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Abstract: Niladri Lake, located in the Takerghat region of Sunamganj, Bangladesh, is a quarry lake formed from an abandoned limestone quarry. Originally a site of industrial limestone extraction, it played a key role in the local and national economies by supplying the Chhatak Cement Factory. After mining had ceased, the quarry gradually filled up with water, eventually forming Niladri Lake. To understand the historical and geological significance of Niladri Lake, the research follows its evolution from an industrial site to a restored water body. The paper covers initiatives to revitalize the region and establish ecological balance by combining environmental awareness, geological heritage preservation, and sustainable tourism. This study uses field surveys, interviews, and impact assessments to explore Niladri Lake's potential for tourism, demonstrating how to restore post-industrial landscapes for environmental and community benefit. The findings emphasize the dynamic relationship between nature and industrial activity and offer significant insights for land reclamation and sustainable tourism development.

Keywords: Niladri Lake; Limestone; Quarry; Geological Heritage; Sustainable Tourism.

Derinlikleri Ortaya Çıkarmak: Terkedilmiş Bir Kireçtaşı Ocağının Takerghat, Sunamganj'da Turizm Noktasına Dönüştürülmesi

Özet: Bangladeş'in Sunamganj bölgesindeki Takerghat'ta yer alan Niladri Gölü, terkedilmiş bir kireçtaşı ocağından oluşan bir taş ocağı gölüdür. Başlangıçta endüstriyel kireçtaşı çıkarımı için kullanılan bu alan, Chhatak Çimento Fabrikasına tedarik sağlayarak yerel ve ulusal ekonomide önemli bir rol oynamıştır. Madencilik faaliyetlerinin sona ermesinin ardından ocak zamanla suyla dolarak Niladri Gölü'nü oluşturmuştur. Bu araştırma, Niladri Gölü'nün tarihsel ve jeolojik önemini anlamak amacıyla, onun endüstriyel bir alandan doğal bir su kütlesine dönüşümünü incelemektedir. Çalışma, çevresel farkındalık, jeolojik mirasın korunması ve sürdürülebilir turizmin bir araya getirilmesi yoluyla bölgenin yeniden canlandırılması ve ekolojik dengenin sağlanması yönündeki girişimleri ele almaktadır. Araştırmada saha çalışmaları, görüşmeler ve etki değerlendirmeleri kullanılarak Niladri Gölü'nün turizm potansiyeli incelenmiş ve endüstri sonrası peyzajların çevresel ve toplumsal faydalar için nasıl geri kazanılabileceği gösterilmiştir. Bulgular, doğa ile endüstriyel faaliyetler arasındaki dinamik ilişkiyi vurgulamakta ve arazi ıslahı ile sürdürülebilir turizm geliştirme konusunda önemli çıkarımlar sunmaktadır.

Anahtar kelimeler: Niladri Gölü, Kireçtaşı, Taş Ocağı, Jeolojik Miras, Sürdürülebilir Turizm.

1. INTRODUCTION

In recent years, the concept of sustainable tourism development has gained global interest as communities aim to balance economic growth with environmental protection. The transformation of abandoned mining and industrial sites into tourist attractions presents a unique opportunity to restore degraded landscapes, maintain ecological integrity, and promote regional development. Based on both geographic and national significance, areas of abandoned quarries are a significant part of the environment. Quarries acquire intriguing morphological features, making them distinctive landmarks. Furthermore, it is vital to keep in mind that these locations have local cultural values and could be a key component of a tourist attraction [1].

With a focus on a destination's distinctive geological features, geotourism is a specialized form of tourism that seeks to give tourists sustainable and instructive experiences [2]. Traditional mining sites, rich in cultural, social, and geological heritage, offer significant potential for geotourism. These locations preserve the "historic signals" of ancient mining activities, connecting visitors to the Earth's geological processes and human history. Transforming such sites into geotourism destinations fosters heritage conservation, education, and sustainable local economic development [3].

Generally speaking, locations or regions with a substantial geoheritage have a particular responsibility to preserve the existing geological features for their significance on a national and worldwide level [4]. In this context, the abandoned limestone quarry at Takerghat, Sunamganj, emerges as a site of significant potential for sustainable redevelopment. Historically, Takerghat served as a center for the extraction of limestone, which was essential to the development of Bangladesh's infrastructure and industry. The quarry's limestone reserves were extensively mined, contributing to the production of cement and other construction materials. Post-industrial landscaping involves repurposing degraded or abandoned industrial sites to integrate them back into the environment and community. Quarry lakes, which develop when excavation pits fill with surface or groundwater after mining activities cease, are one of the most distinctive aspects of open-pit mining [5]. In comparison to the landscape's pre-operational state, these bodies of water reflect a significant and long-lasting change. The resulting quarry lake, named Niladri Lake in Takerghat, is a visually appealing feature as well as an environmentally significant asset, offering chances for sustainable tourism, ecological rehabilitation, and a celebration of the area's industrial past. Industrial heritage, which significantly contributed to human progress during the industrialization era, should be carefully preserved to ensure its transmission to future generations [6].

