Analysis the Land Cover and Land Use (LULC) Change by Unsupervised Classification and the NDVI Method Around Tongi Khal, Dhaka, Bangladesh.

Hosne Ara Sharmin[1], Muhammad Qumrul Hassan[2], Jowaher Raza[2]

[1]Department of Environmental Science, Faculty of Science and Technology, Bangladesh University of Professionals, Mirpur, Dhaka 1216, Bangladesh.

[2]Department of Geology, University of Dhaka, Ramna, Dhaka 1000, Bangladesh.

DOI: https://doi.org/10.51584/IJRIAS.2026.110200040

Received: 07 February 2026; Accepted: 12 February 2026; Published: 03 March 2026

ABSTRACT

Urban and industrial development, along with anthropogenic activities, lead to numerous threats to Bangladesh's water bodies. Over the years, Tongi Khal has been identified as being in a threatened condition due to these activities. This research presents dynamic changes in land use and land cover (LULC) and the condition of Tongi Khal by using GIS and remote sensing techniques.

The LULC changes in the study area are illustrated using Landsat satellite images from 1990, 2000, 2010, 2015, 2020, and 2025 obtained through unsupervised classification and the Normalized Difference Vegetation Index (NDVI) method in ArcGIS 10.3. From 1990 to 2025, the LULC classification in the study area shows a reduction in water bodies and vegetation from 1990 to 2015, followed by an increase in vegetation in 2020 due to COVID19. In 2025, due to excessive industrial development, construction projects, canal infilling, and urban expansion, the waterbody was reduced, resulting in deterioration of the environmental conditions of Tongi Khal. Extensive urban development has led to the conversion of trees into grassland, bare land, and housing to accommodate population growth from 1990 to 2025.

This study will enhance understanding of effective measures to control excessive anthropogenic activities and canal infilling, and to maintain water quantity and support natural restoration processes, such as at Tongi Khal. It will also contribute to future urban land-use planning and river management to tackle the ongoing, alarming pollution and unplanned industrialization.

INTRODUCTION

Land use is the use of land, and land cover refers to the physical surface materials, such as vegetation, water, and soil (Fisher et al., 2005). Land use and land cover (LULC) refers to the conversion of natural land to builtup areas, altering runoff conditions, sediment deposition, and reducing water quality and ecosystem functions (Rahman & Szabó, 2021; Admasu, 2023). Inappropriate land-use management enables environmental degradation, converts natural land to bare land, and accelerates runoff and erosion, thereby causing water pollution (Tahiru et al., 2020). The Normalized Difference Vegetation Index (NDVI) with Land Use and Land Cover (LULC) is used to improve vegetation detection by highlighting differences in plant greenness, increasing class separability, and improving classification accuracy using remote sensing-based techniques (Zhao et al., 2022; Nyssen et al., 2004).

Land-use change dynamics inform understanding of environmental change, effective resource assessment, and sustainable resource management. Constant changes in patterns driven by human activities alter the environment and its services, turning natural land into agricultural land and, eventually, into urban areas (Bewket & Abebe, 2013; Mao & Zeng, 2010).

Land use and land cover (LULC) changes in Bangladesh are driven by population growth, urbanization, infrastructure expansion, and socioeconomic pressures, resulting in the conversion of agricultural land and water bodies into built-up areas (Xu et al., 2020). These changes alter the area's ecosystems by reducing waterbodies, diminishing ecosystem service value, and increasing uncontrollable surface runoff and high surface temperatures (Dewan & Yamaguchi, 2009; Bhuiyan, M. A. H., 2025).

Impacts in Bangladesh include loss of fertile agricultural land, decreased wetlands and vegetation, degraded ecosystem services, and heightened urban environmental problems (e.g., flooding, heat island effects) that challenge sustainable planning and resource management (Dewan & Yamaguchi, 2009; Rahman & Szabó, 2021; Xu et al., 2020).

Tongi Khal and the surrounding Tongi industrial urban area are experiencing severe ecological stress. The water bodies of Dhaka are highly polluted due to unplanned industrial and land development (Bird et al., 2018). Tongi Khal is being encroached due to rapid urbanization and unplanned industrial growth, thus increasing pollution, harming aquatic ecosystems, and undermining local ecological balance (Sharmin et al., 2024; Sakib et al., 2024). Human activities, vegetation loss, urbanization, and industrialization are the primary drivers of land-use and land-cover change around Tongi Khal, thereby affecting water quality (Das et al., 2020).

Considering these concerns, the current study was designed to assess the evolving land-use pattern scenario and its potential environmental effects on local land-use patterns, the number of water bodies, and vegetation loss in these areas. The main objective of this work was to identify anthropogenic activities near Tongi Khal and to assess how land-use changes are affecting the water body.

Study Area

The central water bodies of Dhaka are the Turag, Tongi Khal, Balu, Shitalakhya, and the Buriganga River. Tongi Khal (canal) is a surface water body that connects the Turag River to the west and the Balu River to the east (Das & Ali, 2020). The canal is located approximately between latitudes 23°52'N to 23°53'N and longitudes 90°23'E to 90°29'E. Its length is roughly 15 km and serves as a natural drainage outlet for the Gazipur City Corporation and northern Dhaka.

