African Journal of Agricultural Research Vol. 4(13), pp. 1670-1677, 4 July, 2010
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR09.716
ISSN 1991-637X ©2010 Academic Journals

Full Length Research Paper

The effects of land use/land cover change and demographic processes (1950 - 2008) on soil properties in the Gökçay catchment, Turkey

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Accepted 8 January, 2010

The objective of this study was to analyse the effects of land use/land cover change (1955 - 2008) and migration (1950 - 2008) on the hydrological processes and soil physical properties in the Gökçay river catchment. The study area is located in Çankiri province, Ilgaz district, and Gökçay river catchment (41°04'N, 40°55'E). The necessary data were obtained from forest stand maps (1955 and 2008) and evaluated with geographic information system in order to introduce the effect of this land use/land cover change on soil properties and to assess the patterns during a 53-years period. The largest change has been in the forest openings. The forest has decreased from 25 to 7%. These areas have been used as forest, agricultural and settlement areas. Five sites were sampled in an unchanged forest, cultivated areas, natural rangeland, and sites that were changed from cultivated area to rangeland 10 and 50 years ago. Bulk density, hydraulic conductivity, water stable aggregates, soil organic matter and total nitrogen decreased in cultivated soil as compared to the forest soil. The soil properties of the permanent rangelands and of the cultivated field, converted to rangelands 10 and 50 years ago, were similar. The result showed that it is important to understand effects of spatial and temporal changes of land use/land cover and demographic structure their effects on landscape pattern and soil properties to dis-close the implications for land use planning and management.

Key words: Land use/ land cover, demographic processes, soil, catchment.

INTRODUCTION

Land use/land cover changes (LULCC) are affected by human-induced activities and growth, socio-economic factors, expansion of the forests, grazing, agricultural activities government policies, and environmental factors such as drought (Zhao et al., 2003; Doygun and Alphan, 2006; Kamusoko and Aniya, 2007). Socio-economic changes in rural especially mountainous region is mainly influenced by land-based economies closely related to the structure and function of landscape because agriculture, forestry and mining still constitute major economic activities (Lambin et al., 2003). Mountainous region of Turkey is affected by intense LULCC since 1950s, particularly deforestation and conversion to cropland and rangeland. Between 1938 and 2007 in Turkey, rangeland area decreased by approximately 70% from 41 to 12 million hectares (Mha), while cultivated land increased by about 80% from 13.3 to 24 Mha (SIS, 2007). In the rural region people encroach on forest areas for conversion to other uses, mainly cropland and rangeland though the land is not suitable for these purposes. The conversion of forest to other land uses cause increased water erosion, mass movements, soil compaction by trampling and alteration of the hydrologic cycle, among others. In Turkey 6.4 Million hectare land is under cultivation although it's classified as not suitable for cultivation. These areas are steep, insufficient in topsoil depth and prome to high potential erosion (Göl, 2007). Clearance of forests for agricultural production and grazing is widespread, in particular, in highlands of Turkey. Additionally, semi-arid climate and inclined topography prevailing in the central

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Anatolia render ecosystems vulnerable and unable to recover from incompatible changes in land-use type.

Population increase and migration are the primary causes of LULCC in Turkey. The population of Turkey increased from 21 Million in 1950 to 71.5 Million in 2008 (SIS, 2008). The population increase in rural areas caused unsuitable areas to be cultivated. These areas have been generally owned by unlawful means. Poverty and low income stimulated people living in forest to damage natural resources. According to 1930 records, 75% of the populations were living in rural areas, while 2007 records show that 70.5% of the populations were living in urban areas (SIS, 2007). This increase in urban population is as a result of migration from rural areas to cities. This situation is changing in the last decades. Recently, migration to cities has been slowed and same returned to rural areas. This imigration from cities to rural areas resulted in land degradation especially in mountainous regions due to population increase. In general, young population deserted the cultivated areas converted from forests and rangelands. The sloping areas cultivated with animal power by 1950, could not be cultivated by machine, and these areas become low quality forests. The aim of this study was to analyse the effects of LULCC and migration on the hydrologic processes and soil physical properties in a Gökçay river catchment. We examined ten replicates in each of five adjacent land use types which are natural forest, cultivated areas, native rangeland changed from cultivated areas to rangeland 10 and 50 years ago to determine and compare the soil physical, chemical and hydro physical properties.

MATERIAL AND METHODS

Description of the study area

The study area is located in Çankiri province, Ilgaz district, and Gökçay river catchment (41° 04 'N, 40° 55' E). The acreage of the study area is 12130 hectares. The elevation in the cathment ranges from 790 to 2546 m. There are two major valleys oriented in north of east (Figure 1). The soil order Entisols is mainly associated to this morphological unit (Soil Survey Staff, 1996). On average, physiological and absolute soil depth vary from 50 to 100 cm and 30 to 70 cm respectively.

