Changes in Lake Boyukshor Over The Years

Tunzale Majidova

School of Advanced Technologies and Innovation Engineering, Department of Ecology and Environmental Sciences, Western Caspian University, Baku, AZ1072, Azerbaijan.

Received:01.11.2025 Accepted:18.11.2025 Published: 11.12.2025
https://doi.org/10.54414/TOSR5557

Abstract

Lake Boyukshor, which is one of the significant water ecosystem located in the northeastern part of Baku, has endured transformations closely related to urbanization, industrial activity, and climate change for a long time. According to the comparison conducuted on the data obtained from historical maps, satellite imagery, and monitoring data it is observed that lake's area, depth, and physicochemical water parameters have changed dramatically over the years. Since the second half of the 20th century, the expansion of oil extraction fields, land reclamation, malfunctioning of reservoir systems, and the direct discharge of wastewater into the lake have led to a disruption of the hydrological balance and changes in the morphology of the water body. These changes were not limited to a reduction in area but also negatively affected the ecosystem's biological productivity, sediment composition, and the lake's self-restoration potential. As a result of reconstruction and ecological rehabilitation measures carried out in the last decade, some of the lake's parameters have begun to stabilize, and a relative decrease in water salinity and pollution levels has been observed. However, hydrology and ecosystem functions have not been fully restored, and continuous monitoring of processes and comprehensive ecological management remain necessary. This article provides a scientifically based analysis of the main stages of changes in Lake Boyukshor over the years, the factors that determined them, and the current ecological situation, 2020-2024 were dedicated to studying issues such as the analysis of water and land areas in this region, as well as identifying priority directions for the lake's sustainable protection.

Keywords: Lake Boyukshor, GIS analyses, hydrological regime, field dynamics, space monitoring, sediment analysis

1.Introduction

Lake Boyukshor is one of the largest enclosed lakes on the Absheron Peninsula, located in the rapidly urbanizing northern part of the city of Baku. The lake's hydroecological condition has been altered over the years by industrial waste, the sensitivity of geological structures, and anthropogenic interventions. Infrastructure projects, population growth, and modern urbanization processes since the mid-20th century have caused significant changes in the lake's morphometric indicators. Lake Boyukshor naturally formed as an endorheic saltwater lake. According to historical sources, in the early 20th century, the lake had a relatively large water surface area, shallow depth, and high mineralization. At the mentioned period, the lake was primarily controlled by a natural hydrological regime, and human impact was restricted. Lake's ecosystem has significantly been under pressure by oil production in Baku and the surrounding areas, the expansion of industrial enterprises, and increasing population density since the second half of the 20th century. Industrial wastewater, oil waste, and domestic sewage discharged into the lake, directly or indirectly, resulted in a drastic deterioration of the water's physicochemical composition. In the result, the lake's biodiversity had declined, binging its water quality an ecologically hazardous level. In recent years, large-scale restoration and cleanup measures have been implemented at the state level to improve the ecological condition of Lake Boyukshor. The prevention of sewage, the improvement of coastal areas, and hydraulic engineering measures have led to a relatively positive change in the lake's overall ecological condition.

Although Boyukshor Lake is an important basin for both water reserves and ecological balance, the reduction of its area and the deterioration of its water quality pose ecosystem threats to the region.

To date, many scientists, researchers, and prominent figures have conducted studies and made their contributions to Boyukshor Lake (Zeynalov, 2024). However, certain points that are not addressed in this article have been highlighted. The main objective of this study is to determine the dynamics of change in the area of Boyukshor Lake over the last few decades, to scientifically analyze the natural and anthropogenic factors causing these changes, and to assess the main processes affecting the lake's hydroecological condition using modern geographic information systems (GIS), remote sensing analyses, and hydrological assessment methods.

The following research methods were used to study the changes and problems in Lake Boyukshor over the years:

1. 2. Analysis of remote sensing , and satellite imagery

Data used:

- Landsat 8 OLI/TIRS (2020-2024)

Methodological steps:

1. Selection of cloud-free and same-season images.
2. Performing radiometric and atmospheric correction (DOS1 method).
3. Application of NDWI (Normalized Difference Water Index) and MNDWI (Modified NDWI) indices for water separation.
4. Automatic and visually verified extraction of water contours.
5. Annual calculation of the lake area and comparison over the time series.

This method allows for an accurate and objective analysis of the lake area.

