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## Problems of Boğaçayı Watershed and Watershed Management Recommendations in Resolving These Problems

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### Abstract

This study is analyzed in detail existing land uses, socio-economic structure, environmental issues and problems arising from Boğaçayı watershed in the west of Antalya province.

As a result of this study, the environmental problems of the watershed that have been experienced from the past to the present day are mentioned. Antalya province has exhibited a rapid transformation in terms of urbanization in parallel with tourism development in the last 20 years with rich, historical, natural and cultural heritages in regional and urban perspective. Boğaçayı watershed integrated with Antalya City Centre is in large extent affected from this rapid development. Such rapid growth occurred in city population causes various environmental problems such as unplanned urbanization and squatting, air, water, soil, noise and visual pollution. Also studies conducted by public institutions have been identified in order to prevent environmental problems in the Boğaçayı watershed.

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Based on the results of this study, against the problems of the Boğaçayı basin are developed some suggestions in accordance with the principles of watershed management.

**Keywords:** Boğaçayı watershed, Environmental problems, Watershed management

## **1. Introduction**

Environment is defined as a setting in which living and non-living organisms living with one another and within interaction. Humans play the most important role within this interaction. Having capability of changing environment for desiring to utilize living and non-living organism for their own requirements, human-beings have tried to fulfill their desires without considering living and non-living organisms even themselves [15].

Due to the destruction of natural resources in an increasing way, a special due is attached to management regimes based on Sustainable Development and Sustainable Land Use. Sustainable development and land management is briefly defined as optimal management and use of all natural and artificial possibilities as primarily land, soil and water within a development model not jeopardizing existing possibilities of future generations for meeting their own requirements while meeting the requirements of today's generation [1].

The authors in [8] have revealed considerable differences between topographic, geologic and climatic conditions of Turkey in the study conducted in the issue of "Problems of Primary Watershed Management and Related Studies" and characteristics of related problems in respect with use and management of water and soil. Climatic conditions substantially affected by topography determine plant community characteristics and distributions [2].

Karaş in [11] has stated that sustainable development in its study "New Approaches in Watershed Management" is to be utilized in compliance with use purposes of soil and water resources and this process requires effectively Integrated Watershed Planning and Management implementations.

Antalya province has exhibited a rapid transformation in terms of urbanization in parallel with tourism development in the last 20 years with rich, historical, natural and cultural heritages in regional and urban perspective. Boğaçayı watershed integrated with Antalya city centre is in large extent affected from this rapid development. This effect has mostly emerged as quarries opened for supply of construction materials and damages exposed to environment by such quarries. As a result of this, natural areas, shores, open and green areas, heritage values and water sources in this rapid urbanization process have remained under pressure.

Öztürk in [13] has investigated the studies conducted over environmental problems in Porsuk Brook Watershed and their effects and has developed solution recommendations in line with the principles of watershed management of the problems existing in watershed. (such as pollution, erosion, flood, devastation of vegetation).

Çınar in his research [9] has mentioned importance of preventing improper land use in Boğaçayı Watershed in order for maintaining ecological harmony of Boğaçayı Watershed with Antalya province. It has been emphasized that scientific studies relating to watershed are maintained and the view regarding making a decision according to opinions of experts' persons from different disciplines of local and administrative managements with authority hereunder over the site is of utmost significance in protection of basin.

By considering the studies conducted earlier, it has been aimed that solution recommendations in line with environmental problems of Boğaçayı Watershed from past to our days and effects of such problems (pollution, erosion, flood, devastation of vegetation) have been developed.

## **2. Materials and methods**

### **2.1. Material**

Study site is Boğaçayı Watershed having 830 km<sup>2</sup> rainfall area comprised of 3 main tributaries constituted by Karaman Brook at northern watershed, Çandır Brook at southern brook and Doyran Brook between two watersheds, located at the western part of urban centre and in 10 km distance to Antalya city centre within the borders of Mediterranean borders.

Natural borders of Boğaçayı Watershed is surrounded by Aladağ, Sarı Çınar Mountain, Karadağ and Çatma Mountain in the west, Bekirli Mountain, Ziyaret Mountain, Çal Balı Mountain in the west and Göl Mountain, Kozan Mountain in the north west and Boğaçayı Watershed extends in north western and south eastern direction. Mediterranean region is located in the south east. Within Watershed borders, there are residential areas called as Aşağı Karaman, Doyran, Çakırlar, Hacisekililer, Bahtılı, Karatepe, Akdamlar, Geyikbayırı, Çağlarca. 9269 people live within watershed according to 2011 population census.

