International Water Resources Association
Water International, Volume 32, Number 4, Pg. 590-603, December 2007

Probable Water Crisis in Thrace and Istanbul in the Near Future and a Sustainable Strategy to Overcome it

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Abstract: *The Thrace Region of Turkey, a passageway from Asia to Europe, which includes the most populated city of Istanbul, is threatened by a water crisis in the very near future. The population of Istanbul alone is forecast to reach 30 millions by the year 2025, requiring 3 billion m^3 of water, nearly equal to the total fresh water resources of the region, 3.4 billion m^3. In this study, we consider not only the proportion of the available water resources to be allocated for each competing sector, civil, agriculture and industry, but also attempt to outline integrated water management strategies for each sector. The potential of small earth reservoirs, more than 1,500 in number, is emphasised as a way to develop fresh water resources. Water saving policies in the cities and ethics for water use are also briefly discussed.*

Keywords: *water crisis, water resources, small earth reservoirs, water saving policies, Istanbul, Thrace and Turkey.*

Introduction

Water resources are not distributed evenly in Turkey. For instance, 53% of its fresh water resources are limited to only two basins, Euphrates and Tigris River Basins in the South Eastern Anatolia, while other parts of the country are considered vulnerable to high water stress (State Hydraulic Works, 1999).

The Thrace Region (European part) of Turkey, which includes the largest city, Istanbul, is among the most sensitive areas. Both the region and Istanbul are the most populated part of the country. Although almost 20 % of total population lives in the region, its soil and water resources are only about 3 % of the county's resources. The population density of the region is around 450 people/km^2, though it is above 2 000 people/km^2 for Istanbul (DIE, 2004). Intensive farming, ongoing industrial development and its huge trade potential attract about 400,000 migrants to the region every year (Demirci and Butt, 2001). This puts enormous pressure on natural, especially fresh water, resources. Diffusion of agricultural pollutants into surface and underground fresh water resources, unsustainable urbanisation and industrial development into the water supplying basins worsen the source impairment. The rivers and surface water resources of the region have already been seriously polluted, while local contamination has started in underground water resources. Bearing these in mind, the population of Istanbul is forecasted to be 30 millions by the year 2025 (Eroglu, 1996), which requires 3 billion m^3 water. This amount is equal to ¾ of the total technically usable fresh water resources of the region, which is 4 billion m^3. Therefore, immediate precautions must be taken. The objectives of this study are to define the water resources potential of the region, to identify the problem and to suggest carefully integrated water management strategies for each competing sector – civil, agriculture and industry – and to offer practical solutions designed to save and to develop fresh water resources.

Water Resources Potential of the Region and Istanbul

The Thrace Region is located in the European Part of Turkey, between 26°-29° East longitude and 40°-42° North latitude. The region and its main streams are presented in Figure 1. The comparison of Turkey's and the Thrace Region's water resources is given in Table 1. The annual mean precipitation of the region is 647 mm, which is equal to 15.3 billion m^3 (precipitation multiplied by surface area of the region). Of this amount, 9.6 billion m^3 returns to atmosphere via evapotranspiration and feeds groundwater resources, while 5.7 billion m^3 flows into seas or lakes. Part of this flowing water, 1.9 billion m^3, is left for saving the ecological balance and for preventing reverse flow from the seas. Only 3.8 billion m^3 is technically and economically usable. Additionally, 0.2 billion m^3 flows from the neighbouring countries. Therefore, total water potential of the region is around 4.0 billion m^3 (Konukcu et al., 2004a and Konukcu et al., 2004b).

The amount of available water per capita is 1600 m^3/year for Turkey, in general, while it is only 300 m^3/year for the Thrace Region (Konukcu et al., 2004a and 2004b). According to Falkenmark water stress assessment, water stress begins when per capita water resource is less than 1700 m^3 for all major functions and becomes severe when there is less than 1000 m^3/capita (Postel, 1999). This comparison clearly shows that the sources of the region are far below the severe stress level. The reason why very serious water shortage has not been experienced is that the water allocated to irrigation sector, which consumes almost 70% of all available fresh water resources, is very limited in the region (Konukcu et al., 2004a and 2004b).

