Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 18, Issue 4, 2018
PRINT ISSN 2284-7995, E-ISSN 2285-3952

UPDATING SOIL TYPES DIFFERENCES OF ERODED SLOPE LANDS WITH DIGITAL ELEVATION MODEL (DEM)

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Abstract

The purpose of this work is to demonstrate the algorithm of actions for modern erosion-combating optimization of the land use structure by the example of a specific 30.01 ha study area with the help of updating the eroded soil type differences. Description and refinement of soil type difference was carried out by the way of making soil profiles, half-soil profiles and further surface interpretation on a base of laboratory soil samples results. The creation of a generalized digital elevation model (DEM) also has been taken into account to highlight the determination of slope gradient and the shape of the slope using the archive cartographic material of the scale of 1:10 000. Based on the obtained map of the slopes gradient and the generalized digital model of relief, contours of additional soil type differences were revealed, and appropriate recommendations for their use to precise farming, depending on their belonging to a certain eco-technological groups were presented. Such kind of information in the form of data files provides necessary support for programming the input of fertilizers or soil tillage operations on slopes in system of precise farming.

Key words**:** *erosion, digital elevation model (DEM), soil differences, agro-technological groups*

INTRODUCTION

Water erosion on the slope lands is not a degradation process that had happen in Ukraine by accident. It is a natural and inevitable result of mismanagement of agriculture production system during the last 50 years [3]. For the modern sector of agricultural production in Ukraine that is characterized by a mosaic structure of land use, caused by the consequences of the reform in 1990-ties aimed at dividing the lands of collective farms into appropriate set of private ownership plots. At the same time, a certain part of the land plots continues to be used by the owners, and some are leased to large producers of agricultural products with the possibility of further prolongation with getting a maximal profit.

Such economical conditions and a relatively high number of sloping lands in agricultural production provoke a spreading of erosion processes in Ukraine.

The fact that the soil protection system of land use in slope areas includes previously eroded erosion structures (in the form of trees, terraces, forest belts, etc.) in most cases have become unusable and operated in limited mode (or even does not functioning at all). Taking into account this fact we can confirm conclusions about the prevailing prerequisites for activating the intensification of run-off processes or otherwise, high demand in implementation of soil-conservative contour reclamation system of land use on these territories [10].

In conditions of a limited financial source of material assets, owners of slope lands prefer instead of additional capital investments to combat the emergence and development of water erosion processes, to concentrate production on more plain territories and to take the slope areas out of circulation. At the same time there is a saving of sources and resources, which can be directed to other needs of the economy, namely, the purchase of fertilizers, seeds and fuel.

Among the common ways to combat erosion processes, the organizational and agro-technical measures in the arsenal of land users can be noted, including the soil-conservative contour reclamation system of land use

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mentioned above, change in the direction of vehicle movement during tillage; removal of the most steep part of the field from the land structure; optimal timing of sowing; regime of moisture supplement with crop rotation selection and the way of processing agricultural machinery and others [9].

MATERIALS AND METHODS

The research method included geographic information analysis of the terrain using the Quantum GIS® program [1, 2, 7]. The digital terrain model (DEM) was built on the basis of topographic map data of scale 1: 10 000. Soil differences were determined with the help of a morphological description of the embedded sections, the boundaries between the differences were determined by describing the half-profiles and soil surface inflows, the eco-technological groups were determined on the basis of the slope steepness gradient and degree of soil erosion.

The study site was presented by a field site under hayfields with an area of 30.01 ha on the slope of a convex shape (VV classification according to FAO) of the southwest exposure with an average steepness value of up to 3 degrees [5, 8]. Type of the soil – is a chernozem ordinary loamy with light-clay composition with different degrees of soil erosion.

The purpose of this work was to demonstrate the algorithm of actions for modern erosion – combating optimization of the land use structure by the example of a specific field plot of an irregular geometric shape with an area of 30.01 ha, by clarifying and refining the eroded soil differences and creating a digital relief (elevation) model (DEM).

Study area has been chosen among many others in east-south part of Harkiv region, in Barvinkove town, Ukraine (Fig.1).

