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To cite this article: E N Sagatbaev *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **395** 012047

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A spatio-temporal analysis of the Teniz-Korgalzhyn trench geosystems based on the Landsat and Sentinel satellite image decoding materials

E N Sagatbaev², E P Krupochkin¹ and A N Dunets¹

¹ Altai State University, 61 Lenina prosp., Barnaul 656049 Russia

² L. N. Gumilyov Eurasian National University, 29/1 Shakarim Khudaiberdiuly, Nur-Sultan 010000 Republic of Kazakhstan

E-mail: sagatbaeve@mail.ru

Abstract. The article presents a unique research on the Teniz-Korgalzhyn trench geosystems. Using the computer-aided decoding of multi-zone satellite imagery, the space-time patterns of the structure, functioning, and dynamics of the development of landscape components of the studied area are determined. Using the functionality of contemporary instrumental GIS and interpretation algorithms, the indicators of productivity of geosystems and anthropogenic transformation are determined. Significant anthropogenic factors that do not have a ubiquitous, but local influence on the dynamics of geosystems in the context of significant changes in the ratio of moisture and productivity are established. Conclusions on the need to control anthropogenic influence and ensure the rational use of resources of the territory are made, treating them as a factor of sustainable development.

1. Introduction

The flooded areas, as well as geosystems of runoff dispersion zones in the Teniz-Korgalzhyn lake-flow system, have a significant diversity of biota and high productivity in the Republic of Kazakhstan. A scientifically based assessment of the state, structure, and dynamics of the functioning of these geosystems is required to maintain their ecological balance and to ensure the necessary watering of wetlands.

The research purpose is to conduct a spatial-temporal analysis of the structure and dynamics of the Teniz-Korgalzhyn trench geosystems based on using the computer-based thematic decoding of space imagery. The estimated parameters of terrestrial natural geosystems include the following: slope steepness, maximum collection area, horizontal curvature, maximum curvature, illumination. The parameters of aquatic geosystems (river and lake) include the following: an organic carbon content, humidity, soil reaction, hydrolytic acidity, saturation with bases, a mobile iron content, a granulometric composition. In turn, the parameters of the anthropogenically transformed geosystems (arable land, fallow lands, downed pastures) include the spectral brightness characteristics of vegetation, which are detected from multi-zone images, as well as the elevated phytomass reserves (calculated using the NDVI index).



2. Materials and Methods

The geosystem approach is adopted as a methodological basis. It allows one to establish the distribution of natural complexes of different rank. A geosystem is a part of a territory characterized by uniform terrain, one type or subtype of soil, and a set of plant communities with general species composition and productivity, a similar response to natural and anthropogenic influences, and resistance to them [1], [2].

To determine the boundaries of geosystems and study their dynamics, we used scenes of coatings with the Landsat and Sentinel images. These images were selected from the summer, spring and autumn seasons with the lowest cloudiness. A set of large-scale topographic maps of the region (1: 500 000 - 1: 200 000) were used in the complex with images.

Meanwhile, there is a certain specificity of working with these data. For example, the Landsat TM images are presented in series of different years, from 1982 to 2018. But there is a certain difference between them in the structure of the data itself. The Landsat 5 has the following channel structure: VIS (3), NIR (1), SWIR (2), TIR (1); the Landsat 7 is panchromatic, multispectral: VIS (3), NIR (1), SWIR (2), TIR (1), with a plan resolution of 15 m for the panchromatic channel and 30 m for the multispectral zone; the Landsat 8 is panchromatic, multispectral: VNIR (6), SWIR (2), TIR (2), with a resolution of 15 m for the panchromatic channel, 30 m for the near and middle zone of the spectrum and 100 m for the thermal zone.

To highlight the boundaries and classify the components of geosystems, all the initial data of the remote sensing data were converted into mosaic coatings developed in the ENVI 5.0 program with a spatial resolution of 30 m (1982 - 2013).

For the collection and processing of a modern data slice (2014–2018), remote sensing data from the Sentinel satellites of the 1, 2 series were used in the research.

