Using GIS and Remote Sensing Technology to Determine Geographical Features of Watersheds, Example of Nilufer Creek Watershed

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Abstract

This study forms an example of how medium and large scale watershed studies are coupled with Geographical Information Systems in the determination of the past and present environmental characteristics. In this study, Nilufer Creek Watershed has been studied through the aid of GIS and Remote Sensing Technologies. Within this context, various thematic layers like administrative boundaries, watershed and sub-watershed boundaries, land-use distribution, geology, geomorpholgy, soil, water quality are produced. Besides maps showing the stream network, drainage, sub-watersheds, and Digital Elevation Model of the watershed are presented as examples. These maps are generated to be further used as input data in the modeling of both the watershed and the receiving water quality studies. Thus, while in Turkey, watershed plans and local area plans, with GIS and Remote Sensing Technologies determine the current state of natural resources, physical - biological - ecological characteristics underlined the need to reflect the decisions of land use as it should be examined.

Keywords: Land Use, Nilufer Creek Watershed, Remote Sensing, Water Resources, Watershed Management.

1. Introduction

When examining geographical characteristics of study area as an underlay for the catchment basin planning, geographical position, geomorphologic characteristics, hydraulic structure, structure of soil, climate and vegetation have to be considered.

2. Material and Method

For the purpose of interpretation of data gained from this study and generation of new data, ArgGIS which is a software of GIS has been used. In the Ecological Risk Analysis approach, pollutions in natural resources in the study area and risks stemming from the pollutions have been established. This detection has been made with the support of digitalization of geographical data, evaluation of existing data and association of them with one another, interpretation of chemical analysis results for the catchment basin and CBS maps. However, analysis studies have been assessed by using GIS measurement, inquiring, classification and overlay analysis methods.

2.1. Research Area

Province of Bursa is located in the north west of Turkey between northern latitude of 28°10’ and 30°00’ as well as eastern longitudes of 40°40’ and 39°35’. Province of Bursa is located in Marmara region, the most developed region of Turkey, in Eastern Marmara and has a total land area of 10.819 km². Study area has a land area of 1.288,96 km².

Study area covers portions of counties Yıldırım, Nilüfer, Osmangazi, Gürsu and Kestel of the province of Bursa. Catchment basin of the Stream Nilüfer has been divided into 9 lower catchment basins from perspective of methodological approach and position of pollution measurement stations, and by taking into consideration flow of Stream Nilüfer from source to downward, and drainage conditions from upper catchment basins to lower catchment basins and water division lines. These sub basins include Nilüfer Stream Branch Sub-Basin, Ayvalı Creek Branch Sub-Basin, Cilimboz Creek Branch Sub-Basin, Gökdere Branch Sub-Basin, Hacivat Creek Sub-Basin, Demirtaş Creek Sub-Basin, Hasanağa Creek Sub-Basin, Üçpınar Creek Branch Sub-Basin and Karaağaç Creek Sub-Basin (Fig. 2.).

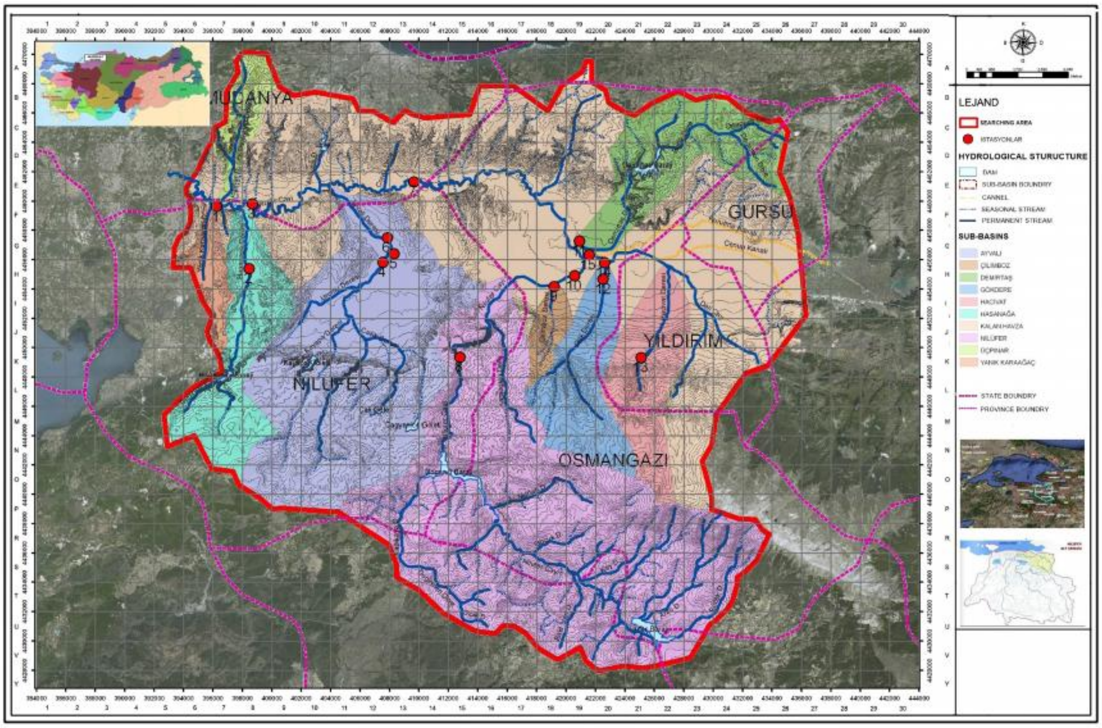

***Fig. 1.** Research area*

3. Findings and Discussion

3.1. Geomorphologic Characteristics

Decisive character of physiographic structure over the micro-macro climate of the catchment basin varies proportionally depending on what morphologic formation shapes catchment basin contains (Atabay, 2003). It is seen that Bursa Plain's latitude above the sea level is 100 to 150 meters, and surface shapes of Bursa are separated from one another with thresholds composed of rift areas and mountains. Around 35% of the terrain within province of Bursa is composed of mountains. The most obvious geomorphologic threshold located to the south of study area is the Mount Uludağ. Major rift areas include the lakes İznik and Uluabat and Yenşehir, İnegöl and Bursa plains. "Bursa Plain is located within Southern Marmara boundaries of Marmara Region. Plain is bordered by the Mount Uludağ (2543 m) that is the highest peak of Marmara region and to the south and Mudanya Hills and the Mount Katırlı to the north. Plain is bordered by, to the east, Aksu-Kazancı Hill threshold separating İnegöl Basin from Bursa Plain and the Village Turan (Boşnak) threshold separating Bursa form Yenişeehir Plain which goes up to 400 meters, and, to the west, is bordered by a threshold area separating the lake Ulubat and Karacabey Plain which is 237 meters high. Within the boundaries set out, Bursa Plain has a land area of 530 km² when the contour line of 200 m is taken as basis, and has a land area of 295 km² when contour line of 100 m is taken as basis ” (Arınç, 2010). Due to extremely high inclination values of the mountains, geomorphologic formations, there is reduced risk of underground and surface water pollution during process of infiltration of the rain waters or pollution discharges by the soil. These values demonstrate medium risk in the plateaus and high risk in the plains due to drainage characteristics determined by the inclination characteristics.