The site is now inert after decades of operation, with a landscape that echoes its industrial past, vast excavations, and abandoned infrastructure. In addition to leaving the region economically and environmentally stagnant, the end of mining activities has given rise to a chance to rethink its future through the growth of sustainable tourism. However, the region is severely limited by a lack of tourism-related activities, which limits its potential to provide tourists with intriguing and varied experiences. The tourism industry in Takerghat confronts challenges, including poor community engagement, environmental threats, a lack of diverse activities, and inadequate amenities. A comprehensive approach is required to solve issues, with a focus on low-impact, sustainable tourism, community-driven projects, and environmentally friendly facilities. This strategy promotes Takerghat's development as a sustainable tourism destination by ensuring long-term sustainability and resilience.

The main objectives of this study are to investigate educational possibilities, evaluate conservation strategies, encourage community engagement, and suggest eco-friendly tourism practices that protect the area's geological heritage. The research explores the types of mining and their environmental implications, focusing on the historical and present state of the Takerghat limestone quarry. Furthermore, the concept of

quarry lakes is examined, emphasizing their potential as important elements of tourism projects in terms of ecology, recreation, and aesthetics.

Various field studies will be conducted to gather data on the environmental, geological, and socio-economic aspects of the Niladri Lake area. The study proposes a thorough plan for revitalizing the Takerghat quarry, demonstrating how creative design, community engagement, and ecological practices can turn abandoned industrial sites into thriving tourist attractions. Supported by case studies of successful quarry rehabilitations, the research highlights strategies for balancing ecological restoration, cultural preservation, and economic growth tailored to Takerghat's unique context.

1.1 Historical Background of the Study Area

The Takerghat Limestone Mining Project, located in Sunamganj, Bangladesh, has a rich history rooted in industrial development. It was initiated in the middle of the 20th century to extract limestone, which is a key raw resource for construction and cement manufacturing. It supplies limestone to the Chhatak Cement Factory, enabling it to produce cement for both national and regional markets [7]. Because limestone from the Khasi Hills was locally calcined for the Bengali market during the British Raj, Chhatak gained importance in the limestone business. Utilizing limestone from the Khasi Hills and later Takerghat, the Assam Bengal Cement Factory was founded in 1940. The facility continues to be a major participant in the local cement market, underscoring the industrial significance of Chhatak. The history and development of the limestone mining project in Takerghat hold significant importance for Bangladesh's cement industry-

<u>Local Resource Discovery</u>: In 1961, geological surveys conducted in Takerghat verified that five drilled pits contained roughly 132.56 million metric tons of limestone. This finding revealed the possibility of domestic limestone extraction [8].

<u>Initial Limestone Extraction</u>: In the 327-acre Takerghat mining project area, formal operations started in 1965 and 1966. Two quarries, totaling 70.69 acres and 92.25 acres, respectively, were the first to extract limestone. By 1980, 1.66 million metric tons of limestone had been removed.

<u>Mismanagement and Corruption</u>: The project was managed by the Bangladesh Chemical Industries Corporation (BCIC), but it was allegedly brought to a halt by the dishonest actions of some authorities, workers, and self-interested labor union members. Allegedly, these acts were deliberate, transforming a once-profitable initiative into a losing industry.

<u>Transfer to Chhatak Cement Factory</u>: Later, the project was placed under the direction of another BCIC establishment, the Chhatak Cement Factory. Even after the transfer, the project's problems persisted, and by the middle of the 1990s, operations had drastically decreased.

<u>Closure in 1996</u>: The mining project was closed around 1996. About 400 employees were moved to other BCIC facilities. With this closure, the region's active limestone extraction came to an end.

<u>Final Shutdown in 2007</u>: On October 2, 2007, 31 officers and employees from the Chhatak Cement Factory were transferred, bringing an end to all project-related activities.