The flow direction is seasonally variable, typically moving from the Turag toward the Balu during the monsoon, but it becomes stagnant or sluggish during the pre-monsoon (dry) season, thereby exacerbating pollutant concentrations (Mobin et al., 2014; REACH, 2024).

It is considered a polluted water body due to the surrounding Tongi industrial zone, located east of Dhaka city (Figure 1). The region has several industries, most of which are located in the Tongi BSCIC, Tongi industrial areas, Cherag Ali, Ershad Nagar, Vhadam, Gazipura, Sataish, and Nimtoli. Polluting industries include textile dyeing, chemical and pharmaceutical, printing and packaging, glass-ceramic factories, food processing, and numerous other sectors (Das et al., 2020).

Numerous unplanned urbanizations and an inadequate Effluent Treatment Plant (ETP) have transformed the Tongi Khal into an "urban drain". According to Das et al. (2020), the canal receives a mixture of untreated industrial wastewater and municipal sewage from the Gazipur metropolitan area. It ultimately discharges into the Balu River, which flows into the Sitalakhya River—a major source of drinking water for Dhaka.

METHODOLOGY

This research uses remote sensing techniques to assess land-use changes and establish a relationship between declines in water bodies and LULC changes. The study has been performed using satellite image-based interpretation and water body analysis. The methodology can be divided into two parts: satellite image-based analysis and analysis of the quantity of water bodies (Figure 2).

Data Sources

Six sets of satellite images from 1990, 2000, 2010, 2015, 2020, and 2025 have been collected from the United States Geological Survey (USGS) archive (https://earthexplorer.usgs.gov/) to interpret the LULC patterns (Table 1).

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue II February 2026

LULC Classification

ArcGIS 10.3 was used in the research to process, analyze, and interpret satellite images to identify LULC change across six time periods. Two classification approaches were used in the study area to examine LULC change, water body quantities, and vegetation. The approaches include unsupervised classification, index-based LULC classification, and NDVI (Normalized Difference Vegetation Index).

These two classification approaches have been used to identify land, water, and vegetation accurately. Unsupervised classification identified a generalized thematic class of information in the study area. NDVI indices primarily focus on changes in vegetation, which are beneficial for observing variation in vegetation cover. The two methods show identical results for total LULC changes near Tongi Khal.

NDVI has been calculated utilizing the following equation (Tania, A.H. et al., 2021):

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Here, NIR = Near Infrared Reflectance value and RED = Red Region Reflectance value. The NDVI ranges from -1 to 1. Densely vegetated areas have positive values around +1, whereas the water body has a value close to -1.

DATA INTERPRETATION

LULC through an Unsupervised Classification Approach

Four LULC classes across six time points in the study area have been classified, including water bodies, vegetation, bare areas, and built-up areas.

A water body covered 722.88 hectares, and 655.74 hectares were vegetated in 1990. Bare land and built-up areas were lower around the water body and vegetation, at 321.21 hectares and 391.5 hectares, respectively. In 2000, the water body and vegetation areas decreased, while bare land and built-up areas increased compared to 1990 (Table 2). The water body, vegetation, bare land, and built-up area were classified accordingly: 719.82 ha, 566.64 ha, 396 ha, and 408.87 ha. The graph shows an upward trend for built-up and bare land, and a downward trend for water bodies and vegetation.

After ten years, the water body covered 697.05 hectares and had decreased slightly. Built-up area and bare land increased moderately, covering 523.71 and 433.35 hectares, respectively. Vegetation covered 437.22 hectares less than before. The decline in water bodies and vegetation was evident again after ten years. As well as the built-up area and bare land, rising to a very high level.

The water body and vegetation covered 585.63 ha and 547.02 ha, respectively, in 2015. Here, water quantities decreased, whereas vegetation increased relative to other years. Due to vegetation development, the rate of bare land has decreased slightly. The built-up area was 534.6 ha, and the bare land decreased from 433.35 to 424.08 ha in 2015.

In 2020, the water body and the bare land decreased compared to 2015 (Figure 3). The water body area was 505.86 ha. However, vegetation increased from 547.02 ha to 567.63 ha. Moreover, the built-up rate is higher than in 2015. Urbanization and industrialization increased the built rate by 596.43 ha in 2020. Bare land was converted into vegetation and a developed area. The bare land decreased from 424.08 to 359.41 ha.

Compared to other years, the built-up land in the study area increased significantly in 2025 due to rapid urban expansion, reaching 817.11 ha. Vegetation cover also decreased moderately from 567.63 ha to 518.22 ha in this period. A large area of the waterbody and vegetation was converted to bare land, increasing from 359.41 ha to 510.66 ha, indicating water resource degradation and vegetation loss. Water bodies covered only 245.34 ha, indicating canal infilling due to rapid urbanization.

Overall, the 2025 land-use changes reflected shifts toward urbanization, industrialization, and environmental degradation.

LULC analysis based on NDVI

This study aims to examine changes from 1990 to 2025 in NDVI classification to assess vegetation, water bodies, and the area's development (Figure 4).

By NDVI approaches, the vegetation covered 819.81 ha in 1990. The area was previously abundant in trees and plants. The water body also covered a vast area of 686.79 ha in 1990. In 1990, the built-up area was less extensive, covering 584.73 ha (Table 3).

