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IDENTIFICATION OF SUSTAINABLE LAKES IN KHOREZM REGION BY COMPARING DATA FROM TRADITIONAL AND MODERN SOURCES

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Annotatsiya: Глобал иқлим ўзгариши қурғоқчил ҳудудлардаги кўлларнинг қуриб кетишига, улар майдонининг қисқаришига сабаб бўлмоқда. Ушбу тадқиқот ишида Хоразм вилояти кўлларининг барқарорлиги ГАТ ва масофадан маълумотлар олиш усуллари ёрдамида аниқланган. Бунинг учун 1980 ва 2020 йиллардаги кўллар географик таққосланиб, йўқолиб кетган, янги пайдо бўлган ва нисбатан барқарор кўллар кўрсатилган.

Калит сўзлар: География таққослаш, ГАТ, масофадан маълумотлар олиш, кўллар, барқарорлик.

Аннотация: Глобальное изменение климата привело к высыханию и уменьшению размеров озер в засушливых регионах. В этом исследовании устойчивость озер в Хорезмской области была определена с помощью ГИС и методов дистанционного зондирования. С этой целью были географически сопоставлены озера, имевшиеся в 1980 и 2020 годах, и были указаны исчезнувшие, вновь образовавшиеся и устойчивые озера.

Ключевые слова: Географическое сравнение, ГИС, дистанционные зондирование, озера, устойчивость.

Abstract: Global climate change has causing drying up and shrinking the lakes in arid regions. The sustainability of the lakes in the Khorezm region was identified by GIS and remote sensing methods in this research. The lakes available in 1980 and 2020 years were geographically compared for this purpose, and disappeared, newly formed, and sustainable lakes were indicated.

Key words: Geographical comparison, GIS, remote sensing, lakes, sustainability.

Introduction.

The main water source that supplies the national economy of the Khorezm region is the Amudarya. The irrigation system with a long history is the main reason of formation lakes in the Khorezm oasis. The formation of lakes in the region also depends on the irrigation methods and planning agricultural crops too. The application of water-saving technologies in the region has led to decreasing water levels and drying of existing lakes. The assessing sustainability of lakes is essential for developing fish farms and recreational use of lakes. The simplest and the most effective way to determine the sustainability of lakes is a periodic comparison of their presence. GIS and remote sensing images may give the chance to easily determine the sustainability of the lakes in the areas.

Literature review.

The reason for the intensive irrigation that began in the first half of the 1900s most of the lakes is less than 100 years old, although irrigated agriculture has existed in the province for over 2,000 years [1, 2, 3]. Analysis of samples of stable nitrogen isotope, dissolved inorganic nitrogen, and residues of dissolved oxygen taken from the sediments of the lake showed that water from irrigation is the main source of the formation of lakes [4]. The transformation of forest and tugai landscapes of the Khorezm region into agricultural landscapes has led to the appearance of hundreds of lakes saturated with irrigation flows. Chemical analysis of samples of cesium-137 and Pb-210 taken from a Shurkul lake showed that the age of lake sediments is about 100 years [5]. Analysis of sediments from 12 lakes in the region showed that the maximum age of the studied lakes was over 450 years, and the minimum is less than 70 years [6]. The underground water table is one of the sources that has protected the lakes from shrinking for hundreds of years if the artificial irrigation and drainage canals will not be counted [7]. The underground water table has risen by more than 10 meters in 2000 years in comparing to the 1950s [8]. It is 2 meters from the surface in recent years [9]. Above mentioned researches determined the age of the lakes, the sources of their saturation in the region. There are more than 400 big lakes that have an area of more than 1 hectare, and experiments were taken from 2 to 12 lakes [5,6,10]. Those research experiments tested in laboratories and so it required more funds. The methods have used this research more based on geographical comparison and it requires fewer expenses.

Study area.

The Khorezm region is located between 41^0 and 42^0 northern latitudes, 60^0 and 61^0 eastern longitudes, in the central part of the Turan lowland, on the territory of the ancient Khorezm-Sarikamysh alluvial delta of the Amudarya. The area of the region is 6.3 thousand km^2 and it is surrounded by the Karakum desert in the southwest and the Kyzylkum desert in the northeast. The surface decreases from east to west and southwest (Fig. 1).

