International Journal of Natural and Engineering Sciences 2 (1): 29-32, 2008
ISSN: 1307-1149, www.nobel.gen.tr

Determining the Main Factors Effecting the Sediment Yield from Derindere Watershed of Sir Dam in Kahramanmaras by Using GIS Techniques

Nuri BOZALI Alaaddin YÜKSEL Abdullah E. AKAY*

KSU, Faculty of Forestry, Forest Engineering Department, 46060 Kahramanmaras, Turkey

* Corresponding Author
e-mail: akay@ksu.edu.tr

Received: August 03, 2007
Accepted: October 12, 2007

Abstract

Sir Dam with 4750 ha of water reservation area is very important fresh water source for Kahramanmaras region. Sir Dam is located in Derindere watershed area where various types of soil erosions have been actively occurred. In the watershed area, the topography is very steep and the soil is very sensitive to erosion. The most of the area is not covered by erosion preventing vegetation and sufficient soil conservation precautions have not been taken during or after constructing the dam. Therefore, considerable amount of sediment yield has been transported into the dam. Besides, the dam is surrounded by near by industrial organizations and large and small size settlements, especially the city center of Kahramanmaras, which leads to a serious pollution problem in the dam due to residential and industrial wastes. The purpose of this study is to determine the effects of physiographic properties of the Derindere subwatershed, representing the features of the watersheds around the Sir Dam, on the sediment yield potential, and to suggest necessary precautions to prevent the dam filled up with sediment. The topographic properties of the watershed were determined by GIS (Geographical Information System) techniques.

Key words: Erosion factors, physiographic properties, DEM, image analysis

INTRODUCTION

One of the most important principles of being a developed country is effectively utilizing the available soil and water resources. Recently, effective use of soil and water resources has become almost identical with appropriate management of the dams [5]. Due to high population and growing industry in Turkey, it has been a serious problem to provide sufficient amount and good quality water [2]. To satisfy this increasing demand to water, numbers of dams and reservoirs have been constructed in many parts of the country.

Constructing dams and reservoirs itself can not be sufficient to increase water resources since providing sustainable and enough water depends on suitable management of the soil and vegetation in dam watersheds [8]. Therefore, prior to planning and constructing dams, land use features, climatic and physiographic properties, and sediment potentials of the water holding area of the dam watersheds should be determined to ensure the success of dams in performing their functions.

In Sir Dam, constructed in 1991, serious sedimentation problem has occurred, likewise in the other large size dams of Turkey (Figure 1). To solve this problem, dam watersheds that provide and hold water into the dam should be analyzed based on scientific methods. In this study, the effects of physiographic properties of Derindere watershed on sediment yield were investigated and possible precautions against sediment were discussed. The physiographic properties analyzed were land use type, land capability, average ground elevation and slope, drainage density, and aspect.

MATERIAL AND METHODS

In order to ensure sustainable management of the dam watersheds, it is required that the sediment yield should be kept within certain limits so that the watershed is not degraded to any further extent. For this purposes, the current conditions of the watersheds, in terms sediment yield potentials, should be analyzed. This section presents series of a field studies and GIS-based spatial analysis, which were performed to investigate the main factors effecting the sediment yield from a sample dam watershed.

Figure 1. A view from Sir Dam watershed.

Study Area

Sir Dam is located in 55 km southwest of Kahramanmaras in East Mediterranean region of Turkey (Figure 2). The watershed area is approximately 1120 ha and placed between the coordinates of 37°30' 48''- 37°40' 03'' N and 37°32' 28''- 37°35' 19'' E. The dam is not only an important source of fresh water in the region, but also an important wetland ecosystem consisting of variety of aquatic plants and animals. The water reserve in the dam is also used for hydroelectricity (725.000 mwh per year) and irrigation purposes.

