

Geomodels of space monitoring of water bodies

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Abstract. Theme of the paper is the solution of flooding geomodels creation for Dniester river basin territory, which uses contact and remote measurements. Natural and anthropogenic factors causing groundwater level rising were analyzed for localization of flooded zones and forecasting of geometric characteristics. Geographic information systems for researched area include the spatial binding of the hydrological elements and observation points, digital model of relief preparation, basin allocation catchment, flooded areas modeling. Structural features include the size and shape of object, brightness disposal within the object, image texture, some others. Possibility of available remote sensing data use allows reducing temporal and economic cost for conducting additional ground measurements for possible flooded areas determining. These methods of geomodels creation are realized for the territory of Dniester Canyon, the hydrogeologic feature of which is connected to the Upper Cretaceous horizon and groundwater.

1 Introduction

This research objective is to create cartographic models of potential flooded zones in the Dniester river basin in Ukraine. Environmental researches, particularly in the context of anthropogenic influence, show negative dynamics of flood events statistical frequency. In order to make well-timed decisions of possible negative consequences preventing or eliminating, remote sensing methods are being actively used. Development of new and improving the existing geomodels creating methods, just as potential flood zones definition, is possible on the basis of remote and contact measurements comprehensive using. It also requires considering hydrogeological conditions diversity and geographical conditions of the researched area [1-3].

Every year the problem of new and new territories groundwater flood is growing. It leads to sanitary and epidemiological deterioration, to groundwater and soil chemical composition changing, to corrosion activity increasing which relate to engineering structures foundation, to dangerous geological events activation, etc.

Experimental researches of anthropogenic factors that were associated with flood in the Dniester river basin are based on expert assessment and information technology methods. Geomorphological researches, geological researches of Dniester canyon, Dniester terrace formation history was made by O. Adamenko, A. Bohutskiy, A. Yatshishin, S. Rudnitskiy, E. Romer. Current environmental situation researchers in the territory of Dniester anti-flood area are considered by Y. Adamenko, D. Zorin, Y. Semchuk and some other scientists. Scientometric analysis results showed a

number of environmental problems in this area which need to solve.

2 Results

The aim of the research is to solve a scientific and practical task of potential flood geomodels creation substantiation in Dniester river basin, which has to base on aerospace and ground measurements.

Prevention of emergencies associated with flood in Dniester river basin requires continuous monitoring with analysis and assessment of received data. Flooded areas detection is carried out using remote and contact methods.

The ecological danger of flooding occurs in such landscapes as river valleys terraced bottoms. It takes the form of destructive coastal erosion, while high water disasters take place in foothills within the boundaries of floodplains. Among geomorphological processes, most hazardous for the environment, are landslides. This phenomenon is wide-spread in areas of erosion-shifting interfluvial and hilly lowlands, landslides and shoals – in mid-high mountains with stiff slopes [4-7].

Chemical pollution of the territory does not have a strong coherence with landscape type; it tends to local sources of influence, around which anthropogenic geochemical anomalies are formed. Totally, there are nearly 18 man-made anomalies in the Dniester Canyon which occupy southern boundary of Ternopil region.

Contact methods allow accurate measurements of the groundwater depth, but some errors can occur in the process their boundaries establishment [8-13]. These methods also require large quantity of material and labor resources.

In the process of degree of risk for the geomodels hierarchical structure formation determining, interval estimates method using helps to make operational decisions

to prevent consequences of dangerous engineering-geological processes in uncertain conditions. This method requires establishing dependencies between model parameters that characterize various possible situations of researched areas, using expert assessment and statistical analysis.

This way contributes to increase the accuracy of flooded zones localization with different degrees of danger [17,18].

Geographic information systems for researched area include the spatial binding of the hydrological elements and observation points, digital model of relief preparation, basin allocation catchment, flooded areas modelling (Fig. 1).

