

# **Balancing Sanctity and Sustainability : Preserving the Ecological and Cultural Integrity of Khecheopalri Lake**

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## **Abstract :**

Khecheopalri Lake, located in the Sikkim Himalayas of India, is a site of profound cultural and environmental significance, revered by both Buddhists and Hindus. Known as a “wish-fulfilling lake,” it draws numerous visitors annually for its spiritual and natural allure. However, the lake faces ecological threats due to increased tourism, including changes in water quality and biodiversity loss. This study explores the cultural heritage and ecological challenges of Khecheopalri Lake, employing methods such as satellite imagery analysis, field surveys, and water quality assessments. Findings indicate a correlation between rising tourist activities and environmental degradation, highlighting the need for sustainable tourism practices. The research underscores the importance of integrating local cultural practices with conservation efforts to preserve this sacred site.

**Keywords :** Khecheopalri Lake; Sustainable tourism; Cultural heritage; Ecological conservation; Environmental degradation.

## **Introduction :**

The Himalayas’ intrinsic beauty, which includes its snow-capped mountains, abundant wildlife, a high altitude that soothes the eyes, and its pilgrimage sites, regularly attracts both domestic and foreign tourists. Because of their extensive mythology pertaining to their way of life and the resources in their immediate environment, the mountain people have preserved the sites’ pristine condition and established taboos regarding human tampering. Because visitors can recognize the links between religious practices and beliefs and environmental conservation and restoration, these places have a significant advantage over other tourist destinations. (Jain et al. 2004)

Sikkim, as a whole, is believed to be sacred by Sikkimese Buddhists. According to the sacred scripture Neysol, the region below Mt. Khangchendzonga in west Sikkim, referred to as Demozong, is considered the most sacred of all being the residence of Sikkim’s deities. This region features a number of glacial lakes in the higher elevations, which are regarded sacred waters (Rai 2002). Khecheopalri Lake in the Sikkim Himalaya of India is considered the most sacred and revered by the local people and its considered to be religious from the point of view of both Buddhist and Hindus. In the Bhutia

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language, “Khecheo” means “in the middle” and “palri” means “lotus”, thus Khecheopalri means “in the middle of the lotus”(EVERSHED & FISH, 2006). According to Buddhists, the lake is a residence place for the Goddess Tara Jestum Dolma, who is the mother of Lord Buddha. Lake Khecheopalri is supposed to be her footprints, as the shape of lake reveals.(Figure 1) Hindus believe that Lord Shiva meditated in Dupukney Cave, which is located right above Khecheopalri Lake. Lord Shiva is honored during “Nag Panchmi,” which normally comes between July and September (nag= snake; Panchmi= fifth day of Bhadua month, a holy month in the Hindu calendar; the snake symbolizes Lord Shiva). (Jain et al. 2004). Another story holds that a Lepcha lady named Nenjo Asha Lham was blessed by the lake goddess and was bestowed with a valuable gem which was lost, and it is the belief of the local people that the gem is buried in the lake and with all these tales, the lake is termed a “wish fulfilling lake”

Besides folklores the lake is also related with several religious event, the most renowned being the Bumchu festival which falls on the 15th day of the initial month of the Lunar calendar, which corresponds with the month of February/March. The uncovering of the container with the sacred water is the main focal point of the festival. The water level in this container is regarded to be a sign of the future prospects for the upcoming year. Annually, the vessel is checked to assess the water level within it. Consequently, if the water level is either higher or lower, it signifies adverse events such as droughts, diseases, and natural disasters. A special recitation is conducted and the seal of the vase is inspected before it is taken out of the case. This paper will explore the cultural significance and the environmental challenges facing Khecheopalri Lake.

