THREE-DIMENSIONAL MODELING OF THE TERRITORY AND WATER AREA OF NATIONAL NATURE PARK «NYZHNOSULSKYI» USING GIS

The article presents the experience in developing digital elevation models (DEMs) of Sulska Cove’s territory and water area near the national park «Nyzhnosulskyy». General digital models were created using existing topographic and bathymetric maps. The processing and data visualization were performed with GIS technologies applications. DEMs present as the basis for a comprehensive study of the national park’s landscape diversity as well as means of fundamental ways of its functioning and activity optimization. The required usage of 3D-modeling representation of NNP «Nyzhnosulskyy» is explained by its better visualization and interpretation of the data. In general, it allows information exchange about the changes of the environmental objects under research. At the same time, it decreases a list of applied tasks which were not possible to be solved using two dimensional data. The tasks which can be solved with the help of digital elevation modeling are very different, especially the following:

- inclination and slope exposure calculation;
- analysis of the runoff area;
- the network of thalwegs and watersheds network generalization, generation of the form a carcass relief system, special points and lines of the relief, local minima (depression) and local maxima;
- ortho-correction of the images;
- measuring the areas and volumes, received from the surface profiles;
- viewing the data in three dimensions, virtual flights creation and light-and-shadow models;
- precise definition of the space and geographical coordinates of the objects;
- combining thematic layers of the digital map, especially air- and space shots using 3D objects;
- performing the realistic representation of the territory and virtual mobility as to the model;
- the analysis of the visibility zones;
- conducting the extrapolation of the longitude points

DEMs of the surface and the based map are integrated into one map, using the common scale for depths and altitudes which gives a better image of the territory (and water area) of the NNP. The creation of this model permits to define the flooded area and to predict the changes in landscape structure of the territory. The relative DEM from Sula Cove’s water area bottom was created based on that data. Using the cartographical composition, the separation of the water landscapes of different types with the complex analysis of the bottom and special biota distribution will be provided.

Keywords: digital elevation models (DEM), national nature park, landscape diversity.

Introduction. Presentation of the landscape researches of national nature parks (NNP) is better to be shown in digital format based on construction of digital elevation models (DEM). The actuality of the application of three-dimensional modeling in natural environment researches of
the NNP is due to the fact that it provides greater visibility and data interpretation, as well as it is the best way to provide the information about changes in the landscape of the observable area. It allows to solve a number of applied tasks, impossible without using two-dimensional data.

By applying DEMs, there are various problems which can be solved: inclination and slope exposure calculation; analysis of the runoff area; modeling of flooding territories, analysis of visibility/invisibility; building three-dimensional images, including block diagrams, cross-sectional profiles, evaluation forms of slopes created by the curvature of the cross and longitudinal section; thalwegs and watersheds network generates a carcass relief system, special points and lines of the relief, local minima (depressions) and local maxima etc. [3,6,8,14,15]. The use of GIS technologies in the study of the landscape structure of NNP can enrich the content and direction of the applied and regional research.

**Brief review of publications and researches on the subject.** The problem of 3D reliefs models visualizing is a subject of many scientific papers, in particular, works by the national scientist I.J. Vasylykha [2] were deeply considered. Researches on this subject were provided also by the following scientists: H. V. Burshtynska [1], A.A. Glotov [3], C. Kuzyk [5], O.R Musin [8], A. Mkrtchyan [9], J.G. Puzachenko [10], Filatov, V. [13], Chromih, V. [15] and others. This problem is considered more widely by V.N. Filatov and K. Mazur, works of whom are dedicated to the problems of spatial display areas, by G.Y. Firsov [14], whose work is devoted to creating DEMs of the bottom basins. The algorithm of modeling and digital approximation methods of surface were developed by Karl Kraus, R. Finstervalder. Theoretical description and usage of DEM in GIS systems were highlighted in the works of B.I. Suhoirsky [12].

**The aim** of the article is to analyze the usage of technical methods and results of creating digital elevation model (DEM) for the national nature park (NNP) «Nyzhniosuls'kyi», to study the possibilities of their usage and optimization, and also to examine the software, which was used to create them.

**Results and discussion.** Digital elevation models, identified as mathematical interpretations of the terrain, based on a discrete set of reference points, allow virtual recreation of the actual surface and its structure with required accuracy. To solve these tasks the DEMs with different horizontal and vertical accuracy are required. The sources of information, required to build DEMs are topographic maps, stereo of aero images and satellite images. People receive data to create DEMs from photogrammetric measurements, geodetic photos, horizontal scanning on maps with results in digital form, materials of distant sounding or using other systems, which give spatial coordinates and high levels of the area points.

