GeoJournal of Tourism and Geosites
ISSN 2065-1198, E-ISSN 2065-0817

Year XV, vol. 45, no. 4spl, 2022, p.1625-1632
DOI 10.30892/gtg.454spl12-983

DETERMINATION OF THE TOURIST POSITION OF LAKES OF WESTERN AND CENTRAL KAZAKHSTAN BY SPACE SURVEY

Moldir N. AZBANTAYEVA
L. N. Gumilyov Eurasian National University, School of Natural Sciences, Astana, Kazakhstan, e-mail: moldir.azbantaeva.90@mail.ru

Aknur B. SAGYNBAYEVA
L. N. Gumilyov Eurasian National University, School of Natural Sciences, Astana, Kazakhstan, e-mail: ago.kz@mail.ru

Yerzhan N. SAGATBAYEV
Astana International University, Higher School of Natural Sciences, Astana, Kazakhstan, e-mail: sagatbaeve@mail.ru

Sergey V. PASHKOV*
M. Kozybayev North Kazakhstan University, Department of Geography and Ecology, Petropavlovsk, Kazakhstan, e-mail: sergp2001@mail.ru

Citation: Azbantayeva, M.N., Sagynbayeva, A.B., Sagatbayev, Y.N., & Pashkov, S.V. (2022). DETERMINATION OF THE TOURIST POSITION OF LAKES OF WESTERN AND CENTRAL KAZAKHSTAN BY SPACE SURVEY. *GeoJournal of Tourism and Geosites*, 45(4spl), 1625–1632. https://doi.org/10.30892/gtg.454spl12-983

Abstract: The article reviews the methodology for assessing water bodies in the territories of Western and Central Kazakhstan. The concept of sustainable development of the region for recreational activities of this study is relevant. Literary sources of research of lakes of Western, Northern, and Central Kazakhstan are analyzed. The study area has excellent opportunities for the development of certain types of tourism. As a result of topographic and bathymetric surveys of water resources of geosystems, the most reliable morphometric data were obtained. Analyzing of the results of remote sensing data processing and index mapping made it possible to assess the area of lakes and determine their main metric characteristics. The article also evaluates the accuracy of the results obtained using various remote sensing materials. The geographical position of the lakes causes differences in the factors of formation of their hydrological regime. The altitude position of the studied lakes is also manifested in the peculiarity of the course of long-term changes in their characteristics. These received and processed research materials will be used for tourist and recreational activities. Recommendations on the tourist and recreational use of lake systems of Kazakhstan are given.

Key words: remote sensing, dynamics, mapping index, recreational potential, resource use, medical tourism, ecotourism

* * * * * *

INTRODUCTION

Currently, the concept of sustainable development has found wide application in the economic, social and environmental sphere of public activity. Tourism is considered to be one of the most active and important industries in many countries and plays a vital role, contributing to the economy of many developing countries. In addition, the tourism industry has provided governments with many opportunities to live in the global economic space, thereby stimulating economic development (Tokpanov, 2021). Tourism has become an important strategy for communities to achieve economic, social and environmental benefits that can contribute to the development of tourist destinations (Huseynli, 2022; Drozdov, 1999). Rapid growth of tourism has increased the role of the community in the tourism development, and scientific geographical research is needed in order to balance the status of communities and other relevant stakeholders in the development of tourism (Inskeep, 1991; Garbuk and Gershenzon, 1997; Akbar et al., 2020; Aliyeva et al., 2019). Depending on the remoteness of the territory of lakes from settlements, remote sensing requires, along with natural conditions, the determination of the tourist and recreational potential of lakes. With the help of remote sensing, methods for determining recreational suitability can be improved. Analysis and assessment of the recreational suitability of natural systems of steppe lakes using the traditional comparative geographical method, remote sensing methods and GIS technologies, regime control methods. Conducting an assessment of the recreational suitability of the territory on the basis of which the specialization of recreational and tourist activities was assumed. Determination of the natural environment and recreational opportunities of lakes using remote sensing during the study.

Natural and geographical factors in the development of tourism are manifested in the geographical location, relief, climate, banks of rivers, lakes and seas, underground riches (mineral waters, caves, etc.), flora and fauna, beautiful, rich nature. Natural and geographical conditions are decisive when tourists choose a place to visit. The wealth of natural resources, the possibility and convenience of their use have a huge impact on the development, pace and manifestations of tourism. An important role is played by the geographical position of the region or country, proximity to the sea, picturesque mountainous and wooded areas, the nature of the coastline, the position of the country in relation to the main suppliers of tourists, the presence of the region on important transit routes. Tourism geographical research using GIS technology can

* Corresponding author

show the current state of tourism factors and what changes have occurred over the years depending on the state of the land (Garbuk and Gershenzon, 1997). One of the components of the general problem of sustainable development of the territory is the problem of conservation of water geosystems, which arose against the background of an increase in anthropogenic load on the territories adjacent to water bodies. In this regard, there is a need to solve the problem of rational and efficient use of this category of land, which can be successfully implemented using reliable and up-to-date information about the state of water systems obtained by remote methods (Burlibayev et al., 2007).

The natural resources of Kazakhstan are unique and diverse. Along with the historical and cultural heritage, water bodies currently provide great opportunities for the recreational potential use, for the tourism development (Dmitriyev et al., 2022). The vastness of the territory, covering several natural zones - from the forest-steppe in the north to the southern deserts, from the landscapes of the Caspian Sea coast in the west to the forests of Altai in the east and the unique mountain systems of the Tien Shan - led to a high diversity of flora and fauna. The fauna of Kazakhstan is represented by a variety of species, both strictly protected and widely used for commercial and economic purposes.