Given the substantial investment made in the project, equipment valued at over 60 crore BDT (Bangladeshi Taka) was underutilized at the time of closure. Following the end of mining operations, groundwater and rain slowly filled the abandoned quarry sites, forming Niladri Lake. This natural transformation turned the former industrial site into a beautiful lake, now a popular tourist destination. The story of the Takerghat limestone mining project is a tale of both industrial success and failure, marked by significant challenges

and a transformative environmental recovery. The transition from a profitable mining operation to a closed project due to mismanagement, followed by the natural formation of Niladri Lake, highlights the dynamic interplay between industrial activity, economic factors, and environmental processes. With its existing prominence as a tourist destination, Niladri Lake offers optimism for long-term economic growth based on the region's historical significance and scenic beauty.

1.2. Geology of the Study Area

The Sylhet-Assam region boasts a rich history of limestone mining, with quarrying in the Khasi hills beginning in the eighteenth century, making it a thriving business in Sylhet. The Takerghat Limestone Development and Transportation Project, spanning 237.93 acres, was initiated by the East Pakistan Industrial Development Corporation (EPIDC) in 1967 and subsequently managed by various entities, including the Bangladesh Industrial Development Corporation (BIDC), Bangladesh Mineral Exploration and Development Corporation (BMEDC), BCIC, and Chhatak Cement Company Ltd.

Takerghat, located in Sunamganj, contains Eocene limestone deposits that range from surface to nearsurface levels, highlighting the area's geological significance. All near-surface extractable limestone deposits in the area have been mined using the open-pit method. Drilling has revealed that the remaining limestone exists as tilted and faulted blocks, dipping at angles of 45–75° toward the south [8]. The total reserves, extending from the surface to a depth of approximately 150 meters, are estimated to be around 14 million tons. The limestone is hard and compact, consisting of both fossiliferous and non-fossiliferous beds. In Bangladesh, the term "Sylhet Limestone" was introduced by Khan (1963) to describe the limestone deposits in Sylhet. The Eocene Limestone is stratigraphically located in the Sylhet Trough and shelf sections beneath the Kopili Formation and above the Tura/Cherra Formation. The earliest known outcrop of Tura sediment is found in the Takerghat region of Sunamganj. It dips southward from the southern margin of the Shillong Plateau and is faulted and folded [9]. The alternating layers of fine- to coarsegrained, cross-bedded sandstones in white, pink, and brown hues, as well as light gray shales, mudstones, and traces of carbonaceous material from the Tura Sandstone, support the limestone deposits in this area of the Sylhet Trough. Although the exact depth of the limestone is unknown, data from boreholes indicates that the beds' greatest thickness is roughly 61.0 meters [8].

1.3. Limestone Mining Scenario of the Study Area

The limestone extraction process at the Takerghat quarry was a comprehensive operation, combining openpit mining with advanced equipment and techniques to maximize efficiency. The process began with the removal of surface layers, exposing the rich limestone deposits beneath [10]. These reserves were reached by drilling holes in the rock with massive drills and then filling those holes with dynamite. The large stone was subsequently crushed up into manageable pieces by controlled explosions. The depth of mining ranged from 80 to 500 feet, ensuring that significant reserves were extracted. Following the fragmentation of the limestone, the broken rock was transported to specified processing zones using heavy equipment like loaders and excavators. Here, the limestone underwent crushing to reduce it to smaller fragments suitable for industrial use. The limestone was then washed in specialized limestone washing pits to remove impurities, improving its quality. To make the limestone acceptable for a variety of uses, specifically the manufacturing of cement, it was screened after washing to divide it into different sizes and grades.



Figure 1. Limestone Mining Scenario in Takerghat Limestone Mining Project

After being processed, the limestone was transported by a rail track system from the quarry to the river. This approach efficiently carried vast amounts of material to the riverside. Once there, the limestone was loaded onto large boats that carried it along the river to the Chhatak Cement Factory. This logistical operation ensured a continuous supply of high-quality limestone for cement production, playing a crucial role in the regional economy and industrial growth. The entire process, from extraction to transportation, was designed to support the cement industry's demand while utilizing the region's natural resources. This methodical approach aided the local economy and established the groundwork for the Takerghat region of Bangladesh's historical and industrial significance.

