Effects Of Physiographic Factors And Some Hydro-Physical Soil Properties On River Follow In Uludere Catchment

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Abstract

*This research was carried out in Ulu Dere catchment located in Çankırı- Yapraklı district of the Central Anatolia. The objective of this study was to investigate physiographic parameters, some hydro-physical soil properties and land use on river follow in Uludere Catchment. Some physiographic factors and land use-land cover were determined and evaluated by using RS&GIS program. Uludere catchment is about 24.3 km^2. Georeferanced Landsat Thematic Mapper data were classified to identify land cover and land uses of the study area. According to classification results, the most common land use type**s** are forest and degraded forest lands (74.9%), pasture and degraded pasture lands (17.4%), agricultural land (rainfed and irrigated cultivated lands) (7.1%), and settlement (0.6%). The study area consists of various topographic features (flat, hilly, rolling etc.). Mountains, hilly and rolling physiographic units are particularly common in the study area. 16.2% of the study area has less than 20 % slope (gentle and moderate) and 83.8% has more than 20% slope (steep and very steep). Mean sea level altitude of the catchment is 1000.5 m. Average annual precipitation and temperature are 530.8 mm and 9.1 ^oC, respectively. After examination of topographic, land use-land cover, geologic and geomorphologic maps and land observation, seven soil profile places were excavated and described in the study area. According to physical, chemical and morphological properties of soils, they were classified as Typic Xerorthent, Lithic Xerorthent, Typic Xerofluvent, Typic Calcixeroll, Typic Haploxerept, and Typic Dystroxerept*

Key words: *Physiography, land use-land cover, hydro-physical soil properties*

Introduction

Soils are essential natural resources with a board range of environmental functions. The degree of soil development appears variously dependent on the different soil forming factors. Together with parent material, climate, biota, and time, topography is one of the five fundamental elements of the soil forming factor theory (Dengiz, 2007; Amundsen et al., 1994; Jenny, 1941). Likewise, topography is central to the catena concept for soil development (Hook and Burke, 2000), which is characterized by leaching and redistribution of elements and soil material along hill slopes. The effect of topography is more pronounced on young and rolling soils than on old and level soils (Birkeland, 1999; Fisher and Binkley, 2000). In addition, hydrologic response is also affected by many factors including land use and management practices; topographic positions, hillslope gradient, aspect, and variance; drainage patterns and density; surficial deposits, soil texture, permeability, water storage capacity, soil hydrologic groups; and land cover in catchment. Furthermore, Seibert et al. (2007) reported that topography is also a major factor controlling both hydrological and soil processes at the landscape scale. While this is well-known qualitatively, quantifying relationships between topography and spatial variations of hydrologically relevant variables and other landscape characteristics such as the variation of soil properties still remains a challenging research topic.

In order to better identify the causes of declining environmental health, we need an understanding of our catchment and the changes that have occurred within its natural boundaries. However, most of the basins or catchments have insufficient data to make conservation planning for sustainable natural resource uses in Turkey. On the other hand, Turkey has been attaching increasing priority to sustainable environmental management and natural resource conservation in recently. For this purpose, advanced computer programs including decision support systems (Geographic Information System and Remote Sensing) have an important role to the speed and efficiency of the overall planning process and allow access to large amounts of information quickly particularly for basin management planning. Especially during the last decade, GIS and RS have received much attention in application related to resources at large spatial scales (Green 1995; Hinton 1996). The main goal of this study was to determine physiographic parameters, some hydro-physical soil properties and land use-land cover using GIS and RS techniques on river follow in Uludere Catchment.

Material and Methods

Field Description

Research area is located in Çankırı, Yapraklı Town, Yukarıöz Coventry, Uludere Basin. The study area is about 2433, 2 ha and located between 40º 45' 00''-40º 52' 30'' North latitude and 33º 37' 30''-33º 52' 30'' East longitude. Research area is established between 1240-1700m heights (Figure 1)

