Search for plans for drinking water basins: Ömerli drinking water basin as an example

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Abstract

Water resources are vital for ensuring the continuity of life on Earth and should be protected. However, water supplies to large cities are currently being polluted and depleted owing to gradual ecosystem degradation from anthropogenic activities. Studies focusing on solutions to pollution and the depletion of water resources must include the rural–urban systems that strain basin ecosystems at every planning stage, including every country, region, and basin at every level. The aim of this study was to determine a new planning method enabling sustainability in water basins within residential areas. The scope of the study included elements of the basin ecosystem and the negative anthropogenic effects of urban systems on the basin ecosystem. Therefore, through systematic and comprehensive planning, basin and urban ecosystems, as well as regional parameters and the interaction between parameters, were examined regarding the current and future situation. The aim was to achieve targets at the maximum level by enabling the applicability of plans and coordination, to align planning decisions with the unique sociocultural aspects of each region, and to integrate them into the current system. Therefore, addressing ecological and socioeconomic systems together and reducing the limitations were the focus of this study. Ömerli Drinking Water Basin, located on the Asian side of Istanbul, was chosen as a project basin to implement the plans, because it meets one-third of Istanbul's water requirement, with a high biodiversity, including rare vegetation types, and has experienced considerable human population growth since 1980. Industrial and mining activities in its vicinity have resulted in environmental impacts, such as erosion, owing to intense agricultural activities and overpopulation. The proposed new planning model, which could be integrated into existing laws through broad participation in the law-making process, is a system in which basin ecosystem boundaries and protected areas are based on scientific facts and where the system is managed from a single center.

Keywords: System analysis, basin ecosystem, basin borders, water resource protection zone, environmental management.

Introduction

Basin ecosystems can be defined as "interacting and interrelated ecological systems that house forests, water, rivers, vegetation, lakes, microorganisms, fauna, soil, different climate systems and geological structures" (Suri, 2000; Figures 1 and 2). It is possible to group the elements mentioned below under the headings physiographic, climatic, edaphic, biotic (Çepel, 1995), and aquatic, and to examine them as subsystems of the basin ecosystem. Having both terrestrial and aquatic characteristics, placing it in the category of Terrestrial Aquatic Ecosystems, the basin ecosystem is extremely complicated with respect to element, function, and interaction. Determining the boundaries of the watershed system correctly will facilitate an analysis of the complex ecological system. Only one-third of the 112 billion m^3 available water resources is utilized in Turkey. Substantial water resources (74%) are utilized for agricultural irrigation. The second biggest consumer of water resources is urban areas (15%) (Table 1).

Table 1. Purposes for which water resources are used (T. C. Ministry of Forestry and Water Affairs, (2014), T.C. Official Gazette. (2014)

Purposes for Which Water Resources Are Used			
	Irrigation %	Industry %	Urban Consumption %
Turkey	74	11	15
World	70	22	8
Europe	33	51	16

Globally, the highest average water consumption is for irrigation, followed by industrial activities. In Europe, most water is used by industrial complexes, followed by urban areas. Water basins comprise natural ecosystems with various natural ecological and hydrological subsystems. They are self-sustaining systems provided they are not adversely affected by human actions. The increase in demand for water per capita owing to population growth and urbanization, coupled with the scarcity of natural resources and the adverse effects of global climate change and ecosystem deterioration owing to incorrect legal and managerial practices, makes resources even more scarce than they already are.

The Millennium Ecosystem Assessment organization (MEA) predicts that global climate change will manifest in changes to ecosystems, such as less snowfall, resulting in decreased underground water availability. According to the findings of scientific studies carried out at different periods, climate change will vary globally depending on the geographical location and physiography of each region, driven by changes in temperature and rainfall volumes (Environmental Protection Agency (EPA), 2013; Turoğlu, 2014). Similarly, there will be an even greater need for irrigation and drinking water in areas with high urbanization rates, especially semi-arid areas (T.R. Ministry of Environment and Urbanization Climate Change Coordination Board (IDKK), 2009). As stated in the 10th Development Plan (2014–2018) Commission Report, winter precipitation in Turkey's western cities has decreased noticeably over the past 50 years. Climatic changes and human activities directly impact all aspects of basin ecosystems. Therefore, studies on the preservation of those water basins that supply most of our drinking and utility water requirements will continue to increase in significance.

Current studies on basins focus exclusively on the physical aspects, omitting the social systems that are known to have a major impact on them. Water basin planning and management occurs at higher levels of the planning hierarchy. The scope of the present study covers urban–rural areas in the hinterland of the water source, as well as plans and strategies for conserving the natural balance and resources of basin ecosystems that are close to metropolitan areas, to ensure that settlement lands around basins are used without damaging basin sub-ecological systems. Water basin management analyzes the complex and multifaceted relationship within and between ecosystems and social systems to achieve sustainability by protecting natural resources and promoting an environmentally conscious approach to planning decisions.

A proposed basin planning and management system based on broad participation has been described in this study. The difficulty of integrating the proposed system into the existing legal system has been addressed and its applicability tested. In other words, together with a new concept of planning and management with its new definition of standard protection distance and habitability, the cited approach includes innovative strategies that can be adapted to the current system and can be used to highlight the extent of the pollution, degradation, and environmental exhaustion caused by current settlement policies and human intervention. The approach also aims to eliminate potentially detrimental factors that exert a negative impact on the basin ecosystem through their socioeconomic characteristics, even though such factors may be located at a safe distance from the basin, making it a unique approach specifically designed to address the issues facing the Ömerli Basin.

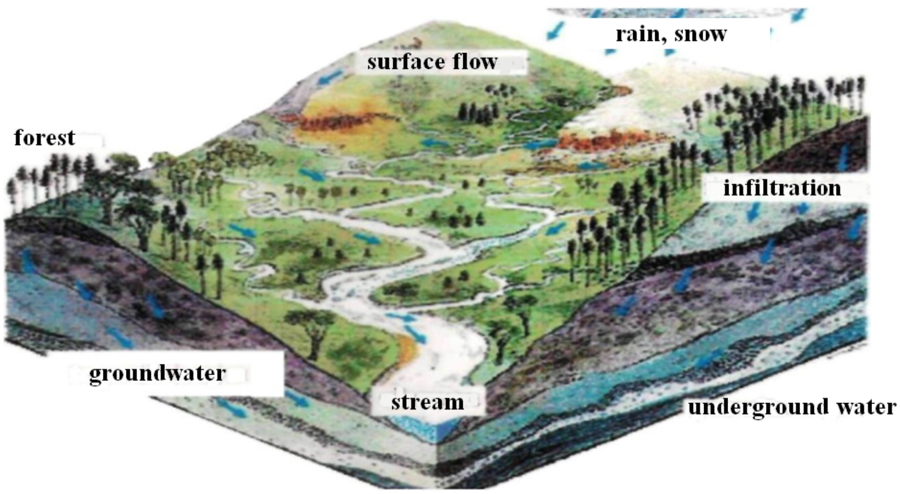


Figure 1. Basin section (Progressive Charlestown, 2015)