Nowadays, quite a large number of software products have been used for creation and analysis of DEMs. In this study 3D Analyst GIS-package ArcGIS (ESRI) has been used. This package contains a lot of advantages because it allows texturing the surface, putting additional objects, conducting the scene’s calculation in real time and maintaining map coordinate systems and projections. In fact, it complements the products of ArcGIS Desktop (ArcView, ArcEditor, ArcInfo) with instruments for creation and surface analysis, and also with two applications for creation and presentation of three-dimensional models: ArcScene (local areas of territory) and ArcGlobe (planetary scale models). As well as the whole line of ArcGIS, the module of 3D Analyst is developed based on the COM-model and uses basic components of ArcObjects which allows to apply the prepared data with analytical functions and means of three-dimensional visualization for creation local and server GIS-applications. 3D Analyst gives many opportunities for highly accurate modeling of little areas using TIN models. TIN models are usually used for accurate modeling of small areas. For TIN-model creation one or more layers are needed, which have the date of absolute altitudes in the attributive table.

**Construction of the digital elevation model of the national nature park «Nyzhniosuls'kyi» territory** is based on application of topographic maps with the scale 1:50 000. The surface of the area is generally undulating and slowly decreases to the southwest. The area along the inside part of the floodplain, which has marks of the absolute altitude — 60–79, lies in the lowest point. Decrease within the territory of the research is uneven. Layering of the relief is caused by greater intensity of lifting in north parts. The minimum value of the altitude in the represented area is 79.3 m, maximum is 141.7 m. Horizontals on the map are drawn in 5 m considering additional horizontals.

In this paper the layer of horizontals (linear layer) was used. From the beginning, the downloaded layers had been exported from the EasyTrace. Layers include linear objects (thick horizontals, basic,
Fig. 1. Digital elevation model of the national park «Nyzhnosulskyy»
additional, landforms such as ravines, rills, pits, screes, precipices) and polygonal objects (landforms). The next step requires horizontals’ combination in one layer. In this case function “merger” should be implemented and saved with other layers. Next part is to fill the table with the required attribute information: the name, height and horizontal topo-code. To construct the TIN-model series of commands should be done: Arc Toolbox — 3D Analyst Tools — Tin Management — CreateTin. After that the layer and the margin of the height should be selected, based on which the future TIN-model will be constructed [7].

In model construction a legend edition is also required (in layer’s features Symbology should be chosen). ArcMap gives wide opportunities for image elevation (color scales) and classification (Classify option). Any numbers of gradations and any intervals between them can be set, colour scales are also editable. By that part of the work TIN-model can be modified and refined by adding new layers of any types that have absolute heights in their attributes. The program Arc Scene, which is part of a full-featured GIS package ArcGIS, was created to build three-dimensional models of computer animations based on Arc GIS data. The first step is to create three-dimensional models from downloaded DTM (TIN or GRID) by using the command Add Data, then to click twice on the name of the added layer of DEM, and to choose the style of model displaying [6–7] in Layer Attributes panel. Vector layers of the scene must be added: relief and relief forms. To display an added vector layer, it is required to open Layer Attributes panel and to choose the symbols. It should be mentioned that new data in Arc Scene are loaded not over the three-dimensional model of relief, but under it — on the zero plane [7,11].

**Construction of the digital elevation model of the national nature park «Nyzhnosulskyi» water area bottom** belongs to a particular group of works, which addresses the interpretation of the relief of the NNP (National Natural Park) «Nyzhnosulskyi». It was integrated into the DEM (digital elevation model) of the studied area surface using a raster calculator, which is a powerful tool in the Spatial Analyst. These two models—the surface one and the bottom one are integrated into a single map with the general scale of the heights and depths, giving a whole view of the territory (and waters) of the NNP (Fig. 1).

In perspectives, construction of this model will allow to define the flooded areas and to predict changes in the landscape structure of the territory. This problem is relevant for various reasons, particularly due to dynamic changes of water in the Kremenchug reservoir.

The idea of more detailed study of water topography near the Sula in the NNP «Nyzhnosulskyi» area appeared as a result of the previous work organized during landscape field works (July-October 2015). Paying attention on the fact that about 70% of the park is the water surface, the necessity of a large research is clear. Landscape conditions of the NNP are determined by a complex of interactions where biotic and abiotic components are in a unity. Abiotic components (hydrological, hydrophysical, hydrochemical regimes) are shaped by the river Sula and waters of Kremenchug reservoir, creating a unique landscape. The process of interaction of the system is unstable in time because the conditions of the lower landscapes of the Sula is characterized by complexity and dynamics, and requires more detailed study and regular monitoring.

Data processing of measurements of the river depth as well as specifying contours had been made by the data of the waters depths in the studied area using navigational maps and measurements conducted by the Institute of Hydrobiology of the NAS of Ukraine in 2012–2013.

Processing of these data was conducted by «Topo to Raster» tool in Spatial Analyst [7]. Based on the data, relatively detailed DEM of the Sulsk Cove bottom waters were developed. Defining different types of water landscapes with the complex analysis of the bottom and spatial distribution of biota will be done based on the map.

**Conclusions.** Digital elevation model of NPP «Nyzhnosulskyi» is an important instrument that provides a lot of measurements to solve many scientific problems: efficient organization of natural resources usage, prediction and evaluation of potential threats, environmental monitoring and improving functional and zoning regime. The usage of specialized morphometric analysis with basic geospatial base will permit to build distributed geographical information systems with analytical elements. Geoprocessing tools and web-services will allow us to obtain the information from different spatial processes online and make management decisions more effective.

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