2. LITERATURE REVIEW

2.1. Integration of the Tourism and Mining Industries

With the process of globalization, societal dynamics are adjusting to evolving social, economic, and global political standards. The tourism sector's market segmentation has greatly increased as a result of the broad acceptance of this strategy. To stand out and separate themselves, tourist locations have adjusted to match new global dynamics. They do this by embracing distinctive qualities and staying ahead of industry trends. The World Tourism Organization states that sustainable tourism must (a) make the best use of available natural resources, (b) respect the sociocultural identity of the area in which it occurs, and (c) benefit the people involved in its development both economically and socially [11]. Geotourism is a recently developed form of "environmentally innovative" tourism. It was once defined as just "geological tourism," but it has since been expanded to include travel that focuses on geology and landscape. It encourages the preservation of geodiversity, tourism to sites, and an understanding of earth sciences through education and enjoyment [12]. In addition to being an economic activity, mining also integrates and alters linked social and environmental sectors, transforming landscape parts and altering the environment, society, and natural resources along the route. At least 500 former mine exploitation sites have been transformed into museums,

parks, and other recreational spaces around Europe. Because of their historical significance, certain mining landscapes and the components that go along with them are regarded as belonging to the human legacy. A few historic mining sites from around the globe are listed on UNESCO's World Heritage List. The development of theme parks, geo-mining parks, geoparks, and other recreational and cultural attractions while maintaining a location's historical and geological identity and promoting an appreciation of both local culture and these features.

Landscape is viewed as a part of human heritage and culture. The cultural landscape, which blends indigenous natural elements with local traditions, has evolved through complex cultural, historical, social, and economic factors, all reflected within the natural environment [13]. According to Bridge (2004), "the mine sits at the nexus of history, politics, and culture, the focal point of a contested moral landscape" as a cultural landscape. One of the best examples of mining heritage tourist activities in Spain is the Riotinto district in southern Andalusia. These "revitalization" efforts, led by the Fundación Río Tinto, include the establishment of a mining museum, the restoration of a mining railway, the preservation of urban areas and archaeological sites, and the planning of guided tours of the mining district. [14]

2.2. Worldwide Initiatives to Rehabilitate Quarries

The ideas of mining tourism are currently being utilized for the mining heritage as a tourist attraction in many countries across the world. Rehabilitating quarries has gained global interest, with countries implementing innovative strategies to transform abandoned extraction sites into valuable ecological, cultural, and recreational spaces.

2.2.1. Tongluo Quarry Park: From an Abandoned Quarry to a Tourist Attraction

Tongluo Mountain in Chongqing, Southwest China, was once a hub for gravel mining due to its rich limestone deposits. There were hundreds of mining companies operating large-scale open-pit mining in the area in the 1990s. This intensive activity resulted in significant land damage, vegetation loss, and ecological degradation. Recognizing the environmental challenges and the urgent need for sustainable solutions, the quarry was officially closed between 2010 and 2012. The cessation of mining left behind 41 abandoned pits of varying sizes, posing substantial safety risks, worsening ecological conditions, and disrupting local livelihoods. The legacy of these activities highlighted the importance of balancing resource extraction with environmental preservation and community well-being.

Ecological Restoration Strategies

In Chongqing, Tongluo Mountain had a radical ecological restoration after intensive mining severely degraded it. Important problems like low water conservation, biodiversity loss, and poor rural landscape quality were found by a thorough survey. The local government responded by creating plans that prioritized ecological design, natural restoration, protection, and cooperative growth. Key initiatives included land greening, water restoration, and biodiversity conservation, integrated with rural revitalization and industrial development.

By promoting tourism and restoring the ecosystem, this all-encompassing strategy made Tongluo Mountain a prosperous tourist attraction. Sometimes referred to as the "green lung of the city and garden for residents," the area currently has recreational, medical, and rural tourist capabilities. The picturesque region has become extremely recognized, drawing over 20,000 tourists at peak periods and being dubbed the "Small Jiuzhaigou Valley of Chongqing," with its beneficial ecological and economic effects being widely praised [15].



Figure 2. Tongluo Mountain Recovery Journey from Abandoned Quarry to Tourist Attraction [15]

Improving the Ecology and Reestablishing the Natural System

Quarry Park serves as a cultural heritage site of the mining industry, embodying the concept of "natural healing and close-to-nature restoration." Restoring the site's ecological integrity is given top priority in the design, along with optimizing the social and economic advantages. It offers an example of sustainable development that incorporates principles that are centered on the environment, culture, and community to restore harmony between people, the land, and the surrounding environment. By the end of 2020, Tongluo Mountain Mine's ecological restoration endeavors had reached a 70% management and recovery rate. By establishing a flourishing ecosystem that drew animals like owls, pheasants, wild boars, and hares, this advancement greatly expanded the amount of forest cover and improved local biodiversity. The improved environment also uplifted the living conditions for over 720 villagers, contributing to a better quality of life and fostering a harmonious coexistence between nature and the community.

