APPLICATION OF SPACE IMAGERY FOR EXPRESS-EVALUATION OF SOIL DEGRADATION IN UKRAINIAN POLISSIA

V.I. Lyalko, L.O. Elistratova, A.A. Apostolov, I. Romanciuc, A.Ya. Hodorovskiy

Scientific Centre for Aerospace Research of the Earth Institute of Geological Science National Academy of Sciences of Ukraine, Kiev

The most important natural resources of Ukraine are land resources which, are due to intensive exploitation, have been degraded on large areas. According to the Ministry of Ecology and Natural Resources in Ukraine, there are about 3.2 million of hectares of degraded and underproductive arable lands, which require urgent measures of preservation [1]. The main factor contributing to the significant development of erosion processes in Ukraine is the high level of economic development of the territories and the use of imperfect technologies in agriculture in particular the territory of the Ukrainian Polissia, which currently is the region with the most terrible environmental situation in Ukraine, where the large areas of soil are alienated due to the result of inefficient use. So, the study of soil degradation is not only an urgent scientific need, but is also an important economic problem of Ukraine, which requires detailed study of the reasons for the deterioration of the quality of land and the development of methods for operational control over the state of land in large-sized areas in order to transfer data to the relevant administrative authorities.

The term "soil degradation" unite all processes, that reduce soil fertility, even to the fully loss of properties that determine the soil as a fertile formation. Soil degradation causes a variety of processes, including water erosion. According to World Resource Institute review (WRI) [2], water erosion is the most serious form of land degradation on a global scale. Water erosion begins with rain drops, that hit the ground. World Meteorological Organization notes, that a drop of rain of 4 mm in diameter reach the earth with enough energy to throw a piece of sand in diameter up to 0.1 cm, with a destiny of 2.65 g/cm to a height up to 6 cm [3]. In Ukraine, according to State Committee of Ukraine on Land Resources 13284,2 thousand Hectares are affected by water erosion provoked by rains (so-called also washed lands) [4].

For soil degradation processes control, both terrestrial and remote (aerospace) research methods are traditionally used. Terrestrial (ground) research methods are based on the use of modern physical, chemical, biological, microbiological, and others methods, which could be characterized by high accuracy and reliability. However, they are not productive, costly and can not be used for operative assessment of large areas. The use of remote sensing can greatly complement ground research. First of all, the use of multispectral space imagery data, which allow to explore large areas of the territory, can clearly and

efficiently represent any changes in the state of soil cover. The availability of space survey materials over the past 50 years allows you to conduct research in the monitoring mode to assess environmental changes. The presence of space images with different resolution permits to perform work at a different scale in accordance to the tasks to be solved. Cost of remote methods research is much less than cost of ground works and could be carried out multiple times with any required frequency.

For example, on the picture from the QuickBird satellite (Figure 1), are detected manifestations of various types of erosion. The plane and linear erosion is known to be distinguished. The investigation of plane erosion is based on the estimation of the degree of photon illumination, which appear due to the flushing of the upper layer of humus and leads to the appearance on the surface of more luminous soil horizons. This assessment is possible to determine both visually and with the use of quantification of spectral reflectance. Quantification of spectral reflectance is a much more sensitive method, but requires a considerable amount of time. In most cases, a visual assessment is sufficient.

The estimation of linear erosion is based on the materials of visual decoding of space images, which allows the forms of relief erosion of various scales to be determined confidently. As an additional method, the change of the spectral brightness of the landscape is studied, as well as in the case of plane erosion investigation. The results of this analysis allow to estimate quantitative intensity of linear erosion and determine its further development direction.

Conducting studies of plane and linear erosion on time-varying images allows us to assess the dynamics of the process and identify the most areas affected.