3.2. Digital Elevation Model (DEM)

Digital elevation model may be defined as digital design of elevations and/or levels defined with combination of point elevation values established with the measurements in the land based on a system or randomly (Turoğlu, 2000).

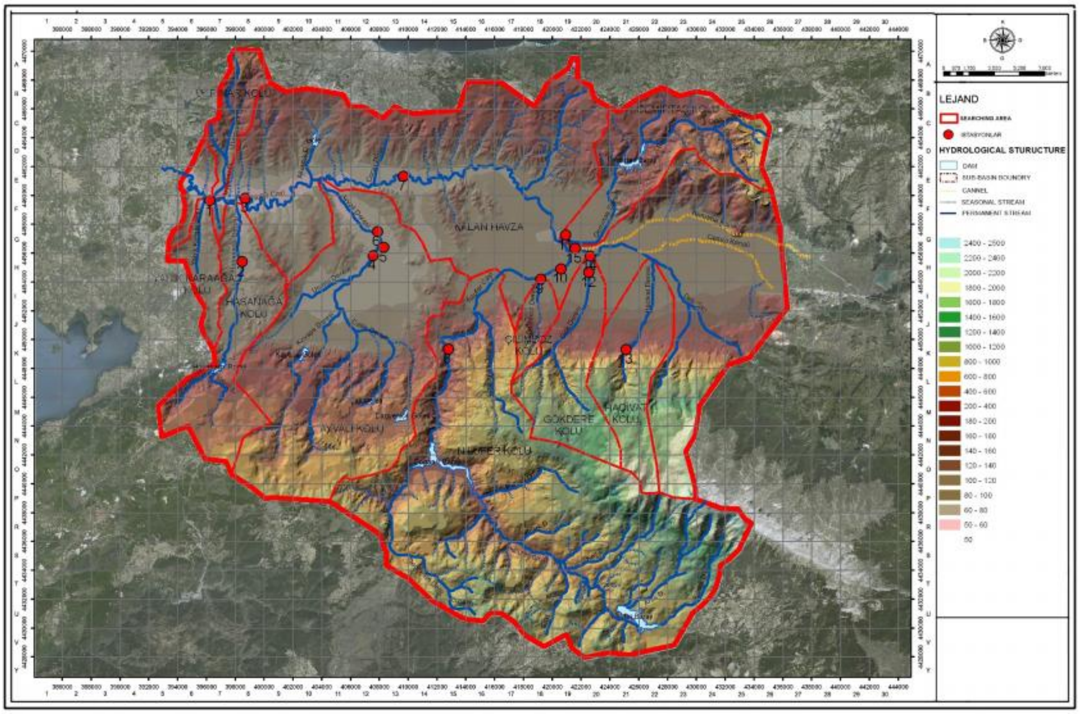

Fig. 2. *Digital Elevation Model*

In this study, existing topographic maps have been digitalized and elevation curves have been drawn after definition of corner edge coordinate systems. In the next phase, these elevation curves have been converted into irregular triangularized network (TIN) system via AreView and, then, raster data by using the same program, and digital elevation model has (DEM) has been generated (fig. 2). Inclination and exposure maps have been generated by using the digital elevation model in this study. In this study, existing topographic maps have been digitalized and elevation curves have been drawn after definition of corner edge coordinate systems. In the next phase, these elevation curves have been converted into irregular triangularized network (TIN) system via AreView and, then, raster data by using the same program, and digital elevation model has (DEM) has been generated (fig. 2). Inclination and exposure maps have been generated by using the digital elevation model in this study.

3.3. Inclination Characteristics

When classifying according to degrees of inclination, drainage and movement characteristics of water have been taken into consideration depending on inclination conditions. As a result of literature screening, studies concerning floods which build a relationship between movement of water and inclination (Turoğlu, 2007), (Turoğlu, 2005) have been used. Except for Nilüfer Stream Branch Sub-Basin and northern hills of the Mount Uludağ, no prominent hills are encountered in the study area. Hill inclination is around 2°-15° and they generally have symmetrical and similar characteristics.

The fact that inclination characteristics are flat and nearly flat prepare an environment conducive to accumulation of water. Therefore, in the study area, lands with an inclination of 0°-2 ° are geomorphologic units which are under risk of soil pollution. These are generally valley floors, and cover 39,36% of the study area. Lands with inclination values being 2° and above are those lands where water movement and pollutions can be easily carried to Nilüfer Stream. Moving of materials depending on gravity comes into being with processes controlled by the inclination. Inclination is influential on erosion, landslide movements in the catchment area and on the land use and structure of soil. Inclination also determines ratio of radiation received by the soil. Surface flow effect degree on the hydrologic structure, soil capability and change in vegetation may be mentioned.

Table 1. *Inclination values of study area*

The Degree of Slope	Area (km2)	Percentage
%0-2	504,37	39,36%
%2-5	90,28	7,04%
%5-15	333,12	26%
%15-100	353,64	27,60%
TOTAL	1.281,42	100,00%

When land areas depending on inclination degrees and percentage values are examined in the study area, it is observed that a large portion of study area is flat with the rate of 39,36% or nearly flat with an inclination degree of 0° - 2°. These are followed by the areas with an inclination degree of 2° - 5° at the rate of 7,04%. Areas where inclination is above 5° - 15° comprise 26% of the entire study area with a land area of 333,12 km². Areas where inclination is above 15° comprise 27,60% of the study area (Fig. 4). These areas have erosion and landslide risks. Landslides are observed in neighborhoods such as Alacahırka, Demirkapı and Mollaarap due to inclination above 45%. Except for Nilüfer Stream Branch Sub-Basin and northern hills of the Mount Uludağ, no prominent hills are encountered in the study area. Hill inclination is around 2°-15° and they generally have symmetrical and similar characteristics.