The ecological landscape of Tongluo Mountain has garnered significant acclaim from tourists since its trial operation in 2021. With daily peaks of 26,000 and an average of over 5,000 during holidays, the site has received 450,000 visitors. More than 200 residents have found work or founded businesses that provide services including dining cars, sightseeing buses, mini-trains, and mine items that are artistic and cultural. Tongluo Mountain hopes to earn a 5A rating as a national tourism destination, with an estimated 800,000 visitors each year. By combining ecological restoration with science promotion, education, culture, recreation, and wellness, it turns its "beautiful ecology" into a "beautiful economy."

2.2.2. Dalhalla: Sweden's Distinctive Outdoor Theatre Built in an Abandoned Quarry

Located in the tranquil landscape of central Sweden just north of Lake Siljan, Dalhalla stands as a one-ofa-kind venue. Once used as a limestone mining site, it has been transformed into one of Europe's most stunning outdoor theaters, known for its amazing acoustics, picturesque setting, and outstanding performances. The former Draggängarna quarry has become Dalhalla, a renowned cultural landmark that has transformed from an industrial site to a destination that attracts thousands of tourists with its unique atmosphere and wide range of artistic offerings.

Background and Transformation

Dalhalla is situated in Dalarna, a part of central Sweden renowned for its stunning scenery and historical importance, approximately 7 kilometers from Rättvik. The location was formerly a working limestone quarry, which was essential for the extraction of stone for building and other uses. The quarry, which was 400 meters long, 175 meters broad, and 60 meters deep, supplied a significant quantity of limestone until it was closed in 1990 [16]. The quarry, once called Draggängarna, has been restored into an amazing location. After more than half a century of blasting and excavation, Dalhalla's acoustically engineered arena was built with three-dimensional proportions that adhere to the golden ratio.

A Perfect Amphitheater in Nature with Outstanding Acoustics

The distinctive physical layout of Dalhalla creates a natural amphitheater that is perfect for outdoor events. Its stone walls naturally improve the sound quality, producing acoustics that are on par with the best outdoor stages in the world. Dalhalla's distinctive architecture guarantees crisp, clear sound, unlike conventional outdoor venues, making every performance special. Accommodating up to 4,000 spectators, the theater combines the quarry's rugged charm with modern amenities, offering a visually stunning and immersive setting. A varied program, including opera, classical music, jazz, rock, and pop events, is presented at Dalhalla every summer. World-renowned artists and ensembles, including the Bolshoi Theatre and Procol Harum, have performed here, drawing audiences from far and wide. Dalhalla presents a vibrant blend of musical genres and creative brilliance with 20 to 30 events every year [17]. Beyond just the shows, visiting Dalhalla is an experience. Setting the scene for the spectacular view of the quarry, the drive to the location winds through tranquil scenery. When music resonates off the rock walls and melds with the outside ambiance, especially at dusk, the scene is genuinely mesmerizing. Dalhalla exemplifies how a disused industrial site can transform into a cultural and natural harmony hub. It offers more than just performances; it delivers a memorable experience of music, art, and a specially revitalized environment.

3. METHODOLOGY

The initial phase of transforming the Takerghat limestone quarry into a tourism destination involves conducting a background survey and reviewing relevant literature to understand the current and historical conditions of the quarry and the surrounding area. This stage adopts a hybrid methodology, combining qualitative and quantitative approaches through a physical survey and interviews with local inhabitants and the mining community to get valuable insights into recent challenges. Additionally, data has been gathered from the Bangladesh Chemical Industries Corporation (BCIC) regarding mining activities, environmental effects, and community involvement, and also from the Geological Survey of Bangladesh (GSB) regarding geological factors.

Field Survey

Through the Field Survey, significant data on the site's current state and potential for growth as a tourist destination will be gathered. Important areas of attention consist of:

<u>Geological Features</u>: Identify significant geological formations, such as unique rock structures, mineral deposits, and fossil evidence that can be highlighted for educational purposes. These features also serve as a draw for tourists with an interest in natural history and geology.

<u>Socioeconomic Conditions of the Mining Community</u>: Evaluating the current socioeconomic status of the mining community is essential for assessing the impact of the tourism transformation. Many locals may rely on the quarry for their livelihoods, and any shift towards tourism must consider their role in the transition. The survey collects data on local employment, sources of income, and attitudes toward tourism in the neighborhood. This helps identify potential benefits, such as new jobs in tourism and hospitality, while also addressing concerns regarding the preservation of traditional mining practices.

<u>Historical Significance</u>: Documenting the historical and cultural significance of the quarry, especially its connection to the mining community, is crucial. The quarry's history, along with any folklore or local heritage tied to the site, will be recorded and integrated into the visitor experience. This helps ensure that the transformation respects and preserves the local culture, offering visitors a richer understanding of the area's past.

