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VOLUME 9

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EDITORIAL NOTE:

These Proceedings contain papers presented at the International Symposium on Operationalization of Remote Sensing, held 19-23 April, 1993, at ITC in Enschede, the Netherlands. The Symposium was organized to coincide with the Inaugural Address of Professor J.L. van Genderen on accepting his chair at ITC on "Operationalization of Remote Sensing Applications". It was also held to promote ITC's role in international cooperation in research, education and transfer of remote sensing technology, and to stimulate discussion, by means of the many plenary, technical, posters, and discussion periods.

The presented papers have been grouped into nine themes namely:

Volume 1: Issues in the operationalization of remote sensing.
Volume 2: Operationalization of remote sensing in Europe.
Volume 3: Operationalization of remote sensing in the Netherlands.
Volume 4: Operationalization of remote sensing in developing countries.
Volume 5: Operationalization of radar remote sensing.
Volume 6: Remote sensing and geoinformatics.
Volume 7: Operationalization of remote sensing for coastal and marine applications.
Volume 8: Operationalization of remote sensing for bio- and agricultural applications.
Volume 9: Operationalization of remote sensing for earth science applications.

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SOIL EROSION ASSESSMENT WITH THE HELP OF REMOTE SENSING METHODS *

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ABSTRACT

On our test site on the northern part of the country (Mátra Mountains) there are various lithological, morphological conditions and special landuse. On the test area importance of relief, plant cover characteristics and the physical properties of the soil types can be emphasized from the point of view of soil erosion caused by water. Different field measurements based on soil mapping were performed to assess the erosion intensity on the area. Landsat digital data were used to calculate the C and K factors of Wischmeier-Smith formula, these results were compared with the field measurement data. The factors of USLE were stored and processed in GIS. The results of field measurement and the values of soil erosion estimated by Wischmeier-Smith formula were compared. We tried to estimate the intensity of soil erosion by distinctive composition of Landsat TM images and it was compared with the USLE values.

Our results show that the punctiform measured data can be extracted regionally but only the remote sensing methods without field measurements are not enough for estimation of soil erosion. We marked off those surfaces which have to be protected against the soil erosion and those ones which potential sites of the destroying process in future.

INTRODUCTION

About 30 % of agriculturally cultivated area of Hungary affected by soil erosion. The soil erosion decreases the soil capability and upset the dynamic ecological equilibrium of soil system. Because of the changes in ownership by reprivatization there is a significant transformation of landuse, agricultural technology and the area of land. The big cooperatives and governmental soil conservation services were defuncted so new owners have short of information concerning with the soil erosion risk.

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The base ecological conditions are not modified by the changes in ownership, therefore we have chosen a catchment area (Fig. 1) as a test site unit and we had to take the fact into consideration that the USLE formula was made to catchment area too. The aim of the study was to locate those areas which are endangered by soil erosion independently from the borders of parcels and to find areas in which the dynamic equilibrium upset.

METHODS

In the investigation we used the unified soil loss equation (USLE - Wischmeier, W.H.-Smith, D.D. 1978). The USLE is an erosion model, which computes the soil loss for a given site as the product of six major factors, whose most likely values at a particular location can be expressed numerically. The soil loss per unit area is (A):

$$A = RKLSCP, \text{ where}$$

R - the rainfall and runoff factor (most important part is the rainfall erosion index), K - the soil erodibility factor, LS - slope length and steepness factor, C - surface covering and management factor, P - support practice factor. We tried to control two complicated factors K and C by the help of remote sensing methods. The K factor was simultaneously experimentally measured in the field using field-plot rainfall simulator. The K factor depends mainly on soil type and texture, which allows using remote sensing method. There are a lot of formula to express the NDVI or the biomass value of an surface. Measuring the vegetation cover characteristics we assess the regional differences of C factor. The C value were also calculated from the suggested tables. We used all bands of Landsat TM image on 7.7.1987, because the rainfall intensity (EI) and the predicted soil erosion give the most highly rate in this early summer period. The LS values were measured with field methods. The maps were digitized under AutoCAD and the results were transferred to IDRISI 4.0 (Eastman, J.R. 1992). In IDRISI the vector base data can be transformed to raster base, and the rasterized data were stored in GIS. The rasterized database can be used to compare the data of field measurement with the remote sensed data and we can choose the best composite of different TM bands to substitute the slow process of the experimental field measurement data if it is possible.