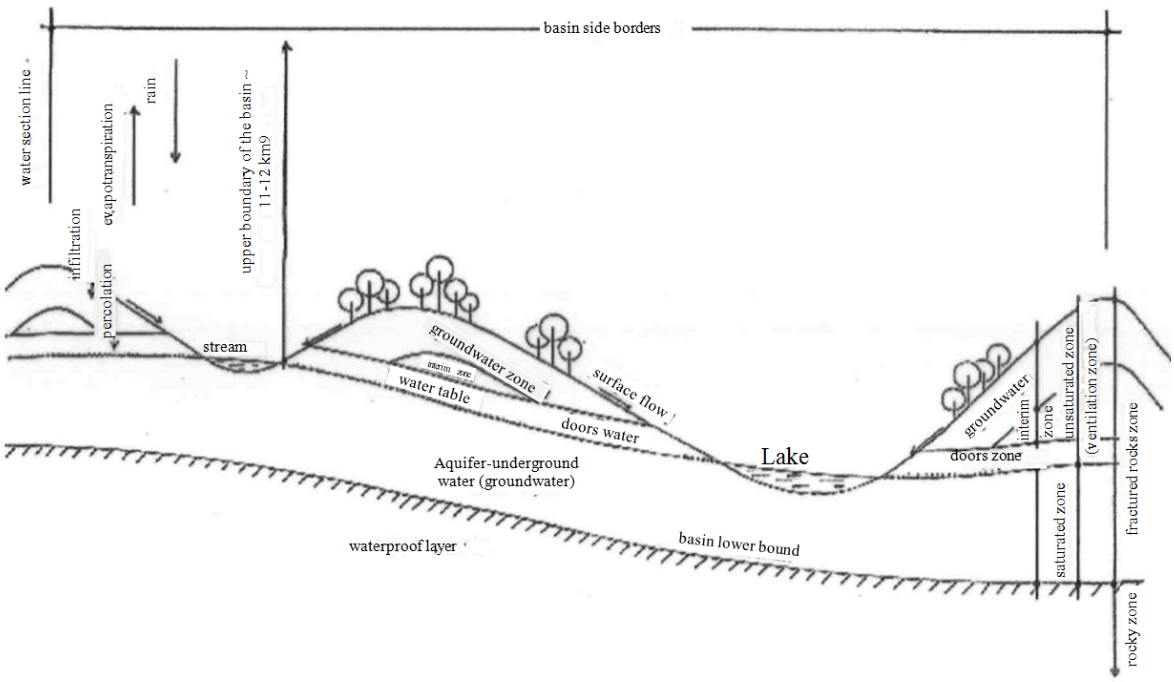


Figure 2. Water movements in the basin and the basin system borders (Suri, 2000)

Methods and Materials

The system approach has been adopted for the clarification of complex interactions between the basin ecosystem and urban settlements. A literature review allowed us to conduct research on old and new maps, plans, and orthophotos. Various institutions were contacted, requesting for documents to assist with the analysis of digital terrain models, geological analysis studies, and the basin ecosystem. Some of the observations and questionnaires were conducted with locals from the area, and for others the assistance of authorized institutions was enlisted. Preliminary investigations studied the cycles resulting in the sustainability of the basin ecosystem. A database of anthropogenic elements that directly and indirectly affected the basin ecosystem was accessed. The study included a detailed review of plans, legislation, and management practices that regulated the basin ecosystem and human settlements. Because there are no studies that specifically examined the habitability of areas around the basin, the focus of this study was to determine the anthropogenic impact and the ways to relieve the basin from pressure from the surrounding settlements that continually encroach the area.

According to data from studies conducted to determine the ecosystem characteristics of the Drinking Water Basin, the side borders in the basin ecosystem were considered the "water section line," i.e., the boundary that passes through the highest sections of the land according to the exit point. Although the definition partially works in terms of surface flow, the same limit may not always apply for underground waters. The horizontal/vertical, cracked/cavernous, permeable/impermeable, porous/nonporous elements of the layers formed by rocks depending on the geological and geomorphological structure of the basin determined the hydrogeological values of the rocks and boundaries of the feeding area (Öztaş, 1997b; Figures 3 and 4).

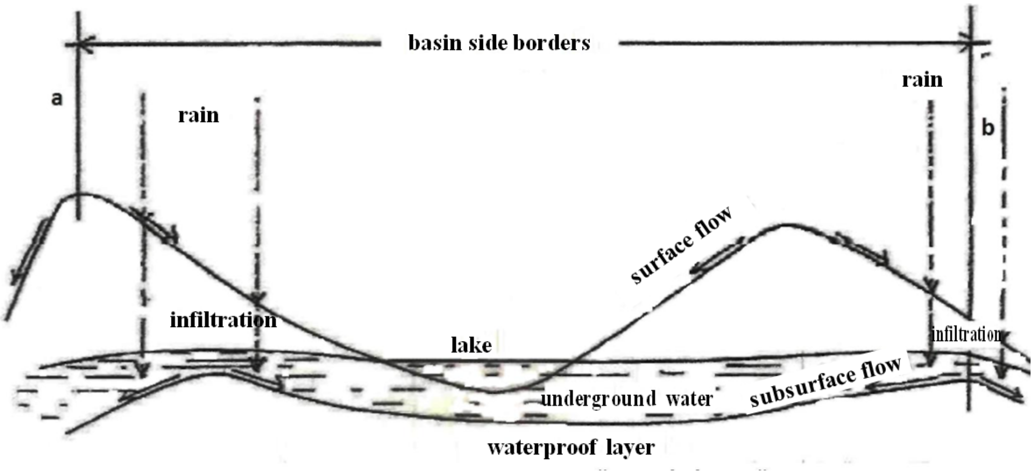


Figure 3. Side borders according to the slope of the impermeable layer (Suri, 2000): (border a) According to surface flow and (border b) According to subsurface flow

