

*Full Length Research Paper*

# Impact of land use on water yield in Darideresi watershed, Turkey

Ayten Erol

Department of Watershed Management, Faculty of Forestry, Suleyman Demirel University, 32260 Isparta/Turkey.  
E-mail: [aytenerol@sdu.edu.tr](mailto:aytenerol@sdu.edu.tr). Tel: +90 0246 211 3988. Fax: +90 246 237 1810.

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The aim of this study is to define guidelines for watershed management for Darideresi watershed in accordance with the previously established potential erosion problems of the area and works conducted by responsible bodies. The study was carried out in Darideresi watershed, which is located in Antalya, near the border of Isparta Province, in Turkey. In this area, an irrigation dam was constructed. Since the watershed is important for the region, it is necessary to determine the erosion problems in it. As such, this research has been designed for this purpose. Moreover, a comparison has been made between resistances of soil to erosion in Darideresi watershed by means of erodibility indices, which depend on land use. The data obtained were evaluated in terms of the effects of water yield. The results of this study revealed that 41% of the forest areas were degraded. The percentage of farmlands on steep slopes were 17%, while the erodibility of soils in forested areas were lower. However, it was found that all land was highly sensitive to erosion. These results show that the dam is under the threat of sediment accumulation. Therefore, forest areas should be preserved and hydrological plans should be applied in the watershed area. In this study, all results were evaluated within the watershed principles and required applications, while water yield in watershed areas was proposed to the concerned authorities responsible for water production of watershed.

**Key words:** Darideresi watershed, erodibility indices, land use types, vegetation and water yield.

## INTRODUCTION

Watersheds are important to reserve the natural resources for water yield. Besides, watershed management is essential to protect the use of natural resources. For the sustainability of the natural resources in watersheds, it is of importance to determine the potential erosion problems in those areas. On the other hand, the susceptibility of the soil to erosion, known as soil erodibility, depends on the runoff and soil resistance to particle detachment by raindrop impact. When the effect of erosion occurs, the vegetation cover of the land is wholly and partly removed from sloping land, while rainwater runs off more rapidly with increased volume. Therefore, erosion indices have been used in some studies for the assessment of soil stability for water yield in watersheds. Recently, efficient use and production of water has become a big problem resulting from the rapid growth of the world population. It must be taken into account that the most efficient principle for watershed management is primarily to protect ecosystems in watersheds, and take social measures in cooperation

with the people living in watersheds.

Watersheds are characterized by meteorological, surface water and groundwater, and physical and biological factors functioning within the context of natural and human disturbance regimes. The quantity, quality and timing of stream flow within a watershed are influenced by these factors (McCommon et al., 1998). Watershed management has not only been integrated with water resources' management, but has also contributed to the sustainable service life of dams. As for the reasons listed earlier, watershed management is extremely vital for sustainable natural resources; therefore, the main goal of watersheds is the diligent management of water yield, since those watersheds are described as dam watersheds, as well. So, for a watershed to collect a sustainable amount of water in a dam, it is required for it to have knowledge of the amount of rainfall going into the dam. The main reason to be considered is that watershed, as a hydrological unit, consists of factors or conditions of land use on water yield.

