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Land management for erosion prevention: A case study for a Turkish nature reserve

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ABSTRACT

As a result of landslides and soil erosion, a substantial amount of soil has been lost in Turkey. Particularly, fertile lands have long been faced with the threat of erosion, largely as a result of traditional (unplanned) land use practices. This threat is more evident in the Black Sea Region with its rough topography and rainy climate. The basic reason for this threat is the lack of organization in land use planning and control. Although proposals, in the context of this requirement, are included in national development plans, they have not been implemented. Accordingly, in this study research based on spatial data evaluation was carried out for Sera Lake located in Akcaabat, Trabzon, Turkey. For this purpose, temporal area, depth and volume changes of the lake were determined by utilizing topographic maps, aerial photographs and hydrographical measurements. To evaluate determined changes in the size of the lake and to produce suggestions to legislators for required sustainable land management activities, information on land use/cover types, land ownership and climate in the vicinity of the lake was utilized. As a result, it was determined that the area, depth and volume of the lake were significantly decreased during the last decades, as a consequence of erosion mainly caused by traditional land use practices; thus, the lake is threatened with the danger of extinction due to erosion. Precautions required for the alleviation of erosion and other adverse environmental effects which largely seem to be caused by harsh physical properties (caused basically by topography) of the region were discussed. In support of the information inherent to the region, traditional arable land use was logically determined as the basic non-natural factor (which is directly prone to erosion) to be rearranged in the context of sustainable land management. In this context, beyond nationwide actions (national agricultural policy and Soil Protection and Land Use Law), which may provide the required land management tools in the long term, it is proposed that planning and accordingly land management activities specific to the study area (Sera Valley) should immediately be commenced in close collaboration with the related public (owners or farmers). However, behaviours of different types of land users (engaged in commercial, subsistence and semi-subsistence farming) and also high number of owners and/or farmers (caused by small pieces of land parcels owned/used in shares) make the desired collaboration almost impossible. This socio-economical problem may be solved by further developing the current land registry and cadastre system in terms of customary land use rights, land use/cover changes and updating procedures.

1. Introduction

Landslides and soil erosion, which are caused by physical (Pimentel and Kounang, 1998; Duman et al., 2005) and socio-economical (Korsching et al., 2001; Boardman et al., 2003; Duman et al., 2005; Altin, 2006) reasons, are among the most important factors that play a role in the changing of the earth's surface. As is the case worldwide, these two factors (physical and socio-economical) are regarded in Turkey as very serious threats. They trigger landslides and erosion, which have an adverse effect on the environment (see Duman et al., 2005; Pimentel, 2006). In Turkey, especially as a result of soil erosion a substantial amount of fertile land is swept into the sea through rivers (Dinç and Çullu, 2005; Irvem et al., 2007; Aydın and Tecimen, 2010). An important portion of the remaining fertile agricultural land is also exposed to the danger of erosion (Suiçmez and Güler, 2005). In this context, in Turkey and especially in the Eastern Black Sea Region, as a consequence of its characteristics, namely, rough topography, rainy climate and

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unplanned land use tradition, soil erosion occurs more frequently than the average of the country. In addition to erosion, these special characteristics of the region expose the land to landslide risk.

In the process of erosion or landslide control, one of the most important recent problems in Turkey is the disorganization in planning and management of the environment (HKMO, 2005). Improving the organization on erosion or landslide control by planning may only be possible in the context of sustainable land management (see FIG, 1999; Williamson and Grant, 2002; WB, 2006). The term sustainable land management, in essence, promotes the idea or principle "to meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987; Ting, 2002). It basically comprises the activity of planning and accordingly development of appropriate land management tools by considering geographical, physical, socio-economical and other aspects of the environment. Unlike sustainable land management, distorted municipal development and traditional (unplanned) land use practices in Turkey result in serious environmental risks, especially in rural areas where planning and land management applications are ignored. Thus, natural disasters in the short or long term become unavoidable. In this context, in the 8th (Turkish) National Development Plan (DPT, 2000), in the section on agricultural policy, such a planning issue was raised and the required precautions were listed in item no. 1301. According to this, with the purpose of prevention of disasters such as deforestation, desertification, soil erosion, flooding, landslides and avalanches, activities of afforestation, erosion control, meadow improvement and social forestry would be developed and, in particular, the afforestation activities of private and judicial persons would be encouraged (DPT, 2000). For the implementation of these anticipated activities, a sustainable land management perspective is, no doubt, required. However, such applications are restricted in Turkey. Only some rare and important ones are on the government's agenda for nationwide application. In this context, agricultural policy implementations (see Inan, 2010) and the application of precautions on environmental and soil protection within the Law on Soil Protection and Land Use should be given as important examples. However, it should be mentioned that considerable disorganization has been experienced so far and further development is strictly required for their application.

