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Journal of FST

Volume-3, Issue-1, July 2025

ISSN:2959-4812

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Assessment of the Impact of Urbanization on Urban Park and Lake with Geospatial Techniques: A Case Study of Dhanmondi Lake, Dhaka, Bangladesh

Md Imran Hossian Rakib[1], Israt Jahan[1*], Tahrima Jui Era[1]

Abstract

Urban parks are vital components of urban ecosystems, providing numerous benefits to both the environment and society. However, urban development has posed significant challenges to the sustainability and functionality of these green spaces. This research assesses the impacts of urban development activities on the Dhanmondi Lake and park area from 1990 to 2022, using Land Use Land Cover (LULC) and Normalized Difference Vegetation Index (NDVI) analyses. The study discovered that vegetation near the lakeside and park area has decreased by 15.74%, water bodies have decreased by 30.76%, and settlements have increased by 42.12%. From the NDVI, it was found that dense vegetation has decreased by 66.73% from 1990 to 2022. This work is significant as it highlights the critical need for sustainable urban planning to preserve urban green spaces. By investigating the spatial trends of urban development around the Dhanmondi Lake and park area, this research provides valuable insights into the potential consequences of such activities. Additionally, it proposes recommendations for future urban planning and park management strategies, including the implementation of green infrastructure, stricter zoning regulations, and community engagement programs to mitigate the adverse effects of urbanization on Dhanmondi Lake.

Keywords: Urbanization, Vegetation, Settlement, Land Use and Land cover Normalized difference vegetation index.

1. Introduction

Urbanization and development have transformed landscapes worldwide, leading to the loss and degradation of urban green spaces. Urban parks, as essential components of urban ecosystems, provide numerous environmental, social, and economic benefits. This research analyzes the impact of development on the park from 1990 to 2022 using spatial techniques like remote sensing and GIS.

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Urban development resulted in a smaller and fragmented Dhanmondi Lake due to encroachments (Ahmed & Rahman, 2015). Vegetation cover declined (Nasreen Hossain, 2009), potentially affecting biodiversity. Water quality deteriorated due to increased pollution and altered hydrology (Ahmed et al., 2019; Ahmad, 2018). Park accessibility varied across areas, raising concerns about social equity (Bhuiyan et al., 2019). These findings highlight the need for sustainable urban planning, effective management strategies, and community involvement to preserve Dhanmondi Lake's ecological health and recreational value (Islam et al., 2019; Rahman et al., 2020).

Originally a 1950s residential project, Dhanmondi Lake transformed into a popular park. However, development activities and encroachments threatened its ecological integrity and recreational value. Studies using remote sensing and GIS showed a reduction in the park area and changes in shape due to encroachment and construction (Hossain, 2008). The decline in vegetation cover may have adverse consequences for biodiversity (Hossain & Sarker, 2020).

Research using GIS and remote sensing identified the impact of development on water quality, including increased pollution and eutrophication (Ahmed et al., 2019). The altered hydrological regime due to urbanization has also been noted, leading to changes in water flow patterns and potential flooding risks (Ahmad, 2018).

The impact extends beyond ecological aspects. Studies explored the socio-economic implications and public perception using spatial techniques. Islam et al. (2019) employed GIS analysis to assess the park's socio-economic value, including its contribution to property values and recreational opportunities. Public perception studies indicated that community members recognize the park's importance but express concerns about encroachment and degradation (Rahman et al., 2020).

Dhanmondi Lake Urban Park has been significantly affected by development. Spatial techniques provided valuable insights to understand these impacts. Because of its location in a densely populated area, its long history of use as a recreational space, and numerous issues (including pollution and encroachment), We have chosen Dhanmondi Lake as my urban park case study However, further research is required to monitor and evaluate the long-term impact of development and to develop comprehensive conservation and management plans specific to Dhanmondi Lake.

This study aims to assess changes in Land Use and Land Cover (LULC) patterns in urban park areas from 1990 to 2022 using satellite imagery and GIS

techniques. It also identifies and analyzes the causes of vegetation loss within these parks, focusing on factors such as urbanization, encroachment, infrastructure development, and policy implications.

2. Methodology

To achieve the objectives of the research both primary and secondary data have been used in the following methodology.