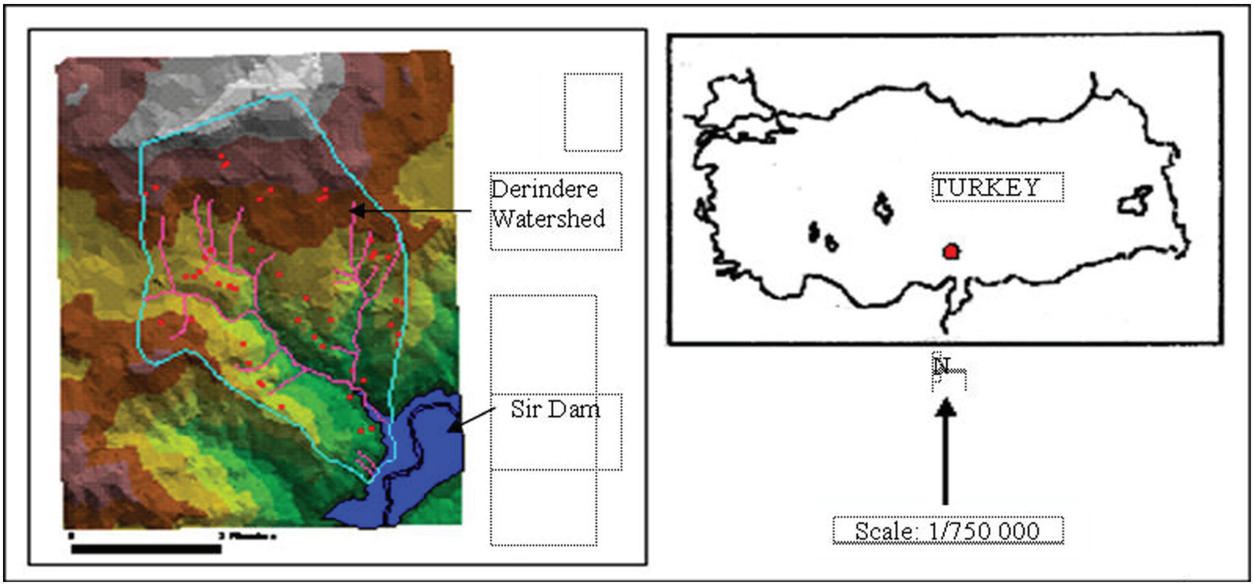

Figure 2. The approximate location of study area with topographic map.

Field Study

Firstly, sample plots of 1000 m^2 were randomly selected from agricultural and forest lands, considering ground elevation classes (i.e. 500-800 m, 800-1100 m, and 1100-1400 m), parent materials, and aspects (north and south). In the field study, different numbers of soil profiles were taken from various parent materials including 14 from lime, 5 from mud, 7 from clay, 3 from quartz, 9 from sand, 3 from basalt, and 5 from side-rubble. Besides, undisturbed soil samples of 92 cylinders were taken from two soil dept classes (i.e. 0-20 and 20-50 cm).

Estimating Physiographic Properties

The physiographic properties of the study area were analyzed by using GIS techniques. Especially, the capability of linking spatial data with attribute information allows GIS technology to assist forest managers in planning forested watersheds [1, 7]. Burrough [3] indicated that using GIS techniques in planning watersheds provides accurate, quick, and efficient way of data management.

In GIS analysis, the contour map with 50 m intervals and stream layer was generated based on a topographic map with 1/25000 scale. The ground elevation, slope, and aspect maps were generated by using contour map. In generating slope map, following equation was used:

$$S = (CL_c/A)100 \qquad (1)$$

where,

S = Average slope in the watershed (%)

C = Contour intervals (m)

L_c = Total length of contour lines (m)

A = Total area of the watershed (m^2)

Other attributes data such as parent material types, land use types, and land capability classes were also generated in GIS environment. In generating GIS database, "Arc", "Arcedit", "Arcplot", "TIN", "Info", and "Tables" extensions were used in ArcInfo [6].

The drainage density increases as the surface runoff increases. The lower drainage density generally occurs in lands with low relief, high vegetation cover density, lower infiltration rate, and strong subsoil structure. The drainage density (D_d) was computed by the following equation, based on total length of the streams (L_s) in km and watershed area in km^2:

$$D_d = L_s/A \qquad (2)$$

RESULTS AND DISCUSSION

Land use types and land capability classes

Land use type effects the amount surface runoff which leads to soil lost in a watershed due to soil erosion. In the study area, two types of land use were detected; forest and agricultural. Based on the GIS analysis on the topographic map, the total areas were 683 ha and 417 ha for forest and agricultural usage, respectively (Figure 3). The rest of the area was used as residential.

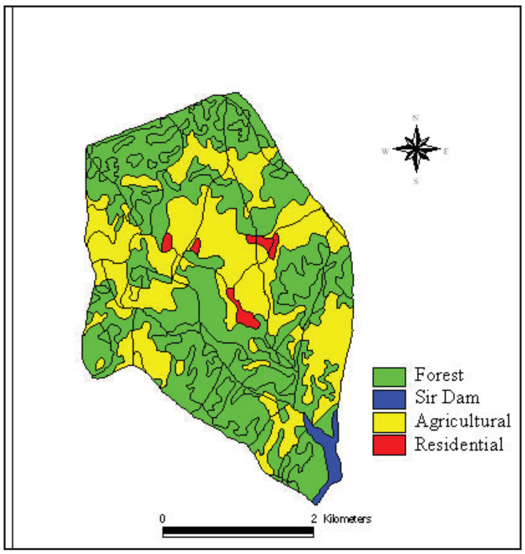

Figure 3. The map of land use types.

