GEOINFORMATICS 2020

EAGE

17521

Assessment of changes a number of surface water bodies within the sub-basin of the Desna River using remote sensing materials

***L. V. Plichko**, **V. I. Zatserkovnyi** *(Taras Shevchenko National University of Kyiv, Institute of Geology)*, **V. K. Khilchevskyi** *(Taras Shevchenko National University of Kyiv)*, **M. Mizernaya**, **A. Bakytzhan** *(D. Serikbayev East Kazakhstan state technical university)*

SUMMARY

Assessment of changes a number of surface water bodies within the sub-basin of the Desna River using Remote Sensing (RS) materials. To assess changes in the number of surface water bodies, the Normalized Difference Pond Index (NDPI) was used. As a result, we obtained a series of images of the study area from all Landsat-8 scenes from April-October 2018, illuminating changes in the parameters of surface water bodies over this period. It is established that the use of the NDPI index makes it possible to estimate the amount and seasonal change in the area of surface water bodies (ponds and reservoirs) in the study area.

Introduction

Accordingly with the development of technologies and processing of remote sensing (RS) materials, requires a detailed study of geosystems and their components, including water bodies using satellite imagery. Thus, effectively solve geo-ecological problems in any territories, reliable information is needed on the number of surface water bodies formed as a result of anthropogenic impact on the surface water of the Desna River sub-basin. Since satellite images are mainly used to study adverse hydrological phenomena, or periodic changes in various geological characteristics of a surface water body. Therefore, important to use the NDPI (Normalized Difference Pond Index) estimate the number of surface water bodies within the sub-basin of the Desna River using remote sensing materials.

Method and/or Theory

1. Study area

In fact, regulate the river runoff on the territory of the sub-basin of the Desna river 1 863 artificial reservoirs (reservoirs and ponds) were created, with a total area of the water mirror of 10,7 thousand ha, in which 203,4 Mm^3 of water were regulated (Grebin et al., 2014).
Therefore, for a quantitative assessment of artificial surface water bodies, the section of the Desna River was selected, which located from the Seim River to the city of Chernigov and belongs to the third terrace of the Desna River basin with an area of 0,97 thousand square kilometers (3.04% of the Chernihiv region), which lies on the Dnieper flat country of Chernihiv Polissya (Derikolenko et al., 1975).

Figure 1 *The location of the study area of sub-basin of the Desna River*

On fig. 1 surface of the study area - gently alluvial valley, complicated by depressions, saucer lake, which in turn leads to an uneven distribution of moisture in the soil. There are loess “islands”. The hydrographic network of area belongs to the Desna River Basin and its tributaries of the Oster River. On the territory of the river there flow 7 rivers with a length of more than 10 km with a total length of 121 km, including the large Desna River (the length in the region is 34 km), as well as such small rivers as Veresoch (39 km), Bystraya (14 km), Ugor (14 km), Vzdvyzha (16 km) (Derikolenko et al., 1975; Simonenko, 1958). There are 132 natural and artificial surface water bodies in the territory, of which: 94 lakes with a total area of 488,0 ha; one pond of 8,5 hectares; 37 ponds with a total water mirror area of about 42,4 ha (Report, 2018). The first pond belongs to the category of «small», the other 37 – «very small» (Khilchevskyi, 2017). Since most of the artificial surface water bodies are built on small rivers, therefore, the water flow of these rivers is regulated by 30-70%. The source of filling of artificial surface water bodies - rain, melt, groundwater (Simonenko, 1958).

2. Method

The NDPI algorithm was developed by J.P. Lacaux (Lacaux et al., 2007). The NDPI is expressed in the short-wave infrared (SWIR) and Green spectral coefficients:

$$NDPI = (Green - SWIR) / (Green + SWIR) \quad (1)$$

The value of the NDPI index for water should be negative and the range of the index is from 0.5 to 0.5. The boundaries of the NDPI index value can change under atmospheric influences. That is why, NDPI allows not only to recognize between small natural and artificial surface water bodies (up to 0.01 ha), but also identify vegetation inside ponds from vegetation outside them (Lacaux et al., 1975).

Examples (Optional)

For the region under study, as part of the Polisskaya natural and climatic zone, a large number of ponds is characteristic. In total, there are 132 reservoirs in this territory, of which: 94 lakes with a total area of 488.0 ha; 1 small pond with an area of 8.5 hectares; 37 - «very small» ponds with a total water mirror area of about 42.4 ha (Report, 2018). The distribution of artificial surface water bodies in the study area according to information from various sources is shown in table 1.