The region has a good quality of underground water resources in Ergene Underground Water Basin, which has a 600 m thick aquifer. The aquifer is in the East-West direction and exhibits pressurised aquifer conditions in its middle part (Kirsac, 2003). Drinking water requirements of major cities (Tekirdag, Muratlı Corlu, Luleburgaz) and many other small towns are supplied from this underground water resource. Total renewable groundwater potential is about 0.4 billion

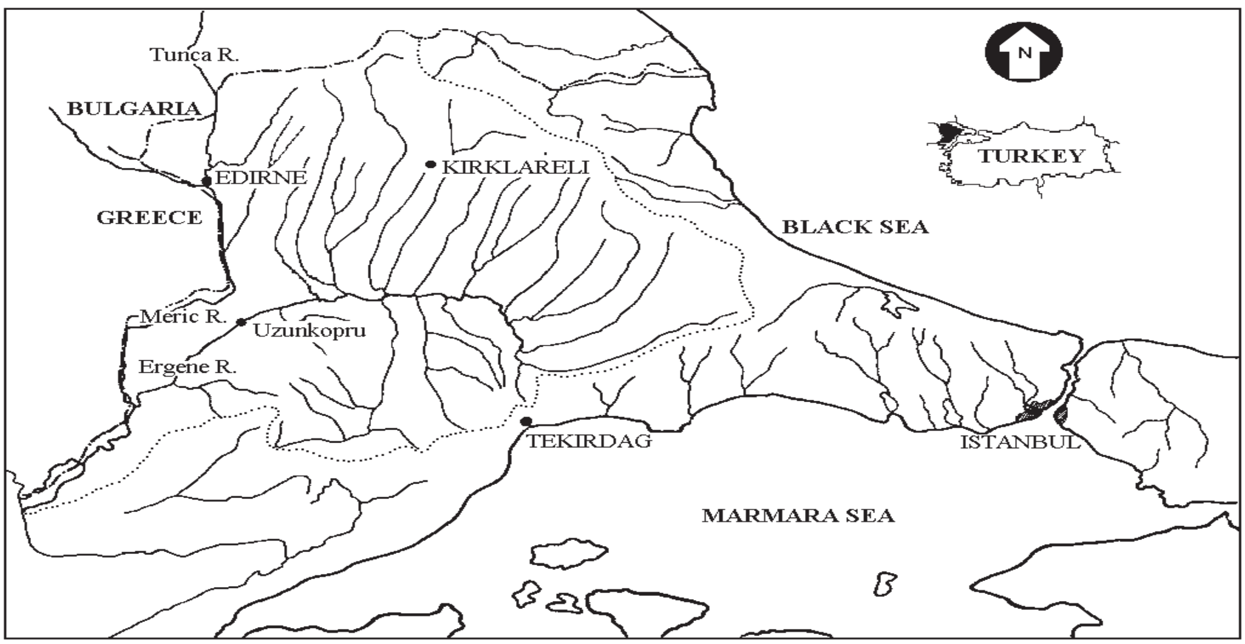

Figure 1. The Thrace Region and its main streams

m^3/year (Kirsac, 2003).

As for Istanbul, water supply has always been problem. Water had been supplied from the wells before Roman and Byzantium Empires found new surface sources outside of the city walls. Water from remote sources had been conveyed by gravity constructing tunnels through the hills and water aqueducts on the valleys. Later, in the Ottoman time, numerous small dams and aqueducts, many of which still stand, were constructed. When the water structure built in Taksim could not meet the water requirement as a consequence of socio-economic development, Sultan Abdulhamit entrusted a French firm with water supply from Lake Terkos in 1882. This firm was responsible for water management until the Istanbul Water Organization was established in 1933 (Avci, 2004).