The first Sentinel-1A radar satellite was first launched into orbit by the European Space Agency (ESA) on April 3, 2014. It became the first in the satellite constellation of the global monitoring of the environment and safety Copernicus. The Sentinel-1A is developed by the Thales Alenia Space. The C-SAR synthesized an aperture radar equipment (developed by Astrium) being installed on board. It provides all-weather and round-the-clock delivery of satellite imagery.

The Sentinel-2A, 2B satellites of the second series are equipped with an optical-electronic multispectral sensor for surveys with a resolution of 10 to 60 m in the visible, near-infrared (VNIR) and short-wave infrared (SWIR) zones of the spectrum. This ensures the display of differences in the state of vegetation, including temporary changes, and it also minimizes the impact on the quality of shooting the atmosphere. In their class, their capabilities correspond to the Landsat-7 and SPOT-5 images.

In the process of thematic processing of images, the calculations of the MNDWI and NDVI indices with the construction of index maps for the entire territory of the Teniz-Korgalzhyn system were applied. NDWI is a measure of the moisture content of soil and leaves [3]. The spectral brightness values in the green (Green) and near-infrared (NIR) spectral ranges are used for the following index calculation:

$$\text{NDWI} = (\text{Green} - \text{NIR}) / (\text{Green} + \text{NIR}),$$

where “Green” is the reflection in the green region, and “NIR” is the reflection in the near infrared region of the spectrum. NDVI (Normalized Difference Vegetation Index) is an indicator of photosynthetically active biomass on the Earth’s surface. The values of spectral brightness in the red and near infrared spectral regions are used to calculate it:

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red}),$$

where “NIR” is the reflection in the near infrared region, and “Red” is the reflection in the red region of the spectrum.

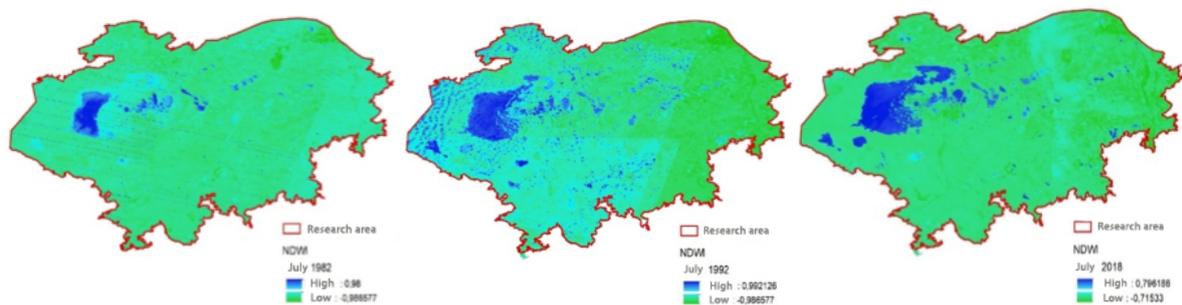


Figure 1. The moisture dynamics of vegetation cover, calculated from the values of NDWI: 1982, 1992, 2018.

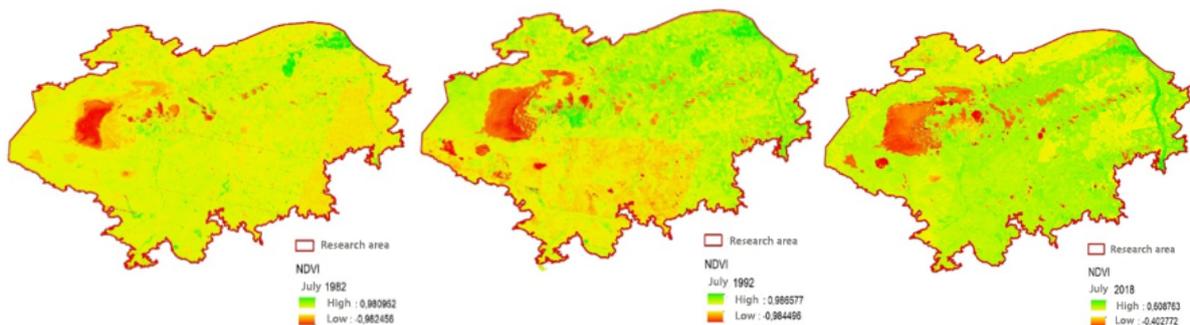


Figure 2. Vegetation intensity dynamics of vegetation, calculated from the NDVI values: 1982, 1992, 2018.