### **2.2. Method**

Primarily geology, hydro-meteorological and general status maps and photographs in the studies conducted up to now by State Hydraulic Works 13rd Regional Directorate as well as data of Antalya Provincial Good, Agriculture and Livestock have been made use of herein. Various studies conducted for Boğaçayı watershed by several public and private organizations have been used in data collection. In addition to this, literature review in this regard has been conducted for shaping the study. The following study program has emerged in line with the data obtained hereof and under the light of earlier studies [10,13].

Investigation of natural qualities and land uses of Boğaçayı Watershed,

- Examination of problems between natural qualities and land uses of Boğaçayı Watershed,
- Developing recommendations for solving problems of Boğaçayı Watershed,

In the first phase of the study; current status of natural qualities and land uses of Boğaçayı Watershed has been revealed. The information regarding natural characteristics of Boğaçayı Watershed within natural qualities of study area has been provided. Also watershed has been examined in terms of land use.

In the second stage of the study, problems emerged between natural qualities and land uses of Boğaçayı Watershed have been analysed. In this respect, the problems posed by land use (erosion, floods and droughts, pollution) and the emergence of what is causing this problem have been investigated.

In the third phase of the study, solution recommendations required to be taken for solving problems of Boğaçayı Watershed have been created.

### **3. Results and Discussion**

#### ***3.1. Natural Characteristics of Boğaçayı Watershed***

Primarily natural, ecological and socio-economic characteristics have been determined for identifying problems of Boğaçayı Watershed and presenting solution recommendations. Boğaçayı Watershed formed by 3 major rivers in integrated status with a city centre in 10 km distance in western direction from Antalya city centre is a watershed having 830 km<sup>2</sup> rainfall area (Figure 1). There are rocks in different age and quality in Antalya. Geological structures in the study area is comprised of Paleozoic (Permian), Mesozoic (Triassic, Jurassic, Cretaceous), Tertiary (Pliocene) and Quaternary formations.

Four main soil groups as to soil classification have been encountered as a result of soil studies conducted within Boğaçayı Watershed area. These soils can be listed as Red Colour Mediterranean soils, Brown Forest Soils, Alluvial Soils and Colluvial Soils [12]. The study area is dominated by Mediterranean climate. What is typical characteristics of this climate is that summer season is hot and dry and winter season is cool and rainy.

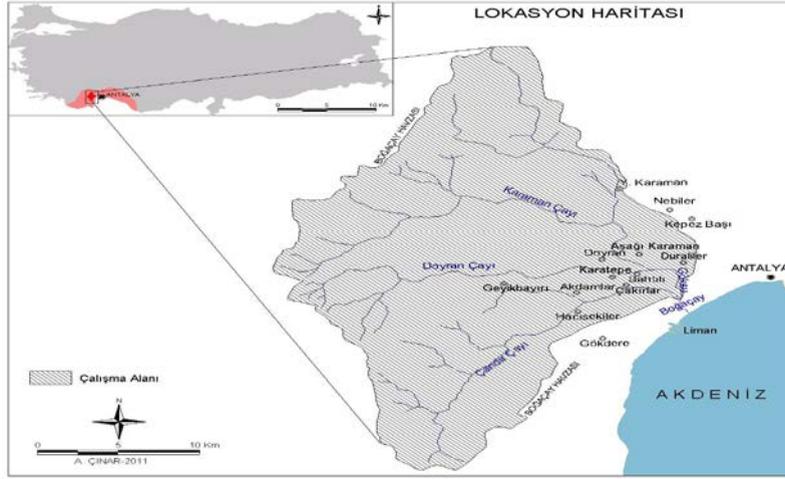


Fig. 1. Boğaçayı watershed location map [9]

Boğaçayı that is the most important river of the site and the watershed occurred herefrom are formed by combination of three major flood character brooks called Karaman, Doyran and Çandır [4].

Drainage network area of Boğaçayı formed together with Çandır, Doyran and Karaman is 830 km<sup>2</sup>. Considering drainage characteristics of Boğaçayı Watershed, it is seen that Boğaçayı Watershed has dentritic drainage network. Characteristics of this drainage network illustrate that river network forms a shape like trunk and tributaries of a tree [6].