2. GIS analyses and geostatistical processing

Indicators analyzed:

- Annual lake area
- Changes in the shoreline
- Expansion of urbanization zones
- Mapping of land reclamation areas

Methods:

- Raster-Vector Integration
- Spatial change maps
- Mann-Kendall trend analysis (statistical significance of change over time)
- Sen's slope estimator (calculation of the annual rate of change)
- Kernel density model (analysis of urbanization density)

This stage ensures the statistical robustness of the spatial variability.

3. Hydroecological Assessment

In this stage, data on the lake's ecology are analyzed:

- Water quality indicators (mineralization, pH, salinity, sulfates, ammonium) (Table 1).
- Calculation of the cover-degradation percentage
- Changes in biodiversity indicators

The hydroecological analysis allows for the assessment of the impact of the area change on the ecosystem.

4. Forecasting Modeling

To determine the future behavior of the lake:

- ARIMA time series model
- Linear and nonlinear regression
- Water balance forecast based on climate scenarios

These models allow for an assessment of how the area will change over the next 10-20 years.

Advantages of the methodology

The methodology of this study is distinguished by the following advantages:

- Use of satellite imagery with high spatial resolution
- Statistically reliable trend analyses
- Integrative assessment of anthropogenic and natural factors
- Objective, repeatable GIS-based methods
- Ecological assessment in accordance with the ecosystem approach

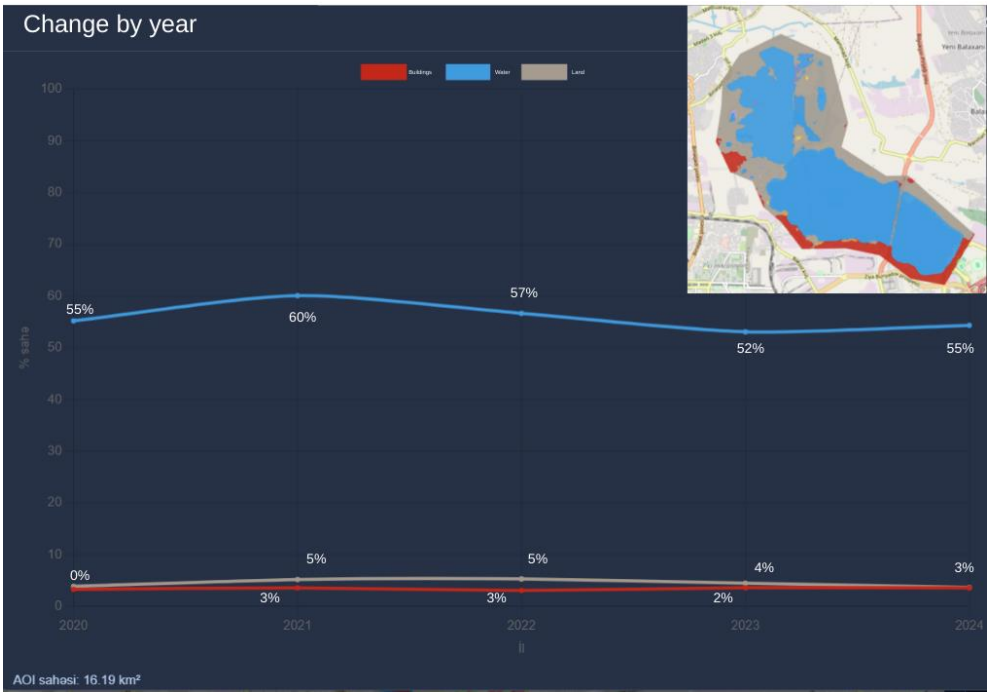

Figure 1. *Observed Changes in Lake Boyukshor (2020-2024)*

The diagram above illustrates the changes in built-up area, water area, and open land area in and around Lake Boyukshor from 2020 to 2024. These indicators are closely related to the intensity of anthropogenic activities in the area, climatic factors, hydromorphological changes, and ecological restoration measures (Aliyev, 2023).

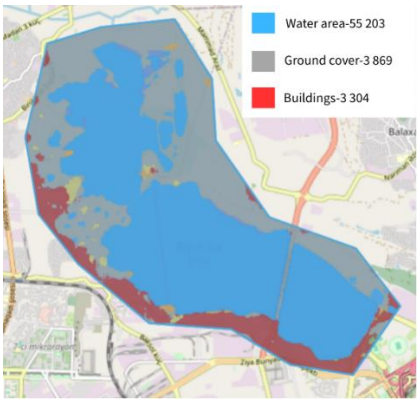

Figure 2. *The area of the water and land parts of Lake Boyukshor in 2020*

I.The water area of 55,203 units in 2020 indicates that the lake had a relatively stable hydrological regime during that period (Hasanov, 2022). During this period:

- The water balance in the lake basin was largely preserved,
- The anthropogenic impact had not yet reached its peak,
- Construction areas (3,304) were limited in nature.