Table 1

The total number of artificial surface water bodies of the Kulykivskyi district of the Chernihiv region according to data from various sources (sub-basin of the Desna river)

Administrative district	The number of artificial surface water bodies	
	According to the materials of the Desnyanskiy BUVR (Report, 2018), piece	According to remote sensing materials, 2018 p., piece
Kulykivskyi	38	86

According to remote sensing data, found 86 surface water bodies in the study area. Thus, it is 48 water bodies more than in the modern statistical reporting of the Desnyanskiy BUVR for 2018, this is due to the fact that during the inventory of the number of artificial surface water bodies less than 0.5 ha were not account ponds - categories «very small» (Grebin et al., 2014).

To quantify artificial surface water bodies using the Normalized Difference Pond Index (NDPI), we selected an image from two different satellites Landsat 8 and Sentinel-2 L2A from 04/30/2018 to 10/07/2018, with cloud cover - 0%, angle 46- 51 °.

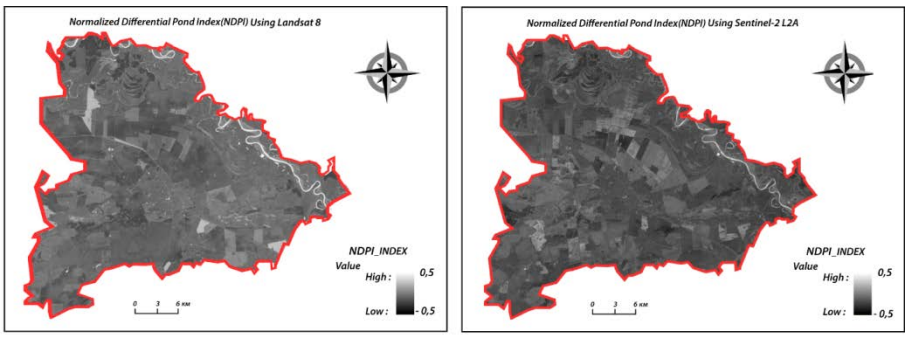

Figure 2 *Quantification of artificial surface water bodies in the Desna sub-basin using the NDPI*

A comparative analysis of images (Fig. 2) from various satellites showed that the number of artificial surface water bodies obtained from the Landsat 8 is slightly larger (86) than of the Sentinel-2 L2A (38). This is due to the Sentinel-2 L2A satellite does not count surface water bodies whose size less than 0.5 ha. Therefore, for further research in assessing changes in the state of artificial surface water bodies, satellite images from Landsat 8 were chosen.

The list of artificial surface water bodies of the Kulykivskyi district for individual settlements is shown in table 2.

Table 2

Distribution of artificial surface water bodies of the Kulykivskyi district of the Chernihiv region by individual settlements (sub-basin of the Desna River)

№	Locality	The number of artificial surface water bodies according to the Desnyanskoho BUVR (Report, 2018), piece	The number of artificial surface water bodies according to remote sensing data, 2018 p., piece
1.	Avdiivka village	1	7
2.	Baklanova Muravika village	4	4
3.	Vershinova Muravika village	8	8
4.	Veresoch village	1	5
5.	Vybli village	1	5
6.	Gorbiv village	2	5
7.	Drimaylivka village	1	5
8.	Drozdivka village	4	6
9.	Zhukivka village	-	3
10.	Kladkivka village	-	6
11.	Kovchin village	2	6
12.	Orlovka village	4	5
13.	Saltykova Divutsa village	-	4
14.	Smolyanka village	2	4
15.	Hubalivka village	3	4
16.	Kulykivka village	2	9
Total		38	86

In table 2 and on fig. 3 shows the number of artificial surface water bodies that have been studied since 30/04/2018 to 10/07/2018 on the territory of the Chernihiv region of the Desna River Basin. As can be seen from the table 2, using remote sensing methods were found small ponds in some villages, according to statistical reporting, they are not listed (the villages of Zhukivka, Kladkivka, Saltykova Divytsa).

Also, using images obtained from all Landsat-8 scenes from April-October 2018 (Fig. 4), studied the changes in the surface water bodies over this period. As a result, images were classified using two colors from 0 to 0,5 blue (surface water bodies) and from -1 to 0 white (land).