After 10 years in 2000, the vegetation area and water body decreased by 627.57 ha and 449.64 ha, respectively. A significant amount of vegetation loss resulted from industrialization and urbanization. This is also reflected in the upward trend in the built-up area, which covered 1014.12 ha.

In 2010, the water body and vegetation were lower than in 2000. The water body area was 449.64 ha in 2000, but decreased to 288.27 ha by 2005. However, vegetation decreased significantly from 627.57 ha to 429.84 ha. Moreover, the built-up rate was again higher than in 2000. The built rate increased by 1373.22 ha in 2010. Decreased water bodies and loss of vegetation were converted into developed areas.

In 2015, the water body's area decreased to 253.35 ha. The vegetation area increased because of the growth of new vegetation. The water body, vegetation, and built-up area were classified as follows: 253.35 ha, 523.62 ha, and 523.62 ha, respectively. The graph shows an upward trend in built-up areas and vegetation, and a downward trend in water bodies. In 2020, the vegetation increased significantly, to about 721.35 ha, and the built-up area decreased (1089.45 ha). The water bodies covered 280.53 ha, the built-up area covered 1089.45 ha, and the vegetation covered 280.53 ha.

In 2025, built-up areas accounted for 61% of the study area. Water bodies decreased to 196.07 hectares and are at risk of extinction. Vegetation covered 612.22 hectares, and some areas became bare due to urban and industrial expansion, anthropogenic activities, and the stress of excessive population.

RESULT AND DISCUSSION

In unsupervised classification, water bodies declined from 1990 to 2025. There are some possible reasons for the decline of water bodies on both sides of the Tongi Khal during the study period, such as (1) the Area covered and development for the housing project, and (2) the transformation of those water bodies into agricultural land because of the reduction of water flows or development activities like brick fields.

There was also massive vegetation degradation from 1990 to 2025. Vegetation losses were acute in the Uttara sector, Ashulia, Tongi, and adjacent areas. The different housing projects have been developed in these areas (Alam, M. J., 2018; Hosen et al., 2021). Over the past few years, Tongi and Ashulia have been recognized as industrialized zones, resulting in significant vegetation loss in these areas. In Uttar-Khand, some vegetated areas have also been reduced over the years.

Besides, significant vegetation loss has been observed in other parts of the canal. Urban areas expanded rapidly from 1990 to 2025. It is clear that in 1990, urban growth was in the middle part of the Tongi Khal, a primarily industrial and commercial zone. Then, urban growth developed in the Tongi and Abdullahpur areas of the Tongi Khal. Industrialization, urbanization, population growth, and economic development were the factors behind the area's development in 2011. Research focusing on the Northern Dhaka region (including Tongi and Abdullahpur) found that more than 50% of wetland areas were lost to infrastructure development (Sultana et al., 2011).

In 2025, urbanization peaked at 817.11, largely concentrated along the canal. As the growing areas mainly consisted of vegetated and wetland areas the previous year, this unplanned urban development has dramatically destroyed the living conditions, environment, and ecosystem of the surrounding canal in Dhaka city (Zakir et al., 2016; Khan et al., 2024; Sharmin Monica et al., 2024). (Figure 5)

From the NDVI thematic classification maps, it was observed that vegetation decreased by approximately 39% from 1990 to 2010 in the study area. There was a gradual decrease in vegetation cover from 1990 to 2010. Vegetation cover in 2015 increased slightly because the data were collected in mid-November (12-11-2015), immediately after the monsoon growing season, when vegetation productivity and greenness typically remain high due to favorable moisture and climatic conditions (Islam & Mamun, 2015). Due to poor satellite imagery, Landsat data from January to April were challenging to analyze for LULC change mapping. In 2020, due to the COVID-19 pandemic, vegetation increased by 24.04% to 34.49% (Rume et al., 2020). Rooftop gardening increased during the COVID-19 pandemic, and satellite imagery from 2020 captured the built-up area as vegetation and a water body (Schreinemachers et al., 2025). Again, in 2025, the dense vegetation converted to grassland, decreasing from 35% in 2020 to 29% in 2025.

However, the built-up area increased by 584.73 ha, 1014.12 ha, and 1373.22 ha, respectively, in 1990, 2000, and 2010. However, the built-up area decreased in 2015 and 2020 because of vegetation cover (Figure 5). From 1990 to 2015, water decreased by 32.84% to 12.11%. The water body increased by only 1% relative to 2020. After five years, the area of Tongi khals decreased from 13% to 9%, covering 196.07 ha in 2025 (Figure 6). In 2025, the built-up area again increased, reaching about 128.04 ha, while the waterbody decreased by 196.07 ha.

The findings reveal that, while trees are rapidly disappearing and being replaced by grassland and bare land, urban and industrial growth along the Tongi khal has been increasing. The Tongi Khal area has seen rapid urban and industrial development in recent years (Alam, M. J., 2018; Bhuiyan, M. A. H., 2025; Hosen et al., 2021). However, during the COVID-19 pandemic, vegetation increased in 2020 due to reduced human and industrial activities (Rume et al., 2020; Schreinemachers et al., 2025). These development activities degrade the natural canal ecosystem by discharging large volumes of water into the canal (Khan et al., 2024; Zakir et al., 2016). Due to the extensive removal of water bodies, these development activities are degrading the environment of Tongi Khal. This again shows that urban development is rapidly expanding in the Ashulia, Uttara sector (middle part), Abdullahpur, and Tongi areas around the Tongi Khal, compared with previous studies (Alam, M. J., 2018; Hosen et al., 2021; Sultana et al., 2011).

