WORKING PAPER 6

Irrigation, Health and Environment

A Review of Literature from Turkey

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INTERNATIONAL WATER MANAGEMENT INSTITUTE

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Cover photograph: A small dam in the Gediz Basin, Turkey by Geoff Kite.

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IRRIGATION, HEALTH AND ENVIRONMENT: A REVIEW OF LITERATURE FROM TURKEY

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INTRODUCTION

In 1997 IWMI's first review of literature on irrigation, health and the environment came out as a working paper presenting examples from Sri Lanka (Steele, Konradsen, and Imbulana 1997). This paper has been widely circulated and was often cited. The present report is, more than the review on Sri Lanka, specific for one country, Turkey and aims to make a wealth of Turkish literature available to the public. The health and environmental aspects of water resources management in Turkey are discussed in five chapters.

The first chapter provides a thorough description of the state of the art regarding recent developments in the water sector, with ample attention being paid to the availability of water and future perspectives, such as the Southeastern Anatolia Project (GAP). In the second chapter epidemiology and control of malaria and schistosomiasis as well as the breeding habitats of the malaria mosquitoes are discussed. The third chapter briefly describes the use and effects of pesticides used in (irrigated) agriculture. In the fourth chapter, water quality issues are identified, presenting existing quality standards. The fifth chapter deals with Turkish wetlands. After a general introduction, the relationship between irrigation, pesticide use and downstream effects is explored in a number of case studies.

It is hoped that this review will serve as a reference and guide for researchers and policy makers linked to water resources development in Turkey and elsewhere.

WATER RESOURCES DEVELOPMENT IN TURKEY

Available Water Resources

Several studies have been carried out within the last decade to address the water resources issues in the Middle East. In most of these studies, Turkey is categorized as a water-rich country. In reality, this is not the case as the temporal and geographic distribution of the water resources potential of the country cannot easily meet the present and the expected needs for water. Total precipitation over Turkey is 501 cubic kilometers. The average annual rainfall in the country is 643 millimeters and varies from 250 in Central Anatolia to 2,500 millimeters in the Eastern Black Sea region (Bilen 1997).

The extremely irregular precipitation and runoff conditions limit the economic exploitation of water resources and require storage of large volumes. As a result, the gap between the total and the exploitable water potential is wide. The annual exploitable water resources potential of Turkey is estimated at 91 cubic kilometers as shown in table 1 (Bilen 1997). When the amount of water that enters Turkey from neighboring countries is added, the technical and economically exploitable water potential is increased to 110 cubic kilometers (Kulga 1994, 1997). Others estimate the total renewable water resources in Turkey as 215 cubic kilometers and the potentially utilizable water supply as 129 cubic kilometers (Seckler et al. forthcoming).

Table 1. Annual water potential of Turkey (Bilen 1997, Kulga 1997).

Contribution		Water potential (km^3)
Total runoff	186	
of which exploitable surface runoff		95
Safe yield of groundwater		+12
Water that enters Turkey from neighboring countries		+19
Water allocated to Syria and Iraq		-16
Total Exploitable Potential		110

The primary government agency responsible for water resources development in Turkey, the State Hydraulic Works (DSI) identifies 26 major river basins (figure 1). The average annual surface flow in all of these basins is 186 cubic kilometers. The largest river basins, in terms of cubic kilometers of exploitable water potential, are the Euphrates (31.61), the Tigris (21.33), the Eastern Black Sea (14.90), the Eastern Mediterranean (11.07) and the Antalya basins (11.06).

The three major objectives of water resources development in Turkey are to provide sufficient quantities of water for domestic and industrial use, for the generation of hydropower and for irrigation. As of 1997, State Hydraulic Works (DSI) has developed domestic and industrial water supply schemes for 11 large cities, providing 1.38 cubic kilometers of water per year. This figure will increase to 2.52 cubic kilometers on the completion of the projects currently being implemented for 19 cities (Cakmak 1997).

Water Demand in Turkey

By the end of 1996, the total quantity of annual water withdrawal by various state agencies, reached 34.2 cubic kilometers. As some quantities of these withdrawals are required for drainage and sewage, the actual consumption of water is less. While the irrigation sector has the largest demand for water, using 25.3 cubic kilometers, 5.3 cubic kilometers are diverted for domestic water supplies, and 3.6 cubic kilometers are used in industries (Bilen 1997, Cakmak 1997).

According to IWMI indicators of water scarcity (Seckler et al. 1998), Turkey has little or no water scarcity. The current water withdrawals are only 43 percent of the renewable water supply and the expected water demand in 2025 is about 183 percent of the present consumption (Seckler et al. forthcoming). However, local water scarcities occur in Turkey. Sometimes, the European part of the country, Central Anatolia, as well as some regions in Western Anatolia are subject to serious water shortages, both for irrigation and domestic water supply (Bilen 1997).

Figure 1. The major river basins of Turkey

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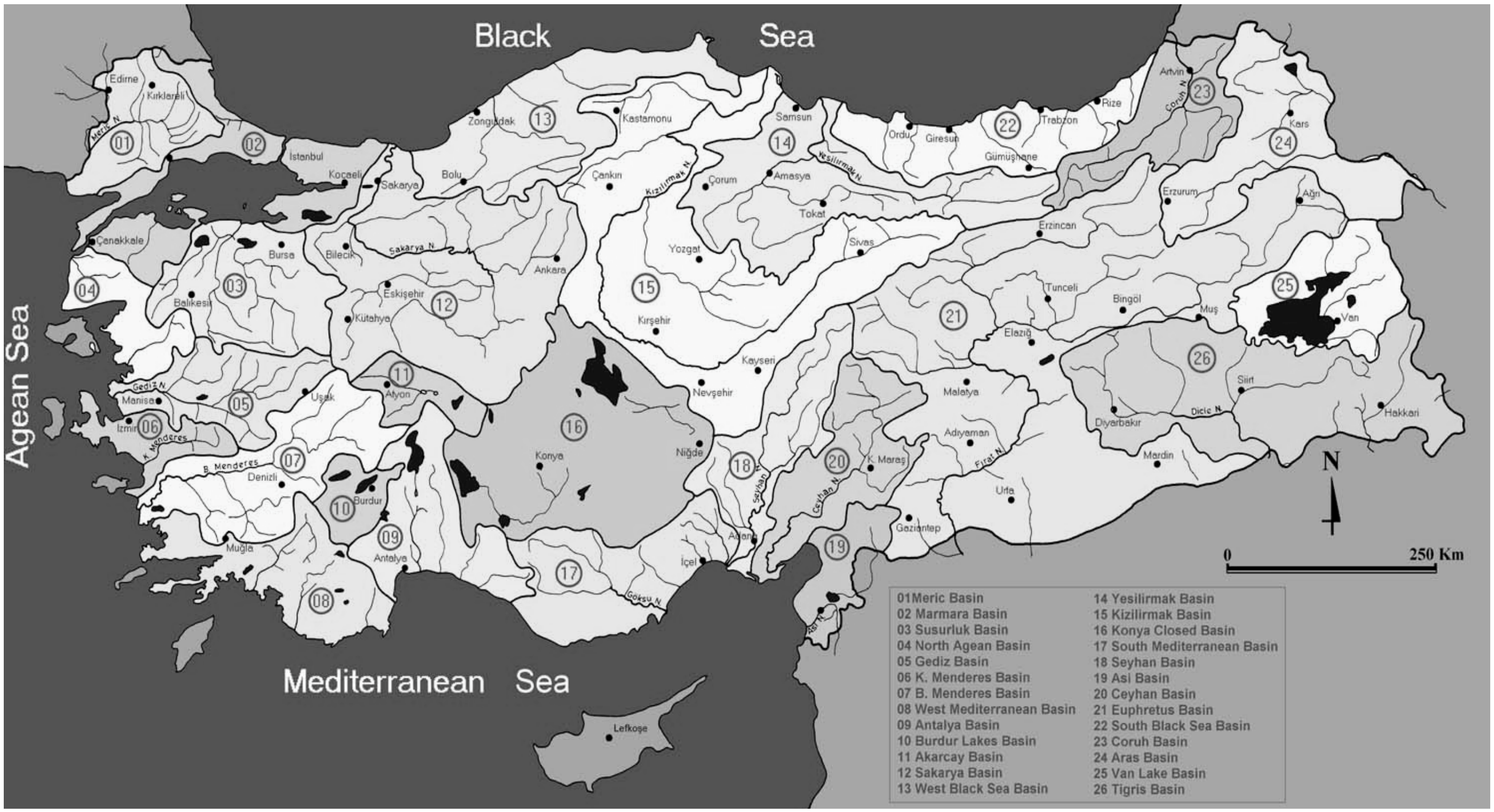
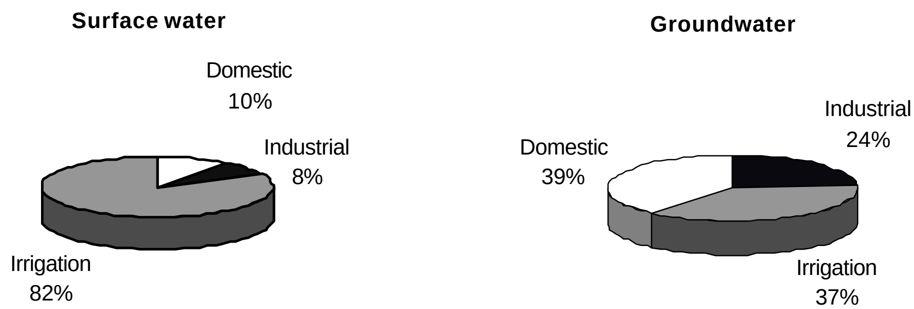


In 1996, the total withdrawal of 34.2 cubic kilometers was mostly (28.2 cubic kilometers) drawn from surface water and to a lesser extent (6 cubic kilometers) from groundwater resources. While irrigation is the most important user of surface water, groundwater is mainly extracted for domestic purposes (figure 2). Most of the irrigated area in Turkey is fed from surface sources (3,907,337 hectares) and only 10 percent (504,965 hectares) from groundwater sources.

Figure 2. Share of sectors in the water consumption from surface water and groundwater resources (Cakmak 1997).



Plans for Future Water Resources Development

Various ancient waterworks are still in use after several centuries. Presently, Turkey is in the process of constructing large-scale waterworks to irrigate 8.5 million hectares of land and to generate 130 billion Kwh/yr (Ozis 1996). Some of the 704 dams and 493 hydroelectric power plants, which were planned in 1997, are presented in table 2.

Table 2. Examples of planned large-scale water work in Turkey (Ozis 1996).

Name of project	Characteristics
Southeastern Anatolia Project	Irrigation of 1.8 million ha
	Energy generation of 27 billion Kwh/year
Atatürk dam	Reservoir capacity of 85 million m^3
	Energy capacity of 2,400 MW
Karakaya dam	Energy generation of 7.5 billion kwh/year
Keban dam	Height of 207 m
Berke dam	Height of 200 m
Altinkaya dams	Height of 195 m
Coruh river dams	Heights above 250 m
Sanliurfa twin tunnels	Length of 26.4 km and diameter of 7.6 m

Turkey aims at further developing the economically exploitable water potential through a number of waterworks, as proposed in the 7th Five Year Development Plan (DSI 1998, DPT 1995). The aims of these proposed water works are as follows:

- Irrigation of 7,122,713 hectares
- Flood control over 684,847 hectares
- Drainage of 130,326 hectares

- Conveyance of 8.1 cubic kilometers of water for domestic supply
- Production of 35,078 megawatts of installed energy capacity
- Energy generation of 123,960 Gwh/year

The five-year plan emphasizes sustainable and integrated management of water resources, with the development of basin-scale management plans that take into consideration the environmental impact of the proposed schemes. Environmental protection and control are major issues when developing water and land resources, as discussed in "National Action Plans" (DPT 1995, DSI 1998).

Of particular interest for the future will be Turkey's enhanced hydro-political role in the Middle East. Several studies are underway to investigate the status of trans boundary rivers in Turkey, and schemes are already proposed to transfer water from southern and eastern basins of Turkey to neighboring countries (Bilen 1997, Uluatam 1998).

General Characteristics of Irrigation

Within the irrigation schemes developed after 1960, areas from 20,000 up to 43,000 hectares are being equipped annually. Considering the population increase and the general development of the country, this is considered insufficient. Acatay (1996) states that the irrigation of at least 100,000 hectares of new land should be implemented annually. The Southeastern Anatolia Project (GAP) is a significant development towards the achievement of this end.

The total amount of economically irrigable land in Turkey is around 8.5 million hectares (Bozkurt and Cakmak 1994, Cakmak 1997). The total area of irrigable and agricultural land (in hectares), the quantity of water available for such purposes and the total drainage areas of the 26 major river basins in Turkey are summarized in table 3. As of 1997, 54 percent of this total, i.e. 4.604 million hectares, have been irrigated by the State Hydraulic Works (DSI), the General Directorate of Rural Services (KHGM) and public facilities. The recent extensions of the irrigated area in Turkey that were opened up between 1970 and 1997 are shown in figure 3.

The total area irrigated by the State Hydraulic Works (DSI) reached 2,398,809 hectares in 1997. In the same year, DSI continued with the construction of irrigation networks covering a total area of 736,000 hectares. Groundwater resources have been used to supply water to the irrigation networks covering 390,571 hectares of land. These networks were constructed by DSI but are currently operated by irrigation cooperatives (Cakmak 1997). DSI has increasingly transferred the operational rights of its surface water irrigation networks to "Irrigation Associations". In 1996, the percentage of irrigated lands transferred to such associations has reached 71.1 percent (figure 4).

Projects developed by DSI are generally based on surface irrigation methods, using either the classical open channel systems or raised canalets. Sprinkler irrigation has been used in certain projects under specific conditions (Kizilkaya 1981, Dikmen 1994). In some DSI projects designed for surface irrigation, farmers use their own pumps and irrigation equipment and apply sprinkler irrigation over a total area of 63,849 hectares and drip irrigation over a small area of 386 hectares. Farmers use such applications in areas with high slopes, uneven ground surfaces, or in areas of highly permeable soils. Despite pumping costs, sprinkler irrigation is found to be more cost-effective in such areas and also in sites where water conveyance between field units is difficult. In 94 percent of the public irrigation systems run in the Aegean, Central Anatolia and Marmora regions, where water is scarce, farmers use

Table 3. The distribution of agricultural and irrigable lands in the major river basins in Turkey (DSI 1998).

Basin No.	Name of the basin	Drainage	Annual average	Agricultural	Irrigable
01	Meric Basin	14,560	1.33	1,095,320	1,077,992
02	Marmara Basin	24,100	8.33	865,704	729,957
03	Susurluk Basin	22,399	5.43	850,046	755,934
04	North Agean Basin	10,003	2.09	367,479	316,348
05	Gediz Basin	18,000	1.95	667,207	623,403
06	K. Menderes Basin	6,907	1.19	222,432	194,799
07	B. Menderes Basin	24,976	3.03	1,044,296	907,383
08	West Mediterranean Basin	20,953	8.93	437,356	406,601
09	Antalya Basin	19,577	11.06	451,224	448,111
10	Burdur Lakes Basin	6,374	0.50	251,403	249,484
11	Akarcay Basin	7,605	0.49	364,411	350,938
12	Sakarya Basin	58,160	6.40	2,814,341	2,681,137
13	West Black Sea Basin	29,598	9.93	855,008	640,057
14	Yesilirmak Basin	36,114	5.80	1,617,206	1,401,213
15	Kizilirmak Basin	78,180	6.48	4,049,796	3,761,142
16	Konya Closed Basin	53,850	4.52	2,182,762	2,134,915
17	South Mediterranean Basin	22,048	11.07	438,281	327,790
18	Seyhan Basin	20,450	8.01	764,673	714,014
19	Asi Basin	7,796	1.17	376,240	331,713
20	Ceyhan Basin	21,982	7.18	779,792	713,670
21	Euphrates Basin	127,304	31.61	4,293,793	4,111,316
22	South Black Sea Basin	24,077	14.90	712,575	350,717
23	Coruh Basin	19,872	6.30	326,220	303,362
24	Aras Basin	27,548	4.63	642,017	641,137
25	Van Lake Basin	19,405	2.39	436,485	433,319
26	Tigris Basin	57,614	21.33	1,148,238	1,137,628

Figure 3. The development of irrigation in Turkey (Cakmak 1997).

