The effects of catchment melioration on land cover case study: Tatlıçay catchment

Alkan Günlü[1], Ceyhun Göl[1,*]

[1]Department of Forest Engineering, Faculty of Forestry, University of Çankırı Karatekin, 18200, Çankırı -Turkey

[*] Corresponding author: drceyhungol@gmail.com

Abstract: The objective of this study was to investigate the effects of catchment melioration studies on land use types and land cover (agriculture-forest-grassland) changes between 1975 and 2016. Tatlıçay catchment has been the subject of flood and erosion control studies for many years. Catchment melioration studies were initiated in 1960. Grazing control, terracing, afforestation and conservation work were carried out in the scope of the studies. In this study, the success of catchment melioration studies carried out between the years 1975 and 2016 and changes in the land use type/land cover (LUTLC) in the catchment were assessed. Tatlıçay catchment covers the mountains north of the city of Çankırı, crosses Acıçay at the city center, and flows into Kızılırmak River southeast of the city. As the catchment located within the transition zone from the humid Black Sea climate to the arid Central Anatolia climate, the land cover becomes poorer towards the south. Climate, soil and topography are the main ecological factors that directly affect land use types of the catchment. Remote Sensing (RS) data and Geographical Information System (GIS) were used to evaluate the usefulness of RS/GIS data to determine the effects of catchment melioration studies in semi-arid region in this study. RS/GIS data can provide more reliable and, low-cost data compared to conventional field and lab analysis methods. The field research was conducted in Tatlıçay Catchment, in Central Anatolia. Land use types in downstream are generally dry farming and degraded grasslands, in upstream are pasture, forests and cultivate area. The properties of soils in these areas are salty, dry, gypsum. Sloped and arid areas are only convenient for being used for dry farming with degraded grassland. Forest areas are mostly located north and northeast (upstream) of the catchment.
Keywords: Remote sensing, Land use, Melioration, Semi-arid, Turkey

1. Introduction

Changes in land use result from the complex interaction of many factors including policy, management, economics, culture, human behavior, and the environment. Inappropriate land use is one of the main reasons for land degradation. Afforestation plays an important role in many semi-arid regions all over the world as a permanent plant cover in terms of preventing erosion, sustainable use of land and water resources, defense against desertification and settling population in rural areas. Therefore, determining the trend and the rate of land cover conversion are necessary for the development planner in order to establish rational land use policy. For this purpose, the temporal dynamics of remote sensing data can play an important role in monitoring and analyzing land cover changes.

The objectives of this study are; to evaluate the effects of catchment amelioration studies on land cover types and land cover changes that have taken place in the last 41 years, to integrate visual interpretation with classification using GIS and to examine the capabilities of integrating remote sensing and GIS in studying the spatial distribution of different land over changes.

2. Material and methods

2.1. Field description

Tatlıçay catchment covers the mountains north of the city of Çankırı, crosses Acıçay at the city center, and flows into Kızılırmak River southeast of the city. The catchment is located at latitude of 40° 33'- 40° 51' north and a longitude of 33° 17'- 33° 46 east (Fig. 1). Its total area is 65468 hectares.