This study also shows that the water body decreased from 1990 to 2025 (Figure 6). As water bodies decrease, water quality will continue to decline (Mobin et al., 2014). From 1990 to 2025, the water body underwent significant changes due to LULC, including the expansion of industrial areas and urban growth, and repeated reductions in water bodies, land, and vegetation occurred. Unplanned industrialization and urbanization along the Tongi Khal contributed to the decline in the water body.

CONCLUSION

Remote sensing facilitates the analysis of LULC change within Tongi Khal. This study has highlighted the use of GIS to identify LULC changes over six years and analyze the rates of change in water bodies, vegetation, and area development. NDVI's approach enabled examination of variation among vegetation, bare land, built-up areas, and water bodies. This study presents the previous and current conditions of the water body and vegetation across Tongi Khal, which have declined alarmingly. The study sought to illustrate changes in water quantity by analyzing the dynamic pattern of LULC change in the Tongi Khal. The two classification approaches have been attempted to present the decline of water bodies from 1990 to 2025. It has also been observed that the area of natural vegetation has decreased over the past few years. It is essential to protect Tongi Khal by reducing pollution sources, complying with regulations, implementing sustainable management practices, and raising public awareness of the deteriorating environmental condition. It is necessary to restore the canal to its former condition by reducing anthropogenic activities and enforcing proper laws. Otherwise, Tongi Khal will become as vulnerable as other rivers in Dhaka. The results of the study will be significant for regulating the urban river and for the sustainable management of Tongi Khal.

REFERENCE

1. Admasu, S., Yeshitela, K., & Argaw, M. (2023). Impact of land use land cover changes on ecosystem service values in the Dire and Legedadi watersheds, central highlands of Ethiopia: Implication for landscape management decision making. Heliyon, 9(4).

2. Bewket, W. & Abebe, S. (2013). Land-use and land-cover change and its environmental implications in a tropical highland watershed, Ethiopia. International Journal of Environmental Studies, 70(1), 126–139. https://doi.org/10.1080/00207233.2012.755765.
3. Bird, J., Li, Y., Rahman, H. Z., Rama, M., & Venables, A. J. (2018). Toward Great Dhaka: A New Urban Development Paradigm Eastward. The World Bank.
4. Das, P., Ali, M. A., & Fattah, K. P. (2020). Assessment of contaminant flux from heavily polluted benthic sediment of Tongi Khal (canal): an ex-situ approach. Desalination and Water Treatment, 179, 272-279.
5. Dewan, A.M. & Yamaguchi, Y. (2009). Land Use and Land Cover Change in Greater Dhaka, Bangladesh: Using Remote Sensing to Promote Sustainable Urbanization. Applied Geography, 29, 390–401.
6. Mao, R. & Zeng, D. H. (2010). Changes in soil particulate organic matter, microbial biomass, and activity following afforestation of marginal agricultural lands in a semi-arid area of Northeast China. Environmental Management, 46(1), 110-116.
7. Nyssen, J., Poesen, J., Moeyersons, J., Deckers, J., Haile, M., & Lang, A. (2004). Human impact on the environment in the Ethiopian and Eritrean highlands—a state of the art. Earth-science reviews, 64(3-4), 273– 320.
8. Rahman, M. M., & Szabó, G. (2021). Impact of land use and land cover changes on urban ecosystem service value in Dhaka, Bangladesh. Land, 10(8), 793.
9. Sakib, M. S., Alam, S., Shampa, Murshed, S. B., Kirtunia, R., Mondal, M. S., & Chowdhury, A. I. A. (2024). Assessing flooding extent and potential exposure to river pollution from urbanizing peripheral rivers within Greater Dhaka watershed. Scientific Reports
10. Sharmin Monica, H. A., Hassan, M. Q., Raza, J., & Khandaker, N. (2024). Comparative analysis of unsupervised land cover and land use (LCLU) classification and the normalized difference vegetation index (NDVI) methods for assessing areas around Tongi Khal, Dhaka, Bangladesh (GSA Connects 2024 Abstract). Geological Society of America.
11. Tahiru, A. D. (2020). Effect of land use and land cover changes on water quality. Springer, Applied Water Science 10:198
12. Tania, A.H., Gazi, M.Y. & Mia, M.B. (2021). Evaluation of water quantity–quality, floodplain land use, and land surface temperature (LST) of Turag River in Bangladesh: an integrated approach of geospatial, field, and laboratory analyses. SN Appl. Sci. 3, 63.
13. Xu, X., Shrestha, S., Gilani, H., Gumma, M. K., Siddiqui, B. N., & Jain, A. K. (2020). Dynamics and drivers of land use and land cover changes in Bangladesh. Regional Environmental Change, 20(2), 54.
14. Zhao, J., Wang, L., Yang, H., Wu, P., Wang, B., Pan, C., & Wu, Y. (2022). A land cover classification method for high-resolution remote sensing images based on an NDVI deep learning fusion network. Remote Sensing, 14(21), 5455.
15. Fisher, P. F., Comber, A. J., & Wadsworth, R. (2005). Land use and land cover: Contradiction or complement. In P. Fisher & D. Unwin (Eds.), Re-presenting GIS (pp. 85–98). John Wiley & Sons.
16. Bhuiyan, M. A. H. (2025). Geospatial analysis of urbanization dynamics and ecosystem services for sustainable urban development in Dhaka city, Bangladesh. [Doctoral dissertation, Hokkaido University].
17. REACH (2024). Monitoring and modelling river water quality to protect Dhaka's river system. University of Oxford/BUET.
18. Mobin, M. N., Islam, M. S., Mia, M. Y., & Bakali, B. (2014). Analysis of physicochemical properties of the Turag River water, Tongi, Gazipur in Bangladesh. *Journal of Environmental Science and Natural Resources*, *7*(1), 27-33.
19. Hosen, M. S., Islam, S., Paul, A., & Bhuiyan, M. M. H. (2021). Geospatial evaluation of land use and land cover changes in Ashulia industrial hub in Dhaka, Bangladesh. Grassroots Journal of Natural Resources, 4(4), 27–41.
20. Alam, M. J. (2018). Rapid urbanization and changing land values in mega cities: Implications for housing development projects in Dhaka, Bangladesh. Bandung Journal of Global South, 5(2), 1–19.
21. Khan, N. S., Shawal, S., Hossain, M. A., Tasnim, N., Whitehead, P. G., & Rahman, M. (2024). Assessing flooding extent and potential exposure to river pollution from urbanizing peripheral rivers within Greater Dhaka watershed. Scientific Reports, 14, 29341.
22. Sultana, M. S., Islam, G. M. T., & Islam, A. S. (2011). Pre- and Post-Urban Wetland Area in Dhaka City, Bangladesh: A Remote Sensing and GIS Analysis. Journal of Water Resource and Protection.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue II February 2026