2.1 Study Areas

Dhanmondi Park and Lake are situated at coordinates 23.746466°N and 90. 376015°E in the Dhanmondi neighborhood of Dhaka, Bangladesh.

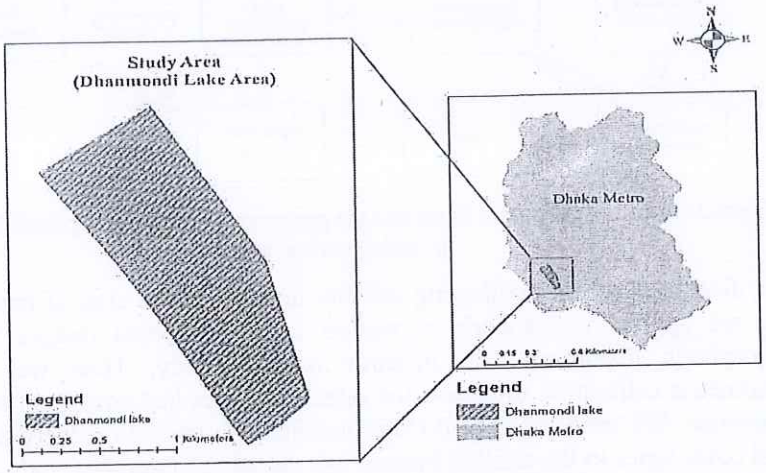

Figure 1: Study Area Map

2.2 Primary Data Collection

i. Acquired relevant geospatial datasets on land use, land cover, and urban development.
ii. After getting the image from the website, there was some atmospheric correction and sorting of data among the satellite images.
iii. Obtained high-resolution satellite imagery from Glovis and USGS for the study area from 1990 to 2022.

2.3 Spatial Analysis

i. Conducted supervised image classification and change detection analyses to identify and quantify changes in park area size.

ii. Applied vegetation indices and object-based image analysis to assess changes in vegetation cover and biodiversity.

2.4 Secondary Data Collection

We performed secondary data analyses to explore relationships between park characteristics and social, economic, and environmental indicators and also the causes and impacts of vegetation loss.

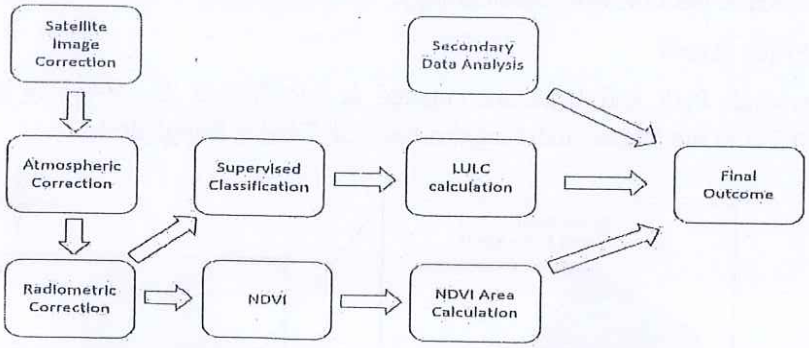

Figure 2: Workflow Diagram illustrates the processing and analyzing satellite imagery, including various steps

The diagram began by collecting satellite images for the area of interest. After that we applied atmospheric correction to the collected images to remove atmospheric distortions and improve image quality. Then we performed radiometric calibration to ensure the satellite images had consistent radiometric properties. We used supervised classification techniques to categorize different land cover types in the satellite images. We calculated Land Use and Land Cover (LULC) based on the classified images and calculated the Normalized Difference Vegetation Index (NDVI) from the satellite images to assess vegetation health and coverage. We determined the area covered by different NDVI values to analyze vegetation changes and conducted secondary data analysis to support and validate the findings from the satellite image analysis. We integrated the results from LULC calculations, NDVI area calculations, and secondary data analysis to derive the final outcomes of the study.

