appropriate manner constitute the essential part of sustainable development of irrigated agriculture as well. Hence, in the early 1990s, GAP-RDA has introduced the Management, Operation and Maintenance (MOM) model in order to identify the most suitable management, operation and maintenance arrangements so that the resources invested in irrigation development are utilised optimally. With the implementation of the MOM model RDA envisages to address many institutional and technical problems which stem from the prevailing structure and practices of irrigation management organizations in Turkey (Alemdaroglu 2000).

With an ambitious start, the MOM Study envisaged to identify the most appropriate organisational structure for water users who are to undertake the management, operation and maintenance of irrigation systems in the region. In line with this major objective, the model is designed to provide a framework for equitable water distribution and higher levels of water use efficiency that ensure the protection of soil and water resources. Hence, socio-economic studies of farmers in the region focussing on their future participation in irrigation activities were conducted along with the evaluation of the current technologies and practices adopted for operation, maintenance and management of large irrigation systems in Turkey and other countries. Through these studies and others the preferred basic management model was developed. The model comprised group organizations that manage the three levels of the irrigation system: the SHW as the supplier of bulk water through the main canals; an Irrigation Authority as the irrigation system operating body; and water user groups at the bottom level (at the secondary and tertiary canal level) directly participating in water management, decision-making processes and costs incurred based on grassroots approach. The model is based on a bottom-up organization of village-level associations of irrigators.

However, the implementation of this theoretical exercise, namely the MOM model has stayed limited, and 38 irrigation associations which were established in the region were realised under the pragmatic approach of SHW. In Turkey the irrigation organizations which have multiplied since the early 1990s, have all been created through the existing local government structures. Hence, these organizations are not a product of any grass-roots movement. SHW staff has been the major initiator and executor of the transfer program. Since 1993 with an accelerated transfer program SHW have managed to transfer 1.5 million ha irrigation schemes to local administrations or to Irrigation Unions (IUs): the innovative form of transfer used where the irrigation scheme covers more than one local administrative unit (e.g., village or municipality). Efforts to increase the amount of area surface water schemes transferred to irrigation management organisations, namely to the irrigation unions have been spurred by the poor performance -in terms of cost recovery, equity, efficiency in O&M and repair of the expanding systems- of many large irrigation schemes by government agencies.

Hence, one can already detect a series of problems merging in the rapid transfer process complicating the future progress of the SHW program. These are largely stemming from the financial shortfalls and organizational weaknesses of the IUs which do not have strong legal standing. Although existing municipality law appears to be providing a workable basis for the formation of the IUs, the process of evolution of IUs make an establishment law specifically for IUs increasingly necessary. Moreover, the undefined nature of water rights in Turkey result in insecure water rights for IUs which could be very costly for them to protect. To overcome these problems IUs must interact constructively with government agencies and technical experts (Kibaroglu 1999).

Although existing irrigation unions in the GAP region have been all formed and operated according to the prevailing model of SHW, two pilot projects have been initiated in two irrigation schemes in the region: Firat Irrigation Union and Kayacik Irrigation Project (still under construction) to improve especially the organizational structures of IUs along with other studies on: a) to enhance participation of irrigators in irrigation investment decisions and in building new irrigation systems; b) to minimize the role of local administrations in the creation of IUs; c) to strengthen the democratic procedure in the formation of governing bodies of the IUs; d) to support the creation of federations of the IUs at catchment level.

Conclusion

In the GAP region, 1.7 millions hectares of land are envisaged to be irrigated especially to boost the agricultural production of the existing land and water resources. Agriculture is, indeed, signified as the leading sector to develop the region. For a long time, existing water resources of the region especially the major surface water resources, namely the Euphrates and the Tigris are thought to be fairly enough for prospective developments in the irrigation sub-sector in the country. However, the GAP being a multi-sectoral integrated development project equally emphasizes the development of other driving sectors of the region such as hydro-power, industry, urbanisation all of which emerge as competing sectors with agriculture in water use. Moreover, in the GAP region irrigation sub-sector water needs for the evolving crop design are hardly calculated in exact manner. There is a very high probability that evolving crop structure (fruits and vegetables) will need more water than planned to be allocated from the existing supply. Hence, within the irrigation sub-sector, water should be used in the most efficient way possible. Furthermore, the major water resources of the region, namely the Euphrates and Tigris rivers constitute a transboundary river system both of which originate in Turkey and flow through Syria and Iraq subsequently. Hence, it is not only the Turkish schemes which demand water at growing rates, but these precious and limited water resources also provide supply for the downstream riparians. Improving the productive efficiency of the irrigation sector (the sector which receives the lion's share of water resources) at national level by all riparians through technological and managerial solutions would also ease the stresses on these transboundary resources.

Hence, action is needed concerning the policy, management, and technological aspects of the irrigation sub-sector in order to enhance the productivity of the systems in an environmentally sustainable manner. The potential sources of irrigation improvement are related to the following dimensions: technology improvement (modernisation); management improvements; farmer participation; and institutional and policy changes. Any program would have maximum impact by addressing all four dimensions simultaneously. The on-going projects pertaining to the irrigation sub-sector which are discussed throughout the paper by and large are all designed to address these four dimensions with a view to improving the patterns as well as levels of water and land resources use in the region.

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[1] It is emphasized by a number of prominent scholars from the faculties of agricultural engineering that the gross irrigation potential in Turkey is 12 m ha. Indeed, the amount of irrigable land in Turkey represents much higher figures than 8.5 m ha through the introduction of modern technologies and rehabilitation of land leveling (Personal communications with Prof. Dr. Osman Yildirim, Faculty of Agriculture, Ankara University, and Prof. Dr. Osman Tekinel, President, K.Maras Sutcu Imam University, April 2000).

[2] International funding agencies, namely the World Bank requires the 'consent' of all the parties (riparian to a transboundary watercourse) on the project to issue financial support to the riparian who envisages to develop a certain portion of the river.

[3] GAP, Ozel Ihtisas Komisyonu Raporu (GAP, Report of Special Expert Commission), TOBB, 1993, pp. 31-58; M Ayyildiz, Y. Gungor, T. Akuzum, O. Yildirim, "Guneydogu Anadolu Projesinde Uygulanabilecek Sulama Teknolojileri," (Irrigation Technologies That Can Be Applicable in the GAP), in GAP: Tarimsal Kalkinma Sempozyumu (GAP: Agricultural Development Symposium), 1986, pp. 305-328.

[4] The Master Plan called for a new entity, namely GAP Regional Development Administration, responsible for the management, monitoring, evaluation, and implementation of this development. Macro-level planning and management, coordination, monitoring, evaluation and implementation in selected areas have been carried out by the GAP-RDA since 1989.

[5] Interview with Dr. Olcay Unver, President of GAP-RDA, General Directorate of GAP-RDA, Ankara, March 30, 2000.

[6] This method involves adapted surface distribution via canals and flumes. The basic principle of the design of this sub-project is the application of a strict predetermined rotation system. Water is not applied at farmers' request but through organized distribution.

[7] Gated pipe delivers water in metered quantities from farm turnout or tube well to a series of furrows. Pipes are available in portable materials. Pipelines take the place of field ditches and convey water across uneven terrain, reducing the need for land leveling. They also eliminate ditch losses, which results in considerable

savings in water (U.S. National Water Commission, “Water Policies for the Future,” U.S. Government Printing Office, Washington, D.C., 1973).