All field measurements were performed in the Gökçay river catchment (120 km^2), (Figure 1). The region is located in the middle of the humid Black Sea and arid central Anatolia zone, which is characterized by terrestrial climate (warm summers and cold winters). According to the Thornthwaite water-balance model, the prevailing climate is semi-arid, mesothermal, semi-arid climate that has middle water surplus in winter and is coded with C_1 B'_1 s b'_3. The mean annual temperature is 10.1°C and annual precipitation is 484 mm (Anonymous, 2007). Topography and slope show great variations with hilly rolling physiographic units that are particularly common in the study area.

Dominant tree species of natural forest are Uludağ fir (*Abies nordmanniana* subsp. *Bornmulleriana* Mattf.), Scots pine (*Pinus sylvestris* L.) and Black pine (*Pinus nigra* Arnold.) (Anonymous, 2008). Most part of natural forest has been fragmented and degraded by human activities such as clear cutting for agriculture, and rangeland. Major crops grown in the area are wheat (*Triticum* spp.) and barley (*Hordeum* spp.). Crop rotation of legumes/cereals is a common practice in the catchment. Fruit trees including apples, apricots, almonds, plums and walnuts are grown in the area. Improper farming is common in the area.

Soil sampling and analysis

Ten replicated disturbed and undisturbed soil samples were collected from different land use/land cover (LULC) of five sites representing natural forest, cultivated areas, and native rangelands that were converted from agrarian to rangeland 10 and 50 years ago. Soil samples were taken at 0 -15 cm (surface layer) and 15 - 30 cm (subsurface layer) depths. The surface layers were A-horizon and the subsurface layers were the upper parts of B-horizon. One hundred disturbed and one hundred undisturbed soil samples were taken to investigate for their physical and chemical properties in the laboratory. Undisturbed soil samples were taken with steel core samples of 100 and 400 cm^3 volume.

Particle size distribution was determined by the hydrometer method (Bouyoucous, 1951). A wet sieving method was used to determine the water stable aggregates WSA (Kemper and Rosenau, 1986). Soil water retention at field capacity (FC), and at permanent wilting point (PWP) and available water capacity (AWC) were measured (Cassel and Nielsen, 1986), plant available water (PAW) was calculated as difference of AWC and PWP. Bulk density (B_b) and sutured hydraulic conductivity (K_{sat}) were determined by the core method (Klute and Dirksen 1986; Blake and Hartge, 1996). Soil pH and Electrical conductivity (EC) were measured by a pH/conductivity meter (Rhoades, 1996). Total nitrogen (TN) was determined with a Kjeldahl (Bremner, 1996) method and $CaCO_3$ was determined by pressure calcimeter (Richard and Donald, 1996). The concentration of soil organic matter (SOM) determined by Walkley-Black method (Nelson and Sommer, 1996). Data were analyzed with SPSS statistical software. Analysis of variance (ANOVA) of two-factor randomized complete plot design was conducted, and differences between individual means were tested with the Least Significant Difference (LSD) test, with a significance level of $p<0.05$.

Database development

The spatial database, developed as a part of this study, including land use type and land cover type maps derived from forest stand maps and field survey in 2008. Forest stand maps were digitized and processed using a Geographic Information System (ArcGIS 9.0) with a maximum root mean square (RMS) error less than 10 m. The associated attribute data were transfered to computer to create the spatial database of the area.

The basic categories of land cover, identified from forest stand map, were land changed from cultivated area to rangeland 10 years ago (CR_{10}), changed from cultivated area to rangeland 50 years ago (CR_{50}), Conifer forest (CF) including *P. nigra, P. sylvestris*, *Abies sp*., Native rangeland (NR), Forest openings (FO), Cultivated area (CA), Degraded forest (<10% crown closure) (DF) and Settlement area (SA).

RESULT AND DISCUSSION

Demographic activities between 1950 and 2008

Population of Turkey rose from 21.0 Million in 1950 to 71.5 Million in 2008, and 75% of population were in rural areas in 1950 while it droped to 30% in 2008 (SIS, 2008). Migrating from villages to cities was 17% until 1980,