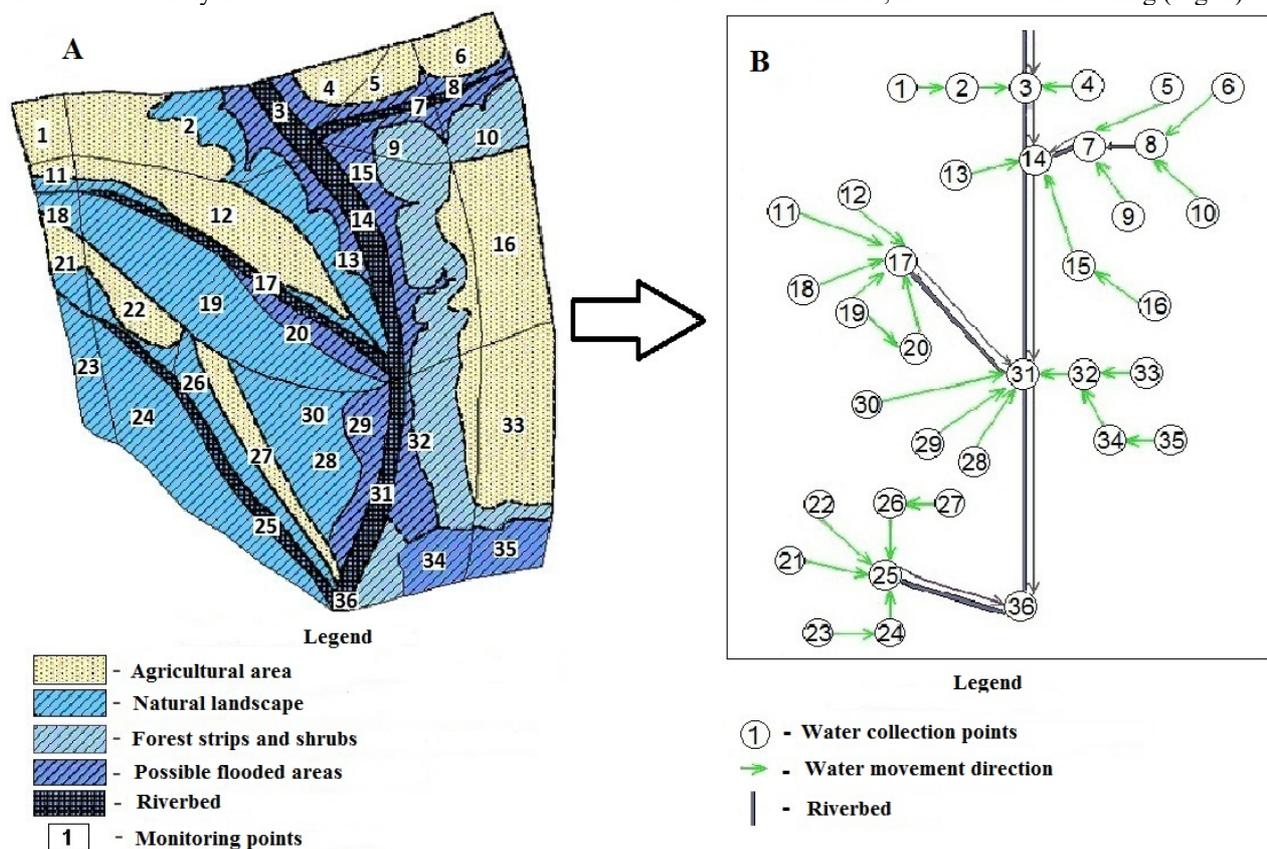


Fig. 1. Cartographic and graph model of the flood on Dniester river segment in rainy weather: A) Map of flooded territory; B) Graph representation of the model.

Proposed flood mapping representation and graph model representation of the Dniester region are basing on aerospace and ground survey using, which include data analysis for obtaining topographical or special maps and digital relief model construction.

Constructed graph shows the points of research and catchment area branching peculiarities on the territory. The final aim of proposed methodology is to assess and to consider actions of flood and deformation accidents struggling [14-16].

Natural and anthropogenic factors leading to groundwater level rise were adjusted for flooded zones localization and geometric characteristics dynamics forecasting. Possible unfavorable processes in flooded zones were established factored in the characteristics of the territory. Four flood categories depending on groundwater lever occurrence, causing factors and possible consequences were separated. Categories I and II accords to areas with groundwater depth is less than 2.5 m, where dangerous phenomena occur. Category III accords to possible flooded areas with a groundwater depth from 2.5 to 4 m, where tendency to groundwater level rise can be noticed. Areas in category IV cannot be flooded, because there are no predictions for flooding if groundwater level is deeper than 4 m.

Cosmobioindication method (by G. Krasovskiy) enables to make monitoring of waterlogged lands. This method [19-21] is based on vegetation conditions (determined by vegetation indexes measurement) depending on land waterlog degree. The application of this method is limited to unpowered soybean soils.