The 3,869 units of open land indicate that the soil cover is generally stable, but that in some areas, soil degradation or human activity has weakened the vegetation cover. This year can be considered a transition and initial restoration phase for Lake Boyukshor.

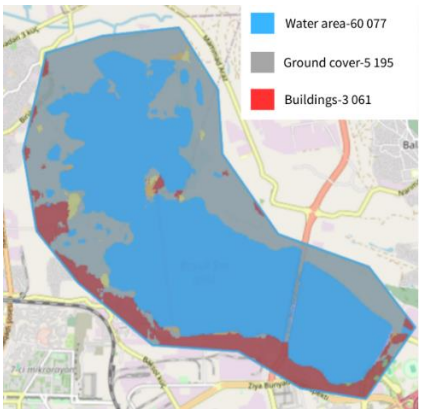

Figure 3*. The area of the water and land parts of Lake Boyukshor in 2021*

II.In 2021, an increase in the water area to 60,077 units was observed, which is the highest value for the entire period. This increase can be explained by the following reasons:

- An increase in precipitation compared to the previous year,
- The impact of measures taken for the lake's cleanup and rehabilitation,
- Weakening of anthropogenic pressure on the lake's area due to a decrease in the area of structures (3,061).

The increase in open land area to 5,195 units in the area:

- Demolition of old industrial facilities,
- Temporary exposure of the soil surface,

• This may be related to pre-construction earthworks. These indicators show that the area is undergoing a phase of transformation.

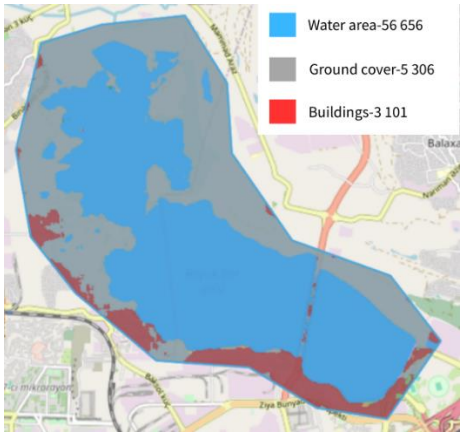

Figure 4. *The area of the water and land parts of Lake Boyukshor in 2022*

III.The reduction in water area to 56,656 units in 2022 indicates that changes are again occurring in the lake's hydrology. This situation:

• The strengthening of drought tendencies in the climate conditions,

• an increase in evaporation during the summer months,

• This can be linked to a decrease in water inflows into the lake

The area of built-up land reaching 3,101 units indicates that urbanization processes have become active again. The fact that there are 5,306 units of open land proves that the soil cover in the area is not yet fully stabilized, and the ecosystem is in a transitional phase.

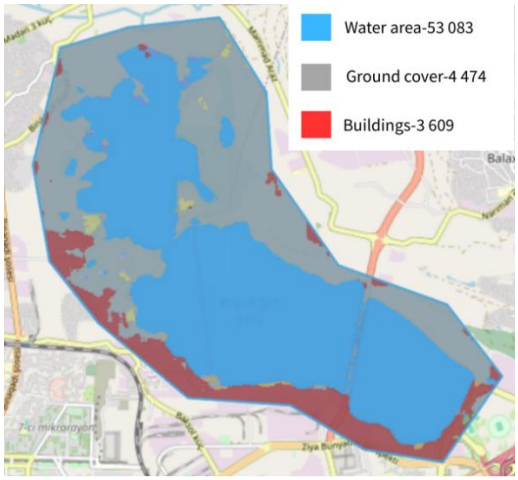

Figure 5. *The area of the water and land parts of Lake Boyukshor in 2023*

IV.2023 can be considered one of the most critical years for Lake Boyukshor. The area of built up land rose to 3,609 units, the highest figure for the period studied. This situation:

• The increase in industrial and infrastructure projects,

• intensive development of the surrounding areas,

• This is linked to a sharp increase in the anthropogenic load.

At the same time, the water area has decreased to 53,083 units:
• Narrowing of the shoreline zones,
• The anthropogenic impact on the water ecosystem,
• This indicates the intensification of negative processes, such as the disruption of the hydrological balance.
The decrease in open land area (4,474) can be explained by either land being covered with buildings or replaced with artificial surfaces in certain areas.