Water requirement has accelerated since the Republic of Turkey was established. Especially after 1950, rapid urbanisation, population growth and industrial development around the city make the water supply a pressing matter. The General Directorate of State Hydraulic Works (DSI) has actively been serving the supply of water by planning and constructing many water structures. It improved the capacity of Lake Terkos in 1971 and built Alibeykoy Dam in Thrace and Omerli Dam in Anatolian part in 1972. Later, in 1989, Buyuk Cekmece Dam was constructed when the water requirement of the city increased further.

The Regional Directorate of DSI in Istanbul was replaced with Istanbul General Directorate of Water and Wastewater Management (ISKI) in order to offer satisfactory services in developing water resources. Its responsibilities include conveying water from a source to the city, purification, constructing main water reservoir in the city and coordinating water distribution systems.

ISKI started by building Sazlidere Dam in the region. However, it did not make satisfactory progress in its early stages and the city suffered a very serious water scarcity. Reasons for the scarcity included: i) long-lasting droughts; ii) shortcomings in the monitoring and restoration of the water and wastewater distribution systems; iii) mismanagement of the limited budget of ISKI. Therefore, the Regional Directorate of DSI, an experienced organization capable of doing investigations on water resources in basin scale, was re-established in 1993 (Karadogan, 2004).

When ISKI management shifted in the later stage, they decided to collect and drive water from the creeks in the Istranca mountain ranges in the Northern Thrace Region into the Black Sea. When this project was completed, a total of 648 million m^3 water sources were created for the Thrace part of Istanbul. Present water sources of Istanbul (for both Thrace and Anatolian part) and their yields are summarised in Table 2.

DSI has initiated the Great Melen Creek Project, which is to be completed in four steps for the fulfilment of the future water needs of Istanbul. It is supposed to meet the water need of Istanbul until 2040. The first stage of the project will be completed in 2008. Water

Resources	**Turkey**	**Thrace Region**
Average precipitation (mm)	652.5	647.0
Volume equivalent gross water potential (billion m^3)	508.0	15.3
Net water potential (billion m^3)	186.0	5.7
Environmental flow (billion m^3)	76	1.9
Technically usable amount (billion m^3)	110.0	4.0
- surface	95.0	3.4
- underground	12.0	0.4
- outside of the country	3.0	0.2
Present consumption (billion m^3)	40.0	1.7

Table 1. Water resources of Turkey and the Thrace Region (Konukcu et al. 2004a and 2004b)

transport from the Anatolian part to the Thrace part will be conducted, for the first time, by a tunnel crossing the Bosporus. While 96.6 % of Istanbul's drinking water requirement is met by surface water, the rest is met from the underground water resources and historical reservoirs.

Present purification units are capable of treating all of the drinking water needs of the city (Table 3). The quality of the purified drinking water is analysed in the laboratories of four different organisations, including the laboratories present in their own units. Water samples (350-400 in numbers) are collected at different points of the distribution systems in the city and microbial and chemical analysis are done on these samples. Monthly reports are prepared and inspected by the City Health Committee.

The quality of drinking water has been enhanced recently through these purification units and through improved distribution systems. The quality of water offered to the residents of Istanbul is better than the standards suggested by World Health Organization (WHO), European Community (EC), US Environmental Protection Agency (EPA) and Turkish Standardisation Institute (TSE) (Codur, 2004).

Evaluation of Present Water Management Techniques in the Region and Sustainable Management Strategies

Limiting the expansion of irrigated land and/or improving the irrigation water use efficiency

The total cultivated land of Thrace is about 1.42 million ha (59.9% of total surface area of the region, 2.37 million ha). Although all cultivated land is potentially irrigable, only 125 103 ha (8.8% of the cultivated land) is presently under irrigation (Istanbulluoglu et al., 2002a). When irrigated, neither waterlogging nor salinity problems are expected of either the Ergene River Basin or the Marmara Basin (Rose et al., 2005; Gowing et al., 2006 and Konukcu et al, 2006). Each of these basins is comprised of hundreds of sub basins and streams (Figure 1).

The weighted mean evapotranspiration (ET) of the region was calculated in light of the crop pattern and water consumption of each crop in order to evaluate the availability of water resources for irrigation (Table 4).