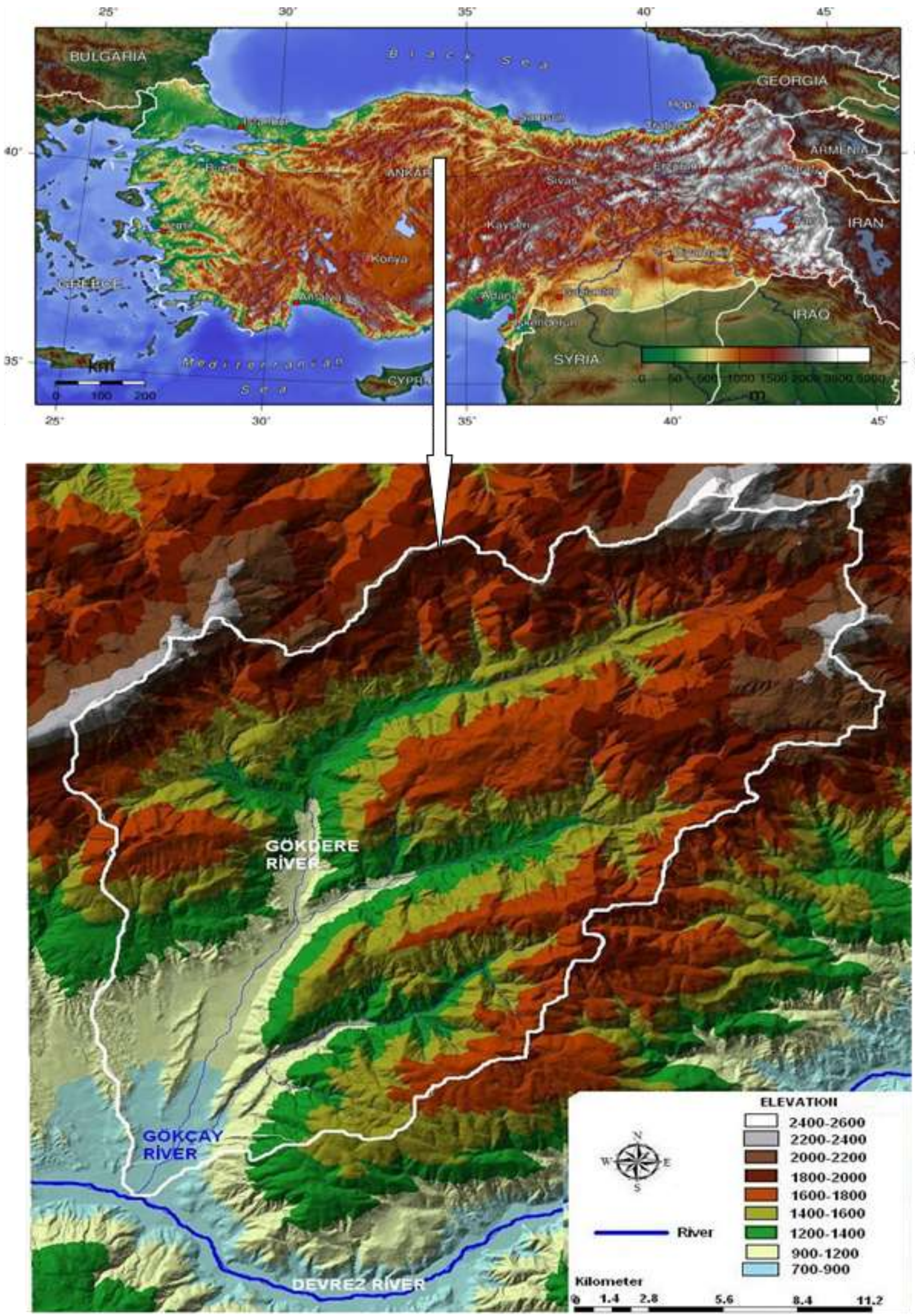

Figure 1. Location and physical maps of the study area.

Table 1. Places of residence in Turkey (1975–2000) (SIS, 2007).

Places of residence	Periods					Total (million)
	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000	
From village to city	0.6	0.9	1.1	1.1	1.1	4.7
Per cent	17	22	17	17	17	
From city to village	0.6	0.4	0.5	0.9	1.4	3.8
Per cent	19	12	12	15	20	

22% between 1980 and 1985, and 17% from 1985 to present (Table 1). The reasons for migration were 20% for job, 12% for education, and 26% for a member of the household. Especially in the plateau and villages in the highlands, young population left from the villages. According to 2007 census, the net immigration rate was -24.9% in the study area between 2000 and 2007 (SIS, 2007), showing that immigration rate in the study area was in oppsite direction.

Immigration from villages to urban areas resulted in different impacts on natural resources and LULCC. Until 1980, population increase and advances in agro-indusrty caused degradation of forest for agricultural purposes. However, in 1990s emigration from rural areas to villages resulted in some of these areas to be deserted. These deserted areas most of which are highly sloping areas, have been afforested.

Land use/land cover change of catchment

The LULC maps for the year 1955 and 2008 are presented in Figure 2. Percentage and quantity of each the LULC types is given in Table 2. Results showed that the LULCC have altered the character of the study area. The main observed trends were the decrease of FO areas including rangeland in the forest at the expense of conifer forest (CF), native rangeland (NR), cultivated area (CA) and settlement area (SA). Deforestation decreased from 2810 ha (24%) to 1516 (12%) (Table 2). Maps of the study area belonging to 1955 and 2008, were analyzed, land use type and change on the land pattern were introduced. The total CF increased from 5753 ha (47%) to 6019 ha (50%) during the 31-year period, net increase of 266 ha (2% of the whole study area) due to mainly afforestation. NR has increased from 157 ha (3%) to 958 ha (7%), It is completely against the general trend in Turkey. CA has increased from 3057 (25%) to 3346 ha (27%) and degraded forest (DF) lands were 1% in 1955 and it become 3% in 2008.