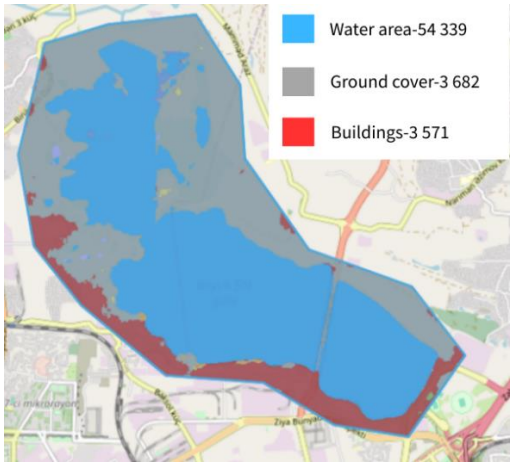

***Figure 6**. The area of the water and land parts of Lake Boyukshor in 2024*

V.The partial increase in the water area to 54,339 units in 2024 can be considered an ecologically positive trend. This increase:

• the result of ecological rehabilitation measures,

• the partial restoration of the water balance,

• It is associated with a relative regulation of anthropogenic pressure.

The stabilization of the built-up area at 3,571 units indicates that urbanization processes are being brought under some control. The reduction in open land area (3,682) strengthens the likelihood of land stabilization, greening, and reclamation efforts.

The analysis for the period 2020-2024 shows that:

• The increase in built-up areas has directly impacted the reduction of water bodies,

• The water area has shown high sensitivity to climate variability and anthropogenic activities,

• Open land areas have served as an indicator of the structural changes occurring in the area.

Continuous GIS-based monitoring of the ecological state of Lake Boyukshor, the restriction of urbanization processes, and comprehensive management measures focused on protecting the water ecosystem are of great importance according to the results obtained from the analysis in different years. (Mammadov, 2021).

The following conclusions can be drawn from this research:

• Agricultural lands are at a 14.2% risk of reduction over 5 years.

• Urban areas are projected to expand by 15.1% within 5 years.

• Forest areas are at a 12.1% risk of reduction.

Table 1. Physico-chemical Parameters of Lake Boyukshor Water in 2025

№	Parameter	Unit	Result	Analysis date	Method	Quality requierments
1.	pH	pH unit	8,60	14.10.2025	ISO 10523:2008	6.5-8.5
2.	Temperature	°C	22	14.10.2025	SM 2550 B:2017	
3.	Odor	bal	4	14.10.2025	QOST-3351-74	2.0
4.	Conductivity	µS/sm	10720	14.10.2025	SM 2510 B:2017	-
5.	Transmittance	%	42	14.10.2025	SM 2120 D:2017	-
6.	Colour	mg Pt /L	<10	14.10.2025	ISO 7887 C:2011	20
7.	Turbidity	NTU	31	14.10.2025	SM 2130 B:2017	-
8.	Total Dissolved Solids	mg/L	8040	14.10.2025	SM 2510 B:2017	1000
9.	Dissolved oxygen	mg O_2l	4,74	14.10.2025	SM 4500 0_2 C:2017	≥4.0
10.	Total hardness	mg $CaCO_3$/L	1100	14.10.2025	SM 2340 C:2017	350
		mg-ekv/L	22			7.00
11.	NH_4^+ (Ammonium)	mg/L	12,0	14.10.2025	SM 4500-NH_3- C:2017	0.5
12.	NO_3^- (Nitrate)	mg/L	1,37	14.10.2025	SM 45 00NO_3- D:2017	45.0
13.	NO_2^- (Nitrite)	mg/L	1,14	14.10.2025	SM 4500 NO_2-:2017	3.3
14.	Phosphate	mg/L	<1,2	14.10.2025	SM 4500 P C:2017	3.5
15.	SO_4^2 (Sulfate)	mg/L	741	14.10.2025	SM 4500 SO_4^2-E:2017	500
16.	Cl^- (Chloride)	mg/L	3191	14.10.2025	İSO 9297:1989	350
17.	Bicarbonate	mg/L	604	14.10.2025	ISO 9963:1994	-
18.	İron	µg/L	45,6	20.10.2025	EPA 200.7:2001	300

As is clear from the table above, the lake's water composition does not meet regulatory standards, and the level of pollution is increasing day by day. This, in turn, leads to the destruction of living organisms in the lake. Additionally, the strong odor, discoloration, and the presence of significant substances and compounds outside of standard limits are also proof that the lake is severely exposed to external impacts.

