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Etat de l'agriculture en Méditerranée : Ressources en eau : développement et gestion dans les pays méditerranéens

Bari : CIHEAM
Cahiers Options Méditerranéennes; n. 1(1)

1993
pages 85-91

WATER RESOURCES PLANNING AND DEVELOPMENT IN TURKEY

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INTRODUCTION

Water is one of the most valuable resources, and a limiting factor for crop production. Agricultural crops are the major consumer of water. Agriculture, with its social and economic aspects, has a dominant role in the nation's life in Turkey. It accounts for nearly 19% of GPD, 9% of exports and 51% of civilian employment.

In the face of population growth and increasing demand for water, deteriorating water quality, increasing environmental degradation, and impending climate change, more effort is required to assess water resources for national planning and management in order to sustain development. Efforts should be directed to overcome the present constraints regarding water resources assessment, and in particular the institutional weakness, inadequate networks, incompatible technologies for field, laboratory and office work. In the present day, there are many handicaps such as deficiency of staff and their capability, and lack of coordination efforts.

In this paper, water resources in Turkey, and the existing level of developement and problems associated with it, will be analyzed.

1. NATURAL RESOURCES OF TURKEY

1.1. Climate

Turkish territory is bounded on three sides by the sea. It is mostly an elevated plateau enclosed by mountains on all sides, except for the west. These mountains act as a barrier to

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the rain bearing wind from the north and south, and leave the interior plains, which make up more than two-thirds of the total area, with an average rainfall of 200 to 500 mm. Average rainfall for all over Turkey is 643 mm. The summers are hot and dry; and the winters may be extremely cold. On the coastal plains a sub-tropical Mediterranean climate prevails. Seventy-five percent of annual rainfall is received in the winter season. Except for the coastal areas, Thrace and Eastern Anatolia, annual rainfall is less than 500 mm, therefore irrigation is of paramount importance. Generally, agricultural production is adversely affected by the shortage in annual rainfall and inconsistency of rainfall during the growing season.

Solar energy in Turkey, which depends on factors such as altitude and seasons, makes it possible to grow arid and semi-arid crops such as bananas and citrus. Also, by allowing 270-day crop growing seasons, it is possible to have 2-3 crops from irrigated areas. However, in Eastern Anatolia with its 60-90 growing days, some crops are harvested before maturation.

1.2. Land Resources

The country has a total area of 77.95 million hectares. Of this area approximately 35 percent is cultivated, 26 percent is grass and pasture, and the remaining 39 percent is forest and unproductive land.

Important changes have taken place with respect to land use in the recent last years. Land use figures are given in Table 1. The area which can be developed for irrigation is estimated by DSI (State Hydraulic Works) at 8.5 million ha gross area (6.4 million ha for major irrigation projects), of which about 4.0 million ha has been developed. The remaining area of about 4.5 million ha is yet to be developed for irrigation. This does not mean that under the present conditions it would be economically feasible to irrigate the whole area. For the Irrigation Master Plan of Turkey, 227 projects covering a gross irrigable area of 2.94 million ha have been analysed. 139 of these covering a gross irrigable area of 2.07 million ha., or 70% of the total area reviewed, have an IRR of 8% or more. If

that same percentage is applied to the area still to be developed, a potential additional irrigable area of 3.2 million ha will be added. It is expected that in the period 1992-2001 a net irrigable area of 1.12 million ha will be developed by DSI. So far DSI has developed 1.69 million ha.

Irrigation development is carried out by the private sector (farmers and groups of farmers) and the public sector (DSI and GDRS, General Directorate of Rural Services). Since 1950 irrigation development by DSI has gradually picked up momentum (Table2).