Boğaçayı Watershed falls within the scope of Mediterranean sub region of Mediterranean climatic region. While typical Mediterranean plant communities durable to summer drought with high temperature and light demand depending on ecological conditions provided by Mediterranean climatic conditions on the areas where elevation is not so high; once devastation status changes with elevation and topographical characteristics, changes will be witnessed in distribution of vegetation [5].

There is a wild life comprised of mammals, birds, reptiles and amphibians within Boğaçayı Watershed. The watershed incorporates 19 mammals as to the studies conducted and publications. Result of the studies and researches conducted earlier on the site has determined that there are 131 bird species belonging to 37 families [3].

### **3.2. Land Use and Socio-economic Structure of Boğaçayı Watershed**

The city of Antalya ranks as the first city in the Mediterranean region in terms of socio-economic development level, population size and growth, economic activities, regional services, infrastructure and transportation. It ranks as 7 within the country. Antalya has made an crucial steps in the path of being an urban metropolitan city showing a rapid development in terms of population and socio-economic aspects throughout not only the region but also the country. Especially developments in the tourism sector has contributed this city to be identified as capital city of

tourism of Turkey and it has become a recognized city both throughout the country and in international arena. Natural resources of tourism such as coasts, bays, climate, beaches, national parks, historic sites, mountains, forests etc. constitute primary resources of tourism [2].

### **3.3. Watershed Management of Boğaçayı Watershed**

#### ***-Environmental problems in Boğaçayı Watershed from past to present***

Antalya province is the city whose population increases rapidly as a result of migration. Such rapid growth occurred in city population causes various environmental problems such as unplanned urbanization and squatting, air, water, soil, noise and visual pollution. Such pollutions occurred in natural environment affect adversely not only physiological disorders but also human health in psychological aspect [7]. Environmental problems occurred so far in working area can be grouped as follows;

- Problems arising from rapid population growth
- Problems arising from unplanned urbanization
- Problems arising from improper land use
- Problems arising from agriculture
- Problems arising from industry and trade
- Problems arising from lack of planning and management
- Problems arising from devastation of natural resources

Rapid population growth in Antalya province has primarily led to unplanned urbanization and as a result of this, it caused time-consuming and insolvable problems such as squatting and urban sprawl (Figure 2).



Fig. 2. Within a watershed developing construction

Boğaçayı coastal plain is a prominent tourism region of Antalya having the world famous Konyaaltı beach. In addition to this, presence of harbour and free zone and proximity to agricultural fields in the north of plain and its being on the road of Kemer have emerged the demand of structuring in the plain. After all, lands in the state of wet lands and citrus groves have been opened to zoning over a time.

Main motive of the problems undergone in Antalya province soils is rapid population advantage and accordingly uncontrolled urbanization movements developed in parallel with this process. The most important and required use land of the soil is agricultural activity. Since rapid growth occurred in city population boosts housing requirement, transformation of existing agricultural lands to housing lands is one of the most fundamental problems seen in Antalya soils.

The first and fundamental problems that rapidly growing population confronts in our working lives is housing requirement. Activities executed on the areas zones for construction for meeting this requirement turns vast majority of the city into construction site and cause several problems such as visual pollution in this case.

While lands as production capital create livelihood and employment source of population living in rural area, this is of great importance in terms of supply of raw material of industry and feeding urban population. The most prominent problem relating to agricultural lands is continuation of land fragmentations carried out through inheritance and it is becoming to threaten food safety as volumetric and spatial concerns.

Economic development is the most important factor damaging environment due to the fact that it increases consumption. Environmental problems increasing with each passing day demonstrate that nature has limited and exhaustible resources and human-beings should act more responsibly and sensibly over their relationship with nature.

Rapid growth of tourism sector in Antalya and side sectors related to tourism has culminated in demand growth for housing, rapid population growth, tourism structuring and infrastructure investments. Thus, increase in the demand for construction has caused performance of construction sector throughout the city in extraordinary pace starting from 1980s to second half of 1990s. Sand and gravel material needs of the construction industry are available in colluvial reservoirs brought by Çandır, Karaman and Doyran Brooks in middle and upper watershed having sufficient reserve and the closest to the city. Especially bedding vicinity of Çandır Brook is the most processed area due to being rich in material.

Demands and pressures of especially urbanization and tourism structuring in Antalya province have led to losing of unfortunately most natural environments and disruption of ecological balances. On the other hand, as a result of being deprived of required ecological knowledge and obligation of doing popular politics experienced by political authorities-local managements from time to time, ecosystem integrity of Antalya province has been very rapidly devastated and is still being devastated [1].