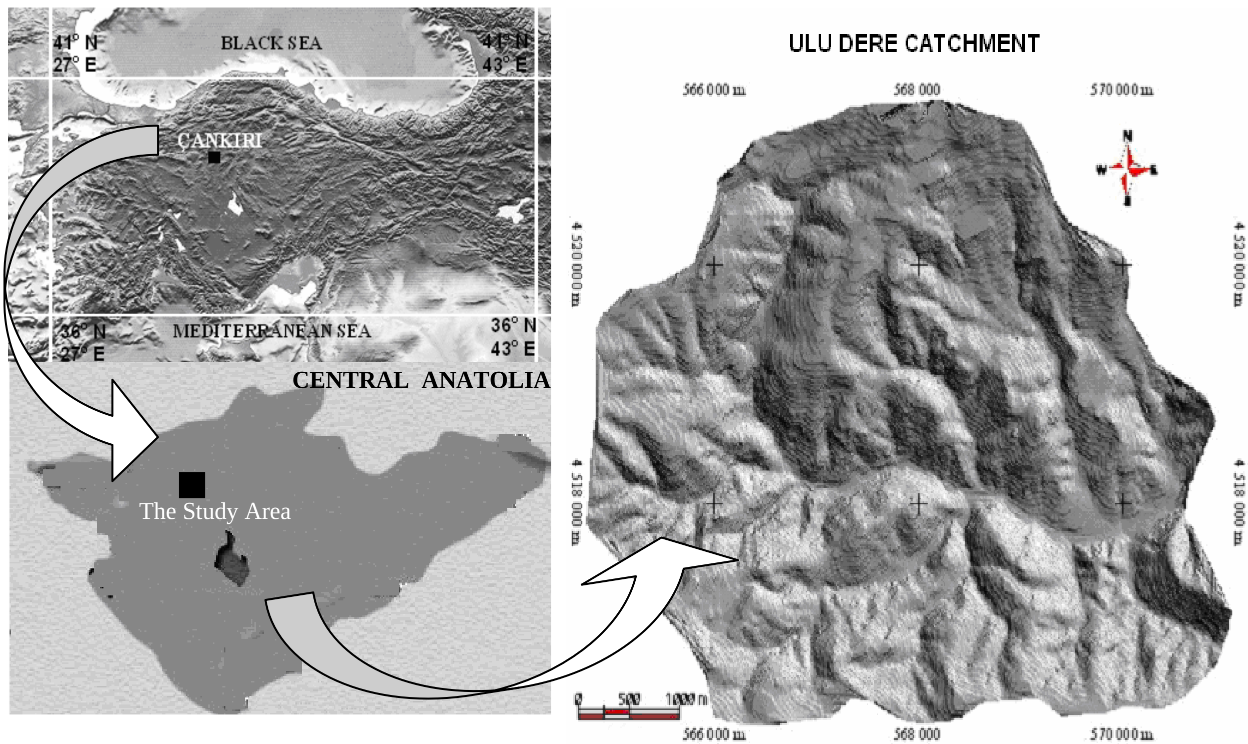

Figure 1. Location of the Ulu Dere Catchment

Research area situated in Çankırı Forest Administration Directorship, Yapraklı Administration Supervisory is the passage district between Middle Anatolia steppe climate and Western Black Sea climate macro climate regions of Turkey. Average annual precipitation and temperature are 530.8 mm and 9.1 ^{o}C, respectively. Climate data derived from the nearest district to research area Yapraklı Meteorology Station (Anonymous, 2005) were examined on the basis of Thornwaite and Erinç methods (Kantarcı, 2000, Özyuvacı, 1999). According to Erinç method Yapraklı Climate Type is "half humid and its plant cover is park scene forest". According to Thornwaite method it has been identified that termed by C2B1's2d symbols "half humid micro thermal having abundant water supply in winter land climate" climate type has determined (Göl and Çakır, 2006) (Figure 2).