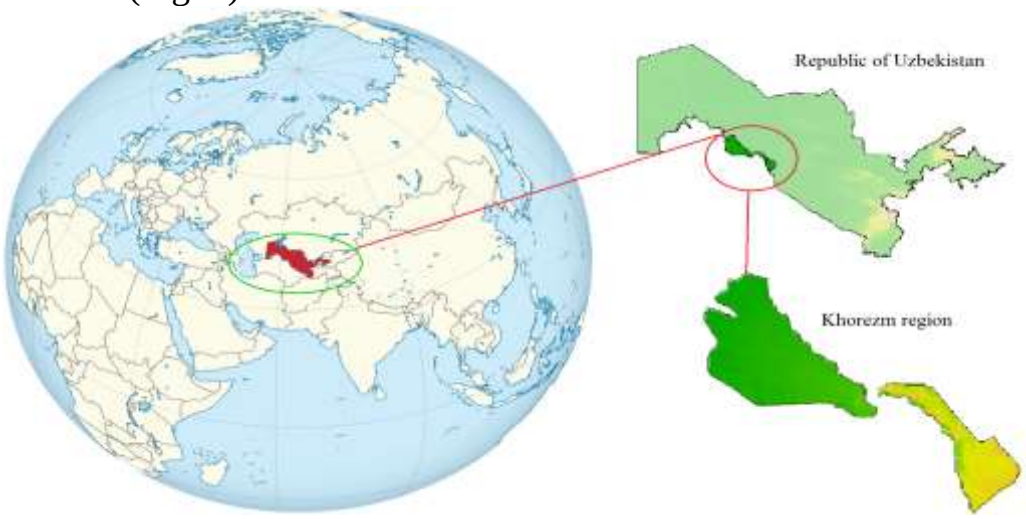

Figure-1. Location of the study area, Khorezm region, Uzbekistan.

Khorezm is located in a temperate climate zone, dominated by the desert climate. The average annual rainfall in the region between 79 mm to 160 mm, of which 6% falls in summer, 14% in autumn, 43% in spring, and 37% in winter. Due to the lack of precipitation in Khorezm, irrigation systems play an important role in the formation of water bodies. Therefore, the region's water resources have long been at the center of discussion.

Research data and methodology

There is some information about the Khorezm water bodies between BC to the 20th century in the historical sources including the works of the Arab historians Istakhri, and Abu Raikhan Beruni, as well as the works of Russian and local researchers. Large-scale topographic maps of the region were created during the period of the former Soviet Union. Data related to the present situation of the lakes can be monitored, downloaded, and analyzed through Google Earth data basis. The methodology of this work is carried out in a simple step, shown in Figure 2. Data related to water bodies from ancient sources on the Khorezm, on large-scale topographic maps in 20th-century, and the current state were compared with Google Earth data by ArcMap. As a result, a clear view of the lakes from the past to the present was taken, and disappeared, newly formed and sustainable lakes database were developed.

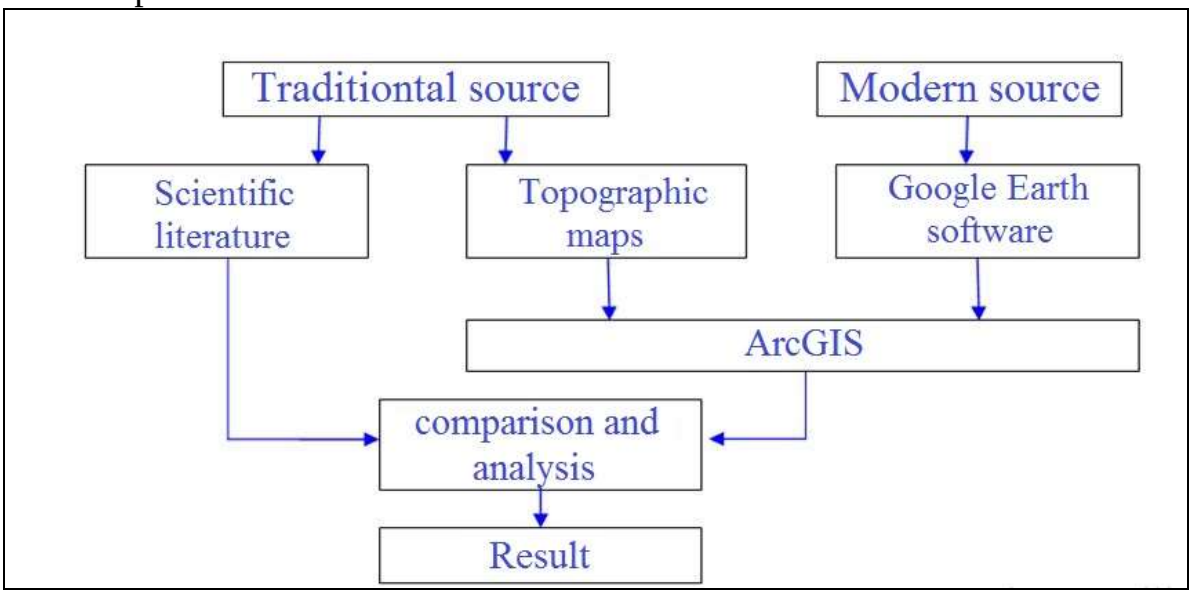

Figure-2. Flowchart of methodology.