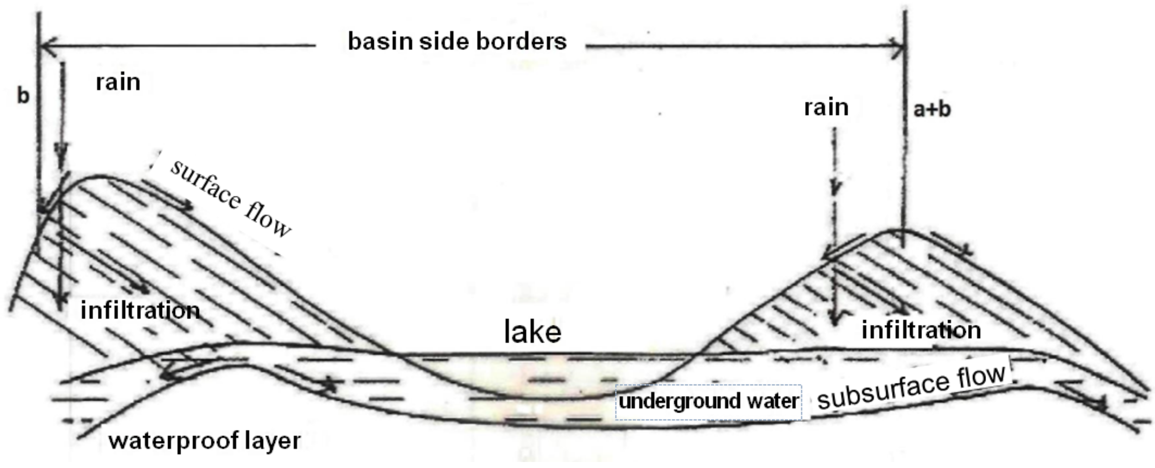


Figure 4. Side borders according to the slope of the layer (Suri, 2000): (border a) According to surface flow and (border b) According to subsurface flow

Therefore, it is important that the basin and especially its side borders are determined through geological and geomorphological analyses (for surface and underground flows of the basin feeding area) according to the physical properties of rocks, rather than based on standard values dictated by legislation, and the water balance sheet should be calculated accordingly to best use the existing water resources (Öztaş, 1997a). An altitude of approximately 11–12 km into the atmosphere (Erinç, 1984) determines the upper limit of the basin ecosystem. Underground waters, geological structures, and forests formed through leakages from the soil have been used to determine the lower boundary (Suri, 2000). The lower limit of the basin ecosystem is determined by the upper boundary (Seyhan, 1977) of the impermeable layer (Seyhan, 1977), which determines the lower limit of the underground water that feeds the dam or the water leaking from the soil, depending on the geological structure of the basin (Figure 2).

The sustainability of the water resources can be achieved through a "planning and management" approach, which results in the preservation and improvement of the vegetation cover, especially the forest habitats with dead cover and soil, enabling retention of rainfall and its underground transmission.

Environmental strains placed on basins through overpopulation and increasing human settlements, gradual destruction of the vegetation and forest cover, the increase in firm ground, together with the resultant negative impact on edaphic and aquatic elements, are foremost among the anthropogenic factors.

Location of Ömerli Water Basin

The Ömerli Dam, which meets approximately one-third of Istanbul's drinking water requirement, covers an area of 621 km^2 according to the Directorate General for State Hydraulic Works (Government Water Works Department [DSI]) data, and is an important reservoir for water storage brought to Istanbul from other sources; it is also an important natural area with rich biological diversity.

The dam is located in Riva Creek Valley, 28 km north of Istanbul (Figure 5). Completed in 1972, the Ömerli Dam is one of the largest reservoirs of Istanbul with a storage capacity of 268 million m^3 of water (Kurtar & Steen, 1993).

Figure 5. Location of the Ömerli Basin (Map of Ömerli Watershed outlined by the author from the Google Maps, 2017)

Ömerli Basin and Its Geological Structure

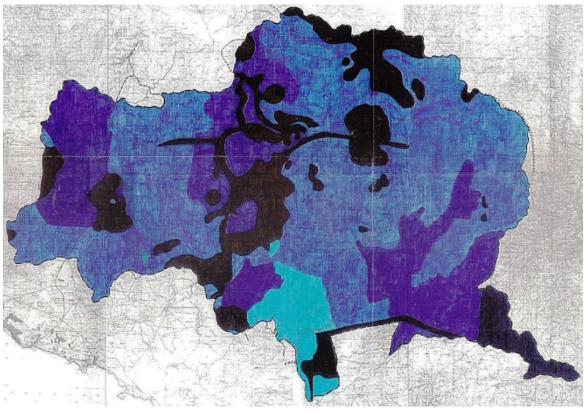
Much of the basin area has sediments carried through morphology, erosion, and water (Kurtar, B., & Steen, D. (1993). The Riva River basin is on the Lower Devonian strata, approximately 200 m thick, consisting of shale, greywacke, and limestone (less permeable). Beneath this layer are Upper Silurian (aged) rocks composed of arkose, schist, claystone, and quartzite (permeable) (Kürüm & Kürüm, 1989). Because quartzite has low carbonate and high silica contents, they affect the water quality positively. Terrace deposits covered the valley floor and contained silty and sandy pebbles located approximately 12 m toward the dam. Apart from sporadically eroded limestone, there were also Paleozoic (oldest) rocks. The limestone within the Devonian old red sandstone covers one-third of the basin. The rocks in Figure 6, which show permeability by geological structure, could be classified as given in Table 2, and the rocks that are defined as less permeable in Table 2 are highlighted in the lightest colors in Figure 6. Highly permeable rocks are highlighted in black.

Table 2. Classification of rocks in Ömerli Drinking Water Basin according to their permeability (Öztaş, 1998)

1 Very permeable	sand, gravel, clayey silt
2	limestone, dolomite
3	limestone, sandstone
4	quartz conglomerate, limestone clayey shale, clayey shale, sandstone conglomerate
5 Slightly permeable	granite

The second column in Table 2 lists the types of rocks with no or low permeability. However, it should not be overlooked that Devonian old red sandstone was influenced by tectonic events over the geological ages.

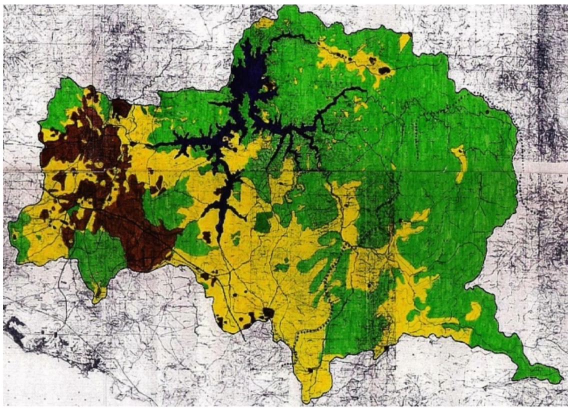
Because limestone, quartz, and volcanic rocks are fragile, they are affected both moderately and extensively from such tectonic events, resulting in broken and cracked structures (Ardos, 1979). The permeability of rocks is determined by fractures, raptures, discontinuities in volcanic rocks and porosity, cracks, melting, and stratification in sedimentary rocks. Therefore, certain sections of the basin may be more permeable than expected, even though the basins are slightly permeable or impermeable. Because permeability will depend on discontinuities in particular, it is estimated that the basin will face high levels of contamination if the pollutants reach the reservoir in this way.