Table 1. Land Resources in Turkey

Land resources	million ha
Total area of Turkey	77.95
Agricultural area	27.70
Total Irrigable area	25.85
Economically potential gross irrigable area	8.5
Present gross irr. area (1991)	4.03
Present net irr. area constructed by DSI	1.69
Source : DSI, 1992	

Table 2. Irrigation Development by DSI in 1000 ha

year	Operated by DSI	Operated by users	Total
1950	123	20	143
1960	185	31	215
1970	521	76	598
1980	755	245	1001
1990	1251	375	1626
1991	1266	422	1689
2001	Projected		2939

Source : DSI, 1991. Irrigation Master plan, Part I. Investment Strategy

1.3. Water Resources

One of the most important aspects of land and water resource developement programs is the determination of the inventory of the resources. If the resources and opportunities are not known accurately before the projects are undertaken, in most cases the installations will not be feasible and failure will result.

The work carried by DSI up to the present time in 26 main drainage basins of the country shows that the annual potential of surface water is 186 billion cubic meters. Of this amount, 95 billion cubic meters can feasibly be developed. On the other hand, the safe groundwater reserve in the country is estimated to be around 12 billion cubic meters. Thus, the combined potential of utilizable water resources in Turkey becomes 107 billion cubic meters a year (Table 3).

Annual average water potential for Turkey's drainage areas shows huge differences. (Table 4).

Table 3. Water Resources in Turkey

Water Resources	
Annual Average Rainfall	642.6 mm
Total Rainfall	501.0 km^3
Surface Water	
Annual Runoff	186.05 km^3
The Ratio of Annual Runoff to Total Rainfall	0.37
Potential Water Use	95.00 km^3
Annual Use (present)	25.6 km^3
Underground Water	
Potential water use	11.6 km^3
Developed Water Amount	6.6 km^3
Annual Consumption	5.4 km^3

1 km^3=1 billion m^3

Source : DSI, 1992. TC. Bayındırlık ve İskan Bakanlığı, DSİ Genel Müdürlüğü

Table 4. Annual Average Water Potential by Watershed Area

Watershed	Annual Runoff (km^3)	% of Total Runoff	(***)Average Annual Output ($l/s/km^2$)
Euphrates (*)	31.61	17.0	8.3
Tigris(**)	21.33	11.5	13.1
Eastern Blacksea	14.90	8.0	19.5
East Mediterrenaen	11.07	6.0	15.6
Antalya	11.06	5.9	24.2
West Blacksea	9.93	5.3	10.6
West Mediterranean	8.93	4.8	12.4
Marmara	8.83	4.5	11.0
Seyhan	8.01	4.3	12.3
Ceyhan	7.18	3.9	10.7
Kızılırmak	6.48	3.5	2.6
Sakarya	6.40	3.4	3.6
Çoruh	6.30	3.4	10.1
Yeşilırmak	5.80	3.1	5.1
Susurluk	5.43	2.9	7.2
Aras	4.63	2.5	5.3
Konya	4.52	2.4	2.5
Büyük Menderes	3.03	1.6	3.9
Van Lake	2.39	1.3	5.0
Northern Egean	2.09	1.1	7.4
Gediz	1.95	1.1	3.6
Meriç-Ergene	1.33	0.7	2.9
Küçük Menderes	1.19	0.6	5.3
Asi	1.17	0.6	3.4
Burdur Göller	0.50	0.3	1.8
Akarçay	0.49	0.3	1.9
Total	186.05	100.0	

(*) Main runoff is 30.25 km^3

(**) Main runoff is 16.24 km^3

(***) These values are obtained from the first base stations

2. EXISTING LEVEL OF DEVELOPMENT

The majority of water resources development projects in Turkey are carried out by DSI and GDRS. Before 1991 there were 141 dams in operation. These dams provide irrigation for 1.648 million hectares (gross) of land and provide 23,598 Gwh hydroelectrical energy. In 1991, nine dams were completed which provided irrigation for 48,451 hectares and annual energy production of 769 Gwh.

Presently 53 dams and hydroelectric-power plants are being constructed and should be completed by 1995. Effective use of these huge projects depends on the completion of irrigated infrastructure in these areas. Upon completion 619,881 hectares will be irrigated.

By 1991, 6.5% of the irrigable area, and 20% of the economically feasible area is irrigated. Only 15% of the water potential is currently utilized. Of this utilization, 58% is used for agricultural irrigation, 24% is municipal use, and the remaining 18% is used by the industry.