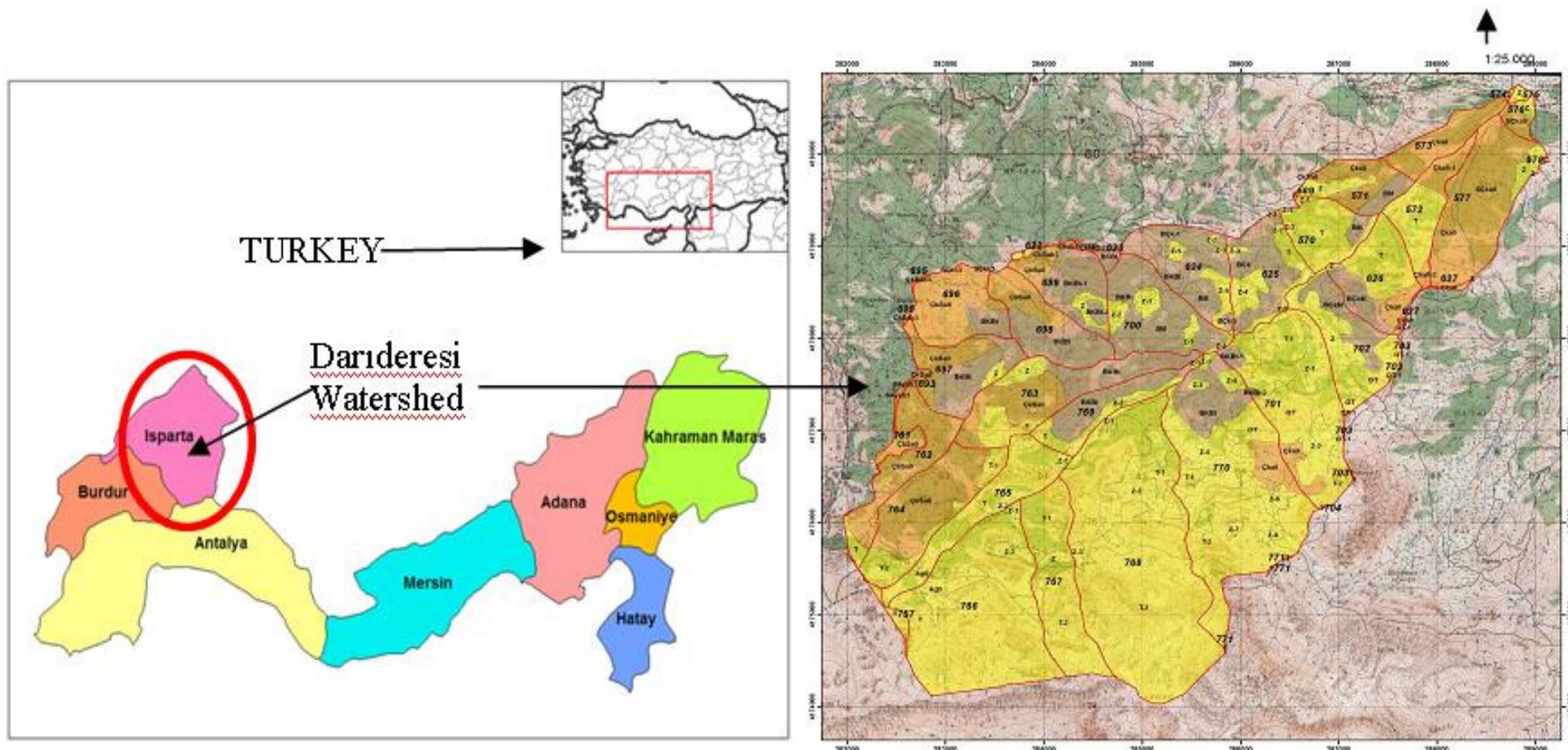


Figure 1. Geographical location of Darideresi Watershed.

In order to improve the efficiency of limited conservation resources, as seen elsewhere in the world, the identification of critical areas and human activities that influence water resources is the primary objective of watershed analysis. Biophysical factors and human impacts should be addressed systematically in forested watershed

management (Zhang and Barten, 2009), since in this study, watershed is one of 26 basins that are in the Mediterranean Basin and Lakes' region (Figure 1). However, the current land used to assess the effect of water yield has been based on erosion indices and erosion control practices developed by the institutions' technical works in

the watershed, because of a dam built in the basin.

**MATERIALS AND METHODS**

In this study, 1/25000 scale topography and 1/100000 scale geological soil maps were used as geographical

background layers. The soil samples for mechanical analysis, soil density, moisture equivalent and organic materials were taken from positions on the same elevation level (1300 to 1350 m), aspect (north), slope degree (35%), the parent material (Eocene flysch) and large soil group (brown forest soil) area of forest agricultural and rangeland areas from 0 to 20 cm depth. Some erodibility indices-dispersion ratio, clay ratio, colloid-moisture equivalent and erosion ratio (Valvis et al., 2005; Balci, 1974) were obtained by using these analyses' values. For evaluation of all the data, variance analysis was used and Duncan multiple comparison test was applied for the significance of the analysis in order to identify the different groups. These indices, called erodibility indices, were used for assessing sensibility of soils to erosion.