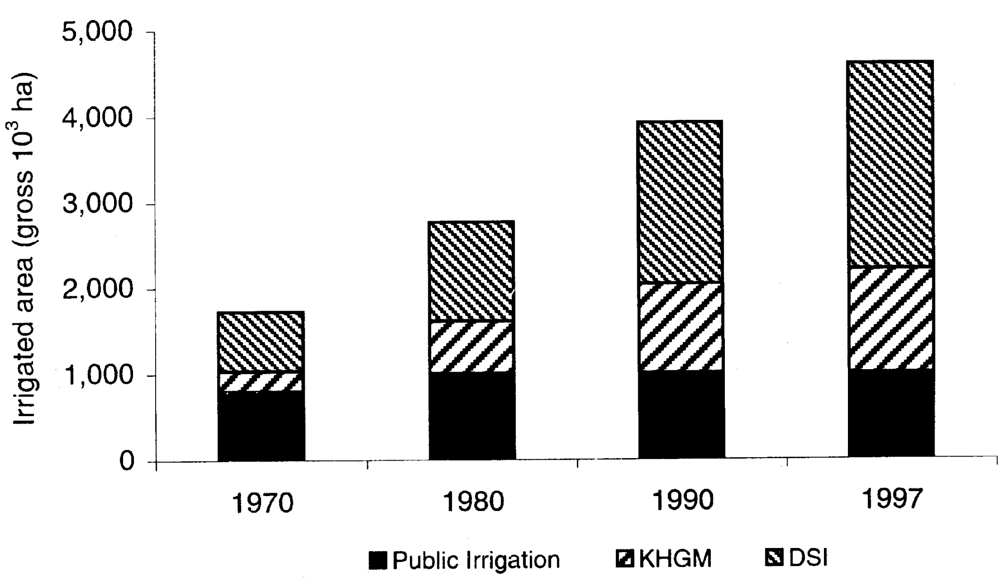
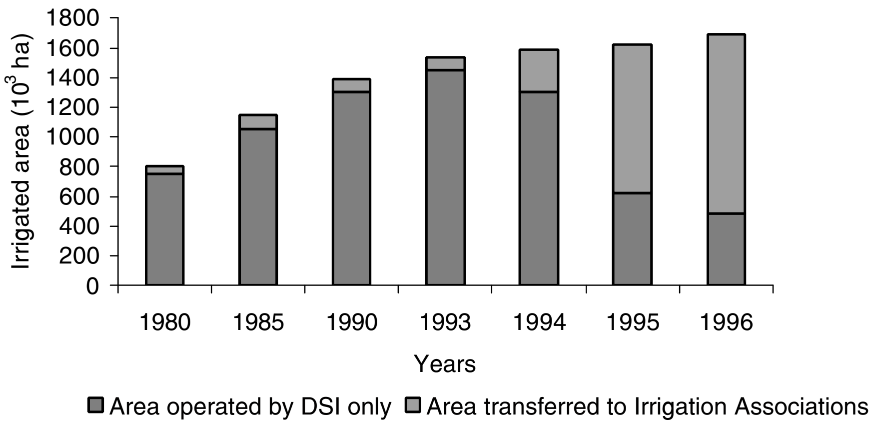


Figure 4.The shared management of irrigation systems in Turkey (Cakmak 1997).



sprinkler irrigation (Dikmen 1994). Extensive studies by DSI have shown that, 20 to 60 percent of the water used for surface irrigation, could be saved by using pressurized irrigation systems, while giving the same crop yields (Sener 1994).

Due to a number of difficulties and limitations, the irrigation systems constructed by DSI do not operate at full efficiency (Bekisoglu 1994, Unal 1994). In 1992, only 906,802 hectares out of the total 1,300,561 hectares were actually irrigated, a percentage of 69.7 (Bozkurt and Cakmak 1994). Table 4 gives the actual rates of irrigated area as a percentage of the area opened up by DSI between 1950 and 1992. Table 5 summarizes the factors, which limited the operation of equipped area in 1990, when approximately only one third of the developed area, over 189 projects, was actually irrigated.

Table 4. Irrigation rates at networks operated by DSI (Bozkurt and Cakmak 1994).

Year	Equipped area (ha)	Irrigated area (ha)	Irrigation rate (%)
1950	122,585	41,439	33.8
1960	184,750	89,283	48.3
1970	521,482	284,775	54.6
1980	755,459	493,604	65.3
1990	1,251,251	857,499	68.5
1992	1,300,561	906,802	69.7

Table 5. Factors hindering the full operation of DSI irrigation networks in 1990 (Bozkurt and Cakmak 1994).

Limiting Factors	Area that could not be irrigated (ha)	Relative importance(%)
Insufficient precipitation	144,220	36.6
Interference with private facilities	64,725	16.4
Left fallow	54,568	13.9
Water scarcity	40,630	10.3
Presence of pasture	29,129	7.4
Topographical conditions	22,501	5.7
High water table level	18,152	4.6
Distribution problems	17,339	4.4
Insufficient soil depth	2,488	0.6
Total	393,752	99.9

Irrigated agriculture plays a significant role in reducing migration from rural to urban areas. In 1989, an investigation was carried out in 19 city-regions[1], where 21 irrigation networks were operated by DSI (Bozkurt and Cakmak 1994). The results revealed that, whereas, the overall rural population of Turkey had decreased between the years 1975-1990, the population had increased in the villages which were situated within the irrigated areas (table 6).

Table 6. The annual rates of population increase (%) from 1975 – 1990 in villages with and without irrigation (Bozkurt and Cakmak 1994).

Region	1975-1980	1980-1985	1985-1990
Villages situated in DSI's irrigation areas	2.2	1.2	0.9
Rural population in studied areas	0.2	1.1	-1.1
Rural population of Turkey	1.3	-1.1	-0.6
Total population of Turkey	2.1	2.5	2.2

The Southeastern Anatolia Project (GAP)

Objectives and Planning

The Southeastern Anatolia Project (GAP) was initiated in 1977 in the southern part of Turkey, covering the lower reaches of the Euphrates (Firat) and Tigris (Dicle) rivers (table 7). The total area is 75,358 square kilometers, approximately one-tenth of the total land area in Turkey.

Table 7. The natural resources potential of the GAP region, in 1990 (Altinbilek 1997).

Resource	GAP	Euphrates and Tigris basins	Turkey
Area (km^2)	75,358	181,918	779,452
Population (10^6)	5.15	8.92	56.9
Irrigable land (10^6 ha)	1.7	2.38	8.5
Surface waters (km^3)	52.9	52.9	186
Hydroelectric energy (10^9 KWh/yr)	27	55	122

GAP is the largest multi-sectoral integrated regional development plan in the country. As an integrated development project relating hydropower, irrigation, industry, transportation, and social infrastructure, GAP has top priority among the national projects of Turkey. Under this project, thirteen major water resources development projects, primarily for irrigation and hydropower generation, are planned to exploit the water and soil resources of the region (table 8). GAP involves the construction of 22 dams and 19 hydropower plants on the Euphrates and Tigris rivers and an irrigation network spread over 1,693,027 hectares (DSI 1980, Ozis 1982, 1983 and 1992, Ozis, Basmaci, and Harmancioglu 1990, Ozal and Altinbilek 1994). The largest unit of GAP comprises the Lower Euphrates Project, which involves five sub-projects (Acatay 1996)

[1] Turkey is divided into 100 administrative units, here referred to as city-regions. Each city-region includes a major city and the rural areas surrounding it.

Table 8. The major projects developed under GAP (Acatay 1996).

Project Name	Type	Area to be irrigated (ha)
Lower Euphrates	Irrigation, hydropower	706,248
Batman-Silvan	Irrigation, hydropower	213,000
Suruç-Baziki	Irrigation, hydropower	146,500
Dicle-Kralkizi	Irrigation, hydropower	126,080
Gaziantep	Irrigation	89,000
Adiyaman-Kahta	Irrigation, hydropower	82,685
Adiyaman-Göksu-Araban	Irrigation	74,410
Garzan	Irrigation, hydropower	60,000
Batman	Irrigation, hydropower	37,744
Cizre	Irrigation, hydropower	12,100
Ilicasu	Hydropower	
Karakaya	Hydropower	
Projects at the border	Hydropower (Birecik, Karkamis)	
Total		1,547,767

The GAP Master Plan was prepared in 1989, by a consortium of a Turkish and a Japanese firm to implement a long-term regional development plan. The agricultural development objectives were defined as follows (Altinbilek 1997):

? To raise the income levels in rural areas by enhancing agricultural productivity and diversifying farming activities
? To provide sufficient inputs to agro-processing industries
? To increase employment opportunities and minimize the migration of people out of the rural areas
? To contribute to the production of exportable surpluses

After the implementation of GAP most of the fallow land will disappear. The diversification of and increases in crop production will create new opportunities for developing agro-based industries and agricultural input producing industries (Altinbilek 1997). Eventually, after the completion of the project it is hoped that the hydropower production capacity and the volume of agricultural production will double, while the irrigated area will be increased by 50 percent. In the region, the gross regional product is expected to quadruple, while doubling the per capita income.

Some of the larger project components are already completed or near completion. The Atatürk Dam has been in operation since mid 1992. Large-scale irrigation started in 1995 when the tunnel system became operational. A number of experimental agricultural research stations have been established. Although the construction work still continues, after the completion, it is hoped that the project will lay the foundation for international cooperation by providing benefits to Turkey's southern neighbors (Altinbilek 1997).

Irrigation Targets

The region where GAP is being implemented has a dry climate. While the average annual precipitation varies between 470 and 830 millimeters over the region, the major inhibiting factor for the agricultural potential of the region is the non-uniform distribution of rainfall during the growing season. Thus, irrigation is a prerequisite to optimize agricultural production in the region (Altinbilek 1997). During the 1996 irrigation season, 40,000 hectares of land were irrigated in the Harran plains. Double and even triple cropping was achieved with the help of irrigation. Utilization of the modern irrigation system may enhance the cash value of agricultural production in these plains ten-to-twenty fold.

The expected outcome of the GAP is sustainable irrigation development through the quality of design and construction, the proper system operation and maintenance, effective monitoring and evaluation and the improvement of system performance when necessary. The following activities were thus proposed in GAP (Altinbilek and Akcakoca 1997):

? Improved management, operation and maintenance of irrigation systems
? Use of improved field water distribution
? On-farm development, canal lining and land leveling to minimize salinity and water logging problems
? Use of improved canal irrigation (control) techniques
? Use of unsteady flow simulation models for the design, operation and control of irrigation systems
? Joint use of groundwater and surface water
? Reuse of drainage water and urban wastewater in irrigation
? Rehabilitation of major watersheds in the upper basins
? Consolidation of land
? Participation of farmers in the form of water users' groups
? Training of farmers and the organization of extension programs

Environmental Assessment

The projects involved in GAP will have both beneficial and adverse environmental impacts in the region. A number of environmental studies have been carried out for the GAP projects (Alpaslan and Turkman 1988, Akar 1994, Alpaslan 1996a, Akkaya 1997). These include studies on the impact of the irrigation and water resources development projects on health (GAP-RDA 1993, Kuman 1995, TÇV 1997). The potential environmental impacts of irrigation schemes in the GAP region on hydrology, pollution, seismic, sedimentation, ecology, socioeconomic conditions, and human health were assessed in terms of being beneficial or adverse.

The main environmental benefits of GAP projects have been identified as follows (Uluatam 1994, Altinbilek and Akcakoca 1997):

? Control of floods and the use of flood water
? Availability of a regular supply of high-quality water
? Preservation of the natural flora
? Increase in the water fauna
? Creation of recreation areas

Uluatam (1994) and Garipoglu (1994) describe the adverse environmental effects of irrigation and hydropower schemes in GAP, as follows:

? Inundation of ecological and cultural heritage sites
? Changes in hydrology
? Damage to the natural fauna from soil excavations
? Negative changes in soil and water quality due to the increased agricultural and urban activities
? Rise of the groundwater table
? Increase in salinity and the contamination of ground water
? Increase in the incidence of water-borne diseases such as malaria and schistosomiasis, but also onchocerciasis and Japanese encephalitis
? Increase of sedimentation in rivers and lakes and soil erosion
? Upsetting of the present ecological and biological balance

In addition to these environmental hazards, high increases are expected in the use of fertilizers and pesticides. Currently, 550,000 tons of fertilizers and 3,500 tons of pesticides are used annually in Çukurova, south of Adana. These amounts are expected to increase 8-10 times after full development of the GAP irrigation projects (Acatay 1996).

In the environmental impact assessment, mitigation measures required to offset the adverse impacts of the irrigation projects were also identified. The following were the main proposed activities for environmental sustainability of water resources development in the region (Altinbilek and Akcakoca 1997):

? Increased efficiency of irrigation systems
? Construction of drainage systems
? Use in improved field water distribution and irrigation techniques
? Reuse of irrigation return flow and urban wastewater in irrigation

VECTOR-BORNE DISEASES RELATED TO IRRIGATION AND WATER RESOURCES DEVELOPMENT IN TURKEY

The two major vector-borne diseases related to irrigation and water resources development in Turkey are schistosomiasis (bilharzia) and malaria. Schistosomiasis occurs sporadically, but the implementation of the large-scale projects within the Southeastern Anatolia Project (GAP) may eventually lead to epidemics. Malaria has long been a significant health problem in Turkey and is still common in areas of irrigation and water resources development.

Epidemiology of Schistosomiasis

Cases of urinary schistosomiasis, caused by *Schistosoma haematobium*, were reported in Turkey since the 1930s, varying from incidental cases to 86 percent of the population being infected (table 9). Some researchers claim that the climatic conditions in Turkish river basins were not favorable for production of

Schistosoma cercariae. However, the conditions along the southern borders of Turkey are not much different from those in Northern Iraq and Syria. In these regions epidemics have already been observed. While there have been a few incidences in the southern border villages of Turkey (Dogulu 1966), *Bulinus truncatus*, the intermediate snail host of urinary schistosomiasis, was also observed in the waters of the Nusaybin region (Malek 1962, Paydak 1979).

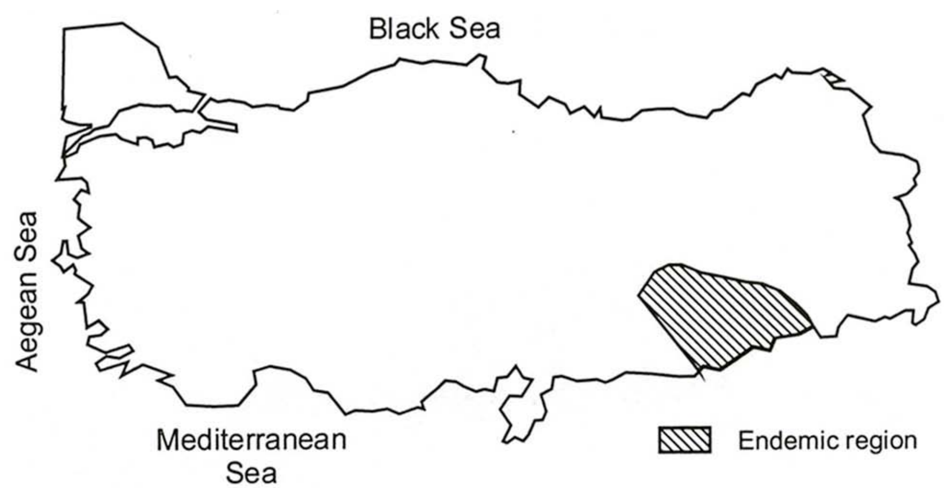
Table 9. Reported cases of urinary schistosomiasis in Turkey.

Site	Prevalence (%)	Year	Author
Mardin	+[a]	1934	Günalp
Akcakale, Nusaybin, Idil, Suruç	+	1950	Berin and Berke
Suruç:			
Gündük Sadik village	86	1956	Gürsel
Gribya	12.5	1959	Cebeci
Mardin	+		
Yalçinkaya:			
Gündük Sadik village	46	1966	Dogulu
Tezharap village	17		

[a] No prevalence reported, only presence of schistosomiasis.

Recently, the Ministry of Health officially declared that *Schistosoma haematobium* is observed sporadically in Turkey and that 210 cases were detected during the period 1990-1995 (Özcel and Özbilgin 1995). The irrigation schemes of GAP are expected to provide favorable conditions for the spread of *Schistosoma haematobium.* To prevent epidemics of schistosomiasis, precautionary measures have been proposed for the region (Uluatam 1994). Figure 5 shows that the distribution of *Schistosoma haematobium* is limited to the Southeast of the country. Although this map dates back to 1978, it does not differ very much from the current situation.

Figure 5. The distribution of Schistosoma haematobium *in Turkey (Yasarol 1973 and 1978).*



Epidemiology of Malaria

Malaria has been an old threat to Anatolian civilizations. In early years of the Turkish Republic, between 1924-1926, intensive efforts were made to control malaria epidemics (Kuman 1995). A malaria eradication program was established in 1957 and the malaria incidence decreased. Out of a total of 896,187 blood samples tested in 1939, 120,060 were positive for malaria. Years later in 1970, only 1,263 malaria cases were reported among the 2,189,875 blood samples. However, the reported number of cases of malaria in 1976 reached well over 100,000 for the first time during the last 20 years. This was largely due to an agricultural development project in the Çukurova region, which attracted a substantial number of migration workers from Eastern areas where malaria at that time was more prevalent. As a result, a serious epidemic of vivax malaria occurred in 1977 (Ramsdale and Haas 1978). Since the 1970s, outbreaks have occurred approximately every decade (figure 6) and WHO even speaks of a "deterioration to epidemic proportions in south-east Anatolia" (Anonymous 1997). Hence, malaria is among the first five infectious diseases that are considered to be a threat in Turkey. Children between 10 and 14 years of age and adult people are the most affected groups (figure 7).

The *Anopheles* mosquitoes in Turkey have developed resistance against a wide range of insecticides used in agriculture (see the section on Control Measures for more details). This resistance largely explains the increase in the incidence of malaria in Turkey (table 10). Another reason stated is the decrease of investments in malaria control by the Ministry of Environment. In the year 1945, 39 percent of the Ministry's budget was allocated to malaria control and in 1997 this was reduced to 4 percent (Kuman 1995).

Figure 8 shows the distribution of malaria in Turkey in the year 1970 (Yasarol 1973). In recent years, Southeastern Anatolia has been a focal area in malaria transmission although malaria has been observed sporadically in other regions of Turkey as well (Kuman 1995).