All our calculations of the indices made it possible to obtain a series of derived images, describing the degree of moisture content of geosystems as one of the agroclimatic indicators, and the intensity of vegetation as an indicator of the state (see Figures 1, 2). A visual and representative analysis of the images allowed us to establish a general trend for the increasing influence of moisture (uneven, with fluctuations in individual periods). For example, in 1992, there was an increase in moisture content not only in the floodplain plains, but also in the denudation plains with a shrub-wormwood-grass vegetation, as well as in the diluvial-proluvial plains with a shrub-wormwood-tyrsa vegetation on chestnut soils, in lakeside alluvial plains with meadows, wormwood, and fescue-wormwood fractions on solonetz and meadow salt marshes with dark chestnut soils. After 20 years, there was a slight decrease in moisture content, which naturally affected the landscapes. So, for example, by 2018, we observe the concentration of moisture mainly in floodplain and lake-alluvial plains with wormwood, feather-grass and meadows on dark-chestnut soils with saline soils (Fig. 3).

The values of the NDVI index are quite strongly correlated with the distribution of NDWI; however, there are some differences. The meridional zones of average degree of moisture (this can be seen in the eastern part of the territory) practically do not manifest themselves on NDVI maps. The NDVI index values here are either medium or higher. From here, we can assume that the productivity of geosystems here depends not only on the nature of wetting, but also on other factors, such as anthropogenic influence, growth of natural / biological load on ecosystems, changes of microclimate in a less favorable direction, etc.

3. Results

In the course of the research, the following was obtained: a generalized map of the Teniz-Korgalzhyn trench geosystems; on the basis of a digital terrain model SRTM, as well as on the basis of interpretation and study of space-time changes of the Teniz-Korgalzhyn lake-flow system, a new landscape map was built.

In the classification of geosystems, three orders were identified: (1) terrestrial natural, (2) terrestrial and anthropogenically transformed, and (3) aquatic.

Natural geosystems include such areas in which the anthropogenic impact has not reached

significant dimensions; moreover, they are only slightly altered by human activity. At the same time, a part of terrestrial geosystems, which have lost their natural soil and vegetation cover, is considered as terrestrial anthropogenically transformed, or rather the natural-anthropogenic geosystems. To aquatic geosystems, we assign the geosystems of the water surfaces of numerous lakes and large rivers.

Two sub-systems emit when studying the Teniz-Korgalzhyn trench: The Middle-Nura sub-geosystem and the Lower-Nura sub-geosystem, whose development is timed to the Nura river runoff within the basin, where space-time connections of channel-forming processes dominate from the source to the mouth.

The digital model of the territory was created using the materials of the SRTM survey. It allowed to identify, in combination with soil conditions, vegetation and geological and geomorphological conditions, the prevailing types of landscapes, as well as to assess their condition and degree of resistance to anthropogenic impact.

So the dominant landscapes are denudation plains with a shrub-wormwood-grass vegetation, deluvial-proluvial plains with a shrub-wormwood-tyrs vegetation on chestnut soils, lacustrine-alluvial plains, wormwood, and fescue-wormwood groups on saline and meadow salt marshes with the participation of dark chestnut soils, etc.. The main forms of relief are flat and low-slope, flat geosystems prevail in the territory, but low-slope geosystems and sandy arrays are also characteristic.