When demographic characteristics and LULCC were evaluated together, interesting results came out. Until 1990, high population increase rate resulted in ever increasing needs for agricultural areas. Pitched forests and rangelands in high mountanious areas, not suitable for agriculture are rapidly changed into agricultural area. The most potent force affecting natural vegetation arises from the direct effects of an expanding human population (e.g. habitat destruction for agriculture, human settlement, land for grazing, etc.) and indirect effects (e.g. pollution) (Grime, 1997; Mwavu and Witkowsski, 2008). This process reversed between 1980 and 2000, especially the emigration of young population from rural areas caused these areas to be deserted. Both the local people and key informants are concerned that land-use and cover changes in the area have occurred with the decrease in agricultural land and forest openning, and this threatens the availability of land for further increases in rangeland. This change was attributed to a number of factors, including the rapid human migration, using tractor for cultivation, decreasing range cattle and afforestation. Similarly, studies elsewhere indicate that ecological dynamics in human-influenced landscapes are strongly affected by socio-economic factors that influence landuse decision-making (Berry et al., 1995). At the time of land studies in 2008, it was observed that agricultural unaccessibility by tractors were covered by grass and forest. Both the local people and researchers explained that quantity of livestock has been decreasing recently. Another drastic change was in forest cover type. While Uludağ fir forests declines in the ratio of 5% (from 1566 to 1069 ha), Scots pine and Black pine forests increases in the ratio of 8% (from 4187 to 4950 ha) (Table 2).

Impacts of land use/land cover change on soil properties

According to the land use types and soil depth, important statistical differences were observed (Table 3). The effects of LULCC on soil physical and chemical properties were analysed by Hajabbasi et al. (1997), Halim, (2007), Sivrikaya et al. (2007), Preston (2008), Nyssen (2008), Cakir (2008), Bensel (2008) and Li et al. (2009). CF soils were significantly more acidic, organic matter affected soil reaction, and AWC, EC, and salinity were not influenced by LULC and soil depth. pH was influenced by LULC with a significant interaction. Water stable aggregates (WSA) were influenced significantly by LULC. WSA values can be used as indicators of soil structural quality (Sinh and Singh 1996; Six et al., 2000). Results have shown significantly higher values of WSA in CF (74%) and NR (78%) top soil compared to CA top soils (58%) and CR_{10} (56%) (Table 3). Due to long-term