3.4. Exposure Characteristics

Exposure influences sunshine duration, frequency, severity and precipitation and vegetation. Water saturation of soil is different depending on the exposure characteristics. The Northern hills' sunshine duration is shorter than the southern hills, and therefore, water saturation of the soil is high in the northern hills but less in the southern hills. In case of water saturation, drainage waters start surface flow without infiltration by the soil. Thus, risk of soil pollution and underground water pollution is higher in the soil with no water saturation.

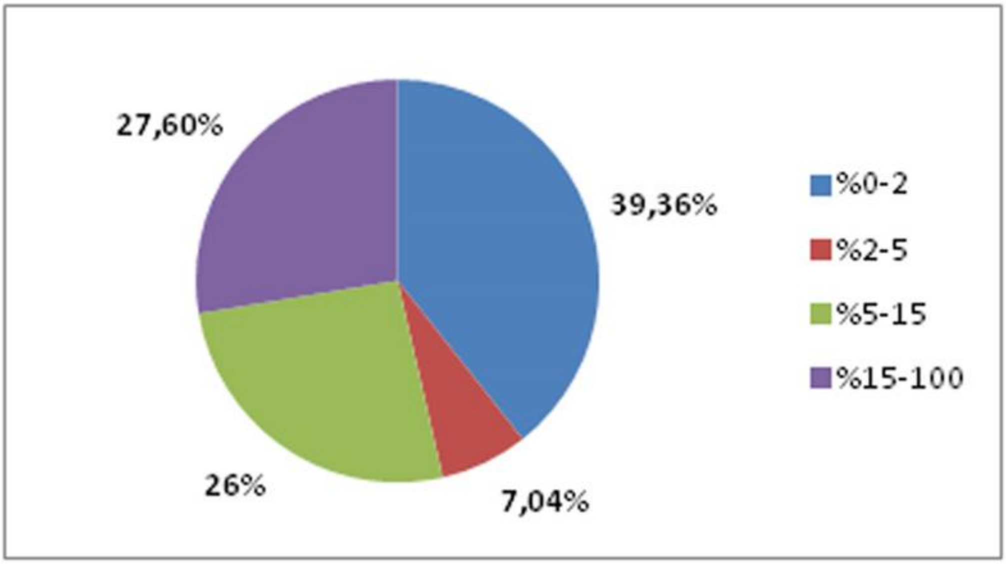

Fig.3 *Percentage distribution of study area depending on inclination degrees*

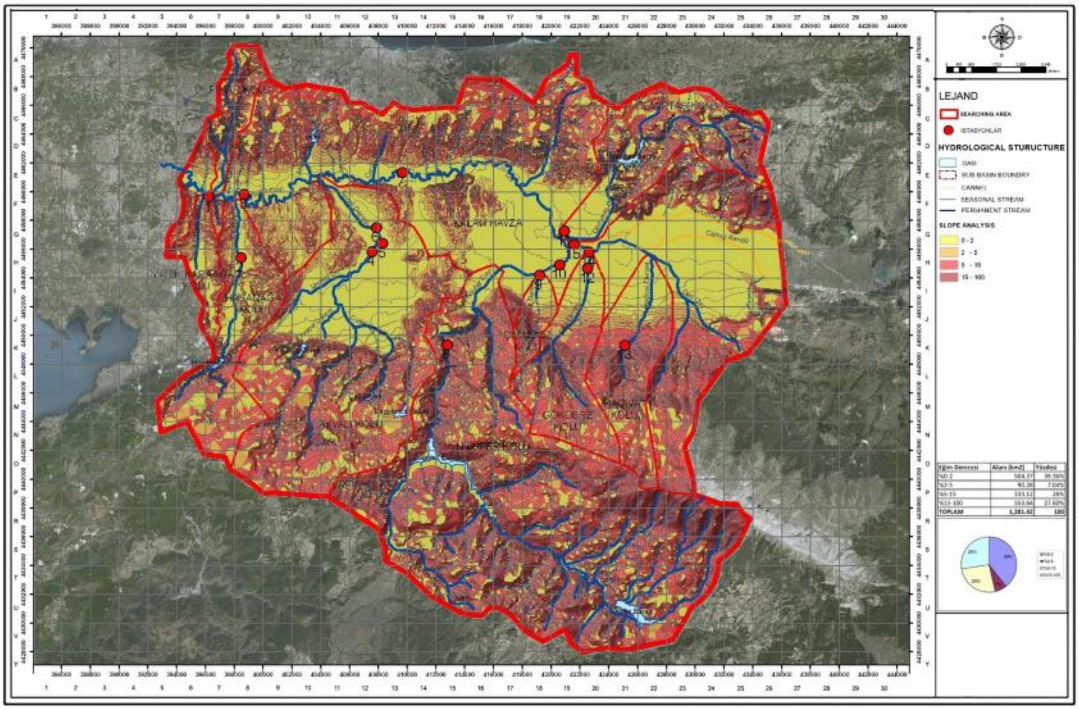

Fig. 4 *Inclination map*

Exposure direction land areas in the study area and percentage values are examined, it is seen that a large portion of study area is flat with the ratio of 28,27% and these are the areas with the highest soil and underground water pollution. Following the flat areas, the exposure value with the largest land area in the study area seems to be in the areas with northern exposure with the ratio of 13,22%. Due to water saturation of soil in these areas, soil and underground water pollution risk is lower than the other exposures. Besides, the fact that pollution discharge in the northern exposures shift to surface flow without being infiltrated by the soil with rain waters is highly likely to create water pollution risk in the Stream Nilüfer. In all other directions, it is observed that there is a balanced distribution in terms of exposure of the study area.