RESULTS

Some factors in USLE formula can be easily calculated or due to the insignificant differences the factor value can be constant, for example P factor is equal to 1 on the entire catchment area, because there was not special soil conservation management.

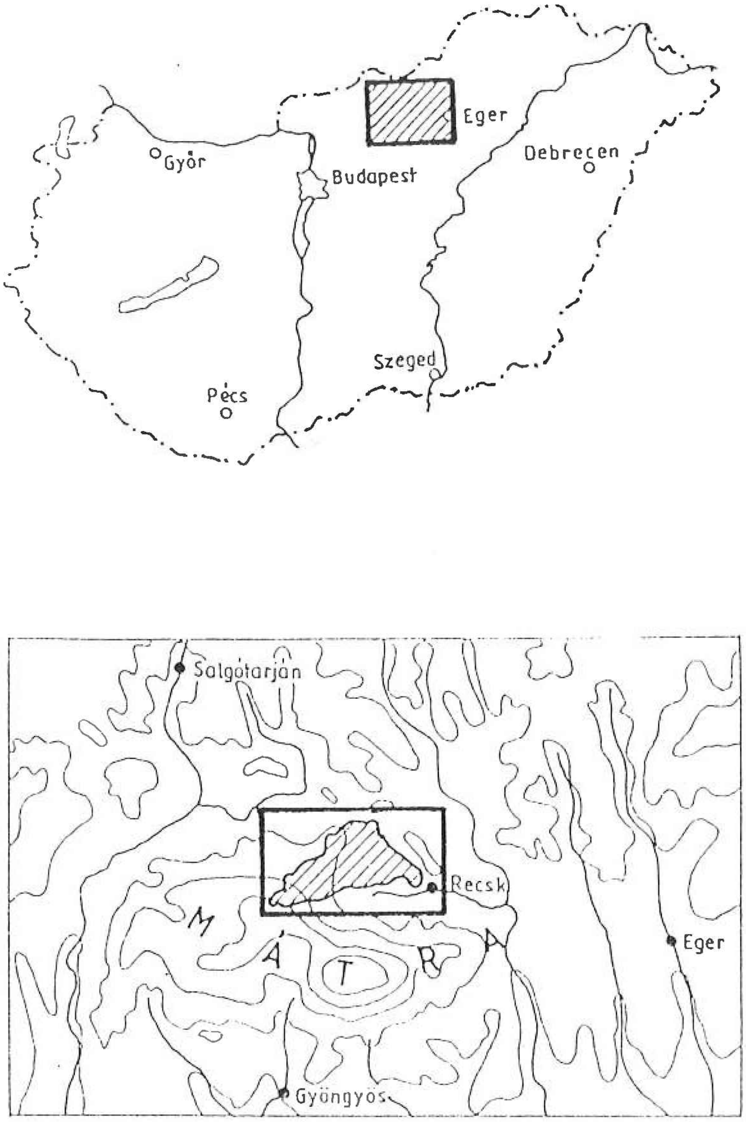

Figure 1 Situation of catchment area in Hungary

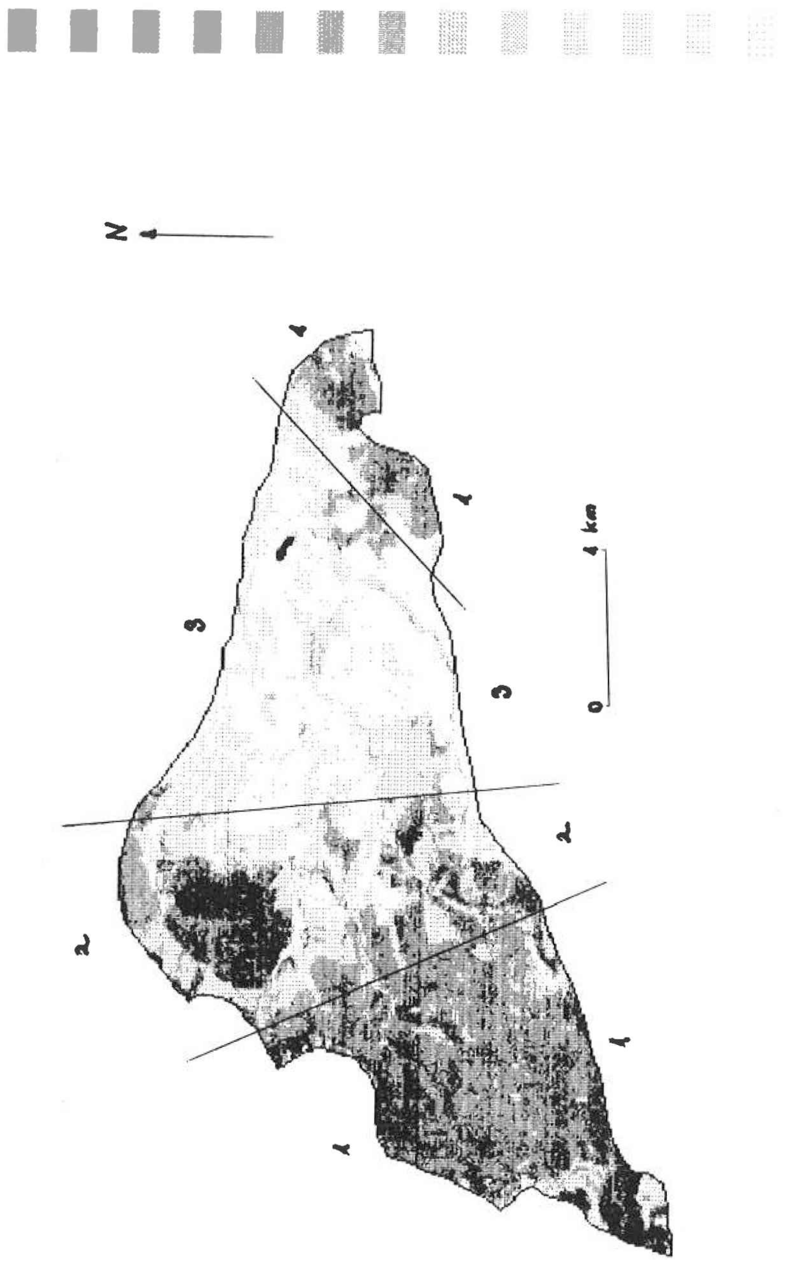

Figure 3 Color composition of TM 7,4,2 bands
(Black&White representation)