## **Study Area :**

Khecheopalri Lake is located at coordinates 27°22'24" N and 88°12'30" E, approximately 147 kilometers west of Gangtok, the capital of Sikkim Himalaya. Situated in the West District at an altitude of 1700 meters above mean sea level, the lake symbolizes the primary area where compact granular snow, known as neve, originally developed and subsequently transformed into a glacier. The southern bank of the Lethang Valley is characterized by a moraine crest. (Raina 1966) The lake's proportions, including a surface area of 3.79 hectares and a maximum depth of 11.2 meters, highlight its significant prominence in the region's landscape. The catchment area of 4.6 square miles supplies water to the lake. (Table 1) The lake's high altitude enhances its exceptional water quality and supports a wide range of plant and animal species, resulting in a varied ecology. The recorded water level of 272,880 cubic meters indicates its ability to hold substantial amounts of freshwater, which is essential for sustaining local plant and animal life, as well as meeting the demands of nearby settlements.

## **Methods :**

To assess the historical land-use and land-cover changes around Khecheopalri Lake, we utilized a combination of satellite imagery and topographical maps. High-resolution satellite images from Landsat 7 for the year 2000 and Landsat 8 for the year 2020 were obtained, along with topographical maps from the Survey of India to provide a baseline for earlier land-use patterns. The satellite images were processed using GIS software (Arc GIS 10.8), with radiometric and atmospheric corrections applied to enhance image quality. A supervised classification technique was employed to categorize land cover into distinct classes such as forest, agricultural

land, water bodies, and built-up areas. Classified images from different years were compared to identify changes in land use and cover over the past two decades.

To understand the ecological health and biomass productivity of forests surrounding the lake, we conducted extensive field surveys in selected forest plots. Plots of 1 hectare each were marked for detailed study, within which trees were identified and measured for diameter at breast height (DBH) and height. Understory vegetation and shrub density were also recorded. Above-ground biomass was estimated using allometric equations specific to the tree species present, while below-ground biomass was approximated as a proportion of above-ground biomass based on established ratios.

Quantifying the extent of biomass extraction and resource utilization by the local community involved semi-structured interviews with local residents and community leaders to gather data on firewood and fodder collection practices. Direct observations and measurements of biomass extracted, such as firewood bundles and fodder loads, were recorded during field visits. The volume of resources extracted per household was calculated and extrapolated to estimate total community-level extraction.

To measure sediment and nutrient deposition rates in the lake, sediment traps were deployed at multiple locations in the lake to collect sediment over a one-year period. The traps were retrieved, and sediment weight was measured. Sediment samples were analysed for nutrient content, specifically nitrogen and phosphorus, using standard laboratory techniques such as the Kjeldahl method for nitrogen and colorimetric method for phosphorus.

Regular monitoring of water quality parameters was conducted through monthly water sample collections from multiple points in the lake. On-site measurements of parameters such as pH, temperature, and dissolved oxygen (DO) were taken using portable meters. Samples were then analyzed in the laboratory for alkalinity, hardness, nitrate, phosphate, and other relevant chemical parameters using spectrophotometric methods.

Assessing the biological health of the lake involved plankton analysis and biodiversity surveys. Plankton samples were collected using plankton nets with a mesh size of 50  $\mu\text{m}$  and preserved in Lugol's iodine solution for later analysis. Samples were examined under a microscope to identify and count phytoplankton and zooplankton species. Biodiversity surveys of the transition zones between the lake and peatland areas were conducted to document species diversity and density of aquatic and terrestrial plants.

To evaluate the impact of tourism on solid waste generation and management, waste audits were conducted at popular tourist spots around the lake to categorize and quantify waste types such as plastic, organic, and inorganic materials. Interviews with local tourism operators, waste management personnel, and visitors provided insights into waste management practices and challenges. Observations were made to assess the effectiveness of existing waste disposal and recycling facilities.