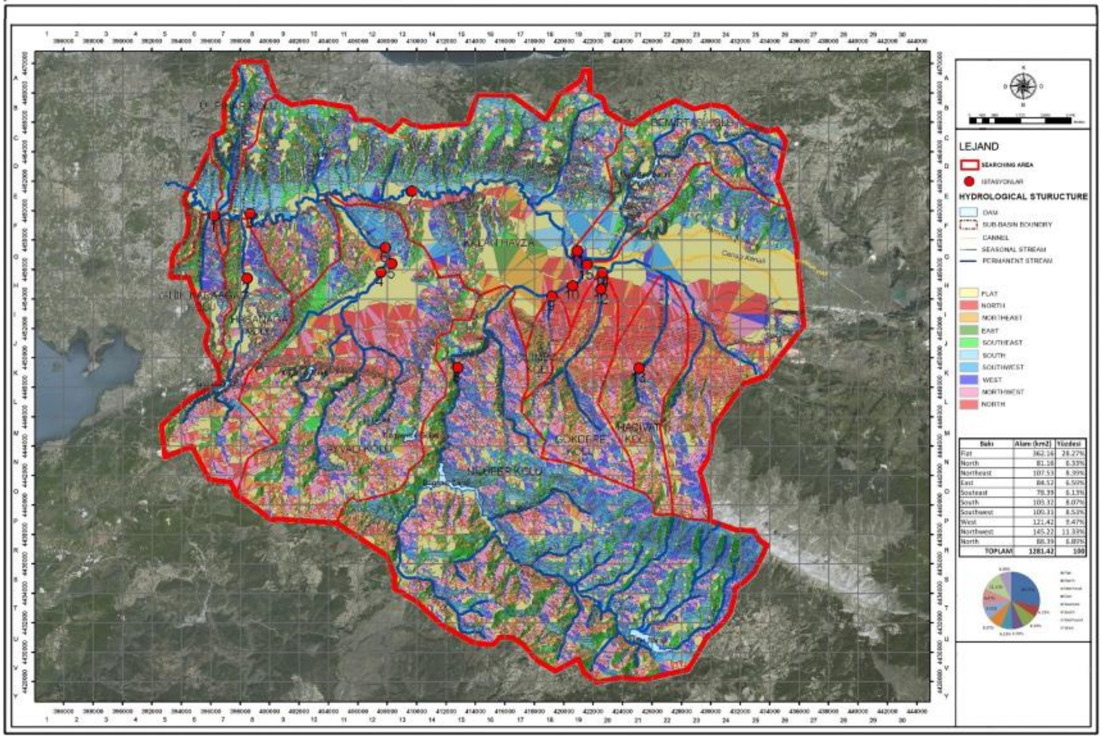

Fig. 5 *Exposure map*

3.5. Geological Structure

Lithology characteristics related to geologic structure have been inspected. Lithologic and stratigraphic characteristics are important since they determine cracks formed and horizonation due to temperature - cooling difference, drainage conditions depending on the distribution of rocks, water excess that starts to flow, and infiltration capability and permeability of the ground. Tectonic characteristics are influential on development of morphology of the catchment basin and hydrographic characteristics.

Existing geological structure play a decisive role on the natural source structure of the study area and characteristics of pollution movement. Distribution of the rock types found in the catchment basin, whether or not these rocks have a porous form, movements of slabs and leakage determine infiltration which is effective in mixing of the pollutions found in the study area with the underground water and routes of underground water movements.

3.5.1. Lithology

Risks posed by different lithologic formations in the study area vary largely. Hydrologic relations between soil type and surface waters, processes assuring movement of the water in the soil depending on formation of soil according to rock types found in the catchment basin (infiltration, percolation, permeability) vary largely. Infiltration is high in the areas where there are rocks with large clearance. This, in turn, increases risk of soil and underground water pollution. Formations of this type found in the study area are alluvia, sandstone – mudstone – limestone, gneiss, travertine and vulcanite deposition rocks.

Table 2. *Exposure values of study area*

ASPECT	AREA (km2)	PERCENTAGE
Flat Areas	362,16	28,27%
North	81,16	6,33%
Northeast	107,53	8,39%
East	84,52	6,59%
Southeast	78,39	6,13%
South	103,32	8,07%
Southewest	109,31	8,53%
West	121,42	9,47%
Northwest	145,22	11,33%
North	88,39	6,89%
TOTAL	1.281,42	100,00%

In those areas where there are rocks with small clearance, infiltration is low, pollution discharges and rain waters do not permeate into underground and join drainage system either by surface flow over soil ground taking place over these rocks and in line with the horizon to which main rock joins through soil horizon. Thus, risk of soil and underground water pollution is reduced. Formations of this type found in the study area metamorphic rocks, metadetritic rocks and metavolcanites.

Lithology is decisive in soil structure of catchment basin, land slide and mass movements and erosion. Changes caused in the hydraulic structure by the lithology determine underground water formation, thermal waters, spring waters, aquifers, sediment status, form and ages, movement and storage situations and hydrologic relations between underground and surface waters.

Lithology of the study area and nearby areas is composed of masses of varying ages. Foundation of the Mount Uludağ located in the south of downtown Bursa is composed of Paleozoic granite (magnetic mass) and metamorphic masses such as gneiss and clay stone formed as a result of transformation of granite under high temperature and pressure. Marbles have spread above these masses in the form of a stripe in the northern skirts of the mount. Keles is covered with the formations dating back to Neogene era, and schists pertaining to main rock appear in patches around Tepedağ region which is a part of Uludağ system (Ternek et al. 1997).

Neogene lime stones which cover a vast area around İnegöl (sedimentary mass) have penetrated into the Paleozoic mass composed of granite and gneiss. In Mudanya, Neogene sedimentary masses such as sand stone and lime stone cover a vary large area. Vicinity of Yenişehir Plain is covered with Neogene hills, and to the west of the region, Paleozoic schist (easily disintegrated clay stone) and lime stones as well as Mesozoic lime stones appear. Bursa Plain is a typical depression area and floor of plain is composed of alluvia. Overall inclination is from east to the west, and drainage is assured by Stream Nilüfer which has its main branches in the Mount Uludağ. This river, as from the west of Nişan Tepe (148 m), embeds into its bed and forms embedded meanders. Northern and southern edges of Bursa Plain is bordered by fault lines of east-west direction. Therefore, hot springs appear in patches along the said fault lines and turned Bursa into a region of thermal spring. Travertine deposits precipitated by the hot springs arising out of fault lines are located in the region between plain and mountainous –hillside areas (Ternek and others. 1997).