There are 835 species of vertebrates, including mammals – 178, birds – 489 (of which 396 are nesting), reptiles – 49, amphibians – 12, fish 104 and round-mouthed - 3 species. The objects of hunting are 34 species of mammals and 59 species of birds (CBD Fourth National Report - Kazakhstan). Despite the fact that Kazakhstan is located almost entirely in the arid and subarid zone, a significant part of the natural ecosystems are wetland complexes, ranging from the Caspian Sea and large lake systems to thousands of fresh and salt lakes scattered on vast steppe plains. In the dry steppes and deserts of Central Asia, water plays a special role (Bragina, 2007). The uniqueness of the natural resources of Kazakhstan and its historical and cultural heritage provides great opportunities for the study and use of natural and historical and cultural sites, recreational potential, for the development of tourism in the Republic of Kazakhstan (Dmitriyev et al., 2022).The objects of this study are lakes of Western Kazakhstan belonging to the Caspian lowland and the Irtysh natural limnological region, as well as lakes of Central Kazakhstan belonging to the Central Kazakhstan region (Figure 1).

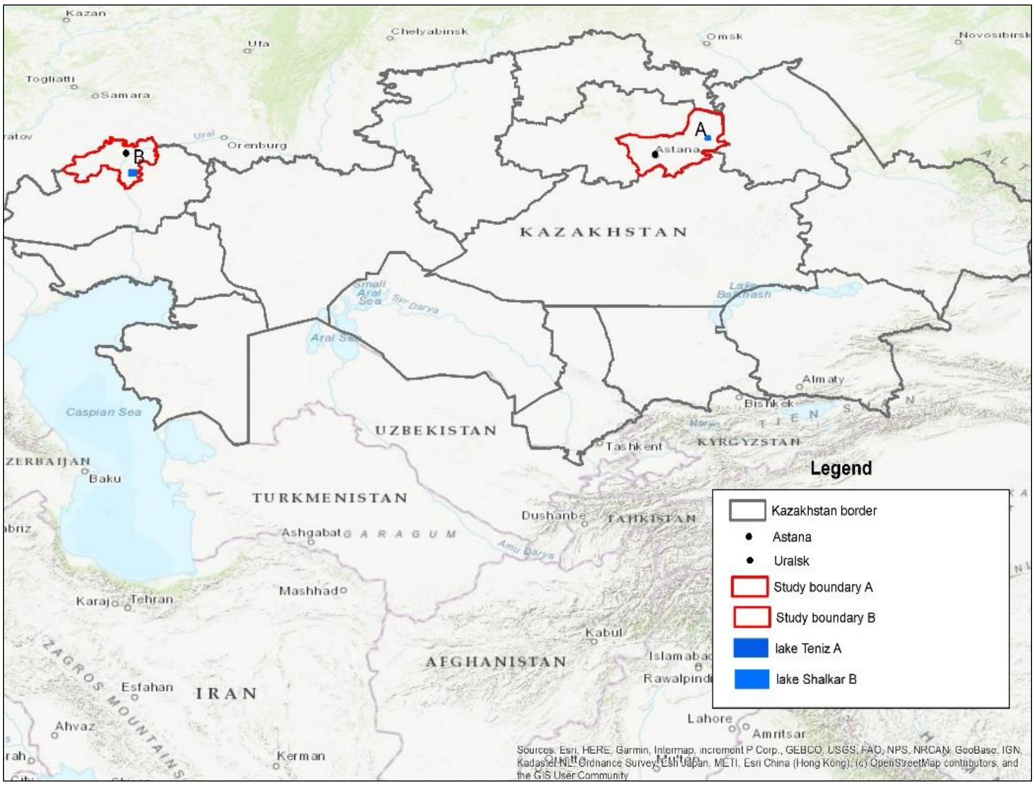


Figure 1. Geographical location of the territories of Western and Central Kazakhstan

The studied territory is located on the North Kazakh plain, bounded by Kazakh uplands from the south and southeast, and gradually merging with the Turgay Plateau in the west. Structurally, the North Kazakh Plain belongs to the West Siberian Plate, the basement of which is composed of intrusive and metamorphic pre-Paleozoic and Paleozoic rocks, is complicated by faults and is characterized by a stepped structure. In the direction of Western Siberia, the thickness of Mesocainozoic deposits does not exceed 300 m, and in the direction of the Irtysh valley, the foundation is submerged to a depth of more than 2 km. According to morphological features, the plain is subdivided into the accumulative plains of the Tobol, Ishim and Irtysh regions. The plains of the Tobol and Ishim regions are dissected by the Torgay hollow and make up the North Torgay or Kostanay plain (Mazhitova et al., 2018). They slightly differ from each other in morphology and developmental history.

In the extreme west of the Republic of Kazakhstan, the vast Caspian lowland extends. It corresponds to the central part of the syncline of the same name of the East European (Russian) platform. The Caspian lowland occupies the lowest hypsometric levels, having absolute marks from 29.6 below the level of the World Ocean (water edge of the Caspian Sea) up to 50 m. The north-eastern part of the North Kazakh Plain is occupied by the accumulative plain of the Irtysh region, slightly inclined to the north and east. Absolute marks decrease in the same direction from 120 to 110 m. Structurally, the plain was also formed within the Irtysh depression, the foundation of which gradually decreases towards the West Siberian invariability. The thickness of the Meso-Cenozoic deposits reaches 2000 m. The left-bank marginal parts of the plain at the junction with the Kokshetau Upland are complicated by flat-topped remnants (Sagatbayev et al., 2019).

In physical and geographical terms, Western Kazakhstan is located at the crossroads of Europe and Asia and is their connecting link. This location, between the relatively humid Eastern European steppes and the sultry deserts of Central Asia, led to a sharp continental and excessive aridity of the climate, the predominance of deserts and semi-deserts in most of the vast territory. The formation of natural conditions from the north is influenced by the East European Plain with a temperate climate and from the south - by Central Asia with a dry and arid climate. The territory of the region covers a significant part of the Caspian lowland, the southern spurs of the Zhalpy Syrt and the Ural Mountains, completely occupies the Mugodzhar Mountains and the Mangyshlak peninsula, the western desert part of Ustyurt.