It is necessary to assess possible risk of groundwater shallow occurrence to determine degree of danger for researched territory. Creation of new and improving existing methods of geomodel developing for potential flooded areas is possible only after comprehensive remote sensing results and ground measurements using. Also requirement is to take hydrogeologic conditions diversity and geographical specific of the area into account.

Fig. 2 shows the structural scheme to develop geomodel for probable flooded zones according to danger degree.

There are four stages to make cartographic model with different flooding probabilities. At the first stage, it is necessary to create cartographic models of probable flooded areas based on the rules of fuzzy production system. Also SRTM (radar topographic survey) data and available ground measurements data have to be used. [22,23].

At the next stage, thematic decoding of aerospace images is made in order to identify geomorphologic

elements and potential sources of anthropogenic impact for developing of cartographical models of natural and man-made flood based on only classification characteristics assessment scale. If it is necessary, photogrammetric image processing is executed. Third stage is to specify the flooding geomodel through overlay operations on cartographic models built on the base fuzzy production system rules and interval scale of evaluation. At the final stage, a complex hierarchical geomodel of probable flooding zones (based on danger degree) is created. It is made through specified geomodel and anthropogenic flood overlaying.

Let us consider the features used in visual analysis of remote survey materials or formalized in the methods

of space images computer analysis. Decryption features can be divided into two main groups – brightness and structural. During visual analysis of images bright features group includes image photon (for monochromatic images), such color characteristics as color tone, color saturation and “lightness” (for color, spectrozonal and synthesized images). During decoding of digital images rendered on the display screen, brightness equivalents of image (for panchromatic), zonal brightness equivalents (for multi-zonal survey) and equivalent of effective scattering area (for radar images) are the brightness features. If synthesis procedure is being used in conditional colors for multi-zonal images visualization, then the color characteristics are also being analyzed.

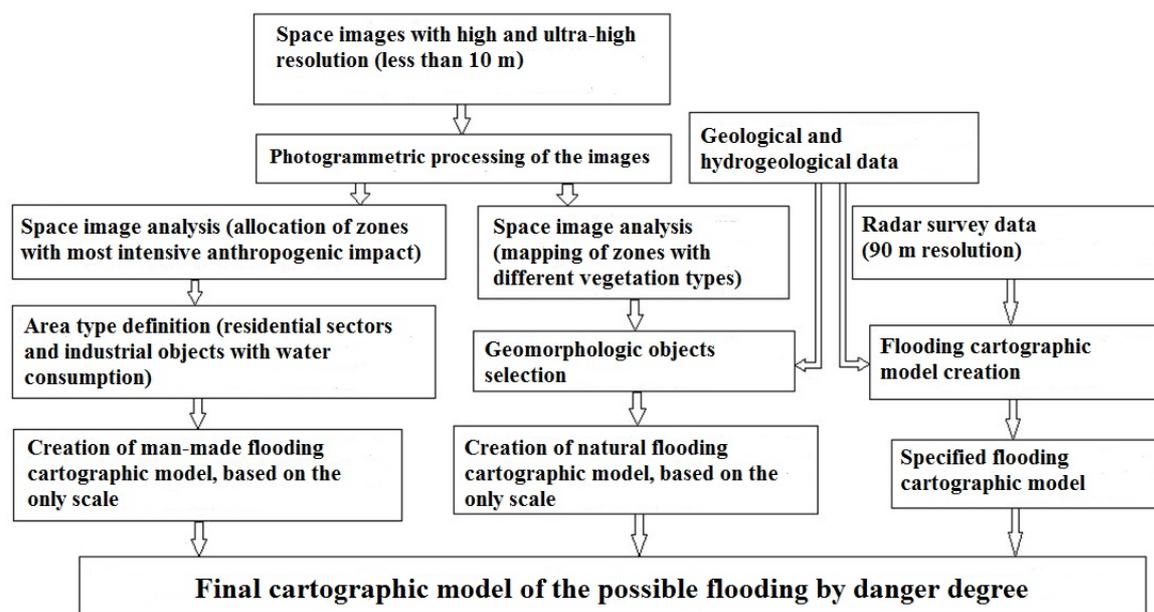


Fig. 2. Method of creating flood cartographic model by danger degree.