Least permeable 5th degree permeable	4th degree permeable	3th degree permeable	2th degree permeable	Most permeable 1th degree permeable

Figure 6. Classification of rocks in Ömerli Drinking Water Basin according to their permeability (Suri, 2000)

When the geological structure (Figure 6) is compared to that in Figure 7 showing the use of existing land, it is seen that open and residential areas are located in areas where rocks with high permeability are found. This will result in domestic and industrial waste infiltrating underground water and the rainwater in open areas being prone to superficial flow rather than going deep underground despite the rock permeability (because there is no vegetation). However, basin boundaries are determined by the water section line on the surface. The anthropogenic effects outside the watershed boundaries also play a role in the pollution of streams and reservoirs, because groundwater movements determine the watershed boundaries depending on the geological structure.



forest	open area + agricultural area	settlement

Figure 7. Land usage in Ömerli Drinking Water Basin 1996 (Suri, 2000)

Ömerli Basin Anthropogenic Effects

According to the Ministry of Environment and Urban Planning, "water pollution" ranks first among Istanbul's environmental problems (ÇŞB, 2014). Ömerli İçme Suyu Basin is one of the most vulnerable regions affected by this situation. Current development plans, legislation, and administrative practices are the most effective factors in the proliferation of anthropogenic influences.

As mentioned above, negative factors such as nonsanitary establishments, eutrophication, deforestation, firm ground, erosion, domestic and industrial waste, roads, cemeteries, and garbage disposal areas reduce the water quality. Some of the domestic waste originating from the settlements around the basin has been directed to the Paşaköy Treatment Plant for processing; however, a certain portion of the agricultural, domestic, and industrial waste is released into lakes with wastewater collected in cesspools reaching the reservoirs leaking through the soil layers. Of the seven streams feeding the reservoir, four streams on the north and south basins delivered first-grade quality water, one stream at the southern basin delivered first-grade quality water, and the other delivered third-grade quality water, with the stream on the west with two branches delivering fourth-grade quality water according to the "Inter-continental Water Resources Criteria" (SCRC).

Ömerli Basin: The Impact of Plans and Legislature

Water Pollution Control Regulation and Drinking Water Basin Regulations are leading regulations that will shape basin planning. Amnesty laws for illegal housing are also important with increasing urbanization. Illegal housing built on areas close to settlements were granted legitimacy with Amnesty Laws for Illegal Housing numbered 2981, 3290, 3366, which were abolished in 2012, pursuant to Act 6306. The common theme through all plans for basins (Istanbul Environmental Plan [CDP], 2009) is provisions regarding zone protection.

The establishment of protection zones was noted similar to the protocol dated December 15, 1976 (DSI, SSYB, & IIB, 1976), and these zones were used to provide protection for drinking water sources until the zoning plans were made. A review of the technical specification (attached as an appendix to the protocol) revealed that settlements are still allowed, although with restrictions, providing they are some distance away from the basin, (housing, frozen industry, tourism facilities, etc.), but it also allowed structures, such as waste dumping grounds near basins, provided they are located far from the basin, even though their harmful effects are proven. Further, the statement which reads “Measures set out for absolute, short, middle, and long-range protection zones for future settlement plans” must be explicitly referred to in the list of conditions that predicates the construction of settlement areas around water resources upon a special protocol.

Legislation (Water Pollution Control Regulation, Istanbul Water and Sewerage Administration [ISKI] Regulation) regarding Ömerli Basin sets out an absolute short–middle–long-range protection zone for basins with urbanization increasingly creeping toward long-range protection zones. The distances of conservation zones specified in the Water Pollution Control Regulation and ISKI Regulation are the same, but the urbanization rates set out in the ISKI Regulation are higher. Densities specified in the Regulation (Table 3) will be calculated over the gross area. The value for the gross area is open to interpretation and it is difficult to predict the density of housing on the net area depending on its size.

Table 3. General Directorate of Istanbul Water and Sewerage Administration Legislation (2011)

Housing densities that need to be observed for each basin until the enactment of zoning plans and special provisions according to Annex 2, Article 16 of the Water Pollution Control Regulation			
Basin	Municipality	Medium distance protected area average density (persons/ha)	Long distance protected area average density (persons/ha)
Ömerli	Ataşehir	60	95
	Çekmeköy	60	100
	Kartal	20	25
	Maltepe	20	25
	Pendik	20	25
	Sancaktepe	40	120
	Sultanbeyli	40	150
	Şile	20	25
	Tuzla	20	25

However, the already existing land use (Figure 7) has significantly exceeded the sizes specified in the regulations and plans. The basin has been described as being the “entirety of the area that directs its waters to the same location.” Water in all parts of the basin reaches the reservoir after a certain period. Therefore, it would not be scientific to make planning and building decisions for the Ömerli Basin according to a standard protection level. High-density housing areas within the boundaries of Istanbul’s basins are kept in the plans.

According to the Ömerli Drinking Water Basin Environmental Protection Plan enacted in 1984 (1/25,000 scale) (Figure 8), relocation of settlements that are too close to the basin are planned by placing restrictions on how far the settlements can spread, or other measures. It is safe to assume on account of the current housing policies, settlements have been retained around basins and have spread in a restricted manner.

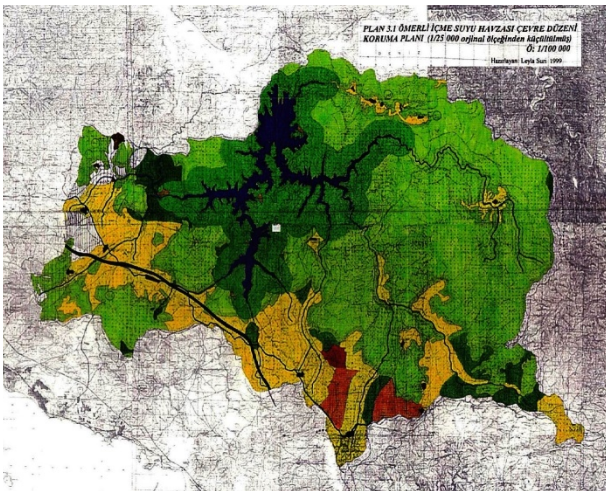


Figure 8. Ömerli Drinking Water Basin Environmental Protection Plan enacted in 1984 (1/25,000 scale) (T.C. Ministry of Public Works and Settlement, 1984)

The basin plan that includes parcelling and the floor area ratio values for agricultural areas contains provisions for the construction of certain agricultural structures around basins. Especially, large agricultural complexes such as cattle farms should not be located too close to basins, owing to their adverse impact on the water quality. A comparative study of Figures 8 and 9 indicates that a large portion of the "agricultural land" on the plan has been converted into settlement areas (housing, industry) that are not used for agricultural purposes, and the housing densities set out in the plan have been violated.