Geographical and tourism bases allow or directly influence the development of tourism in the region. The environmental conditions of the region allow to develop certain types of tourism such as water, ecological, scientific, and other types of tourism. As a result of the topographic and bathymetric surveys, reliable morphometric data were obtained, which are presented in the articles of Muravlev (1973). These works represent the studies of the lakes of Western, Northern and Central Kazakhstan.A significant number of lakes belonging to the southern lake belt of the Northern Hemisphere are scattered over the vast expanses of Kazakhstan. According to Muravlev (1993) there are 48,262 lakes, of which 45,248 are small lakes with an area of less than 1 km². Lakes are especially numerous in the northern part of Kazakhstan, where there are many closed depressions. The Caspian lowland and Irtysh natural limnological area is characterized by a high amount of lakes (Table 1). The largest lake is aboutTeniz, located between the rivers Esil and Yertis. Its area is 3104 km². Central Kazakhstan's natural-limnological region is distinguished by a large number of lakes, but a smaller number of lakes (Table 1). The largest lake is Teniz with an area of 3104 km², the river flows into it.

Table1.The lake character of the territories located in the Central Kazakhstan Caspian lowland and the Irtysh natural-limnological area

Natural limnological areas	Number of lakes			total area lakes, km²	Area of regions km² as of 02/01/1967	Lakes territories,%
	Less than 1 km²	More than 1 km²	Total			
Caspian low land	3176	84	3260	908	151339	0.6
Irtyshskaya	2252	238	2490	1458	44 948	3.24
Central - Kazakhstan	4 879	327	5 206	3 104	155 001	2.0
Total:	7131	565	7696	4562	199949	5.24

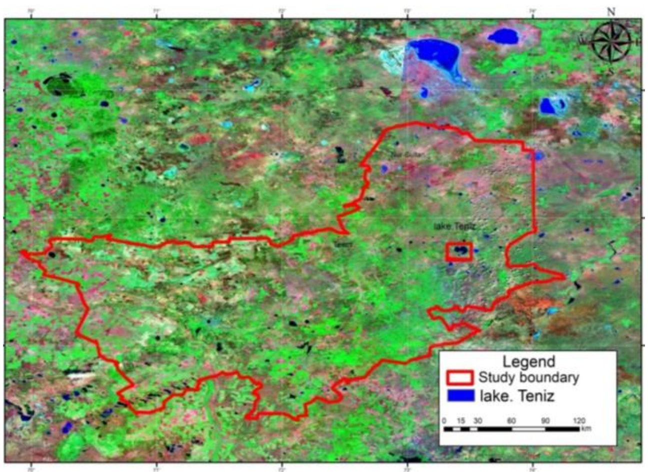


Figure 2. Geographical location of Lake Teniz.The Landsat-5 satellite image was used, https://www.usgs.gov/landsat-missions/landsat-5

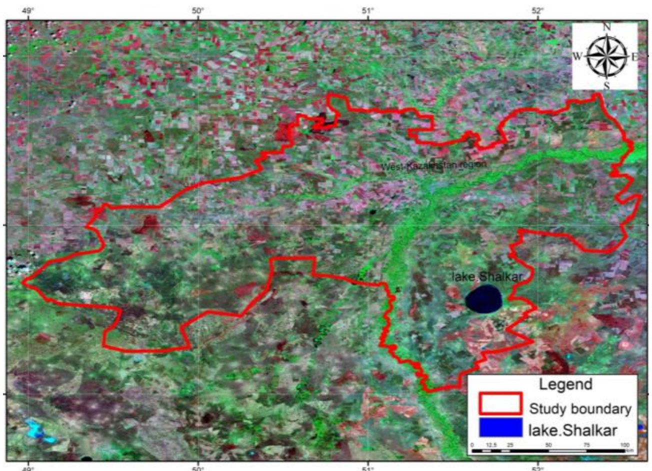


Figure 3. Geographical location of Lake Shalkar (Landsat-5 https://www.usgs.gov/landsat-missions/landsat-5)

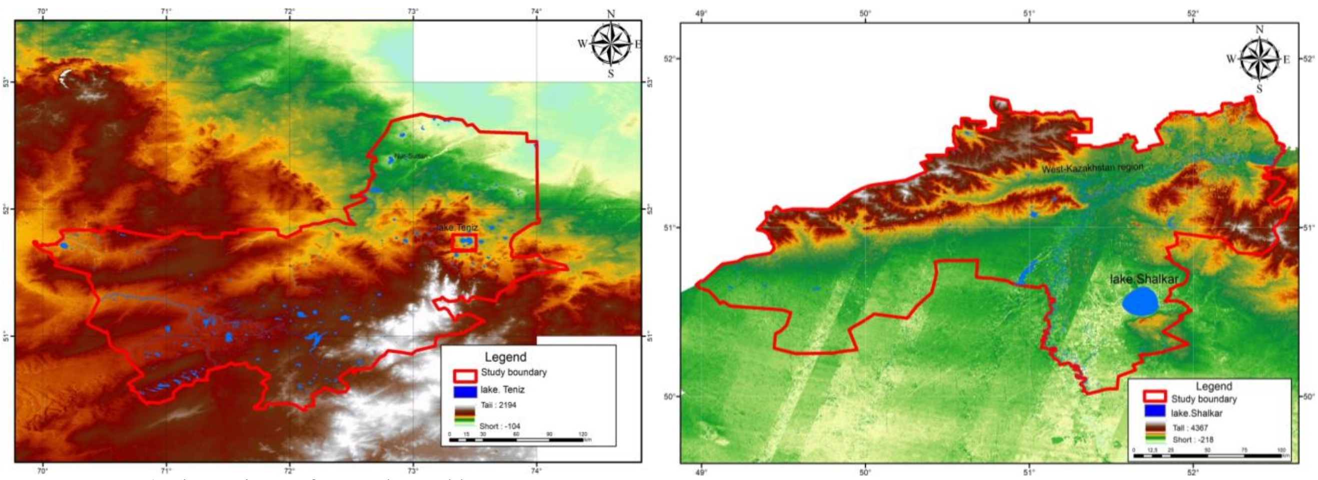
Lake Shalkar is located 100 kilometers from the city of Uralsk in the West Kazakhstan region. This natural reservoir is very ancient, it is a remnant of the former Caspian Sea (Figure 3).