23. Zakir, H. M., Sattar, M. A., & Quadir, Q. F. (2016). Impact of urbanization and industrialization on irrigation water quality of a canal - a case study of Tongi canal, Bangladesh. Journal of Environmental Science and Natural Resources, 9(2), 109-115.
24. Rume, T., & Islam, S. M. D. (2020). Environmental effects of COVID-19 pandemic and potential strategies of sustainability. Heliyon, 6(9), e04965.
25. Schreinemachers, P., Kumar, S.S. & Uddin, N.M. (2025). Impact of home gardens promoted among urban residents in Dhaka, Bangladesh. Food Sec. 17, 1039–1052.
26. Islam, M. M., & Mamun, M. M. I. (2015). Variations of NDVI and Its Association with Rainfall and Evapotranspiration over Bangladesh. Rajshahi University Journal of Science and Engineering, 43, 21–28.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue II February 2026

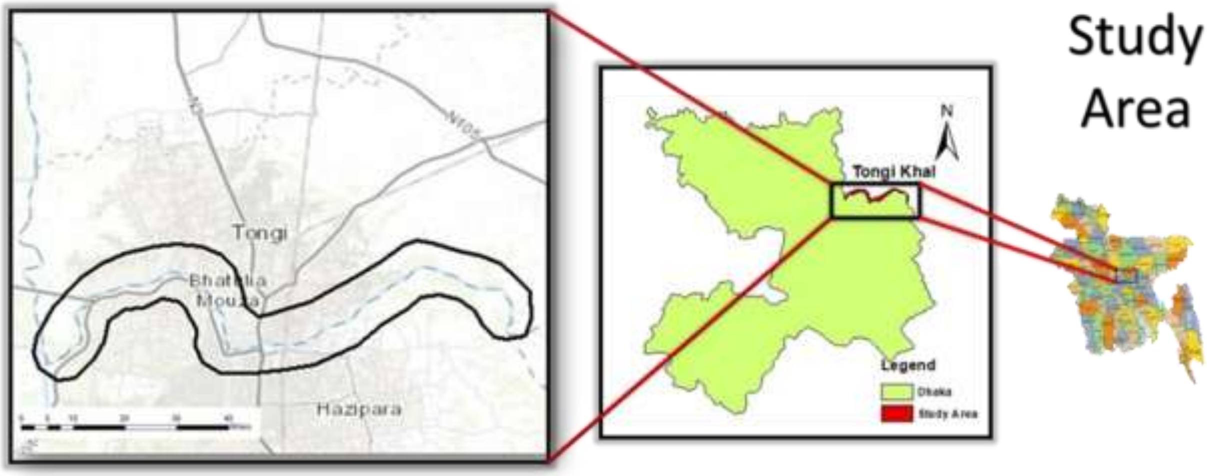

Figure 1: Map showing the location of the study area.