The most common type of malaria in Turkey is caused by *Plasmodium vivax.* Additionally, *Plasmodium falciparum, Plasmodium malaria* and *Plasmodium ovale* were detected, but not in indigenous cases (Unat, Yasarol, and Merdivenci 1965, Unat et al. 1991, table 11). Vivax malaria is less dangerous than malaria tropica (caused by *Plasmodium falciparum*); yet, it may still result in death although such cases are not always reported.

The Ministry of Health has carried out surveys on the incidence of malaria in Turkey between the years 1990 and 1994 (table 12). In these surveys the country was divided into five regions (figure 9). The increased incidence of malaria shows a different pattern in each of the malaria regions (figure 10). The high number of malaria cases in Region IB in the years 1994 and 1995 suggests that there is a potential for future epidemics in this area, where the Southeastern Anatolia Project (GAP) is being implemented.

An interesting feature of the regional distribution of malaria in Turkey is the spread of the disease by seasonal workers, who move temporarily in and out of different regions. Essentially, city-regions in Malaria Region IB are the suppliers of such workers.

The incidence of malaria in Turkey exhibits a seasonal character. The number of cases starts increasing in March to reach a maximum in the summer (figure 11). A decrease in the number of cases is observed after October (Akdur 1997 and 1998). Such seasonality is explained by the subtropical climate of Turkey as well as by the breeding habitats of the *Anopheles* mosquitoes.

Figure 6. The incidence of malaria in Turkey from 1925-1997 (Akdur 1997 and 1998)

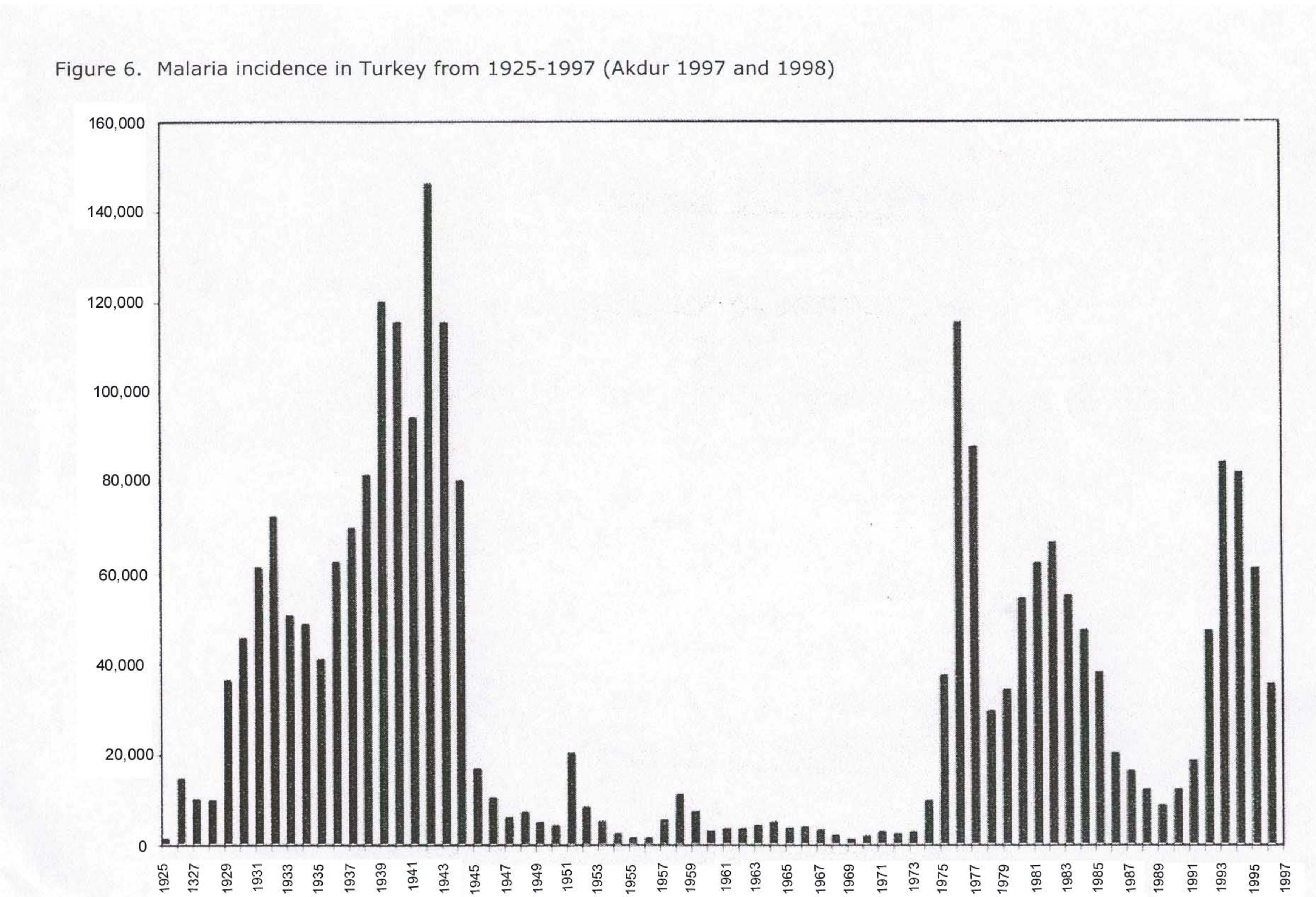
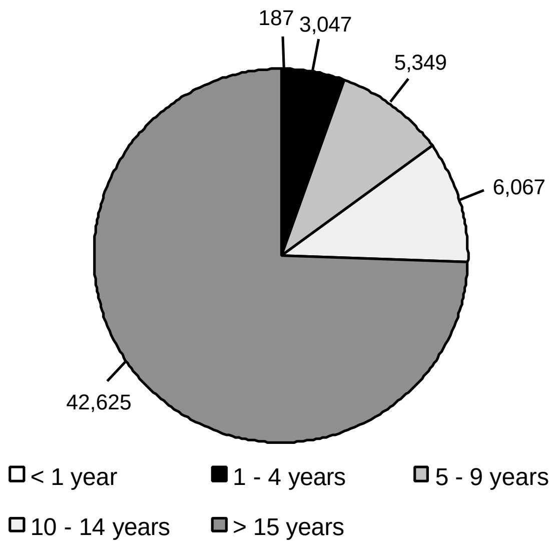


Figure 7. Distribution of malaria by age group (number of cases) over the period 1985 – 1997



(Akdur 1998).

Table 10. The increase in malaria transmission in Turkey (Kuman 1995).

Year	Tested samples	Positive cases	Slide positivity rate (%)
1939	896,187	120,060	13.4
1970	2,189,875	1,263	0.06
1988	2,831,154	16,245	0.57
1990	2,209,298	8,680	0.39
1991	2,018,647	12,218	0.61
1992	2,119,150	18,676	0.88
1993	1,939,243	47,203	2.43
1994	1,990,986	84,345	4.24

Figure 8. Distribution of malaria in Turkey in 1970 (Yasarol 1973).

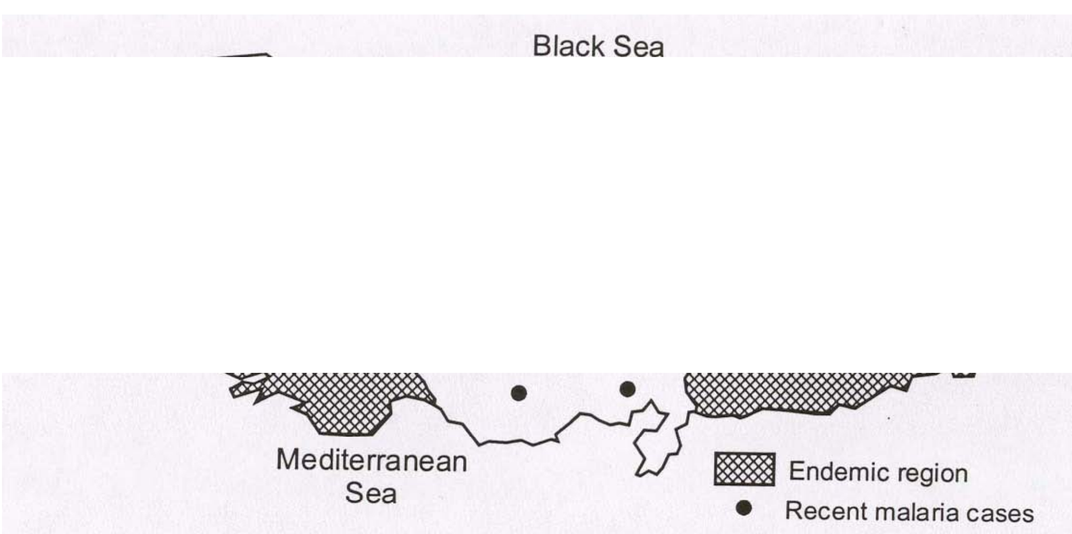


Table 11. The distribution of malaria cases with respect to the type of parasite (Kuman 1995).

Year	*P.vivax*	*P.falciparum*	*P.malaria*	*P.ovale*	Mixed infections
1990	8,674	5	1	-	-
1991	12,209	5	1	-	3
1992	18,662	11	-	-	3
1993	47,198	4	-	-	2
1994	84,317	24	2	1	1

Table 12. Number of tested and positive samples as well as slide positivity rates (SPR) of malaria in Turkey over the period 1990-1994 in 5 regions (Kuman 1995).

Year	Samples	Malaria Region					TOTAL
		IA	IB	II	III	IV	
1990	Tested samples	472,509	798,919	537,064	268,917	131,889	2,209,298
	Positive samples	2,883	4,703	786	277	31	8,680
	SPR (%)	0.61	0.59	0.15	0.10	0.02	0.39
1991	Tested samples	457,191	674,572	512,207	239,410	135,267	2,018,647
	Positive samples	3,248	8,051	626	245	48	12,218
	SPR (%)	0.71	1.19	0.12	0.10	0.04	0.61
1992	Tested samples	543,367	734,627	498,876	236,693	105,587	2,119,150
	Positive samples	4,402	13,444	505	239	86	18,676
	SPR (%)	0.81	1.83	0.10	0.10	0.08	0.88
1993	Tested samples	449,881	741,712	448,931	210,855	87,855	1,939,234
	Positive samples	4,567	40,709	1,382	403	142	47,203
	SPR (%)	1.02	5.49	0.31	0.19	0.16	2.43
1994	Tested samples	438,749	833,187	437,555	211,246	70,249	1,990,986
	Positive samples	8,253	72,617	2,348	916	211	84,345
	SPR (%)	1.88	8.72	0.54	0.43	0.30	4.24

Figure 9. Malaria regions of Turkey (Akdur 1998).

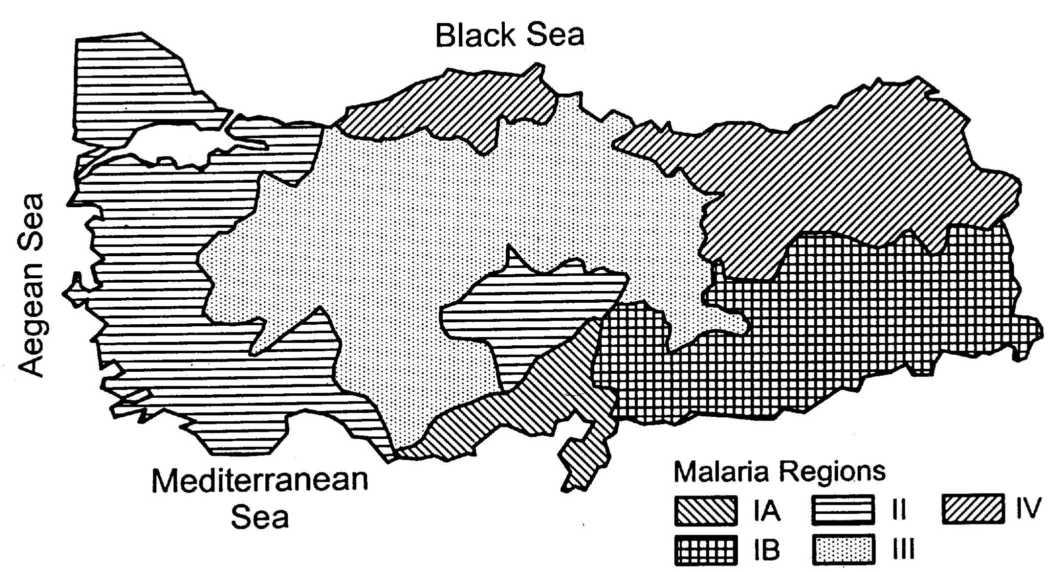


Figure 10. Regional distribution of malaria in Turkey (Akdur 1998).

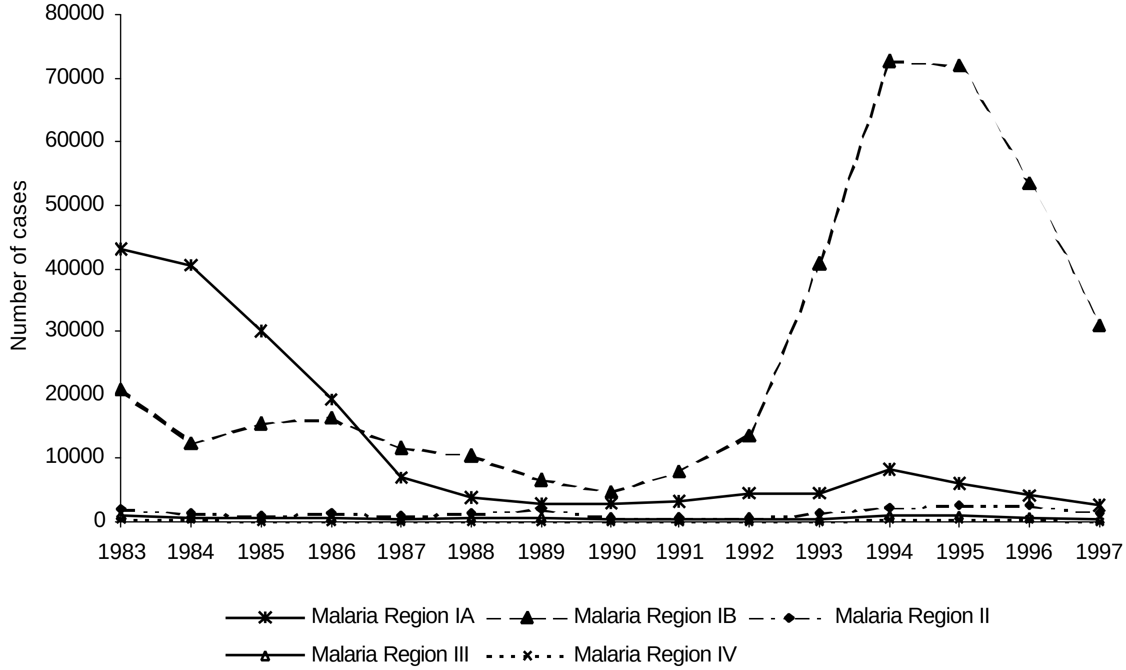
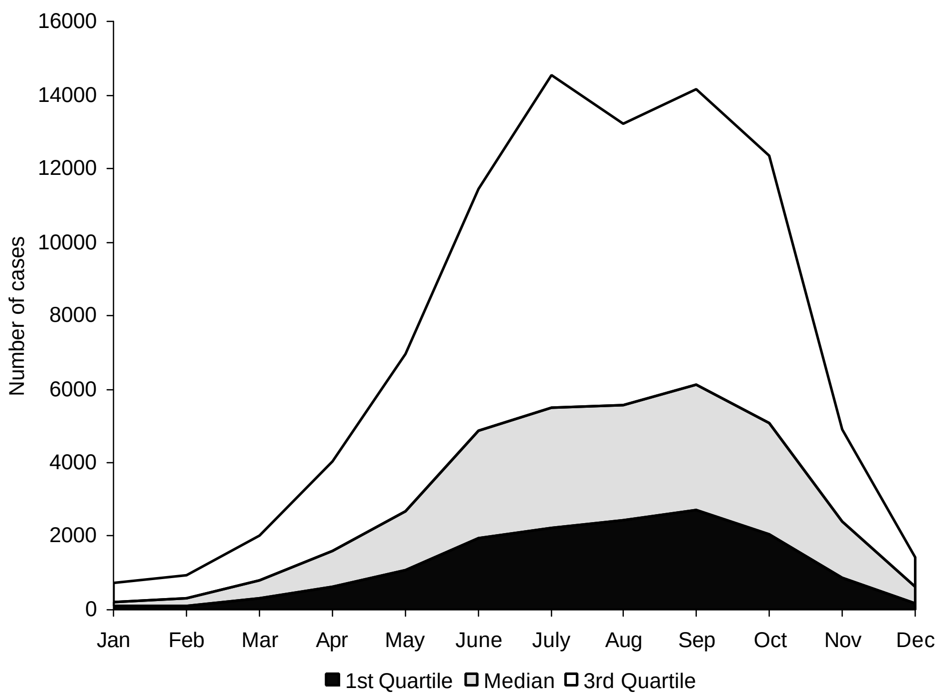


Figure 11. Seasonal pattern of malaria incidence in Turkey over the period 1987-1997 (Akdur 1998)



Breeding Habitats of the Vectors of Malaria

Mosquitoes belong to the Culicidae family of the Diptera group and have several species. Carriers of malaria are all *Anopheles* mosquitoes belonging to the subfamily of Anophelinae (Kasap and Alptekin 1997). In Turkey, 17 different *Anopheles* species have been found (table 13). Of these, *Anopheles sacharovi* is the major carrier of malaria in Turkey (Mimioglu, Kasap, and Kasap 1979, Kasap et al. 1987, 1988, Kasap 1990). *Anopheles superpictus, Anopheles hyrcanus* and *Anopheles maculipennis* may play a role in malaria transmission as well, but only as secondary vectors (Kasap and Alptekin 1997, Unat et al. 1991). In addition, *Anopheles melanoon, Anpheles claviger* and *Anopheles subalpinus* have been reported as transmitters of malaria (Kasap and Kasap 1983; Özcel and Daldal 1997).