The number and area of lakes are given without taking into account ponds, reservoirs and lakes. There are 2491 Plyosovye lakes with a total area of 49.79 km^2 (Muravlev, 1993). Lake basins belong to different genetic groups, which causes a wide variety of lakes in size, shape, depth, regime, and hydrochemical features. Differences in the genesis of basins depend both on endogenous factors - the latest tectonic movements, seismicity, rock lithology, and on exogenous factors – the action of river erosion, wind, ice, karst, suffusion, and gravitational processes. At the same time, one cannot ignore the changes caused by human activities and climate fluctuations (Seliverstov, 1990). Currently, these lakes are mainly used in agriculture, some are considered as a recreational areas and for the protection of aquatic life. The study of the tourist opportunities of these lakes and other objects without the use of remote sensing causes difficulties, since the vast territory, the complex morphostructure of the relief, and the lack of knowledge for the development of tourism. Lake Teniz is located in the Akmola region in the Korgalzhyn district of Central Kazakhstan, southwest of the country's capital city of Nur-Sultan (Figure 2) (Dzhanaleeva, 2014). The total area is 304 m (Sagatbayev et al., 2019). In recreational geography, recreational limnology is engaged in the study of natural-territorial complexes consisting of a reservoir and adjacent territory, for the purpose of recreation, health promotion and restoration of physical and psycho-emotional forces of a person (Akhmatov, 2005).The assessment of the recreational potential of lakes for organizing recreation in general is usually based on 4 main aspects: functional, sanitary-hygienic, psychological-aesthetic and technological (Kalov, 2012).

RECREATIONAL POTENTIAL OF LAKES

The lake is characterized by relatively shallow depths, in windy weather, it is completely covered with waves with white caps, it resembles a real sea with the sound of the surf, which is especially noticeable near the shore. The slightly saline waters of the lake, with their rich food, create excellent conditions for the reproduction of fish and waterfowl, so it has long been a recognized place for fishing and hunting. It has great potential for recreation and tourism.

Scientific research on Lake Shalkar started at the beginning of the 20th century. It was scientifically substantiated that the lake was formed on the site of a destroyed salt dome, the edges of which are considered to be Mount Santas. Chalk Mount Santas is located on the northern shore of Lake Shalkar (Sarsenov, 2004). It has an elongated shape, from south to north, with a length of 7-8 km. The height of the hill is small, about 20 km, but it noticeably rises above the water surface of the lake and the flat surrounding steppe. From the south, the mountain is adjoined by a saline plume covered with saline. Lake Shalkar is a natural monument; it is protected by the state. The Shalkarbiohydrological reserve was organized by the decision of the regional administration in 1992. It occupies 260.0 thousand hectares, including the water area of the lake. Shalkar, Alzhan and their immediate surroundings within the Akzhaik region. Lake Shalkar occupies up to 242 sq. km. With a length of 18.4 km, a width of 14.7 km and a depth of up to 18 m, it collects about 1.1–1.4 billion cubic meters liters of water. The water is brackish - various salts contain up to 4.6 grams per liter, of which 2.5 gram are chlorides. It has a therapeutic and health-improving effect. The lake is fed by river runoff - Yesenankaty, Sholakankaty and by a channel from the river Ural. In high-water years, part of the water is discharged through the Solyanka canal to the Urals. The geographical location of lakes causes differences in the factors of the formation of their hydrological regime. The altitudinal position of the studied lakes is also manifested in the peculiarity of the course of long-term changes in their characteristics. Therefore, all metric measurements were carried out taking into account three-dimensional terrain models (Figure 4).



a) The territory of Central Kazakhstan b) The territory of Western Kazakhstan

Figure 4. Digital model of the relief of the studied territories

The digital model of the studied territories relief demonstrates the Lake Teniz and the Nura River at 300–500 m above sea level. The Shalkar lakes have been formed in the alluvial sediments of the high terrace of the Caspian lowland at altitudes from 100 to 300 m above sea level (Sagatbayev et al., 2019). At altitudes from 100 to 300 m above sea level in alluvial deposits of a high terrace Caspian lowlandselongated lakes formed (Lake Shalkar). On lacustrine-alluvial plains with a height of 100 to 300 m, the largest reservoirs are located, surrounded by lake terraces (large and small Teniz).

As a result of our cartographic measurements, the following data were obtained on the size of the largest lakes in Western and Central Kazakhstan (Table 2). For individual lakes in Western and Central Kazakhstan, there is other information about the size (Muravlev, 1993).

Table2.Morphometric characteristics of the studied objects

Lake	Catchment area, thousand km²	Absolute height, m	Lake area, km²	Length, km	Width, km	Maximum depth, m	Water volume, km³
Shalkar	20	16.7	242	19	15	18	1.1
Teniz	94.9	304	1162	74	40	8	0.6

Earth remote sensing (ERS) methods were used to study the dynamics of lakes. In the framework of this study, the area of lakes is understood as their size at a specific point in time (at the time of satellite imagery). In the framework of this study, the area of lakes is understood as their size at a specific point in time using satellite imagery. Square kilometers are used as the area unit, since this unit of measurement is most often used to work with areal objects in various geographic information systems (GIS). The method of aerospace sensing is based on the use of images, which, as practice shows, represent the greatest opportunities for a comprehensive study of the Earth's surface. DZ methods are based on the use of sensors that are placed on spacecraft and register electromagnetic radiation in formats that are much more adapted for digital processing, and in a much wider range of the electromagnetic spectrum. Most DZ methods use the infrared range of reflected radiation, thermal infrared radiation and the radio range of the electromagnetic spectrum. Satellite images were used to study the condition of lakes, for example, the area of the water surface. In the course of the study, such an indicator of the state of lakes as the area of the water surface was estimated-thisareal characteristic that constantly changes with time. In our studies, the water surface area is about lake surface F (km^2) excluding islands. The most important morphometric parameters should also includethe length and width of the lakes, as they allow you to determine the area of the water mirror, the length of the coastline, the volume of water in the reservoir, and other indicators. The length of the lake L (km) is the shortest distance between the two most distant points of the coastline of a reservoir, measured along its surface. Average Width (km) is the quotient of dividing the surface area of the reservoir F by its length; maximum width Bmax (km) – the greatest distance between the banks along the perpendicular to the length of the reservoir.