3. Results

3.1 Land Use and Land Cover (LULC) Map

The results revealed that by 2022, the percentage of land area under human occupation had climbed to 69.84%, from 27.72% in 1990. Vegetation coverage had dropped from 103.68% of the land area in 1990 to 89.99% in 2022. From a

height of 50.22% in 1990, the percentage of land covered by water fell to 45.19% in 2022. Bare land was reduced as a percentage of total land area from

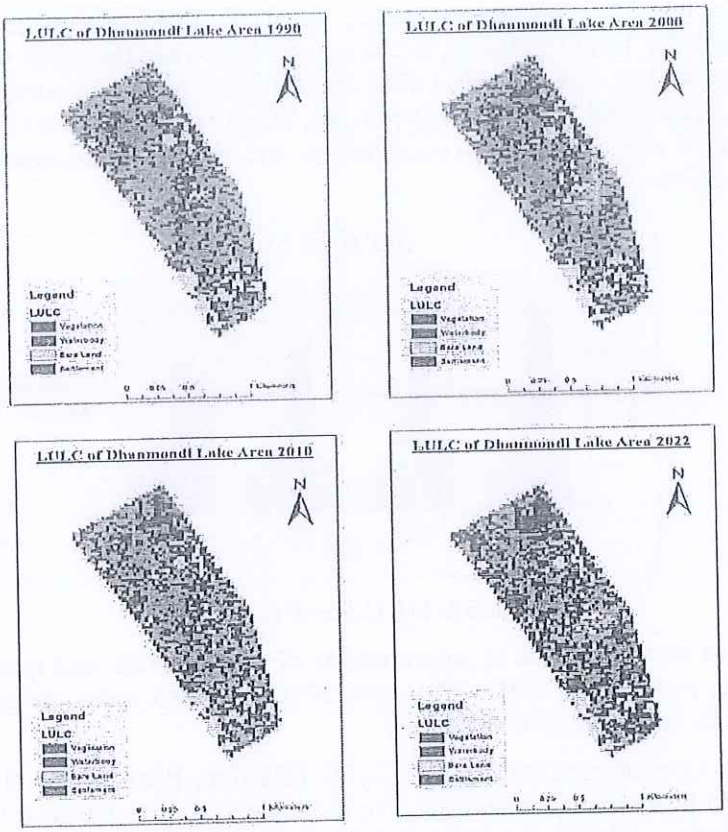

Figure 3: Change of LULC

19.8% in 1990 to 3.1% in 2022. The growth of cities was largely to blame for the rise in the built-up land share.

It has been shown (Fig. 3) that there has been a significant change in the land use/land cover of this area over the past 32 years. The increase in the percentage of land area in settlement and the decrease in the percentage of land area in vegetation, water body, and bare land are all cause for concern.

3.2 Land Use and Land Cover (LULC) Trend

Land Use and Land Cover (LULC) trend analysis is essential for understanding long-term changes in land use patterns and their implications for various socio-

environmental processes. It provides valuable insights into the dynamics of land cover transitions, enabling informed decision-making in land management and policy development. LULC maps are crucial for assessing the impact of land use changes on the environment, aiding in monitoring deforestation, habitat fragmentation, loss of wetlands, and changes in land cover that affect ecosystems and biodiversity. They are also vital for managing natural resources, such as forests, agricultural lands, and water bodies, helping to identify areas suitable for agricultural expansion, forest conservation, and watershed management (Roy, Singh, & Soni, 2018)

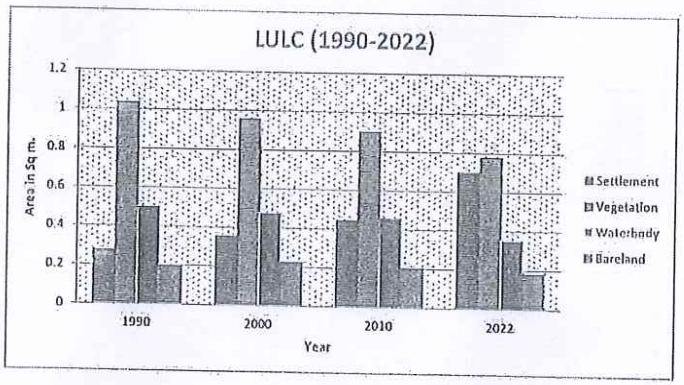

Figure 4: LULC Area Measurement

The chart shows the area in square meters of four different land types in four different years: 1990, 2000, 2010, and 2022. The land types are settlement, vegetation, water body, and bare land.