Table 13. Anopheles species in Turkey (Postiglione, Tabanli, and Ramsdale 1973, Yasarol 1973, Merdivenci 1984).

An. algeriensis	*An. maculipennis*	*An. plumbeus*
An. amaurus	*An. marteri*	*An. pulcherrimus*
An. claviger	*An. melanoon*	*An. sacharovi*
An. elutus	*An. messeae*	*An. subalpinus*
An. hyrcanus	*An. multicolor*	*An. superpictus*
An. hyrcanus mahmuti	*An. nigripes*	

The most important carrier of malaria in Turkey, *Anopheles sacharovi,* prefers water that has a high content of oxygen (12.4 mg/l on average) and occurs rarely in water environments that contain high concentrations of phosphates, nitrites, chlorides and nitrogen. This mosquito is able to tolerate moderately salty water (up to 4-4.5 mg/l), which explains the breeding of *Anopheles sacharovi* in the Çukurova region, south of Adana, and in its coastal areas (Kasap and Alptekin 1997). Another reason for this situation is that *Anopheles sacharovi* prefers habitats with temperatures varying between 19° and 34° C. The mosquitoes breed in lakes, swamps, irrigation canals, pools, and similar water bodies with slowly flowing water. Especially in south central Anatolia, *Anopheles sacharovi* is breeding very abundantly in pools and structures in irrigation canals and drainage ditches (Giglioli 1979).

The female *Anopheles sacharovi* mosquitoes that breed in the Çukurova region spend most of their energy to live through the winter. They can survive five to six months between November and April (Alptekin and Kasap 1997). The mosquitoes lay their eggs towards the end of March and the first generation of *Anopheles sacharovi* comes to life by the end of April. A second generation may be produced later in the summer. During this period, the life span of the mosquitoes is approximately 20 to 30 days (Kasap et al. 1991).

In the Çukurova region, the concentration of *Anopheles sacharovi* is highly variable within the year and from year to year (Alptekin 1991). Normally, the density is at a peak in June, decreases in July and August, and makes another peak in October and November (Kasap et al. 1981). This pattern closely resembles the seasonal incidence of malaria (figure 9 and Kasap, Kasap, and Mimioglu 1988). It is generally rather low in winter and spring (Kasap and Alptekin 1990, Alptekin and Kasap 1996).

One of the suspected secondary vectors of malaria in the Çukurova region, *Anopheles superpictus*, breeds mainly in cool highlands. Larvae of *Anopheles hyrcanus* are found more frequently than those of *Anopheles superpictus,* especially in the moderately salty waters which are abundant in the coastal areas.

However, since *Anopheles hyrcanus* can exist only in limited habitats, its capacity to spread malaria is low (Kasap and Alptekin 1997).

Further, Sahin (1983 and 1984) noted that *Anopheles hyrcanus* and *Anopheles algeriensis*, as well as *Aedes aegypti*, *Aedes vexans*, *Culex pipiens* and *Culex tritaeniorhynchus* are potential carriers of chronic filariasis caused by *Wuchereria bancrofti*. These mosquitoes also have been found in and around Antalya.

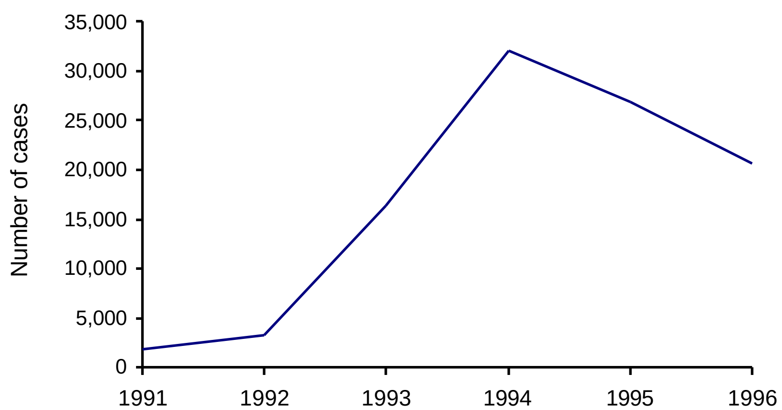
Perspectives for the GAP Region

Akdur (1997) argues that appropriate techniques and precautions should be considered when operating the irrigation system. The highest number of malaria cases is observed in Malaria Region IB, where the Southeastern Anatolia Project (GAP) is being implemented. Also, three of the major city-regions where increased incidences were noted, are situated in the GAP region: Diyarbakir, Batman, and Sanliurfa (table 14 and figure 12). Kuman (1995) claims that the expansion of irrigated agriculture in the GAP region will change the ecology of the area and lead to more favorable conditions for *Anopheles* breeding (Akdur 1998).

Table 14. The trends in malaria incidence (number of new cases) in some city-regions (Kuman 1995).

City-region	1992	1993	1994
Adana	3,126	9,592	7,092
Batman		8,198	17,061
Diyarbakir	4,168	15,898	31,263
Sanliurfa	3,578	5,126	6,488

Figure 12. Increased malaria incidence in the city-region of Diyarbakir (Ilçin 1998).



Seasonal migration of workers between Çukurova (Malaria Region IA) and the GAP area (Malaria Region IB) sets a perfect ground for the spread of malaria and schistosomiasis. There is also short-term migration (military and others) to and from Syria, Iran and Iraq, which may lead to epidemics of *Plasmodium falciparum* (Kuman 1995).

Control Measures against Malaria and Schistosomiasis

In Turkey, control measures for malaria have long been applied as this disease has a fairly long history in the country. The main strategy has been chemical mosquito control and draining of marshes. Chlorinated hydrocarbons were used successfully as insecticides both for agricultural and health purposes between 1940 and 1960 (Kasap and Alptekin 1997). However, *Anopheles sacharovi* developed resistance against DDT in 1959 and against dieldrin in 1970 (Gokberg 1959, Zulueta 1959, Curtis 1962, Ramsdale 1975, Giglioli 1979, Ramsdale, Herath and Davidson 1980, Kasap 1989). Therefore, the sales of aldrin, dieldrin, chlordane and BHC were prohibited in 1979, and in 1980 DDT was added to the list.

The use of organochloride compounds was replaced by the application of organophosphates such as malathion, which was banned in 1984 due to the resistance developed at tolerance levels (Kasap and Alptekin 1997). During the period 1984-1990, another organophosphate insecticide (pirimiphos-methyl) was used with success and in 1991 resistance was not detected in *Anopheles sacharovi*. Currently, only endosulfan is used as a chlorinated hydrocarbon. In addition, bendiocarb from the carbomate group was also used until 1996 so that different insecticides were applied on a rotational basis (Kasap et al. 1992).

Currently, mosquito control is carried out by the municipalities in the urban areas and in rural areas by the Turkish Agency for Malaria Control. The latter normally prefers larvae control, whereas municipalities usually spray insecticides from the air. In recent years, the focus has been on the use of biological control measures, using bacteria (*Bacillus thrungiensis israelensis*), predator fish (*Gambusia afinis*), and growth hormone inhibitors such as methoprene (Altosid) and pyriproxyfen (Sumilarv). It seems that these products can be used in the future too, as their continued use does not seem to lead to the development of resistance in mosquitoes, attack only the target mosquito population, minimize environment pollution, have long periods of effectiveness, and can be applied with standard equipment (Geldiay and Deveci 1990).

As schistosomiasis occurs only sporadically in Turkey, there are practically no prescribed control measures. Researchers have recently proposed that surveys to detect infected cases should be conducted immediately. They expect the disease to spread in the GAP region after development of water structures and irrigation systems and urge the government to adopt a policy towards effective control of the disease (Özcel 1995, Özcel and Özbilgin 1995).

THE USE OF PESTICIDES IN TURKEY

Production, Registration and Prohibition of Pesticides

Pesticide production in Turkey has increased over the years. From 1960 to 1994, the number of companies licensed to produce technical pesticide compounds and formulations increased from 17 to 53 and the number of importing firms increased from 10 to 61 (EFT 1995). The number of active ingredients used in pesticide formulations increased from 105 to 281, while the amount of pesticide used per year increased from 23,425 tons to 32,363 tons as shown in table 15. As of 1994, 1378 different pesticides, mainly insecticides, herbicides and fungicides, were registered in Turkey (table 16).

Within the last twenty-five years, the Pesticide Commission of the Ministry of Agriculture and Rural Affairs has cancelled the registration of 32 different pesticides, including mixtures, because of their toxic effects, ineffectiveness, or carcinogenic and adverse environmental effects (table 17).

Table 15. Total quantities of plant pesticides manufactured and imported from 1960 – 1993 (TÇV 1995).

Year	Quantity (tons)	Cost (TL)
1960	23,425	39,065,763
1965	35,656	82,073,700
1970	50,804	188,951,119
1975	48,132	915,100,135
1980	43,740	5,620,953,153
1985	37,703	44,489,435,611
1990	34,055	526,219,000,000
1993	32,363	2,513,232,000,000

Table 16. Registered agricultural pesticides in Turkey by groups in 1986 and 1994 (TÇV 1995).

Agricultural pesticide group	Number of registered pesticides	
	1986	1994
Insecticides	336	694
Acaricides	49	62
Petroleum oils	23	20
Fumigants	8	26
Nematicides	16	20
Rodenticides	2	9
Molluscicides	5	5
Fungicides	81	208
Bactericides	3	6
Herbicides	148	240
Other chemical compounds	5	88
TOTAL	676	1,378

Table 17. Cancelled (November 1994) and prohibited pesticides in Turkey (EFT 1995, TÇV 1995).

Group name	Product name
Insecticides	Aldrin, endrin, dieldrin, chlordane, parathion-ethyl, leptophos, DDT, BHC, lindane and other BHC/DDT mixtures, heptachlor, arsenic compounds, toxaphene
Acaricides	chlorobenzilate and chlordimeform hydrochloride, chloropropylate
Nematicides	DBCP (dibromochloropropane)
Fungicides	methoxyethylmercury chloride, phenylmercury acetate, phenylmercury chloride, cyhexatin
Herbicides	dinoseb, 2, 4, 5-T, fluorodifen, MSMA, neoron/MSMA
Avicides	queltox
Other chemical compounds	daminozide

Use of Pesticides

According to a study done by the United Nations Food and Agriculture Organization (FAO) on the use of pesticides in Turkey , the applied amounts of active ingredients are lower than the world average, i.e., only 0.6 kg/ha. Over the last few years, the total amount of pesticides used in Turkey has not changed very much (table 18).

The use of pesticides in Turkey increased by 18 percent from 1982 to 1988, while it decreased by 10 percent between 1988 and 1992 (table 19). However, more toxic pesticides were used in smaller doses to protect plants from pests and diseases, which increased the hazardous effects and environmental pollution risks (ETF 1995). Almost a third (29 percent) of the pesticides in Turkey are applied to cotton while vegetables come second in the use of pesticides.

Table 18. Annual pesticide use (tons) in Turkey between 1990 and 1995 (Çevre Bakanligi 1997) and in the period 1995-1996 (Atalay et al. 1998, TÇV 1998).

Pesticide group	1990	1991	1992	1993	1994	1995	1995/96
Insecticides	17,652	10,412	13,125	12,265	11,229	14,850	16,530
Acaricides	904	982	1,372	1,162	697	1,252	786
Fumigants and nematicides	2,223	2,745	2,428	2,499	2,588	2,982	1,500
Molluscicides	1,152	984	903	1,216	875	1,203	
Oils	47	77	49	38	51	81	3,327
Fungicides	5,503	5,599	5,910	5,868	4,862	4,987	6,270
Herbicides	6,346	7,191	5,861	9,133	8,511	7,583	8,237
Others	228	230	190	182	145	355	--
TOTAL	34,055	28,220	29,838	32,363	28,958	33,243	36,400

Table 19. The annual use of active ingredients in pesticides in Turkey (kg), excluding copper sulfate, sulfur compounds and mineral oils.

	Use of active ingredients		
Pesticide group	1982	1988	1992
Insecticides	3,138,890	2,989,532	2,997,668
Acaricides	244,440	286,873	340,337
Fumigants and Nematicides	117,980	395,966	577,840
Molluscicides	900	236	2,438
Oils	1,763,153	2,019,556	1,865,517
Fungicides	1,465,511	2,589,368	2,300,802
Herbicides	2,020,078	3,736,481	2,772,022
TOTAL	8,750,452	12,018,012	10,856,624

The largest amount of pesticides (40 percent of the total) is used in the Mediterranean region in Adana, Içel and Antalya and 25 percent is used in Izmir, Manisa and Aydin areas (Canyurt 1997, Delen 1997a and 1998, TÇV 1998). This means that four to five large city-regions account for 65 percent of the use, while less than 10 percent is used in the GAP region (table 20). The use of pesticides is expected to increase in large proportions, once the development of the entire Southeastern Anatolia project (GAP) is completed, unless specific efforts are made to keep it at a minimum (Uluatam 1994).

Table 20. The use of pesticides (active ingredients in kg) in some Turkish city-regions in 1996 (Delen, Tosun, and Yildiz 1998).

City-region	Use of pesticides (kg)	Share in total use in Turkey (%)
Gaziantep	155,109	1.12
Mardin	72,872	0.50
Adiyaman	56,821	0.41
Sanliurfa	150,252	1.08
Antalya	1,472,111	10.66
Içel	2,453,448	17.78

Toxicity of Pesticides

Pesticides have different toxic effects on various forms of life and are considered as poisonous to human beings and animals. If the pesticides introduced into an ecosystem do not have a direct and immediate effect on certain groups of organisms, they may still have indirect toxic effects on them after some time (Ince and Bekbölet 1991, Gençsoylu, Benlioglu, and Oncuer 1998). The circulation of pesticides in the environment is complex. For example, pesticide particles may mix with air; enter the soil and then the groundwater through rain and irrigation. They may be absorbed by plants and in turn be transferred to human beings and animals when they are consumed as food. Pesticides may thus affect human beings in a number of ways: directly, through secondary toxic effects, by reducing the available types of food, by degrading the habitat, by changing the number of rival species and through problems of resistance (EFT 1995). The mechanisms involved will be discussed in more detail below, as far as they are specific to Turkey.

Direct Toxic Effects

The direct toxic effect of a pesticide occurs when the pesticide enters the human body, either through the respiratory tract, the skin, or the mouth. This type of poisoning is called "acute poisoning". Apart from suicide, acute poisoning may occur as a result of the careless use of pesticides or as a result of misuse outside agriculture. Human contact with them may occur either during the production, transportation, storage, or use of pesticides, or during the consumption of the products that contain pesticide residues (Delen and Tosun 1997, Delen 1997b). The symptoms of poisoning begin to appear within a short time depending on the dose and the degree of toxicity (Çevre Bakanligi 1997). Incidents of poisoning and death caused by pesticides are reported to the Ministry of Health and the Ministry of Agriculture (table 21). Despite treatment, 3-9 percent of the poisonings resulted in death.

The degree of toxicity of pesticides is usually expressed in terms of their lethal dose (LD) as determined in the laboratory on various test animals. For example, LD50 is the dose (milligrams of pesticide per kilogram of body weight) capable of killing 50 percent of the animals. The toxicity of the pesticides increases inversely with the size of these figures (table 22).

Table 21. Poisonings and deaths caused by pesticides in Turkey (EFT 1995).

Year	Number of persons poisoned	Number of deaths	Fatality rate (%)
1977	1,716	73	4.25
1978	947	79	8.34
1979	309	12	3.88
1980	449	36	8.01
1981	1,251	34	2.71
1985	590	51	8.64
1988	726	44	6.06
1991	1,134	65	5.73

Table 22. Acute toxicity of certain pesticides (in milligrams of pesticide per kilogram of body weight) absorbed through the mouth or skin (EFT 1995).

Pesticide group	LD50 (mg/kg) Orally administered to mice	LD50 (mg/kg) Injected to rabbits
Chlorinated hydrocarbon insecticides		
Endrin	7.5	15
Aldrin	39	98
Toxaphene	80	780
Lindane	88	900
DDT	113	2,510
Endosulfan	30-100	359
Organophosphorus insecticides		
Azinphos-methyl	5-20	220
Fenitrothion	800	1,300
Dichlorvos	56-80	107
Diazinon	300	3,600
Malathion	1,000	4,100
Herbicides		
Thiobencarb	1,300	2,900
2.4-D	375	1,500
Atrazine	1,780	3,500
Chlorsulfuron	5,545	3,400
Fungicides		
Dodine	1,000	1,500
Benomyl	10,000	10,000
Zineb	5,200	5,000
Maneb	7,900	10,000
Thiabendazole	3,200	-

The effects of pesticides on humans may be due to either their particular chemical composition itself, or their breakdown products known as metabolites. Some of the chemicals are deposited, while others destroy nerve cells without accumulating. The following pesticide compounds are being used in Turkey or were used during the recent past. The use of some of these were either discouraged or banned by the Ministry of Agriculture and Rural Affairs:

Mercury-Containing Compounds. Inorganic and organic mercury-containing pesticides are toxic to all living organisms, and their tolerances are zero. The liver absorbs mercury ingested into the body, and it spreads from there to all the other organs. It can accumulate in the vital organs, particularly the liver, the kidneys and the brain. Due to these extremely toxic effects, the registration of all mercury-containing pesticides, which had been used for many years as seed dressing, was cancelled and sales prohibited by the Ministry of Agriculture and Rural Affairs in 1985 (EFT 1995). Following this prohibition, complaints related to mercury poisoning have declined significantly.