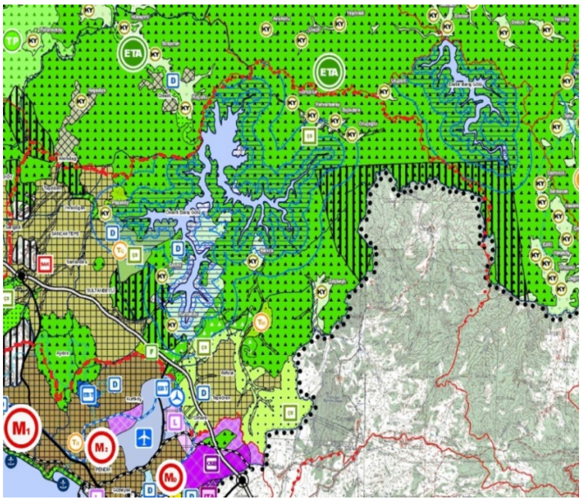


Figure 9. The Ömerli Drinking Water Basin in the 1/100,000 scale Istanbul Environment Plan endorsed by the Istanbul Metropolitan Municipality in 2009 (Istanbul Metropolitan Municipality, 2009)

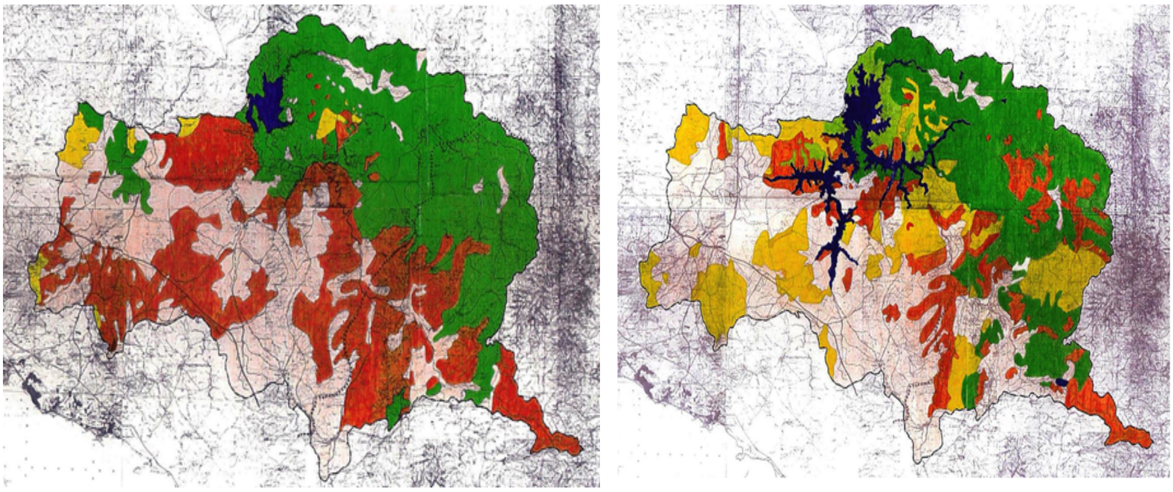
Most industrial waste (95%) reaches lands or rivers either directly or via cesspools (İSKİ, 1999). The same plan contained the floor area ratio value, which means parcelling and settlement rights for new settlers in forest lands. In the 1/100,000 scale, the Istanbul Environment Plan which was approved in 2009, the protection zones were processed based on the standard measures in the regulation (Figure 9). The mentioned plan does not include areas outside the jurisdiction of the Istanbul Metropolitan Municipality. It is also seen that areas opened for settlement have been included within areas inside the basins that are to be rehabilitated. A comprehensive analysis and review of subscale plans is necessary for rural settlements that also cover villages located around the basin. A top-scaled plan that provides net data applicable to the subscale plan is a significant approach for ensuring basin integrity. Because the part of the basin that is within the borders of the city of Kocaeli is outside the jurisdiction, the plan has not been included in the approval limit. Taking into account the basin's integrated structure and the hinterland relations, the basin plans should cover the entire basin. However, the implementation of the plan is restricted to the city's sphere of jurisdiction, but Istanbul's population has increased from areas outside its jurisdiction. Therefore, water basin planning and management should also be considered as a regional issue. It would be highly beneficial if a higher body (possibly the Ministry of Environment and Urban Planning) across different government agencies was established for development of the entire basin. According to current practices, the Ministry of Environment and Urbanization has the sole authority for executing planning and developmental projects across cities.

Changes in the Ömerli Basin Forest Areas

Forest lands around the Ömerli Basin are being rapidly replaced by settlement areas and agricultural zones. According to studies carried out in the Ömerli Drinking Water Basin in Istanbul between 1970 and 1990 (Hızal & Özer, 1998), 2,400 hectares (24,000,000 m^2) of forest land have been replaced by open areas. At the end of the same period, the area covered by more water consuming tree trees increased by 17.5%, whereas the area covered by low water consuming tree species decreased by 21.6% (Table 4, Figure 10).

Table 4. The change in forest lands and open areas around the Ömerli Drinking Water Basin over the past 20 years (Hızal & Özer, 1998)

Land Use	1970 (ha)	%	1990 (ha)	%	Difference (ha)	%
Forests						
Efficient Production For.						
Coniferous forests	1,043.0	1.8	9,204.0	15.9	+8,161.0	14.1
Leafy grove forests	127.0	0.2	2,053.5	3.6	+1,926.5	3.4
Total	1,170.0	2.0	1,1257.5	19.5	+1,0087.5	17.5
Coppice forests						
Fertile natural coppice	15,416.5	26.7	14,163.0	24.5	−1,253.5	−2.2
Infertile coppice	20,477.5	35.4	9,232.5	16.0	−11,245.0	□−19.4
Total	35,894.0	62.1	23,395.5	40.5	−12,498.5	−21.6
Total Forest Area	37,064.0	64.1	34,653.0	60.0	−2,411.0	−4.1
Open Areas						
Agriculture, Housing, Industry, etc.	19,646.5	34.0	20,302.5	35.1	+656.0	1.1
Water surface	1,109.5	1.9	2,864.5	4.9	+1,755.0	3.0
Total Open Area	20,756.5	35.9	23,167.0	40.0	+2,411.0	4.1
Grand Total	57,820.0	100.0	57,820.0	100.0	0.0	0.0



Fertile coniferous forests	**Fertile leafy coppice**	**Infertile leafy coppice**	**Open area housing agriculture**	**Fertile coniferous forests**	**Fertile leafy coppice**	**Infertile leafy coppice**	**Open area housing agriculture**

Figure 10. Type and location of Ömerli Drinking Water Basin forests (1970–1990) (Suri, 2000)

Changes in Ömerli Basin vegetation over the past 20 years reduced the amount of water by 11,613,525 m^3/year (annual water requirement of 500,000 people).