Areas developed for irrigation by DSI have shown increases over the last ten years. Table 5 shows the irrigated area development between 1980 and 1990.

Table 5. Areas Opened for Irrigation by DSI (1980-1990)

Year	Surface Area (ha)	Ground Water Area (ha)	Total Area (ha)
1980	847277	153297	1000574
1981	866071	185285	1051356
1982	904260	212780	1117040
1983	950380	231605	1181985
1984	1012880	252185	1265065
1985	1109060	261810	1370870
1986	1186540	271095	1457635
1987	1230390	277045	1507435
1988	1254695	281535	1536230
1989	1307318	289855	1597173
1990	1327650	298520	1626170
1991(*)	1372651	316100	1688751

Source : DSI, 1992

During this ten year period, the greatest increase (105,805 ha) was in the 1984-1985 period, and the smallest increase (28,997 ha) was in the 1989-1990 period.

In the areas developed for irrigation, expected land utilization is not realized up to this day. Observed crop pattern in these areas is different than planned. Cereals and cotton are dominant crops in the irrigated areas (cereals, 18.5%; cotton, 35%). However, recently in the coastal areas, secondary crops such as soybeans and corn are planted after wheat is harvsted. This results in more efficient land utilization (Table 6).

3. SOUTHEAST ANATOLIA PROJECT

The most important and ambitious water resources development project in Turkey so far is the South East Anatolian Project, or in short the GAP Project. It is a regional based development project in the lower Euphrates and Tigris region covering an area of about 74,000 km^2. The project covers most of the provinces of Diyarbakir, Sanliurfa, Mardin, Gaziantep, Adiyaman, Siirt, Batman, and Sirnak. The project involves integrated development of irrigated agriculture and agro-industry and supporting services, including communications, health and education.

GAP project is a multipurpose integrated project, and will include dams and hydroelectric power plants constructed on the Euphrates and Tigris, irrigation systems, and various infrastructure investments such as transportation, telecommunication, industrial investments, education and health centers, and related development investments.

Fundamental reasons for the planning of the GAP project are irrigation and hydroelectric energy systems which are intended to develop the natural water resources of the area. The construction started in 1976. The largest unit of the GAP is the Lower Euphrates project whose construction is still continuing. This subproject includes the Atatürk dam which is

Table 6. Land Utilization in DSI Irrigation Areas and Crop Pattern

Year	Irrigation Quantity	Area Opened for Irrigation (ha)	Area Actually Irrigated (ha)	Irrigation Ratio* (%)	Crop Pattern in Actually Irrigated Area (%)							
					Cereal	Sugar Beet	Cotton	Rice	Fodder Crops	Citrus	Fruits and vegetables	Other
1970	82	521482	284775	54.6	27.1	5.0	37.2	3.6	3.8	0.7	6.5	16.1
1975	108	671242	420003	62.6	14.7	6.2	42.9	3.7	3.2	1.2	7.6	20.5
1978	116	763119	496845	65.1	16.3	6.9	39.1	3.6	3.0	1.3	9.0	20.8
1979	118	779119	508090	65.2	18.3	6.5	35.5	4.6	3.3	1.4	7.7	22.7
1980	120	755459	493604	65.3	11.7	6.6	43.9	2.8	4.0	1.6	8.0	21.4
1981	115	773410	561397	72.6	11.6	8.6	39 5	4.3	3.9	1.5	7.7	17.9
1982	119	813585	605647	74.4	18.5	8.2	32.6	3.9	3.6	1.6	8.2	23.4
1983	131	879210	622869	70.8	18.9	8.8	33.9	2.2	3.4	1.8	8.3	22.7
1984	139	964565	706795	73.3	15.6	7.6	42.4	2.6	3.2	1.6	7.8	19.2
1985	150	1060440	794850	75.0	17.9	6.2	35.6	2.3	2.7	1.3	8.2	25.8
1986	159	1115240	831600	74.6	23.0	6.7	27.7	1.9	2.6	1.8	7.6	28.7
1987	172	1156990	806715	69.7	19.3	7.7	26.6	1.7	2.8	2.1	7.7	32.1
1988	181	1201340	816274	67.9	16.4	7.0	36.0	1.9	3.2	2.2	8.0	25.3
1989	181	1231100	935344	75.9	24.9	7.0	27.0	2.3	2.8	1.9	8.3	25.8
1990	193	1251251	857499	68.5	23.7	9.0	24.2	0.9	3.0	2.3	8.2	28.7

* Irrigated Area/Irrigable Area

Source: DSI, 1992

the largest water structure ever built in Turkey. Besides increasing energy and agricultural production, it will have significant effects on the social structure of the region.

