Degradation of Cultivated Soils in a Semiarid Area of Greece

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Abstract: The soil loss, which results from the erosion processes, will be very serious, if conservation measures are not going to be undertaken very soon in central Greece. The main causes, which induce erosion in the study area, are (1) Irrigation water, (2) Torrential rainstorm, (3) Slope inclination (4) Land use and agricultural practices. The rain erosivity which was estimated using the Fournier index (FI) after analyzing the meteorological dada of the studied area is low (class 1), which means the rain induced erosion is generally low. In fact this is not exactly the real situation. Very often torrential rainstorms of usually short duration cause intense erosion (120-150 ton • ha^{-1} • y^{-1}) with heavy damages to agricultural fields and infrastructure and must be taken seriously into consideration. The estimated volume of erosion in relation to slope degree is from 21 to 310 ton • ha^{-1} • y^{-1} for inclinations 3.5% - 25%. The interpretation of aerial photography and satellite imagery] together with image analysis and GIS helped in recognizing and mapping areas with soils of higher erodibility and thus more susceptible to erosion.
Keywords: soil erosion, slope inclination, irrigation, land use

1 Introduction

The soil loss which results from the erosion processes in the central part of the Thessalian plain (the so called middle Thessalian hill ridges) in Greece and their relation to land use and agricultural practices and the problems which will arise from land degradation in the area, in the near future will be very serious, if conservation measures are not going to be undertaken very soon. The landscape in the middle Thessalian hill ridges is dominated by undulating to hilly terrain Often torrential rainstorms of short duration especially during summer and early autumn may cause severe erosion with large damages to agricultural fields and infrastructure and must be taken seriously into consideration. The intensity and duration of rain or the kind of vegetation cover and its density e.g. play a decisive role, (Zachar, 1982). During August of 1999 torrential rainstorms were a usual phenomenon. The method of irrigation used and the exercising of a not well planned and scientifically approved land use system and the agricultural practices applied contribute to soil erosion a lot. The misuse of irrigation water in the study area consists a serious problem. According to Rachinskaz (1972) as the slop inclination increases, the importance of soil properties which affect the intensity of erosion degreases, while the importance of slope aspect as an erosion factor increases. Regardless of the relative extent of the various phases of erosion processes, it may be stated that rain intensity is the most important factor governing soil erosion caused by rain. The slope inclination is considered as a basic factor in soil erosion. As the slope becomes steeper the runoff coefficient increases, the kinetic energy and carrying capacity of surface flow becomes greater, soil stability and slope stability decreases, splashing erosion increases and the possibility of soil displacement in a downhill direction during plowing is greater, thus the livelihood of soil erosion increases with the growing steepness of the slope. Hudson and Jackson (1959) established that under extreme tropical conditions the exponent of slope inclination is approximately $E= f(I)^2$ (Where I= inclination).

Land use of the study area is characterized by the cultivation of winter cereals such as the winter wheat and winter barley which occupy almost half of the acreage.Vetch (vicia sativa) is also used as an annual winter crop in rotation with the winter cereals. The burning of the straw every year, almost immediately after threshing is a very bad habit which helps soil erosion. Moreover this habit is the cause of a great number of fires taking place during the summer time in Greece. This practice is in one hand the cause of serious erosion problems thanks to the bare soil surface and the summer /autumn torrential rains and on the other hand, the burning of the straw is depriving soil from organic matter which thus is burnt and eliminated and also helps the disintegration of the soil particles. Another very important issue in this area and beyond, is the over-consumption and misuse of the agricultural pesticides and fertilizers by the growers. This has as a result that relatively high quantity of these agrochemicals in suspension with soil particles, to reach the base level of the area, which is the river Pinios, contributing thus to the pollution of the river system and the sea.

The aim of this paper is to study the erosion in relation to slope inclination, in the hills of central Thessaly uplift and to evaluate the usefulness of Remote Sensing Techniques and geographic information systems (GIS) in the estimation of erosion.