Resources	From the year	Yield (million m^3/year)	% in total
Groundwater, historical reservoirs etc.	1453, 1893	10	0.9
Elmali dams I and II	1893, 1950	15	1.3
Terkos Lake	1883	162	13.7
Alibeykoy Dam	1972	36	3.0
Omerli Dam	1972	235	19.9
Darlik Dam	1989	97	8.2
Buyukcekmece Dam	1989	120	10.2
Yesilvadi Regulator	1992	10	0.9
Istranca Creeks Step I (Duzdere, Kuzuludere and Buyukdere dams)	1995	44	3.7
Sile deep wells	1996	30	2.5
Istranca Creeks Step II (Elmalidere, Sultanbahcedere, Kazandere and Pabucdere dams)	1997, 2000	191	16.2
Sazlidere Dam	1998	85	7.2
Yesilcay Reservoir	2003	145	12.3
Total (Thrace + Anatolian part)		1 180	100.0

Table 2. Present water resources of Istanbul and their yields (Codur, 2004)

The percentage area of the crops in the cropping pattern was multiplied by their monthly ET data. Monthly relative ET in a particular month was employed in order to obtain monthly weighted mean ET in this month. Evapotranspiration data of the crops was obtained from the field studies conducted in the region by Tekirdag Agricultural Faculty and Kirklareli Research Institute of Rural Services for different crops grown in the region, such as the sunflower (Karaata, 1991; Erdem et al., 2001; Orta et al., 2002a; Erdem and Delibas, 2003 and Erdem et al., 2006a), wheat (Orta et al., 2002b; Baser et al., 2004 and Orta et al., 2004), rice (Yakan and Surek, 1990), maize (Cakir, 1998 and Istanbulluoglu et al., 2002b), sugar beat (Yakan and Kanburoglu, 1991), watermelon (Orta et al., 2003 and Erdem et al., 2005a), potato (Erdem et al. 2005b; Erdem et al., 2006b and Erdem et al., 2006c), and bean (Erdem et al., 2006d).

The weighted mean of seasonal water consumption was computed as 570 mm, assuming 80 % field application efficiency (Sener, 2004; Albut, 1996) and taking the long-term mean of effective precipitation. Multiplication of this value by the surface area gives the volume of required irrigation water, which does not include conveyance efficiency.

It can be inferred from Table 4 that 0.7 billion m^3 water is required for irrigation when 570 mm water is supplied to the presently irrigated area (125 103 ha), which is only a small part of potentially irrigable land of the region. When municipal and industrial usages are added, a total of 1.7 billion m^3 is calculated, which is half of the present water potential of the region. When the whole potentially irrigable land (1.42 million ha) of the region is planned for irrigation, after constructing all necessary infrastructures and improving field conditions for irrigation, about 8.1 billion m^3 water will be required. This amount is far beyond the capacity of the region. Therefore, such planning is not suggested in the future. Instead, total irrigation efficiency of 30% in the presently irrigated area should be improved by replacing open earth channels as water distribution systems with pipes. Deficit irrigation should also be applied. Deficit irrigation studies conducted in the region suggest that a considerable amount of irrigation water may be saved without causing economically significant yield lost. For instance, Istanbulluoglu et al. (2002b) conducted research to investigate the water use-production relationship of maize under Thrace conditions and found that 2 irrigations at more sensitive stages, tasseling and cob, instead of 3 irrigations, saved 26 % of irrigation water against only 2.7% yield reduction. Okursoy (2005) proved that irrigation deficit up to 75% and 25% for wheat and sunflower, respectively, may be applied economically.