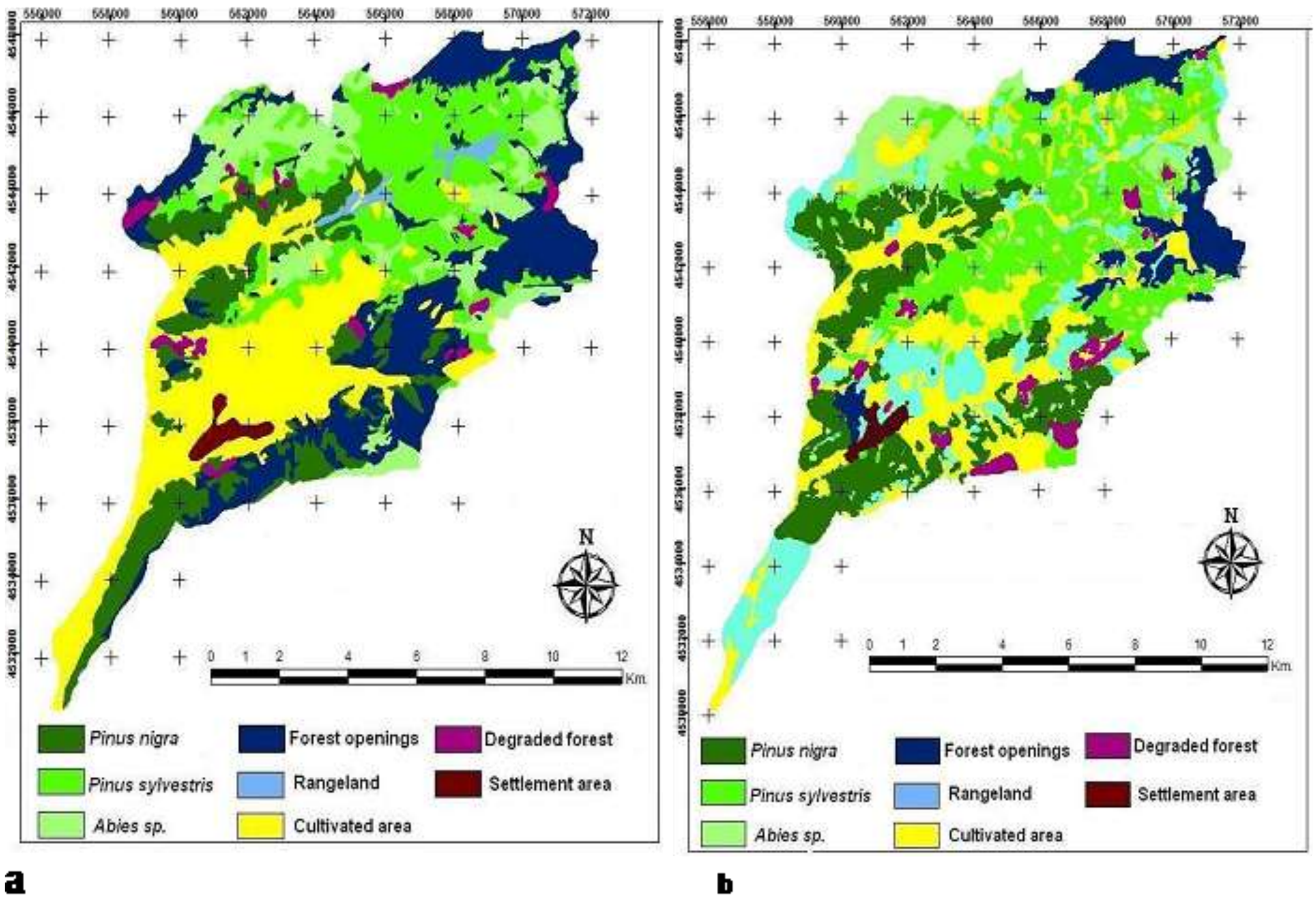

Figure 2. LULC in Gökçay river catchment during the period of 1955 (a) and 2008 (b).

Table 2. LULCC in the study area from 1955 to 2008.

LULC		Forest stand maps				Changing Per cent
		1955		2008		
		ha	Per cent	ha	Per cent	
CF	Scots pine Black pine	4187	34	4950	42	8
	Uludag fir	1566	13	1069	8	-5
NR		157	2	958	7	5
FO		2810	24	1516	12	-12
CA		3057	25	3346	27	2
DF		188	1	270	2	1
SA		165	1	210	2	1
Total		12130	100	12130	100	

cultivation WSA in CA soils were degraded. Soils become more susceptible to erosion since macroaggregates are disrupted (Elliott, 1986; Cambardella and Elliott, 1993; Six et al., 2000). The soil depth did not make significant difference in WSA within each land-use type. Previous studies showed that soils with a higher WSA is likely to have a greater resistance to soil degradation and erosion (Luk and Hamilton, 1986; Teixeira and Misra, 1997)

Table 3. Summary statistics of soil properties for five land uses∗.

	Depth (cm)	pH	EC_e	WSA	SOM	TN	AWC	K_{sat}	B_b
CR_{10}	0-15	7.4±0.1	1.8±0.1	56±5.4	$4.2\pm0.2^{A}{}_{b}$	0.2±0.0	15.6±1.1	$8.3\pm2.7^{A}{}_{c}$	$1.27\pm0.1^{A}{}_{b}$
	15-30	7.2±0.5	1.1±0.1	51±5.0	$1.4\pm0.2^{B}{}_{c}$	0.1±0.0	14.6±0.8	$2.3\pm1.2^{B}{}_{c}$	$1.37\pm0.2^{B}{}_{a}$
	Mean	$7.3\pm0.2_{a}$	1.4±0.1	$54\pm5.4_{b}$	2.8±0.5	$0.1\pm0.0_{b}$	15.1±0.9	5.3±2.1	1.32±0.2
CR_{50}	0-15	7.1±0.1	1.2±0.1	67±4.7	$3.3\pm0.1^{A}{}_{bc}$	0.2±0.0	13.6±0.8	$12.3\pm3.1^{A}{}_{b}$	$1.32\pm0.2^{A}{}_{a}$
	15-30	7.0±0.1	1.1±0.1	61±8.4	$2.9\pm0.3^{A}{}_{b}$	0.1±0.0	12.8±0.9	$2.7\pm1.5^{B}{}_{c}$	$1.41\pm0.2^{B}{}_{a}$
	Mean	$7.0\pm0.1_{a}$	1.1±0.1	$64\pm6.2_{ab}$	3.1±0.1	$0.1\pm0.0_{b}$	13.2±0.6	7.5±2.1	1.36±0.2
NR	0-15	6.2±0.3	1.1±0.1	78±8.1	$5.4\pm0.5^{A}{}_{b}$	0.3±0.0	15.8±1.0	$13.5\pm3.9^{A}{}_{b}$	$1.20\pm0.1^{A}{}_{c}$
	15-30	6.8±0.2	1.4±0.1	68±7.3	$2.6\pm0.5^{B}{}_{b}$	0.1±0.0	13.6±0.9	$4.6\pm1.9^{B}{}_{b}$	$1.29\pm0.1^{A}{}_{b}$
	Mean	$6.5\pm0.2_{a}$	1.2±0.1	$73\pm7.2_{a}$	4.0±0.5	$0.2\pm0.0_{ab}$	14.7±0.8	9.1±1.6	1.24±0.0
CF	0-15	5.5±0.3	1.0±0.1	74±8.7	$7.6\pm0.8^{A}{}_{a}$	0.4±0.0	16.4±0.2	$27.8\pm4.1^{A}{}_{a}$	$0.96\pm0.1^{A}{}_{d}$
	15-30	5.7±0.1	1.0±0.0	68±6.5	$4.8\pm0.4^{B}{}_{a}$	0.2±0.1	15.5±0.9	$9.9\pm1.5^{B}{}_{a}$	$1.14\pm0.1^{B}{}_{c}$
	Mean	$5.6\pm0.1_{b}$	1.1±0.1	$71\pm7.2_{a}$	6.2±0.8	$0.3\pm0.0_{a}$	15.9±0.8	18.8±3.1	1.05±0.1
CA	0-15	6.1±0.3	1.2±0.1	58±8.1	$2.6\pm0.5^{A}{}_{c}$	0.3±0.0	15.8±1.0	$9.6\pm2.9^{A}{}_{c}$	$1.21\pm0.1^{A}{}_{c}$
	15-30	6.0±0.2	1.3±0.1	63±8.3	$1.3\pm0.5^{B}{}_{c}$	0.1±0.0	13.6±0.9	$2.2\pm0.9^{B}{}_{c}$	$1.37\pm0.2^{B}{}_{a}$
	Mean	$6.0\pm0.2_{a}$	1.2±0.1	$61\pm7.2_{ab}$	1.9±0.5	$0.2\pm0.0_{ab}$	14.7±0.8	5.4±1.6	1.28±0.1