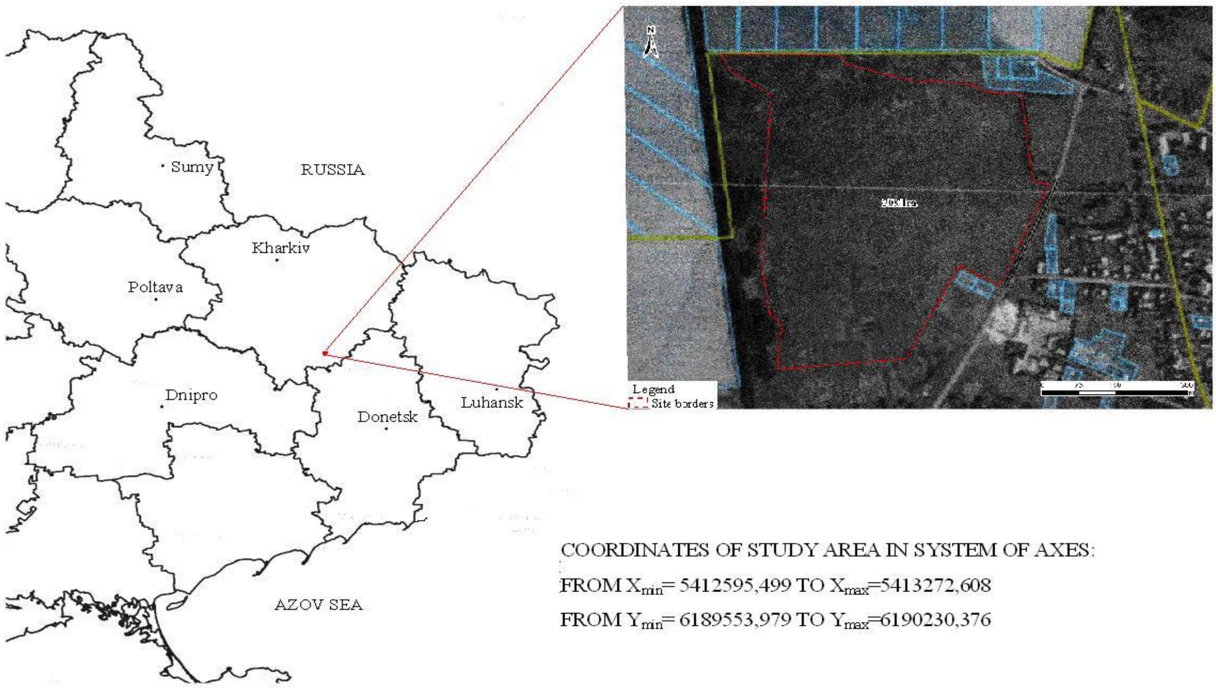

Fig.1. Map of study area (t. Barvinkove, Kharkiv region, Ukraine, 2017).
Source: Google and Bing Satellite Imagery

In order to increase the information content of the cartographic material, soil profiles were indicated on all the schemes and maps, although the places of their bookmarking varied as the soil cover was studied with the help of soils samples analyze from soil profiles and half-profiles based on the obtained generalized digital elevation model presented on cartographic scheme (Fig. 4).

To create such scheme two transitional maps in QGIS environment were created (Fig. 2).

