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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 com mon 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.

Анастасія Сплодитель
ТРИВИМІРНЕ МОДЕЛЮВАННЯ ТЕРИТОРІЇ ТА АКВАТОРІЇ НАЦІОНАЛЬНОГО ПРИРОДНОГО ПАРКУ «НИЖНЬОСУЛЬСЬКИЙ» З ВИКОРИСТАННЯМ ГІС

У статті викладено досвід розробки цифрових моделей рельєфу (ЦМР) території та акваторії Сульської затоки у районі національного природного парку «Нижньосульський». Оглядові цифрові моделі створено із використанням існуючих топографічних та батиметричних карт. При обробці та візуалізації даних застосовані геоінформаційні технології. ЦМР слугують основою для комплексного вивчення ландшафтного різноманіття національного парку та обґрунтування шляхів оптимізації його діяльності.
Ключові слова: цифрові моделі рельєфу (ЦМР), національний природний парк, ландшафтне різноманіття.

Анастасия Сплодитель
ТРЕХМЕРНОЕ МОДЕЛИРОВАНИЕ ТЕРРИТОРИИ И АКВАТОРИИ НАЦИОНАЛЬНОГО ПРИРОДНОГО ПАРКА «НИЖНЕСУЛЬСКИЙ» С ИСПОЛЬЗОВАНИЕМ ГИС

В статье изложен опыт разработки цифровых моделей рельефа (ЦМР) территории и акватории Сульского залива в районе национального природного парка «Нижнесульский». Обзорные цифровые модели созданы с использованием существующих топографических и батиметрических карт. При обработке и визуализации данных применены геоинформационные технологии. ЦМР служат основой для комплексного изучения ландшафтного разнообразия национального парка и обоснования путей оптимизации его деятельности.
Ключевые слова: цифровые модели рельефа (ЦМР), национальный природный парк, ландшафтное разнообразие.

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 NNPs 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. Suhovirsky [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) «Nyzhniosulskyi», 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, stereos 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 «Nyzhnosulskyi» 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,