Area covered by the lithologic formations found in Stream Nilüfer Catchment Basin (fig. 6), their positions within the study area and general characteristics are listed below (MTA):

Table 3. *Surface distributions of the lithologic formations in Stream Nilüfer Catchment Basin*

GEOLOGICAL FORMATION	Area (km2)	Percentage
Alluvium	260,24	20,19%
Travertine	111,46	8,65%
Slope Wash	131,96	10,24%
Sandstone-Mudstone-Limestone	266,78	20,69%
Paleozoic Metamorphic	315,72	24,49%
Gneiss	63,55	4,93%
Metapelitic Rock	6,34	0,49%
Metavolcanic	3,06	0,24%
Rocks of volcanic sediment	130,08	10,09%
TOTAL	1.289,19	100,00%

Table 4. *Geologic formations of Stream Nilüfer Catchment Basin*

Sub-basins	GEOLOGICAL FORMATION									Total Area (km2)
	Alluvium	Travertine	Slope Wash	Sandstone-Mudstone-Limestone	Paleozoic Metamorphic	Gneiss	Metapelitic Rock	Metavolcanic	Rocks of volcanic sediment	
Ayvalı	48,54	35,46	34,13	48,69	44,76	-	-	-	-	211,58
Cilimboz	2,74	4,12	0,24	-	0,21	4,63	-	-	-	11,95
Demirtas	11,47	13,03	42,98	0,14	-	-	4,52	-	-	72,14
Gokdere	9,25	5,82	2,59	-	3,79	16,99	1,82	-	15,54	53,99
Hacivat	9,01	5,89	3,25	-	0,94	13,84	-	-	20,1	53,03
Hasanaga	1	18,81	17,5	28,58	-	-	-	-	-	65,9
Nilufer	2,82	6,65	1,86	2,09	254,49	3,55	-	-	75,63	347,09
Ucpinar	2,15	-	1,49	14,67	0,56	-	-	-	2,82	21,68
Yanik Karaagac	0,86	2,66	-	14,18	0,56	-	-	-	-	17,7
Other Basins	172,4	19,01	27,92	158,43	10,96	24,52	-	3,06	15,99	434,14
TOTAL (km2)	260,24	111,46	131,96	266,78	315,72	63,55	6,34	3,06	130,08	1.289,19

3.6. Hydrologic Structure – Surface Waters

3.6.1. The Stream Nilüfer

Stemming from south western hills of the Mount Tepel (2012 m) 10 km north eastern of Keles county center stretches along south western skirts of the Mount Uludağ. Around the village Misi, its flow turns towards the north and enters Bursa Plain. It flows through the plain through an improved bed in a south to north direction and turns towards the west in the north of the village Dereçavuş. By the way, waters of the major creeks stemming from the south of Bursa Plain and flowing downwards from northern hills of Uludağ such as Aksu, Kestel, Deliçay and Gökdere and the creeks Narlıdere, Sarpdere and Kelesen which flow from the north are discharged and combined in one branch. After this point, Ayvalı Creek stemming from Çakırköy Plain joins the stream which flows towards the west around the village Göbelye.

The Stream Nilüfer flows through a large valley and joins the River Susurluk around the village Hayırlar. Length of the Stream Nilüfer which has an overall inclination of 2% is ~168 km, its average water volume is 458.848.800 cubic meters /year, its water catchment basin is 680 km², and its annual average flow rate is 16,77 cubic meters /second. Immense changes take place in the level of Stream Nilüfer throughout the year, and it has an irregular regimen. Flow rate of the Stream Nilüfer ranges from 1,13 cubic meters³/s to 55 cubic meters/s (Buski, 2010).

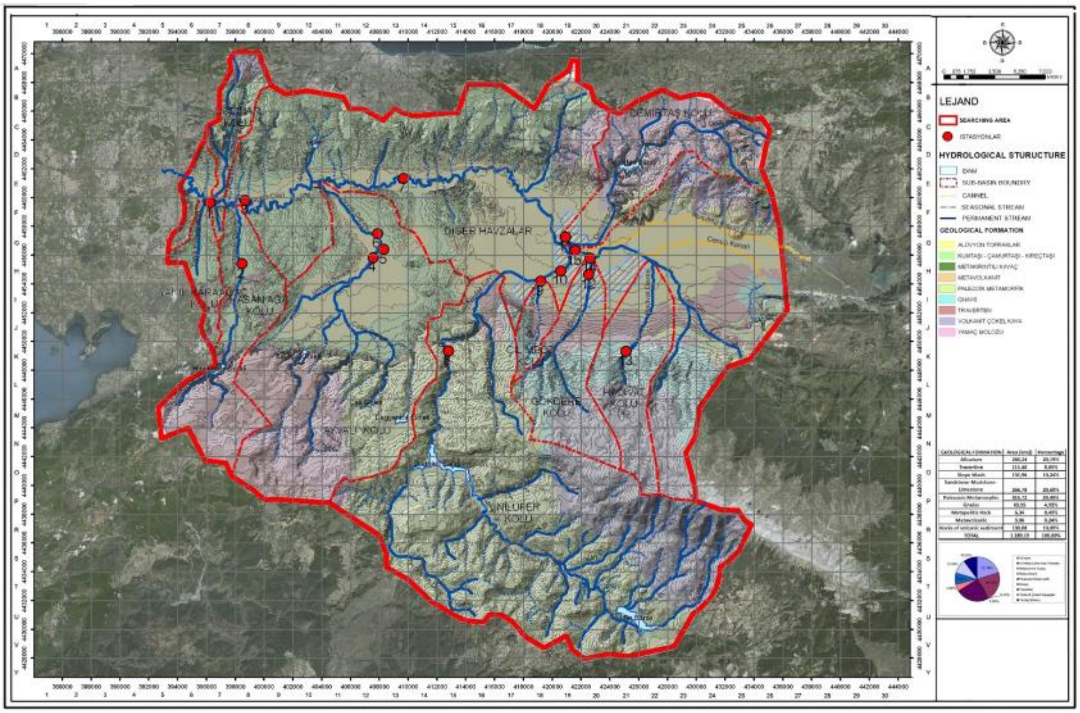

Fig. 6 *Geology Map*

Stream Nilüfer is one of the important water sources of Bursa. Apart from potable and utility water supply for the city, it is also partially used for irrigation in those plains where the Stream Nilüfer passes through. Stream Nilüfer is directly exposed to direct discharge of the majority of domestic and industrial waste waters. Until 1997, domestic waste water of the settlements located in the catchment basin used to be discharged into the Stream Nilüfer. Waste waters of the settlements such as Ürünlü, Tahtalı, Çalı, Demirci, Kayapa, Yaylacık and Alaadinbey to the west of the city Reach the Stream Nilüfer through DSİ irrigation channels and Ayvalı creek. Also, various industrial establishments located in the Stream Nilüfer also pollute the catchment basin with their waste waters (Kaynak, 2002).

Average waste water quantity taken by the stream at the places it passes through the city from the treatment plant discharges is at the level of 370.000 cubic meters/day and corresponds to the value of 4,2 cubic meters/s (Üstün, 2006).