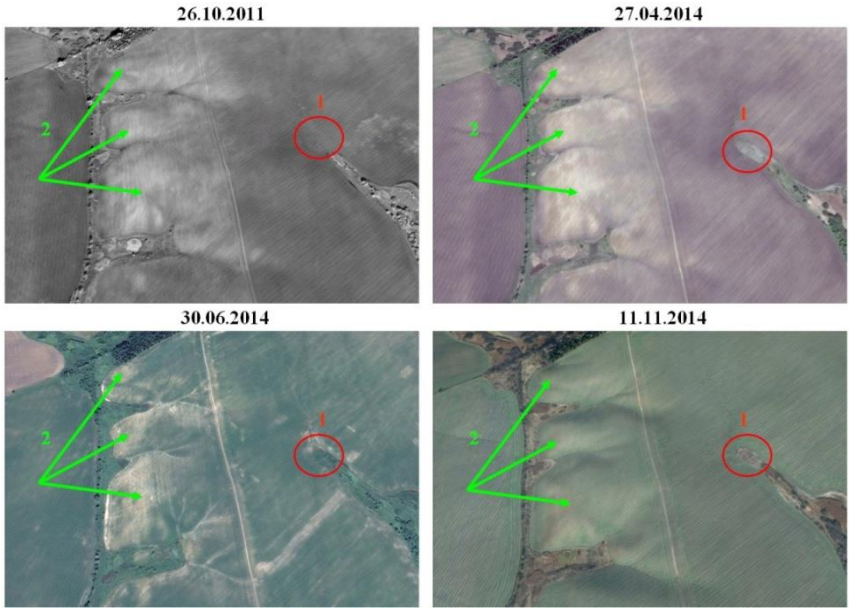

Fig. 1 – Examples of linear and plane erosion on the territory of Ukrainian Polissia:
1 – linear erosion; 2 – plane erosion.

By comparing the existing images, is possible to consider that the better manifestation of linear erosion could be observed in the spring and summer photographs, the worse of it is seen in the picture from October 26, 2011 and even worse on the picture from 11.11.2014. Thus, the quality of images decoding depends not from a year, but from a month of shooting. The comparison between the images made on October 26, 2011 and April 27, 2014 allows us to assert that at point 3 we have an increase in the size of linear erosion and it is possible to estimate its further increasing.

The above examples demonstrate the possibility to assert the potential and expediency of operatively determining the plane location and linear erosion based on materials of space multizonal surveying of large size territories. The use of images taken at different times allows us to quantify the intensity of the planar and linear erosion processes. The information obtained can be used by the relevant authorities for the purpose of planning the work on soil protection, as well as for monitoring the execution of the planned work, the timing of its execution and the size of the work performed.

The analysis and estimation of the risk of soil-erosion processes of the territory of Ukrainian Polissia on the basis of a digital model of relief using multispectral space images was made. Determined potentially hazardous erosion areas based on satellite imagery Landsat, Shuttle. On figure 2 is shown the index of intensity of erosion differentiation of relief ER part of the territory of the Ukrainian Polissia which according to the physical and geographical conditions belongs to the zone of mixed (coniferous-deciduous) forests of the Polissia region, such as the following physical and geographical regions: Volyn, Zhytomyr, Kiev, Chernihiv, Novgorod-Siversky Polissia [5].