These indicators are needed not only for the exploitation of lake territories, but also for the development of scientific and recreational tourism. The metric characteristics of the lakes were calculated from satellite images Landsat-5.8 ERS-2, Quick Bird (Smith et al., 2007), whichmade it possible to observe the seasonal and long-term dynamics of lake areas (Figure 3). The choice of images was also determined by the availability of a data archive for more than thirty years, which made it possible to trace the intra-secular cycles of lake level fluctuations. An important task was to identify seasonal fluctuations in lakes (Erokhin and Kopylov, 2002). To solve this problem, we analyzed a series of images taken in different years. To observe the rhythm of the lakesRadar images were used in the Irtysh natural limnological region (Garbuk and Gershenzon,1997), which are not affected by the cloudiness typical for this area, especially in the warm season. Despite their application, special attention was paid to the issues of assessing the accuracy of remote measurement of lake areas using optical and radar images, since it is a difficult task to conduct a quantitative analysis of the dynamics of saline and flowing areas under global climate change (Kashkin and Sukhinin, 2001).

METHODOLOGY

The results of field research, methods of statistical processing, mathematical analysis, and mapping have been used in this research. The integrative indicator, which is calculated by the weighted average method, has been used to assess the level of recreational potential of each district (Semochkina, 2012; Baryshnikov et al., 2019; Dmitriyev et al., 2021). Analysis of the accuracy of remote measurement of lake areas using Landsat-5 and Landsat-8 and ERS-2 images was carried out by comparing the results of measurements of lake areas taken from these images with the data of area measurements on Quick Bird images, which were considered as reference ones due to their rather high resolution (Moiseenko, 1994). In studies of the measurement error of lake areas, images of the same year were selected. Measurements of the areas of lakes on satellite images were carried out using ENVI 5.0 tools.

To determine the boundaries of the lakes and study their dynamics, we used scenes of coverage by Landsat and Sentinel images. The images were selected for the summer, spring and autumn seasons with the lowest possible cloud cover. In combination with images, large-scale topographic maps of the region (1:500,000–1:200,000) were used. Meanwhile, there is a certain specificity of working with this data. So, for example, Landsat TM images are presented in a series of different years, from 1982 to 2018. But between them, there is a certain difference in the structure of the data itself. Landsat 5 has a channel structure – VIS (3), NIR (1), SWIR (2), TIR (1); Landsat 7 – panchromatic, multispectral: VIS (3), NIR (1), SWIR (2), TIR (1) with a horizontal resolution of 15 m for the panchromatic channel and 30 m for the multispectral zone; Landsat 8- 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 identify the boundaries and classify the components of geosystems, all the initial remote sensing data were converted into mosaic coverages developed in the ENVI 5.0 program with a spatial resolution of 30 m (1982–2013).

To collect and process the modern data slice (2014 - 2018), remote sensing from the Sentinel–2 satellites series was used in the studies, whichwere launched into orbit on April 3, 2014, by the European Space Agency (ESA). It became the first in the space constellation of satellites for global monitoring of the environment and safety Copernicus. Sentinel-1A was developed byThalesAlenia Space. C-SAR synthetic aperture radar equipment (developed by Astrium) is installed on board, which provides the all-weather and round-the-clock supply of space images. In the process of thematic processing of images, calculations of NDWI, MNDWI and NDVI indices were applied with the construction of index maps for the studied territories (Tek, 2018). NDWI is an indicator of the moisture content in the soil and leaves of plants. To calculate the index, spectral brightness values in the green (Green) and near infrared (NIR) spectral ranges are usedterritories (Tek, 2018):

$$NDWI = (Green - NIR) / (Green + NIR), \quad (1)$$

where Green is the reflection in the green region, NIR is the reflection in the near infrared region of the spectrum.

NDVI (Normalized Vegetation Difference Index) is an indicator of photosynthetically active biomass on the earth's surface. To calculate it, the values of spectral brightness in the red and near infrared spectral ranges are used (Hanqiu, 2006):

$$NDVI = (NIR - Red) / (NIR + Red), \quad (2)$$

where NIR is the reflection in the near infrared region, Red is the reflection in the red region of the spectrum(Hanqiu, 2006).During processing, the so-called water index is used. The green and middle infrared ranges are used to calculate the index. The modified normalized difference index of water is calculated by the formula (Hanqiu, 2006):

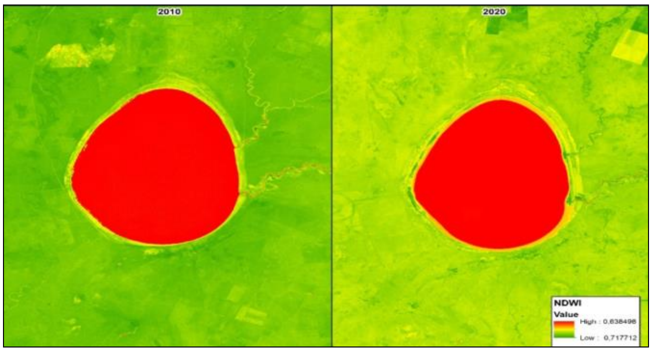
$$MNDWI= GREEN-MIR/GREEN+MIR, \quad (3)$$

where MIR is a middle infrared band such as TM band 5.

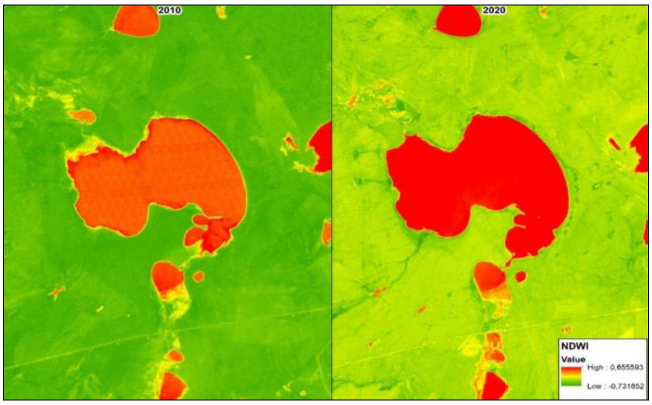
RESEARCH RESULTS AND DISCUSSION

Research in the field of tourism includes articles in the field of tourism geography, tourism management and marketing. Marketing, sustainable development of the territory and natural values are expressed in the following positions. And work in the GIS-technological direction is noticeably absent or is represented to a lesser extent.