3.7. Soil Structure

Within framework of thesis, soil structure has been evaluated under two meta titles such as large soil groups and land capability classes. Different soil types of the study area and land capability classes have differences in terms of risks posed by them. Soil develops depending on topography, geomorphologic structure, geologic structure and hydrologic structure characteristics. Whether soil has clay or sand structure affects erosion, mass and landslide movements as well as surface flow and processes assuring movement of water within the soil (infiltration, percolation, permeability). Physical characteristics of soil and surface of soil, moisture of soil, wetting capability of soil, viscosity of the soil surface, and vegetation are the factors determining the infiltration capacity. With the sandy soils, infiltration is too high and surface flow is low. This, in turn, increases risk of soil and underground water pollution. These types of soil found in the study area alluvial and colluvial soils. With the clay soils, infiltration is too low and surface flow is high. Pollution discharges and rain waters do not permeate into the underground and join the drainage system either through surface flow from the soil surface and in the direction of horizon where soil horizon and parent rock combine. Thus, risk of soil and underground water pollution is reduced. These types of soils found in the study area are brown red Mediterranean soil, brown forest soil without lime, brown forest soil, rendzina and vertisol soils. Detailed characteristics of these soil types are explained below.

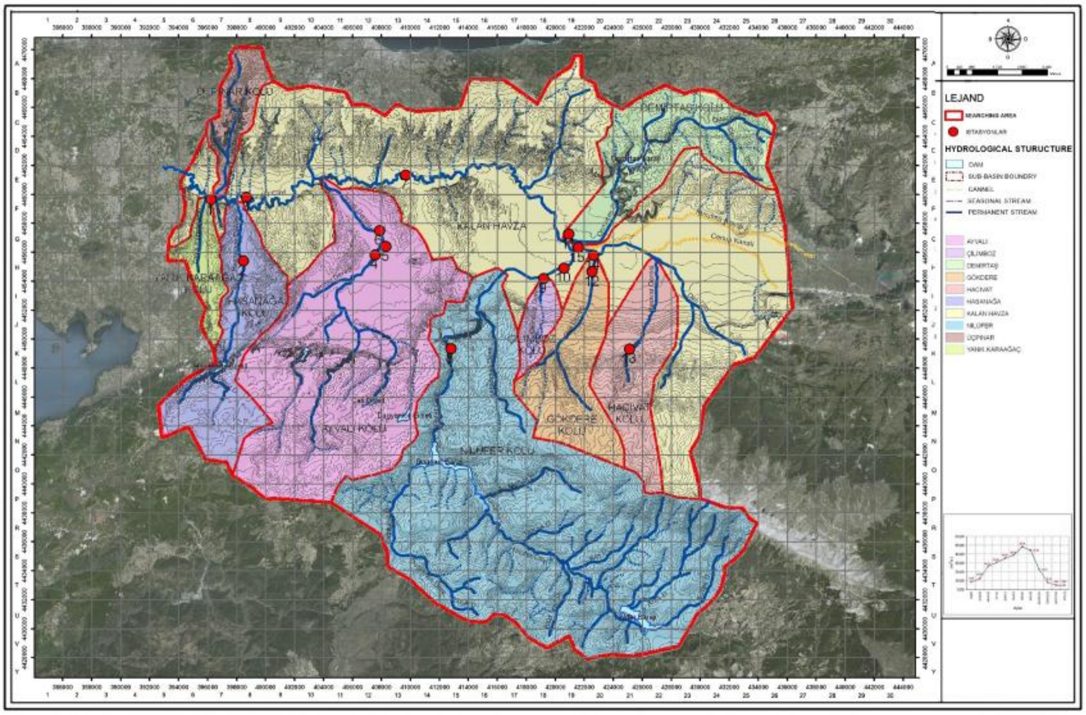

Fig. 7. *Hydrography map of the research area*

Although characteristics of the soil are shaped by physical geography features such as parent rock characteristics, geomorphologic characteristics and climate, there is an ecological interaction between soil type and land capability class and land use which is human geography feature in the study area. As a result of accumulation of the organic materials caused by the forest dead cover over the forest areas, characteristics of soil and, thereby, soil texture, structure and infiltration characteristics vary. Likewise, soil's physical and chemical characteristics vary as a result of the basic activities in the agriculture fields. While location should be selected according to land capability class and soil type, land use also modifies the characteristics of the soil and is decisive on the risks of pollution.

Assessment of characteristics, surface areas and percentage distributions of the major soil groups found in the study area (fig. 8);

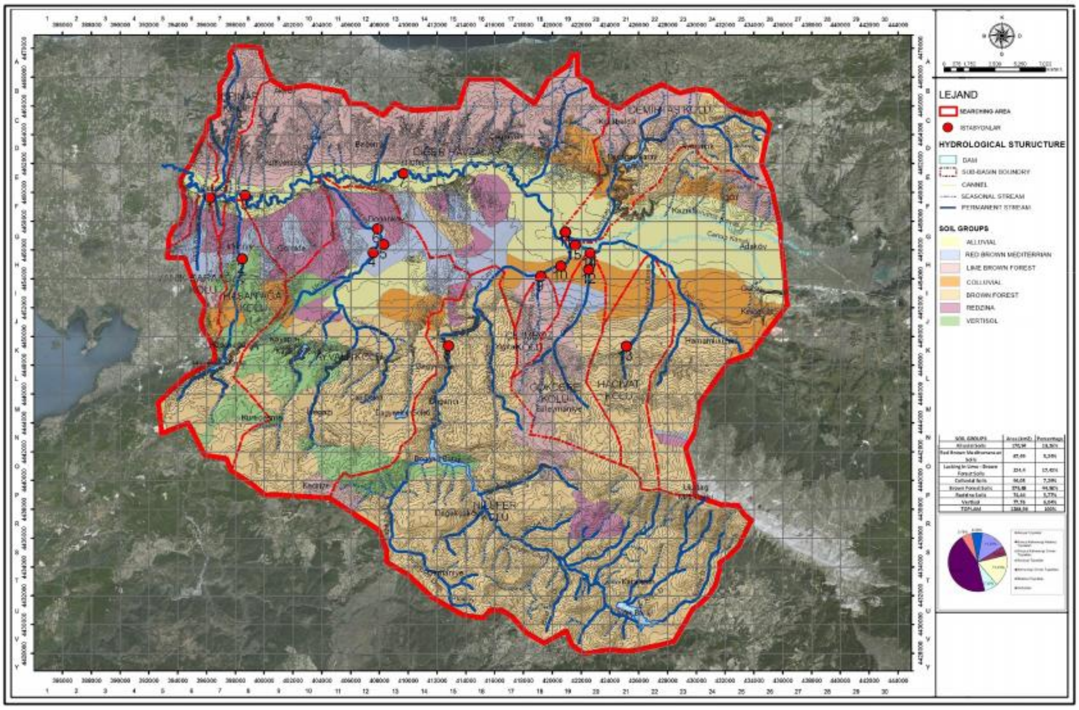

Fig. 8. *Map of soil groups*

Table 5. *Surface area and percentage distribution of soil groups in Stream Nilüfer Catchment Basin*