Uncontrolled and unsupervised operation of quarries and illegal material procurements cause colossal devastation in brook bedding and environmental pollution day by day in the vicinity of Boğaçayı Watershed and at the same time, capturing materials from vast areas has led displacement of brook bed. Due to adverse situations emerged, Antalya Local Environmental Committee requested to close down these quarries with a decision adopted in 1997. Immediately after the decision in question, some construction companies established stone extraction and grinding facilities over north-facing slopes of Güz yaka (Üzümcek) mountain located in Boğaçayı Watershed and initiated to extract required materials from here. Several firms making use of this uncertainty created with the decision of Local Environmental Committee started to carry on operation on these locations [9].

It is noteworthy that forestry areas in upper part of Boğaçayı Watershed are devastated with the reasons such as opening fields, excessive and premature grazing and forest fires. (Figure 3). However, carstic areas with fully devastated forest cover have taken a bare and stony-rocky look. Scrub community has become widespread on the areas where calabrian forests are devastated or over-operated and especially overgrazing is continued.



Fig. 3. Open field in the forest area

### ***3.4. Problems emerging as a result of environmental problems from past to present in Boğaçayı Watershed***

Problems caused by environmental environmental problems from past to present in working area can be summed up as follows;

- Water pollution
- Soil pollution
- Solid waste
- Visual pollution
- Noise pollution
- Air pollution
- Erosion
- Overflow-flood problem

Antalya city is one of the centers where rapid population growth, unplanned urbanization and squatting are heavily seen. Moreover, in addition to environmental problems seen in parallel with tourism activities and difference between winter populations with summer population, infrastructure deficiency is the most striking cause of water pollution with urban causes. Given hydrological and geological properties of the region, it is seen that pollution of especially underground waters is inevitable [14].

Main motive of the problems undergone in Antalya province soils is rapid population advantage and accordingly uncontrolled urbanization movements developed in parallel with this process. The most important and required use land of the soil is agricultural activity. Since rapid growth occurred in city population boosts housing requirement, transformation of existing agricultural lands to housing lands is one of the most fundamental problems seen in Antalya soils. The second striking problem is agricultural activities conducted intensively in the region. Chemical substances used for enhancing product quality and efficiency in especially greenhouse operations causes disruptions in natural structure of soil. The combined result of these two applications is that soils cannot be used again and for longer periods. When the above-mentioned applications are expected to continue in our time and in the future, measures and studies required to be conducted in this regard need to be urgently implemented. Improper agricultural activities, use of non-agricultural land, devastation of forests, livestock, mining, waste storage and soil erosion can be considered as the major soil problems [1].

Solid waste volume emerging together with rapidly increasing population in Antalya province is also growing constantly. 90 % of solid wastes emerged in our working area is domestic origin. Industrial wastes are in small extent due to non-development of industry in the province and thus they are considered as special wastes.

The majority of tourism centers located within the borders of watershed is small residential area having low annual revenue. Solid waste volume generated is increasing in parallel with two-folded populations of these districts and villages in summer season. (Figure 4).



Fig. 4. Within a watershed solid waste

Environment is covered with lime dust as a result of operations in quarries and a unsightly landscape is created with these operations. (Figure 5). Furthermore, dusts emerged from the quarries near to road comes on the road and when these dusts are get wet with light rain or water, road becomes extremely slippery. And this case constitutes a dangerous situation for drivers.



Fig. 5. Caused by quarry dust clouds

"Noise" is one of the most important environmental problems in Antalya province that is rapidly growing and with increasing population. Being an agricultural and tourism city, rapidly growing population causes increases of transportation and infrastructure needs with each passing day in Antalya province. For solution of these needs, the number of motor vehicles is gradually increasing and infrastructure works are maintained on continual basis and

flight transfers are organized for both residential population on site and for tourists and all these components cause growth of noise pollution.

Material generation and gallery opening from quarries working on hillside area as well as sand-gravel quarries operated in brook bed are carried out with explosive substance. During this process, dense dust clouds spread around. Dust clouds generated by dense truck traffic as a result of infrastructure deficiency lowers efficiency in agricultural areas and disturb nearby locals with noise pollution created therefrom and threatens life and property safety [12].

