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Geographic Information Mapping Methods in the Study of Floodplain Landscapes of the Great Don Bend

Natalya Khavanskaya
Volgograd State University,
Institute of Natural Sciences
Department of Geography and Cartography
Volgograd, Russia
khavanskaya@volsu.ru,
http://orcid.org/0000-0001-9217-6529

***Abstract* — The article presents preliminary results of the analysis of the current state of floodplain landscapes. The starting materials of the study are publicly available digital data sources. These include the digital terrain model SRTM 1 arc-second; digital soil map of Russia on a scale of 1: 2 500 000; Landsat 8 multi-channel satellite image. The basis of the study is remote methods of geographic information mapping: processing and classification of a digital elevation model; overlay operations with electronic layers (zonal statistics function); semi-automatic decoding of a satellite image. The study of floodplain landscapes covers three stages. The first is to study the geomorphological conditions of the territory. At this stage, it is necessary to compile a relief map of the considered section of the Don floodplain and analyze the altitude changes downstream of the river. The second stage includes a description of the soil cover and a change with a decrease in topography. Further, it is necessary to compile a soil map of the territory. The third and final stage includes deciphering the satellite image in a semi-automatic mode, by the method of image classification. The result is a land-use map that depicts forests, hayfields, arable land, and water bodies. The article concludes about changes in geomorphological and soil conditions in the direction downstream of the river on the active economic use of floodplain landscapes.**

Keywords: floodplain, landscape, Don, geoinformation mapping, SRTM, Landsat 8

I. Introduction

Floodplain landscapes are the azonal type of landscapes, i.e. they are typical for the various landscape and climatic zones of the world. In science, there are many areas of study of river floodplains. For example, there are studies of the structure of floodplains [1, 2, 3, 4, 5], the dynamics of geological and geomorphological processes [6, 7], the compilation of historical reconstructions of floodplain landscapes [8], and the assessment of the ecological state of floodplain landscapes and soils [9, 10, 11, 12, 13], the conditions for irrigated agriculture [14], the study of groundwater in river floodplains [15] and the dynamics of floodplain landscapes in general [16]. The author previously participated in scientific work devoted to geophysical monitoring of groundwater in river floodplains [17]. The presented review is incomplete and demonstrates the existing scientific interest in floodplain landscapes. The study used a landscape-ecological approach, the purpose of which was to study the current state of the natural landscapes of the Great Don Bend.

Don is the second most important river, after the Volga, in the Volgograd region of Russia. Throughout its length, the Don formed a wide floodplain that is the part of the river valley annually filled with water during the spring flood. This article discusses the section of the Don floodplain from the Kletskaya village to the Vertyachy village which belongs to the middle stream, where the river curves and forms the so-called Big Don Bend.

The lowland nature of the Don River and favourable climatic conditions contributed to the highly productive floodplain landscape with characteristic forest and meadow vegetation in the middle of the subzone of dry steppes. The same conditions determined the development of traditional types of economic activity: agriculture, fishing, hunting. The rapidly developing tourist and recreational sphere has become one of the new economic areas.

Methods of geographic information mapping refer to remote research methods. They allow obtaining preliminary scientific data on the state of the territory using open electronic sources. First, we are talking about Earth remote sensing data presented in the form of satellite imagery spectra, digital terrain models and electronic cartographic resources.

The geoinformation mapping methods make it possible to cover a large territory and assess its environmental status both at a particular point in time and in retrospect, therefore they integrate into landscape-ecological research.

II. Materials and Methods (Model)

For GIS mapping of floodplain landscapes, we used the ArcGis 10.3 ESRI program. The source materials used in the study, we divided into three groups.

A. US Geological Survey (USGS) data.

This group includes the digital terrain model SRTM 1 arc-second with a resolution of about 30 m. Model

developers are The National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA). SRTM (Shuttle Radar Topography Mission) was produced in February 2000 from the space shuttle Endeavor [18]. USGS provides free access to download SRTM files through its EarthExplorer web application.

Next, we extracted a site corresponding to the floodplain of the Big Don Bend. Terrain classification was carried out every 10 m. As a result, we got a layer of floodplain heights by ranges: 30-40 m, 40-50 m, 60-70 m, this gives a conclusion about a change in the height of the Donskaya floodplain throughout its entire length.

B. Data from the unified state register of soil resources in Russia

Digital soil map of Russia on a scale of 1: 2 500 000 in ESRI Shape format and explanatory tables in Excel format are publicly available on the website of the unified state register of soil resources in Russia [19].

The map shows the boundaries of landfill polygons. The explanatory tables correspond to the map attribute data structure therefore, through the Connect and Connect function, we added them to the map and expanded its description.

Attribute tables contain data such as the soil index of each soil allotment, the soil name, group affiliation of the allotment, the unique number of the parent rock, its name, the zonal type of this soil allotment. Thus, we identified soil types and their zonal affiliation for the analyzed territory.