1= forested area

2= transitional zone

3= cultivated area

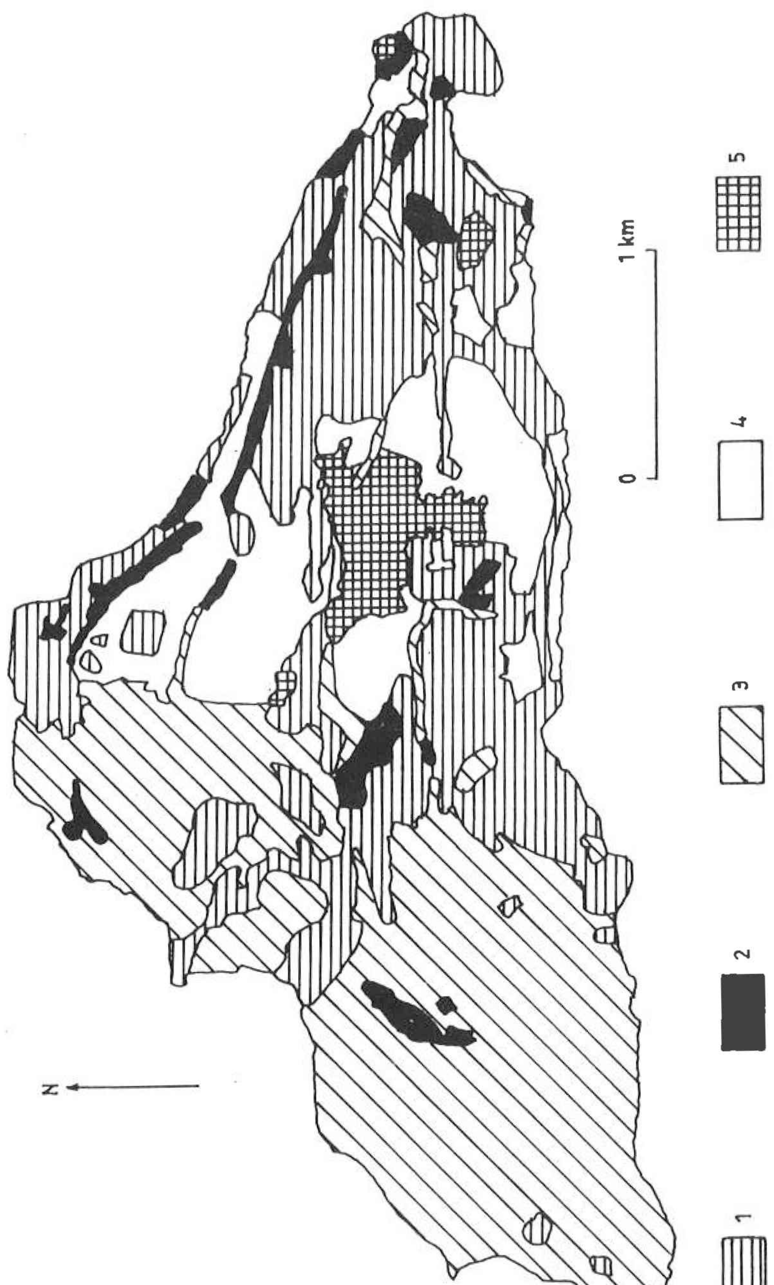

Figure 4 Series of succession of plant associations on catchment

1=degraded, 2=initial, 3=optimal, 4=cultivated area
5=settlement

plant associations appear as a narrow ecological corridors between the degraded and the optimal associations. A present these areas develop toward the regressive phase. If the human activity decreases on these area then progressive development will be possible. The optimal association is the oak forest with hornbeam as well as submontane beeches situated on higher surfaces. We consider as optimal association the alder forest on the wet surfaces and grassy association on slopes. The pattern of the area shows that the former homogeneous biotopes of plant associations were divided into smaller patterns which isolated from each other. This process of dissection is called fragmentation in ecology. Usually the fragmentation is unfavourable for the development of the living beings on a given area and we can state that the earlier series of succession have smaller stability than that of the climax phase. But the stability may be high if the series of succession make for the natural development. The instability is always consequence of some kinds of intervention into the natural processes.

The value of C factor is determined by many factors such as by the ratio of plant cover changing by the plant growth and by the crop management. Major variables that can be influenced by management decisions include crop canopy, residue mulch, tillage, landuse residual etc. For the evaluation of C value six crop stage (from tillage to harvest) used to distinguish. Being C very complex factor, it is not expected to create a composite of TM bands, which reflect the C value correctly. We supposed that the most significant factor is the density of vegetation cover (the morphometrical characteristics of the catchment are similar). The NDVI is used for the assessment for the crop production. This volume increases as vegetation gains chlorophyll and becomes greener. In our case the density of the cover was more important, so we use the band4/band3 relation (Fig. 5).