Analysis and results

There are some interesting ideas about the formation of the Khorezm lakes. There are many long-dried streams and canals crossed through the southern edge of the cultural line of the oasis near the Karakum Desert. It is the result of the ancient water flow direction of Amudarya when it reached Sariqamish depth. In the ninth century, Abu Rayhan Beruni wrote about the oldest tributary of Amudarya that is known as the Mazbudast network, and it flowed into Sariqamish. There was not formed an oasis in that period. Also, the legend of Sultan Sanjar and Turabekkhanim says that after the Amudarya blocked its way near Pitnak, flooded water began to flow to Karakum along the edge of the oasis, so that a series of lakes formed. These lakes are also considered as the result of the old riverbed of the Amudarya and are

called "Daryo ag'nagan" (the place where the river is broken). Local historians call this chain of lakes an artificial canal built by the legendary king Faridun. It corresponds to the system of lakes known in the literature of the XIX century as "Turundaryo" or "Zeykash". In 1871, N. Petrusovich called these places "Turundaryo" (a river that stopped flowing). V. Lohutin writes: -"The Turundarya began near Khazarasp city and flows through the southern edge of the Khiva city, and later disappeared at the height of Beshikkir and the height of Chigilikirish. Near the Yassiqir, Qalaliqir, and Duzqir heights, it reappeared and reaches the Ajinquyi wells". These lakes also considered as the result of Dovdon floods [2].

Topographic maps at a scale of 1: 100,000 containing 1980-1981 years data were added to ArcGIS. The database of lakes of the Khorezm region for 1980-81 was created by digitizing the shore of the lakes. There were only 505 lakes and other water bodies in the Khorezm region. The total area of these lakes was 109.02 km^2 and the average area was 0.21 km^2. The largest of these lakes is Ulugshurkul lake, with an area of 27.4 km^2, while the smallest is Otolikkol lake, with an area of only 0.007 km^2. All of the 505 identified water bodies are not single lakes. The old large lakes divided into 2 to 16 small pieces in learned 50 cases. For example, Dongizuldi lake, which is located in Khazarasp district with a total area of 0.7, was divided into 15 water bodies with an average area of 0.05 km^2 (Figure 3).

216 lakes of that database are saltwater lakes with an average area of 0.26 km^2 and a total area of 56.8 km^2. There are some unnamed lakes on the topographic map. There are 196 unnamed lakes with an average area of 0.08 km^2 and their total area of 17.4 km^2. Such water bodies were labeled with the name of the nearest geographical objects. For example, "unnamed lake northern part of Khiva".