The remoteness of tourist and recreational objects of Kazakhstan, the difficulties of research in the field are currently being implemented by remote sensing. This promising approach or method awaits future research. The purpose of the article is to show the possibilities of the remote sensing method in the study of lakes in Kazakhstan (Wendt, 2020).

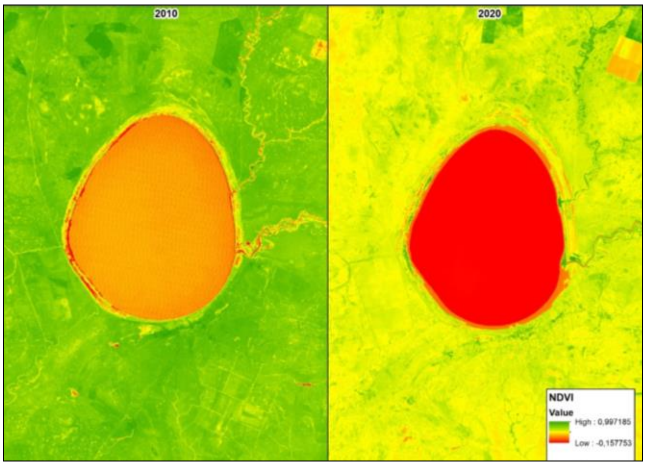


a) Lake Shalkar 2010

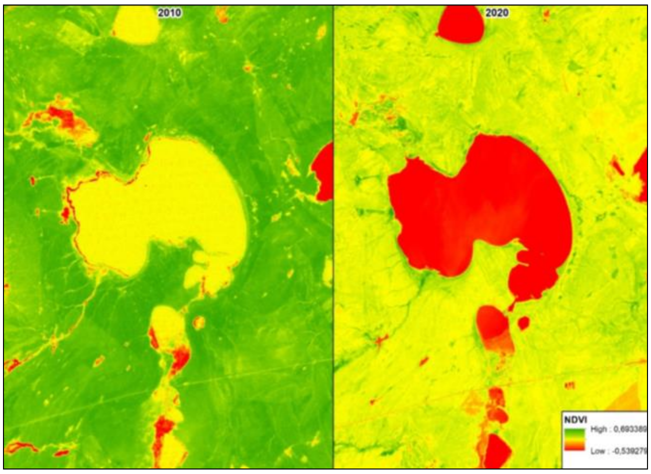


b) Lake Teniz2010

Figure 5. Determination of the area of Teniz lake taking into account the NDVI index in the period 2010-2020



a) Lake Shalkar 2020



b) Lake Teniz 2020

Figure 6. Determination of the area of Lake Teniz taking into account the NDVI index in the period 2010-2020

In the course of the study, calculations of the NDWI, MNDWI and NDVI indices with the construction of index maps for the studied territories were effectively used to highlight water bodies in satellite images (Figures 5, 6). This method of detecting reservoirs based on multispectral data is based on the fact that water largely absorbs radiation in the infrared range. In this case, the index values corresponding to the water surface will take only positive values. This property made it possible to determine the area of water bodies with sufficient accuracy. The analysis of the measurement results showed that the relative error in measuring the areas of lakes, taking into account the MNDWI index, decreases with an increase in their area. Thus, for Lake Shalkar, the error is > 4.11 km²; for Lake Teniz, the error is >2.20 km²; the average error of measuring lake areas in Landsat images does not exceed 3%.

In the images, taking into account the NDWI index, the error in measuring the areas of lakes increases with increasing their area. So, for Lake Shalkar, the error is > 4.09 km²; for Lake Teniz, the error is > 4.49 km²; the average error of measuring the areas of lakes in Landsat images does not exceed 2%. In the images, taking into account the NDVI index, the error in measuring the areas of lakes, taking into account the increase in their area, decreases. So, for Lake Shalkar, the error is > 2.32 km²; for Lake Teniz, the error is > 1.79 km²; the average measurement of lake areas in Landsat images does not exceed 1%. Calculations based on imagesERS-3 and Landsat-5 made it possible to characterize the lakes, an example of which is presented in Table 3. Long-term observations andcalculations based on satellite images for the period from 1975 to 2018 showed thatfrom 1940 to 1982 there was a decrease in the levels of lakes and a reduction in their areas in the Teniz-Korgalzhyn depression Lake Shalkar. From 1986 to 1992, an increase in the area of lakes was observed. From 1992 to 2018 in the Irtysh natural-limnological region lake Teniz – A has increased, and the areas of lakes in the Central Kazakhstan region lakeTeniz – B are declining, which may indicate the beginning of a new climatic cycle similar to the period 1940-1982. We believe that the study approach of using remote sensing is necessary for the development of tourist and recreational infrastructures. Let's compare the measurement error of lake areas on Sentinel and Landsat index images. Table 4 shows the results of measurements of lake areas, taking into account the indices MNDWI, NDWI, NDVI.

Table 3. Characteristics of lakes in the study area

№	Name	**Initial data**			
		2010	2020	2010	2020
1	Lake number according to the reference book (scheme)	2255		1539	
2	The lake and its location	Shalkar, 1 km W Chalkar village		Teniz, 25 km W of the village. Urkendeu	
3	Inflowandoutflow	The Shell-Ropes and Isenkaty rivers flow in, the Solyanka River flows out		The river Nura flows into it, brook. Espesai, Mal. and Blo.-Tabylgisai and 2 dry	
4	Height above sea level, m	16.7		304,4	
5	Lakearea, km², 1940 y.	**260.00**		**1161.54**	
6	Lakearea, km², 2021 y.	**242**		**1162**	
7	Length, km		18.4	74.1	
8	Maximumwidth, km		14.7	32.2	
9	Coastlinelength, km			488.0	
10	Coastlinedevelopment			4.0	
11	Drying P, non-drying N	P	P	P	P
12	MNDWI	4.11		2.20	
		Measurement errors - **1.9**			
13	NDWI	4.09		4.49	
		Measurement errors – **0.40**			
14	NDVI	2.32		1.79	
		Measurement errors – **0.53**			

