The dynamics of flooding of the territory during spring floods in the Desna River basin (Chernihiv region)

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SUMMARY

The article considers of example of studying the dynamics of flooding of area during spring floods in the Desna River basin using modern remote sensing methods. The use of the spectral index of the normalized difference in refractive indices of water (NDWI) made it possible to find out the dynamics of changes in the area of surface water bodies in the Desna River basin in different years. It has been established that the flooded areas and the intensity of the process are constantly changing. Also, the long-term dynamics of flood development in the Desna River basin were investigated using satellite images for different years. It has been determined the process of flooding is activated in high-water years in those areas where natural (climatic) factors are dominant. On the basis of the study, maps of the long-term dynamics of the development of floods in the Desna River basin of the Chernigov region were constructed.

Introduction

Flooding of territories has recently become of the widespread modern geological processes, which develops under the influence of natural and man-made factors (Figure 1).

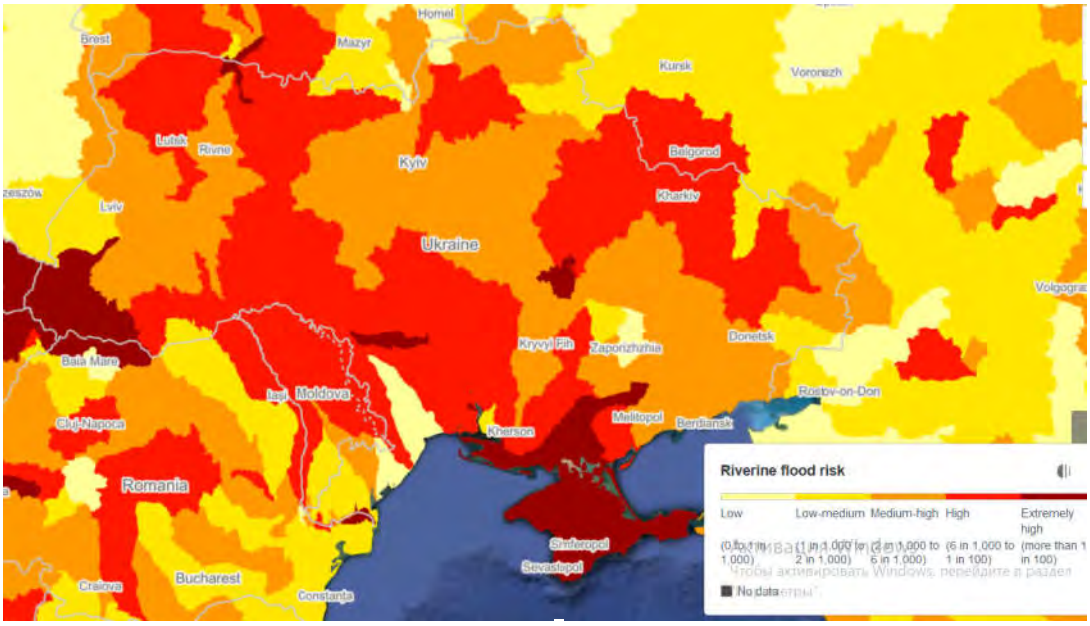

Figure 1 *Flooding risks on the territory of Ukraine* (*Flooding risk map in Ukraine, 2020)*

Organization of surface runoff is the most important measure to prevent floods of various types and causes. Therefore, the areas of flooding of territories that occurred during the spring flood on the Desna River in the Chernihiv region were analyzed.

The development of the process of flooding leads to uneven subsidence of soils with subsequent deformation of structures of buildings and structures, a decrease in the solid characteristics of soils and the occurrence of landslide displacements on slopes, changes in the chemical composition of soils, a decrease in the infiltration capacity of the soil mass and swamping of the territory. As a result, there is a deterioration in the sanitary conditions of the population, pollution of surface water, etc *(The state of technogenic and natural safety of the Chernihiv region in 2018, 2019)*.

Forecasting possible flooding of territories is one of the necessary conditions for preventing their consequences. This requires complete and reliable information about the terrain, the state of surface water bodies, the long-term dynamics of flood development, the water level at hydrological observation posts, etc. Remote sensing methods are used different for processing information on flooding of territories.

Method and Theory

At present, it is difficult to imagine the study of surface water bodies without the use of satellite research methods. Space images can be used to assess the state of surface water bodies *(Plichko et al., 2020)*, long-term dynamics of floods, etc. The main advantages of space images are: continuity of information content of the image(, simultaneous coverage of the water area and coastal areas.