Questionnaire Survey

The transformation of the Takerghat limestone quarry into a tourism destination will involve a thorough engagement with the local mining community. Information will be obtained from people who work in mining as well as the larger local population via a questionnaire survey. The community's opinions about tourism development, its possible effects on local livelihoods, and their participation in associated activities will be major topics of focus. The survey will also explore concerns about preserving local culture and the social impact of tourism on traditional ways of life.

Mapping and Documentation

Mapping will play a crucial role in documenting the quarry's geological and infrastructural features, which are essential for planning tourism development. The following aspects will be mapped and documented:

<u>Geological Mapping</u>: Documenting the mineral deposits, structural features, and any significant geological formations such as chhora (water stream), and tilas (low hills) that could attract tourists.

<u>Infrastructure Mapping</u>: Recording the current infrastructure in the area, including roads, utilities, abandoned workshops, and buildings, to assess their potential for adaptation to tourism development.

Land Use Analysis: Determining current land uses in and around the quarry area will assist in identifying places that need to be maintained.

Precedent Study

Studying similar projects around the world provides valuable insights into successful approaches to transforming abandoned quarries into tourism destinations. It focuses on architectural best practices, sustainable interventions for tropical climates, and innovative uses of natural rock. The study highlights the work of renowned architects who have utilized natural rock formations to create functional and aesthetic designs, as well as adaptations for tropical climates to minimize environmental impact. Additionally, it explores how quarries have creatively integrated surrounding rock into both architectural features and environmentally sustainable practices.

4. RESULTS OF THE STUDY AREA

4.1. Site Location and Surrounding Area

The research area is situated in the Takerghat area of the Sunamganj District, close to the Indian border. It is located at 25°11'45.5"N latitude and 91°10'26.5"E longitude. Adjacent to Tanguar Haor and approximately 35 kilometers away from the district center, the Niladri Lake, which originated from an abandoned limestone quarry, is well-known for its clear blue waters and picturesque surroundings. Its closeness to India's Meghalaya Hills, which act as a natural border, offers a breathtaking backdrop of lush greenery and natural landscapes, boosting its potential as a major tourist destination for sustainable development.



Figure 3. The Map shows the Geographic Position of Niladri Lake and the Adjacent Areas

The site surroundings of Niladri Lake vividly reflect its rich industrial history, intertwined with natural beauty. Among the remnants of its past are several abandoned machines that were once integral to the limestone mining operations. These machines, used for extracting and processing limestone, now stand as silent witnesses to the site's industrial heritage. Nearby workshops, where limestone was crushed into smaller pieces for industrial purposes, remain as physical markers of the site's former vibrancy. These structures served a vital role in preparing limestone for use in cement production and other industries. An old rail track that was originally used to load and transport limestone taken from the quarry adds to the area's historical value.

Additionally, a limestone washing pit can be found on-site that is involved in cleaning and preparing the raw limestone to meet industrial standards. Natural features like chora (streams) also run through the study area, adding to its ecological value and aesthetic appeal. Niladri Lake is a perfect location for investigating

sustainable tourism prospects while conserving its legacy because of the contrast between natural features and industrial remnants.



The serene beauty of Niladri Lake

Spoil mound

Figure 4. Scenic Landscape of Niladri Lake and Its Surrounding Environment

4.2. Site Evolution

The development of the site is a fascinating tale of natural recovery and industrial transformation. In the early British era, the region was first covered in dense trees, often referred to as "jungle." As time passed, human settlements began to establish themselves during the late British period, altering the natural landscape. In 1961, a geological survey led to the development of the Takerghat Limestone Mining Project. The subsequent quarrying activities reshaped the area, as limestone was extracted for various industrial uses, notably in cement production.



Figure 5. Site Development and Landscape Changes Through Time

However, with the cessation of mining, the landscape began to evolve once again. The abandoned quarry was eventually filled with water by 1995, becoming Niladri Lake. This shift from an industrial site to a natural lake marked a significant change, creating a serene water body with clear blue waters surrounded by a rejuvenated ecological environment. Today, the site offers a balance of historical insights and scenic beauty, combining its industrial past with its growing tourism industry. The mine's depth varied from 80 to 500 feet, while Niladri Lake's depth is around 120 feet, reflecting the vast scale of the original quarry and its transformation into a tranquil lake.