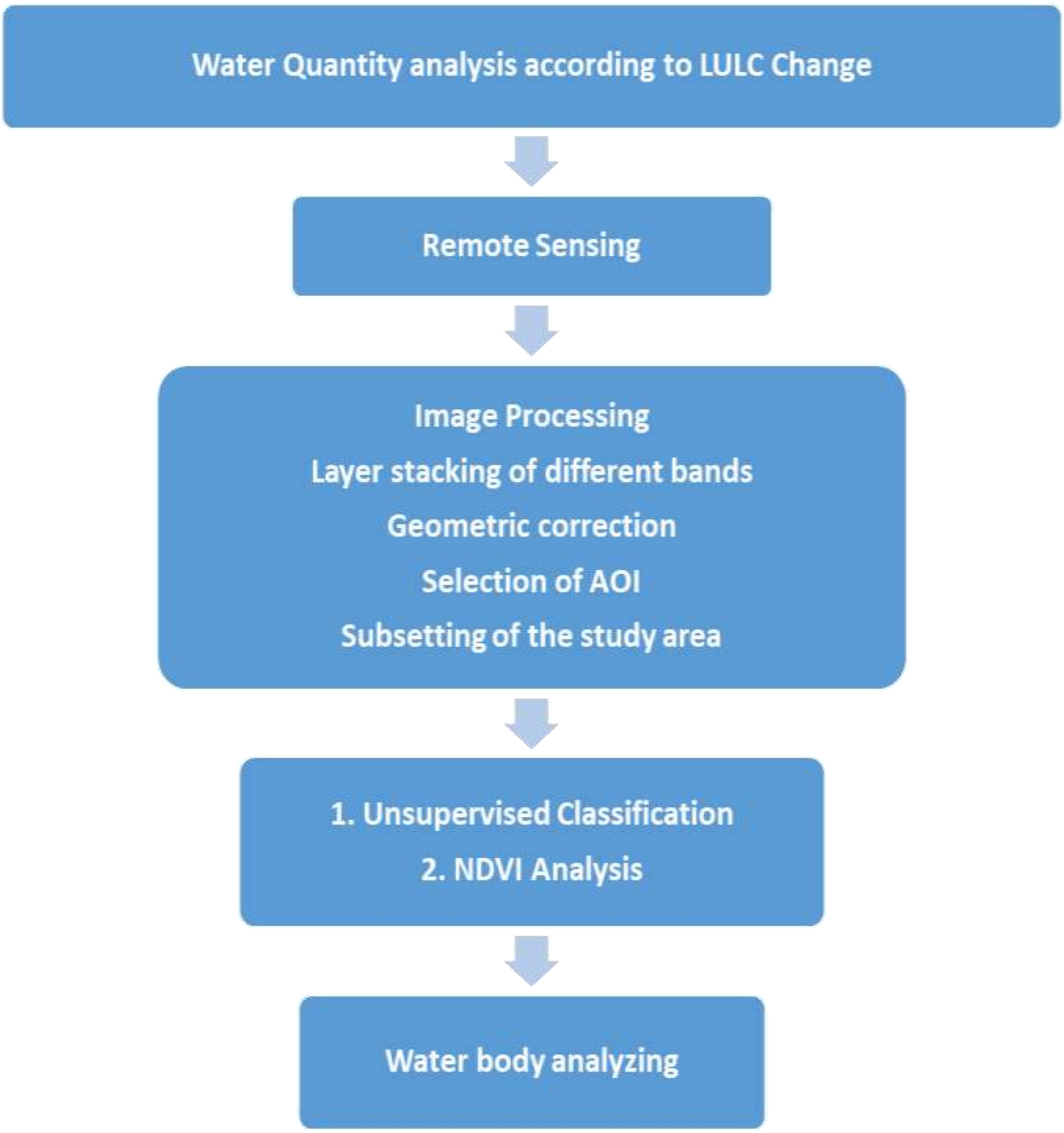

Figure 2: Methodology Chart.