Radiocarbon dating was employed to determine the age of sediment layers and understand historical deposition patterns. Sediment cores were extracted from the lakebed using a gravity corer, and samples were sent to a radiocarbon dating laboratory where they were pretreated and analyzed using accelerator mass spectrometry (AMS) to determine the age of different sediment layers. (Table 2)

This comprehensive approach ensured that the various dimensions of Khecheopalri Lake's environmental and cultural significance were thoroughly investigated, providing a robust foundation for sustainable conservation strategies.

## **Results :**

### **Water Quality Data :**

The water quality data for Khecheopalri Lake indicates a slight shift towards increased pH, alkalinity, and nutrient levels, while dissolved oxygen (DO) has decreased marginally. The pH has moved from 6.8-7.2 to 7.0-7.4, suggesting a shift towards alkalinity likely due to organic matter decomposition and increased tourist activities. Alkalinity has risen from 40-80 mg/L CaCO<sub>3</sub> to 50-90 mg/L CaCO<sub>3</sub>, potentially caused by runoff carrying bicarbonates from disturbed soils. This trend can buffer pH changes but might affect species sensitive to higher alkalinity. DO levels have decreased from 8.0-10.0 mg/L to 7.5-9.0 mg/L, likely due to higher biological oxygen demand from increased organic matter, stressing aquatic organisms. Phosphate-phosphorus levels have increased from 0.01-0.05 mg/L to 0.02-0.06 mg/L, and total nitrogen has risen from 0.5-1.0 mg/L to 0.7-1.2 mg/L, both indicating nutrient enrichment from agricultural runoff, waste, and tourism-related activities. (Table 3.) These changes pose a risk of eutrophication, leading to algal blooms and oxygen depletion.

## **Tourism's Influence on Lake Quality and Local Culture**

Because of its distinctive terrain, abundant biodiversity, and numerous ethnic, religious, and cultural facets, Khecheopalri Lake in the Sikkim Himalayas of India is becoming more and more well-known among tourist. The people of Sikkim hold Khecheopalri Lake in the highest regard in terms of its religious significance. The statistics about the number of tourists visiting Khecheopalri Lake from 2012 to 2021 demonstrates a steady increase in visitor numbers, except for the years 2020 and 2021, which experienced a decline in tourist influx owing to COVID-19 restrictions (Figure 2). The continuous increase in tourism may be ascribed to several causes, such as enhanced accessibility, advertising campaigns, and the surging appeal of the lake as a pilgrimage and tourist spot.

The association between heightened tourist activity and the degradation of the lake's water quality and surrounding ecology is apparent. With the increasing number of visitors, there has been a corresponding rise in the strain on the delicate environment of Khecheopalri Lake. The arrival of visitors brings a multitude of environmental concerns, including pollution and the degradation of habitats. Pollution is a major consequence of increased visitor activities. As the number of visitors to the lake increases, there is a proportional rise in littering, trash production, and automobile pollution. Plastic garbage, specifically, presents a significant peril to the aquatic ecosystem due to its ability to pollute the water and cause harm to aquatic organisms. Moreover, the act of discarding non-biodegradable garbage in and around the lake worsens the pollution issue, resulting in the deterioration of water quality.

Apart from deteriorating the water quality excess waste generation is also impacting the local beliefs and the culture of the local people. The lake is one of many "moving landscapes" within Sikkim. Khecheopalri's several mythologies explain how and why it moved to its current locale. All of

the myths stress the importance of personal and ecological purity and cleanliness. Once the lake becomes dirty, it moves to a new location. (EVERSHED & FISH, 2006). One source, Tshering Topgay Bhutia, an employee at the local school, spoke of the people's responsibilities to maintain the lake clean. He continued, "We as villagers have to stroll around the lake cleaning up the litter that the tourists leave behind because if the lake's spirit becomes dirty or dissatisfied she will leave." Another respondent Pema Bhutia states that "The birds would always pick up the leaves as soon as they drop from the lake and play a pivotal role in maintaining the purity of the lake".