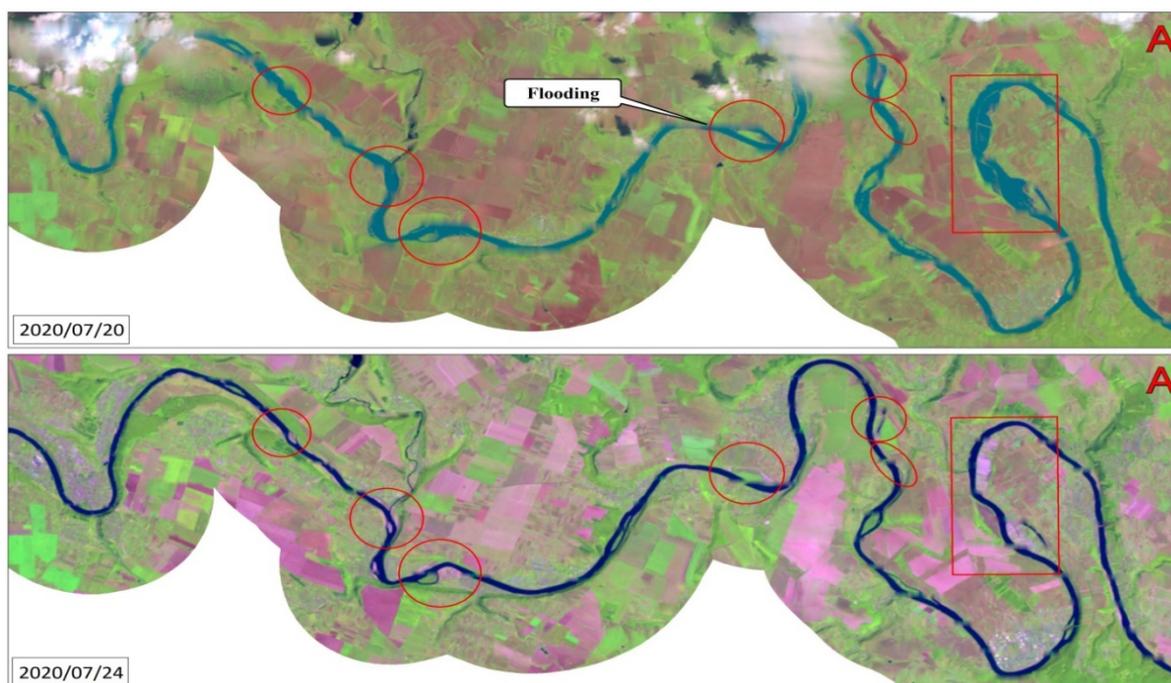


Fig. 3. Flooded areas in Dniester river basin between Dobrilyany and Ustia villages in 2020 is on a fragment of space image SENTINEL 2 (10 m resolution).

Structural features include the size and shape of object, brightness disposal within the object, image texture, some others [24-35]. The initial source for the space images thematic analysis is various thematic maps. Together they give information about localization of objects and spatial disposal of indicators. This disposal characterizes ecological situation in the environment or anthropogenic impact level in its components, localization of impact sources and its scale. Therefore, main processes in space images thematic analysis are represented as images segmentation for planar and linearly extended objects identifying, as Fig. 3 shows.

Remote sensing methods allow to make flood monitoring and to analyze its dynamics, but they have a number of disadvantages due to high difficulty of data analysis and delay in obtaining the space images.

Flooded zones localization on space images is carried out on indirect features, such as presence of floodplains, swamps and relief depressions. Flooded areas mapping is possible on threshold values of mathematical expectation and dispersion of color intensity on red, green and blue channels [36-49].

Digital panchromatic image with a 10 m-resolution (4800 x 4800 pixels) was analyzed in ERDAS IMAGINE software using controlled classification method.

3 Conclusions

Methods for geomodels making for probable flooded zones were developed and implement for territories in Dniester river basin. Its geomodels consider degrees of danger which formed in conditions of insufficient information.

Scientometric analysis of geomodels creating methods for flooded territories showed that possible flooded areas timely detection and prediction of dangerous accidents is possible only with complex use of remote and ground measurements with their subsequent rationing and analyze.

Possibility of available remote sensing data use allows reducing temporal and economic cost for conducting additional ground measurements for possible flooded areas determining. While the accuracy of predictive parameters do not reducing.

The developed cartographic models of possible flooding areas allow determining and visually assessing the degree of flooding under different modes of pressure horizons use, which have a hydraulic connection with groundwater. These methods of geomodels creation are realized for the territory of Dniester Canyon, the hydrogeologic feature of which is connected to the Upper Cretaceous horizon and groundwater.

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