In general, it is fair to say that the patterns of distribution of geosystems of a region are determined by the following interrelated factors: climatic conditions and the geological and geomorphological structure of the territory. It is the ratio of these factors that causes a significant diversity and contrast of habitats. However, over the past few decades, as follows from the analysis of multi-temporal images, while maintaining all the prevailing landforms and its morphometric properties, other factors such as climate and soil cover have changed significantly, and anthropogenic influence has increased.

4. Discussion

Based on the integration of classical geographic research methods with remote sensing methods and the GIS tool base, new data on the state, structure, and dynamics of the functioning of the Middle-Nura and the Lower-Nura sub-geosystems of the Teniz-Korgalzhyn trench were obtained.

For the study area, a soil map at a scale of 1: 200,000 was updated; in the ArcGIS environment, a new map of geosystems on a scale of 1: 200,000 and 1: 500,000 was compiled. The structure of the legend on the presented maps is based on the classification divisions of geosystems of various ranks. So, on the basis of the geosystem map, many aspects of differentiation and areal relationships between various sub-geosystems are identified. Thus, a detailed geosystem structure of the region is determined. Here it is worth noting the important role of information obtained from the interpretation of multi-zone satellite imagery in the form of structural components of the environment, classified and recognized in images of different spatial and radiometric resolutions.

In addition to the distinguished structure of geosystems, the value indicators, namely the soil-vegetation indices (NDWI, MNDWI, NDVI), are the basis for calculating their productivity. Many side factors (such as species composition of vegetation, closeness, condition, slope exposure and surface slope angles, soil color under sparse vegetation, etc.) affect their numerical values. For example, according to Rouse et al., 1973 and Krieglner et al., 1969, if the density of vegetation cover is more than 70%, the index is moderately sensitive to changes in the soil background [4], [5]. To avoid such situations that weaken the reliability and information capabilities of remote sensing data, remote surveys are best carried out along selected key areas and routes that best cover the diversity of the studied area.

5. Conclusion

Our studies clearly show the feasibility of using, along with the classical methods of physical-geographical research, innovative methods of remote environmental surveys based on the GIS tools and computer-aided decoding algorithms.

The established spatial-temporal changes in the state and structure of the Teniz-Korgalzhyn trench

geosystems make it possible to single out the following as key factors: climatic conditions, geological and geomorphological structure, and anthropogenic influence. The latter has a direct impact on the anthropogenic transformation of geosystems, which is confirmed by a decrease in the productivity of landscapes in the floodplain part and the most densely populated areas. However, it is fair to note that this does not fit into the overall dynamics. For example, a time analysis of July images from 1982 to 2018 shows a whole inverse pattern, i.e. an increase in vegetation activity. Perhaps this is a consequence of the improving microclimate of the territory as a whole, although it does not exclude the increased anthropogenic influence in local foci. The presented methodology can be recommended for mapping and monitoring land use, monitoring changes in vegetation, water resources.

References

- [1] Dzhanaleeva K M 2014 *Physical-geographical zoning of the Republic of Kazakhstan* (Almaty, Kazakhstan: EveroEvero)
- [2] Dunets A N 2000 Anthropogenic transformation of geosystems on the territory of the Altai Mining District In *Mountains and man: anthropogenic transformation of mountain geosystems* (pp 54-57) (Novosibirsk, Russia: Siberian Branch of the Russian Academy of Sciences Publishing House)
- [3] Xu H 2006 Modification of Normalized Difference Water Index (NDWI) to enhance open water features in remotely sensed imagery *International Journal of Remote Sensing* **27**(14) pp 3025-3033
- [4] Rouse J W, Haas R H, Schell J A, and Deering D W 1973 Monitoring vegetation systems in the great plains with ERTS In *Proceedings of the Third ERTS Symposium* (vol 1) (pp 309–317) (Washington, DC: NASA)
- [5] Kriegler F J, Malila W A, Nalepka R F, and Richardson W 1969 Preprocessing transformations and their effects on multispectral recognition In *Proceedings of the Sixth International Symposium on Remote Sensing of Environment* (pp 97-13) (Ann Arbor, MI: University of Michigan)