The soil removed during limestone extraction was initially dumped in various areas surrounding the quarry. Over time, these piles of soil naturally formed low hills, contributing to the site's changing topography. These mounds not only reshaped the landscape but also enhanced the site's natural beauty. As the years passed, these artificial hills became integrated into the environment, adding to the scenic value of the area.



Figure 6. Evolution from the 1990 Takerghat Mining Operations (Photograph of Takerghat limestone quarry, ca. 1990, retrieved via Google; original source unknown) to the Current Natural Setting of Niladri Lake

The combination of the abandoned quarry, the newly formed hills, and the surrounding natural features now add a unique visual appeal, which could be a significant attraction for tourists visiting the area. This transformation highlights how industrial activities, while reshaping the land, can also create aesthetically pleasing features that blend with nature.

4.3. Tourist Attraction

The area surrounding Niladri Lake offers a diverse range of natural and cultural attractions, making it a significant destination for visitors. A major factor in attracting tourists to the area is Tanguar Haor, a wetland that is on the Ramsar list. Monsoon, Post-monsoon, and Winter are its three unique seasons, each of which adds to a dynamic environment that affects both local livelihoods and tourism-related activities. Several key attractions add to the appeal of the region. Takerghat Zero Point, located near the border, holds geographical significance, while Borochora and Barek Tila are known for their scenic landscapes. The Jadukata River has religious and cultural significance and is well-known for Pona Tirtho. Joynul Abedin Shimul Bagan, a striking forest of bombax trees, becomes particularly popular in spring when the trees bloom in vibrant red, creating a mesmerizing spectacle for visitors. The Meghalaya Hills' proximity to the location adds to its allure by offering a stunning backdrop of dense greenery and wilder landscapes. Additionally, from the study area, one can observe ongoing limestone extraction activities across the border in India, a reminder of the region's industrial past. Together, these elements contribute to the region's tourism potential, blending natural beauty, cultural heritage, and historical significance into a unique and evolving landscape.

Tourism in the Niladri Lake region has seen significant growth since it became widely recognized as a tourist destination in 2015. Currently, the site attracts approximately 500,000 visitors annually, solidifying its status as a prominent tourist hotspot. While the number of visitors fluctuates due to seasonal and external factors, the overall trend indicates increasing interest in the area. If a well-structured tourism development project is implemented, the growth rate of tourism is projected to rise by 2.5% annually from 2024 to 2034. This growth potential emphasizes how important it is to plan for sustainable tourism, develop infrastructure, and engage in conservation initiatives to guarantee long-term advantages for the environment and the local people.



Figure 7. Increasing Trend in Tourism Rate Over Time

4.4. Miners' Present Situation in Takerghat

Since limestone mining in Takerghat has ceased, the local population, especially the former miners and their families, has faced serious socioeconomic difficulties. Many have been forced to look for other sources of income due to the financial uncertainty caused by the loss of mining jobs. Some have transitioned to agriculture, small-scale businesses, or eco-tourism activities like boating, while others work as loading or Barki laborers. However, the economic security that mining used to offer is often neglected by these replacements.

Currently, limestone is imported from India, and Barki laborers play a crucial role in loading and unloading the transported limestone. Although there are some job chances due to this physically demanding activity, wages are still poor and inconsistent. Migration has become a common strategy for survival, with many workers leaving for urban areas or other regions in search of better opportunities. Families rely on remittances from migrated members to sustain themselves, but this shift also brings social challenges, including family stress and potential community conflicts. Implementing skill development programs and financial diversification is essential for ensuring long-term stability. The difficulties faced by former miners and their families might be lessened by promoting ecotourism, enhancing regional infrastructure, and establishing long-term employment prospects.

4.5. Challenges and Obstacles to Tourist Development

Inadequate Tourism Infrastructure and Facilities: The tourism infrastructure in the Niladri Lake region remains underdeveloped, with limited accommodation, dining, and transportation options. A lack of funding and strategic planning has hampered the construction of the necessary infrastructure to properly host and serve tourists. As a result, tourists could discover that the location does not satisfy their basic comfort needs, lowering the quality of their trip.

Lack of Conservation Awareness: Both visitors and residents lack awareness of the significance of environmental preservation. This gap in awareness has resulted in environmental degradation, including pollution, unsustainable practices, and the neglect of natural resources. The absence of targeted conservation initiatives has further exacerbated the challenge, placing the area's ecological balance at risk. Again, most tourists are unaware of the historical significance of Niladri Lake due to the lack of information dissemination.

Limited Access to Pre-Travel and On-Site Information: The availability of reliable pre-travel and onsite information for tourists is inadequate. Promotional materials, maps, visitor guides, and signage that might help visitors navigate the area or learn about its attractions are noticeably inadequate. This absence of accessible information discourages potential visitors and leaves many tourists unable to fully explore and enjoy the destination.