Apart from all these indices, some maps and documents were utilized to evaluate the results obtained from some protocols and reports regarding the area. Besides, the data collected were evaluated by means of the method, which is evaluative, statistical, and comparative for the study. Documents, regarding Darideresi watershed, were retrieved from the institutions (Isparta Regional Directorate of Environment and Forests, and Regional Directorate of State Hydraulic Works) and they include: (1) Protocols between the two institutions; (2) forest management plans; (3) reports regarding construction of the dam; and (4) 1:25.000 scaled maps and stand maps. These documents were mainly responsible for afforestation, controlling of erosion works, and creating positive effects on water yield in the watershed. Thus, there were some documents and 1:25.000 scaled maps combined with stand maps pertaining to the institutions mentioned earlier and which were studied as a result of the contributions of land use to water yield in Darideresi watershed. Besides, erosion indices of the study field have been determined for analyzing the effect of land uses on water yield. The study field is in the district of Isparta Province, in the southern east of the central county and in the north of Isparta-Antalya highway. However, one part of the Isparta Creek forms the water resource of the watershed.

## RESULTS AND DISCUSSION

Erosion processes have been researched in Darideresi soil, and it can be defined as a process of detachment and transportation of soil material. The susceptibility of the soil to erosion, known as soil erodibility, depends on runoff and soil resistance to particle detachment by raindrop impact. When the vegetation soil's cover is wholly or partly removed from sloping land, rainwater runs off more rapidly and increased in volume. In this way, soil erosion starts and causes great damage to the soil and vegetation which may remain. Since reasons of erosion are known, erosion indices have been used in some studies to assess soil stability for water yield in watersheds (Özyuvaci, 1976; Schachtschable et al., 1993). According to these studies, the constant value of erosion rate is 10; but when it is higher than 10, it means that soils are not resistant to erosion. Soils of the research area are sandy because of parent material, but upon surveying the erosion rates of land use, it has been seen that the erosion rate is higher in range soils rather than agriculture and forest soils. Therefore, the survey has revealed that all land uses in the watershed, particularly in range lands, are not resistant to erosion.

Colloid moisture equivalent rate and amount of organic matter of forest soils were higher than agriculture and

range soils. Many other researches showed that colloid moisture equivalent rate of soil varies in accordance with the texture and organic matter amount of soil (Çevik, 1999; Balci, 1964; Morgan, 1985; Kırdar and Sariyev, 2002; Özyuvaci, 1976; Sönmez, 1994; Balci, 1996). The results of these researches demonstrated that the organic matter amount had an impact on absorption of water and on the colloid moisture equivalent rate as well. Similarly, it is known that the high clay rate means that the colloid moisture equivalent rate is high. In this study, dispersion rates showed that soils were not resistant to erosion; due to the dispersion rates of all forest, agriculture and range soils were higher than 15%. To a great extent, the soils of the research area have higher rates of clay, but the erosion resistance rate of rangeland soils were found to be lower than those of forest soils. In the same way, the erosion resistance of soils increases when the clay rate decreases (Valvis et al., 2009). As an erodibility index, colloid moisture equivalent rate also implies permeability of soil (Balci, 1974). If this rate is high, the soil is more resistant to erosion. In other words, it means that infiltration is higher, but runoff is lower. In this research, the acquired results have shown that runoff in forest soils is lower than that in agriculture and range soils. Considering all results of Darideresi watershed, it has been seen that forest, agriculture and rangelands are not resistant to erosion, and accordingly, this condition is riskier in terms of erosion threat.