In the southeast plains, besides the deficient soil resources and the climatic conditions, the main factor that adversely affects the agricultural development is the insufficient rainfall especially during the summer months. By supplying water to overcome water deficiency which is the major factor that inhibits the growth of various kinds of plants, productivity will increase. By employing contemporary agricultural methods work opportunities will increase, and it will encourage the growth and improvement of other sectors and services.

Natural resources potential of the GAP is given in the table below. Table 7 clearly shows the vast natural resources potential of the region. The population growth rate of the region is much higher than the national average, and the literacy level is much lower than Turkey's average. The total number of villages in the area is 4110.

Table 7. Natural Resources Potential of the GAP*

	Potential of Turkey (%)
Project Area	10
Population	9
Irrigable Area	25
Surface Waters	25
Ground Waters	25
Hydroelectric Energy	25
Petroleum	100
Phosphate	100

* Balaban, A., 1990

The GAP system consists of 13 subprojects, 7 on the Euphrates and 6 on the Tigris rivers (see Tables 8 and 9)

Table 8. The GAP subprojects

	Energy Production (Gwh/year)	Project Irrigated Land (hectares)
The Euphrates Projects:		706.208
Lower Euphrates	8.245	
Karakaya	7.354	
Border Euphrates	3.170	
Suruç-Baziki	107	146.500
Göksu-Araban	82.685	82.685
Adıyaman-Kahta	509	74.410
Gaziantep	89.000	89.000
The Tigris Projects :		
Dicle Kralkızı	444	126.080
Batman	483	37.749
Batman Silvan	670	213.000
Garzan	315	60.000
Ilisu	3.830	
Cizre	1.000	121.000
Total	26.127	1.656.632

The irrigation and energy production units of the system consist of 22 dams and 19 hydroelectric power plants. Following the completion of the project, 1.65 million hectares of land will be irrigated (including grounwater irrigation), and 27 Kwh of energy will be obtained annually. This energy is eqtal to Turkey's total energy production for 1981. The area which will be irrigated is more than the total public irrigated land since the beginning of the Republic. A 30-year period is foreseen for the completion of the physical structures of the whole project. The investment cost is equal to the national annual budget, and 60%

of this amount will be spent on the irrigation systems, and 40% for the construction of the power plants.

Table 7 shows that 2/3 of the development potential is in the Euphrates, and 1/3 in the Tigris subsystems.

The largest units of the GAP project are the Atatürk Dam and Hydroelectric Power Plant, together with the Sanliurfa Tunnels. The total hydroelectric power capacity of this project is going to be 8.1 billion kwh/year, and the total irrigation area covered by five projects will be 706.208 hectares. The two most important irrigation projects are the Sanliurfa-Harran and Mardin-Ceylanpinar Irrigation Projects which envisage the irrigation of 470.000 hectares. The water necessary for these projects will be supplied through 26.4 km of two parallel tunnels with an inner diameter of 7.62 m each.

Table 9 gives summary data on the 13 major irrigation projects in the GAP Project. Though 37% of the projected investment has been completed already, mainly for the construction of dams and hydro power plants, less than one percent of 1.635 million ha targeted for irrigation has so far been developed.