It has been witnessed that unplanned material procurements without permission from beds of sand-gravel quarries and brooks as a result of land observations conducted in Boğaçayı Watershed cause disruptions in river beds. In addition to this, vegetation in the vicinity of bedding is gradually removed. This situation adversely affects ecology of the basin. Therefore, residential areas in Boğaçayı Watershed are exposed to risk of overflowing and flood at all times. Spreading to a vast area of materials such as rock, gravel, debris brought by flood waters and water accumulation in agricultural lands has been experienced for several times. With operations of zoning for construction, damage extents of overflowing and flood have further grown in size (Figure 6).



Fig. 6. Flood resulting image

### ***3.5. Boğaçayı Watershed management studies***

8 reports set out below from past to present have been issued by DSI 13th regional directorates within Boğaçayı Watershed. These are;

- Boğaçayı project planning report, 1974,
- Antalya Boğaçayı Plain Hydrogeological Investigation Report, 1977,
- Boğaçayı overflowing protection planning report, 1995,
- Report of natural structural tools,
- Additional report of natural structural materials of reclamation on Antalya, Boğaçayı, Çandır and Karaman brooks,
- First investigation report of upper watershed of Antalya Centre-Çakırlar, Çandır brook, 1999,
- Overflowing protection project of Antalya Çandır and Karaman brooks, 2000,
- Preliminary report of reclamation of Antalya, Boğaçayı, Çandır and Karaman brooks, 2010.

These reports have been updated as to existing artistic engineering structures and zoning plan status and it has taken its final shape in project preliminary report of Antalya Boğaçayı, Çandır and Karaman brooks conducted in 2010. In this report, separate solution recommendations have been created for each tributary by considering existing reclamation facilities of Boğaçayı and its tributaries, existing artistic engineering structures and zoning plans.

A vast majority of the studies conducted within Boğaçayı Watershed has been performed in relation to protection of overflowing of agricultural lands and the said lands have been zoned for construction in large extent over a time and investigation of reclamation facilities conducted has been duly carried out and it has been decided that reclamation studies conducted in regard to protection of agricultural lands are to be revised in a way that will protect zoning sites.

There is no available prevention and erosion mapping study conducted so far for Boğaçayı Watershed. A commission was established for conducting an afforestation work in coordination with governorship in 2001 and condition of watershed was investigated and it was concluded that the watershed is sufficiently with forests and there is no need for afforestation works.

Construction works conducted over rivers within Boğaçayı Watershed are executed by DSI. After completing the studies, cleaning works of rivers are conducted by municipality. Sediment cleaning is performed by Konyaalti municipality for preventing filling of river beds periodically.

Investigations are carried out by a commission comprised of operating director deputy, operating chief, cadastral chief once a year routinely by forestry operating directorate to stone sand and gravel quarries located within Boğaçayı Watershed in cases of issuance of complaint etc. in the issues of whether permitted areas are breached or not. In the event permitted areas are breached as a result of investigation is determined, required official procedures are imposed. Consequences may arise up to revocation of license as a result of penal sanction. There has been only one legal process relating to quarry belonging to Kadıahmetoğulları so far and as a result of jurisdiction, the court has found justified.

Rather than forestry operating institution, Mining Department and Provincial Special Administration Institution

periodically carries out inspections for quarries and checks whether status of extracted mine and its working system is compliant or not.

#### **4. Conclusions and Recommendations**

Boğaçayı Watershed is a watershed integrated with Antalya provincial city. Watershed has not lost its natural environmental characteristics yet. However, environmental problems as regards watershed in parallel with rapid growth of the city are increasing day by day. The problems encountered in Boğaçayı Watershed are various and currently continue.

The problems encountered in the field;

- Problems arising from rapid population growth
- Problems arising from lack of natural awareness,
- Problems arising from fertilizer applications and irrigation performed on agricultural lands,
- Problems arising from improper land use and unplanned urbanization,
- Problems occurred as a result of urbanization pressure and misuse of lands zoned for construction,
- Problems occurred as a result of pitting in riverbed resulting from material taken for a long time from Karaman, Doyran, Çandır brooks and consequently ponding occurred herein and degradation of brook bed,
- Problems arising from devastation of natural resources and vegetation,
- Problem of overflowing and flood risk occurred as a result of misuse of bedding vicinity and structuring expanding around overflowing bed and quarries with unauthorized opening,
- Problems arising from failure of understanding of use and planning as an integral part of the site, in other words, without contemplating on the basis of watershed.