The environmental degradation around Lake Boyukshor directly arises from anthropogenic activity, so industrial waste, sewage, transportation, and atmospheric pollution have severely damaged the lake's water balance and its chemical and biological indicators. While the lake's ecosystem was deteriorated by strong intensity of anthropogenic factors, the restoration process carried out within preventive measures have begun to yield some positive results. Therefore, it is necessary to continue comprehensive monitoring and restoration programs for long-term ecological stability. The main factors causing the reduction of Lake Boyukshor's area are as follows (Aliyeva, 2019).

1. Urbanization and urban planning processes

1.1. Expansion of the city of Baku

The rapid expansion process carried out in Baku city since the second half of the 20th century has resulted in large-scale development of land areas around Boyukshor Lake. Several factors such as biulding residential complexes, industrial zones, and transportation infrastructure disrupted lake's natural shorelines, and a portion of the water body was drained and converted into dry land (Mammadov, 2018).

1.2. Landfilling and Reclamation Works

Land reclamation works carried out around the lake as part of urbanization processes have played a significant role in the reduction of the lake's area. During these processes, the lake's shallow areas were artificially filled, resulting in a reduction of the total water surface area. Some measures carried out under the name of reclamation disrupted the ecosystem's balance because they were not scientifically justified (Guliyev, 2017).

2. Industrial Activity and Technogenic Impacts

2.1. Oil and gas production

For many years, oil and gas extraction has been carried out around Lake Boyukshor. The establishment of oil fields, wells, and service roads resulted in the sacrifice of a portion of the lake, reducing the water body's area. Furthermore, waste generated during the extraction process has caused pollution of the lake and a decrease in its biological activity.

2.2. Collection of Industrial Waste

Waste from industrial enterprises was discharged uncontrollably into the lake and its surroundings for a long time, which then formed deposits. These deposits caused the bottom of the lake to elevate, resulting in its becoming shallower. This shallowing has contributed to the desiccation of certain areas of the lake.

3. Disturbance of the Hydrological Regime

3.1. Changes in the Natural Water Balance

The water balance of Boyukshor Lake is primarily formed by precipitation, groundwater, and evaporation. The natural inflows to the lake have been been blocked , causing the water balance to shift negatively due to urban development and engineering projects.

3.2. Drainage and Permeable Systems

Drainage systems in the surrounding areas diverted the waters entering the lake to other directions, which decreased lake's water reserves and shrunk its area.

4. Climate Change and Natural Factors

4.1. Increase in Temperature and Evaporation

The increase in average annual temperature as a result of climate change in recent years has intensified the evaporation process in Lake Boyukshor, which led to a drop in water level and a reduction in area.

4.2. Instability of the precipitation regime

The lake’s water supply has deteoriated due to uneven distribution of precipitation over the years, leading to the water level to drop drastically in some periods.

5. Sediment Accumulation and Shallow Depths

Sediments formed by solid particles and industrial waste entering the lake over time, reduced its depth. Consequently, the edges of the lake have lost moisture at a faster rate, transforming into arid land.

6. Biological Factors

Aquatic plants and microorganisms have been negatively affected by the deterioration of water quality; in some instances, excessive plant growth has shrunk the lake's open water areas.

7. Long-term impact of anthropogenic pressures

The pace of area reduction has intensified due to uncontrolled human activity that have diminished the self-recovery ability of the lake ecosystem.

8. Management and planning problems

In earlier periods, the lack of coordinated ecological management mechanisms prevented the protection process of Lake Boyukshor. The insufficient legislative and control mechanisms accelerated the area's decline.

9. Socio-economic factors

Areas surrounding the lake have been intensively used due to the factors such as population growth, increased demand for land, and economic interests.

The study indicates that a complex process , such as urbanization, industrial activity, disruption of the hydrological regime, and climate change driven by anthropogenic impacts contributed to the reduction in the area of Lake Boyukshor. To ensure its long-term protection, it is necessary to conduct scientifically based management alongside sustainable conservation practices.

3.Consequences of the area reduction

The decline in the area of Lake Boyukshor cannot be viewed as only physical-geographic change, since this process has caused complex and substantial consequences in ecological, hydrological, biological, socio-economic, and urbanistic spheres. The shrinkage of lake's area has damaged the ecosystem's integrity, impaired its natural functions, thus negatively impacting the common ecological security of the city of Baku. Above mentioned consequences are explained in detail below.

3.1. Disruption of the Hydrological Regime and Impacts on the Water Balance

Lake's hydrological regime was changed dramatically by the recuction its area. The shrinking of water surface, has led to a higher proportion of water being lost through evaporation,, weakening the lake's self-regulating mechanism. Some lake areas have turned into seasonal marshlands due to the decline in water level, resulting in the deterioration of water quality (Mammadov, 2019).