We analyzed the soil-geomorphological conditions using the Zonal Statistics tool, where the input data were the polygons of the soil map and a classified digital terrain model.

C. Earth Remote Sensing Data

Remote sensing data from the Earth include satellite images. Landsat 8 is an American Earth remote sensing satellite launched into orbit on February 11, 2013. It was created jointly by NASA and USGS. Getting high-quality multi-channel images requires two sets of tools: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) [20]. This study used the Landsat 8 satellite image taken on July 14, 2016, which is publicly available on the USGS website and downloaded via the EarthExplorer web application. The image resolution is 30m.

To decipher floodplain landscapes, we performed preliminary processing of the image and compiled a composite band B6-B5-B4. The choice of this combination is because it creates colour contrast. In this contrast, healthy vegetation, especially forests, has a bright green colour, the soil has shades of pink, and water has from deep blue to black colour.

After manual processing, we manually decoded the boundaries of the floodplain of the study area. Deciphering the landscape structure was carried out according to the classification&training method. This method is based on the creation of samples of training polygons and assigning them the corresponding names. So in the picture, we highlighted training poligons: forest, hayfields, arable land, water. At the end of the work, the Classification tool automatically selected the types of objects indicated in training ranges for the rest of the territory.

III. Results and Discussion

After implementing the methods described above, we obtained the following results (Fig. 1).

A. Geomorphological conditions

By the nature of the change in the altitude of the floodplain in the relief, we identified two sections.

- From the Kletskaya village downstream to the Sirotinskaya village. The prevailing heights are 40-50 m. At the border of the floodplain with the Don slopes, in some areas, the heights increase to 60 m and reach a maximum of 70 m on the border with the Archedin-Don sands.
- From the Sirotinskaya village to the Vertyachy village there is a decrease in elevations to 30-40 m.

B. Soil cover

In the studied area of the floodplain of the Great Don Bend, the main soil types are: alluvials saturated soils occupying the central part of the floodplain. Dark-chestnuts medium-loamy soils of dry steppes and semi-deserts are characteristic for the right-bank part of the floodplain where the Don goes around the East Don ridge (Fig. 2).

Downstream from the Sirotinskaya village, the soil cover becomes more diverse. There is a change of alluvials saturated, dark-chestnuts and residual-calcareous and calcareous Soils of dry steppes. Alluvials saline, chestnuts, chestnuts solonetzic and solonchakous appear. Subsoil formations include sands that form the surface in the northern part of the floodplain. Table I presents a detailed description of soils.

TABLE I. Soil Types of the Big Don Bend

№	Soil characteristics	
	Types of main soil	***Zone***
1	Sands	Subsoil formations
2	Alluvials saturated	Floodplain and marching soils
3	Dark-chestnuts	Soils of dry steppes and semi-deserts
4	Dark-chestnuts residual-calcareous and calcarious	Soils of dry steppes and semi-deserts
5	Alluvials saline	Floodplain and marching soils
6	Chestnuts	Soils of dry steppes and semi-deserts
	Sierosands	Soils of steppes
8	Chestnuts solonetzic and solonchakous and solonetzes	Soil complexes of steppes and semi-deserts
9	Chestnuts solonetzic and solonchakous	Soil complexes of steppes and semi-deserts

C. The spatial structure of land use

As mentioned earlier, we identified 4 types of objects according to remote sensing data (Fig. 3). After vectorizing the layer, we calculated their area: forests occupy about 200

km^2, hayfields - 235 km^2, arable land - 140 km^2, water (Don and its canals) - 48 km^2.

The given land use structure demonstrates the active economic use of the floodplain. In floodplain conditions the most preferred type of agricultural nature management is hayfields. Lush meadow vegetation is a good fodder base for cattle, and haying helps to prevent landscape fires.

Arable land occupies about 23% of the floodplain. Floodplain dark chestnut and chestnut soils are exposed. Near settlements, both in the right-bank and left-bank parts of the floodplain, there are separate plots of arable land.