Table 4. Areas of lakes calculated taking into account vegetation indexes

Name of indexes	Name of the lake area, satellite system			
	Lake area, km² Teniz		Lake area, km² Shalkar	
	Sentinel	Landsat	Sentinel	Landsat
MNDWI	261.22	263.54	1163.76	1161.97
NDWI	279.07	274.98	1158.48	1154.02
NDVI	261.72	265.83	1154.67	1152.47
Measurementerrors km²	**260.44**	**268.12**	**1162.31**	**1156.16**

Analysis of the obtained data presented in the table showed that the error in measuring lake areas on Sentinel multi-zone satellite images is less than on Landsat-5 images, due to the high spatial resolution of Sentinel images (20 m) compared with Landsat-5 (30 m) (Sagatbayev et al., 2019). As noted above, according to long-term observations, there is an impulse change in the area of lakes associated with a change in climatic conditions in the study areas.

These changes do not depend on the human anthropogenic activity. Therefore, the development of the recreational system and the intensification of resource use will not lead to the degradation of these resources with efficient and rational use.Thus, the territory of the Shalkar and Teniz lakes region has a high tourist and recreational potential, which is explained by the favorable socio-economic situation. The main type of tourism and recreation here can be developed medical tourism and ecotourism, which has both scientific and educational significance.

Determining the area of lakes, taking into account the NDVI index, is necessary for the placement of recreational facilities along the banks. The development of the tourist and recreational system and the intensification of resource use will not lead to the degradation of these territories if they are used efficiently and rationally. We have found that th e territory of the region of lakes Shalkar and Teniz has a high tourist and recreational potential, which is explained by a favorable socio-economic situation. The main type of tourism and recreation here can be developed in medical tourism and ecotourism, which has both scientific and educational significance.

CONCLUSIONS

Modern methods and software tools make it possible to take the metric characteristics of lakes. Long-term observations andcalculations based on satellite images for the period from 1975 to 2018 showed that from 1940 to 1982 there was a decrease in the levels of lakes and a reduction in their areas in the Teniz-Korgalzhyn depression and Lake Shalkar. From 1986 to 1992, an increase in the area of lakes was observed. From 1992 to 2018, in the Irtysh naturallimnological region (Lake Teniz-A) increased, and the areas of lakes in the Central Kazakhstan region are declining, which may indicate the beginning of a new climatic cycle similar to the period 1940-1982. The analysis of the data obtained showed that the error in measuring lake areas on Sentinel multi-zone satellite images is less than on Landsat-5 images, which is due to the high spatial resolution of Sentinel images (20 m) compared with Landsat-5 (30 m). This allows the choice of places in the construction of objects of tourist and recreational value. Calculations of the NDWI, MNDWI and NDVI indices with the construction of index maps for the study areas were effectively used to identify water bodies on satellite images.

Depending on the remoteness of the territory of the lakes from settlements, we determined the tourist recreational potential of the lakes using remote sensing. Now it is necessary to improve the methods for determining the recreational suitability of the territory. The determination of the natural environment and recreational opportunities of lakes using remote sensing during the study was confirmed with the results obtained (Figures 6, 7 and Tables 3, 4). The territory of the Shalkar and Teniz lakes region has a high tourist and recreational potential, which is explained by the favorable socio-economic situation. The main type of tourism and recreation here can be developed medical tourism and ecotourism, which has both scientific and educational significance. The most important types of lake activities are swimming, recreational and professional fishing, various types of leisure by water, sports events, and other types of recreation. The use of remote sensing data allows the use of modern high-tech methods for the analysis and interpretation of actual data, which expands the possibilities of monitoring studies of spatial and temporal changes in the environmental conditions of the territory.

REFERENCES

Akbar, I., Mazbayev, O., Seken, A., & Udahogora, M. (2020). Local residents' participation in tourism at a world heritage site and limitations: Aksu-jabagly state nature reserve, Western Tian-Shan, Kazakhstan. *GeoJournal of Tourism and Geosites*, 28(1), 35–51. https://doi.org/10.30892/gtg.28103-450

Aliyeva, S., Chen, X., Yang, D., Samarchanov, K., Kozhokulov, S., Mazbayev, O., Issanova, G., & Sekenuly, A. (2019). The socioeconomic impact of tourism in East Kazakhstan Region: assessment approach. *Sustainability (Switzerland)*, 11(17), 4805. https://doi.org/10.3390/su11174805

Akhmatov, S.V. (2005). *Features of recreational limnology methods*. Materials of the 6th International Scientific, Educational and Practical Conference on October 26-27, 2005 «Opportunities for tourism development in the Siberian region and adjacent territories», Tomsk, TSU, 2005 93-95, (in Russian).

Burlibayev, M.Z., Kurochkin L.Y., Kashcheeva, V.A., Erokhova, S.N., & Ivashchenko, A.A. (2007). *Globally significant wetlands of Kazakhstan (Teniz Korgalzhyn system of lakes)*. Edited by Astana: UNDP, 2, 286, ISBN 9965-9007-4-4.

Bragina, E.A. (2007). *Globally significant Wetlands of Kazakhstan: the Global Environment Facility project [Integrated Conservation of Priority Globally Significant Wetlands as a habitat for migratory birds: demonstration in three territories]*. Astana, 286, (in Russian).

Baryshnikov, G., Fomin, I., & Nasarova, T. (2019). *Using mathematical modeling in predicting the economic efficiency of lake-commercial fish farming in cross-border areas of northern Kazakhstan*. IOP Conference Series: Earth and Environmental Science, 395(1), 88-93, 012017. https://doi.org.10.1088/1755-1315/395/1/012017

Drozdov, A.V. (1999). *Ecotourism: definitions, principles, signs, forms / A.V. Drozdov // Actual problems of tourism. Prospects for the development of tourism in the south of the Moscow region: a collection of reports and conference abstracts.* Moscow: RMAT, 32-41, (in Russian).