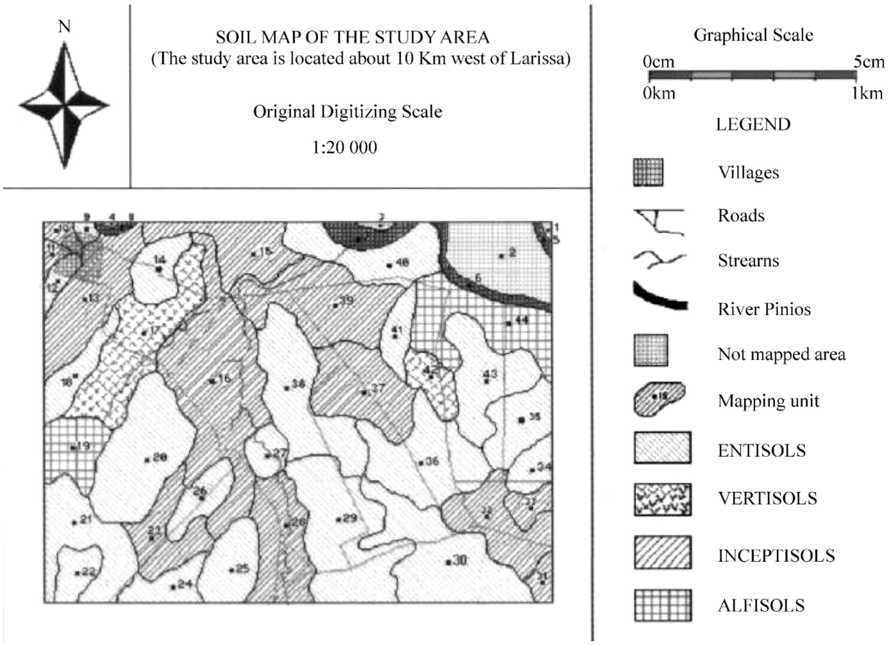

Fig.1 Digital soil map of the study area with soil mapping units, urban areas, road and drainage network layers upon it

2 Materials and methods

The necessary information's for estimating the relationship between slop inclination and surface erosion came up in a preliminary stage from field observations, experimental measurements, former studies, empirical information and remote sensing techniques. Detailed soil survey was conducted in the study area (Fig. 1) and soil auger holes together with soil profiles were described and sampled, (Soil survey staff, 1993 and soil conservation service, 1997).

Describing natural and artificial soil profiles helped in estimating macroscopically the degree of soil erosion, from the exposure or not at the soil surface of the underlying soil horizons. The exposure at the surface of the underlying horizons or parent material may be very useful in estimating the degree of erosion (Fig. 2). Other signs of the degree of erosion are the removal of soil material around the topographical posts (Fig. 3) and the exposure of the roots of the trees above soil surface (Fig. 4). For instance in one topographic post the today's surrounding soil surface is 15 cm below the base of the post, which means that a soil volume of 15 cm depth has been removed since the topographic post was constructed in 1975. If we calculate the erosion rate we shall find that the depth of the lost soil material reaches to 5mm/year (125mm/25=5mm/year) or 5m^3 of soil material per year or 75 ton • ha^{-1} • y^{-1}.

Iron bars were used stuck at the corners of a one square meter (1m^2) plots, in the fields with slope inclination from 3.5 %— 25 %. During the year of lowering of the soil surface was measured and the soil loss was estimated. We also used experimental devices specific for the collection and measurement of the volume of erosional material. This estimation concerned the resulted soil erosion from the rain the year and the irrigation water. The field trials were covered with the cotton crop during spring, summer and autumn, while the fields remained fallow during the winder.

In this study panchromatic aerial photographs and Landsat 5 Imimages were used. The analyses of the relative tone values of the aerial photos gave much information about areas of higher risk of soil erosion than others. (Floras and Sgouras, 1993)With satellite image analysis and processing we acquired a number of CC, PCA, NDVI, soil indices, DTMs (Fig. 5) and other images which were used for interpretation and relevant information extraction. GIS was an indispensable tool for the compilation of the soil and other thematic maps of the area. All the relevant information was input, processed and analyzed using PC ARC/INFO and ArcView.

3 Results and discussion

The intensity of the rain is particularly important as an erosivity parameter, because it is a feature of the rainfall, which in addition to amount can be recorded by conventional meteorological stations. The climate of the area considered Mediterranean (arid to semiarid) and the soils are classified as belonging to the orders of Entisol, Vertisoils, Inceptisols and Alfisoils, (Fig. 1).