The area of settlement has increased by 42.12% from 1990 to 2022. This is the most significant change in the data. The increase in settlement areas is likely due to population growth and urbanization. The area of vegetation has decreased by 15.74% from 1990 to 2022. This is the second most significant change in the data. The decrease in vegetation area is likely due to deforestation and other forms of land use change. The area of water body has decreased by 30.76% from 1990 to 2022. This is the third most significant change in the data. The decrease in water body area is likely due to water pollution, climate change, and other factors. The area of bare land has decreased by 8.12% from 1990 to 2022. This is the smallest change in the data. The decrease in bare land area is likely due to the expansion of settlement and vegetation areas. Overall, the data shows that there has been a significant loss of natural areas in the past 32 years. This loss is likely due to a combination of factors, including population growth, urbanization, deforestation, and climate change.

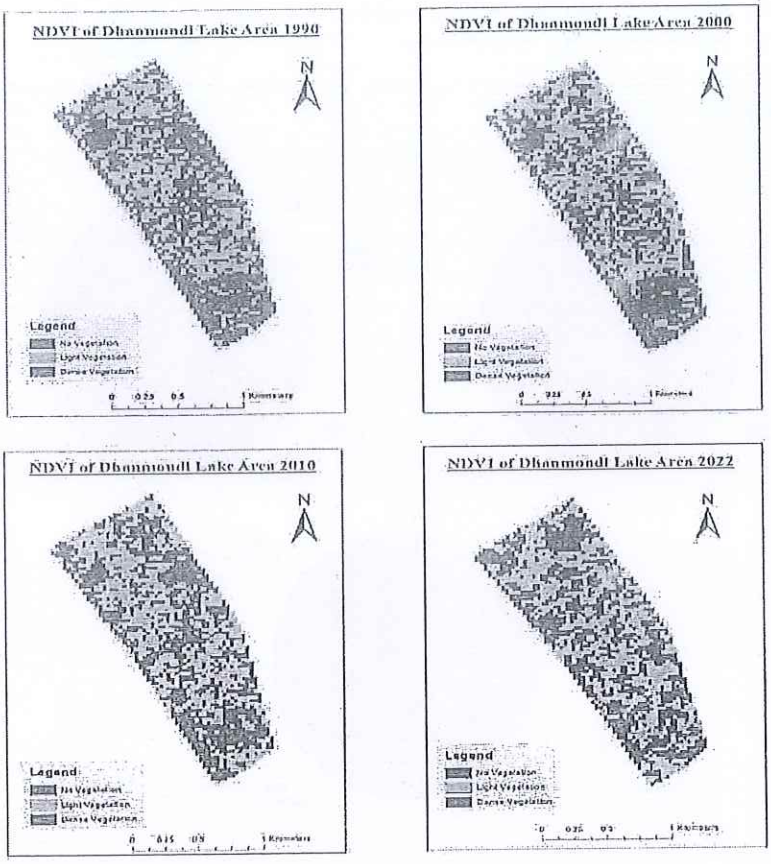

Figure 5: NDVI of Dhanmondi Lake Area

3.3 Normalized Difference Vegetation Index (NDVI)

The use of NDVI for assessing vegetation changes is widely accepted and applied in remote sensing and ecological research. Numerous scientific studies have utilized NDVI as a reliable indicator of vegetation dynamics and health.

The use of NDVI (Normalized Difference Vegetation Index) for assessing vegetation changes is universally recognized and extensively applied in remote sensing and ecological research. This powerful tool has been harnessed in numerous scientific studies, serving as a robust indicator of vegetation dynamics and health. Figure 3 provides a compelling visual representation of the NDVI for the Dhanmondi Lake area across four pivotal years: 1990, 2000, 2010, and 2022.

These maps vividly depict the temporal shifts in vegetation cover, illustrating both the spatial distribution and intensity of vegetative health. Such detailed analyses underscore the transformative changes in the landscape, offering invaluable insights into ecological trends and urban development impacts over the decades.