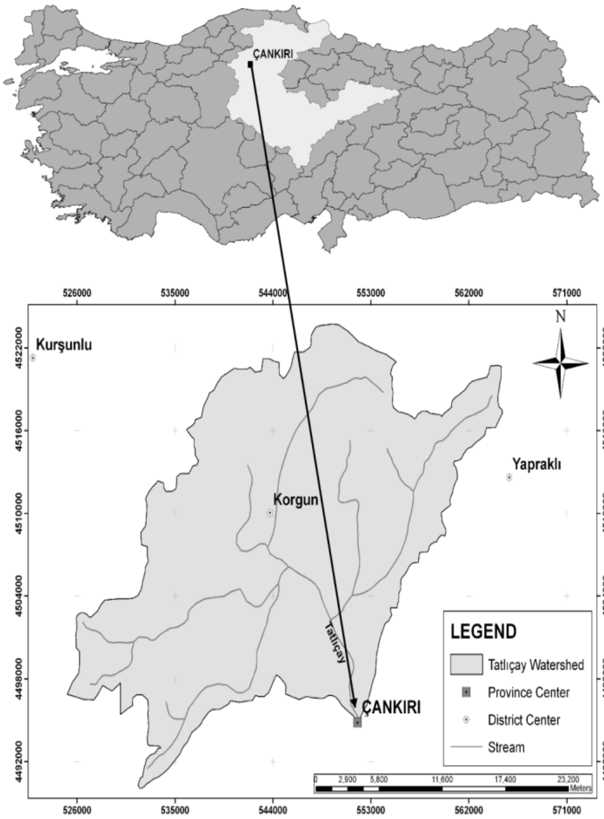

Figure 1. Location of Tatlıçay catchment within Kızılırmak basin

Topographic structure is diverse and shows an ever changing characteristic. Topographic structure and elevation are the two main determinants of the diverse land usage and land cover in the catchment. In the upper portion of the catchment, land types are not suitable for agricultural production. Land cover is of degraded forest type and bovine breeding is prevalent. In contrast, dry farming, degraded pasture and ovine breeding are common in the lower catchment. The catchment has a sloped structure and 50 % of it consists of steep and vertical fields. This has significant effects in terms of type of land usage, land cover, erosion and distribution of settlement areas.

There are two meteorological stations within the catchment and five more outside it. The long term measurement results collected by these stations show that the catchment has three main climate zones. The catchment is within the transition zone from the humid climate of Black Sea to Central Anatolia continental climate. While in 21 % of the catchment semiarid climate is dominant, sub-humid and continental arid - semiarid climates are dominant in the other 16 % and 63 % of the catchment respectively.

In the northern part (upstream) of the catchment, a place which is under the influence of Black Sea climate and which reflects the characteristics of sub-humid climate, mean daily temperature is 9.1 ^{o}C and mean annual rain fall is 530.8 mm (Anonymous, 201a - 2010b)). In the sections where water surpluses are observed in winter season, best forests and grassland of the catchment are situated. In this section, forest villages and villages, where irrigated farming is carried out, are present (Göl et al., 2010). Middle of catchment with semiarid climate, mean daily temperature is 10.7 ^{o}C and mean annual rain fall is 500 mm (Anonymous, 2010a). Downstream with arid-semiarid climate, mean daily temperature is 11.1 ^{o}C and mean annual rain fall is 417 mm (Anonymous, 2010b). Mean annual rain fall of the catchment is 391 mm and shows that Tatlıçay is generally under the influence of a semiarid and arid climate.

Bedrock and soil properties are the main factor that directly affects water quality and vegetation structure of the catchment. There are two different geological formations (Oligo-Miosen gypsum, Miocene series) (Doğan, 2002; Ketin, 1962; Yuksel et al., 2001) in the catchment. Geological structure should be taken into account in the catchment management planning.

As the catchment located within the transition zone from humid Black Sea climate to arid Central Anatolia climate, is examined from north to south, the farther we go south, land cover becomes poorer. Climate, soil and topography are the main ecological factors that affect land use of the catchment and change in its land cover. Areas with arid, salty and gypsum bearing soils form degraded pasture grounds with poor land cover. Sloped and arid areas are only convenient for being used for dry farming with degraded pasture grounds. Sloped and semiarid areas, on the other hand, are convenient for being used as forests and in-forest pasture grounds.

Forestlands within the catchment are mostly located north and northeast of the catchment. The forest intensity in these areas originates from the fact that the influence of the humid Black Sea climate is strong in these areas. In the upper catchment part there are forests and rich alpine pasture lands. Soil of this area is salt and gypsum free. On the other hand, the lower catchment section consists of extensive degraded pasture grounds and farming areas. No bodily forests exist in the lower catchment section but bushes that need little water and herbaceous type of vegetation. There is strong erosion in the lower catchment section due to human pressure and over herding.