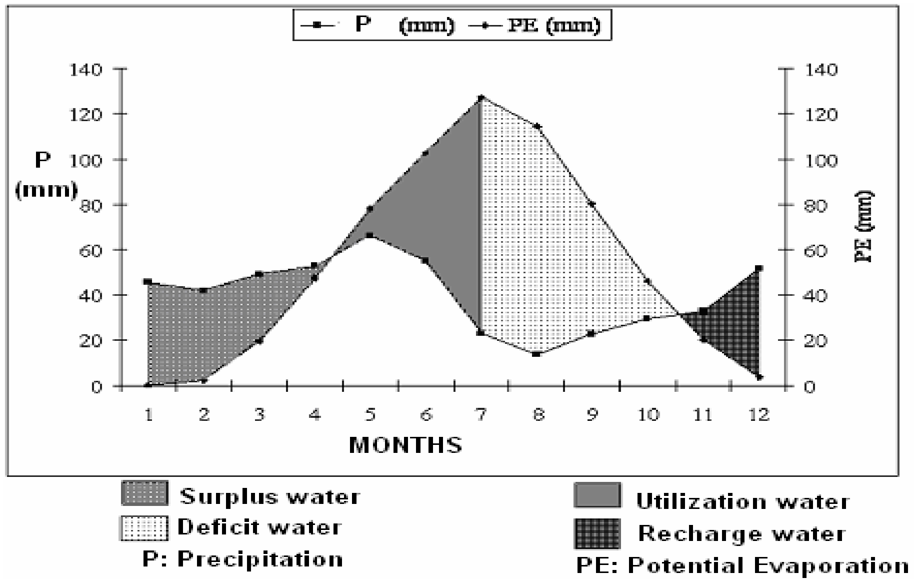

Figure 2. Soil water balance of the study area

In the study area ground base was composed of ophiolitic series and basalt. From the northern direction area covered with Ilgaz massif height Neojen internal sea residues area dominant. The district is represented by Eosen ipsilateral sea gray marls, Oligosen large red color conglomerates, Miose evaporate series and Pliocene chipping grid stone (Anonymous, 1967). Alpine orogeny phases have been identified. An intensive magmatic activation is remarkable in the district. It underlies the bases of split-andesite-basalt magmatic activities seen in north of Yapraklı Town. In north east of Çankırı in Yapraklı Town and around Upper kreatic has constituted more often grey and bright fasciate and possesses an abundant fauna (Ketin, 1962).

Research area is situated in Iran-Turan flora district which is one of the three biggest flora district in our country. On the basis of Davis karelian system it is located in A4 square. In the light of data derived from management plan in the related district Scotch pine (*Pinus sylevestris* L.), Black pine (*Pinus nigra var. Pallasiane* L.) and Uludağ fir (*Abies bornmülleriana* Mattf) forests are dominant species (Anonymous, 1996). In the plant study performed in places where the soil profiles are revealed observed plants are; Scotch pine, Fir, Black pine, juniper (*Juniperus comminis subps. Nana* L.), plenty of pea family (*Leguminosea spp.*) rose haw (*Rosa canina* L.) wild pear (*Pirus elaeagrifolia*), azarole (*Creteagus monogya*), blackthrone (*Palirus spina-christi* Mill), gum-tragacanth plant (*Astragalus* spp.), blackberry (*Rubus canescens* L.) species.

Digital elevation model-DEM, Landsat-5 TM image, geological maps and meteorological data were used to prepare land use-land cover, soil map and soil data-base of study region. All these data were analysed using of TNT mips 6.4v Micro Image GIS and RS program (1999). Descriptions of soils in the study area were accomplished according to soil survey manual (1993). Soil samples collected from all horizons were analyzed for total soluble salts, CEC (cation exchange capacity), pH, texture, organic matter, $CaCO_3$ and bulk density. Soil classification was accomplished using soil taxonomy (1999).

Result and Discusion

Land use and land cover of the Ulu Dere Catchment

Landsat-TM image (Figure 3) was analysed to determine land use and land cover of the study area using TNT mips 6.4v Micro Image GIS and RS program. Land use and land cover pattern are the most crucial elements in catchments hydrological cases, since it is the only factor that can readily be altered, and provides also effective soil erosion control in basin. In addition, soil erosion has accelerated due to inappropriate land uses and continuous cultivation on steeper land (Millward and Mersey, 1989). With development comes changing land use, a resulting feedback on the local and regional hydrologic cycle. In addition, forest clearing for agricultural use, implementation of different farm management practices or the reversion of agricultural land to forest all impact the surface and sub surface water fallow pathways. Therefore, these activities play important role on the catchment (Reed et al, 2004). In the research area, Scoth pine and Fir were the dominant tree species. Grassland areas were destructed by excessive pasturage. Usually agriculture is implemented in the form of fallow dry agriculture. According to image analysis results, the main land uses of the study area are forest and degraded forest lands (74.9%), 25.1 % is pasture, degraded pasture, settlement, rainfed agriculture and irrigated lands (Table 1 and Figure 3).