Comparing the composite with the map of potential vegetation it can be laid down as a fact that the composite significantly reflects the differences of biomass distribution. On the western part of the catchment the dense homogenous forests are typical, while on eastern part the different types of arable land show the condition of surface in connection with the spatial differences in landuse (after harvest, in development, growing, the differences in residual mulch etc.). Especially those areas can we delimit, on which there are large areas with distinctive plant cover (eg. arable land, acacia grove - grassland, deciduous forest on the northern part of the test area).

Multiplying the above mentioned factors we have calculated the soil loss value (Fig. 6). Compering these results with the plant cover conditions we can state the following rules. If the plant cover is stable than the soil erosion does not reach the value of 10-15 t/ha/y, while on the cultivated land the soil

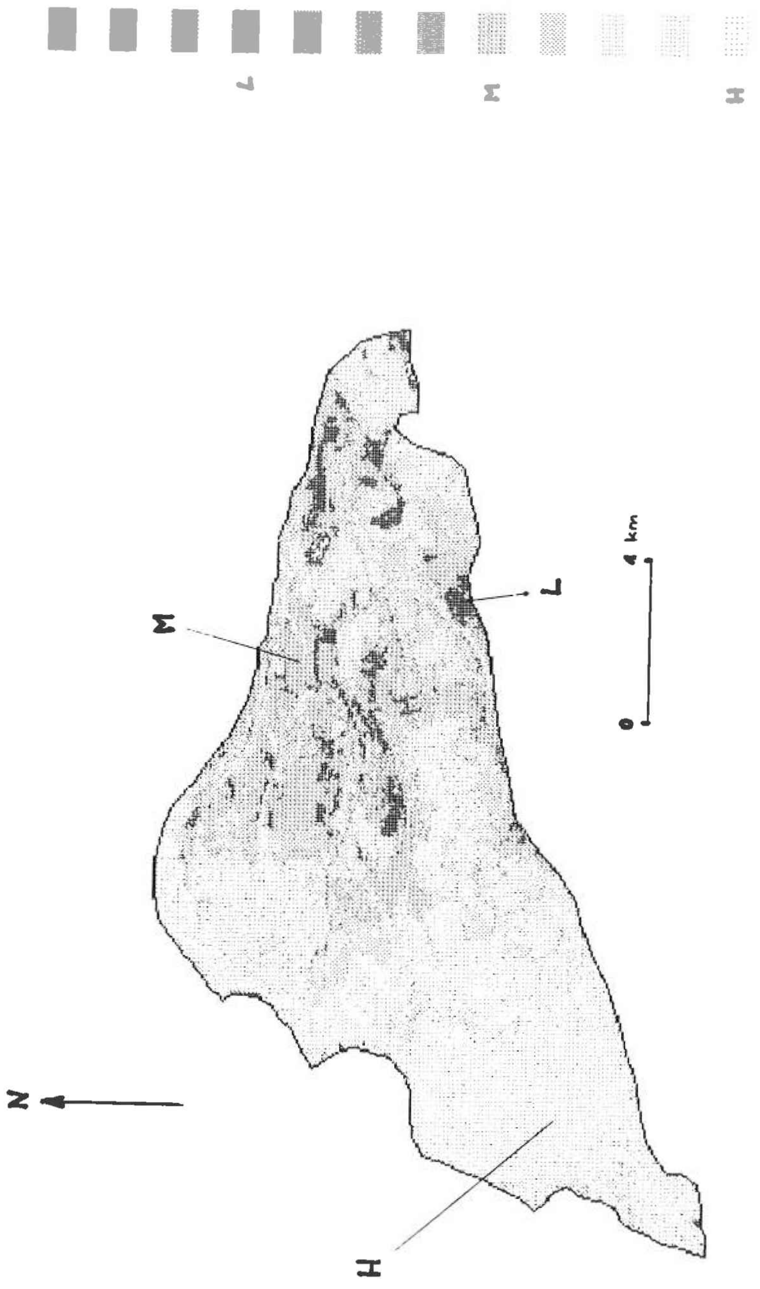

Figure 5 Biomass production on catchment area

L= low biomass production

M= medium biomass production

H= high biomass production

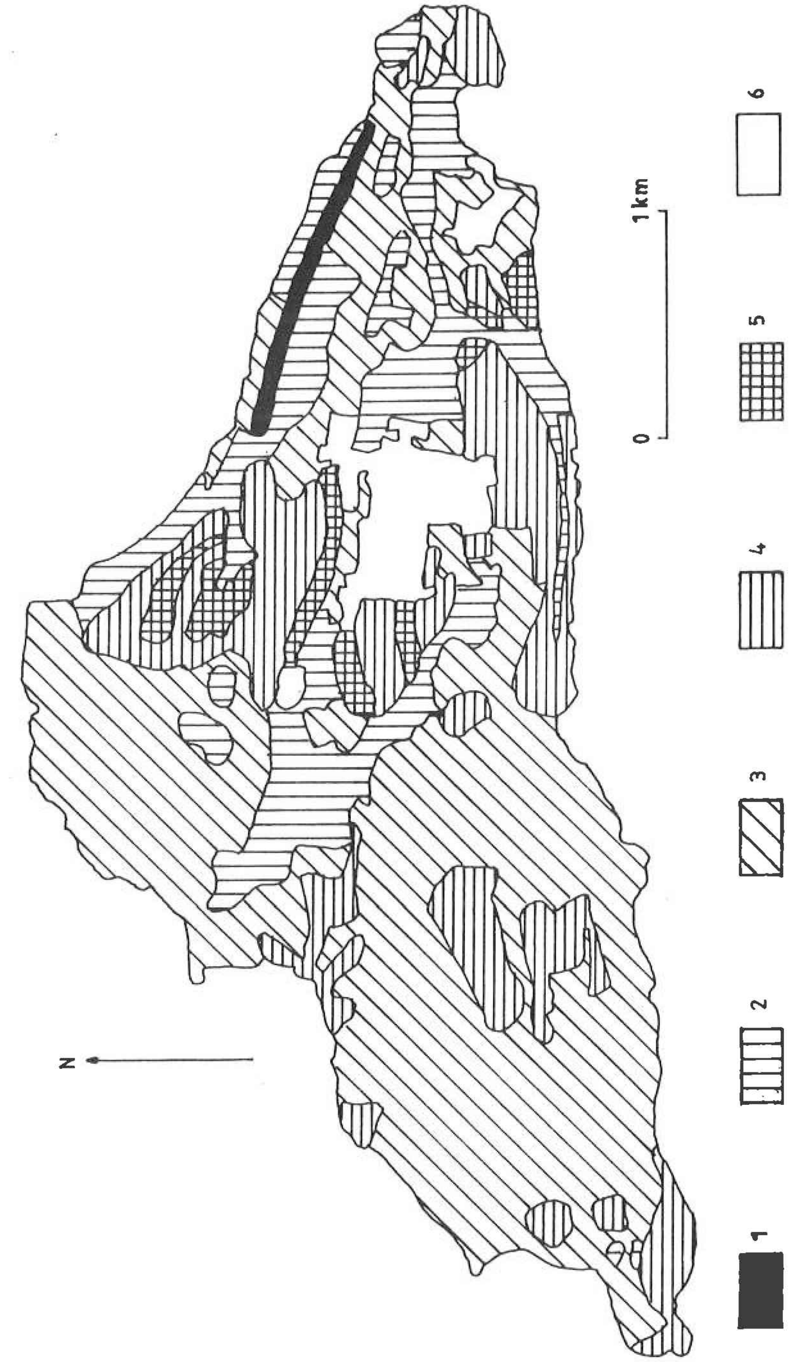

Figure 6 Map of soil erosion on the catchment area

1= <1 t/ha/year, 2= 1-5, 3= 5-10, 4= 10-15,

5= 15-30, 6= settlement

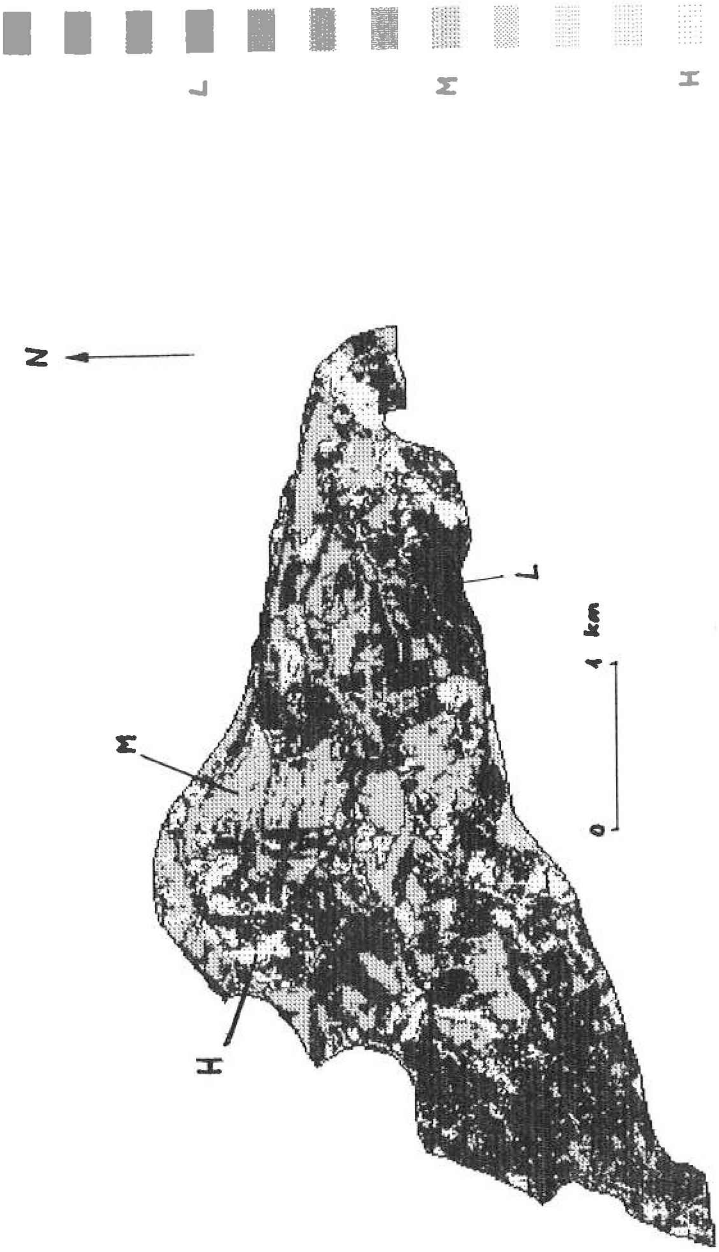

Figure 7 Color composition of Greeness Index and Wetness Index (Black&White representation)

L= low soil erosion

M= medium soil erosion

H= high soil erosion

erosion is always higher than the above mentioned value (25-30 t/ha/year). The reason for soil erosion on the forested lands is the physical and genetic properties of the soils while on the cultivated test site the steepness of land slope and plant cover.

Due to the close connection between the plant cover, the soil and plant moisture and the soil erosion we have chosen such compositions in which these factors can appear. It is well known (Banninger, 1986, Crist, 1983) that the wetness and the plant cover density can be expressed:

Greenness Index: 0.7243(TM4)+0.0840(TM5)-0.1800(TM7)
Soil Wetness Index: 0.3406(TM4)-0.7112(TM5)-0.4572(TM7)

According to the histogram of pixel values the area is divided into three categories:low (L), medium (M) and high (H) plant cover density and similar to this areas of low (l), medium (m) and high (h) soil moisture. From the point of view of soil erosion the following combinations were selected:

low soil erosion : H,l + M,m + M,l
medium soil erosion: H,m + H,h + L,l
high soil erosion: L,m + L,h + M,h

This selection (Fig. 7) proved to be useful to assess the degree of soil erosin and to locate the areas effected by soil erosion potentially.

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