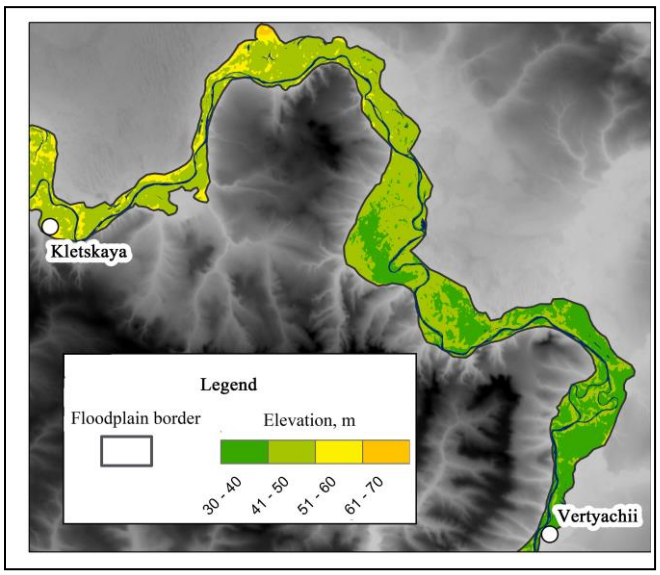

Fig. 1. The relief of the floodplain of the Great Don Bend

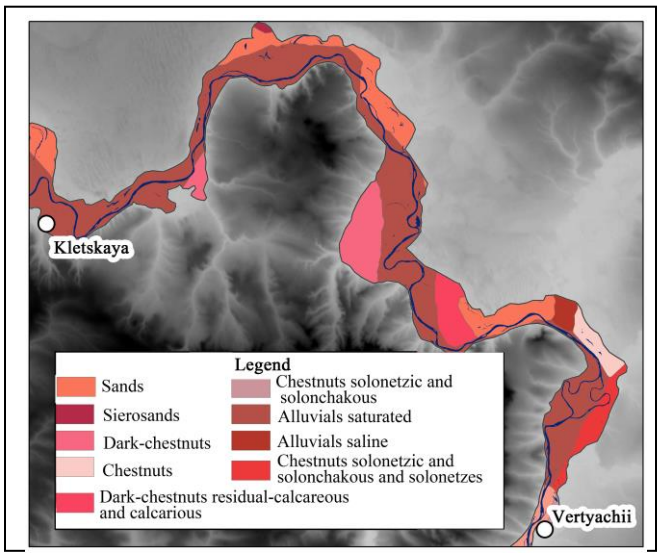

Fig. 2. The Soils of the floodplain of the Great Don Bend

Natural forests are in the near-river part of the floodplain and depressions located in the river sediments of the Don where water enters the flood. On the whole, the planned pattern of the forest repeats the pattern of water channels and forms the so-called mane floodplain.

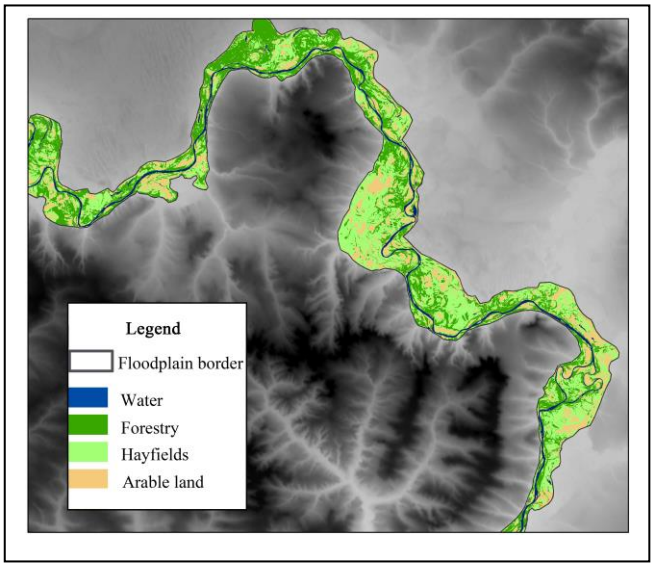

Fig. 3. Land use structure of the Great Don Bend

IV. Conclusion

The presented methodology for analyzing the state of floodplain landscapes of the Big Don Bend based on remote methods of geographic information mapping includes three stages.

A. Selection and processing of a digital elevation model

The digital terrain model SRTM 1 arc-second with a resolution of 30 m is sufficient to describe the terrain of an area of more than 600 km^2. This resolution avoids unnecessary detail while preserving typical features and terrain parameters for its comprehensive analysis.

B. Space image preparation and decryption

The used method of decoding a satellite image classification&training requires a high level of researcher`s qualification. In the technical implementation, the problem may arise of decoding of insignificant elongated polygonal objects, for example, river channels. Therefore, for the reliable result, it is necessary to compare the results of decryption with the original space image and, if necessary, make adjustments.

The use of Landsat 8 as a starting material is justified since the developers provided the opportunity to select images by date, presence or absence of cloudiness, lighting. The composition band B6-B5-B4 allows distinguishing different types of objects on a contrasting basis.

C. Using the digital soil map of Russia

The study of soil cover is an integral part of landscape-ecological studies. The soil reflects its ecological state and potential productivity and is the main factor in the development and distribution of agriculture.

Open access to the digital soil map of Russia allowed us to analyze the spatial distribution of the main soil types and bypass the stage of collecting cartographic material on paper and its digitization.

Based on the data obtained at each stage, we concluded:

The elevation of the floodplain decreases in the direction downstream of the Don River from the Kletskaya village to the Vertyachy village, which indicates an increase in erosion incidence.

With a decrease in relief, solonezic soils appear. It is especially seen in the left-bank part of the floodplain, the area from the Krasnodonsky village to the Vertyachy village.

The considered section of the floodplain of the Big Don Bend is actively used in agriculture, more than 20% is arable land. Natural forest vegetation occupies about 30% about the same amount falls on hayfields.

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