Ömerli Basin Administrative and Demographic Structure

A total of 60% of the basin was within the jurisdiction of the Ministry of Public Works and Settlement, whereas 40% of the basin was within the jurisdiction of the Istanbul Metropolitan Municipality until the enactment of Act 6360 in 2012, according to which the metropolitan municipal borders started being counted as provincial administrative borders (Figure 11). The biggest population increase in the Ömerli Basin was recorded when the towns and villages around the basin were not within the jurisdiction of the Metropolitan Municipality and the same period shows an upsurge in the administrative status of the basis settlements.

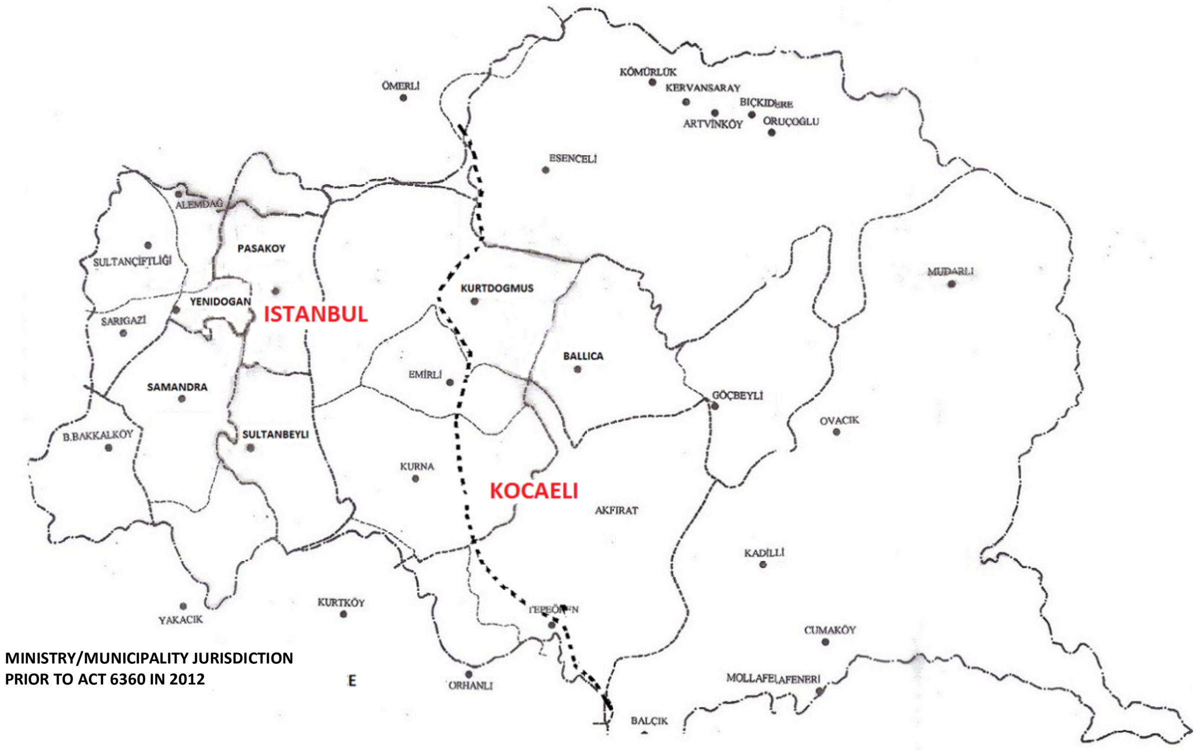


Figure 11. Administrative borders of Ömerli İçme Suyu Basin settlements (Suri, 2000)

As of 2000, there were two provinces (Istanbul, Kocaeli), eight districts (Beykoz, Ümraniye, Kartal, Pendik, Tuzla Sultanbeyli, Şile, Gebze), twenty villages, five towns, and three neighbourhoods within the boundaries of the basin. In particular, population growth in the west and southwest of the basin is above the Istanbul population growth rate. As can be seen from Table 5, there was a rapid population growth on the western parts of the basin in Sarıgazi, Sultançiftliği, and Yenidoğan in the 1980s, which then spread to the middle sections in the following years when Maltepe, Kartal, Sultanbeyli, and Ümraniye witnessed population growths above the national level. The change in land use owing to a population movement during the mentioned period can be clearly observed in Figures 12 and 13.

Table 5. Ömerli Basin population movement (Suri, 2000, Statistical Institute of Turkey, 2015)

	Population of the Basin Settlements									Population of the County						
Years	1975		1980		1985		1990		1997	2007		2008		2010		2015
Name of the Settlement	Population (person)	Rate of İncrease (annual average) %	Population (person)	Rate of İncrease (annual average) %	Population (person)	Rate of İncrease (annual average) %	Population (person)	Rate of İncrease (annual average) %	Population (person)	Population (person)	Rate of İncrease (annual average) %	Population (person)	Rate of İncrease (annual average) %	Population (person)	Rate of İncrease (annual average) %	Population (person)
ÜMRANİYE	5553	13	9346	9	13745	44	43354	18	99 037	897260	-38	553935	4	603431	3	688347
MALTEPE			500	14	850	55	3197	-8	1276	415117	0	417605	2	438257	2	487337
KARTAL	5559	1	5499	2	6186	49	21351	17	47376	541209	-21	426748	1	432199	1	457552
PENDİK	1494	3	1716	5	2177	5	2757	2	3087	520486	4	541619	4	585196	2	651736
TUZLA	548	3	620	17	1147	18	2185	11	3813	165239	3	170453	5	185819	5	234372
SULTANBEYLİ	1804	7	2431	11	3741	422	82298	11	146000	272758	3	282026	2	291063	5	321730
ŞİLE			887	6	1164	0.7	1209	2	1339	25169	11	28119	1	28753	3	33477
GEBZE			2834	3	3279	5	3965	2	4394	521291	-41	305557	0	308485	3	350115
TOPLAM	14958	12	23833	7	32289	83	160316	13	306322	3358529	-18	2726062	3	2873203	2	3224666

Population figures until 1997 refer to the population within the basin, whereas those following 1997 refer to the total population of the entire district.