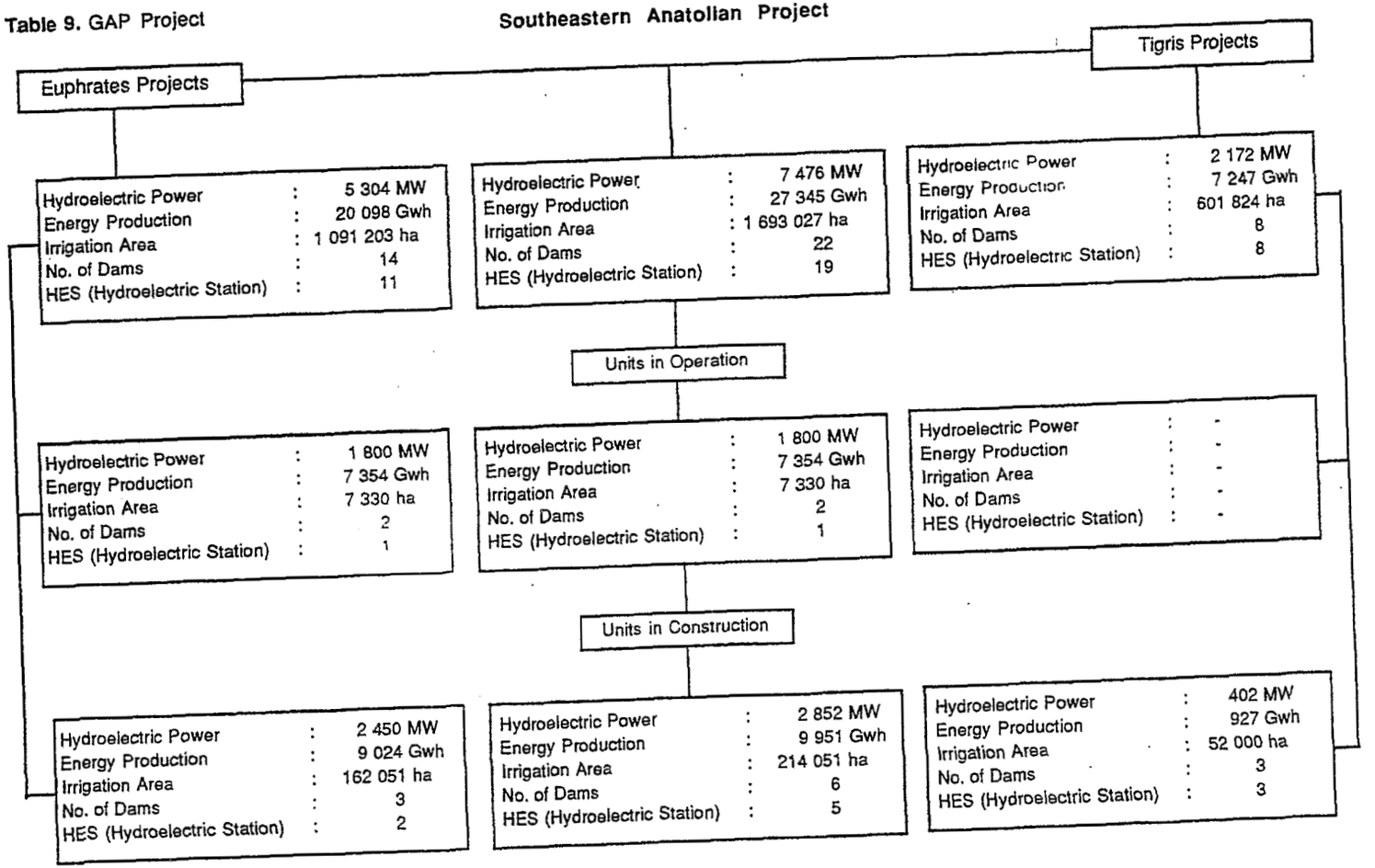
4. PROBLEMS ASSOCIATED WITH LAND DEVELOPMENT

In order to obtain the maximum benefit and cover the increased production costs, the project must be based on a reasonably efficient system, supplemented by application of fertilizers and accompained by disease and pest control as well as by appropriate crop rotation. The cost of intensification is high and can only be recovered by ample yields of high value crops per unit areas. In addition, the project area must also be supplemented by the creation of such facilities as roads, electricity and domestic water supply systems, means of transportation, storage depots and socio-cultural institutions like education centers, schools and clinics.