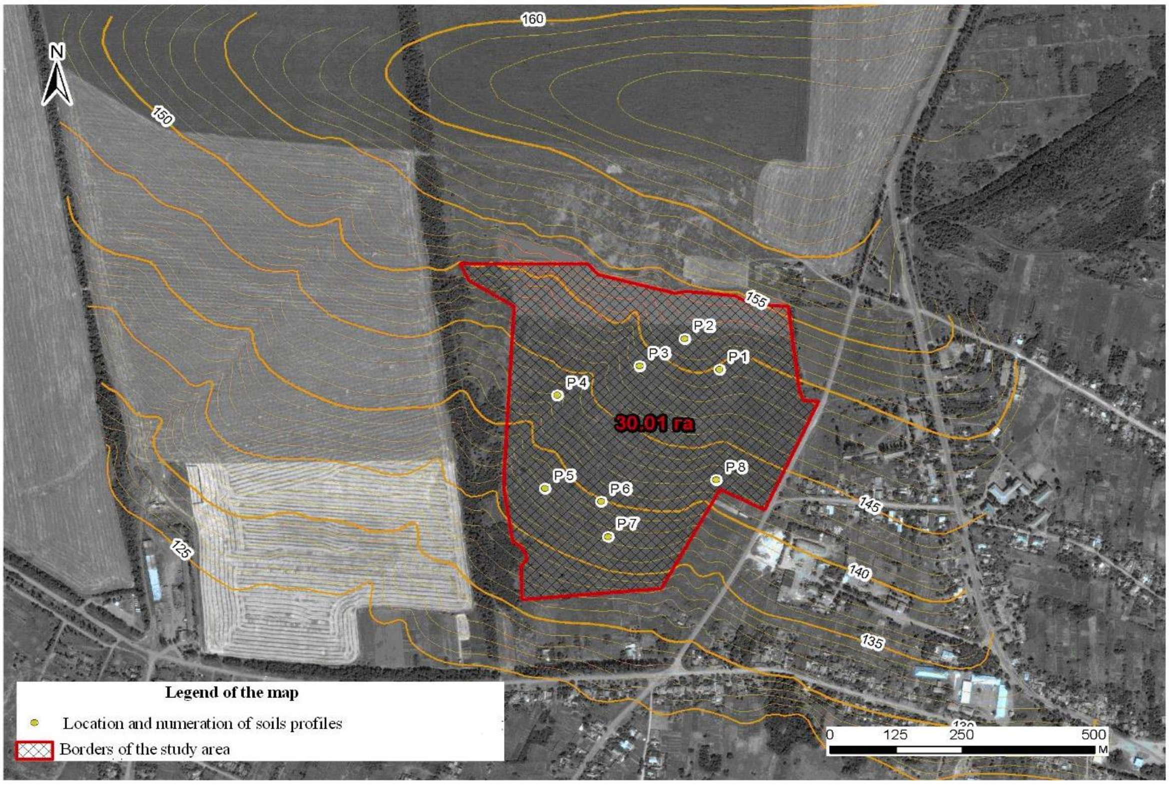

Fig.2. The map of the study area with location of soil profiles and allocated diagonals of altitudes (topographic map of scale 1:10 000).
Source: Google and Bing Satellite Imagery

RESULTS AND DISCUSSIONS

Based on the geographical information analysis of the terrain, the distribution of the territory was carried out according to existing altitudes and appropriate requirements for implementation in precise farming were revealed. With the help of mathematical modeling of erosion processes, cartograms of potential soil erosion for the territory of the site have been created and zones of increased erosion hazard with potential soil erosion of up to 3-5 t/ha per year have been identified.

It is established that according to analyses of selected soil samples from soil profiles of this area such three types of soil are presented below:

(i)Chernozem ordinary slightly eroded heavy loam and light-clay (code 65 e);

(ii)Chernozem ordinary moderately eroded heavy loam and light-clay (code 66 e);

(iii)Meadow (deposited) chernozems and meadow chernozem heavy loam and light clay soils (code 209 e).

The next step of the research is the generalization of the images obtained on the basis of the digital elevation model (DEM) of relief with the selected soil profiles spots and slope gradient degree [4, 6]. Results of such interpretation are presented below (Fig.3).

Since the aim of this study was to describe in detail the algorithm for improving the soil differences based on the additional material obtained in the form of the results of the geo-morphological description of soil profiles, half-profiles and laboratory analysis of the samples, no detailed explanation was planned for the origin of theses identified eroded soils.

It is possible to assume at the hypothesis level the fact that possible erosion preventive influence of nearby relief elements such as roads, forest belts, and trees was not as efficient as it should be and provoked soil run-off processes during the last years.

Prior to research, the land in this area was mostly of the heavy loam and light clay chernozem but without considering the deg
ree of run-off processing.