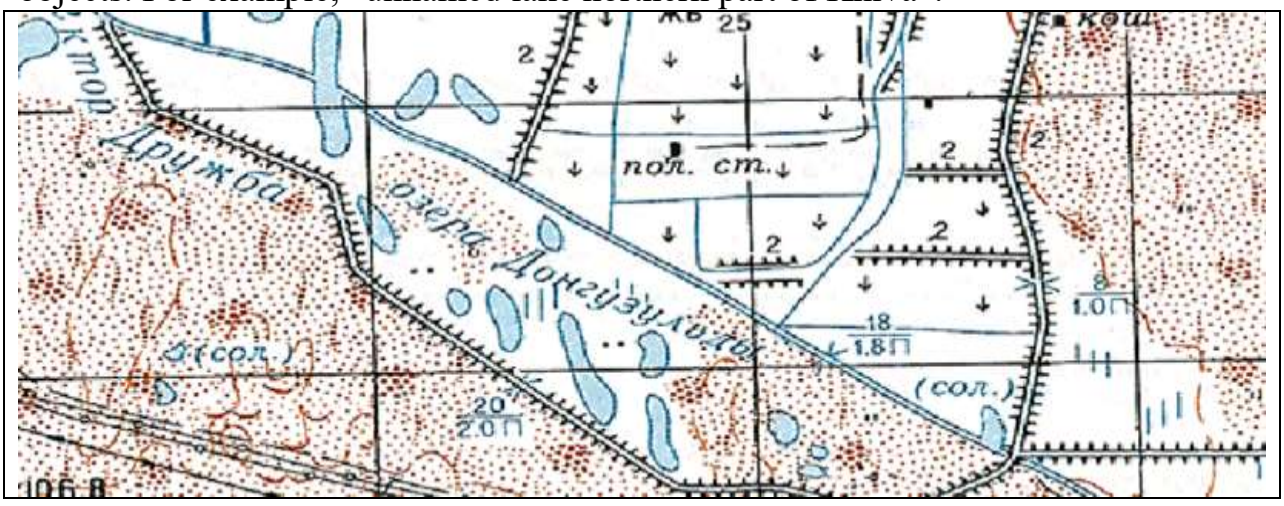

Figure 3. Dongizoldi lake was divided into 15 water bodies.

Another example, the map shows 13 unnamed lakes with an average area of 0.06 km^2 and a total area of 0.83 km^2 near Naimanqir territory in the Yangiaryk district. These lakes are labeled as unnamed lakes 1, 2 .... 13 in Naimanqir (Figure 4).

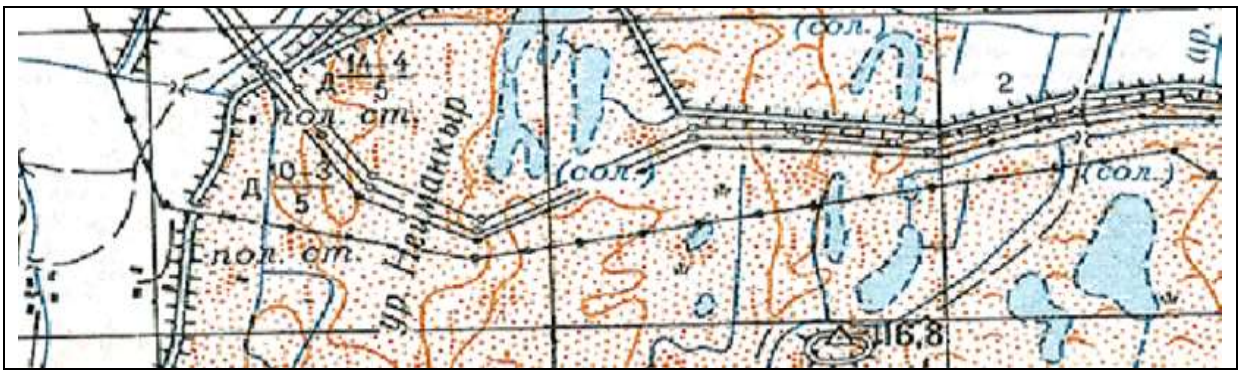

Figure 4. Unnamed lakes near the Naimankir territory.

Google Earth gives a chance to digitizing recent lakes with high-resolution images. The existing lakes and artificial reservoirs in the territory of the Khorezm region in 2019 were digitized based on the shoreline and created Google Earth lakes database. There are some lakes labeled with the name of farmers' lands in the Regional state agriculture and water resources departments, Land resources and state cadastre departments, the Statistics Committee, and the regional branches of the Uzbekbaliksanoat association database. Some others have no names, fragmentation of named lakes into dozens of small parts, and the other unnamed thousands of artificial water bodies formed. Thus, they were coded with special numbers. The special codes consist of the initials of the district names and the sequence of numbers to be included. For example, GL_1,2, ... 88 lakes in the Gurlan region, YQL_1,2 ... 75 lakes in the Yangiarik region, etc. Using the software capabilities and comparing the images belong to different periods, seasons from 2005 to 2019 years the lakes separated from flooded fields. When analyzing the data of existing water bodies based on the Google Earth program, it was determined that there are 2030 lakes and artificial water bodies in total. The average area of these reservoirs is 0.09 km^2, and the total area is 180.6 km^2. 162 of them are small artificial pools with an area of 0.01-0.05 hectares. There are 868 water bodies with a surface area of over 0.01 km^2, with an average area of 0.2 km^2. The scale of the map was the reason for the small number of water bodies in the 1980s. However, the smallest bodies of water could be well-identified using Google Earth.

Using the both database from the 1980s and the Google Earth the following results were obtained:

1. Data on 181 water bodies with an average area of 3.79 m^2 and a total area of 6.86 km^2, which existed in the 1980s and have dried up and disappeared present date, have been restored.