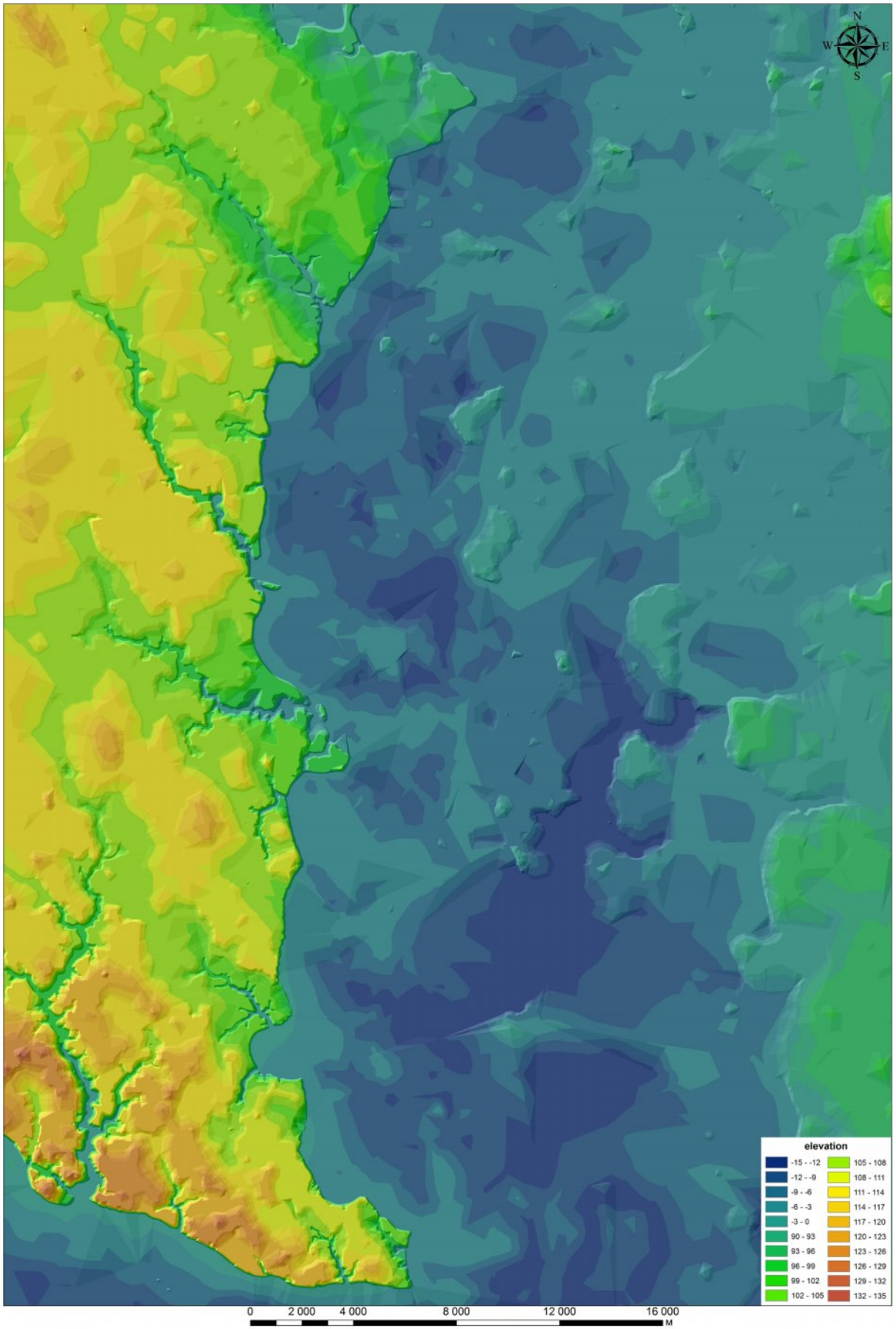

Fig. 1. Digital elevation model of the national park «Nyzhnosulskyy»

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 Arc GIS, 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 NPP 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 intime 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 measurement works 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 Sulska 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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Список використаних джерел:

1. Бурштинська Х. Цифрове моделювання рельєфу з використанням ПЗ Surfer та ГІС ArcGis / Х. Бурштинська, О. Дорожинський, П. Зазуляк, О. Заєць // Геодезія, картографія і аерофотознімання. – 2003. – Вип. 63. – С. 196-200.

2. Василиха І. Особливості цифрового моделювання складних типів рельєфу / І. Ю. Василиха // Геодезія, картографія та аерофотознімання. – 2007. – Вип. 68. – С. 269-279.

3. Глотов А. Геоинформационное моделирование долинно-речных ландшафтов Среднерусской лесостепи/ А. А. Глотов, В. Б. Михно // Вестник ВГУ. – 2013. – Вип. 1. – С. 47-52.

4. Дорожинський О. Л. Фотограмметрія / О. Л. Дорожинський, Р. Тукай. – Львів: Видавництво Національного університету «Львівська політехніка», 2008. – 332 с.

5. Кузик З. Цифрове моделювання рельєфу засобами ГІС-технологій для Національного Карпатського заповідника «Сколівські Бескиди» / З. Кузик // Зб. наук. пр. Зах. геодез. т-ва УТГК. – 2010. – Вип. 1. – С. 242-246.

6. Луцанова А. М. Особливості створення та візуалізації 3D моделей рельєфу за допомогою сучасних програмних продуктів / А. М. Луцанова // Часопис картографії. – 2013. – Вип. 7. – С. 44-52.

7. Митчелл Э. Руководство ESRI по ГИС анализу. Географические закономерности и взаимодействия / Э. Митчелл. – М: МГУ, 2001. – 190 с.

8. Мусин О. Р. Цифровые модели для ГИС / О.Р. Мусин// Информационный бюллетень ГИС Ассоциации. – 1998. – Вип. 4(16)-5(17). – С.28–29.

9. Мкртчян О. С. Принципи автоматизованого ландшафтно-екологічного картування [Електронний ресурс] / О. С. Мкртчян. – Режим доступу : http://www.lnu.edu.ua/faculty/geography/Strukt/Biblio/alphavit/Ukr/Ukr%20M/Mkrtchian/12.pdf

10. Пузаченко Ю. Г. Многовариантность картографического отображения ландшафта / Ю. Г. Пузаченко, Д. Н. Козлов // Материалы XI международной ландшафтной конференции «Ландшафтоведение: теория, методы, региональные исследования, практика». – 2006. – С. 123-125.

11. Сінна О. І. Тривимірне моделювання за допомогою ГІС та його використання у ландшафтно-екологічних дослідженнях [Електронний ресурс] / О. І. Сінна. – Режим доступу: http://dspace.univer.kharkov.ua/handle/123456789/4102.

12. Суховірський Б. І. Географічні інформаційні системи / Б. І. Суховірський. – Чернігів: Державний інститут економіки і управління, 2000. – 196 с.

13. Филатов В. Н. Основные проблемы пространственного представления местности в цифровых картографических изделиях / В. Н. Филатов, К. В. Мазур // Геодезия и картография. – 2007. – Вип. 4. – С. 35-38.