Table 1. land use and land cover of the study area

Land use and land cover class	Area (ha)	Ratio (%)
Degraded pasture	92.7	3.8
Degraded forest	641.2	26.4
Rainfed agriculture	113.3	4.7
Pasture	332.0	13.6
Forest	1180.1	48.5
Irrigated agriculture	59.0	2.4
Settlement	14.9	0.6
Total	2433.2	100

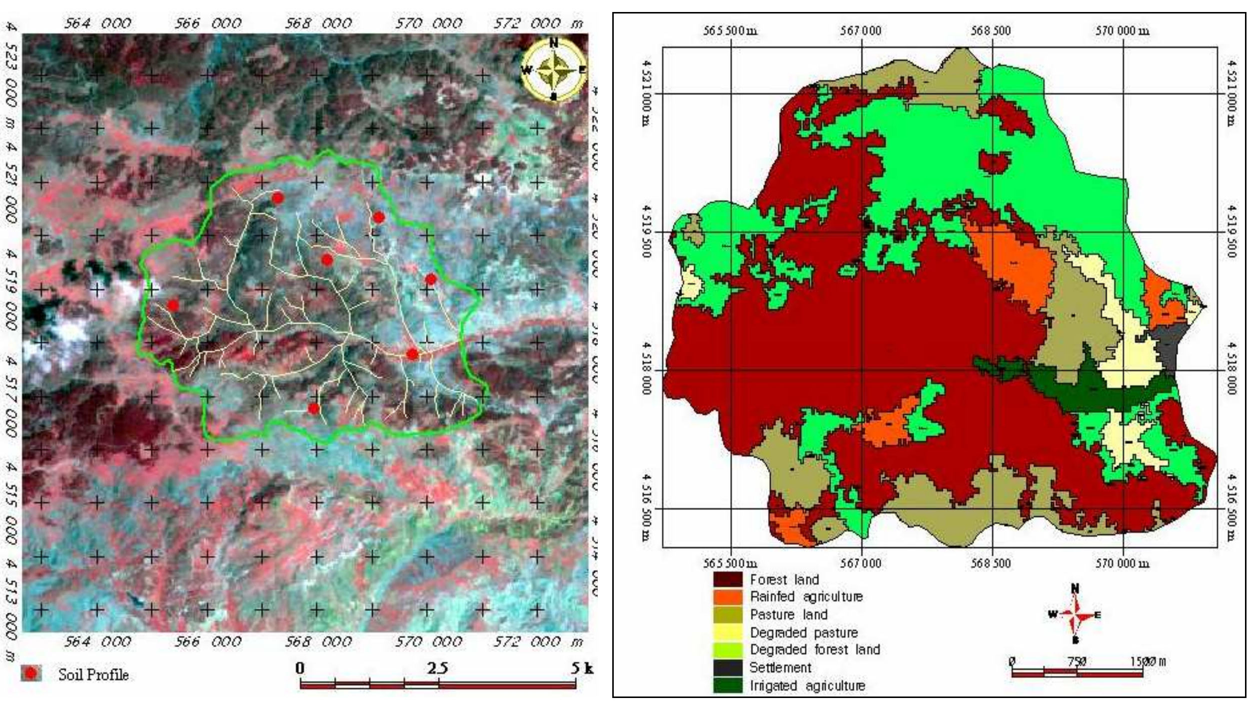

Figure 3. Landsat-TM image, soil profile, land use and land cover of the Uludere Catchment

Topgraphic and Draiange Characteristics of the Uludere Catchment

The topographic and drainage characteristic of the catchment where the study is implemented is given in Table 2. According to GIS application, the area of the basin 24.3 km^2 and profile slope of main waterway is %5. Stream density, main waterway slope, drainage density, bifurcation ratio and drainage pattern were calculated. Topography in the basin is moderately undulated and the basin is characterized mainly by rounded hilltops. Drainage pattern of the Uludere catchment is dendritic drainage. A dendritic drainage pattern is the most common form and looks like the branching pattern of tree roots. It develops in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take.