*Abbreviations:EC_e- Electrical conductivity ($dS.cm^{-1}$), WSA-water stable aggregate (%), SOM-soil organic matter (%), TN-total nitrogen (%), AWC-available water capacity (%), K_{sat}-saturated hydraulic conductivity ($cm.h^{-1}$), B_b-bulk density ($gr.cm^{-3}$),

Lowercase letters indicate statistically significant differences among soil properties affected by the different land uses ($p<0.05$). Uppercase letters show statistically significant differences between land use for the cases that there were interactions between land use type and soil depth ($p<0.05$). Land changed from cultivated area to rangeland 10 years ago (CR_{10}), changed from cultivated area to rangeland 50 years ago (CR_{50}), Native rangeland (NR), Conifer forest (CF) including *Pinus nigra, Pinus sylvestris*, *Abies sp*, Forest openings (FO), Cultivated area (CA).

(Table 3). Conversion of the CF into CA resulted in sig-nificant decreases of both the concentration and stock of SOM (Table 3). A trend of increased SOM content of soils under forests was observed that both layers of soil significantly had higher amounts of organic matter in forest than the other LULC. Soil characteristics CF_{10} and CF_{50} have changed with the LULCC. Change from CA to NR, SOM content in the soils increased significantly ($p<0.05$). Over the last two and half decades, the scientific community has made noticeable efforts in order to understand LULCC as part of the climate system (Mahmood et al., 2006). Sig-nificant difference ($p<0.05$) in SOM between the forest and the other LULC will lead to a reduction in the nutrient and soil organic carbon content. The conversion of NF and NR into CA is known to deteriorate soil properties, especially reduces SOM and changes the distribution and stability of soil aggregates (Ross, 1993; Singh and Singh, 1996). LULC type has a great effect on hydrologic regime and soil water content (Schultz et al., 2004).

Results have shown significantly higher values of saturated hydraulic conductivity (K_{sat}) in CF top soil (27.8 $cm.h^{-1}$) compared to NR soils (13 $cm.h^{-1}$) and CR50 (12.3 $cm.h^{-1}$), CA (9.6 $cm.h^{-1}$) and CR10 (8.3 $cm.h^{-1}$) (Table 3). These results demonstrate that the effect of LULCC on K_{sat} was confined to topsoil in the soil profile. Forests are generally known for a high soil infiltration capa-cities and hydraulic conductivity, enhancing base flow (Buytaert, 2007). K_{sat} was significantly greater in the CF soils than that in other LULCs, indicating importance of natural forest in regards to water transport processes in landscape. Results of the analysis indicate that conversion from CA use to NR increases K_{sat}. The NF and NR generate the highest $K_{sat,}$ whereas CA generates the lowest K_{sat}. Allen (1985) reported that soil compaction by the tillage decreased macroporosity and hydraulic conductivity and increased susceptibility of soils to erosion. In catchment scale, forest areas may be positively influenced by relevant hydrological functions like infiltration, percolation, and base flow that subsequently affect the water regime in a catchment. Conversion of the subsoils yielded different results. Subsoils in CA, CR_{10} and CR_{50} exhibited lowest K_{sat}, resulted from the compaction caused by grazing. There was significant difference in the bulk density between LULCs, which was attributed to the compaction of the topsoil due to overgrazing of the rangelands and agricultural mechanization. This process could get worse by the continuous use of machinery for cultivation (Lal and Henderlong, 1997). Similar findings showing that deforestation and subsequent tillage practices resulted in approximately 20% increase in bulk density and a 50% decrease in SOM in a soil depth of 0 - 30 cm over 20 years in the central Zagrous Mountain in Iran were reported by Hajabbasi et al. (1997). In addition, following conversion from natural forest, a decline in soil aggregation resulted in the increased bulk density. Bulk density was high in 15 - 30 cm of CA, CR_{10}, and CR_{50} due to compaction effect of tractor tyre.