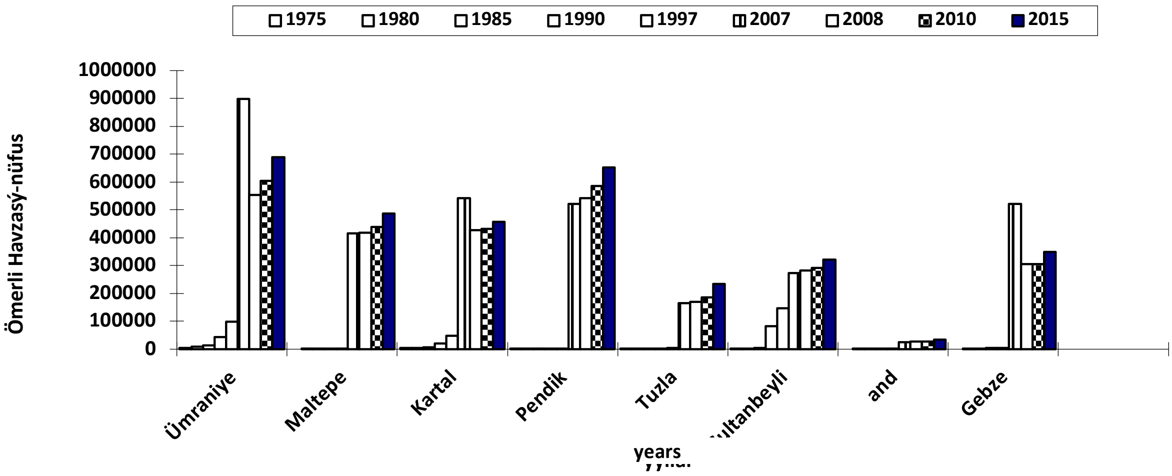


Figure 12. Ömerli Basin 1975–2015 population increase (Graphed by the Author based on Table 5)

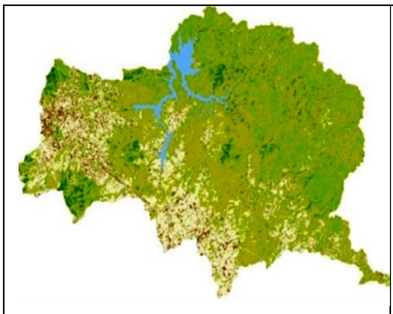
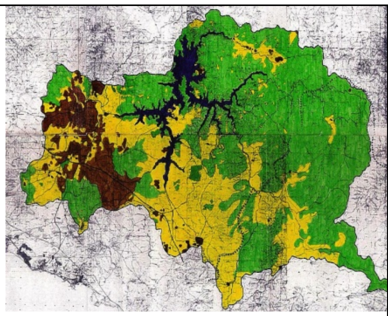
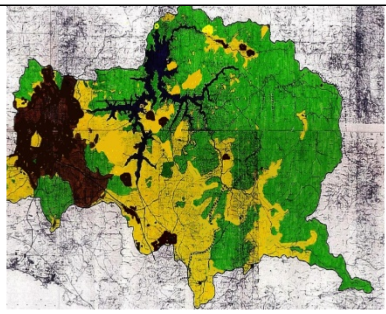
		
1987 Ömerli Basin land use	**1996 Ömerli Basin land use**	**2010 Ömerli Basin land use**

Figure 13. Changes in the land use of Ömerli Drinking Water Basin (Istanbul Technical University [ITU], 2015; Suri, 2000, 2015)

Referring to the population growth between 1990 and 1997, Sultanbeyli had a population growth of 420%, Sarıgazi 99%, Yenidoğan 95%, Büyükbakkalköy 55%, Samandıra 53%, Sultançiftliği 32%, Paşaköy 22%, and Emirli 12%. Currently, the rate of population growth is low compared to that of previous periods, but the population increase in places close to the basin, especially in its western and southwestern parts, was above the current Istanbul population growth levels. Administrative changes follow based on the rapid increase in population (Table 6). According to Act 6360, signed into law in 2012, jurisdiction of the Metropolitan Municipalities has been extended to include provincial administrative boundaries. However, as mentioned earlier, a part of the Ömerli Basin is within the boundaries of Kocaeli City, and therefore basin planning and management requires the coordination of the upper board.

	The Period to 1989		1989		1992		1994	
Name of the Settlement	Administrative Status	The District Where It Is Located	Administrative Status	The District Where It Is Located	Administrative Status	The District Where It Is Located	Administrative Status	The District Where It Is Located
Esenceli	Village	Beykoz	Village	Beykoz	Village	Beykoz	Village	Beykoz
Alemdağ	Village	Üsküdar	Village	Ümraniye	Village	Ümraniye	Town	Ümraniye
Sarigazi	Village	Üsküdar	Village	Ümraniye	Village	Ümraniye	Town	Ümraniye
Sultançiftl.	Village	Üsküdar	Village	Ümraniye	Village	Ümraniye	Town	Ümraniye
Yenidoğan	Village	Üsküdar	Village	Ümraniye	Village	Ümraniye	Town	Ümraniye
B. Bakkalköy	Neighbourhood	Kartal	Neighbourhood	Kartal	Neighbourhood	Maltepe	Neighbourhood	Maltepe
Paşaköy	Village	Kartal	Village	Kartal	Village	Kartal	Village	Kartal
Samandra	Village	Kartal	Village	Kartal	Town	Kartal	Town	Kartal
Emirli	Village	Kartal	Village	Pendik	Village	Pendik	Village	Pendik
Kurtdoğmuş	Village	Kartal	Village	Pendik	Village	Pendik	Village	Pendik
Ballica	Village	Kartal	Village	Pendik	Village	Pendik	Village	Pendik
Kurna	Village	Kartal	Village	Pendik	Village	Pendik	Village	Pendik
Göçbeyli	Village	Kartal	Village	Pendik	Village	Pendik	Village	Pendik
Tepeören	Village	Kartal	Village	Pendik	Village	Tuzla	Village	Tuzla
Akfirat	Village	Kartal	Village	Pendik	Village	Tuzla	Village	Tuzla
Sultanbeyli	Village	Kartal	Town	Kartal	District	Sultanbeyli	District	Sultanbeyli
Kömürlük	Village	Şile	Village	Şile	Village	Şile	Village	Şile
Kervansaray	Village	Şile	Village	Şile	Village	Şile	Village	Şile
Artvinköy	Village	Şile	Village	Şile	Village	Şile	Village	Şile
Biçkidere	Village	Şile	Village	Şile	Village	Şile	Village	Şile
Oruçoğlu	Village	Şile	Village	Şile	Village	Şile	Village	Şile
Kadilli	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze
Mudarli	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze
Balçik	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze
Cumaköy	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze
Mollafeneri	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze
Ovacik	Village	Gebze	Village	Gebze	Village	Gebze	Village	Gebze

Table 6. Vertical mobility in the administrative status of the Ömerli basin settlements (Suri & Kansu, 1999)

Ömerli Drinking Water Basin Changes in Land Use

Based on the afforestation efforts carried out between 1990 and 2014, a 4% (1039 Ha) increase was achieved in forest lands; however, coppice trees with relatively low water consumption should be chosen instead of leafy and coniferous trees with high interception.