The most common method for studying long-term dynamics of the state of surface water bodies on multispectral images is an algorithm based on the spectral index of water – NDWI (Normalized Difference Water Index) proposed by Gao B.C. in 1995 *(Gao, 1995)*. NDWI calculations are based on

the ratio of difference and sum of green (560 nm wavelength) and near infrared spectral band (842 nm wavelength) (1):

$$NDWI = \frac{B_{GREEN} - B_{NIR}}{B_{GREEN} + B_{NIR}}, \quad (1)$$

where B_{Green} - green spectral band, B_{NIR} - near infrared spectral band.

Examples (Optional)

Examples of studying the state of surface water bodies and studying the long-term dynamics of floods were carried out within the Desna River basin of the Chernigov region. The choice of the object of study is due to the fact that the Desna river basin is characterized by weak dissection of the relief, low filtration properties of rocks, shallow occurrence of groundwater levels, and significant density of river network. All these natural conditions contribute to the development of the process of flooding on the Desna River in the territory of the Chernihiv region, which in some years can become catastrophic. During the last 100 years, the maximum flood discharge was observed 5 times (1908, 1917, 1931, 1942, and 1970) (*Report on the state of the environment in the Chernihiv region in 2017, 2018)*. Such floods of varying availability lead to erosion of banks, flooding of land areas and settlements, and cause significant damage.

Consequently, in order to assess the development of floods, based on the analysis of long-term remote sensing data, we identified potentially hazardous areas of the Desna River basin to predict, prevent and minimize losses in the future.

Therefore, to study the dynamics of the state of surface water bodies in the Desna river basin, the Normalized Difference Water Index (NDWI) was used (Figure 2). The resulting images were classified using two colors from 0 to 1 yellow (land resources) and from -1 to 0 blue (surface water bodies). Green spectrum and reductions in surface water NIR reflectivity NDWI reflects surface water among wetlands and provides a measure of the extent of surface water coverage (Table 1).

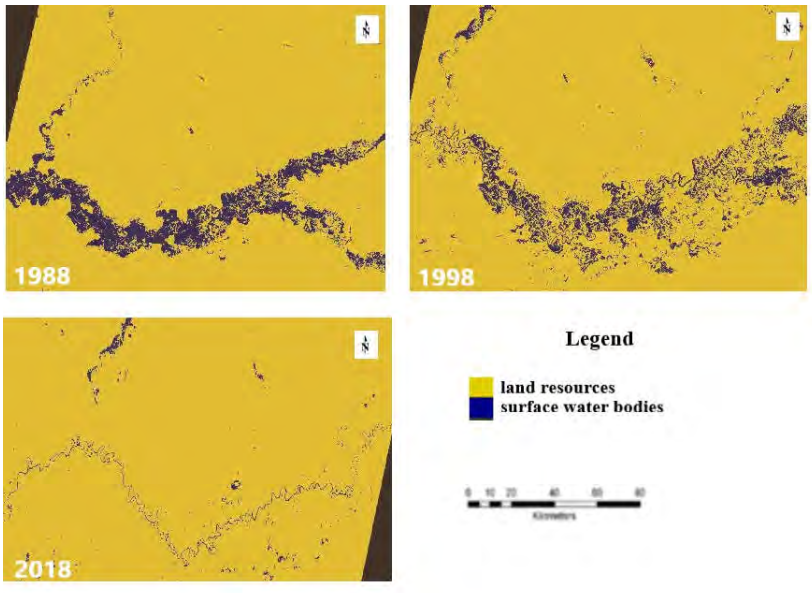

Figure 2 *Results of studying the dynamics of the state of surface water bodies in the Desna River basin using the Normalized Difference Water Index (NDWI)*

As a result of applying the NDWI index, for the selected section of the Desna River basin from the Seim River to the city of Chernigov (excluding the Snov River) (Figure 2), it was found that on the image from April 20, 1988, the area of land resources was obtained - 1115.19 km^2 and the area of surface waters during a flood - 438.33 km^2. In the picture from April 16, 1998, the surface water area decreased and amounted to 296.11 km^2, and the area of land resources - 1124.83 km^2. The surface water area during the flood in the image from April 14, 2018 is 142.06 km^2, and the area of land resources was 2189.06 km^2.