The land capability classification of the study area was obtained from the Inventory of Soil Resources Report from Soil and Water Resources National Information Centre. Then, land capability layer was generated by performing GIS techniques and observational field studies (Figure 4). The dominant land capability classes were VI and VII with the area of 126 ha and 994 ha, respectively.

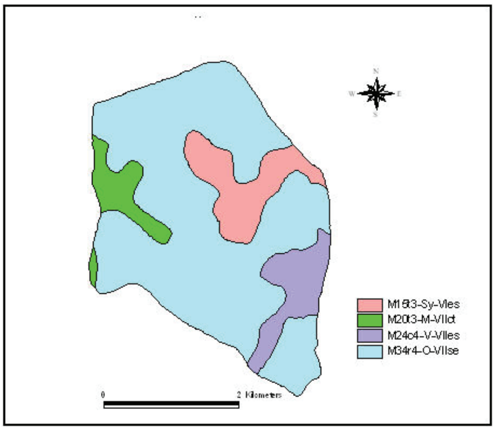

Figure 4. The map of land capability classes.

The results from the land capability classification indicated that agricultural land use was not appropriate in the study area. However, local people have been used about 37% of the available lands for intensive agriculture. The forests in the area were degraded due to illegal openings for agricultural use and illegal cuttings, which resulted in presence of low and very low quality forests. Therefore, surface soil has been eroded and filled the dam, which then reduced its economic life time. In order to preserve these areas, appropriate land use types should be applied according to land cover classification, and illegal opening and cuttings must be prevented [9].

Ground Elevation and Slope

The temperature in the watershed varies with the changes in ground elevation, which reflects the amount and types of precipitation. Regarding with changes in temperatures, the elevation affects the type, density, and growth rate of the vegetation, which are some of the main erosion factors that influence the sediment yield [10]. The elevation in the watershed was from 350 m to 1779 m with average value of 1334 m. Figure 5 indicated the digital elevation model of the watershed generated based on the contour map. Due to high average ground elevation, the watershed has received high amount snow in winter and most of the snow melts during the heavy rainfalls of spring, which results in intensive runoff and soil erosion.

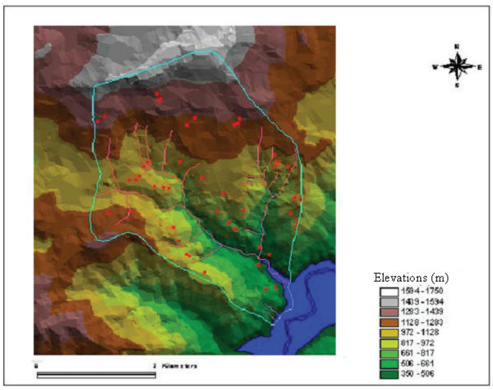

Figure 5. Digital Elevation Model (DEM) of the study area.

In watersheds with steep ground slope, runoff water can rapidly reach the stream beds and cause high stream flow events [10]. By using GIS tools, the average ground slope of the study area was computed as 47%. The ground slope map was indicated in Figure 6.

Drainage Capacity

The drainage capacity is defined as the capability of stream network in discharging total rainfall from the watershed [11]. In this study, after generating graphical database, the drainage capacity was examined by computing drainage density based on the digital maps. The drainage density was found to be 1.46 using Equation 2. This value indicted that available water in the watershed were properly discharge through the stream network. The stream classes were also generated using GIS tools and the indicated in Figure 7.

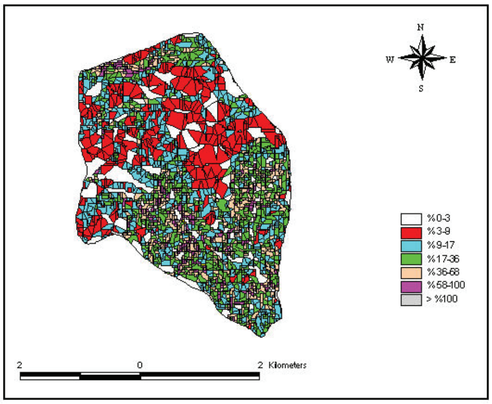

Figure 6. The slope map of the study area.

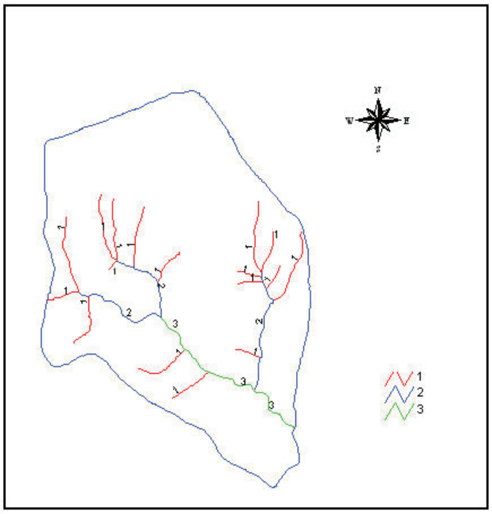

Figure 7. Stream classes map of the study area.