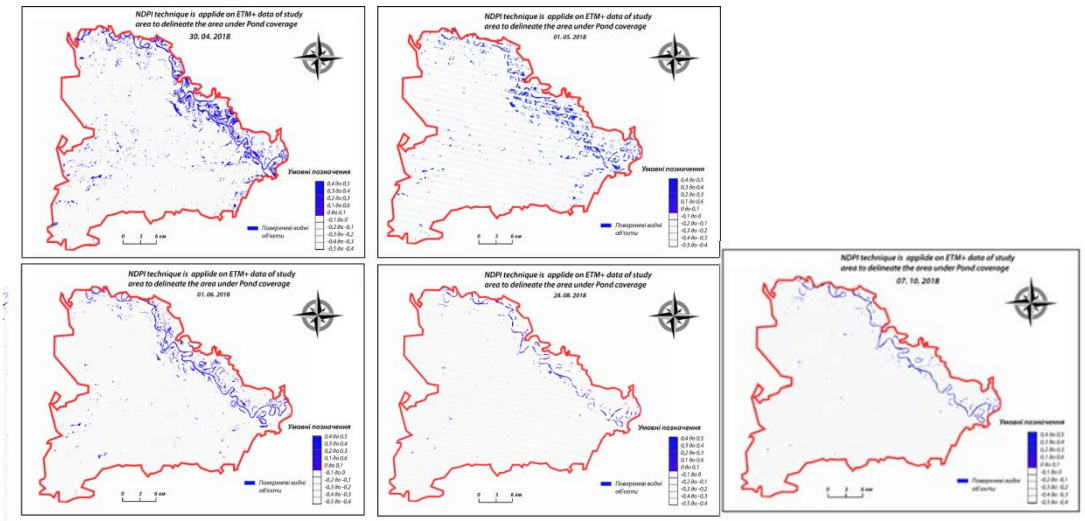

Figure 4 *The results of the assessment of the area of surface water bodies and the seasonal change in their number in the sub-basin of the Desna River*

As can be seen from fig. 4 in April 2018, during the spring flood, the surface water bodies in the study area occupy 3,456,18 ha (3,72% of the total area of the study area). In May 2018, the area of water bodies was 2519,64 ha (3,69%). In June, 2018, the area of water bodies is 1328,58 ha (1,51%). In August 2018, the area of water bodies in the study area was 534,69 ha (0,65%), and in October of the this year - 903,80 ha (0,93%). The data obtained indicate that with increasing temperature the evaporation becomes much greater and surface water bodies begin to dry out. Obviously, this dynamics should be associated in general with climatic conditions (in addition, this is due to the fact with the regime of precipitation in the study area).

Conclusions

Thus, the studies show that remote sensing methods can significantly clarify the number of artificial surface water bodies within the study area in the direction of increasing their number compared to statistical data. This turns out to be an additional unaccounted for local resource.

The use of the Normalized Difference Pond Index (NDPI) provides an objective assessment of the seasonal dynamics of the surface water bodies in the study area, and can significantly complement the planning for their use throughout the year.

References

Derikolenko O.I., Pistuna M.D., Machikhina F.M., Ischuk S.I. [1975] Chernigiv region: (economical and geographical characteristics), Kyiv, 165 p. (in Ukrainian).

Grebin V.V., Khilchevsky V.K., Stashuk V.A., Chunaryov O.V., Yaroshevich O.E. [2014] Water Fund of Ukraine: Artificial reservoirs - reservoirs and ponds: Directory. Kyiv, Interpress LTD, 164 p. (in Ukrainian).

Khilchevskyi V.K. [2017] Functionally-genetic and hydrochemical classification of ponds. *Hidrologiia, hidrokhimiia i hidroekologiia*, **3 (46)**, pp. 6-11. (in Ukrainian).

Lacaux J.P., Tourre Y.M., Vignolles C., Ndione J.A., Lafaye M. [2007] Classification of ponds from high-spatial resolution remote sensing: Application to Rift Valley Fever epidemics in Senegal. *Remote Sens*, Environ, **106**, pp. 66–74. (in English).

Report on the state of the environment in the Chernihiv region in 2017 [2018] Department of Ecology and Natural Resources of the Chernihiv Regional State Administration, Chernihiv, 276 p. (in Ukrainian).

Simonenko V.D. [1958] Chernigiv region: (Geographical sketch), Kyiv, 152 p. (in Ukrainian).