3.2. Changes in Water Physicochemical Properties

As lake's area decreased, its water volume also declined, leading to higher concentration of pollutants. As a consequence, water mineralization levels increased, salinity rose, and the relative amount of heavy metals approached dangerous levels. These changes have weakened the water's self-purification capacity, elevating ecological risks (Hasanova, 2018).

3.3. Decrease in Biodiversity

The contraction of Lake Boyukshor has seriously affacted its biodiversity, as reducted water levels has limited the habitats of fish, planktonic organisms, and aquatic plants. In particular, sensitive species have vanished due to deteriorating oxygen regime, leading to simplification process in the ecosystem. The disruption of the food chain has markedly diminished the ecosystem's resilience.

3.4. Degradation of Coastal Ecosystems

The reduction in the lake's area has caused significant changes in the structure of the coastal zones. Areas that were previously covered by water have become dry land, and soil salinization and erosion processes have intensified in these areas. The destruction of coastal vegetation has limited the habitat for birds and other organisms (Rzayeva, 2017).

3.5. Impacts on the microclimate

Lake Boyukshor is a necessary microclimate regulator for the city of Baku, so decline of the lake's area led to an increase in temperature amplitude in the surrounding territories, a decrease in humidity, and an intensification of the heat island effect. These reported results negatively affected human health and living comfort

3.6. Increase in Sanitary-Epidemiological Risks

The reduction in the lake' area, has increased the portion of shallow and stagnant waters, creating favorable conditions for the proliferation of pathogenic microorganisms and pests. The spread of bad odors and air pollution, especially in the summer months, have created sanitation problems in surrounding settlements.

3.7. Socio-economic consequences

The reduction in the area of Lake Boyukshor has also had a negative impact on the socioeconomic development of the surrounding areas. Its classification as an ecologically problematic area has decreased land values and weakened its investment attractiveness. At the same time, the loss of recreational potential has negatively impacted the population's quality of life.

3.8. Urban and Planning Problems

The unstable land areas formed as a result of the lake's shrinkage have become risky zones for urban development. The weakness of the soil's geotechnical properties has created additional risks during construction and increased the cost of engineering countermeasures.

3.9. Disruption of the ecological balance and long-term risks

The reduction in area has weakened the ecosystem's ability to self-regenerate, increasing the risk of the lake's complete loss in the long term. This process can lead to a disruption of regional ecological balance and the irreversible loss of biological resources (Mammadova, 2025).

An extensive analysis shows that the consequences of Boyukshor Lake's shrinking are multifaceted and profound. The disruption of the hydrological regime, deterioration of water quality, loss of biodiversity, and socio-economic problems have formed an interconnected web (Huseynova, 2024). Comprehensive and scientifically grounded restoration strategies are necessary to address these consequences. The protection of Lake Boyukshor is of strategic importance not only ecologically but also socially and economically (Rzayeva, 2023).

4.Recommendations

To address the aforementioned problems, the following measures have been deemed appropriate:

To fight aganist the shrinkage of Lake Boyukshor demands a comprehensive, multi-level, and long-term measures, which should not be limited to technical and engineering solutions, but should also encompass ecological, legal, socio-economic, and institutional mechanisms. Below mentioned measures are necessary for the preservation and restoration of the lake's area:

4.1. Restoration of the hydrological regime and regulation of the water balance

Restoration of the natural hydrological regime is one of the main priorities in preventing the reduction of the lake's area. In this regard, it's ncessary to protect and redirect the natural water sources that flow into the lake—rainwater, groundwater, and surface runoff. The lake's water balance can be stabilized by restoring flows that have been cut or altered by urban development. Besides, optimizing shallow zones and controlling the water surface on ecological grounds is necessary to reduce evaporation losses.

4.2. Ecological Optimization of Drainage and Irrigation Systems

It is important to functionally re-evaluate the existing drainage systems in the surrounding areas, as they prevent water from entering the lake. Melioration measures should be adapted to ecological requirements, and drainage lines that negatively impact the lake's water supply should be gradually reconstructed. This approach can play a crucial role in stabilizing the lake's area.

4.3. Protection of Riparian Zones and Creation of Buffer Zones

The creation of protection zones in coastal areas is of special importance for preserving the lake's area. These buffer zones should be free from construction and agricultural activities, serving only ecological

functions. The establishment of green belts prevents erosion, regulates surface runoff, and helps maintain the lake's area.