Table 1 *Comparative analysis of data from satellite images*

Date	Land resources,%	Surface water bodies,%
20.04.1988	71,78	28,22
16.04.1998	79,16	20,84
14.04.2018	93,91	6,09

A comparative analysis of the data obtained from Table 1 showed that the percentage of land from 1988 to 2018 increased by 22.13%, respectively, the area of surface water bodies decreased.
Areas of natural flooding in the region are located in the floodplain of the Desna River (Novgorod-Seversky, Krupskaya, Sosnitsky, Mensky, Kulikovsky, Kozeletsky districts), the Seim River (Bakhmach, Borznyansky districts), the Snov River (Snovsky, Gorodnyansky districts) and in areas with natural relief depressions (Nezhinsky, Nosovsky, Kulikovsky, Koryukovsky districts).
For each of the selected flooding areas, space data were analyzed. As a result, retrospective images of the Desna river valley were obtained, on which flooding zones were recorded and a map of long-term dynamics of spring floods in the Desna River basin was constructed (Figure 3).

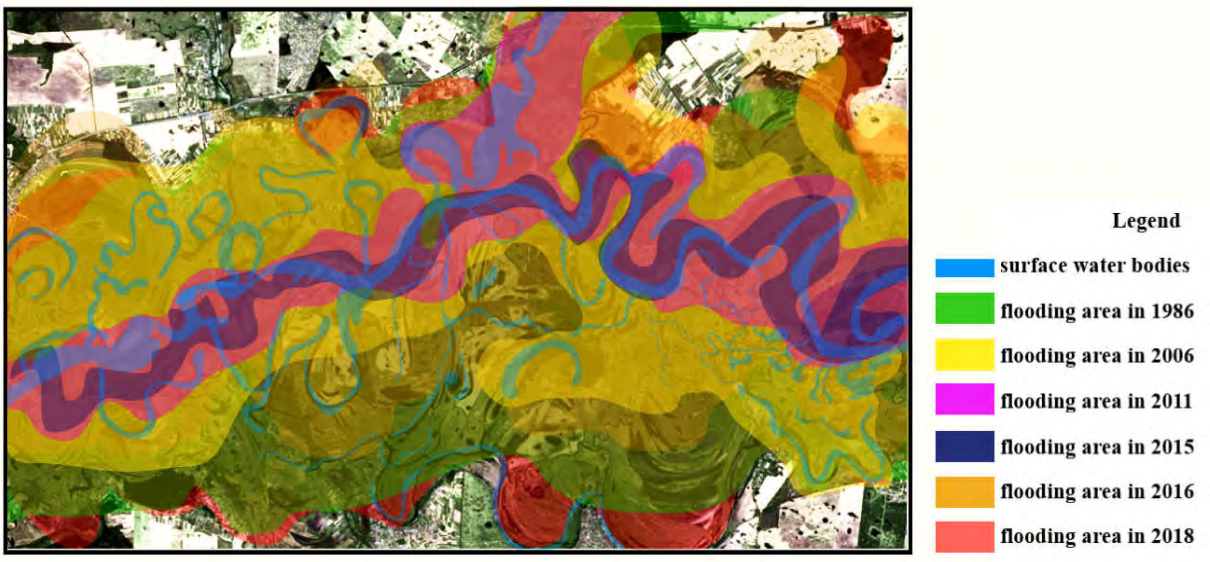

Figure 3 *Dynamics of flooding in the Desna river basin according to remote sensing data for the spring period of 1986-2018*

According to the data obtained from Figure 3, it has been established that the size of the flooding zones is determined by the natural decrease in the relief of the territory of the Desna River basin. The main causes of technogenic flooding in settlements in the Desna River basin are: violation of the conditions of surface water runoff by various types of construction, due to the development of water erosion of the channel, as well as the destruction of the above-floodplain terrace, on which roads, engineering structures, and residential buildings are mainly built. Also, in the zone of possible flooding, there are treatment facilities that belong to housing and communal services, which discharge

wastewater into surface water bodies, and this directly affects the condition and quality of surface water within the Desna River basin of the Chernihiv region.

Conclusions

Thus, the study of the state of surface water bodies is possible using the spectral index of the Normalized Difference Water Index (NDWI), which studies the dynamics of changes in the area of surface water bodies within the Desna River basin in different years. It has been established that the areas of flooding and the intensity of the process are constantly changing. Also, the long-term dynamics of flood development in the Desna River basin were investigated using satellite images for different years. It was determined that the process of flooding becomes more active in high-water years in those areas where natural (climatic) factors are dominant. According to the results of the study, a map of the long-term dynamics of flood development in the Desna River basin in the territory of the Chernihiv region was constructed.

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