The following recommendations can be developed for remedying environmental problems determined within the watershed as a result of the study conducted;

- As a generally encountered problem, coordination deficiencies between public organizations and private sector firms should be placed onto a legal order at once.
- As in definition of watershed management, environment should be handled within a system where all stakeholders are included as a whole and management studies should be conducted within the framework of required plan program.
- As a result of data to be gathered, current state of the watershed should be determined and required plans should be made against risky situations likely to occur and required applications should be put into implementation. The studies conducted should be revised and updated periodically.
- Even if quarries located within in-forest areas because of an obligation, they should be permitted; inspections of those authorized should be performed without any delay. Quarries with expired use life should be ensured to be rehabilitated as soon as possible.

- Green areas with high importance in terms of all aspects within urban settlements should be preserved and new green areas should be added on continual basis.
- Services performed on the areas with no zoning plan causes emergence of other problems. Zoning planning works contemplated to be zoned for construction for this reason should be completed as soon as possible.
- Water resources that are a scarce source in our times are contaminated as a result of activities such as structuring, industry, agriculture and livestock. Developing water resources required without causing leaving under more pressure should be handled in the basis of conservation, use and planning processes.
- Unnecessary and improper use of fertilizer in agricultural activities within watershed should be avoided.
- Since Boğaçayı Watershed is in integrated state with Antalya city centre and population of Antalya is incessantly growing and eligibility of climatic conditions and especially volume of tourism potential are high, it is apparent that existing problems in our time will continue in the future. For this reason, Boğaçayı Watershed should be taken into conservation as soon as possible and its future with required cooperation should be saved.
- Since Boğaçayı Watershed is an attraction centre of Antalya, it is used for purposes rather than agricultural lands. As a result of this, deterioration in severe extent has emerged in soil structure. If it continues in this way, it is likely that adverse consequences will show up for the region in the future. For this reason, misuse of lands should be avoided.
- Boğaçayı and its tributaries are of utmost importance for Antalya. For the time being, perimeter of these tributaries in inert position should be arranged in a way which will meet recreational needs of Antalya public and tourists without damaging environment and should be provided to the service of the public. In interviews with local people, local people especially desire Boğaçayı Watershed to be saved from this negative condition and they would like to have park areas whereby a lot of various activities are present.
- Intense structuring pressure as a result of sheltering emerged together with increasing population has causes especially disruption of natural ecological characteristics in lower part of the watershed and structuring goes forward towards middle and upper sections of the watershed. Structuring should not be permitted for avoiding full disruption of the watershed and the sites should not be zoned for construction.
- Problems occurred as a result of pitting in riverbed resulting from material taken for a long time from Karaman, Doyran, Çandır brooks and consequently ponding occurred herein and degradation of brook bed has put flood water in uncontrollable state. Vegetation should be conserved for minimizing flood risk likely to occur on the site and misuse of the land should be avoided and structuring in the vicinity of Boğaçayı should not be permitted. In addition to this, unauthorized material procurement of sand-gravel-stone quarries should be ceased.
- These are available over colluvial reservoirs in upper watercourses of Karaman brook and alluvial coating in the vicinity of Bahtılı and Çakırlı and Yukarı Karaman villages within lower sections of Boğaçayı Watershed. I. class lands in questions must not be allocated to any other area use rather than agricultural purposes.
- Karaman ,Doyran and Çandır brooks remaining within Boğaçayı Watershed are being tried to be directed without considering their hydrological properties and as a result of this, vegetation of brooks over flood beds are devastated. Water resources located within the watershed for this purpose should be directed in line with their hydrological properties.

—Boğaçayı Watershed bears unique properties from its environment with its ecological characteristics it possesses. All public institutions and private sector managements should fulfil their due duties for conserving watershed ecology and transferring it to future generations. Moreover, integrated air management plan of the site should be performed for ensuring coordination between all organizations of the state.

—Inspection of quarries located within Boğaçayı Watershed should be performed without any delay and unauthorized material procurement should be ceased and this will firstly minimize ponding and overflowing over the beds and it will ensure conservation of feeding resource of worldwide known Konyaaltı beach.

—That lower part of Boğaçayı Watershed remains within urban area day by day aggravate the works of preventing flood risk. Therefore, existing structuring in the vicinity of bedding should under no circumstances be permitted.

—The area between two bridges where Boğaçayı brook pours into sea is a wet land. This site should be conserved due to its ecological characteristics.

### **Acknowledgement**

This study has been taken from a part of a thesis called "Problems of Boğaçayı Watershed and Watershed Management Recommendations in Resolving These Problems" supported by the Scientific Research Projects Unit of SDU (Suleyman Demirel University, Isparta- Turkey) (No: 3267-YL1-12).

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