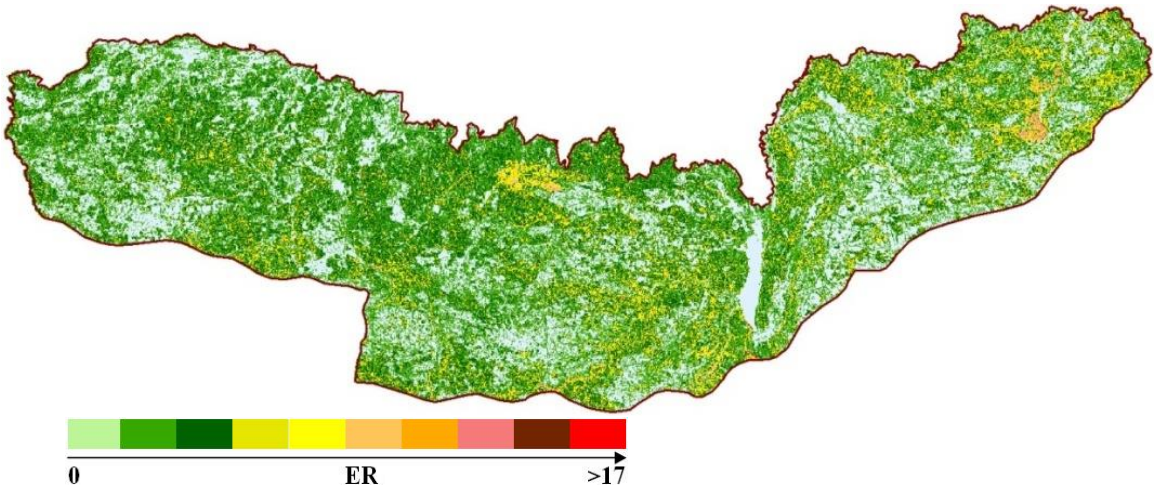

Fig. 2 – The value of the index of intensity of erosion differentiation of the relief (ER) fragment of the territory of the Ukrainian Polissia on the data of DEM from the satellite Shuttle.

Detailed methodology for calculating this index is presented in [6–8]. The color gradations from red to light green indicate the levels of danger of landslide differentiation of the relief by the index ER. By the values of the index from 0 to 2 (from light to dark green), the level of danger is absent; from 2 to 7 (mustard and yellow) the level is weak; from 7 to 10 (light orange) level is significant; from 10 to 13 (dark orange) level is strong; from 13 to 17 (dark pink) level is very strong; > 17 (dark brown and red) level is catastrophic.

One of the leading factors of erosion appearance is climatic conditions. If the precipitation exceeds a certain threshold, then the soil will overpower itself with moisture, the level at the surface aquifers will increase and the soils will start to sink. Such activation begins when the monthly rainfall norm is higher 2–3 times more than the monthly average. Especially when rapid accumulation of moisture, saturation and overflow of soils occurs during the intense storm rains for a long time, large and fleeting melting of snow in large volumes, and increasing of groundwater level. According to database of meteorological stations, established on the territory of Ukrainian Polissia for the last 40 years, a schedule of the number of days with very heavy rains (30 mm or more for 12 hours or less) has been elaborated (Figure 3). The analysis showed that heavy rainfall in the studied area dropped every year. An average of 104 rainy days were observed for the entire period. For each individual year, the minimum number of 73 rainy days were observed in 1979, with a maximum of 146 rainy days in 1990. For the last 15 years of the XXI century the average number of rainy days increased by 4 days and amounted to 108 days. In 15 years, the maximum number of days with heavy rain was in 2008 – 133, the minimum in 2005 – 94 days.