In conclusion, it has been revealed that forest agriculture and rangeland are not resistant to erosion. Erosion indices of the study field have been determined for analyzing the effect of land uses on water yield (Tables 1 and 2). According to the Thornthwaite equation, the type of climate in the research area is similar to oceanic climate that has insufficient moist, mezothermal, scarce water or short water. Geological formation of watershed consists of limestone, andesite, flysch and alluvial deposit. The basic soil group of the area is Brown Forest Soil, whose landuses vary in forestland, rangeland (often extensively destroyed and recovered forestlands) and agricultural lands (with Legume and Gramineae). The research area does not cover arable lands or restricted arable lands and woodlands. Contrarily, it consists of six shallow and cultivated lands; therefore, there is a critical erosion problem in the areas. The vegetation type varies both in the upstream and downstream parts of the watershed, and on the northern and southern aspects. In a case when variation of the watershed, in terms of altitude on the lower side and southern aspect of the vegetation, is 1460 m, the vegetation is oak, juniper, thorn apple and gramineous; but on the northern aspect, when the variation is 1460 m, it consists of *Pinus nigra* and cedar. On the other hand, when the variation of the upper side is 1460 m, the vegetation varies as a pure cedar stand. On the vegetation of the Northern aspects, the vegetation consists of *P. nigra* and oak. In general, there are often

**Table 1.** The results of variance analysis regarding erodibility indices.

Erodibility indices	Relation between land use and erodibility indices (F coefficient)
Dispersion rate (%)	1.819 N.S
Clay rate	7.976*
Colloid- moisture equivalent rate	3,831*
Erosion rate	3.843*

N.S: Non-significant statistically; \*: significant statistically (5% level).

**Table 2.** The constant values of some erodibility indices, and a comparison of the research results thereof.

Dispersion rate (%)	Colloid-moisture equivalent rate	Erosion rate	Clay rate (%)
>15 not resistant to erosion	<1.5 not resistant to erosion	>10 not resistant to erosion	Big clay rate means erodibility of soil rises
<15 resistant to erosion	>1.5 resistant to erosion	<10 resistant to erosion	
<b>Mean rates from the research area</b>			
39.45%	0.53	95.09	7.69%

*Quercus coccifera* and *Juniperus oxycedrus*, but *Styrax officinalis*, *Berberis vulgaris*, *Creteagus crategina*, *Rosa canina* and *Prunus spinosa* are rarely seen in the downstream of the watershed.

The size of Darideresi watershed is 2497.8 ha and is characterized as a big watershed that is vulnerable to erosion in terms of topographical structures, vegetation and land use. In the area, the prevailing slope is highly steep with 65%, and is followed respectively by a slope close to highly steep with 24%, steep slope with 7%, mid slope with 2%, sloped with 1% and slight slope with 1%. However, the dominant aspects are generally the North and South, while the average height and slope is 1569 m and 57.7%, respectively. There is just one residential area called Darideresi Village in the watershed, and it does not have the same properties with Isparta Province, in terms of the social and economical properties. However, it has a population of 100 and it accounts for 50 dwelling. The watershed is located in the South of Turkey, into the border of Isparta and near the border of Antalya. It is one of 26 basins that are in the Mediterranean watershed and Lake Region. One of the parts of Isparta Creek forms the water resource of the watershed. All these features showed that it is vulnerable to erosion in terms of topographical structures, vegetation and land use due to topography with highland, high slope and high altitude. Hence, there is a critical erosion problem in the area. The area is a topographical highland that is hilly, with high slope and high altitude; although it was misused so that it could be exposed to intensive and lasting erosion. On the other hand, there is a dam in the watershed, whose commencement date of construction was in 1995 and the completion date was in 2009. No work has been conducted in the upstream of the watershed with respect to water yield. In the area, two

institutions were generally responsible for dam construction and erosion control, so as to provide water yield. These institutions are Isparta Regional Directorate of Environment and Forests (RDEF) (RDEF, 2010) and Regional Directorate of State Hydraulic Works (RDSHW) (RDSHW, 2004). In the watershed, soil conservation applications were done in these institutions, and they were mainly liable for afforestation, erosion control and water yield increase in the watershed. The first work by these institutions on the area was applied in 1969. Since then, no significant work has been carried out; and some minor attempts have been made by the institutions independently. In 2003, a protocol was signed between the two institutions on the watershed management in Darideresi watershed. The results that were determined as regards the watershed showed that the construction date of the dam in the watershed took a long time, but in the dam area, sufficient measures were not taken in terms of the conservation of the present vegetation (Erol et al., 2009). In the same way, the first exclusive effort by institutions was carried out in 1969 and the second one was fulfilled as a part of protocols in 2003 (Yamamoto and Duffy, 1963). Some of these protocols revealed that some principles designated the common works between the institutions in a watershed of a dam, but in the research watershed works conducted, it was shown that the institutions did not act in concurrence.