Digital elevation model-DEM, geological maps and meteorological data were used to prepare land use-land cover map and characteristics of catchment. All these data were analyzed using of ArcINFO software ArcGIS 9.2 program. Remote Sensing (RS) data and Geographical Information System (GIS) were used to evaluate the usefulness of RS/GIS data to determine the effects of catchment melioration studies on land use changes. In order to determine those effects, satellite images (1975 and 2016), forest maps and some local information were used to evaluate of the changes of land uses in study area. The database (developed around 1976 from satellite images) was used as the source of land use data in this study. Digital topographic maps digitized from hardcopy topographic maps with scale of 1 : 25,000 were used mainly for geometric correction of the satellite images and for some ground truth information. In this study, post-classification change detection technique was applied. Post classification is the most obvious method of change detection, which requires the comparison of independently produced classified images. Post-classification comparison proved to be the most effective technique, because data from two dates are separately classified, thereby minimizing the problem of normalizing for atmospheric and sensor differences between two dates. Cross-tabulation analysis was carried out to analyze the spatial distribution of different land cover classes and land cover changes.

3. Result and discussion

3.1. Effects of catchment melioration on LUTLCC

In this study, multi-temporal land use types and land cover changes (LUTLCC) were determined by integrating GIS and remote sensing data. Specifically, Landsat 7 ETM+ (Enhancement Thematic Mapper Plus) satellite images from 1976 to 2016 with approximately 30 m resolution were employed as base data.

Imagery for use in land use type and land cover (LUTLC) should be prepared so that the “before and after” images match each other as closely as possible spatially, spectrally and radio metrically. In this way, the only differences detected should be those that have actually occurred on the ground. All images were rectified to UTM zone 36N, WGS 84 using the rectified Landsat images as the reference source for image to image registration. In addition, 1:25,000 scale digital topographic maps were used in that process.

Post-classification change detection technique was carried out, through cross-tabulation GIS module, for the classification results of 1975 and 2016 images in order to produce change image (Fig. 2 - 3) and statistical data about the spatial distribution of different land cover changes and non-change areas (Table 1).

Changes among different land cover classes were assessed. During the study period, a very severe land cover change has taken place as a result of catchment melioration projects. These changes in land cover led to increased forest areas (10%) and decreased grassland areas (-18%) in part of the study area (Table 1).

Table 1. Land use types and land cover changes

Land use type and land cover	1976 year		2016 year		Change (+/-)	
	Area	%	Area	%	Area	%
Forest	10499.3	15.9	17299.7	26.2	6800.4	10.3
Water	49.7	0.0	90.9	0.1	41.2	0.1
Cultivated Area	12361.9	18.7	13709.7	20.7	1347.8	2.0
Settlement	3735.2	5.7	5257.4	7.9	1522.2	2.2
Plantation Forest	378.9	0.6	2788.3	4.2	2409.4	3.6
Grassland	39002.8	59.1	26881.6	40.9	-12121.2	-18.2
Total	66027.8	100	66027.8	100		