Chlorinated Hydrocarbon Compounds. This group of pesticides accumulates in the adipose tissue of the body, and gives rise to chronic poisoning and other diseases. Deposits in the liver, for example, may cause cirrhosis. Among this group of pesticides, dieldrin is known to pass through the placenta to the fetus and through the mother's milk to babies. As in many other countries, the use of chlorinated hydrocarbons, apart from the diflubenzuron and endosulfan groups, has been completely banned in Turkey.

Organophosphorus Compounds. Two important enzymes in the body, cholinesterase and acetyl cholinesterase, are rendered inactive by the effects of organophosphorus pesticides. Even after treatment for acute intoxication, conditions such as muscular weakness, depression, inability to concentrate, irritability, headaches and visual disturbances may persist for 2-3 months.

The Ministry of Agriculture and Rural Affairs has discovered that the organophosphorus pesticide methamidophos, which is not recommended due to its very strong and persistent toxic effects, has been widely used in vegetable gardens in 1991. Vegetables have been marketed 1-9 days after the application of pesticide. If such practices are not avoided, they may create serious irreversible health and environmental problems in the near future (EFT 1995).

Other compounds. The fungicides zineb, maneb, and mancozeb (EBDC) are widely applied on fruits and vegetables in Turkey. The breakdown products contain ethylenethiourea, which in recent years has been determined to have carcinogenic, teratogenic and mutagenic activities. The use of EBDC compounds should be avoided, since the breakdown may occur even during processing or cooking of the product (EFT 1995).

Secondary Effects

These refer to poisonings brought by eating either animal or vegetable foodstuffs that contain pesticide residues. Such cases are usually referred to as chronic poisoning. In the Southeastern Anatolian region, for example, the Porphyria disease was observed in 3,000 persons who ate wheat seed treated with hexachlorobenzene pesticide. With a fatality rate of 3-11 percent, this incident of poisoning awakened concern throughout the world (Çevre Bakanligi 1997, Jarrell et al. 1998).

The maximum amount of residue permitted to be found on foodstuffs for human consumption is referred to as tolerance level, and is expressed in parts per million (ppm) or in mg/kg body weight. The consumption of agricultural products with pesticide residues above tolerance level is highly dangerous for human health (EFT 1995). In 1990 a "National Tolerance List" for Turkey was compiled. This list shows the maximum acceptable tolerance values for 81 pesticides and plant growth regulators on grains, seeds, dried fruits, fruits and vegetables, and milk and milk products (table 23).

Table 23. Tolerance values of pesticides in food (EFT 1995). Banned pesticides have not been included in the table.

Pesticide group	Food	Tolerance (ppm)
Insecticides		
Carbaryl	Rice	5
	Leafy vegetables	10
	Carrots	2
	Beans	5
Dimethoate	Wheat	0.2
	Potatoes	0.05
	Apples, peaches	1
	Apricot	2
Dichlorvos	Tomatoes, peppers, cucumber	0.2
	Fruit (citrus excluded)	0.1
	Milk	0.01
Malathion	Dried fruits	8
	Citrus fruits	4
	Vegetables	1
	Carrots	0.5
Fungicides		
Benomyl	Peaches	3
	Citrus fruits	5
	Watermelon, cantaloupe	0.5
	Milk, milk products	0.05
Dinocap	Apples, pears, strawberries, grapes	0.1
	Watermelon, cantaloupe	0.1
Herbicides		
2.4-D	Grains	0.5
	Meat, milk, eggs	0.02
	Potatoes	0.2

Depending on the degree of toxicity of the pesticides used against blights and pests, there are certain periods of time that must elapse between the final application and the harvest. If the crop is harvested immediately following pesticide application, pesticide residues may cling on to the plant surface. Consumption of such foods may constitute grave hazards for human and environmental health. In 1963 in Bursa, seven out of 32 persons who ate peaches treated with parathion died in one day (Çevre Bakanligi 1997). In Ankara , DDT residues below tolerance level were found in milk, butter and animal adipose tissue in 1976/77. However, in the same study, it was determined that amounts of aldrin and dieldrin in milk and certain butter samples were higher than recommended tolerance levels (TÇV 1995).

Environmental Effects of Pesticides

Of the pesticides used in Turkey in 1996, 28.2 percent belonged to the hazardous group (table 24). A quarter (23 percent) of the total used in Denizli and 34 percent in Aydin were made up of hazardous pesticides (Delen, Tosun, and Yildiz 1998).

Table 24.The use of hazardous pesticides (kilograms or liters of active Ingredients) in Turkey in 1996 (Delen, Tosun, and Yildiz 1998).

Pesticides	Use 1996 (kg or l)
Highly hazardous (WHO standards)	1,614,444
Chlorinated hydrocarbons	617,511
Pesticides carrying heavy metals	855,462
Methyl bromide	779,073
TOTAL	3,866,490

Development of Resistance

Certain harmful insects and disease agents are known to have developed resistance to pesticides with time. Once resistance to a particular pesticide has been acquired, the use of it must be discontinued immediately. Further use in increased doses is not economical and it only pollutes the environment. Following the extremely wide spread use of systemic fungicides in the 1970s, many varieties of fungi have acquired resistance to pesticides. In addition, *Anopheles sacharovi*, the most important vector of malaria, was determined to have acquired resistance to DDT in 1958, to dieldrin in 1964 and to BHC in 1967 in Turkey. Therefore the use of these insecticides for malaria control was discontinued (EFT 1995).

Effects on Water

In areas where agro-chemicals are extensively used, the hazardous effects of pesticides and fertilizers threaten the use of groundwater sources for drinking. In the agricultural plains of Bornova (Izmir) the excessive use of agro-chemicals resulted in significant groundwater pollution, with nitrate concentrations in the groundwater reaching the limit value of 45 mg/l (Izmir Ticaret Odasi 1995).

The aquatic half-life of the chlorinated nitrobenzene based fungicide quintozene, which is used against fungi on dry seed in Turkey, is between 15 days and 6 months. Observation of quintozene residues in fish during this period shows that more care must be taken in using this fungicide. It has to be noted here that, the use of this fungicide in aquatic agriculture is officially allowed in only nine out of the twenty-four European countries (EFT 1995).

Various proportions of pesticide residues are encountered in drains, irrigation canals, small bays, certain lakes, and in well water. Table 25 gives an example of a study on this subject done in Turkey. As the table shows, certain pesticides have been observed to contaminate irrigation, drainage and well water in varying degrees.

In Turkey, the majority of pesticides are manufactured in the Istanbul area, while their use is highest in the Mediterranean region, particularly in the Çukurova region south of Adana. Consequently, the negative effects of pesticides are most frequently observed in these areas. For example, pesticide residues in the waters of Seyhan Dam, and in the soil of that region, were detected by analyses carried out in recent years. Pesticides such as lindane, heptachlor, aldrin, dieldrin and DDT, which were found to have left residues, have since been banned (TÇV 1995).

Table 25. Residue amounts of 4 types of insecticide (in micrograms of insecticide per sampled litre of water) in water samples collected during the period 16-19 May 1976 in the area irrigated from the Adana Seyhan Dam (EFT 1995).

Sampled locations	Amounts of insecticide residues (µg/l)			
	Lindane	Heptachlor	Aldrin	Endosulfan
Irrigation Canal				
Dam regulator	0.06	0.14	0.28	-
Main canal	0.06	0.15	0.52	0.1
Zeytinlik village	0.28	-	0.40	-
Çiçekli village	0.13	-	0.68	-
Drainage Canal				
Sirkenli village canal	0.08	-	0.90	0.20
Pasaköy-Danisment area	0.19	0.69	0.48	0.18
Çavus Inapli area	0.24	-	0.79	0.27
Dörtagaç village	0.16	0.18	0.17	-
Village Water				
Kamisli village	0.16	-	0.89	0.17
Pasa village	0.22	0.73	0.65	0.26
Kilise village	0.31	-	1.13	0.21
Çiçekli village	0.37	0.19	0.81	-

In 1975, chlorinated hydrocarbon residues of DDT, BHC, aldrin, dieldrin and endrin were detected in industrial fish oils and in the tissue of such fish as anchovies, whiting, grey mullet, red mullet, surmullet, and horse mackeral, caught between Trabzon and Eregli on the Black Sea coast. This discovery demonstrated that the Black Sea is also becoming polluted with agricultural pesticides. It was, however, determined that these residues were not as yet at such a level as to constitute a hazard for human health (TÇV 1995).

During 1976-1977, high levels of pesticides were detected in various species of fish and samples of shrimp obtained from the Mediterranean coast between Iskenderun and Antalya. The total level of organic chlorinated insecticides found in fish flesh was determined to be 0.339 mg/kg with DDT detected in 100 percent of the fish samples, dieldrin in 74.7 percent, BHC in 99.1 percent, aldrin in 86.7 percent and endrin in 65.5 percent. Another study in 1976-1978 on Mediterranean fish and shrimp specimens, encountered total mercury and methyl mercury in all specimens and ethyl mercury in 61.6 percent of them. Average mercury levels were determined to be 0.345 mg/kg for total mercury and 0.319 mg/kg for organic mercury residue (TÇV 1995).

Waste from the European countries carried by the river Danube and pesticide residues carried by rivers flowing through Russia to the sea around Crimea have been cited as playing a role in the increase of pesticide residues in the Black Sea (TÇV 1995). Amounts of DDT found in Black Sea fish were found to be greater than those found in Mediterranean fish, while BHC isomers, aldrin, dieldrin and endrin levels in Mediterranean fish were higher than those in Black Sea fish.

Effects on Beneficial Insects

Between 1980 and 1985 significant reductions were observed in the populations of the predatory insects *Huppodamia variegata* Goeze and *Anisochrysa crane (steph*.) in the Adana region. It is suggested that this was an effect of the use of pesticides, containing endosulfan, pirimicarb, deltamethrin, azinphos-methyl, chlorpyrifos-ethyl, ddiazinon, dimethoate, renthion, rormothion, malathion, methidathion, methoate, parathion-methyl, phosalone, posmet and phentriazophos as their active ingredients, in the fruit orchards around Adana (EFT 1995).

The use of pesticides has an adverse effect on honeybees and silkworms, both of which have an important place in the nation's economy. The toxic pesticides sprayed by aircraft in the Aegean and Mediterranean regions affect the mulberry leaves, which are the natural food of silkworm larvae. It has been advised that their leaves must not be collected under any circumstances during periods when these areas are being treated with pesticides (TÇV 1995).

Widespread aerial spraying of pesticides is more damaging to honeybees than applications that use ground equipment. A total of 995 tons of the pesticides decis, komithion, imperator and agromethrin were sprayed by aircraft, over an area of 44,235 hectares in Thrace and the Southeast Anatolian region in 1987, to control the wheat pest *Eurygaster integriceps* Put. Despite prior warnings to beekeepers, thousands of colonies of bees were exterminated. Herbicides and fungicides are not as harmful to bees as are insecticides. However, it has been found that when the herbicides, dinoseb, 2.4-D and atrazin are applied, they have an immediate toxic effect on bees. This effect diminishes progressively over the following days. Therefore in order to minimize the toxic effects of pesticides on bees, it is suggested that when and where possible, to use nightly applications of short, persistent, and low toxic pesticides during the non-blooming seasons of plants.

Effects on Animals

Pesticides are also hazardous to other living creatures in the environment. Especially in Çukurova (Adana), large quantities of pesticides are used on cotton (Atalay et al. 1998, TÇV 1998) and this has caused a substantial loss of wild life in the area and even in as far as the Toros mountain region (Uluatam 1994).

The effects of pesticides on birds usually occur through their feeding on chemically destroyed insects. As a result of careless placement of poisoned wheat in mouse holes to fight the field mouse menace, many meadowlarks died in the Southeast Anatolian region in 1982 from eating the seeds (EFT 1995).

One of the chief reasons for deaths among the *Geronticus eremita*, a migratory bird facing extinction, is the toxic effect of agricultural pesticides. Between 1950 and 1960, following intensive treatment with DDT and dieldrin, around 650 of these birds died in the breeding area of Birecik, a sub-province of Sanliurfa. Furthermore, the use of persistent pesticides has been responsible for the birds' failure to breed. In a study done in 1964, lethal doses of DDT derivatives were detected in both the eggs and the offspring of these birds. The bird population of the Birecik colony, which failed to produce a single offspring up to 1972, had declined to around 23 pairs in 1973. In 1983, only eight pairs exhibited reproductive success.

WATER QUALITY ISSUES IN TURKEY

Although surrounded by water on three sides, and with an intimate relationship with the sea, Turkey's inland fresh water resources are severely limited. Therefore, the enactment of comprehensive legislation to protect fresh water supplies for the growing consumer needs and to protect the coast and the seas with their vast potential for the development of fishing and tourism, has become a vital necessity.

Water Pollution and the Protection of Water Resources

Institutions and Legislation

In Turkey, many ministries and government agencies are responsible for the protection of water resources and the control of water pollution. The ministries working in this field and the major agencies acting under the authority of these ministries are the Prime Ministry, the Ministry of Environment, the Ministry of Energy, the Ministry of Agriculture, the Ministry of Tourism, the Ministry of Industry, the Ministry of Public Works, the Ministry of Health, and the Ministry of Transportation (EFT 1995).

In addition, local government administrations are also engaged in the efforts towards water pollution control (EFT 1995). Under the laws governing the municipalities, the Istanbul Water and Sanitation Administration was established in 1982. This administration has issued regulations against the pollution of the drinking water supply. It has set standards for the disposal of sewage, and has commenced implementing them in the city of Istanbul. In 1987, similar institutions were set up in Ankara and Izmir, and these have issued their own regulations (EFT 1995).

There is a large number of voluntary foundations, societies and other organizations that actively participate in studies on water pollution and its control in Turkey. In addition, scientific institutions and universities offer education and carry out research on water pollution and its control in Turkey (EFT 1995). Turkey co-signed a number of international conventions and protocols on water quality, which are mostly concerned with the protection of the Mediterranean Sea.

The law most applicable to the prevention of water pollution in Turkey is the 1971 Aquatic Products Law. It is found that, since this law assesses only aquatic environments from the standpoint of their suitability for raising fish, it falls far short of providing a solution to the problem of water pollution on a nationwide basis. The first step towards true environmental legislation was taken in the 1982 Constitution, with the enactment of an important Environment Law in 1983. Since then, several regulations have followed to facilitate the implementation of this law. Further more, Turkey has enacted a number of laws, regulations and statutes on the subject and is also a party to a number of international agreements directly or indirectly concerned with the environment and water pollution. There are various governmental agencies and institutions that are responsible for preventing water pollution. Therefore, as the authority is spread out over a number of different agencies, effective water pollution control has never been achieved. However, once the need for comprehensive legislation with wide ranging powers over the control of water pollution was realized, the Water Pollution Control Regulation was enacted in 1988, in line with the 1983 Environment Law (Resmi Gazete 1988).

The 1988 Water Pollution Control Regulation

The purpose of the Water Pollution Control Regulation was to define the legal and technical principles regarding the protection of the national water resource potential. This regulation preventing water pollution was enacted to ensure the use of water in the best possible way that would be harmonious with the socio-economic development efforts of the nation. The main priorities of the regulation are the prevention of the spread of water pollution over the country's surface, the protection of groundwater, the prevention of coastal and sea pollution, and the regeneration of polluted aquatic environments. These priorities, which have been made operational, are summarized below (Resmi Gazete 1983, 1988).

Classification of Aquatic Environments. Under the Water Pollution Control Regulation of 1988 all water resources have been classified according to criteria of uses and quality. This has been done with the view of controlling water pollution effectively. First, water quality criteria are used to determine the effects on human and other forms of life of various polluting elements found in water. Second, it is described what kinds of damages may arise in which concentrations and under which conditions. Based on this classification, the restrictions on waste discharges and the principles for their protection are then derived. Also, if there is a need to demarcate special protected areas near the water resources or if it is required to upgrade water from a particular source to the highest quality, the principles governing the sort of measures to be taken and how water samples are to be assessed, are spelled out in the Regulation.

Direct Wastewater Discharges from Point Sources. According to the Regulation, wastewater may be discharged either into the general sewage systems, directly into a receiving environment, or into the sea. The waste discharge standards in the Regulation are the principal means of controlling the discharges, because they are legally effective and convenient to implement. Every water pollutant source over a given size is required to make a report and to obtain a permit. The report should include the amount of their industrial production with production flow charts showing sources and nature (hazardous or not) of wastewater. It is only after an inspection by the relevant authorities, that a discharge permit is issued.