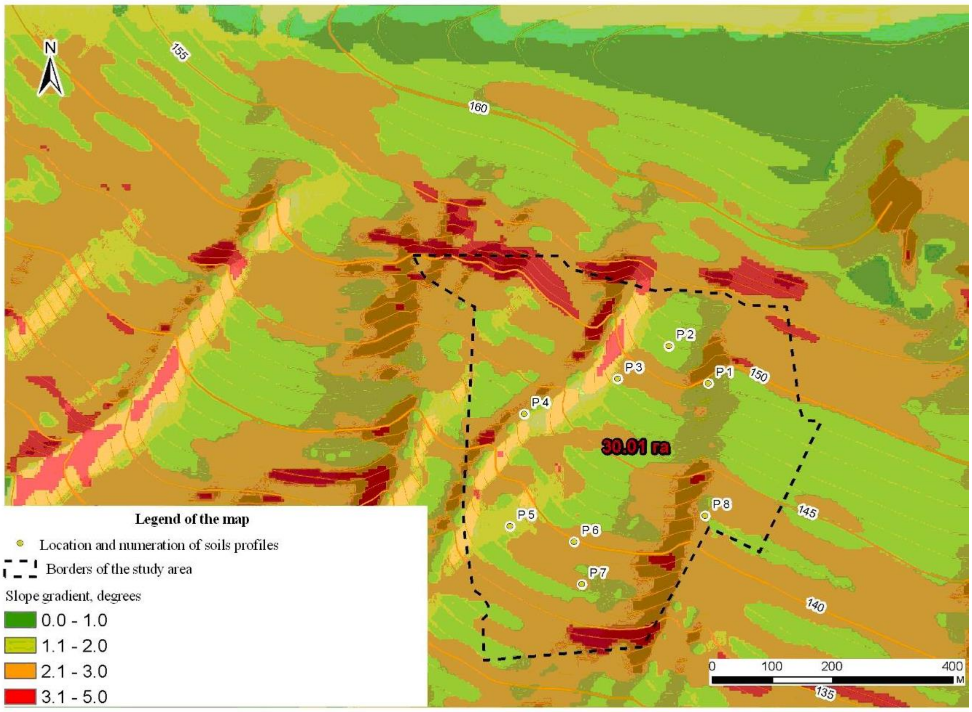

Fig.3. Map of the digital relief map for the research site with the allocation of slope gradient (in degree) in current QGIS version.

As a result of the processing of laboratory analysis data and descriptive information on soil profiles, it was possible to distinguish three soil differences, which differed in humus content, degree of run-off processes, and consequently in the thickness of the humified upper soil profile.

The generalization of the research area included the definition of the shape of the slope, the identification of transitional zones for soil material, as well as the removal and sedimentation zones (Fig.4).

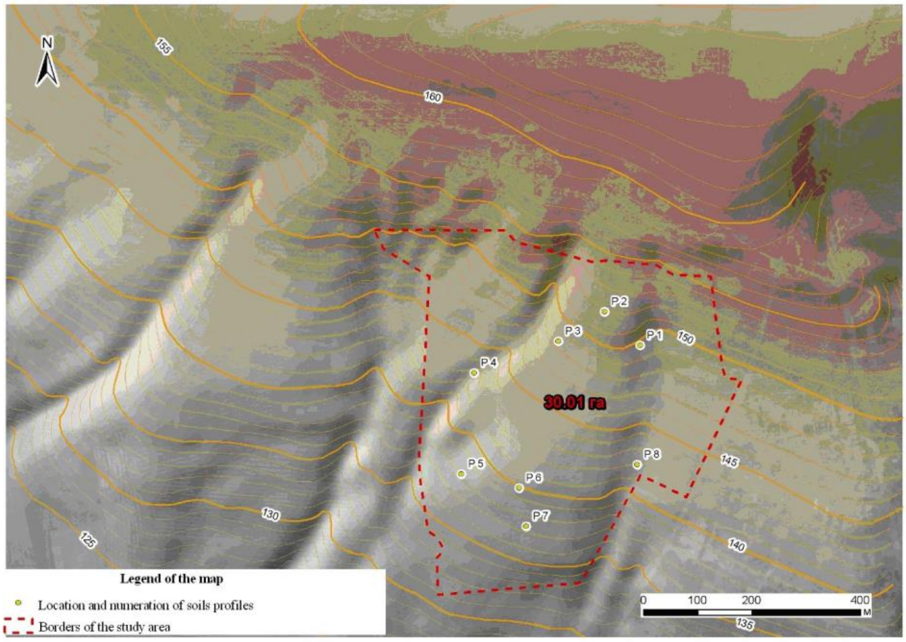

Fig.4. Cartographic scheme of generalized digital elevation model with positive (light) and negative (dark) relief curvatures of research area in current QGIS version.

It is established that the whole surface of the slope is represented by differences of different erosion degree. The zone of removal of soil materials is formed in the upper part of the site (spots of soil profiles 2 and 3 on the scheme), transition (run-off) passes from top to bottom in the western and eastern parts (spots of soil profiles 1 and 4), dividing the site into th
ree parts visible on the scheme. In these parts of the plot, visible traces of flushing are shown leading down the slope. The tabulation of other spots (soil profiles 5-7) confirmed the assumption of the continuation of the zone of removal on south of the lower boundary of the experimental site with the accumulation of soil material on the territory next to spot of soil profile 8.

The surface has an aligned character with an general inclination angle of from 1-2 to 2-3 degrees, in contrast to the negative curvatures of up to 3-5 degrees in north-west upper top and south east bottom parts of study area, which borders on the road – a natural barrier to transition and accumulation of the removed soil material. The analysis of the percentage ratio of soil differences showed that chernozem ordinary slightly eroded heavy loam and light-clay (code 65e) occupies 62.3% of the site area; chernozem ordinary moderately eroded heavy loam and light-clay (code 66e) occupies 37.0% of the site area; meadow (deposited) chernozem and meadow-chernozem heavy loam and light-clay soils (code 209e) - the area of 0.7 % of the site area (Fig.5).