Conclusion

Changes in the LULC are a result of complex interactions between physical, biological, economic, political, and social factors. Socio-oeconomic development, decrease of the human and livestock population, and a change of livestock type have all influenced changes in the traditional pattern of woodland utilization (Salehi, 2008). This study showed that different LULCC and revegetation had different effects on soil properties. The effect of LULCC on soil physical and chemical properties should be accounted to examine and simulate ecosystem dynamic in the high land mountain ecosystems of Turkey. Lands coverted to rangeland 10 and 50 years ago, aquired charecteristics of natural rangeland. Socio-economic and demographic changes effected LULC types. Much of the changing occurred until 2000s and there has been a subsequent deceleration and even local reversal of such processes since then. Emmigration from villages to urban areas reversed in the years of 2000 (SIS, 2007). Deserted areas are likely to be used again for agricultural and grazing purposes. This necessiates developing new land use policies toward these areas. Inappropriate land use is the main factor for the destruction of natural resources.

Most of the land has become less productive because of an increasing population and improper cultivation of agricultural land. This kind of pressure on forestland resources threatens the stability of forest land. Misuse of land in forest villages is the main factor for the increase in rural poverty and the degradation of forests. Problems are encountered when it comes to the use of natural resources in the forest villages of Turkey. Therefore, it is necessary to intervene to end this misuse of land. Measure should be taken under the following headings to prevent further misuse: problems regarding in-forest settlements should be solved; practices providing income generation and food security should be carried out; farm forestry and community forest applications should be developed; and undamaged forest resources should be protected with buffering zone forest management applications.

REFERENCES

Allen J (1985). Soil response to forest clearing in the United States and in the tropics: Geol. Biol. factors, Biotropica, 11: 15-27.

Anonymous (2008). 1996–2015, General Directorate of Forestry (GDF), Regional Directorate of Ankara, Forest District Directorate of Ilgaz, Management Plan of Forest Sub-district of Yenice.

Anonymous (2007). Ilgaz Meteorology Station, Climate Values (1978–2007), Republic of Turkey Ministry of Enviroment And Foretsry, Turkish State Meteorological Service,Turkey.

Bensel T (2008). Fuelwood, deforestation, and land degradation: 10 years of evidence from Cebu province, The Philippines, Land Degradation Dev., 19: 587-605.

Berry MW, Flamm RO, Hazen BC, MacIntyre RL (1995). The Land - use Change Analysis System (LUCAS) for Evaluating Landscapen Management Decisions. http://www.cs.utk.edu_lucas/publications/ieee/ieee.html

Blake GR, Hartge KH (1996). Bulk Density and Particle Density, In: Methods of Soil Analysis Part 1. Physical and Minerological Methods, ASSA, 9: 363-381.

Bouyoucous GJA (1951). Recalibration of the Hydrometer for Making Mechanical Analysis of Soil, Agro J., 43: 434-438.

Bremner JM (1996). Methods of Soil Analysis, Part 3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series Madison-USA. p. 5.

Buytaert W, Iniquez V, Bievre B (2007). The effects of afforestation and cultivation on water yield in the Andean Paramo, For. Ecol. Manage., 251: (1-2): 22-30.

Cakir G, Un C, Baskent EZ, Kose S, Sivrikaya F, Keles S (2008). Evaluating urbanization, fragmentation and land use/land cover change pattern in Istanbul city, Turkey from 1971 to 2002, Land Degr. Dev., 19: 663-675.

Cambardella CA, Elliott ET (1993). Carbon and nitrogen distrubition in aggregates from cultivated and native grassland soils, Soil Sci. Society Am., 57: 1071-1076.

Cassel DK, Nielsen DR (1986). Mehods of Soil Analysis, Physical and Mineralogical Methods-Agronomy Monograph (2nd edition) Madison-USA.Soil Sci. Am. Am. Soc. Agric., 1: 9.

Doygun H, Alphan H (2006). Monitoring urbanization of Iskenderun, Turkey, and its negative implications. Environ. Monitoring Assessment 114: 145-155.

Elliott ET (1986). Aggregate structure and carbon, nitrogen, and phosphorus in native and cultivated soils, Soil Sci. Society Am., 50: 627-633.

Göl C (2007). The relatonships between land use types and soil organic carbon, I. Turkey Climate change congress, TİKDEK 200, 11–13 April 2007, İTÜ, İstanbul., pp. 411-419.

Grime JP (1997). Climate change and vegetation. In Plant Ecology, 2nd edition, Crawley MJ (ed.). Blackwell Science: Oxford, UK; pp. 582-594.