On a global basis, almost 70% of all water withdrawn for human use is currently soaked up by agriculture with an average irrigation (overall resource) efficiency of 40% (UN/WWAP, 2003; Prinz,

Names of purification units	Year installed	Capacity (m^3/day)	% of total
Elmali	1950, 1994	50 000	1.4
Kagithane Celebi Mehmet	1972	378 000	10.6
Omerli Muradiye	1972	320 000	9.0
Omerli Orhaniye	1972, 1995	500 000	14.1
Buyukcekmece	1989	400 000	11.2
Kagithane Yildirim Beyazid	1996	350 000	9.8
Omerli Osmaniye	1998	220 000	6.2
Ikitelli Fatih Sultan Mehmet	1998	420 000	11.8
Omerli Emirli	2001	500 000	14.1
Ikitelli II. Beyazid	2003	420 000	11.8
Total		3 558 000	100.0

Table 3. Purification units in Istanbul and their capacity (Codur, 2004)

2004). Even 10% saving in agriculture is more than the required amount of all domestic use (Postel, 1999). In any case, it is possible to improve it to 50% (Postel, 1999).

Protecting groundwater and surface water resources re-use of wastewater

The main river of the Thrace Region, Ergene River, has been increasingly polluted by the factories in the river basin. Water analysis data in 1984, when industrialization started, showed that it could be safely used for irrigation (Becer, 1984). However, it cannot be profitable anymore (Konukcu et al.2004a and 2004b) due to its salt, NH_4^+, NO_3, Na, Cl, B and O_2 concentration. Many of the factories use the fresh water they need for heating, cooling or for other process and then dispose the effluent into River Ergene or its tributaries.

In the Ergene groundwater basin, there are 13 wells for research, about 400 wells for irrigation and more than 3000 wells for private factories. They are irregularly scattered in the basin and their depths vary from 100 to 250 m (Konukcu et al., 2004a and 2004b).

The water levels in the research wells are directly correlated with the total annual precipitation. The aquifer is fed during the period between November and May, while water is pumped during the whole year for industrial and civil uses, and during April-September for irrigation.

Getting permission from the authorities (local governments within the border of a municipality settlement area and DSI outside of the settlement area) to build a well and pump water is very easy. But, unwisely, use of groundwater above its renewable capacity is not controlled. These authorities fail to put the existing rules and regulations into action due to the lack of equipment and expert staff. A significant local shrinking has been recorded in the middle part of the basin, near Cerkezkoy, Corlu and Luleburgaz, where most factories are located. Water usage over the annual renewable capacity should not be permitted and it should be priced reasonably for each sector. The most efficient solution for overcoming these problems is the implementation of a well-designed 'Basin Management Plan,' together with the European Union Water Framework Directives, which is discussed in more detail below.

The disposal of contaminated water into the flow is forbidden and every factory is required by law to have a purification unit (Environmental Law no. 2872). However, this does not work due to high infrastructure and operational costs. To reduce these costs, central treatment units must be built. The treated water may then be used for agriculture or any other purpose that does not need high quality water.

Presently, green areas and parks in Istanbul and other cities are irrigated using purified drinking water. A considerable part of Istanbul's drinking water is, and will continue to be, diverted from remote resources

Crop pattern	% of crop pattern	Crop water consumption (mm)							Season total
		Apr.	May	June	July	Aug.	Sept.	Oct.	
Wheat	58	55	139	81	6	-	-	-	281
Sunflower	35	13	22	99	76	16	-	-	226
Forage crops	3	2	5	8	8	10	5	1	39
Rice	2	-	5	8	10	8	5	-	36
Sugar beet	1	1	1	3	3	2	1	-	11
Maize	1	1	1	2	2	1	-	-	7
Crop water req. (mm)		72	173	201	105	37	11	1	600
Eff. precipitation		38	35	30	16	13	25	51	
Net requirement		34	138	171	89	24	-	-	456
Gross req. (mm)		43	172	214	111	30	-	-	570

Table 4. General crop pattern and crop water consumption for a median year in Thrace

such as Istranca, about 150 km away, and Melen, which is about 130 km from the city. A significant part of the municipal wastewater in Istanbul is already treated and discharged into the sea. By the end of 2006, all municipalities should have treated their wastewater. The treated water can be diverted for irrigation purposes. Because wastewater is very rich in nutritional elements, this will also prevent environmental pollution by reducing the use of chemical fertilizers (Schwarz, 1990). Municipalities in the region, which are not experiencing a serious water shortage at this stage, do not find this attractive since it requires extra cost to install a separate distribution system to pump the treated water. Although the recirculation of treated water to irrigation areas is not a simple matter, it is worth it if region runs into an acute water crisis. As for the inland urban areas, the treated water may be used in the lower parts.