Limited Benefits for the Local Community: Tourism initiatives in the area have not sufficiently contributed to the economic and social well-being of the local community. A lack of opportunities for employment, entrepreneurship, or community-based tourism activities has resulted in limited community engagement and support. Because the local population isn't motivated to actively participate in or support tourism activities, the gap hinders the sustainable growth of the industry.

Scarcity of Food and Accommodation Options: The region provides limited options for food and lodging. Although houseboats provide some lodging and dining options, they are not enough to satisfy the wide range of guest tastes. Additionally, visitors looking for other lodging or food options have to make the trip to Sunamganj, which is inconvenient and detracts from the appeal of the destination.

5. DISCUSSION AND RECOMMENDATIONS

The study identifies two major challenges concerning tourism development at Niladri Lake: the lack of tourist facilities and the limited awareness of the site's rich history, particularly its connection to the Takerghat Limestone Mining Project. This research suggests developing a tourism destination that combines community involvement, historical preservation, and contemporary infrastructure to address these issues.

An experience center based on the concept of open-pit mining is a key component of the proposed hub. This center will preserve and narrate the history of Niladri Lake and the Takerghat limestone quarry, offering visitors an engaging and instructive experience. The architectural design of the center adopts a subterranean approach, blending seamlessly with the natural environment while reflecting the mining heritage of the area. This design ensures a harmonious balance between development and nature while respecting the ecological and aesthetic integrity of the site. To address the gap in tourist facilities, the hub would include diverse accommodation options, ranging from eco-friendly lodges to resorts, alongside restaurants offering local and international cuisine. These amenities are meant to make guests' stays enjoyable and unforgettable, which will encourage longer visits to the area. Recreational and educational features would also be integrated into the site, offering tourists opportunities to explore the quarry-like landscape, engage in leisure activities, and discover the history and natural beauty of the area. The landscaping of the site, which includes walking tracks, shady spots, and green spaces, is similarly important because it improves the hub's visual appeal and practicality. A dedicated parking facility will further improve accessibility and convenience for visitors, ensuring a seamless experience from arrival to departure. A significant aspect of the recommendation is the financial and social inclusion of the local mining community. By involving locals in the hub's operations, for example, through roles as guides, artisans, or service providers, the project will create sustainable livelihoods and cultivate a sense of ownership within the community. This involvement ensures that the economic benefits of tourism are shared fairly, strengthening community support for tourism initiatives and conservation efforts.



Figure 8. Masterplan Proposal for the Revitalization of the Study Area

6. CONCLUSION

This study has examined the transformation potential of the abandoned limestone quarry at Niladri Lake, demonstrating its viability as a sustainable tourism destination. Repurposing the quarry not only restores a once-degraded landscape but also promotes regional development and economic potential, according to the findings of thorough site analysis, historical research, and community participation. By integrating conservation strategies with responsible tourism practices, the site can serve as both a cultural landmark and an ecological asset. The integration of the site's historical and industrial heritage into tourism planning reinforces its cultural significance, allowing visitors to engage with its rich past while experiencing the natural beauty of the area.

Additionally, the proposed development, including an experience center, accommodation facilities, and recreational spaces, aligns with sustainable tourism principles. The project's master plan, which combines historical, educational, and recreational components, ensures visitors a comprehensive and engaging experience. The findings emphasize the need to balance tourism growth with conservation efforts. An increasing number of visitors may present challenges in resource management and environmental sustainability. Therefore, continuous monitoring and adaptive strategies are crucial to preserving ecological integrity while enhancing the visitor experience. Incorporating the mining community into tourism activities can also promote long-term financial stability and motivate them to actively protect the site's

historical significance. This approach creates opportunities for economic, social, and environmental benefits (Table 1).

Category	Opportunities
∛ Environmental	 Restores degraded land and quarry ecosystem Encourages biodiversity and eco-awareness Promotes sustainable land use
👬 Social	 Revives local culture and traditions Engages the community in tourism roles Improves local infrastructure and education
š Economic	 Creates alternative jobs for ex-miners Boosts local businesses (food, crafts, lodging) Attracts funding and investment

Table 1. Development Opportunity Framework

Ultimately, the transformation of Niladri Lake into a tourism hub exemplifies a forward-thinking approach to sustainable redevelopment. Through strategic planning and community-led projects, the location could develop into a major historical, cultural, and ecological attraction that will benefit locals and tourists for many years to come.

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