For each branch of industry, separate standards governing direct discharges into receiving environments have been determined, so that each sector is required to put forth equal technological efforts to purify their wastewater. Adequate safety measures have to be taken before the industrial wastewater can be discharged into the city sanitation network or directly into a receiving environment. The discharge permits are to be renewed at regular intervals, after further inspections determining whether the measures taken are conform the standards set in the regulation. When applying for permits for the first time, new industrial plants have to conform to all standards set in the Regulation. Those industries already in operation are given a grace period of transition to conform to the stipulated standards.

Taking cost/benefit ratios into account, the discharge standards described in the Regulation have been kept at rather tolerant levels at the start, in view of their effects on the nation’s development efforts. It is noted that the standards specified in the 1988 Water Pollution Control Regulation are inadequate for protecting especially sensitive receiving environments. The ultimate intention, however, is to introduce more and more stringent standards in the future as the need for better protection of the environment arises or in the light of problems encountered in actual practice.

Urban Wastewater Systems. Large treatment plants incorporate high safety reserve capacity against fluctuations in wastewater outputs, pollution loads, and shock loads. This type of wastewater treatment allows for the collection and treatment of industrial wastewater, together with domestic wastewater in urban areas. A prerequisite for this arrangement is that the industrial wastewater in question does not cause any damage to the general sanitation network, or the treatment facilities. If such a potential exists, the damaging pollutants should undergo treatment, prior to their introduction into the general treatment system. Alternative ways of discharging wastewater into the treatment system are also stated in the Regulation.

Water Quality Standards

Inland Water

Inland waters are classified in four water quality classes, ranging from High Quality to Highly Polluted, on the basis of a range of parameters (table 26). The 1988 Water Pollution Regulation also describes the types of water uses, for which each of the first three quality classes are suitable (table 27). Highly Polluted water cannot be used for any of these particular purposes.

Drinking Water

The current water quality standards for drinking water are established by the Turkish Institute of Standards and are coded as TS266. The latest version of these standards includes a description of spring (Class 1) and potable (Class 2) water, each with its own properties, sampling and analysis methods, and means of controlling the quality of water conveyed for consumption. The properties of drinking water are considered in three groups as: physical and chemical, bacteriological, and radiological (TSE 1965). The standards are set for sources of water that are to be consumed without treatment (table 28).

The fourth section of the Water Pollution Control Regulation defines prohibitions and principles of water quality planning and management. A zone of "absolute protection" is defined to surround a water supply reservoir at a distance of 300 meters. All kinds of activities are prohibited within this zone. The "short-distance protection zone" encompasses the area that extends up to 700 meters from the defined outer boundary of the absolute protection zone. Agriculture is permitted in this area provided that fertilizers and pesticides are not used, while animal farming is prohibited. The "intermediate distance protection zone" extends to a distance of 1 km from the boundary of the short-distance protection zone. Here too agricultural activities are permitted but without the use of artificial fertilizers and pesticides.

Irrigation Water

The total salt concentration (via EC measurements) and the Sodium Absorption Ratio (SAR) together determine the sodium and salinity hazard of irrigation water (figure 13). Water quality criteria pertaining to different classes of irrigation water are specified in table 29, with maximum permissible concentrations of heavy metals and toxic elements in table 30.

Routine Monitoring of Water Quality

Turkey is presently developing a nation-wide water quality monitoring network, involving two major agencies: State Hydraulic Works (DSI) and Electrical Works Authority (EIE).

State Hydraulic Works started sampling in 1979 at 65 sites and is currently monitoring more than 1,000 sites. The measurements are taken on a monthly basis with several gaps and missing values, while available data records cover a short term only (the longest being 10 to 14 years). Two groups of variables are observed: variables that are to be monitored at every site and more specific variables at particular sites, depending on water use and sources of pollution.

Table 26. The classification of inland waters according to quality (Resmi Gazete 1991).

Water quality variables	Water quality classes			
	I	II	III	IV
	High quality	Moderate quality	Polluted	Highly polluted
Physical and inorganic-chemical parameters				
Temperature (°C)	25	25	30	>30
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0
Dissolved oxygen (mg O_2/l)[a]	8	6	3	>3
Oxygen saturation (%)[a]	90	70	40	>40
Chloride ion (mg Cl^-/l)	25	200	400[b]	>400
Sulfate ion (mg SO_4^{2-}/l)	200	200	400	>400
Ammonia-nitrogen (mg NH_4^+-N/l)	0.2[c]	1[c]	2[c]	>2
Nitrite-nitrogen (mg NO_2^--N/l)	0.002	0.01	0.05	>0.05
Nitrate-nitrogen (mg NO_3^--N/l)	5	10	20	>20
Total phoshate (PO_4^{3-}-P/l)	0.02	0.16	0.65	>0.65
Total dissolved solids (mg/l)	500	1,500	5,000	>5,000
Color (Pt-Co Unit)	5	50	300	>300
Sodium (MgNa^+/l)	125	125	250	>250
Organic parameters				
COD (mg/l)	25	50	70	>70
BOD (mg/l)	4	8	20	>20
Total organic carbon (mg/l)	5	8	12	>12
Total Kjeldahl-Nitrogen (mg/l)	0.5	1.5	5	>5
Emulsified oil and grease (mg/l)	0.02	0.3	0.5	>0.5
Methylene-blue-active substances (MBAS)(mg/l)	0.05	0.2	1	>1.5
Phenolic substances (volatile) (mg/l)	0.002	0.01	0.1	>0.1
Mineral oil and derivatives (mg/l)	0.02	0.1	0.5	>0.5
Total pesticides (mg/l)	0.001	0.01	0.1	>0.1
Inorganic contamination parameters[d]				
Mercury (?g Hg/l)	0.1	0.5	2	>2
Cadmium (?g Cd/l)	3	5	10	>10
Lead (?g Pb/l)	10	20	50	>50
Arsenic (?g As/l)	20	50	100	>100
Copper (?g Cu/l)	20	50	200	>200
Chromium (total) (?g Cr/l)	20	50	200	>200
Chromium (?g Cr^{+6}/l)		20	50	>50
Cobalt (?g Co/l)	10	20	200	>200
Nickel (?g Ni/l)	20	50	200	>200
Zinc (?g Zn/l)	200	500	2,000	>2,000
Cyanide (total) (?g CN/l)	10	50	100	>100
Fluorine (?g F^-/l)	1,000	1,500	2,000	>2,000
Free chlorine (?g Cl_2/l)	10	10	50	>50
Sulfur (?g S^2/l)	2	2	10	>10
Iron (?g Fe/l)	300	1,000	5,000	>5,000
Manganese (?g Mn/l)	100	500	3,000	>3,000
Boron (?g B/l)	1,000[e]	1,000[e]	1,000[e]	>1,000
Selenium (?g Se/l)	10	10	20	>20
Barium (?g Ba/l)	1,000	2,000	2,000	>2,000
Aluminium (mg Al/l)	0.3	0.3	1	>1
Radioactivitiy (pCi/l) 1. alfa-activitiy	1	10	10	>10
2. beta-activitiy	10	100	100	>100
Bacteriologic parameters				
Fecal coliform (MPN/100 ml)	10	200	2,000	>2,000
Total coliform (MPN/100 ml)	100	20,000	100,000	>100,000

[a] Either concentration values or saturation ratios must be satisfied.
[b] This concentration limit should be decreased when chlorine-susceptible plants are irrigated.
[c] The value of free ammonia-nitrogen should not exceed 0.02 mg NH_3-N/l due to pH value.
[d] The criteria under this group indicate the total concentrations of chemicals.
[e] The criteria may have to be decreased down to 300 ?g/l when boron-susceptible plants are irrigated.

Table 27. The suitability of the classified inland waters for different purposes (Resmi Gazete 1988).

Water quality class	Suitable purpose
I. High Quality	Domestic water supply after disinfection Recreational water uses including swimming Trout fisheries All types of farming
II. Moderate Quality	Domestic water supply after appropriate or advanced treatment Recreational purposes Fisheries other than trout Irrigation (see also irrigation water quality criteria) All other uses except those in class I
III. Polluted	Industrial water supply except for food and textile industries

Table 28. The physical and chemical properties of drinking water (TSE 1965).

	Spring water	Potable water	
Water quality variables	Maximum value	Permissible value	Maximum value
Toxic substances			
Lead (pH)	-	-	0.05 mg/l
Selenium (Se)	-	-	0.01 mg/l
Arsenic (As)	-	-	0.05 mg/l
Chromium (Cr^{+6})	-	-	0.2 mg/l
Cyanide (CN)	-	-	0.01 mg/l
Substances that affect health			
Fluorine (F)	1 mg/l	1.0	1.5 mg/l
Nitrate (NO_3)	25 mg/l	-	45 mg/l
Substances that affect the potability of water			
Color	5 units	5 units	50 units
Turbidity	5 units	5 units	50 units
Taste and odor	odorless, normal taste	odorless, normal taste	Odorless, normal taste
Residue of evaporation	500 mg/l	500 mg/l	1500 mg/l
Iron (Fe)	0.3 mg/l	0,3 mg/l	1.0 mg/l
Manganese (Mn)	0,1 mg/l	0,1 mg/l	0,5 mg/l
Copper (Cu)	1 mg/l	1 mg/l	1.5 mg/l
Zinc (Zn)	5 mg/l	5 mg/l	15 mg/l
Calcium (Ca)	25 mg/l	75 mg/l	200 mg/l
Magnesium (Mg)	10 mg/l	50 mg/l	150 mg/l
Sulfate (SO_4)	20 mg/l	200 mg/l	400 mg/l
Chlorine (Cl)	20 mg/l	200 mg/l	600 mg/l
PH	7,0-8,5	7,0-8,5	6,5-9,2
Residual chlorine	-	0.1 mg/l	0.5 mg/l
Phenolic substances	-	-	0.002 mg/l
Alkaline-benzo-sulfonate	-	0.5 mg/l	1.0 mg/l
$Mg+Na_2SO_4$	-	500 mg/l	1000mg/l
Indicators of pollution			
Total organic substances	2,0 mg/l	3.5 mg/l[a]	-
Nitrite	-	-	-
Ammonia	-	-	-

[a] Bacteriological analysis should be interpreted with care if the total organic substance concentration is above 3.5 mg/l.

Figure 13. The Classification of irrigation water on the basis of total salt concentrations and SAR (Resmi Gazete 1991).

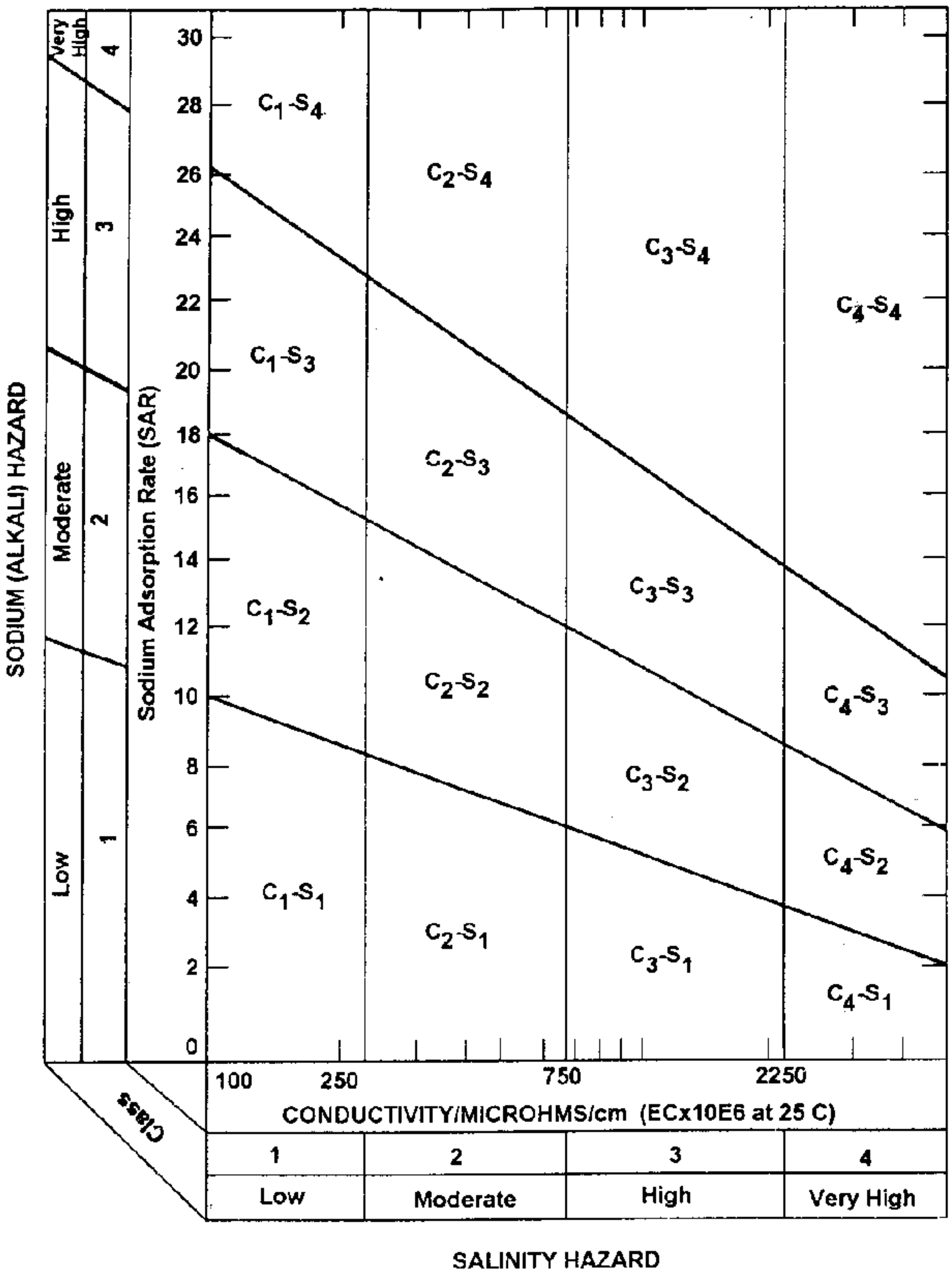


Table 29. Quality criteria for irrigation water (Resmi Gazete 1991).

Quality Criteria	Class of Irrigation Water				
	Very good	Good	Can be used	Can be used with caution	Unsuitable (bad)
$EC_{25}x10^6$ (? mhos/cm)	0-250	250-750	750-2,000	2,000-3,000	>3,000
Variable sodium percentile (Na %)	<20	20-40	40-60	60-80	>80
Sodium absorption ratio (SAR)	<10	10-18	18-26	>26	
Residue of sodium carbonate (RSC)					
meg/l	<1.25	1.25-2.5	>2.5		
mg/l	<66	66-133	>133		
Chlorides (Cl^-)					
meg/l	0-4	4-7	7-12	12-20	>20
mg/l	0-142	142-249	249-426	426-710	>710
Sulfates (SO_4^{-2})					
meg/l	0-4	4-7	7-12	12-20	>20
mg/l	0-192	192-336	336-575	576-960	>960
Total salt concentration (mg/l)	0-175	175-525	525-1,400	1,400-2,100	>2,100
Boron concentration (mg/l)	0-0.5	0.5-1.12	1.12-2.0	2.0	
Class of irrigation water (according to figure 13)	C_1S_1	C_1S_1, C_2S_2, C_2S_1	C_1S_3, C_2S_3, C_3S_3, C_3S_2, C_3S_1	C_1S_4, C_2S_4, C_3S_4, C_4S_3, C_4S_2, C_4S_4, C_4S	
NO_3^- or NH_4^+ (mg/l)	0-5	5-10	10-30	30-50	>50
Fecal coliform (1/100 ml)	0-2	2-20	$20-10^3$	10^2-10^3	$>10^3$
BOD5 (mg/l)	0-25	25-50	50-100		
Suspended solids (mg/l)	20	30	45	60	>100
PH	6.5-8.5	6.5-8.5	6.5-8.5	6-9	>6 or <9
Temperature	30	30	35	40	>40

Table 30. The maximum permissible heavy metal and toxic element concentrations in irrigation water.

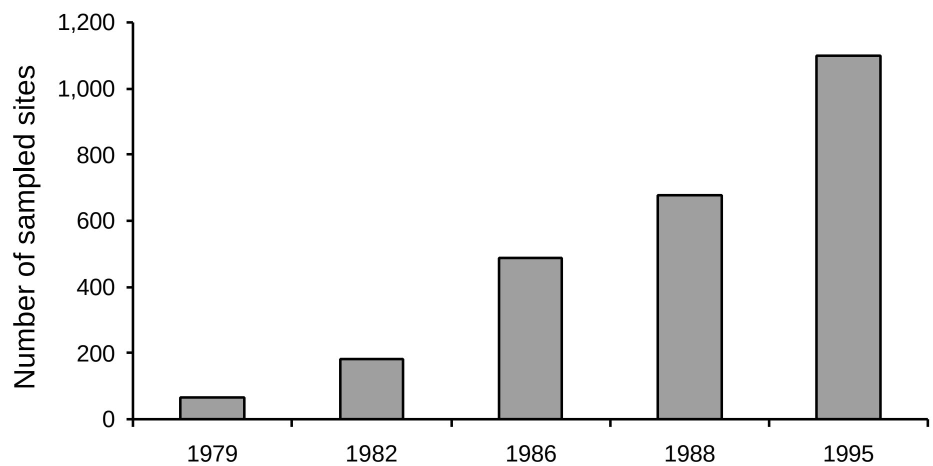
Elements	Maximum total amount for unit area (kg/ha)	Maximum permissible concentrations	
		All kinds of soils when continuous irrigation is practiced (mg/l)	Clay soils having pH values of 6.0-8.5 when irrigated for less than 20 years (mg/l)
Aluminum (Al)	4,600	5.0	20.0
Arsenic (As)	90	0.1	2.0
Berylium (Be)	90	0.1	0.5
Boron (B)	680	-[c]	2.0
Cadmium (Cd)	9	0.01	0.05
Chromium (Cr)	90	0.1	1.0
Cobalt (Co)	45	0.05	5.0
Copper (Cu)	180	0.2	5.0
Fluorine (F)	920	1.0	15.0
Iron (Fe)	4,600	5.0	20.0
Lead (Pb)	4,600	5.0	10.0
Lithium (Li)[a]	-	2.5	2.5
Manganese (Mn)	920	0.2	10.0
Molybdenum (Mo)	9	0.01	0.05[b]
Nickel (Ni)	920	0.2	2.0
Selenium (Se)	18	0.02	0.02
Vandium (V)	-	0.1	1.0
Zinc (Zn)	1,840	2.0	10.0

[a] For irrigated citrus fruits
[b] Only for acidified clay soils with high iron content
[c] Given in table 26

The Electrical Works Authority has started water quality sampling in the early 1970's. Currently, at 79 of 285 stream gauging stations, water quality is observed to assess the quality of rivers for purposes of irrigation and to assure the safety of hydraulic structures. Like State Hydraulic Works, the Electrical Works Authority also performs monthly observations on a rather uniform basis.