Dmitriyev, P.S., Fomin, I.A., Wendt, J.A., Ismagulova, S.M., & Shmyreva, O.S. (2022). Regional aspects of creation complex routes ecological tourism on the territory of North Kazakhstan region: *GeoJournal of Tourism and Geosites*, 2, 485–492. https://doi.org/10.30892/gtg.41220-854

Dmitriyev, P.S., Wendt, J.A., Fomin, I.A., & Nazarova, T.V. (2021). Transport accessibility of the lake ecosystems in the North Kazakhstan region as a factor of tourism development. *GeoJournal of Tourism and Geosites*. 35(2), 289–296. https://doi.org/10.30892/gtg.35204-650

Dzhanaleeva, K.M. (2014). *Physico-geographical zoning of the Republic of Kazakhstan.*[Textbook.Settlement]. Almaty: Evero, 327 (in Russian).

Erokhin, G.N., & Kopylov, V.N. (2002). *Using NOAA/AVHRR data for operational space monitoring of the Siberian environment.* Proceedings of the international symposium "NOAA Image of Siberia".Novosibirsk, 85–91, (in Russian).

Garbuk, S.V., & Gershenzon, V.E. (1997). *Space systems for remote sensing of the Earth*. Moscow: Publishing house A and B, 296, 154–163.

Hanqiu, X. (2006). Modification of Normalized Difference Water Index (NDWI) to Enhance Open Water Features in Remotely Sensed Imagery**.** *International Journal of Remote Sensing*, 27(14), 3025–3033. https://doi.org/10.1080/01431160600589179

Huseynli, E. (2022). Sustainable tourism and its environmental, economic, social benefits to the host destinations. *Tourism and Leisure Management.*Austria,10–14. https://doi.org/10.13140/RG.2.2.31912.03845

Inskeep, E. (1991). *Tourism Planning: An Integrated and Sustainable Development Approach*. New York, Van Nostrand Reinhold, 508.

Kalov, R.O. & Kiloev, D.D. (2012). Geoecological assessment of the natural and recreational potential of lakes (on the example of Kazenoy-Am lake). The treasures of the Adyghe (Circassian) International Academy of Sciences. 14(1), 153–156.

Kashkin, V.B., & Sukhinin, A.I. (2001). Remote sensing of the Earth from space. Moscow: Logos, 263.

Mazhitova, G.Z., Pashkov, S.V., & Wendt J.A. (2018). Assessment of landscape-recreational capacity of North Kazakhstan region. *GeoJournal of Tourism and Geosites*, 23 (3), 731–737. https://doi.org/10.30892/gtg.23309-323

Muravlev, G.G. (1973). *Small lakes of Kazakhstan.* [Resources and use in agricultural production]. Alma-Ata: Kainar, 180 (in Russian).

Muravlev, G.G. (1993). Lakes of Kazakhstan and what awaits them. Alma-Ata, 187, (in Russian).

Moiseenko, A.E. (1994). *The current state and prospects for the use of remote sensing of the Earth from space in order to study natural resources and ecology.*A review. M.: Nauka, 103, (in Russian).

Sagatbayev, Y.N., Pashkov, S.V., Dunets A.N., & Mazbayev, O.B. (2019). Landscapes of the Teniz-Korgalzhyn depression in the republic of Kazakhstan: evaluation of ecosystem functions and opportunities for tourism. *GeoJournal of Tourism and Geosites*, 26(3), 1046–1056. https://doi.org/10.30892/gtg.26328-416

Sagatbayev, Y.N., Baryshnikova, O., Krupochkin, Y., & Mazbayev, O. (2019). Evaluation of changes in ecological conditions of wetlands in the Teniz-Korgalzhin depression (Kazakhstan), *Ukrainian Journal of Ecology*, 9(4), 719–722, UDC 528.88: 911.52 (571.15).

Sagatbaev, E.N., & Dunets, A.N. (2019). *Spatio-temporal analysis of the geosystems of the Teniz-Korgalzhyn depression based on the data deciphered from Landsat and Sentinelsatellite images*. Reports of the national academy of sciences of the Republic of Kazakhstan ISSN 2224-5227, 5(327), 154–161. https://doi.org/10.32014/2019.2518-1483.156

Sarsenov, B.B., Lezhnikov, P.S., & Mamin, A.N. (2004). *Tourist map of Lake Shalkar (West Kazakhstan region).*World Discovery, 6, 118–125, (in Russian).

Seliverstov, Y.P. (1990). *Spatial-temporal organization of geomorphological systems.* Leningrad: *LSU*, 396, (in Russian).

Semochkina, S.S. (2012). *Assessment of landscape and recreational potential of the flat territory of the left bank of the Ob by biological indicators.* Izvestia AltSU, 3/1 (75), 138-141, (in Russian), Accessed 25.01.2021. http://izvestia.asu.ru/2012/3-1/index.ru.html

Smith, L.C., Sheng, Y., & MacDonald, G.M. (2007). A First Pan-Arctic Assessment of the Influence of Glaciation, Permafrost, Topography and Peatlands on Northern Hemisphere Lake Distribution.*Permafrost and Periglacial Processes*, 18, 201-208. https://doi.org/10.1002/ppp.581

Tek, B.K. (2018). *Ndvi, ndbi and ndwi calculation using landsat 7 and 8.*Geomatics for Sustainable Development, GeoWorld, Volume II, Bangkok, Thailand. https://www.researchgate.net/publication/327971920

Tokpanov, E. (2021). Prospects for the development of health tourism on lakeRay in the Almaty region of the republic of Kazakhstan.*GeoJournal of Tourism and Geosites,* 37(3), 2021, 888-893. https://doi.org/10.30892/gtg.37320-722

Wendt, J.A. (2020). Directions and area of tourism research in Kazakhstan. *GeoJournal of Tourism and Geosites,* 32(4), 1418–1424. https://doi.org/10.30892/gtg.32433-589

*** CBD Fourth National Report - Kazakhstan (Russian version) https://view.officeapps.live.com/

Article history: Received: 12.08.2022 Revised: 09.11.2022 Accepted: 09.12.2022 Available online: 30.12.2022