Wastewater is reused for irrigation purposes in many countries around the world on all of the populated continents (USEPA, 1992). A number of these countries have developed guidelines that give quality criteria, as well as advice on how effluents should be reused. Examples of these guidelines are summarised in the USEPA guidelines for water reuse manual (USEPA, 1992). Types of wastewaters used for recycling include treated and untreated sewage effluent (Shereif et al., 1995; Asano et al., 1996), storm water runoff (Asano et al., 1996), domestic greywater (Anderson, 1996), and industrial wastewater (Asano et al., 1996). These different water types can vary in quality; that is, with regards to the contaminants present. The quality and contaminants present will also impact the level of treatment required, which, in turn, impacts the economic viability of reusing the various wastewaters.

Toze (2006) lists both the benefits and risks from re-using wastewater. The reuse of water is just one source of water that has potential for use in an agricultural setting. Reused water does, however, have a major advantage in that it is usually a constant and reliable supply, particularly from sources such as treated sewage effluent or industrial discharges. As well as being a constant source of water, water suitable for reuse is produced in large volumes, which, if not used, would be merely discharged into the environment. It is well known that discharge of effluents, treated or non-treated, into the environment, particularly natural water bodies such as lakes, rivers and the coastal marine environments, can cause severe environmental degradation. This degradation is often related to the presence of organic and inorganic nutrients, which can cause problems such as eutrophication and algal blooms. Reusing these discharged effluents can significantly reduce, or even completely remove, the impact of these effluents on receiving environments. In addition, the reuse of wastewaters for purposes such as agricultural irrigation reduces the amount of water that needs to be extracted from environmental water sources (USEPA, 1992; Gregory, 2000). Wastewaters can often contain significant concentrations of organic and inorganic nutrients, including nitrogen and phosphate, for example. There is potential for the nutrients present in recycled water to be used as a fertiliser source when the water is recycled for agricultural use. Soil micro organisms have been observed to have increased metabolic activity when sewage effluent is used for irrigation (Meli et al., 2002; Ramirez-Fuentes et al., 2002).

Potential risks from using recycled water include the presence of the most common human microbial pathogens in recycled water (viruses bacteria, protozoa helmints), ii) trace organics and heavy metals, iii) endocrine disrupting chemicals, iv) pharmaceutically-active compounds, v) nutrients, vi) salinity, as well as vii) public concern (Toze, 2006: i).

The principal mechanism for overcoming these difficulties is the pre-treatment of the recycled water. As mentioned above, the risk from microbial pathogens is significantly reduced with the treatment of water (Peasey et al., 2000; Toze, 2006). Treatment of recycled water also reduces the concentration of organic and inorganic nutrients, trace organics and heavy metals. The most difficult contaminant to remove is salt and other cations and anions. The only effective treatment mechanism to remove salt molecules and ions is reverse osmosis membrane filtration. Such a high level of treatment is far too expensive to be economically viable for irrigation of crops and turf. While it is difficult and expensive to remove salt and other recalcitrant contaminants from recycled water, they can be managed by effective use of the water. If the soil is porous enough and low in clay then all that is often required is monitoring the leaching of the water through a soil profile (Harris and Urie, 1983). Alternatively, water with a lower salinity can be blended with recycled water to reduce the concentration of salt. Another strategy is conjunctive water use. This involves leaching salt out of the soil profile through the occasional irrigation of fields with a water source that has a low sodium concentration. This is done in order to flush accumulated salt out of the soil profile (Slavich et al., 2002; Surapaneni and Olsson, 2002).

Additionally**,** guidelines on how effluents should be reused for irrigation purposes should be developed in light of the soil, plant climate and effluent characteristics of the region.