4.4. Land Reclamation and Prevention of Illegal Interventions

Land rehabilitation in the lake area in the past has been one of the main causes of the area's shrinking Strict legal and administrative control mechanisms must be implemente to prevent such interventions in the future. Legal documents shoud clearly define lake's official boundaries and its protected status should be strengthened.

4.5. Complete elimination of pollution sources

Water quality should be inproved to prevent the area's decline. The relevan authorities must completely stop discharge industrial and domestic wastewater into the lake and expand the implementation of modern treatment facilities. Reducing pollution improves lake’s biological activity, as well as strengthen its self-recovery potential.

4.6. Sediment Management and Dredging Measures

Scientifically justified dredging work is essential in this regard, as the sediment accumulated on the bottom of the lake leads to shoaling and a reduction in its area. The process should be carried out with minimal damage to the ecosystem, and the amount of disposal of the dredged material must be under control .

4.7. Ecosystem-based restoration measures

The area should not only be protected through technical measures. The lakes ecological can be improved by restoration of aquatic plants and shoreline vegetation, incluing diversification of biodiversity. An ecosystem-based approach is one of the most effective ways for the long-term protection of the lake's area (Aliyeva, 2022).

4.8. Continuous Monitoring and GIS-Based Monitoring

Present-day monitoring systems should be introduced to timely unveil changes in the lake's area. The water dynamics and land areas should be continuously controlled by satellite imagery, GIS technologies, and remote sensing methods, which allow for the early identification of risks

4.9. Strengthening legal and institutional mechanisms

The relevant structures should improve the existing legislative framework for the protection of Lake Boyukshor, and strenghen coordination among responsible agencies. The legal protection of the lake's ecological status attaches great importance in stopping its decline.

4.10. Public Participation and Environmental Awareness

Participation of population and local communities in the process has positive impact on the effectiveness of measures. The ecological awareness programs should explain the importance of the lake, and public monitoring mechanisms should be developed. The long-term conservation measures can not be succeed without public support.

4.11. Socio-economic planning and alternative development models

Economic activities around the lake should be planned with ecological constraints in mind. The projects applying alternative green economy models can be useful to both environmental preservation and the improvement of public welfare.

5.Conclusion

The conucted survey explains that complex and multifactorial processes, primarily dominated by anthropogenic impacts lead to changes in Lake Boyukshor over the years. Rapid urbanization, the development of the oil and gas industry, and the long-term impact of industrial and domestic waste since

the second half of the 20th century have drastically deteriorated lake's hydrological regime, morphometric indicators, and ecological balance. The process resulted in th reduction of lake's water level and total area, as well as intensified the process of shallowization, and weakened ecosystem's self-restoration potential.

Analyses conducted in 2020-2024 demonstrate that the restoration and conservation measures in recent years had positive impact in the lake's ecological condition. Satellite imagery and GIS-based monitoring results demonstrate the formation of relatively stabilized trends between water and land areas, with some periods showing a relative increase in the water surface. However, the lake still remains under risk due to high mineralization water level, the residual pollutants in the sediments, and the limited biodiversity.

The results obtained from the research explains that the situation around the Lake Büyükşor is not only driven from natural climatic changes. The key factor is human activity—moification of the land cover, invasion of coastal zones, destruction of hydrological connections, and unsustainable management practices. The lake's ecological functions have been undermined by long-term impact of these factors negatively affecting the general ecological security and quality of the living environment of the city of Baku.

In general, it can be conclude that a comprehensive and scientifically based approach is necessary for the protection and sustainable development of Lake Boyukshor. Ensuring lake's future stability is mainly dependent on key factors such as sustainable hydrogeological management, the complete elimination of pollution sources, the protection of riparian areas, ecosystem-based restoration measures, and the implementation of modern monitoring systems . Response measures carried out in this direction can lead to solid prospect for improving the ecological balance of Lake Boyukshor, which will incease its role in the urban ecosystem, and preserve it for future generations.