In the study area the rain erosivity calculated from the Fournier index, after analyzing the meteorological dada is very low (class 1), (Demoyiannis, 1988) but the intensity of torrential rainstorms of sort duration are excessively high. It was estimated that the soil loss reached 120 tons/ha eroded, in hills with slope inclination 15%—18%. The erosion from empirical measurements approach to 75 $ton \cdot ha^{-1} \cdot y^{-1}$. This figure exceeds at least six times the soil loss tolerance which is referred in the RUSLE of the USDA Agricultural Handbook No. 703, 1997. The soil materials removed by rain estimated from 0 to 6 $ton \cdot ha^{-1} \cdot y^{-1}$, and from rain and irrigation waters from 20 $ton \cdot ha^{-1} \cdot y^{-1}$ to 210 $ton \cdot ha^{-1} \cdot y^{-1}$. This means that many tons of very fertile soil, accompanied by high rates of agrochemical, fertilizes and other polluting substances, reaches the base level of the study area which is the bed of river Pinios and via the river, finally the sea. From the preliminary data it was concluded that the relationship between Slope=S and Erosion=E can be expressed with the mathematical equation $E=a*S^b$, where E= the erosion in $ton \cdot ha^{-1} \cdot yr^{-1}$ and a,b= numerical coefficients. From the results found that a=4.07 and b=1.52, the correlation coefficients r^2= 0.79. From the above equation, if we overview some extreme cases which increase or decrease erosion, we can get an idea about the erosion rate in the study area.

From the processed satellite images lots of information was exacted concerning the physiographic elements of the study area. The DTM model was very useful in acquiring a general view and idea, how is the physiograhy of the study area and so making more easy[*] to compare the relief and topography shown clearly in the DTM images with the rest of the extracted images and fieldwork data, (ESRI In., 1997).

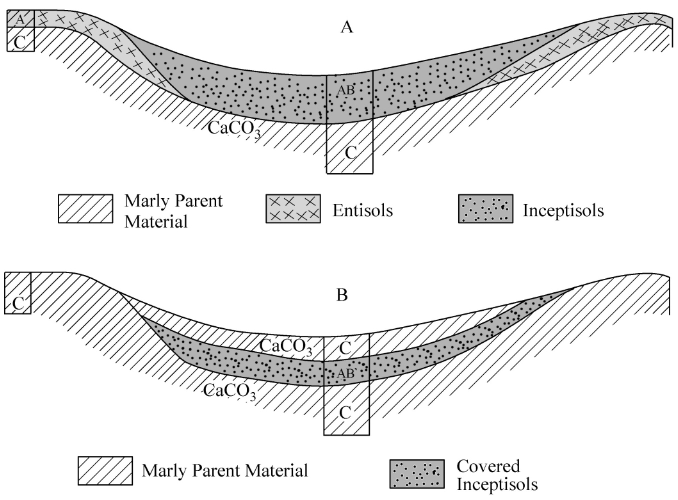

Fig.2 Erosion between hills A and B in the study area

Fig.3 Removal of soil material around the topographical posts

Fig.4 Estimation of the degree of soil erosion from the tree age and the depth of the removed soil material, which can be calculated from the height of the exposure of the tree roots

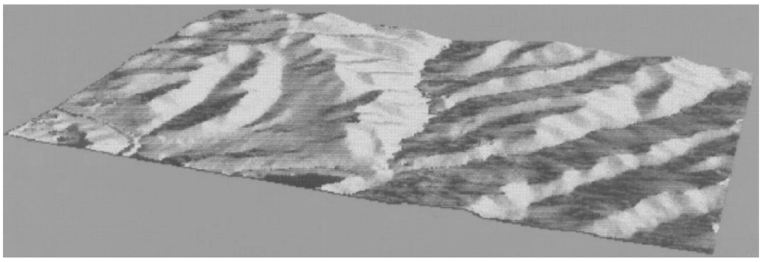

Fig.5 DTM image of the study area seen from NW. Pinios river is flowing at the lower left hand. Relief and topography is quite well represented in this image

4 Conclusions

As a final conclusion we can say that soil erosion in the study area, which may be used as a pilot area for the central Thessalian hill ridges, is lagerly due to irrigation water, slope inclination, torrential rain-storms and the specific land use types together with the applied agricultural practices. The values of the soil loss are extremely large, a fact that puts the decision makers in front of their responsibilities as far as it concerns the revising of the land use planing of the greater area around the study area and beyond (FAO, 1976) This means that a Land Evaluation should take place for a more comprehensive Land Use Planning and Environmental Protection. The Pinios river system, which forms the base level of the greater area around the study area, should be protected from pollution, because it is very fragile and extremely vital to human life and wellbeing.

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