Increasing water storage and availability

Water shortage and contamination of Ergene River obliges the authorities to manage the existing water resources carefully and to find new sustainable sources. Water scarcity problems in industry, agriculture and municipalities may be solved by small earth-filled reservoirs. They also provide the following economical and environmental benefits (Postel, 1999): i) they do not need big rivers and valleys; ii) there is no need to divert rivers, which destroys the ecological balance downstream; iii) they allow multi-purpose use of water resources such as irrigation, domestic, fish culture and recreational areas (Li et al., 2005); iv) they insure against water scarcity in the dry periods since the precipitation is irregularly distributed, both in time and space.

The Thrace Region has such a favourable topographic condition that, technically and economically, at least 1500 reservoirs can be built in the region (Kasap, 1988). However, recent figures of dams and reservoirs constructed by State Hydraulic Works (DSI) and General Directorate of Rural Services (KHGM) are very limited in number compared to its potential (Table 5).

Considering ongoing climate change

In order to investigate the regional effects of global climate change, the world can be divided into ten regions. The Thrace Region is placed in the Mediterranean Geographical Region. In theory, by the date 2050, the temperature of this region will increase by 2 °C in winter and 2-3 °C in summer. However, precipitation is forecasted to increase in winter slightly, while a decrease of 5-25% is expected during the summer (Kadioglu and Saylan, 2004, Ozguler, 2002). Probable temperature increases of 1-2 °C together with 10% decrease in precipitation may cause 40-70 % decrease in annual water yield of a river in that region (Postel, 1999). Studies in Cyprus (Tsiourtis, 2004) have shown that climatic changes and more frequent drought events during the last 30 years have caused a reduction in precipitation around 14% of the long term average, with 40% reduction of the availability of the natural water resources (Tsiourtis, 2004). Therefore, any careful water management policy should also consider the global climate change. Droughts should be identified and risk analysis studies should be carried out for the preparation of drought preparedness.

Water Saving Policies in the Cities

Province	State Hydraulic Works (DSI)		Rural Services (KHGM)	
	Dam	Reservoir	Reservoir	SLR*
Edirne	4	37	43	86
Kirklareli	3	7	29	96
Tekirdag	1	9	30	43
Istanbul	4	-	10	5
Canakkale	2	2	3	-
Thrace Region	14	55	115	230

*: Small livestock reservoir

Table 5. The number of dams and reservoirs by province in Thrace Region (Konukcu et al. 2004a and 2004b)

The water requirements of the cities in the Thrace Region, especially Istanbul, are increasing as a result of population growth, migration, rising quality of life standards and industrialisation. These demands will soon exceed the capacity of local resources. Water resources planners are thus looking for remote resources. This strategy has two main limitations: economical and environmental. Instead of expensive, complex water structures, such as big dams and diverting river beds, simple water saving techniques that have been practiced during past droughts are attractive means of sustainable water use (Postel, 1999). Simple techniques may include mounting new water saving fittings, preventing leakage, using high efficiency methods in irrigation of recreational areas, choosing low capacity toilet tanks, reasonable pricing and education. 10-30% savings are possible by applying one or more of these methods (Postel, 1999). The leakage losses from the supply systems of Istanbul reach up to 30% (Codur, 2004), while no data is available for the other cities.

Changing Attitudes Toward Water Resources and Capacity Building

Presently, in the agricultural sector, water is priced based on the area to be irrigated and crop type, and not on the volume of water consumed. This practice is due to the lack of equipment on the irrigation systems capable of measuring farmers' use of excess water. In industry and domestic use, water is priced precisely within the border of municipalities, although it is not controlled in the rural areas. Water pricing in agriculture should be based on the volume of water consumed.

One of the principal reasons for running into water shortages in many regions is the underestimation of the real value of water. To obtain water cheaply implies that it is abundant, that anyone can get it without much effort and that nothing will be sacrificed when it is wasted. Therefore i) water should be priced at a level designed to encourage efficient use and discourage waste, ii) the capacity of society should be taken into account during the planning of water service, iii) society should be educated and trained on environmental and social issues, based on the principle that water is a 'worldwide need' not a 'worldwide good' iv) all stakeholders should participate in decision and actions.