The breakout of the COVID-19 pandemic in 2020 and 2021 resulted in a temporary decline in visitor influx to Khechopalri Lake owing to travel restrictions and lockdown measures. This reprieve offered an opportunity for the environment to recuperate from the demands of tourism-related activity. However, it also emphasized the link between tourism and environmental deterioration, stressing the necessity for sustainable tourist practices and conservation measures to maintain the lake's ecology.

In conclusion, the rising tourist influx to Khechopalri Lake has had severe consequences on its water quality, surrounding ecology and the culture of the local people. The association between increased tourism and environmental deterioration underlines the critical need for sustainable tourist management systems and conservation measures. By taking steps to minimize pollution, limit tourist activities, and conserve natural habitats, we can assure the long-term preservation of Khecheopalri Lake and its important ecological legacy.

## **Demographic distribution :**

The demographic distribution based on caste and community highlights the varied cultural diversity that surrounds Khecheopalri Lake. The Lepchas and Bhutia's are two prominent communities in the region, making up 22.44% and 47% of the population, respectively. (Figure 3) (Table 4). These tribes, have strong connections to their indigenous customs, hence they highly value the lake and frequently include rituals and ceremonies into their cultural activities to show respect for its sacredness famous being the Bumchu Festival. However, the presence of other communities such as Chhetri, Mangar, Sherpa, and Others cannot be overlooked. Despite their smaller population sizes compared to Bhutias and Lepchas, these communities also hold the Khecheopalri Lake in high regard due to its connection to Hinduism which is one of the major religions in Sikkim, it likely impacts the beliefs and practices of other communities residing in the area. The sacredness of Khecheopalri Lake in Hindu mythology, possibly ascribed to it being associated with deities such as lord shiva, could be a unifying factor among the diverse communities, leading them to also consider the lake sacred.

## **Discussion :**

The data presented in this study reveal significant changes in the water quality of Khecheopalri Lake, correlating with the increase in tourist activities. The pH, alkalinity, and nutrient levels have shown an upward trend, indicating environmental stress. The decrease in dissolved oxygen is particularly concerning as it affects aquatic life, leading to potential disruptions in the lake's ecosystem. The rise in phosphate-phosphorus and total nitrogen levels highlights the influence of agricultural runoff and waste associated with tourism.

The cultural implications are equally critical. The local beliefs and practices emphasize the purity of the lake, which is central to their spiritual and cultural identity. The degradation of the lake not only threatens the ecological balance but also undermines the cultural heritage of the local communities. The narratives and folklore associated with the lake, such as the belief in its "wish-fulfilling" powers, reinforce the need for maintaining its sanctity.

The temporary respite during the COVID-19 pandemic underscored the adverse impact of tourism and highlighted the potential for recovery when human activities are minimized. This period provided a unique opportunity to observe the lake's resilience and the positive effects of reduced anthropogenic pressure.

Moving forward, it is imperative to adopt sustainable tourism practices that balance visitor influx with conservation efforts. Strategies such as regulating the number of visitors, implementing strict waste management protocols, and promoting eco-friendly tourism can help mitigate the adverse effects. Engaging local communities in conservation efforts ensures that their cultural practices are respected and integrated into the preservation strategies.

In conclusion, the study underscores the urgent need for a comprehensive approach to conserve Khecheopalri Lake. By addressing both environmental and cultural dimensions, we can safeguard this sacred water body for future generations. Sustainable tourism and community-driven conservation initiatives are key to achieving this goal.

## **Conclusion :**

The research highlights the critical need for sustainable tourism and conservation measures at Khecheopalri Lake to address the adverse impacts of increased visitor activities on its ecological and cultural integrity. The study reveals significant changes in water quality, with rising pH, alkalinity, and nutrient levels, coupled with a decrease in dissolved oxygen, signalling ecological stress. The cultural ramifications are equally concerning, as the degradation of the lake undermines the spiritual and cultural values held by the local communities.

