

Sustainable Development of Irrigation Systems in The Southeastern Anatolia Project (GAP) Region

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ABSTRACT: 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, far greater emphasis should be placed on demand management. Countries 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 scarcity problem should incorporate policies for improving management and allocation practices, and also upgrading and modernizing water delivery structures in major sectors of the economy such as the agriculture. The paper 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).

1 INTRODUCTION

Since irrigation accounts for some 75 percent of water withdrawals world 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. 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 (modernization); management improvements; farmer participation; and institutional and policy changes. Any program would have maximum impact by addressing all four dimensions simultaneously.

The paper 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). GAP constitutes a unique case to be examined, since a transboundary river system, namely the Euphrates and the Tigris rivers are the major 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.

2 GAP: AN OVERVIEW

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 importance of GAP to Turkey beyond hydropower and/or foreign exchange is obvious, given the underdevelopment of the southeast and the government's desire to stabilise the area politically through significantly raising the population's standard of living. Turkey aims to develop water resources of the region for

socio-economic poverty alleviation and balanced regional development. Thus, among the development objectives of the GAP there lies '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).

GAP, in its historical context, was formulated as a package of water and land resource development project in the 1970s, which was later on transformed, in the early 1980s, to a multisectoral, socioeconomic regional development program, and then into a sustainable human development project in the 1990s. GAP being the largest multi-purpose integrated development project of Turkey is envisaged to expand the irrigated area by adding 1.7 m hectares (ha) to the current 4.16 m ha of irrigated area. The majority of the GAP Region lies in the Euphrates-Tigris basin. The total catchment area of the Euphrates in Turkey, upstream of the Syrian border, is 103,000 km² of which 22% lies within the GAP Region. The mean annual run off near the Syrian border is estimated to be 31 billion m³. The Tigris River, in the east of the GAP Region, drains a catchment of 38,000 km² north of the Syrian border; 30,000 km² of this basin lies within the GAP Region. The mean annual discharge in Turkey is estimated to be around 17 billion m³. The water quality of both rivers is good and suitable for irrigation with electrical conductivity values of below 0.6 mhos/cm and SAR of below 0.4. In order to utilise the available water resources, GAP envisages the construction of 22 storage dams and 19 hydro-power plants, of which 14 dams were completed and 6 hydro-power plants are in operation. Of the total area of the region, around 3.9% was irrigated in 1985. After the completion of GAP irrigation projects this would increase to 22.6%. As of June 2002, 215,080 ha had already been brought under irrigation.

Alongside with the initiation of the major irrigation systems in the GAP in 1995, especially in the renowned Sanliurfa-Harran Plain, different irrigation technologies have been tested to ensure planned development and efficient utilization 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. Considering that water is the most important input for raising agricultural yield, the project aims to utilize 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. Moreover, it is now recognized that for the existing and proposed irrigation developments to be sustainable the present levels of cost recovery must be increased and, in line with worldwide trends, encouragement must be given to the greater devolution of management responsibility to water users. Against this background, GAP Regional Development Administration (GAP-RDA), major agency for coordinating all development activities in the region, has commissioned the GAP Management, Operation and Maintenance Study (GAP MOM) in order to identify the most appropriate management model for large scale irrigation systems about to be brought into operation in the region. Hence, the analysis will also be supported with the discussion on the MOM Project.

3 SUSTAINABILITY OF IRRIGATION

The holistic approach adopted by the GAP is based upon an expanded principle of sustainability whose definition has been developed by the GAP-RDA 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) and 'societal sustainability.'

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.

4 PROJECTS TO IMPROVE DESIGN, OPERATION, MANAGEMENT AND MAINTENANCE OF CONVEYANCE, DISTRIBUTION AND ON-FARM IRRIGATION SYSTEMS IN THE GAP REGION

4.1 *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).

4.2 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, 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 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 (DSİ-Turkish acronym), 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. 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, DSİ 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.

4.3 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. 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 DSİ, 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.

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

Irrigated agriculture is the foundation for sustained development of the GAP Region. If it fails to perform up to the expectations, this will seriously weaken the economic base of the region and threaten the sustainability of the national budget and adds to the complexity of the management role of the state. Furthermore, there is the proven fact that bottom-up management increases efficiency and productivity. The consequence will inevitably be that limited resources must be spread over a wider area, with a consequent fall in the standard of system management, operation and maintenance and the quality of technical support provided to the farmers. This in turn will result in falling levels of service, reduced efficiency of water use, increased salinity and drainage problems and lower crop production. As the farmers' ability to pay for the services reduces, so the quality of the services falls further and the downward spiral continues. This can be reversed only by means of fundamental changes in the institutional structure, aimed at ensuring that the farmers' management ability is fully utilised and resources as a whole are used most efficiently in order to maximise water use efficiently and improve crop production. The idea of privatisation or management transfer is not new and is adopted in many parts of the world. There is a wide range of organisational model in use to fulfil the aim of handing over the irrigation networks, each situation requiring its own individual assessment and approach.

The main aim of irrigation projects is to raise the welfare level of farmers. It is necessary to establish effective training and extension, marketing and input supply systems as well as effective management, operation and maintenance of irrigation. From this point of view, GAP-RDA started a project entitled 'Management, Operation and Maintenance of GAP Irrigation System (MOM)' in 1992. The major objective of the MOM model is to provide an institutional and organisational framework within which the proposed management model can be replicated. The management model is required to satisfy the major study objectives. The model is based on a bottom-up, participatory approach. It provides a framework for water distribution and water use efficiency leading to sustainable production techniques that ensure the protection of the soil and water resources. It will allow independence in finance and in the decision making process of the management organisation and maximise the responsibility of the individual.

Traditional farming methods for rainfed lands don't make the best use of irrigation, so GAP has co-ordinated a project for the training of local farmers and their organisation into water user groups with the responsibility for planning among themselves their use of the available water. The project provides advice and training to local farmers who have formed local water user groups. These water user groups collectively manage the end use of irrigation, collect payments for irrigation services, and engage in other participatory activities. Recent projects that tested this management model in the GAP Region showed an 11 percent savings in water use and an increase of 177.5 percent in cropping intensity due to the shift to growing two crops per year. Marketing studies were also coordinated for identifying new crop varieties that need less water, and that can generate more income in the region. However, the issues that we now face involve capacity building for line ministries so that they are able to support water user initiatives on a region-wide scale, and cost recovery for irrigation where farmers have been led to expect irrigation for next to nothing.

5 CONCLUSION

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, urbanization 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 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. 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 technological and managerial solutions with a view to improving the patterns as well as levels of water and land resources use in the region.

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