14. Фирсов Г. Ю. Цифровые модели рельефа дна в электронной геодезии / Г. Ю. Фирсов // Геодезия и картография. – 2008. – Вип. 4. – С. 49-53.

15. Хромых В. В. Цифровые модели рельефа: Учебное пособие / В. В. Хромых, О. В. Хромых. – Томск : ТМЛ-Пресс, 2007. – 164 с.

References:

1. Burshty`ns`ka, X., Dorozhy`ns`ky`j, O., Zazulyak, P., Zayecz` O. (2003). Cy`frove modelyuvannya rel`yefu z vy`kory`stannyam PZ Surfer ta GIS ArcGis [Digital terrain modeling using Surfer and ArcGIS software]. Geodesy, cartography and aerial photography, 63, 196–200.

2. Vasy`ly`xa, I. (2007). Osobly`vosti cy`frovogo modelyuvannya skladny`x ty`piv rel`yefu [Special features of digital modeling of complex terrain types]. Geodesy, cartography and aerial photography, 68, 269–279.

3. Glotov, A. A., Mihno, V. B. (2013). Geoinformacionnoe modelirovanie dolinno-rechnyh landshaftov Srednerusskoj lesostepi [GIS modeling of valleys and river landscapes of Central Russian forest]. Vestnyk VHU, 1, 47–52.

4. Dorozhy`ns`ky`j, O. L., Tukaj, R. (2008). Fotogrammetriya [Photogrammetry]. L`viv, Ukraine: Vy`davny`cztvo Nacional`nogo universy`tetu «L`vivs`ka politexnika», 332.

5. Kuzy`k, Z. (2010). Cy`frove modelyuvannya rel`yefu zasobamy` GIS-texnologij dlya Nacional`nogo Karpats`kogo zapovidny`ka «Skolivs`ki Besky`dy`» [Digital terrain modeling by means of GIS technology for the National Carpathian reserve “Skolivski Beskydy”]. Scientific Papers of the Western geodesic association UGCA, 242.

6. Luczanova, A. M. (2013). Osobly`vosti stvorennya ta vizualizaciyi 3D modelej rel`yefu za dopomogoyu suchasny`x programny`x produktiv [Special features of creation and visualization of 3D terrain models using modern software]. Journal of Cartography, 7, 44-52.

7. Mitchell, Je. (2001). Rukovodstvo ESRI po HYS analyzu. Geograficheskie zakonomernosti i vzaimodejstvija [The ESRI Guide to GIS Analysis. Geographic laws and interaction]. Moscow, Russia: MGU, 190.

8. Musin O. R. (1998). Cifrovye modeli dlja GIS [Digital models for GIS]. Newsletter of the GIS Association, 4(16)-5(17), 28-29.

9. Mkrtchyan, O. S. Pry`ncy`py` avtomaty`zovanogo landshaftno-ekologichnogo kartuvannya [Principles of automated landscape and environmental mapping]. Available at : http://www.lnu.edu.ua/faculty/geography/Strukt/Biblio/alphavit/Ukr/Ukr%20M/Mkrtchian/12.pdf

10. Puzachenko, Ju. G., Kozlov, D. N. (2006). Mnogovariantnost' kartograficheskogo otobrazhenija landshafta [Multivariancy of landscape mapping]. Proceedings of the XI International Conference of landscape «Landscape Science: theory, methods, regional studies, practice», 123-125.

11. Sinna, O. I. (2011). Try`vy`mirne modelyuvannya za dopomogoyu GIS ta jogo vy`kory`stannya u landshaftno-ekologichny`x doslidzhennyax [Three-dimensional modeling using GIS and its application in landscape and environmental studies]. Available at: http://dspace.univer.kharkov.ua/handle/123456789/4102.

12. Suxovirs`ky`j, B. I. (2000). Geografichni informacijni sy`stemy` [Geographic Information Systems]. Chernigiv, Ukraine: Derzhavny`j insty`tut ekonomiky` i upravlinnya, 196.

13. Filatov, V. N., Mazur, K. V. (2007). Osnovnye problemy prostranstvennogo predstavlenija mestnosti v cifrovyh kartograficheskih izdelijah [The main problems of spatial representation of the area in digital map products]. Geodesy and Cartography, 4, 35-38.

14. Firsov, G. Ju. (2008). Cifrovye modeli rel'efa dna v jelektronnoj geodezii [Digital models of bottom terrain in electronic surveying]. Geodesy and Cartography, 4, 49-53.

15. Hromyh, V. V., Hromyh, O. V. (2007). Cifrovye modeli rel'efa: Uchebnoe posobie [Digital terrain models : tutorial]. Tomsk, Russia: TML-Press, 164.