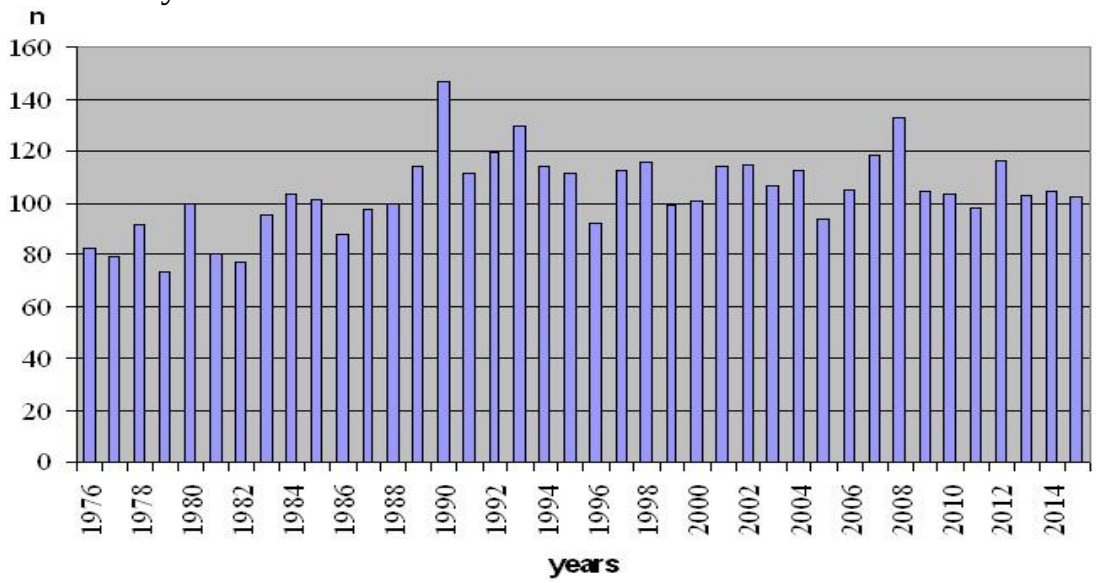

Fig. 3 – Number of days n with very heavy rain (30 mm or more for 12 hours or less) on the territory of Ukrainian Polissia.

In addition, one of the types of soil degradation is the microdepression forms of relief, which also depend on the amount of precipitation [9]. Figure 4 shows examples of microdepression forms on some fragments of the territory of the Ukrainian Polissia.

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Fig. 4 – Examples of microdepression forms of relief on fragments of the territory of Ukrainian Polissia, coordinates of image center:
a) 50°58'47.38" N, 31°08'31.15" E; b) 51°32'02.90" N, 32°17'38.69" E.

As a result of annual spring-summer flooding, is observed accumulation of water in the depressed areas. Excessive humidification if microdepressions leads to significant losses in agriculture.

Conclusions. As a result of the conducted research, the territory of Ukrainian Polissia was divided in accordance with the erosion risk degree. Satellite observations make possible to quickly detecting of the negative processes and effects that occur with soil cover especially in uncontrolled places where appropriate services and governing administrative authorities have to react and to take urgent agrotechnical measures for suspension and elimination of erosion processes. The obtained results can be used for the rapid assessment of the erosion hazard of any area for which a digital elevation model is made.

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ПРИМЕНЕНИЕ ПРОСТРАНСТВЕННОГО АНАЛИЗА ПРИ ИЗУЧЕНИИ ЛАНДШАФТНО-ЭКОЛОГИЧЕСКОЙ ОРГАНИЗАЦИИ ТЕРРИТОРИИ (НА ПРИМЕРЕ ООПТ)

О.М. Ковалевская [1], В.Л. Андреева [2]

[1]Белорусский государственный университет, Минск
[2]Белорусский государственный педагогический университет, Минск

Основой национального богатства любой территории является ее природно-ресурсный потенциал, в структуре которого значительную часть составляют почвенно-земельные и лесные ресурсы. В настоящее время их учет производится раздельно, однако использование ГИС-технологий позволяет существенно облегчить работу с огромными массивами постоянно обновляющейся информации.

При осуществлении ландшафтно-экологического анализа пространственной организации регионов актуальной остается проблема выбора универсальных территориальных единиц, которые позволяют количественно и качественно оценить их потенциал. В наших исследованиях было решено в качестве прикладной пространственной единицы использовать закономерно организованные повторяющиеся в пространстве природные комплексы – почвенные комбинации (ПК). Наличие у них определенной структуры является доказательством получения и хранения информации об окружающей среде [1, 2].

Объектом исследования выступали земли охраняемых территорий Белорусского Поозерья – Березинского биосферного заповедника (ББЗ) и национального парка «Браславские озера» (НПБО). Работа заключалась в