Hajabbasi MA, Jalalian A, Karimzadeh HR (1997). Deforestation effects

on soil physical and chemical properties, Lordegan, Iran, Plant Soil, 190: 301-308.
Halim R, Clemente R, Routray JK, Shresthar P (2007). Integration of biophysical and socio-economic factors to assess soil erosion hazard in the upper Kaligarang Watershed, Indonesia, Land Degradation Dev., 18: 453-469.
Kamusoko C, Aniya M (2007). Land use/cover change and landscape fragmentation analysis in The Bindura District, Zimbabwe, Land Degradation Dev., 18: 221-233.
Kemper WD, Rosenau RC (1986). Aggregate stability and size distribution. In: A. Klute, Editor, Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods, second ed. Agronomy Monographs 9, ASA-SSA, Madison, WI, pp. 425-442.
Klute A, Dirksen C (1986). Hydraulic conductivity and diffusivity. In: A. Klute, Editor, Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods, second ed. Agronomy Monograph s, 9, ASA-SSA, Madison, WI, pp. 687-734.
Lal R, Henderlong P (1997). Flowers, M. forages and row cropping effects on soil organic carbon and nitrogen contents, In: Lal, R., Kimble, J.M., Follett, R.F., Stewart, B.A. (Eds.), Management of Carbon Sequestration in Soil. CRC Press, Boca Raton, FL, pp. 365-380.
Lambin EF, Geist HJ, Lepers E (2003). Dynamics of land-use and land-cover change in Tropical regions. Ann. Rev. Environ. Res., 28: 205-241.
Li XY, Ma YJ, Xu HY, Wang JH, Zhang DS (2009). Impact of land use and land cover change on environmental degradation in lake Qinghai watershed, northeast Qinghai-Tibet Plateau, Land Degradation Dev., 20: 69-83.
Luk H, Hamilton H (1986). Experimental effects of antecedent moisture and soil strength on rainwash erosion of two luvisols, Ontario, Geoderma., 37: 29-43.
Mahmood R, Pielke RA, Hubbard KG (2006). Land use/land cover change and its impacts on climate, Global and Planetary Change, p. 54.
Mwavu EN, Witkowski ETF (2008). Spouting of woody species following cutting and tree- fall in lowland semi-deciduous tropical rainforest, North-Western Uganda, For. Ecol. Manage., 225: 982-992.
Nelson DW, Sommer LE (1996). L.E. Methods of Soil Analysis. Part 3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series Madison-USA, p. 5.
Nyssen J, Naudts J, De Geyndt K, Haile H, Poesen J, Moeyersons J, Deckers J (2008). Soils and land use in the Tigray highlands (Northern Ethiopia), Land Degradation Dev., 19: 257-274.
Preston DA (2008). Understanding and assessing land degradation - comments on research in Chuquisaca, Bolivia. Land Degradation Dev., 19: 119-121.
Rhoades JD (1996). Methods of Soil Analysis, Part 3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series Madison-USA. p. 5.
Richard HL, Donald LS (1996). Methods of Soil Analysis, Part 3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series Madison-USA. p. 5.
Ross SM (1993). Organic matter in tropical soils: current conditions, concerns and prospects for conservation, Prog. Phys. Geogr. 17: 265-305.
Salehi A, Wilhelmsson E, Derberg USO (2008). Land cover changes in a forested watershed, Southern Zagros, Iran, Land Degradation Dev., 19: 542-553.
Schultz KJ, McGlaynn BL, Elsenbeer H (2004). Impacts of Land Use and Cover Change on Soil Hydraulic Properties, Rondonia-Brazil, American Geophysical Union, Spring Meeting.
SIS (State Institute of Statistic) (2007). Statistical Yearbook of Turkey, 2007. State Institute of Statistics Prime Ministry Republic of Turkey.
SIS (State Institute of Statistic) (2008). Statistical Yearbook of Turkey, 2008. State Institute of Statistics Prime Ministry Republic of Turkey.
Sivrikaya F, Akir GC, Kadiogullari AI, Keles S, Baskent EZ, Terzioglu S (2007). Evaluating land use/land cover changes and fragmentation in the Camili forest planning unit of Northeastern Turkey from 1972 to 2005, Land Degradation Dev., 18: 383-396.
Sinh S, Singh JS (1996). Water-stable aggregates and associated organic matter in forest, savanna, and cropland soils of a seasonally dry tropical region, Biol. Fertility Soils, 22(1-2): 76-82.
Six J, Elliott ET, Paustian K (2000). Soil Structure and Soil Organic Matter: A Normalized Stability Index and the Effect of Mineralogy, Soil Sci. Soc. Am. J., 64: 1042-1049.
Soil Survey Staff (1999). Soil Taxonomy, A Basic of Soil Classification for Making and Interpreting Soil Survey. USDA Handbook Washington D.C. USA. p. 436.
Teixeira PC, Misra RK (1997). Erosion and sediment characteristics of cultivated forest soils as affected by the mechanical stability of aggregates, Catena, 30: 119-134.
Zhao B, Nakagoshi N, Chen JK, Kong LY (2003). The impact of urban planning on land use and land cover in Pudong of Shanghai, China. J. Environ. Sci., 15: 205-214.