SOIL GROUPS	Area (km2)	Percentage
Alluvial Soils	170,94	13,26%
Red Brown Mediterranean Soils	67,49	5,24%
Lacking in Lime - Brown Forest Soils	224,4	17,42%
Colluvial Soils	94,05	7,29%
Brown Forest Soils	579,88	44,98%
Redzina Soils	74,44	5,77%
Vertisol	77,76	6,04%
TOPLAM	1288,96	100%

As can be understood from the above figure, 79,45% of study area soils is composed of brown red Mediterranean soil, brown forest soil without lime, brown forest soil, rendzina and vertisol soils. Common feature of these types of soils is low infiltration capacity. In other words, soils covering almost 80% of the catchment basin have features that enable water dropping on the soil to start flowing directly. Despite reduce risk of soil pollution and underground water pollution in these areas, surface water pollution is high.

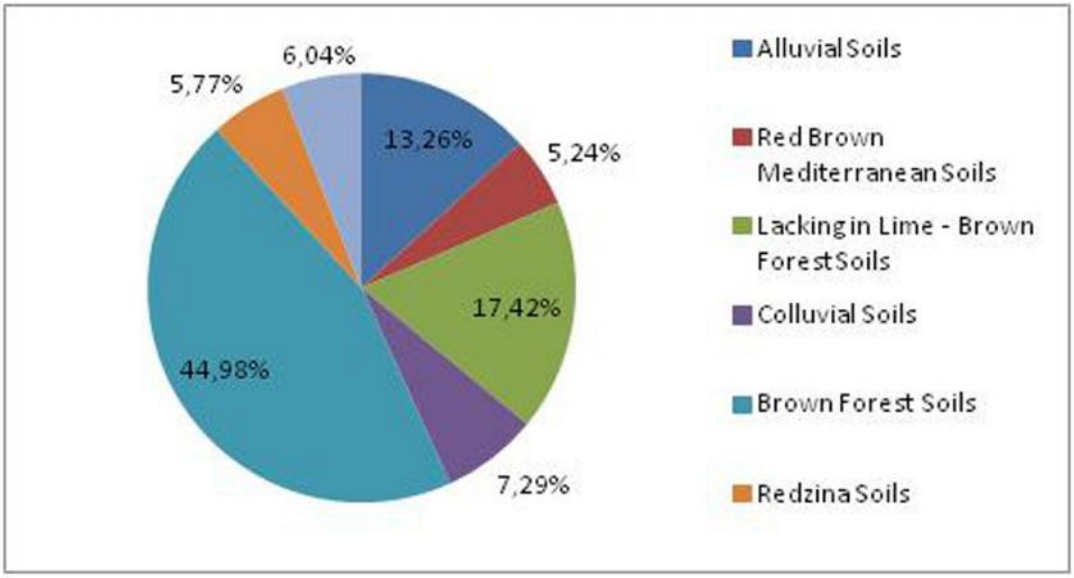

Fig. 9 Percentage distribution of soil groups in the Stream Nilüfer Catchment Basin

When features, surface areas and percentage distributions of the major soil groups found in the study area are evaluated on the basis of sub-basins;

Table 6 *Surface area of the sub-basins in the Stream Nilüfer Catchment Basin*

Sub-basins	SOIL GROUPS							Total Area (km2)
	Alluvial Soils	Red Brown Mediterranean Soils	Lacking in Lime - Brown Forest Soils	Colluvial Soils	Brown Forest Soils	Redzina Soils	Vertisol	
Ayvalı	18,66	20,12	2,92	10,02	96,72	22,31	40,8	211,55
Cilimboz	-	0,68	11,18	-	0,08	-	-	11,94
Demirtas	9,43	-	24,21	8,92	29,57	-	-	72,13
Gokdere	0,32	5,17	21,8	4,14	22,55	-	-	53,98
Hacivat	1,35	-	-	9,22	42,46	-	-	53,03
Hasanaga	1,53	4,86	0,16	6,8	24,17	5,23	23,08	65,83
Nilufer	-	2,34	13,33	1,78	308,11	10,14	12,29	347,99
Ucpinar	1,21	-	19,91	-	-	-	-	21,12
Yanik Karaagac	0,67	7,04	2,65	2,21	-	3,75	1,36	17,68
Other Basins	137,77	27,28	128,24	50,96	56,22	33,01	0,23	433,71
TOTAL (km2)	170,94	67,49	224,4	94,05	579,88	74,44	77,76	1.288,96

3.8. Land Capability Classification

As a result of digitalization and evaluation on the basis of sub-basins at the study area scale of the land capability classification map for province of Bursa drawn up by Directorate-General of Rural Works, land capability classification surface areas and percentage distributions of Stream Nilüfer Catchment Basin has been established (Fig. 10 – Fig. 11).

As can be see in the Table 8, the 7th class soils cover 55,99% of the study area while they form the upper value within the capability classification. The lower value is formed by the 3rd class soils with 3,32%. Ratio of the 1st class soils that have agricultural and ecological value is close to the lower limit value with 4,70%. Bursa Plain has the 1st and 2nd class soil capability, major part of the plain area is used by the settlement and industry, and agricultural fields shrink every year.

When surface areas and percentage distributions of the major land capability classes found in the study area are evaluated on the basis of sub-basins;

Table. 7. *Land capability classification surface areas and percentage distribution of the Stream Nilüfer Catchment Basin*

Land Capability Classification	Area (km2)	Percentage
Class 1	60,58	4,70%
Class 2	164,87	12,79%
Class 3	42,75	3,32%
Class 5	88,94	6,90%
Class 6	106,17	8,24%
Class 7	721,8	55,99%
Settlment	104,08	8,07%
TOPLAM	1.289,19	100,00%