The temporary decline in tourism during the COVID-19 pandemic provided a unique opportunity to observe environmental recovery, emphasizing the potential benefits of reduced human activity. This period underscored the necessity for implementing sustainable tourism practices, such as regulating visitor numbers, improving waste management, and promoting eco-friendly tourism initiatives.

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Engaging local communities in conservation efforts is paramount to ensuring the preservation of their cultural heritage and the ecological health of the lake. By adopting a holistic approach that balances tourism with environmental stewardship and cultural respect, Khecheopalri Lake can be safeguarded for future generations. This study serves as a call to action for stakeholders to collaborate in developing and enforcing policies that protect this sacred and ecologically significant site.

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## LIST OF TABLES

*Table 1. Quantitative analysis of Khecheopalri lake*

Longitude	88.1883° E
Latitude	27.3492° N
Surface elevation	1700 metres
Surface area	3.79 hectares
Average depth	7.2 m
Maximum depth	11.2 m
Catchment area	4.6 sq. mi
Water volume	272,880 cubic metres

*Table2. Methods used for collecting data.*

Aspect	Methodology	Tools/techniques
Land-use/ cover change	Historical data analysis using satellite images and topographical map.	GIS, Remote Sensing
	Mapping and quantifying land-use changes	
Forest, ecology and biomass	Field surveys to estimate biomass productivity	Field Measurements
Productivity	Quantifying biomass extraction by locals and livestock	Calculations based on field data
Sediment and nutrient deposition	Sediment traps to measure annual sediment deposition	Sediment trap
Physio-chemical parameters	Regular monitoring of water quality parameters	pH Meters, Dissolved Oxygen Meters, Spectrophotometers
Biological parameters	Plankton sampling and analysis	Plankton Nets, Microscopes
	Surveys of transition zones between lake and peatland	Field Surveys
Tourism related solid waste	Auditing and categorizing solid waste generated by tourists	Waste Audit, Categorization Techniques
Radio carbon dating	Collecting and analysing sediment	Radiocarbon Dating Techniques

*Table 3. details of water quality.*

Parameter	Original Value	New Value	Comments
pH	6.8 - 7.2	7.0 - 7.4	Slight increase due to increased organic matter decay
Alkalinity (mg/L CaCO <sub>3</sub> )	40 - 80	50 - 90	Increased due to more soil runoff
CaCO <sub>3</sub> )			
Dissolved Oxygen (mg/L)	8.0 - 10.0	7.5 - 9.0	Slight decrease due to higher organic load
Phosphate-Phosphorus (mg/L)	0.01 - 0.05	0.02 - 0.06	Increase due to tourism-related pollution
Total Nitrogen (mg/L)	0.5 - 1.0	0.7 - 1.2	Increase from agricultural runoff and waste



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Table 4. Demographic Distribution of population by community living near Khecheopalri lake. (Source Field survey)

Community/Caste	Households	Population	Percentage
Chhetri	3	20	4%
Mangar	3	25	5.10%
Sherpa	12	72	14.69%
Lepchas	22	110	22.44%
Bhutias	43	230	47%
Others	5	33	6.70%
Total	490	490	100%

## ***LIST OF FIGURES :***



*Figure 1. Bird's eye view of Khechopalri lake and its surrounding biodiversity.  
(SOURCE GANGTOK TIMES)*