Table 2. Topographic and Drainage Characteristics of Ulu Dere Catchment

Description of the Basin	
Basin area, km^2	24.3
Minimum altitude, m	1240
Maximum altitude, m	1700
Average altitude, m	1000.5
Bifurcation ratio	5
Stream density, km/km^2	7.7
Profile slope of main waterway, %	5
Drainage density	3.588
Drainage pattern	Dendritic

In addition, some topographic attributes such as slope gradient, aspect, relief and average altitude were calculated from digital elevation models (DEM) with a 10-m grid-cell size (Figure 4)

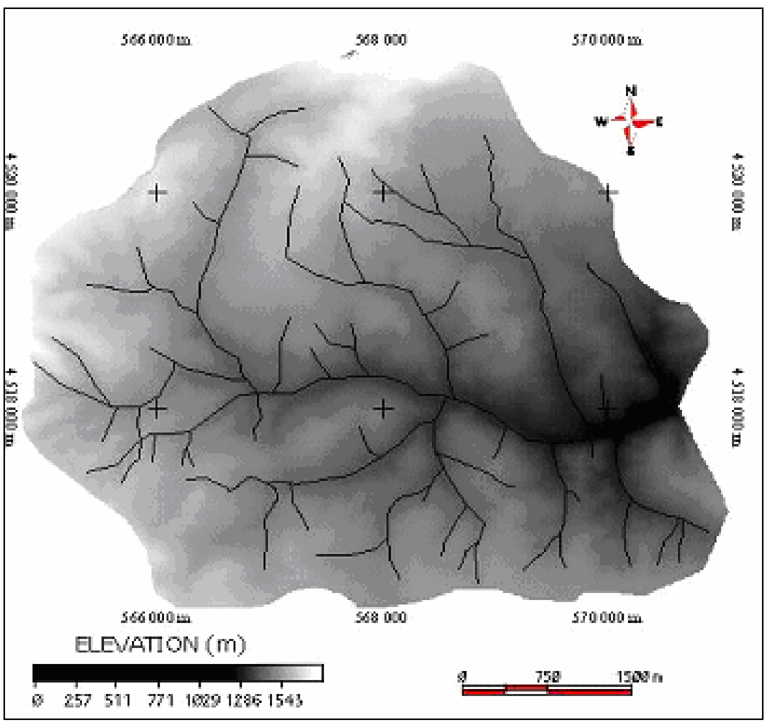

Figure 4. Digital Elevation Models (DEM) of the Ulu Dere Catchment

5.6% of the study area has less than 12% slope (very gentle, gentle and low) and 10.6% of the area is between12-20% slope gradient and 83.8% of the study area has more than 20% slope varying from steep to very steep from which runoff can easily occur (Table 3 and Figure 5). Steep and very steep areas are located on Lithic Xerorthent, and some part of the Typic Calcixeroll.

Table 3. Solpe distribution of the Ulu Dere catchment

Slope class (%)	Area (ha)	Ratio (%)
Very gentle 0-2	7.6	0.3
Gentle 2-6	19.2	0.8
Low 6-12	106.8	4.5
Moderate 12-20	258.4	10.6
Steep 20-30	367.8	15.1
Very steep 30+	1670.9	68.7