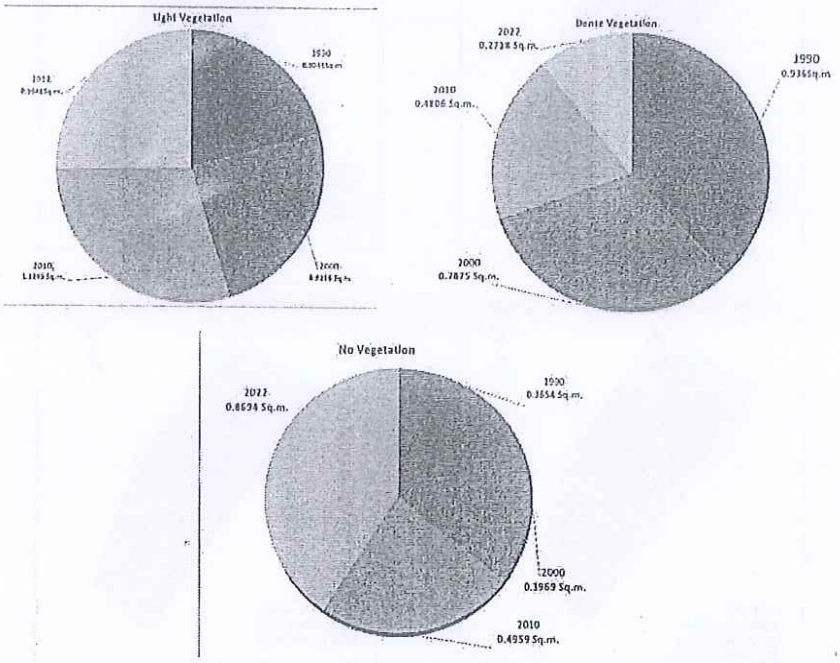

Figure 6: NDVI Area Calculation

This figure depicts a comparison of Normalized Difference Vegetation Index (NDVI) values across four vegetation categories: light, dense, no vegetation, and unspecified, spanning a period from 1990 to 2022. NDVI is a metric derived from satellite imagery that gauges the health and density of vegetation by analyzing the reflectance properties of near-infrared and red light.

4. Discussion

A Land Use and Land Cover (LULC) map is a vital tool for understanding and managing the dynamic nature of land use patterns and changes in an area. It provides valuable information about the distribution and types of land cover within a specific region. LULC maps play a crucial role in various fields,

including urban planning, natural resource management, environmental assessment, and disaster management (Ali, 2017). From the LULC result we can see that the vegetation is decreasing and also NDVI support the LULC result. Urban parks serve as important spaces for recreation, exercise, and socialization. Losing a park like Dhanmondi Park would mean the loss of a dedicated space for people to engage in activities such as walking, jogging, picnicking, playing sports, and spending leisure time outdoors. This can limit opportunities for physical activity and negatively impact the well-being of residents, especially those who rely on the park for recreational purposes.

Vegetation helps to mitigate the urban heat island effect by providing shade and evaporative cooling. When vegetation decreases, the surrounding areas can become hotter, leading to discomfort for city dwellers and increased reliance on air conditioning. Vegetation acts as a natural buffer against noise pollution by absorbing and scattering sound waves. A decrease in vegetation can result in increased noise levels in urban areas, affecting the quality of life for city dwellers. Additionally, the loss of greenery can negatively impact the aesthetic appeal of the area, leading to a decline in overall well-being.

NDVI provides insights into ecosystem dynamics, such as changes in vegetation types, successional stages, and species composition. It helps researchers and ecologists understand the impact of natural disturbances, such as fires, floods, or droughts, on vegetation patterns and ecosystem functioning. NDVI data assists in land management and planning decisions. It helps identify areas with high vegetation cover suitable for conservation, urban green spaces, or afforestation projects. Conversely, areas with declining NDVI values may indicate the need for land restoration or reforestation efforts.