Aspect

The aspect affects the temperature rate, which reflects the water loss through the transpiration and evapotranspiration [10]. Besides, the time and the intensity of snow melt is effected by the aspect [4]. The results from the GIS analysis indicated that the percentages of the north and the south aspects in the study area were 21.36 % and 78.64 %, respectively. Therefore, the area was mostly located in the south aspect with relatively high temperature. Figure 8 indicated the aspect class in the watershed.

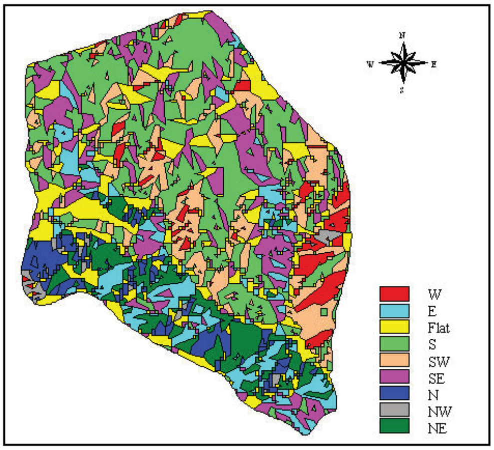

Figure 8. Aspect map of the study area.

CONCLUSIONS

In this study, the effects of physiographic properties of Derindere watershed on sediment yield were determined by using GIS techniques and possible precautions against sediment yield were suggested. The results indicated that GIS can be effectively used for the analysis of watershed conditions. The success of GIS-based method highly depends on the reliability and accuracy of the spatial data.

The results also indicated that wetland management plan has become necessary for Sir Dam watershed. To prevent soil loss and sediment yield, upper watershed of Sir Dam should be enhanced by constructing terraces and detention and check dams to reduce slope of stream channels. Besides, longitudinal structures such as hedges should be used to prevent landslide and gully erosion.

To prevent illegal cuttings, necessary protection measures should be taken and economical conditions of the local people should be improved. The biological and ecological impacts of the alternative usage on the dam should be investigated. To reduce or completely prevent the pollution, necessary limitations and prohibitions should be determined.

REFERENCES

[1] Başkent EZ, Jordan GA. 1991. Spatial Wood Supply Simulation Modeling, The Forestry Chronicle, 676(6): 610-621

[2] Bozali N. 2003. A Research on Physical, Chemical, and Hydrological Properties and Erodibilities of Soil under Various Land Use Types in the Watershed of Sır Dam in Kahramanmaras, Msc Thesis, A.I.B.U, Bolu. 179 p.

[3] Burrough P. 1990. Principles of Geographical Information System for Land Resources Assessment. Oxford University Press, USA. 206 p.

[4] Coughlan JC, Running SW. 1997. Regional ecosystem simulation: A general model for simulating snow accumulation and melt in mountainous terrain. Landscape Ecology. 12(3): 119–136.

[5] Cepel N. 1986. The Ecological Principles of Land Use Planning for Upper Dam Watersheds. I.U. The Journal of Faculty of Forestry, Series: B. 36(2):17-27.

[6] ESRI. 1999. Understanding GIS: The ARC/INFO Method, John Wiley & Sons, Inc. New York. 600 p.

[7] Kose S, Baskent EZ. 1993. The Importance of Geographical Information System (GIS) in Turkish Forestry. I. Forestry Congress. 15(18): 195-204.

[8] Ozhan S. 1987. Forest and Water Relations in Watershed Planning Studies. Land Use Planning in Upper Dam Watersheds Symposium, Ankara. pp: 441-445.

[9] Reis M, Yuksel A, Erdas O, Tonguc F, Akay AE. 2007. Afforestation Practices in Preventing Erosion in Watersheds of Turkey. International Congress on River Basin Management (General Directorate of State Hydraulic Works (DSI) in collaboration with WWC). 22-24 March. Antalya, Turkey. pp: 115-120.

[10] Ulu F, Ayan S, Yuksel A. 1999. Determining the Physiographic Factors Effecting the Stream Regimes in Uzungol Watershed, Trabzon. The Symposium on Applications of City Information System by Local Administrations, Trabzon. pp: 287-296.

[11] Zhou Q, Yang X, Melville MD. 1996. A GIS Network Model for Sugarcane Field Drainage Simulation, in Proceedings of 8th Australasian Remote Sensing Conference, 25-29 March, Canberra, Vol. 2, pp: 366-372.