Both agencies are expanding their networks in terms of sampling sites and variables sampled (figure 14). However, this expansion is carried on without clearly defined objectives and guidelines. As government subsidies are withdrawn, the monitoring agencies are now questioning the performance of the existing networks. The first step is an assessment of the efficiency and cost-effectiveness of current monitoring practices (Harmancioglu, Özer, and Alpaslan 1987, Alpaslan and Harmancioglu1990, 1991a, 1991b, 1993a, 1993b, Harmancioglu and Alpaslan 1992, Harmancioglu, Alpaslan, and Singh 1992a, 1992b, 1992c, 1994, 1998, DEU 1993, Harmancioglu, Alpaslan, and Özkul 1994, Harmancioglu, Alpaslan, and Alpaslan 1994, Özkul et al. 1995, Alpaslan 1996b, Harmancioglu et al. 1996, Harmancioglu, Özkul, and Alpaslan 1998, Harmancioglu, Singh, and Alpaslan 1998). The result of such an evaluation should lead to a redesigning of the process to assure an optimal performing network.

Figure 14. Water quality monitoring by State Hydraulic Works (DSI) from 1979 to 1995 (Harmancioglu et al. 1994a).



Harmancioglu et al. (1994a) have initiated the assessment process in Gediz and Sakarya basins. They have disclosed that monitoring networks in Turkish rivers are far from being systematic, and further, that monitoring objectives and information expectations are not clearly defined (Alkan et al. 1995). At present, DSI and the water resources research team established at Dokuz Eylul University are cooperating in a research project for assessment and redesign of the monitoring network, in the Gediz River basin in Western Turkey (Harmancioglu et al. 1998).

Some studies have disclosed that water pollution has reached significant levels in Antalya, Kizilirmak, Sakarya Seyhan, Susurluk, Northern Agean, Meriç, Marmora, Gediz, Yesiirmak, and Büyük Menderes basins (Alpaslan, Harmancioglu, and Özkul 1993, Harmancioglu et al. 1993, 1994b, 1997, Alpaslan, Harmancioglu, and Saner 1994a, 1994b, Alpaslan et al. 1995, 1997, Barbaros et al. 1996, Çevre Bakanligi 1997, Harmancioglu and Alpaslan 1998).

Reuse of Wastewater

Existing Standards

Standards for the re-use of wastewater for irrigation are given in the Water Pollution Control Regulation. Wherever water for irrigation is scarce, it is recommended to re-use treated wastewater that meets the water quality criteria needed for irrigation. These criteria are determined jointly, by DSI, the Bank of Provinces, and the Ministry of Agriculture and Rural Services. According to these criteria, the following parameters for treated wastewater should be examined prior to their use for irrigation. (Resmi Gazete 1991):

? Total dissolved solids concentrations and electrical conductivity
? Sodium concentration, relative to other salts
? Concentrations of boron, heavy metals and other toxic substances
? Ca++ and Mg++ concentrations
? Total solids, organic substances and floating substances such as oil and grease
? Pathogenic microorganisms

Table 31 describes the basic principles and technical limitations to be applied when re-using wastewater in irrigation. Table 32 presents the same when industrial wastewater is used.

Table 31. Principles and technical limitations for using wastewater in irrigation (Resmi Gazete 1991).

Type of agriculture	Technical Limitations
Fruit and grape harvesting	Sprinkler irrigation is prohibited Fruits that have fallen down should not be eaten Fecal coliform numbers should be less than 100 / 1,000 ml
Fiber plants and seed production	Surface or sprinkler irrigation can be applied Biologically treated and chlorinated wastewater can be used in sprinkler irrigation Fecal coliform numbers should be less than 1,000 / 100 ml
Fodder, flower plantation, oil plants and plants that will not be eaten raw	Surface irrigation can be applied using mechanically treated wastewater

Table 32. Suitability of wastewater from different types of industries for irrigation (Resmi Gazete 1991).

Appropriate for irrigation	Appropriate for irrigation only if the water is treated so as to comply with the values of tables 29 and 30.	Not appropriate as irrigation water
Brewery, Winery, Malt, Yeast, Potato, Vegetable processing, Marmalade, Fruit processing, Dairy, Potato starch industries	Sugar, Rice and Cereal starch, Tannery-glue, Animal-glue, Slaughterhouse, Meat-packing, Margarine, Pulp and paper, Textile, Fish, Metal industries	Soap, Inorganic heavy chemical, Dye stuffs and intermediates, Pharmaceutical, Metal, Cellulose, Pyrolisis plant, Fuel and oil, Coal washing, Steam power plants, Explosive industries

Options for the Use of Wastewater in Irrigation

Despite the elaborate standards mentioned above, wastewater is not yet used for irrigation in any actual case in Turkey, except for some small industries and a pilot project under GAP. Specific studies have investigated the possibilities of re-using wastewater for irrigation purposes (Sarikaya 1994). One study was carried out by the Dokuz Eylül University, which focused its attention on the use of treated urban wastewater from the Cigli treatment plant, currently under construction, to irrigate the Menemen plains. Two investigations for the Southeastern Anatolia Project (GAP) focused on the re-use of drainage water and on the use of urban wastewater (Altinbilek and Akçakoca 1997):

Re-use of drainage water in the Urfa-Harran plain. It is estimated that approximately 40 percent of the water supplied for irrigation will be lost to drainage during the irrigation season. As this rate is very high, it is recommended to re-use this drainage water for irrigation purposes and thus reduce the quantity of irrigation water to be diverted from the Atatürk dam. In addition, the problems related to the disposal of drainage water are reduced and a smaller salt load will be carried downstream. An annual water balance study examined the collection of drainage water by diversion structures and its conveyance to pumping stations where it was to be lifted back into canals to irrigate the lower parts of the plain (DSI 1992). The impact of re-use on the quantity and quality of water draining from the Urfa-Harran plain was then used as a model study (GAP-RDA 1994). The results indicated that there are significant advantages in re-using as much drainage water as possible, depending upon the development of irrigation and cropping patterns in the plain (Altinbilek and Akcakoca 1997).

Re-use of urban wastewater in irrigation. In the GAP region, urban wastewater is planned to be used in irrigation without any treatment. However, this may lead to health hazards. A pilot study has been started to assess the feasibility of using slow-rate land-treated urban wastewater in irrigation. This will be implemented in three phases. First the potential treatment sites will be evaluated. Then a slow-rate land treatment system will be designed, followed by the preparation of application projects and the final implementation (Altinbilek and Akcakoca 1997).

WETLANDS IN TURKEY

Importance of Wetlands

Wetlands are generally no more than six meters in depth, with stagnant or slow flowing, fresh, salt or brackish water. These temporary or permanent bodies of water include lakes, marshes, swamps, lagoons, slow flowing segments of rivers, stagnant canals, flood plains and tidal regions on the coasts. Turkey is a country rich in wetlands, ranking first in this respect among the Middle Eastern and European countries, with the exception of the Commonwealth of Independent States (former USSR). The number of wetlands in the country exceeds 250 with a combined area of approximately one million hectares. Almost 75 wetlands are larger than 100 hectares. In addition to these natural wetlands, Turkey also has a large area of artificial wetlands consisting of dammed lakes and reservoirs (TÇV 1993). Of all Turkish wetlands, 60 percent has freshwater, 20 percent salt water and another 20 percent brackish water.

After tropical forests, wetlands are the ecosystems with the largest production of organic matter per unit area. For this reason, wetlands are of considerable economic importance and play an important role in regulating the relative humidity of the environment, in the movements of the water table, and in the generation of oxygen. Wetlands are, therefore, among the ecosystems that need most protection.

Turkey's wetlands are important because they are concentrated in Anatolia, which is crossed by two major bird migration routes. Of the close to 400 species of birds found in Turkey, 250 are migratory birds. Approximately one-third of the 110 species that migrate to Turkey in summer, breed and find refuge in Anatolia. Aquatic birds, classed as winter migratory birds make up the remainder. These too use Turkey's wetlands as their winter stopover. According to the criteria of the Society for Conservation of Natural Life, 61 wetlands satisfy the criteria of an Important Bird Habitat (Yarar and Magnia 1997). Turkey adopted the Ramsar Convention on Internationally Important Wetlands as a habitat for birds in May 17, 1994, and identified five wetlands as Ramsar Land: Göksu Delta, Manyas Bird Sanctuary, Sultan Marsh, Lake Burdur and Lake Seyfe. Based on international criteria, 18 wetlands have been classified as first class (Class A), areas that can offer refuge and food to over 25,000 birds at a time. An additional 45 wetlands have been identified as Class B, accommodating 10,000-25,000 birds (TÇV 1993).

Threats to Wetlands

With the adoption of the 1952 Environmental Impact Evaluation Regulation, wetlands have been classified as "sensitive regions", and the preparation of an Environmental Impact Assessment (EIA) became compulsory for most activities concerning these Wetlands. The most serious unfavorable development encountered in the preservation of wetlands is intentional draining. Swamps and marshes have been drained and reclaimed for agriculture and for malaria control (EFT 1995). As Demirel (1998) points out, malaria is one of the most significant factors among wars, earthquakes, and fires that led to destruction of civilizations in Anatolia. The early practices of fighting against malaria included the drying of the Cellat swamp, which is now called Cumaovasi and covered by agricultural lands and the Izmir airport. Several lakes such as Gavur, Emen, Amik, and Mizmilli were converted into cotton fields (Demirel 1998). With time, the original purpose of malaria control gave way to the new purpose of land reclamation for economic purposes. The total area of wetlands drained by 1986 exceeded 190,000 hectares (TÇV 1993).

Only 35 percent of the land reclaimed as a result of these draining projects has actually become useful for farming. The area registered as national treasury land and allocated to peasants is even smaller. Ownership disputes are still continuing over a part of these lands. The parts of the drained areas unsuitable for agriculture were turned over to the neighboring villages as pasture land. Unfortunately, this land has become unproductive due to salinization, burning of peat, and wind erosion.

The loss of wetlands in the Mediterranean countries is highly significant. In fact, internationally important sites listed under the Ramsar Convention are threatened. The main causes of the problem are population pressure, lack of public and political awareness, lack of political will, over-centralized planning procedures and financial policies. The plans for dams in Turkey are so extensive that multilateral agencies should examine their funding plans in the light of its policy of protecting 'intact rivers'. Whilst environmental impact assessments are undertaken in Turkey, they tend to be rather narrowly defined and closely linked to the objectives of the agency promoting the project. There seem to be a limited knowledge base on wetlands in Turkey, which is a major handicap for both conservation efforts and policy formulation. One of the major problems facing Turkish wetlands is the sectoral and centralized nature of planning (Holllis 1994). Hunting, and especially the implementation of hunting rules, is a serious problem in Turkish wetlands, as is the case in most Mediterranean countries (Finlasyon, Hollis, and Davis 1992). However, it must be emphasized that whilst hunting can degrade wetlands functioning as habitats for water birds, it does not represent a major threat to the integrity of the habitat, as does inappropriate water management (Hollis 1994).

A second important threat to the wetlands is pollution, both directly and indirectly by rivers that feed them. Particularly suspended solids in contaminated rivers accumulate in stagnant wetlands. The heavy metals and pesticides cause mass deaths of fish, frogs and waterfowl. Another threat to wetlands is the collection of bird eggs and frogs, cutting and burning of grasses, grazing cattle, especially water buffalo, in the shallow areas.

Hollis (1994) listed several recommendations for the Turkish government and water sector to be put into practice for the protection of wetlands. These recommendations state that the government, in collaboration with non-governmental organizations and the scientific community, should undertake an inventory of Turkish wetlands. This should encompass functions and values as well as hydrology and ecology. ‘Lost’ and degraded wetlands ought to be included so as to form the basis for any future policy of wetland restoration (Hollis 1993). Then the government should incorporate into the mission of State Hydraulic Works (DSI), the enhancement of the conservation, sustainable use, and restoration of wetlands. The government will also have to implement a policy of charging the true cost for water and electricity, i.e., by taking into account the full cost of protection measures for the environment and full and continuing compensation for losses downstream due to dams. Then a commitment should be made by the Government to integrate the management of water resources and wetlands across national boundaries. DSI should also undertake integrated river basin planning in conjunction with all other related agencies and interest groups. The approach must also recognize all demands and all resources within the context of sustainable development. DSI should subject every dam project to a searching scrutiny of its environmental, social, and economic impacts especially in downstream reaches, and undertake an overall cost benefit analysis, that acknowledges opportunities foregone in the past as well as those of the future. Operational strategies for dams should maintain, as far as possible, the downstream regime of water and sediment flows (Hollis 1994).

Some Turkish Wetlands

Four wetlands in Turkey will be discussed in detail to present the different issues related to wetland management.

Göksu Delta

The Göksu Delta (130 square kilometers) has been built out into the sea by the deposition of sediments from the Göksu River’s catchment area (10,069 square kilometers). The main hydrological features of the delta are the high annual river flow of 3,456,000 cubic meters and a strong seasonal climatic cycle. The highest flows in April come from snowmelt and floods occur with velocities of over 2,000 m^3/s during this period. The groundwater is replenished by infiltration of the river water and underground flow from the coastal mountains (83 m^3/day in the uppermost 4 meters). Both in the groundwater and on the surface in the lagoons and the river mouth, interfaces of freshwater and salt water can be found (Hollis 1994).

The Delta has a thriving agricultural sector based upon citrus groves, the cultivation of rice, irrigated vegetables, and wheat. There is a strong fishing industry in the coastal lagoons and offshore where the nutrients and freshwater of the Göksu river are vital to the productivity of the coastal zone. A strong beach-based tourist sector has developed in the 1980s, although its spread around the entire delta has been halted by the declaration of the delta as a Special Protection Area. Marine turtles nest on some of the beaches. The rich avifauna in this Class A wetland, make the Göksu delta particularly attractive to hunters and poachers (DHKD 1992).

Irrigation. The water regime of the delta has been greatly transformed by the canalization of the river, and the commissioning of the extensive irrigation system (20 m^3/s for 5,900 hectares). The irrigation scheme has flushed salt from soils and groundwater, raised groundwater levels locally, and generated a substantial flow of agricultural runoff to the two coastal lagoons of Akgol and Paradeniz. Akgol has been transformed from a seasonal salt plain to a perennial lake, with the salinity varying from 1 to 10 g/l. While these freshwater inflows have, so far, been largely beneficial to environmental and fishery conditions, there are long-term threats from sedimentation (up to 0.6 meters since 1968), eutrophication from nutrients, and pollution by pesticides and herbicides.

Future developments. The planned Kayraktepe dam will generate 991 GWh of hydro power, further reduce the flood risk in the Delta, and deliver approximately the same flow each month to the sea. However, the environmental impact assessment for the dam did not discuss the downstream impacts. Yet, it is felt that the silting-up of the reservoir (7 million tons/year) and the loss of spring flushes of freshwater, sediment and nutrients will degrade the coastal ecosystem, reduce fisheries productivity and lead to significant coastal erosion.

The qualities of the Special Protection Area is also threatened more immediately by plans for an airport, by a planned extension of the irrigation scheme to the low-lying coastal zone, by “illegal” construction of houses and buildings, and by the mining of sand from the coastal dunes.

Recommendations. The Turkish Society for the Protection of Nature (DHKD) identified clearly that the delta’s greatest need is for integrated management. A catchment master plan should address the issues of water resources and demands in the Göksu Basin, with regard to irrigation, flooding, drinking water supply, environmental protection, effluent disposal, water quality, river and coastal fisheries, hydro power potential, and conservation of nature.

Many opportunities are available for water management to promote nature conservation objectives for the Specially Protected Area, once the ecological limits for each of the lagoons and marshes have been specified. Maintenance and enhancement of environmental and economic conditions is well possible because the current average river flow (110 m^3/sec) is five times the direct usage. Moreover, the delta and coastal zone has a particular ecological richness, and there already is a synergetic integration of agriculture and environmental protection in the area (DHKD 1992).