4.1 Causes of Urban Park Area Change

Urban parks play a crucial role in mitigating the heat island effect by providing shade and evaporative cooling. The removal of a park can lead to increased surface temperatures and reduced cooling effects, contributing to higher urban temperatures. Additionally, parks help to improve air quality by acting as filters for pollutants. Without a park, there may be a decrease in the absorption of pollutants, potentially leading to poorer air quality in the area. The major causes of the ecosystem destruction in Dhanmondi urban park are many. (Nowak, 2016) From different secondary data some main causes are found which are:

4.1.1 Urbanization and Land Use Changes

Urbanization often converts natural areas into built-up infrastructure, encroaching on spaces surrounding lakes and leading to their loss (Ahmed et al., 2019). Dhanmondi Lake in Dhaka, Bangladesh, has experienced rapid urbanization, resulting in increased demand for land for housing, commerce, and transportation. This expansion has significantly reduced natural areas, fragmenting habitats and diminishing biodiversity (Akther et al., 2020). Infrastructure development, including roads and buildings, has led to vegetation loss and altered ecological processes, with land reclamation for construction further encroaching on natural spaces (Akther et al., 2020). Inadequate urban planning, weak regulation enforcement, and improper land management have exacerbated these issues, allowing unplanned development to proliferate (Hasan et al., 2021). Consequently, the loss of natural areas has adversely affected biodiversity and ecosystem services, including water filtration, flood regulation, and recreational opportunities (Akther et al., 2020).

4.1.2 Land Reclamation

Land reclamation involves the process of converting water bodies or wetlands into land suitable for development purposes. In the case of Dhanmondi Lake, land reclamation has been carried out to create additional land for various infrastructure projects, including roads, buildings, and embankments. This has led to the encroachment and loss of natural areas surrounding the lake (Akther et al., 2020). The expansion of urban infrastructure in the vicinity of Dhanmondi Lake has resulted in the loss of natural areas. Construction of roads, bridges, and buildings often requires the conversion of natural habitats and green spaces into built-up structures. As a result, the natural areas around the lake have been diminished or completely eliminated (Hasan et al., 2021). Infrastructure development and land reclamation can significantly alter the hydrology of the lake and its surrounding areas. By modifying natural drainage patterns, such activities can disrupt water flow and reduce the capacity of the lake to retain and absorb water. The degradation of aquatic ecosystems and the disappearance of natural regions are both possible results of tampering with hydrological processes (Akther et al., 2020). Based on these findings, our recommendations emphasize the necessity for more effective zoning policies, stringent environmental regulations, and proactive conservation measures to mitigate further environmental degradation. The alignment of results with those of other researchers underscores the urgent need for comprehensive urban planning and sustainable land management practices to preserve the natural areas surrounding Dhanmondi Lake and similar urban ecosystems.

4.1.3 Population Growth and Increased Demand for Space

Rapid population growth and increased urbanization put pressure on available land for development. As cities expand to accommodate growing populations, natural areas are often sacrificed for housing, transportation, and other urban infrastructure (Moss, 2014).

4.1.4 Pollution and Eutrophication

Studies by Xu et al. (2019) demonstrate that urbanization and human activities significantly contribute to increased pollution and eutrophication of lakes, mirroring the situation observed in Dhanmondi Lake. Discharge of pollutants into the lake has led to deteriorating water quality, harming the aquatic ecosystem and natural areas, similar to the observations by Akther et al. (2020) and Halim et al. (2019). Eutrophication, caused by excessive nutrient enrichment, is a major concern for Dhanmondi Lake, as reported by Akther et al. (2020) and Halim et al. (2019). The influx of nutrients promotes algal blooms, just as in other studies, depleting oxygen levels and causing ecological imbalances. These findings on Dhanmondi Lake echo the detrimental effects of pollution and eutrophication on aquatic life documented in other studies (Akther et al., 2020; Halim et al., 2019). High pollutant concentrations and excessive nutrient levels can lead to the death of fish and other organisms, disrupting food chains and further degrading the lake's natural areas.

4.1.5 Lack of Conservation and Management

Inadequate conservation and management practices, including limited enforcement of regulations, weak governance, and insufficient monitoring, can contribute to the loss of natural areas in lakes. Without proper protection and management strategies, urban lakes may face degradation and encroachment (UN-Habitat, 2010).

4.1.6 Encroachment on Park Areas

In line with studies by Suntharamoorthy (2019) on the consequences of illegal land occupation, encroachment on park areas within Dhanmondi can occur through construction, informal settlements, or unauthorized activities. This, as observed in other studies, can lead to a decline in the park area and limit public access to recreational spaces. Furthermore, similar to the environmental degradation documented by Suntharamoorthy (2019), illegal occupation in Dhanmondi parks can result in practices like land clearing and tree felling. These practices disrupt the park's ecological balance and biodiversity, potentially causing the loss of natural vegetation, wildlife habitats, and water bodies.