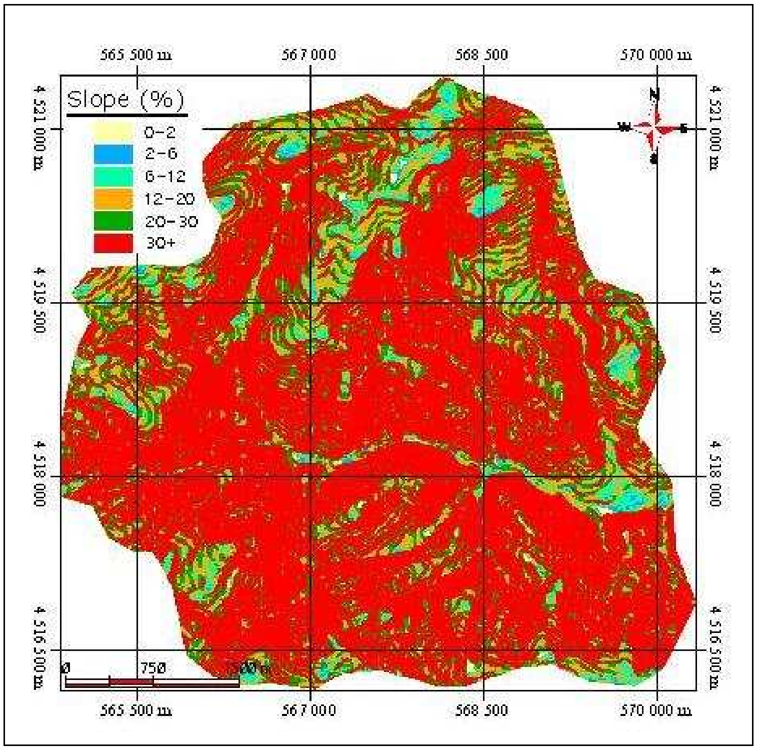

Figure 5. Slope map of the Ulu Dere Catchment

Soil physical and chemical properties that have been taken into consideration in this study showed variability as a result of dynamic interactions among natural environmental factors such as climate, parent material, land cover-land use and topography (Dengiz et al, 2006). Especially, the topographic influence on soil properties is apparent in the soil catena concept. Seibert et al. (2007) used measured soil properties from the Swedish National Forest Soil Inventory, which is a long-term inventory of permanent sample plots from the Swedish National Forest Inventory. It includes a description of soil types and soil horizons as well as sampling of organic and mineral soil horizons for subsequent chemical analyses. After examination of topographic, land use-land cover, geologic and geomorphologic maps and land observation, seven soil profile places were excavated and described in the study area. According to physical, chemical and morphological properties of soils, they were classified as Typic Xerorthent, Lithic Xerorthent, Typic Xerofluvent, Typic Calcixeroll, Typic Haploxerept, and Typic Dystroxerept. Most of the study area soils have shallow depth (0-20 cm). Effect of topography on soil thickness has been reported by many researchers (Benny and Stephens, 1985; McIntosh et al., 2000; Rezaei and Gilkes, 2005). While the deepest soil formed on low slope class (5-10 %) classified as Typic Haploxerept and Typic Calcixeroll, shallow soils cover on steep slope located on Typic Xerorthent, Lithic Xerorthent, which is the obvious effect of soil erosion process. All soil profiles include high sand ratio and vary between sandy loam and sandy clay loam except Profile 4 that has clay and clay loam. The horizon orders of the profiles in the study area were defined to be A-B-C form except for especially Profile 1, Profile 3, Profile 5 and Profile 7 which have A-C or A-R horizons. This means, these soils have no diagnostic subsurface horizons and low pedogenetic development. Therefore, these soils can be defined as young soils. There are no significant differences in the values of pH 7.10-8.19 and a very high base saturation except Profile 4 and Profile 7 that have acid reaction in their horizons (Table 4). Soil thickness, bulk density, coarse fragment content and sand ratios can be control and effects on soil hydraulic conductivity and surface water runoff. The bulk density and hydraulic conductivity are varied from 1.17 to 1.67 $g.m^{-3}$ and from 1.23 to 30.37 $cm.h^{-1}$ respectively by particle distribution. Bulk density was primarily lower in forest soils. Bulk density of forest and grassland soils was found below 1.03 $gr.cm^3$ whereas, in agriculture soils it was found over that ratio. This case can also be say for field capacity, wilting point and available water capacity influenced from particle distribution. Profile 4 has higher field capacity, wilting point and available water capacity values than other soil profiles. Soil organic matter content depends on the complex interaction of several factors including the quantity and quality of litter fall, climatic factor, soil properties (especially the amount and type of clay), and erosion Dahlgeren (1997). Organic matter content changes between 0.05 to 15.31% in the study area. Whereas forest and pasture lands (Profile 3, 4 and 6) have high organic matter, other land use and land covers have low organic matter. For all soils, the organic mater is highest in the surface horizon and decreases sharply to its lowest level in the subsoil.

Conclusion

This research was carried out in Ulu Dere catchment located in Çankırı- Yapraklı district of the Central Anatolia. The objective of this study was to investigate physiographic parameters, some hydro-physical soil properties and land use on river follow in Uludere Catchment. One of the most dangerous characteristics of the erosion-productivity problem is its difficulty of detection (Langdale, 1985) since erosion is generally a gradual process and because of the long time spans involved. Therefore, productivity reducing may not be recognized until land is no longer economically and ecologically suitable for growing crops. Also, this situation valid for the study area. Because, rainfed agricultural, clearing forest and overgrazing activities have been done at high slope lands of the study area. Thus, steeper slope contributes to greater runoff, as well as to greater translocation of surface materials down slope through surface erosion and movement of soil. Therefore, require similar soil conservation managements which are considerable for reducing runoff velocity and improvement soil condition. In addition, during data collection, analysis, manipulation, and using manual methods require too much cost and time consuming. Today advanced computer programs such as Geographic Information System and Remote Sensing contribute to the speed and efficiency of the overall planning process and allow access to large amounts of information quickly (Dengiz, 2005). It is also very easy to update or modify data involved in GIS database in future.