Even the sediment-related problems resulting from the Kayraktepe Dam could be overcome by innovative management techniques involving continuous dredging of the reservoir and artificial injection of the resulting sediment into the flow from the dam. Arguments that such a scheme would not be economically feasible suggest that the present price of Turkish electricity does not reflect its inherent costs in terms of coastal erosion, land loss, reduced fisheries productivity, and salinization of farmland. An artificial winter flood flow would bring ecological benefits, assist fisheries, and help to transport any residual sediment along the channel out to the coastal zone (Hollis 1993).

Kizilirmak Delta

The wetlands of the Kizilirmak delta consist of lakes and marshes on the eastern edge of the delta behind the dunes, Karabogaz Lake and associated marshes on the western edge of the delta, and the braided meandering alluvial channel of the river itself. The lakes and marshes are presently fed by groundwater flow from the river, drains, and dunes, by small local streams, surface water from the delta and the drains, and rainfall (Hollis 1994).

The cropping of the delta includes extensive areas of rice, melons, vegetables, and second-crop winter vegetables. The lowest land is intensively grazed. The Class A coastal wetlands are in remarkably pristine condition and have been shown to hold a remarkably diverse range of species and a very large number of breeding waterfowl, including several international threatened species (WIWO 1992).

Irrigation. The dams at Derbent and Altinkaya, just upstream from the delta, are complete. The reservoirs are filled and hydropower is being generated. These dams will ensure that there are no further floods in the channel through the delta. The dams are also preventing any sediment from reaching the coast. Serious coastal erosion is inevitable in the coming years. The agricultural lands of Kizilirmak Delta are extensively irrigated from the canals, the river and groundwater and the existing drainage system appears to function well. The farmers undertake exploitation of these sources. The irrigation water is derived from a simple diversion structure on the river and the whole irrigation and drainage scheme, save a small area served by a tunnel in the eastern part of the delta, is gravity-fed. It appears to be uncomplicated with relatively modest capital costs, and high profits. However, there is a possibility that even the present scale of informal irrigation might over-exploit the delta’s existing water resources. Additional water supplies may need to be furnished in the near future (Hollis 1994).

Substantial lengthy, though poorly constructed, embankments have been installed on both sides of the river from the Derbent downstream. The creation of embankments facilitated vigorous extraction of gravel from the riverbed. This extraction will eventually lower the river level, reduce the groundwater recharge in the delta, and facilitate the intrusion of seawater.

Future developments. A substantial expansion of the irrigation and drainage scheme is planned to include an additional 8,000 hectares below the 2 meter elevation mark. Several kilometers of deep intercepting open drains have already been dug in unconnected sections along the fringe of the wetlands of the delta. A deep, drained polder on the land below 2 meters will inevitably have some effect on the wetlands. For instance, the wetlands’ water level will be above that in the polder leading to infiltration from the wetlands to the agricultural area. This reversal of groundwater flows will cause important ecological changes in the wetlands (Hollis 1994).

Recommendations. There are several alternative techniques to the heavy engineering and capital-intensive approach adopted in the past to develop the resources of the Kizilirmak Delta. Elements in these alternatives could include pumping of water from the river for irrigation, enhancing natural infiltration of river water to the groundwater of the delta, extensive use of the river and existing drainage canals for the transmission of irrigation water in summer, feeding the wetlands with direct supplies of clean river water, creating a multiple use buffer zone around the wetlands, enhancing of the fisheries potential of the wetlands, and reed bed treatment of the sewage from Bafra.

A scheme for the land above the 2-meter mark could be developed and implemented immediately. It should be done in full consultation and collaboration with all of the interested parties. Such a limited scheme must secure the present scale of irrigation in the immediate future. The project should be implemented initially in the lands most remote from the wetlands. The scheme must be flexible and allow for any different arrangements subsequently decided upon for the land and wetland below 2 meters (Hollis 1994).

Sultan Marshes (Kayseri)

The Sultan Marsh is a Class A refuge for waterfowl and declared a Waterfowl and Nature Conservation Area (TÇV 1993). The Sultan Marshes were designated as a potential area for a Ramsar site in 1993. The Kayseri Culture and Natural Assets Protection Agency also declared this area as a Natural site of the 1st Degree in July 1993 (TÇV 1993). Nevertheless, because of the size of the area and easy accessibility, illegal hunting of protected species still continues.

The people from the neighboring villages practice reed cutting. In spring, very small amounts of green rushes are cut by scythe and used as forage with a minimum of disruption of the habitats of waterfowl along the shores. Cutting of reed is done at the end of summer, fall and winter to be used as roofing and to produce straw.

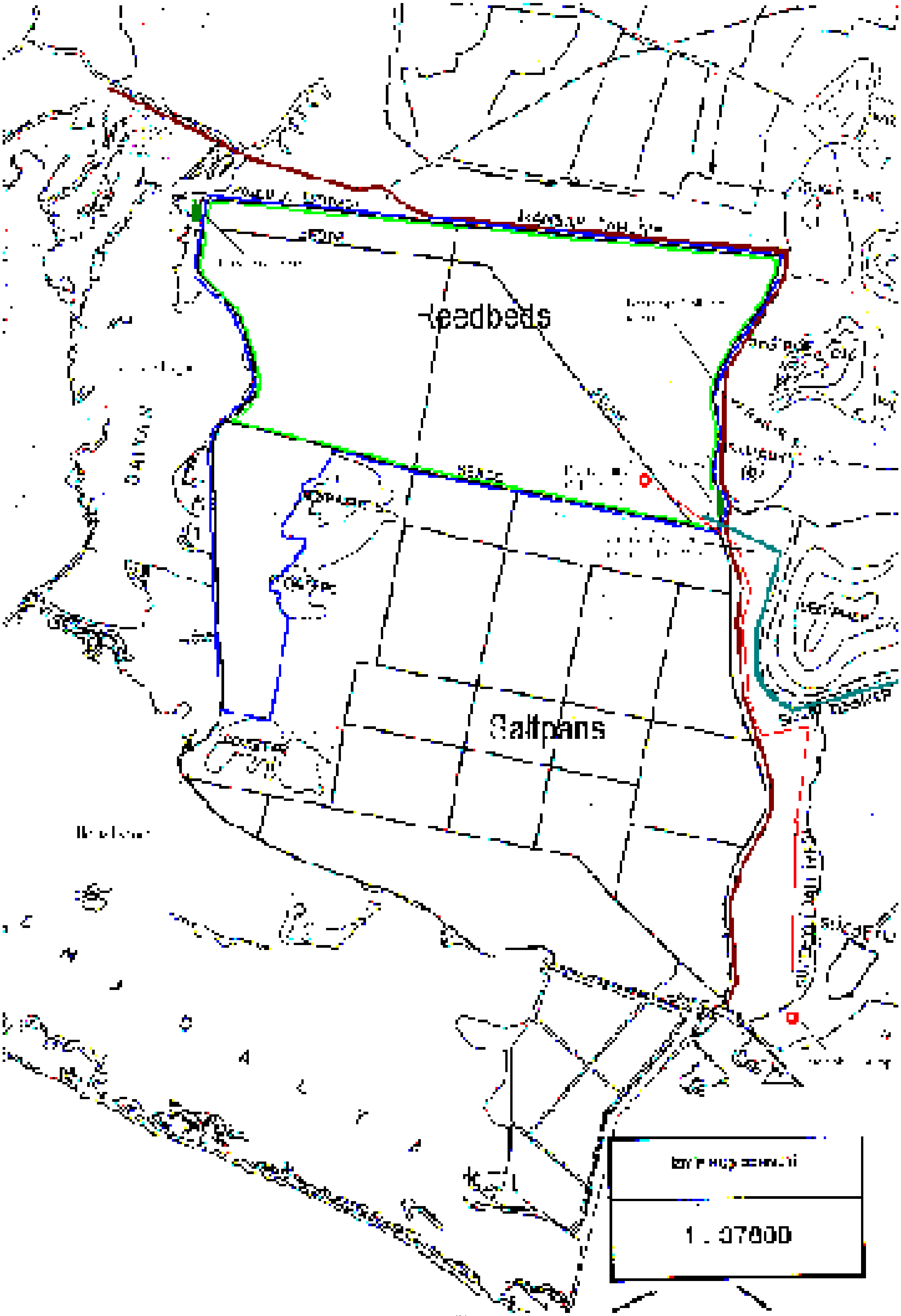
Future Developments. The main part of the reed beds and of Lake Yay will not be drained. The unused irrigation water will be channeled into the freshwater marsh and the lake. This water, carrying chemical fertilizer residues and pesticides from an area of 42,000 hectares, will accumulate in the marsh and the lake, and cause pollution of the fresh and saltwater ecosystems. Another effect of this influx and excess of water in the marshes and the lake will be a gradual decline in the salinity of Lake Yay, which is a saltwater ecosystem. Waterfowl such as flamingo, avocet and shelduck, that inhabit this wetland will inevitably be affected. The grasslands will be reduced from 35,900 hectares to 3,000 hectares, threatening the habitats of crane, stone curlew, black bellied sand grouse, and other birds which breed in the grasslands.

Kus Cenneti

In early 1999, IWMI performed an analysis of the Kus Cenneti wetland, using a wide variety of available data to apply the hydrological model SLURP. The paper by De Voogt et al. (forthcoming) largely forms the basis for this case study.

The Izmir Bird Paradise Kus Cenneti is a recognized Ramsar site, which provides refuge and food to over 25,000 birds. The 8,000 hectares large wetland forms the main feeding and breeding location within the Gediz River delta; ecologically one of the most important wetlands in Turkey due to its favorable climatic conditions and location on one of the main flyways for migrating birds. The northern part of the Kus Cenneti consists of two fresh water reed beds while the southern part comprises flooded and abandoned evaporation saltpans, hills and cliffs (figure 15). State Hydraulic Works (DSI) and the salt company have made low dykes around the reed bed to protect the area from salt-water intrusion.

Figure 15. Some characteristics of the Kus Cenneti wetland. The scale is estimated.



Irrigation. The Gediz River has a length of about 275 kilometers and drains an area of 17,220 square kilometers. The river network consists of some small reservoirs and the large Demirköprü reservoir, which is used for generating hydropower and for the irrigation of 125,000 hectares. The water from the reservoirs is diverted to irrigation systems on both sides of the river through three regulators. In addition, there are many smaller irrigation schemes depending on groundwater. The main crops grown in the basin are cotton and grapes.

At present the reedbeds in Kus Cenneti are dependent on rainfall and diversions from the Menemen Left Bank irrigation system. Rainfall is about 540 mm/year, which is not sufficient to sustain the reedbeds without an additional water supply. The Rama fresh water project installed a pump that extracts fresh water from a shallow aquifer. The pump flow of 0.055 m^3/s, is not sufficient either to preserve or restore the reed bed area, especially as the water is slightly saline (1 g/l) and brings about 1,700 tons of salt per year into the reed bed. Drained water from the nearby irrigation systems flows to the Gediz River. A sluice was constructed (discharge point in figure 15) to allow water into the redbud area along existing channels. However, this water is very saline (up to 9 g/l) and highly polluted with agro-chemicals.

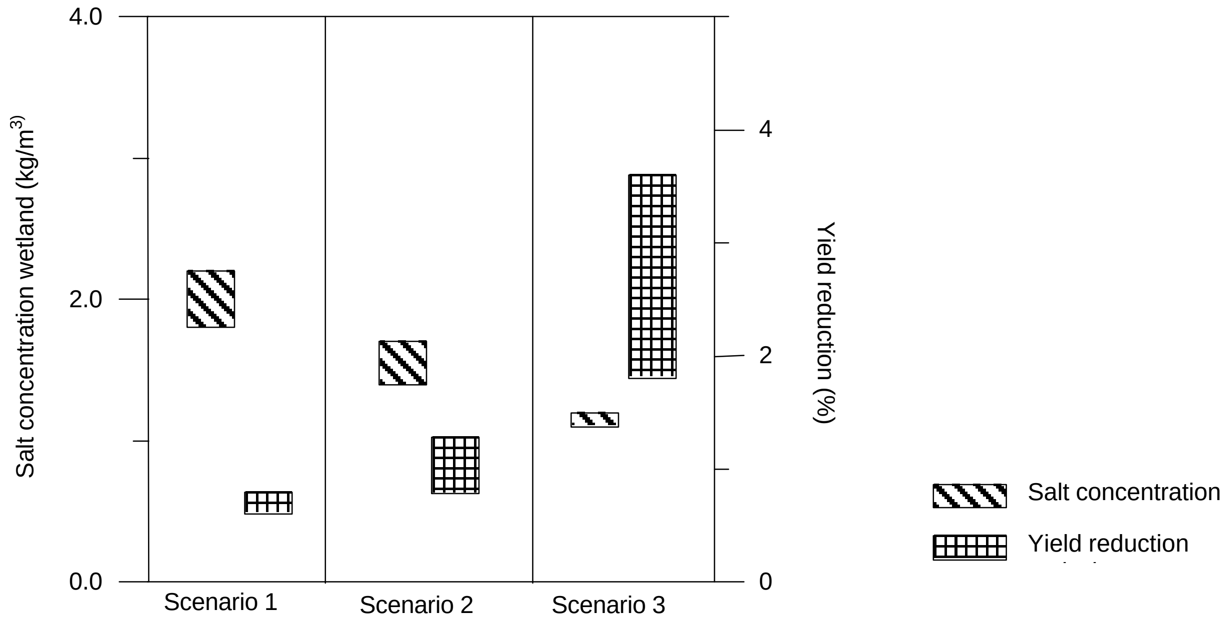
The diversion weir in the Gediz River feeds 18 m^3/s into two irrigation systems. The remaining river water has a hydraulic head of 10 meters from the regulator to the sea, which is too low for the water to flow into the reed beds, so pumping would be required. However, the quality of the river water is low due to untreated sewage (RAC/SPA 1993).

Future developments. Urban areas, within the basin as well as Izmir just outide the boundaries, are expanding at an expected annual average of 11 percent for the period 2000-2030 (International Office for Water 1999) and groundwater pumping is therefore expected to increase as well. The growing competition for water within the Gediz Basin hampers the allocation of sufficient water to the Kus Cenneti wetlands and may therefore threaten wildlife in the region.

Assessments of the water requirements of the wetland were based on the evapo-transpiration and available rainfall. In wet years some 7,600,000 cubic metres of water would be required in Kus Cenneti to keep the salt level constant, and in dry years almost double that amount (14,200,000 cubic meters) would be needed. Water allocations in the Gediz Basin would inevitably have to be modified to satisfy this demand. The deliverable supply depends on weather conditions outside the irrigation seasons. In dry years the deliverable supply exceeds two times the Kus Cenneti demand and in wet years by a factor of 6. If the Kus Cenneti is continuously flushed with low salinity water, damage to the reed beds will be prevented. But even if the water requirement is supplied once a week, fluctuations in the salt concentrations are not expected to be more then 12 percent.

Figure 16 shows the results from three scenarios as evaluated with the SLURP model. Obviously, less water for the wetland means higher salinity levels and, consequently, less favorable conditions for wildlife (scenario 1). On the other hand, depending on weather conditions, an increase in water supply for the wetland can have a substantial effect on irrigated agriculture with yield reductions in the range of 2-4 percent (scenario 3). Scenario 2 shows an intermediate situation.

Figure 16. Relationship between expected salt concentrations in the Kus Cenneti and the reduction in transpiration for three scenarios.



For the third scenario it was assumed that all the water required for the wetland would be diverted from the Menemen Left Bank irrigation system. Several other alternative water management options have been simulated. In these options, water for the wetland was extracted from all irrigation schemes in the basin. However, limiting the diversions only to the Menemen Left Bank is the simplest option to carry out and offers clarity to farmers, as every water application is the same.

Recommendations. The following recommendations can be made for improving the condition of Kus Cenneti and simultaneously minimizing yield losses in the Gediz Basin:

? Encourage farmers to apply water saving technologies.
? In dry years, reduce water deliveries in each irrigation canal by a few percent and divert this to the wetland.
? In wet years, keep all canals full and deliver an additional flow of 3 m^3/s to Kus Cenneti.
? Investigate the possibility of direct pumping from the Gediz River into the reed beds.
? Initiate a study on the tolerance of the reed beds in the Kus Cenneti to different salt concentrations. This will provide a better understanding of the water requirements.
? Extend the secondary irrigation canal in Menemen Left Bank to the borders of the Kus Cenneti as was already recommended by RAC/SPA (1993).

CONCLUSIONS

This report has provided a wealth of information on irrigation, health and the environment in Turkey. However, it has also shown that insight into the linkages between the different health and environmental impacts is limited and further research is required.

Detailed information is available on the production and consumption of pesticides. Now the link with irrigation should be studied to try and quantify whether or not more pesticides are applied in irrigated agriculture. Currently, very few data are available on the occupational exposure of farmers in Turkey, be it in irrigated areas or in rain-fed agriculture. The downstream effects of pesticides in groundwater or surface water will be more widespread in the case of irrigation, as drainage flows in Turkey are shown to be quite high, affecting many wetland areas, particularly river deltas.

The planned large-scale irrigation projects in Southern Anatolia (GAP) are expected to create substantial economic benefits and enhance Turkey's strategic regional position. However, the region seems very vulnerable and GAP may have serious repercussions on human health, notably malaria and schistosomiasis, as well as on the environment, mainly birds and aquatic ecosystems. Therefore, these projects require the special attention of planners and executives in the agricultural and water sectors as well as in public health for preventive measures

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