The shift in other areas can be observed in Table 7.

Table 7. Changes in land use during the period 1997–2014 in Ömerli Drinking Water Basin (adapted from ITU, 2015; Suri, 2000)

Land Use	1997	2006	Difference 1997–2006	2014	Difference 2006–2014
Forests	22,961.64	24,007.56	4.56%	24,000.38	–0.03%
Shrubs	14,836.65	12,317.73	–16.98%	12,171.19	–1.19%
Agricultural lands	10,278.63	6,312.84	–38.58%	9,721.35	53.99%
Water surfaces	1,868.13	2,061.67	10.36%	2,001.37	–2.92%
Settlement areas	7,546.5	10,280.44	36.23%	12,755.58	24.08%
Empty spaces	5,798.25	4,808	–17.08%	N/A	
Total	63,289.8	59,788.24		60,649.87	

From 1990 to 2014, although shrubs decreased by 18%, settlement areas increased by 250%, and agricultural areas increased by 60% (Hızal & Özer, 1998; ITU, 2015). As mentioned previously, disappearing vegetation and the increase of hard floors negatively impact the soil, forest, and water relation to an irreversible extent. Highways, industrial complexes, mining exploration ventures, etc., play an important role in the pollution of basins. The impact of highway and mining exploration activities is largely owing to destruction of the vegetation cover, the polluting impact of vehicles using the highway, and that of load vehicles used for mine exploring activities and the materials they carry. For instance, a 10 km portion of the Transit European Motorway (TEM) Highway passes through Ömerli Basin, and the number of cars passing at peak hours is greater than 10,000. From the perspective of basin subsystems and the interactions between them, it becomes obvious that anthropogenic factors that place a strain on the basin ecosystem originate from current to planning–law-making–management practices. The sustainability of urban and watershed systems is directly proportional to the combined handling of planning and implementation programs, socioeconomic demands, and the ecosystem transport capacity. The overlapping authority of various institutions causes executive confusion (Table 8).

	Land Use						
The Organisation Concerned	**Settlement**	**Agriculture**	**Infrastructure**	**Forest**	**Business**	**Protection**	**Sanction**
B.Ş.B.B. (Istanbul Metropolitan Municipality**)**	X	—	X	—	X	X	X
District Municipalities (BŞBB)	X	—	X	—	—	X	X
Town Municipalities	X	—	X	—	—	X	X
Independent District Municipalities	X	—	X	—	X	X	X
Villages	X	—	—	—	—	—	—
Provincial Directorate of Environment and Urbanization Province	X	—	X	—	X	X	X
Provincial Directorate of Environment and Urbanization (Highway/Railway Etc.)	—	—	X	—	—	—	—
İSKİ (BŞBB)	—	—	X	—	X	X	X
DSİ (BAY. ve İSKAN BAK.)	—	—	X	—	X	X	—
Ministry of Forests	—	—	—	X	—	—	—
Ministry of Energy and Natural Resources	—	—	—	—	X	X	—
Head Department of Mining Enterprises (Ministry of Energy and Natural Resources)	—	—	—	—	—	—	—
Ministry of Tourism	X	—	—	—	—	—	—
Ministry of Culture	—	—	—	—	—	X	—
Ministry of Environment	—	—	—	—	X	X	—
Turkish General Staff	X	—	—	—	—	—	—
Ministry of Health	—	—	—	—	—	X	—
The Bank of Provinces (Ministry of Public Works)	—	—	X	—	—	—	—
General Directorate of Rural Community Services the Ministry of Agriculture and Rural Affairs	—	X	X	—	—	—	—

Table 8. The list of institutions with jurisdiction for the basin (Suri & Kansu, 1999) refers to powers granted for ensuring the continuity and quality of the water that comes from the basin

Conclusion

This study has aimed to address shortcomings regarding the integrated handling of ecological and socioeconomic systems, and has highlighted the impact of anthropogenic elements, within a limited scope. Naturally, there are complex and numerous interactions between ecological and social systems. The study has focused primarily on thresholds determining the basin tolerance, with emphasis on the geological structure. It has also focused on the significance of addressing a combination of natural and social systems. The study has been supported through examples from current planning decisions, legislation, and management practices, indicating that the current pollution issues that the basin faces cannot be surmounted through limited policies that focus solely on the basin. The clear conclusion we can draw from this study is that a well-planned and organized development plan across the whole nation is needed, in addition to organizing settlement plans according to available resources and revisiting current legislation for settlement planning to make it more sustainable.

As can be inferred from the limited examples cited above, current practices are not enough to obviate the current trend of deterioration and degradation within basin ecosystems. The sustainability of the basin ecosystem requires integration of the legal, administrative, and planning systems. The legal system should encompass a holistic approach for the protection of air, water, and soil resources (legislation under the responsibility of Ministries of Agriculture, Forestry, Water, Tourism, Environment, and Urbanization). The roles and duties of government agencies with authority over basins must be set out more clearly to avoid confusion. The Ministry of Environment and Urbanization can be authorized as the supreme board empowered with the authority to prepare regional plans.

In the context of planning hierarchy, the powers and responsibilities of institutions should be clarified.

Plans should have an integrated structure based around basins and be properly integrated into urban plans.

Ecological, geological, and hydrogeological analyses and user expectations and tendencies, as well as the socioeconomic structure should all be assessed together, especially the vital resources of the ecosystem.

Users should be made aware that intervention on any part of the basin affects the overall structure. Environmental plans for basins must be obligatory. Broad participation should be ensured in the planning and application stages. Financial resources for the application should be determined by law. A system must be established that is based around transparency and openness regarding payments to those that use the basin water and cause its pollution. Upper scale watershed plans should include decisions that provide guidance for lower scale plans. Basin management should have a multidisciplinary and autonomous structure consisting of upper–lower units and inspectors.

To summarize, the implemented methodology and plan should help solve problems arising from planning policies, legislation, and management, ensure resource sustainability, and be fully integrated with international standards and managed from a single center within the country.

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