The history of agriculture irrigation shows us that success of an irrigation project depends, in addition to engineering structure, on the solution of land, water and human problems in the project area.

Table 9. GAP Project

Southeastern Anatolian Project



Source DSI, 1992

In Turkey, up to the present time, the phase of irrigation development has not drawn sufficient attention in project planning and implementation in comparison to engineering structures, i.e. storage, diversion, conveyance and distribution systems. Until recent years, under the lure of immediate gains, most of the major irrigation projects have been put on service even before their main distribution and drainage networks are completed.

In these projects, even at the end of their assumed development period, the area actually irrigated was not more than a small fraction of the area initially planned.

4.1. Farm Irrigation Distribution System

The main objective of farm distribution systems in irrigation projects is to convey the water form the tertiary outlet to the plots without waste, and to provide the controlled application of water to the field. Not mentioning the land development works recently begun in two major projects (Seyhan and Gediz), engineered farm irrigation distribution systems are lacking. A study made on earth field ditches on three irrigation projects in Central Anatolia has shown that seepage losses were 7.2 to 42.9 percent per hundred meters of field ditch length. Considering the relatively greater length of field ditches in an irrigation project, seepage losses may create lots of damage.

4.2. Field Drainage

Until recently, the importance of drainage was not recognized till salinity-alkalinity became a problem. Today, in the newer projects the need of drainage is recognized, and provision for the principal drainage system is incorporated in the project planning. But again, in most of the irrigation project, except where the topography and soil conditions are such that natural drainage suffices, field drainage is lacking.

4.3. Land Preparation for Irrigation

In irrigation projects, the land must be prepared to receive the water before efficient application of irrigation can be accomplished. Therefore land preparation is an important item of irrigation development. Attempting to irrigate land with an uneven surface results in low efficiency of water use, soil erosion, excessive labor requirements, in salinization of the soil. The fields that have adequate surface drainage often do not require subsurface drainage (17). Excluding the Seyhan and Gediz projects, in which extensive land preparation works are undertaken, inadequate leveling and preparation is prevalent in all irrigation projects in Turkey.

4.4. Salinity Control

In recent centuries vast areas of salt-affected soils have developed from man-made causes such as irrigation without provision for adequate drainage, application of an insufficient amount of irrigation water, or from a combination of these. Saline and alkaline problems arise even when drainage facilities are adequate, unless sufficient irrigation water is applied to provide for both crop needs (consumptive use) and accessory leaching of excess salts out of the root zone of soil.

In some older projects (Cumra, Menemen, Seyhan, etc.) detrimental changes have occurred in the soils as a result of inadequate drainage. Resultant salinization has discouraged farmers from changing dry land practices to irrigation farming. For example, in the oldest irrigation project of the country (Cumra) 42 percent of the land is still left to fallow.

4.5. Management of Irrigation Water

The method of water application finally adopted, whether it be surface, sprinkler or subsurface, must satisfy the following criteria:

1) Uniform distribution of water, 2) minimum erosion or other damages to the land, 3) maximum efficiency in the use of water, and 4) practical and economical performance from the aspects of crop, labor requirement, cost of land preparation, and maintenance. High application efficiency and uniform distribution of irrigation water on the fields are prerequisites of good irrigation.

CONCLUSION

Under Turkish conditions, successful amalgamation of land and water is of primary importance in the development of the country. Considering the limitation imposed with respect to water resources, the country has 8.5 million hectares of irrigable land potential. With the full development of this potential, if the production can be increased four times over to the dry conditions, this increase could be equivalent to plowing and additional 25.5 million hectares of dry land.

To have a successful irrigation project with high productivity the following measures are required: comprehensive survey and analysis of the soils; selection of productive crops and animals that are adaptable to the regional conditions, and the continuity of production once the project is complete; proper determination of the total amount of land opened for irrigation; deterrence of land use for purposes other than irrigation; efficient distribution of the irrigation water; education of the public on modern agricultural methods; effective drainage adaptable to the region, and effective education for the growers.

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