The aim of this study is to determine temporal change in Sera Lake (situated in Akcaabat County, Trabzon Province, Turkey) and accordingly prove the predicted continuous erosion and to establish the relation to the need for sustainable land management for prevention of erosion and also other adverse environmental effects by evaluating both the vicinity of the lake and the watershed as a whole in different aspects. The rationale behind relating the temporal change in the lake with erosion is that the size of lake water surface has decreased dramatically, although there has not been any observable (significant) change in the lake water level. For this purpose, temporal changes in the area, depth and volume of the lake were determined by using a variety of spatio-temporal data (hydrographic surveys, cadastral/topographic maps and aerial photographs). For evaluation purposes, information on land use (sizes and types of land parcels) and land ownership (number of shareholders) in the close vicinity of the lake, as well as land cover (classification of Landsat ETM data), topography (TIN from 1/25,000 scale topographic maps) and climate (meteorological data), was also used. For analyses of the data, geographical information technology and digital photogrammetry were used.

2. Materials and method

In this study, Sera Lake and its vicinity were studied as a whole in different aspects (erosion, land use tradition, land use/cover, land ownership and the need for sustainable land management activities) by using different types of data with different geographical coverage. Temporal change detection in the lake was carried out to reveal predicted (with observations) erosion in the watershed. The lake itself was used as a natural erosion measurement station for the whole watershed because it has a naturally diverse and erosion-resistant land cover. Therefore, it was not thought to be required to measure erosion for each type of land cover. In fact, it is known that non-natural land cover, which emerges as a result of traditional land use habits, causes erosion, the extent of which is unknown. For the determination of temporal changes in the lake, aerial photographs, topographic maps, cadastre maps and also hydrographical surveying data of different dates were used. For the evaluation of environmental factors responsible for the detected change, land registry data, topographic maps (topographic features), land cover data and climate data were used. Evaluation was carried out by associating the proved erosion with topographic (slope and land cover), climatic and socio-economic (land ownership and land use traditions) characteristics of the region and by considering deficiencies of current nationwide so-called sustainable land management activities/tools (see Section 3 for more information).

2.1. Study Area

Selected as the study area, Sera Lake is located 10 km away (to the west) from the city centre of Trabzon Province and 2 km inland from the coast (see Fig. 1-a and b). It is located within the administrative boundaries of Akcaabat County, Trabzon Province of Turkey. It is situated at the geographic coordinates 40°59′14″ N and 39°37′02″ E. The lake came into existence as a result of a landslide in 1950 and has in time become a nature reserve and also a tourist destination. The land mass caused by the landslide partially reflected flow patterns but was basically a uniform slide, which was 650 m long, 350 m wide and 65 m thick (Fig. 2). The volume of the mass was 15 million m^3. The mass blocked the flow of the Sera River, and 2.5 months later a lake that was 4 km long, 150–200 m wide and 55 m deep was formed (Boztaş, 1986).

Since its existence, any important shift in the use of water from the lake and of its environment has not been experienced except for a few local restaurants, which attract local people and also tourists. However, it has been observed that the lake water surface decreased in time, although its water level has remained almost unchanged except for seasonal variations. The geological structure of the lake vicinity was previously presented by Bulut et al. (1991) and Eyuboglu et al. (2006, 2007).

The valley where Sera Lake is located is within the Eastern Black Sea Region Watershed in Turkey. This grand watershed forms the Turkish part of the Caucasian Ecologic Region, which is one of the five biologically diverse regions (in the world) identified by the World Wildlife Fund (WWF) and thus has international importance in terms of nature conservation (WWF, 2014).

Sera Valley has an extremely steep (average slope 23°) topography (see Fig. 1-c). In addition, it is quite a rainy and climatically mild region. The average yearly precipitation in the region is 822 mm/m^2. The monthly averages (which may not change significantly over the years) of temperature and precipitation for the last 35 years are presented in Fig. 3. As in the whole Black Sea Region, traditional (unplanned) land use and subsistence/semi-subsistence farming are common in the valley (EC, 2003; Inan et al., 2011). It is well known that large-scale commercial farming is almost impossible in the region due to both topographic structure and issues on land ownership or land use rights.