We must be aware of the limits of the available water resources and learn to live within these limits. Instead of searching for new remote water resources, we must look at our region, our surroundings and especially our houses and ourselves. We should never forget that every litre of water wasted contaminates hundreds, even thousands, of litres of clean wate.

Implementation of the European Water Framework Directives in Turkey

A number of governmental and non-governmental organizations have direct and indirect interests in the development and conservation of water resources in Turkey. The institutional framework has three levels: decision-making, executive and user level. At the decision-making level, the Prime Ministry and State Planning Organization and Ministries are involved. Governmental Organizations under the ministries are the executive levels. There are both governmental and non-governmental organizations at the water user level. The four main organizations responsible for the development of water resources are General Directorate of State Hydraulic Works (DSI), General Directorate of Rural Services (KHGM), General Directorate of Iller Bank (Iller Bank) and General Directorate of Electric Power Resources Survey and Development Administration (EIE). More than one institution working on each individual initiative sometimes causes duplications or partial overlaps and difficulties in the implementation of water legislation in Turkey. The most effective solution for overcoming these problems may be the implementation of a well-designed 'Basin Management Plan' in accordance with the European Water Framework Directives (WFD). Within the framework of this management model, the activities of the institutions should be redefined. (Akkaya and Efeoglu, 2004).

As a candidate for entry into the European Union (EU), Turkey has to adopt and implement the EU

WFD into Turkish Environmental Legislation. Water is the main element of the environment and, starting from this premise, the EU has enacted a directive on water resources management in 2000, called 'Water Framework Directive.' The main purpose of this directive is to establish a framework for the conservation of surface, coastal, ground and transitional waters. While EU member countries are working on converting their current legislation to these directives, the main aim of which is to manage all water resources in a basin on an integrated basis, there are also some activities on the implementation of these directives in Turkey. In this context, a project called 'Implementation of EU WFD in Turkey' was started in February 2002, with the financial support of Dutch MATRA Programme. All governmental institutions taking part in water management participated in this project. At the end of this project, a draft of the 'Integrated River Basin Management Plan,' will be prepared for the pilot project area of Buyuk Menderes River Basin. The project will end in 2009. The number of this kind of projects should be increased. Thrace Region would be a good representative pilot area since it covers all types of water resources, as well as multiple water users and polluters.

Conclusions

Present water mismanagement, coupled with rapid industrialization and unsystematic urbanization, will inevitably lead to a water crisis in the Thrace Region, in general, and Istanbul, in particular, in the near future. If careful strategies for the sustainable use of resources are applied, the crisis may be overcome. The following precautions may be suggested:

Authorities should decide what proportion of the available water resources are to be allocated to particular sectors – including the civil, agriculture and industrial sectors – and must establish carefully integrated water management strategies. Expanding the irrigated area is not suggested. Moreover, present water distribution systems in the irrigation projects should be improved using pipes, rather than open channels, and present total irrigation efficiency of 30% should be improved. Deficit irrigation should also be applied. Water should be priced at such a level as to encourage efficient use and discourage waste. Water pricing in agriculture should be based on the volume of water consumed not on the area or crop type.

The ongoing contamination of surface and underground water resources should be prevented by establishing new laws and regulations. Industrial and municipal wastewater should be treated and treated water should be directed to sectors that do not need high quality water. Underground water usage above the annual renewable capacity should not be permitted and it should be priced reasonably for each sector. The potential of small earth reservoirs should never be disregarded. A significant part of the water is consumed for domestic purposes. Therefore, water saving techniques in the cities must be put into practice. Beside technical strategies, social strategies should also be underlined. People should be educated on environmental and social issues, based on the principle that water is a 'worldwide need' not a 'worldwide good.'

A well-designed 'Basin Management Plan' in accordance with the EU WFD should be implemented and the activities of the institutions taking part in developing water resources should be redefined within the framework of this management model.

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