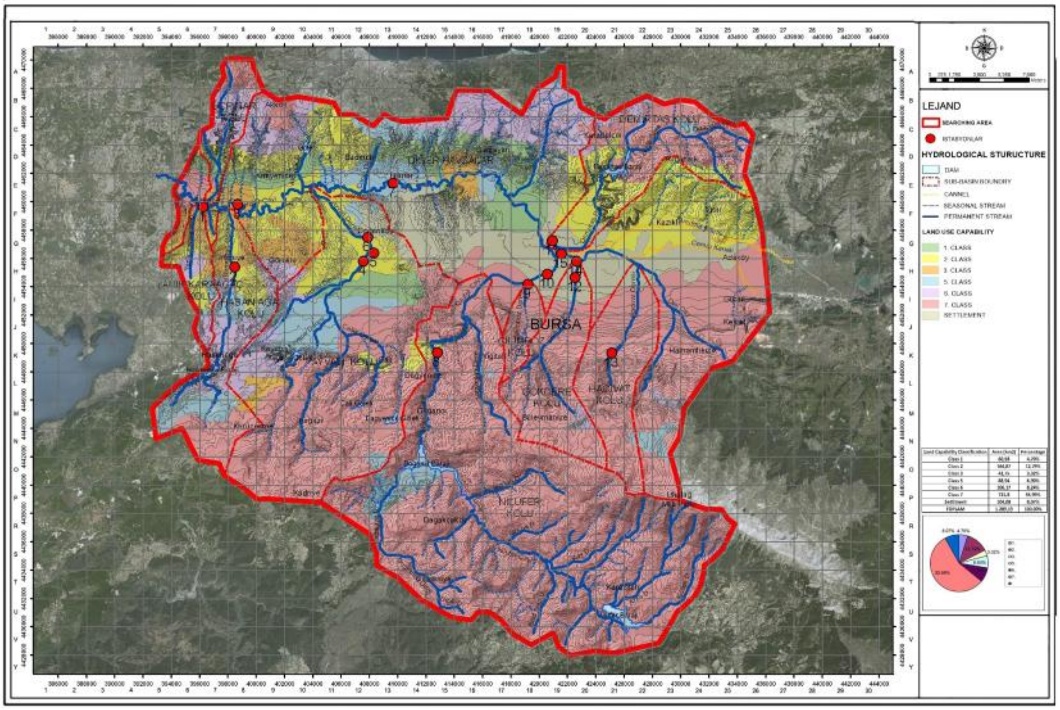

Fig. 10. *Land capability classes*

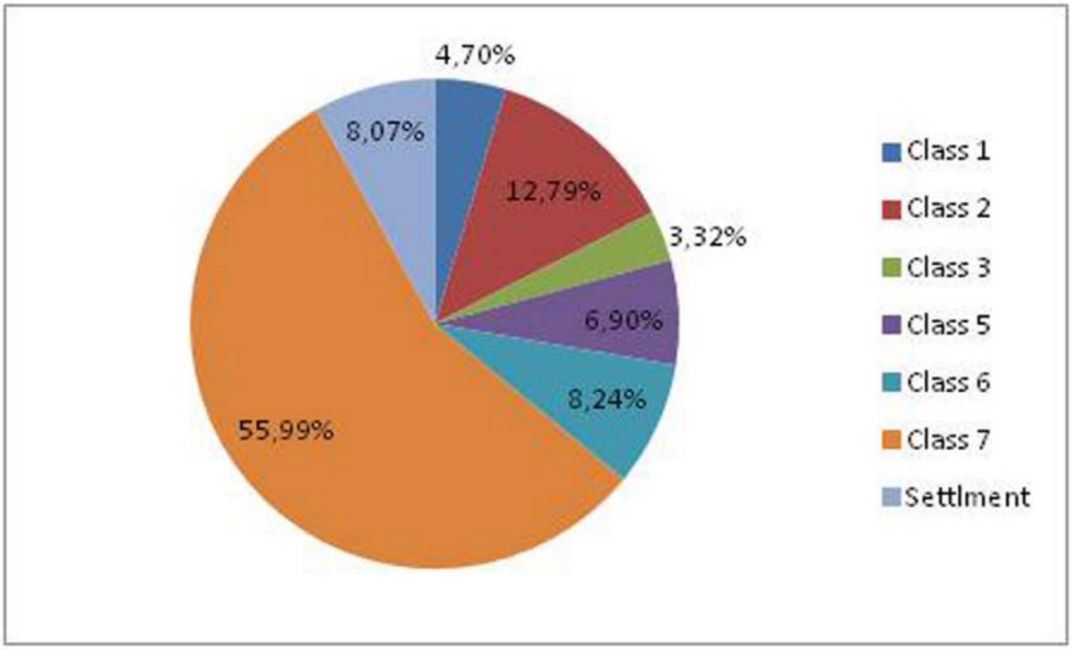

Fig. 11. *Percentage distribution of land capability classification of the Stream Nilüfer Catchment Basin (KHGM, 2005)*

Table 8. *Surface areas of the land capability classes of sub-basins in the Stream Nilüfer Catchment Basin*

Sub-basins	Land Capability Classification							Total Area (km2)
	Class 1	Class 2	Class 3	Class 5	Class 6	Class 7	Settlement	
Ayvalı	12,53	28,55	4,35	24,87	13,22	120,36	7,7	211,57
Cilimboz	-	-	-	-	-	11,73	0,21	11,95
Demirtas	-	23,72	-	1,46	3,18	39,85	3,9	72,11
Gokdere	-	-	-	-	1097	46,65	5,36	53,99
Hacivat	-	-	-	0,53	0,17	50,04	2,29	53,03
Hasanaga	-	9,8	6,8	18,01	17,77	13,49	-	65,86
Nilufer	-	2,03	-	11,2	0,91	334,04	-	348,18
Ucpinar	1,24	2,74	1,01	-	10,75	5,38	-	21,12
Yanik Karaagac	-	5,66	4,82	1,9	5,2	0,12	-	17,71
Other Basins	46,81	92,37	25,77	30,97	52,99	100,14	84,62	433,67
TOTAL (km2)	60,58	164,87	42,75	88,94	106,17	721,8	104,08	1.289,19

Results

Study area is under the influence of an important environmental pollution stemming from a dense urbanization pressure caused by the planning decisions passed at different times. In order to reveal these environmental pollutions and pollution risks, it is obvious that it is not likely to walk through and examine the catchment basin with land studies. When medium and large scale catchment basins are taken into consideration, use of CBS and remote sensing devices is inevitable. Also, studies are accelerated by using these devices and, in turn, costs are reduced. Owing to this study conducted in the Stream Nilüfer Catchment Basin and sub-basins, it has been demonstrated how beneficial and useable CBS technique is in terms of determining characteristics of catchment basin required for catchment basin and water quality modeling studies which are the foundation of decision supporting system. It is of paramount importance to generate different thematic studies concerning different scenarios linked with the catchment basin with regards to basin studies and share the same with decision makers.

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