2. A database of 1670 newly formed water bodies with an average area of 0.02 km^2 and a total area of 31.8 km^2 was identified. These lakes are widespread in the region and are concentrated along the banks of the Amudarya, as well as in the southern and southwestern parts of the region.

3. Relatively stable water bodies that existed in the 1980s and have survived to the present have been identified. Determination of stable water bodies was carried out by two contrasting comparison methods.

In the first method, lakes from the 1980s were selected and compared with overlapping lakes available in the present days. It was found that 360 of the existing

lakes existed in the 1980s, and their average area at that time was 0.29 km^2 and the total area was 107.6 km^2. In the second method, the above process was performed in reverse order. That is, the current lakes were selected and compared with the lakes of the 1980s, and a database on the current state of the existing lakes in both periods was formed. In this way, 360 of the lakes that existed in the 1980s have survived to the present day. However, their current average area is 0.4 km^2 and their total area is 148.5 km^2 (Figure 5). The total area of water bodies in both periods has now increased to 40.4 km^2 in comparison to the 1980s. For example, in the Khiva fish farm in the 1980s (Fig. 8, highlighted in green) the catchment area was 13.7 km^2, and in 2019 years (Fig. 8, highlighted in red) the catchment area has increased to 26.1 km^2.

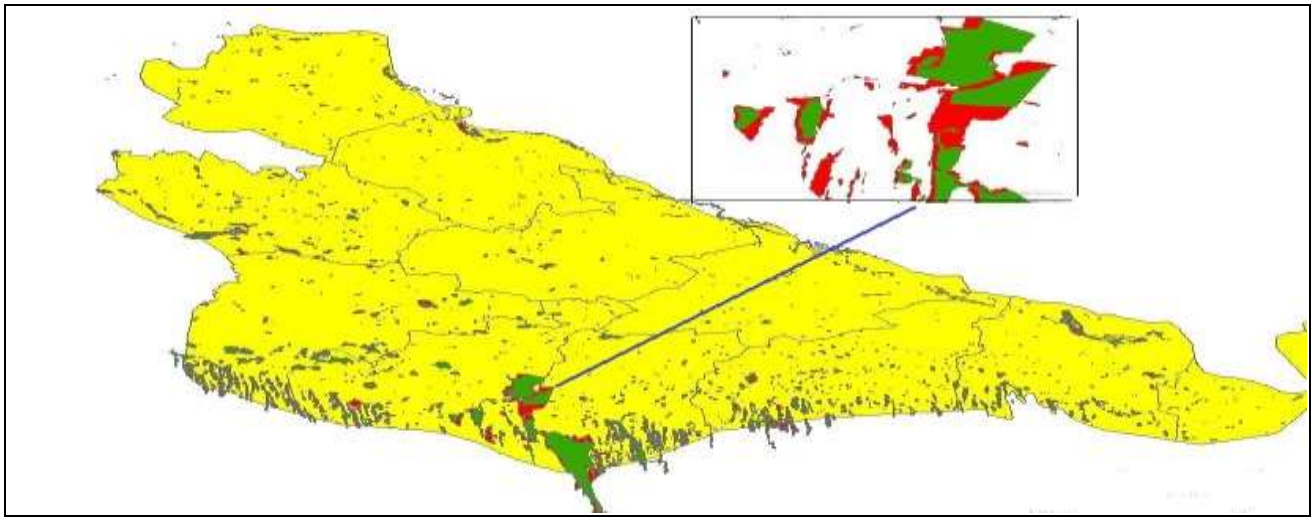

Figure 5. Sustainable lakes.

To see this more clearly, we describe the area of the lake in the 1980s in a vector file, and the area today in a raster file. Comparing the current (raster) image of the lake with the Google Earth program and the vector file of the 1980s, we can clearly see that the lake area has expanded (Figure 6).

Figure 6. The territory of the Khiva fish farm in the 1980s (in a brown vector file) and today (in raster file).

The areas where the lakes are reported in historical sources are consistent with the lakes that existed in the 1980s and today. Based on these analyzes, recommendations for the use of lakes in various sectors of the economy can be developed.

Conclusions

Sustainable lakes can be recommended as reliable for developing fish farms. Lakes area that dried, disappeared, and changed to agricultural lands more reliable for fish farming than creating any unstable areas. The methods used in the work can be useful to carry out monitoring, assessing for fishing, and registering to the database of lakes. These analyzes can be highly effective if the irrigation system based on flood irrigation. When water-saving technologies use in the whole region then it needs detailed investigations. Further investigations can include the distance from irrigation canals, altitude in comparison collectors' elevation, and the other sources.

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