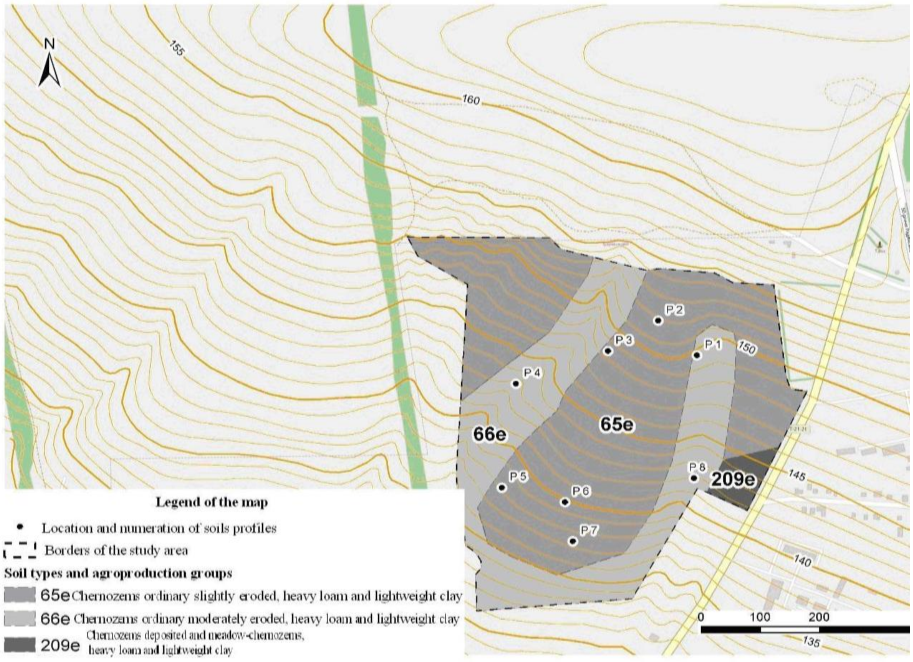

Fig.5. Updated mapping scheme of study area with selected soil differences in current QGIS version.

Since all the listed soil types are situated on the slopes with gradient from 0° to 5°, they belong to the two eco-technological groups. The first eco-technological group of soils consists from lands with steepness of slopes 0-3°. In the frame of this group – are lands that suitable for intensive use in agriculture. Lands of this group are not or subject to weak water erosion with a length of the runoff line is 300-400 meters and potential intensity of soil run-off is nearly 5 t/ha per year.

The second eco-technological group consists of lands that are subject to weak and moderate soil erosion. Slope gradient varies from 3 up to 5°. The length of the runway is 400-600 meters. Potential soil run-off intensity does not exceed 6-10 t/ha per year.

The last one – third eco-technological group presents lands with slope gradient more than 5°. The length of the run-off exceed 600 meters and potential soil run-off intensity exceed 10 t/ha per year. In case of further plans for their cultivation and other technological operations strongly recommended withdraw them from agriculture production for the amelioration and "forestization" periods. The lands are presented here with moderately and highly eroded soil types with no possibility to organize tillage and other technological operations.

After determination within a slope a set of plots with high amount of ravines on a small scale, next part of activities should include a territory of a large scale terrain for a whole area of watershed.

Since first eco-technological group of lands has almost no limitations for a crops growing, for a second one a recommended minimal percentage of perennials is above 50 % and crops rotations oriented on soil protection and excluding crops, growing in wide inner rows (sunflower, beet, corn and other).

According to all stated above, crops cultivation on slopes should be based on biological and technological soil-protecting principles. Hayfields, as well as perennials in crops rotation, provide additional amount of nitrogen and soil organic matter. This is strengthening the surface with cover in form of roots and crops residues and help to reduce previous dynamic of erosion processes.

This data and information about area percentage of different soil erosion degrees are present a valuable tool to take into account at the preparatory stage of optimization of eco-technological groups of particular field in the system of precise farming.

CONCLUSIONS

Modern land use, based on outdated schemes of production sites location, requires their verification in order to refine the degree of developing dynamics of erosion processes and last information about the area of eroded soils. One of the ways of such check-in is to refine the data about the differences between results of soil run-off erosion processes, whose can be eliminated by input of fertilizers after implication in operational programs of precise agriculture.

DEM (digital elevation model) is lined up with other software environments for downloading into the land-use optimization technology or software; DEM in such case clearly shows the classification of the study area slope gradient forms; borders between different eroded soil types and organize appropriate soil-protective land use.

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