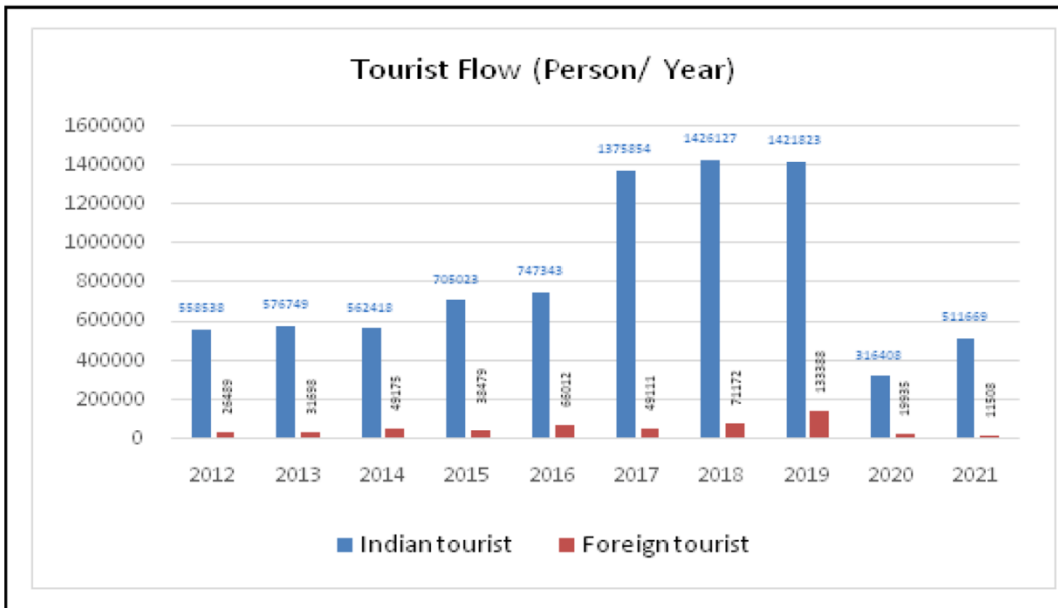


Figure 2. Tourist inflow in Sikkim from 2012 to 2022 (Data source : WWW.CEICDATA.COM/ Ministry of Tourism)

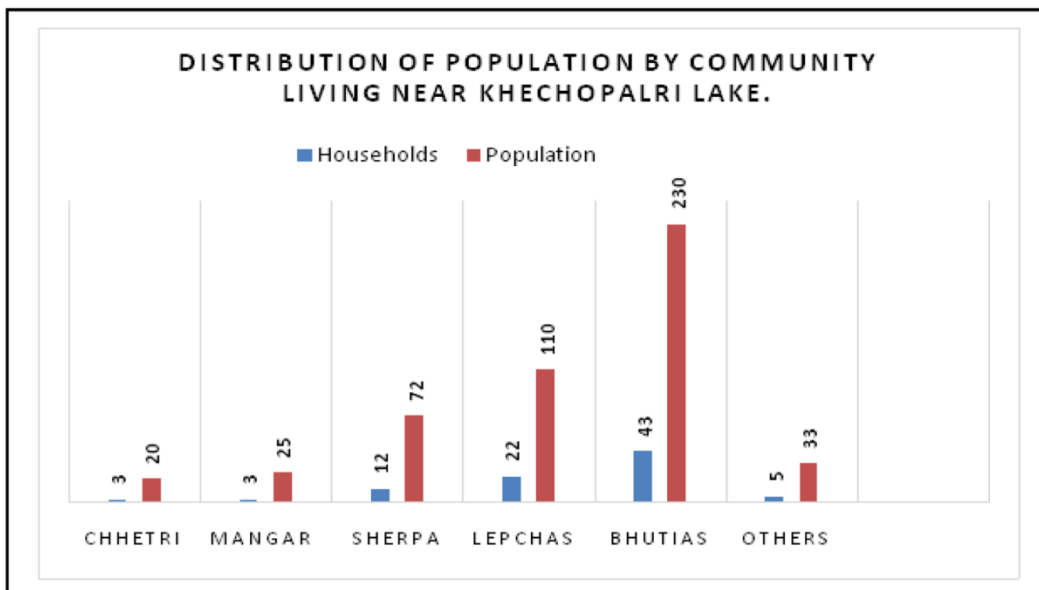


Figure 3. Demographic Distribution of population by community living near Khecheopalri lake. (Source Field survey)