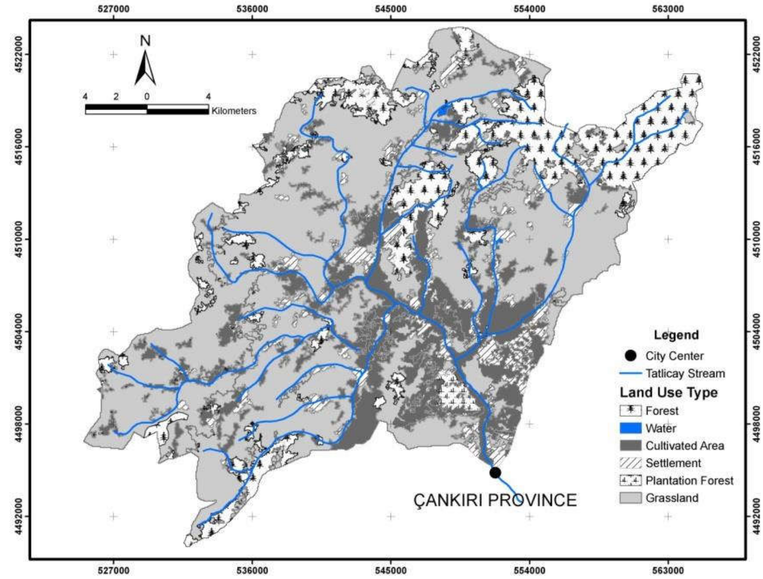

Figure 2. Land use types and land cover in 1975 year

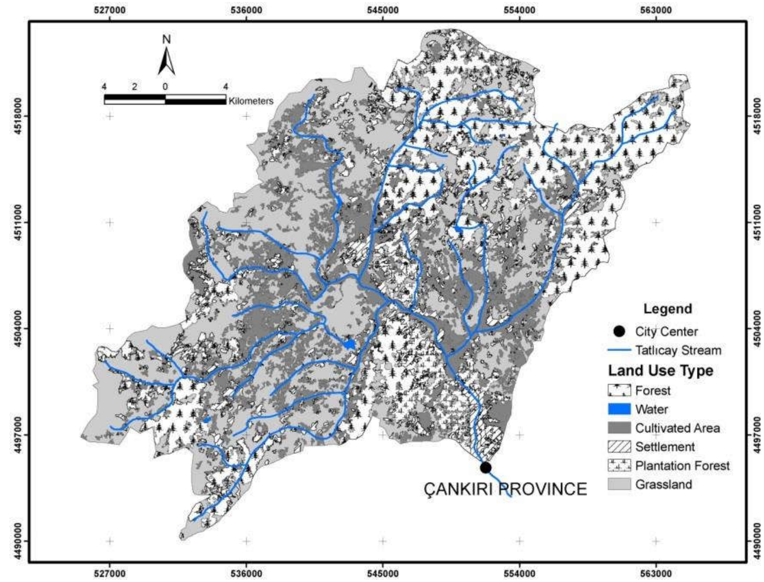

Figure 3. Land use types and land cover in 2016 year

Conclusion

Geographic Information System and Remote Sensing (GIS/RS) contribute to the speed and efficiency of the overall planning process and allow access to large amounts of information quickly. It is also very easy to update or modify data involved in GIS database in future. Water scarcity and low precipitation are major constraints at the research area, which is located in the north of the Central Anatolia. GIS/RS systems may help and guide planners and other technical staff in determination of proper land use management systems.

References

Anonymous, 2010a. Korgun Meteorology Station, Climate Values (1972– 2006), Ministry of Forestry and Water Affairs, Turkish State Meteorological Service, Turkey.

Anonymous, 2010b. Çankırı Meteorology Station, Climate Values (1980– 2010), Ministry of Forestry and Water Affairs, Turkish State Meteorological Service, Turkey.

Doğan U., 2002. Subsidence Dolines Formed by Gypsum Karstification at The East of Çankırı. Gazi University, *Journal of Gazi Education Faculty*, 22 (1), 67-82.

Göl C., Çakır M., Baran A., 2010. Comparison of Soil Properties Between Pure and Mixed Uludag Fir (Abies nordmanniana ssp. bornmülleriana Mattf.) Stands in Ilgaz Mountain National Park, *Ekoloji*, 19, 1-73

Ketin İ., 1962. Geology Map (1:500 000 Scale) of Turkey, Sinop, *Journal of General Directorate of Mineral Research and Exploration*, Ankara.

Yüksel M., Dengiz O., Göl C., 2001. Evaluation of Land Use Suitability for Çankırı-Kenbağı Forestry Nursery Soils, *Journal of the Southeastern Anatolia* Forestry Research Institute, Ministry of Forestry Volume: 176, GDA Volume: 12 - 3, IS SN 1301-6253, Elazığ. Turkey.