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Table 4. Some physical, chemical and hydro-physical properties of the study area's soils and classification according to Soil Taxonomy (1999)

Horizon	Depth	Texture (%)			Class	Coarse fragment <2 mm (%)	pH	EC (dS m^{-1})	CaCO3 (%)	Field Capacity (%)	Wilting Point (%)	Available Water Capacity (%)	Hydraulic Conductivity ($cm.h^{-1}$)	Organic Matter (%)	Bulk Density gr/cm^3
		Clay	Silt	Sand											
Profile 1 / Typic Xerorthent															
A	0-30	25	16	59	SCL	38	7.6	2,14	2,9	20,09	9,61	10,48	5,91	0,72	1,43
C1	30-50	20	20	60	SCL	24	7.6	0,22	2,1	19,49	6,39	10,09	15,21	0,14	1,54
C2	50-65	26	25	49	SCL	42	7.8	1,94	1,7	21,76	10,30	11,45	14,25	0,21	1,50
C3	65-91	16	18	66	SL	48	7.8	2,45	1,7	17,92	8,77	9,15	--	0,09	--
C4	91+	28	23	49	SCL	32	7.8	1,88	1,7	23,36	10,94	12,41	--	0,08	--
Profile 2 / Typic Haploxerept															
Ap	0-11	19	20	61	SL	46	7,2	0,96	0,64	15,17	7,67	7,50	10,20	1,30	1,67
A2	11-30	26	18	56	SCL	43	7,3	1,44	0,64	21,44	8,67	12,86	4,57	0,94	1,60
Bw	30-66	41	21	38	CL	30	7,1	1,46	0,36	27,09	10,83	16,25	3,52	0,64	1,34
C	66+	32	22	46	SCL	38	7,3	1,12	0,36	27,17	9,66	14,50	--	0,90	--
Profile 3 / Lithic Xerorthent															
A1	0-5	20	27	53	SCL	58	6,1	1,51	0,22	42,69	17,07	25,61	17,63	15,23	1,44
A2	5-20	24	24	52	SCL	38	6,9	1,42	0,64	23,83	9,53	14,29	30,37	3,04	1,29
C	20-37	20	10	70	SCL	20	7,1	1,70	0,36	17,46	6,98	10,47	22,28	0,79	1,55
R	37+	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Profile 4 / Typic Dystroxerept															
A	0-13	32	36	32	CL	41	6,4	1,76	--	37,53	15,01	22,52	3,20	15,31	1,03
Bw	13-33	43	26	31	C	27	6,4	1,81	--	34,39	13,75	20,63	1,23	3,04	1,17
C1	33-58	36	30	34	CL	34	6,5	1,86	--	36,14	14,45	21,68	--	0,54	1,24
C2	58+	33	46	21	CL	23	6,7	1,50	--	34,87	13,94	20,92	--	0,22	--
Profile 5 / Typic Xerofluvent															
A	0-33	14	31	55	SL		8.34	1.60	20.13	21.30	8.52	12.78	5.11	1.02	1.44
C1	33-80	11	12	77	SL	28.85	8.67	1.30	32.88	14.15	5.66	8.49	20.58	0.24	1.56
C2	80-104	18	18	64	SL	19.67	8.93	1.20	26.15	17.31	6.92	10.39	15.45	0.05	--
C3	104+	20	16	64	SCL		8.75	1.76	24.93	19.65	7.86	11.79	--		--
Profile 6 / Typic Calcixeroll															
A	0-20	27	25	48	SCL	--	7.88	1.72	32.02	25.35	10.14	15.21	15.59	7.96	1,20
Bw	20-34	32	24	44	SCL	4.70	8.13	1.46	35.39	23.82	9.53	14.29	19.63	1.21	1,28
BC	34-55	29	22	49	SCL	--	8.10	1.06	24.43	21.71	8.68	13.03	14.92	0.74	
Ck	55+	30	24	46	SCL	--	8.19	1.27	58.74	22.14	8.85	13.28	--	0.96	--
Profile 7 / Lithic Xerorthent															
A	0-19	30	19	51	SCL	34	6,7	1,05	0,57	19,44	7,78	11,67	4,22	1,30	1,55
C	19+	32	16	52	SCL	51	6,5	1,18	0,36	19,63	7,85	11,77	5,14	0,25	1,52

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