4.1.7 Disruption of Park Functionality

As highlighted by Allain & Collins (2021) in their study on park functionality, illegal occupation can disrupt the core purposes of park areas in Dhanmondi. Parks serve as essential recreational spaces, promote urban greenery, and contribute to residents' well-being. Similar to their findings, illegal occupations in Dhanmondi parks can undermine these objectives by altering the park's intended use, restricting public access to these recreational spaces, and potentially diminishing the overall aesthetic and environmental value of the park.

4.2 Impacts of Urbanization

Similar to findings by Akther et al. (2020) and Hasan et al. (2021), illegal occupation of park areas in Dhanmondi can have detrimental effects on the public well-being and surrounding communities. These occupations restrict access to open green spaces, crucial for recreational activities that contribute to physical and mental health. Studies have shown that spending time in nature can reduce stress levels, improve mood, and encourage physical activity. The loss of these spaces due to illegal occupation can, therefore, negatively impact the health and well-being of residents who rely on the park for these benefits.

Furthermore, parks serve as important community hubs, fostering social interaction and a sense of belonging. Community events and gatherings often take place in parks, strengthening social bonds between residents. Illegal occupation that restricts access to these spaces can disrupt these social connections, potentially leading to a decline in community cohesion.

By highlighting these negative consequences, this research aligns with existing knowledge on the importance of parks for public health and community well-being. It further strengthens the argument for protecting Dhanmondi Park from illegal occupation.

5. Recommendation

Dhanmondi Park is among the most frequented green spaces in the capital city of Dhaka, Bangladesh. People of all ages can participate in the wide range of recreational opportunities that are available in this expensive and green area. However, had it been better incorporated into the urban fabric, the park could provide the city with much more benefits than it already does. The following are some potential approaches that could be thought about in order to improve the park's functionality and its integration into the urban environment:

5.1 Multi-functional Design

Designing the park to accommodate various activities and user needs can maximize its potential. This includes incorporating amenities such as playgrounds, sports facilities, walking paths, seating areas, and spaces for community events. The aim is to create a diverse and inclusive environment that caters to the needs of different age groups and interests (Madzlan et al., 2016).

5.2 Green Infrastructure

There are many advantages to incorporating green infrastructure features into the park. Storm water can be better managed, water quality can be improved, and environmental sustainability can be increased with the help of features like rain gardens, bio swales, and green roofs. (Carrus et al., 2017).

5.3 Ecological Restoration

Implementing ecological restoration practices can help revive and preserve natural ecosystems within the park. This may involve reintroducing native plant species, creating habitat features for wildlife, and promoting biodiversity conservation (Spielmann et al., 2018).

5.4 Community Engagement

Involving the local community in the planning and management of the park can foster a sense of ownership and promote active participation. Engaging residents, community groups, and stakeholders through consultations, workshops, and volunteer programs can help generate ideas and ensure the park meets the needs and aspirations of the people (Colding et al., 2013).

5.5 Accessibility and Connectivity

Creating easy access points and improving connectivity to the park can encourage more people to use and enjoy the space. Enhancing pedestrian and cycling infrastructure, improving public transportation access, and providing clear way finding signage can enhance the park's connectivity to the surrounding urban fabric (Gómez-Baggethun et al., 2013).

5.6 Smart Technologies

Integrating smart technologies, such as smart lighting, interactive displays, and Wi-Fi connectivity, can enhance the visitor experience and improve park management. These technologies can provide real-time information, support interactive engagement, and assist in monitoring and maintenance activities (Caragliu et al., 2011).

6. Conclusion

In conclusion, the implementation of various facilities and initiatives aimed at enhancing Dhanmondi Lake and park must be accompanied by regular monitoring to ensure optimal service delivery. Regular monitoring will enable ongoing assessment of the effectiveness of introduced measures, allowing for timely adjustments and improvements as needed. This commitment to monitoring will be crucial in maintaining the park's functionality and ensuring its continued benefit to the community and the environment.

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