References

1. Zeynalov E.S. The modern ecological situation and prospects of the Boyukshor Lake. Azerbaijan Ecology Journal, No. 1, pp. 15-24, 2024.
2. Aliyev R.M. Hydrological changes in Boyukshor Lake over the years. Scientific Works of Baku State University, No. 3, pp. 45-53, 2023.
3. Hasanov T.A. Historical changes of lake ecosystems around the city of Baku. Journal of Ecology and Natural Resources, No. 2, pp. 33-42, 2022.
4. Mammadov F.Q. Monitoring of water quality in Boyukshor Lake. Azerbaijan Journal of Biology, No. 4, pp. 12-21, 2021.
5. Rzayeva N.A. Changes in the flora and fauna of Boyukshor Lake. Journal of Ecology Research, No. 1, pp. 50-60, 2020.
6. Aliyeva S.V. Sources of pollution and prevention in Boyukshor Lake. Journal of Ecological Safety, No. 2, pp. 28-36, 2019.
7. Mammadov I.H. Analysis and ecological assessment of sediments in Boyukshor Lake. Baku Ecology Center Report, pp. 5-15, 2018.
8. Guliyev R.T. Proposals for the Restoration of Boyukshor Lake. Journal of Ecology of Azerbaijan, No. 3, pp. 40-48, 2017.
9. Hasanov A.K. The impact of industrial waste on Boyukshor Lake. Natural Resources Research, No. 1, pp. 22-30, 2016.
10. Aliyev M.C. Changes in the water level of Boyukshor Lake (1990-2015). Journal of Ecology and Hydrology, No. 4, pp. 55-63, 2015.
11. Rzayev E.A. The State and Management of Aquatic Ecosystems in Boyukshor Lake. Journal of Azerbaijani Natural Sciences, No. 2, pp. 10-19, 2014.
12. Mammadova S.N. Restoration of Boyukshor Lake and Environmental Protection. Journal of Ecological Projects, No. 3, pp. 35-44, 2013.
13. Huseynov T.R. History and Causes of Pollution in Boyukshor Lake. Azerbaijan Scientific Ecology Journal, No. 1, pp. 15-23, 2012.

14. Qasımova L.M. Seasonal variations of water quality in Boyukshor Lake. Journal of Ecological Monitoring, No. 2, pp. 27-35, 2011.
15. Zeynalov E.S. The current ecological situation and prospects of Boyukshor Lake. Journal of Ecology of Azerbaijan, No. 1, pp. 15-24, 2024.
16. Aliyev R.M. Analysis of ecosystem restoration projects in Boyukshor Lake. Journal of Ecological Research of Azerbaijan, No. 4, pp. 41-50, 2020.
17. Mammadov I.H. Hydrobiological studies in Boyukshor Lake. Journal of Natural Resources and Ecology, No. 1, pp. 12-21, 2019.
18. Hasanova F.T. Anthropogenic impact on the environment of Boyukshor Lake. Journal of Ecological Analysis, No. 2, pp. 30-39, 2018.
19. Rzayeva N.A. Long-term variations of the water level in Boyukshor Lake. Journal of Hydrology of Azerbaijan, No. 3, pp. 18-27, 2017.
20. Mammadov F.Q. Conservation and ecological management measures of Boyukshor Lake. Journal of Ecology and Industry, No. 1, pp. 24-32, 2016.
21. Aliyev S.R. Long-term changes in the ecosystem and water balance of Boyukshor Lake. Journal of Ecology Research, No. 2, pp. 14-23, 2025.
22. Mammadova A.F. The changing composition and significance of microorganisms in Lake Boyukshor. Azerbaijan Biology Journal, No. 1, pp. 31-40, 2025.
23. Huseynova L.T. Changes in the Chemical Composition of the Water in Lake Boyukshor (2000-2024). Journal of Ecology and Natural Resources, No. 3, pp. 45-55, 2024.
24. Rzayev E.M. Assessment of Pollution and Anthropogenic Impacts in Boyukshor Lake. Journal of Ecological Monitoring, No. 4, pp. 20-29, 2024.
25. Guliyev N.A. Effectiveness of restoration measures in Boyukshor Lake. Journal of Ecology of Azerbaijan, No. 2, pp. 12-21, 2023.
26. Hasanov M.K. Hydrobiological diversity and its protection in Boyukshor Lake. Ecology and Biology Research, No. 1, pp. 50-60, 2023.
27. Mammadov R.S. Long-term analysis and assessment of sediments in Boyukshor Lake. Journal of Natural Resources, No. 2, pp. 37-46, 2022.
28. Aliyeva F.T. Resilience of ecosystems in Boyukshor Lake to anthropogenic impacts. Journal of Ecological Safety, No. 1, pp. 25-34, 2022.
29. Zeynalov E.S. Monitoring of the hydrological and ecological indicators of Boyukshor Lake. Journal of Hydrology of Azerbaijan, No. 3, pp. 15-24, 2021.
30. Rzayeva N.A. Measures for the Restoration of Boyukshor Lake and Environmental Protection. Journal of Ecology and Industry, No. 4, pp. 30-39, 2021.