In the study of Erol et al. (2009), they stated that the research area was not planned with the aim of having a water yield, in that the watershed could not have led to water yield by human factor, soil and vegetation; although human resources (land use), soil resources (intensive and highly intensive erosion), topographic structures (high slope and altitude) and vegetation (destroyed forestlands) had poor features in terms of water yield. As

such, the aim of erosion and flood control was not adequate. Although the required organization process was not carried out by the institutions, the area was used for water yield with quality and quantity, since it was an obligation in the watershed. To sum up, a dam for irrigation has been constructed in Darideresi watershed and the construction work was initiated in 1995 and completed in 2009. Due to the topography of the land, no work has been carried out on the upstream of the watershed during the construction process. Moreover, the area was misused and exposed to intensive and lasting erosion. In the watershed, the total area (2497.8 ha) has the productive forestland (521.1 ha), the destroyed forestland (190.8 ha), the open land (1508.3 ha) and the unproductive coppice land (277.6 ha). The area has been demonstrated as agricultural lands (Z), rocky lands (T), treeless forest soil (OT), presently wooded lands (Ag) and earlier wooded but destroyed lands (Cedar, Acacia, Black pine, Oak) (Figure 1) (Isparta Regional Directorate of Environment and Forests, 2010) in the forest management plans, which were provided with the works of Isparta Regional Directorate of Environment and Forests. However, land use of the area is generally described as agricultural, destroyed oak coppice and afforested (RDEF, 2010).

## Conclusions

Resistance of soil to erosion in Darideresi watershed was defined by means of erodibility indices. They were evaluated according to the water yield. The present land use of the watershed and the effect of land use on water yield in the watershed have been based on erosion indices and technical works of institutions in the watershed. It can be said that there is a vital linkage between land use and water yield. In the watershed, productive forests still cover 20.86% of the total area. On the other hand, the remaining lands comprised 79.14% of the unproductive and open lands that are mainly found in the hills and mountains, but the forested areas in the upland watershed are very important as they supply freshwater for dam reservoir. In the same way, land cover in these areas plays an important role in the dam reservoir's economical life. The destruction of upper watershed forests is often seen as the cause of increased erosion caused by parent material and topographical conditions; however, the institutions have not fulfilled their responsibilities. The results of this study have shown that the principle for watershed management has not been identified by the institutions. Also, the results showed that the construction of the dam took quite a long time (1975 to 2009). Moreover, no sufficient measures were taken regarding the watershed soils to erosion and the evaluation of the relationship between erodibility and land use types in terms of water conservation of the vegetation of the land during construction. Despite the

protocol signed in 2003, the institutions did not act in accordance with the improvement of the area. Thus, the watershed should have been managed by human factor, soil and vegetation for water yield. It can be expressed that human resources (land use), soil resources (intensive and very intensive erosion), topographic structures (high slope and altitude) and vegetation (destroyed forestlands) have poor features in terms of water yield.

In the watershed, soil conservation applications were performed. Although it was an obligation for the watershed to perform these applications, works that aimed at erosion and flood control were insufficient. Even though it was observed that the area dealt with the quality and quantity of the water yield, the required organization process was not carried out by the institutions; as such, the institutions should have had a watershed management plan. In other words, the institutions' works should have been based on the watershed management approach. In the future, the present land use will cause negative effects on water yield. To sum up, all results of the investigation have been evaluated in accordance with watershed principles. Also, it has been proposed to the concerned authorities responsible for water production of watershed, so as to acquire the required applications for water yield in the watershed.

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