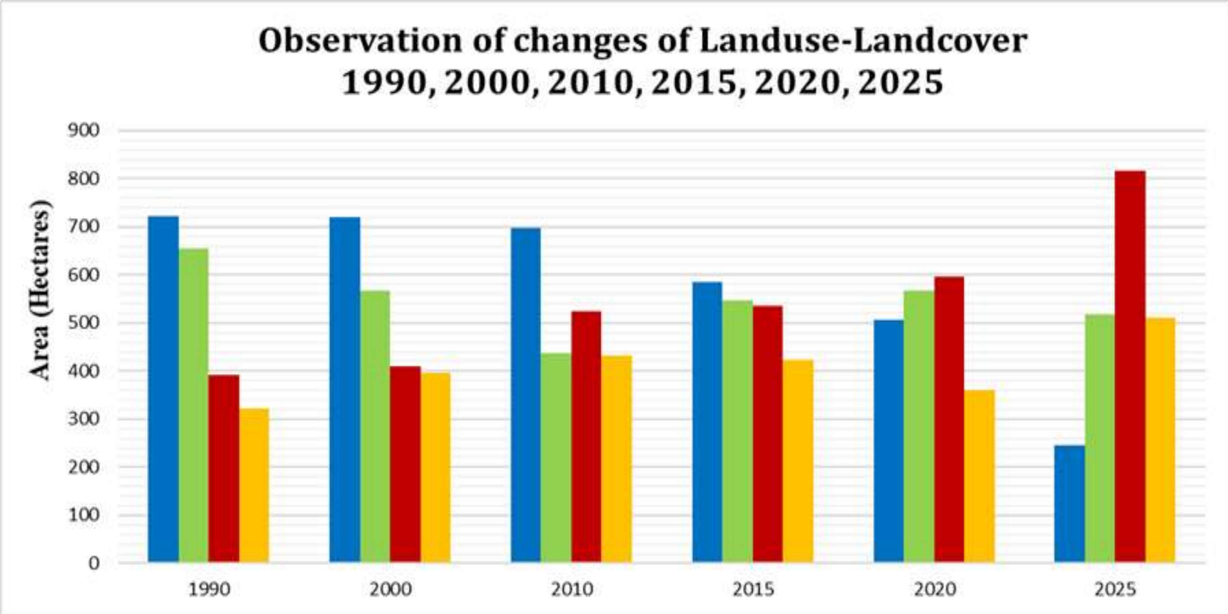

Figure 3: Observation of LULC changes by unsupervised classification

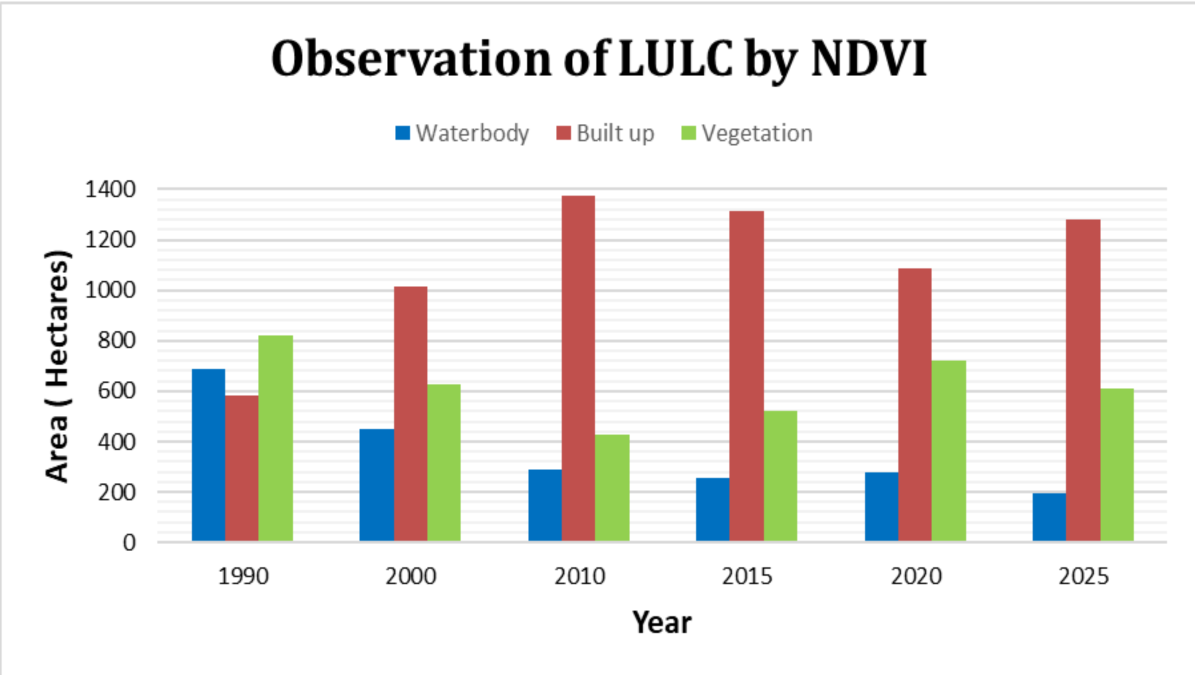

Figure 4: Observation of LULC changes by NDVI

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue II February 2026

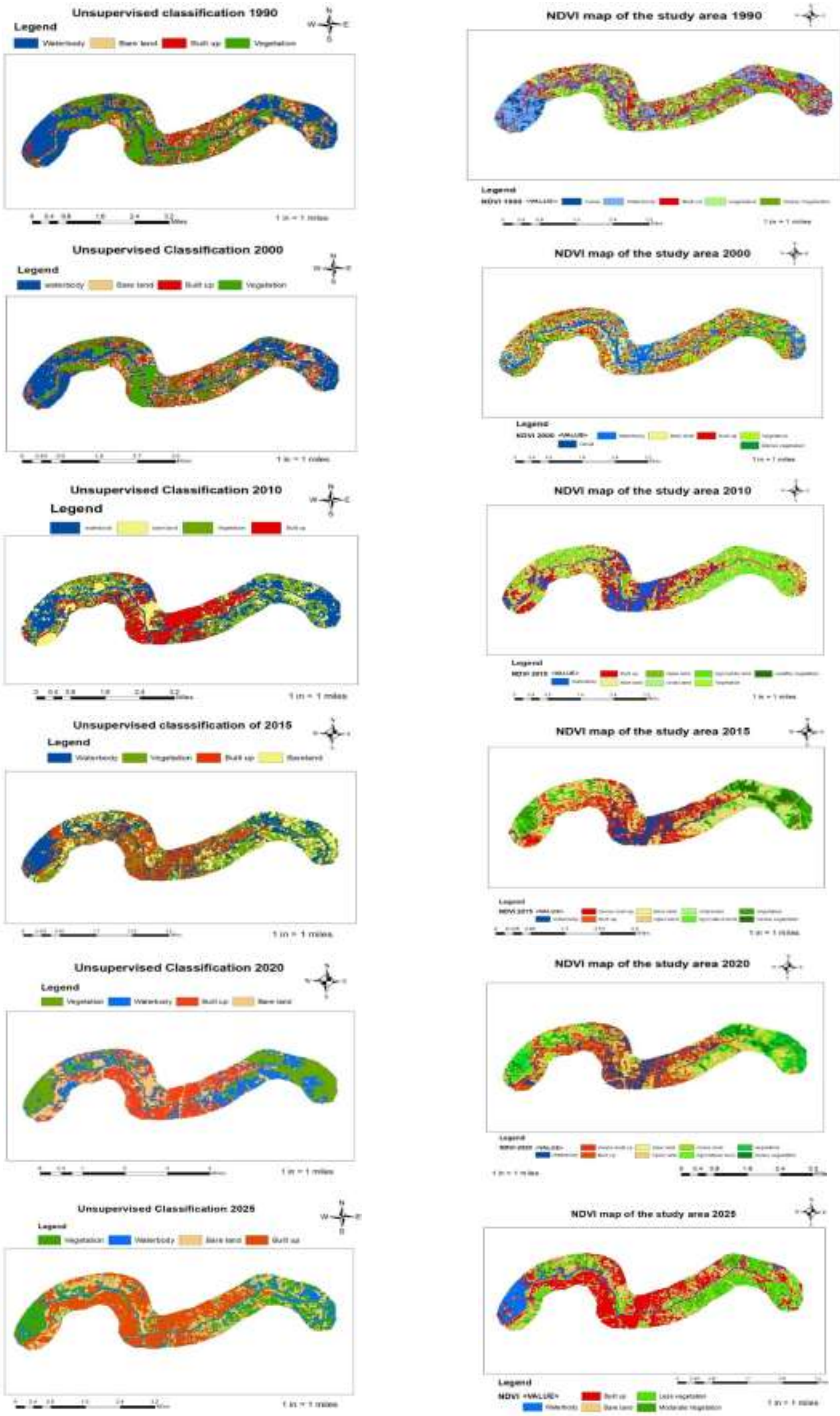

Figure 5: Comparative Year-wise LULC Thematic Maps (1990, 2000, 2010, 2015, 2020, and 2025) Derived from Unsupervised Classification and NDVI Methods.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue II February 2026

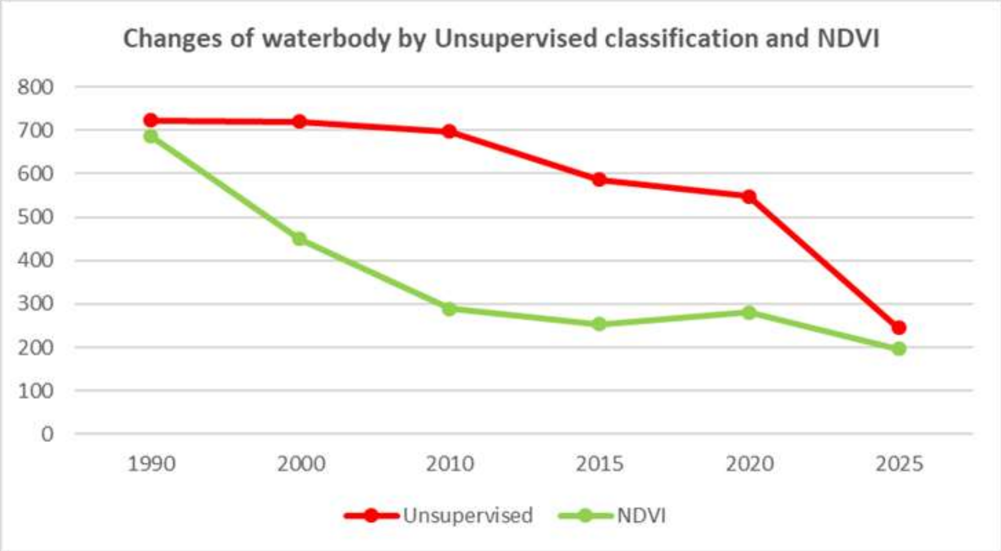

Figure 6: Change of waterbody based on two classifications

Table 1: Satellite images specifications with their acquisition dates

Sensor platform	Projection	Acquisition date	Resolution of used Bands	Path/ Raw
Landsat 4-5 (TM)	UTM, Zone 46 WGS 84	29-04-1990	30	137/44
	UTM, Zone 46 WGS 84	19-01-2000	30	137/44
	UTM, Zone 46 WGS 84	30-01-2010	30	137/44
Landsat 8 (OLI/TIRS)	UTM, Zone 46 WGS 84	12-11-2015	30	137/43
	UTM, Zone 46 WGS 84	30-03-2020	30	137/43
	UTM, Zone 46 WGS 84	23-11-2025	30	137/44

Table 2: LULC Changes determination by Unsupervised Classification from 1990 to 2025

Year	1990	2000	2010	2015	2020	2025
Classes	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Waterbody	722.88	719.82	697.05	585.63	505.86	245.34
Vegetation	655.74	566.64	437.22	547.02	567.63	518.22
Built up	391.5	408.87	523.71	534.6	596.43	817.11
Bare land	321.21	396	433.35	424.08	359.41	510.66

Table 3: Summary results of area change based on NDVI of the study area from 1990 to 2025

Year	1990		2000		2010		2015		2020		2025	
Classes	Area (ha)	(%)	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Waterbody	686.79	33	449.64	22	288.27	14	253.35	12	280.53	13	196.07	9
Built up	584.73	28	1014.12	49	1373.22	66	1314.36	63	1089.45	52	1283.04	61
Vegetation	819.81	39	627.57	30	429.84	21	523.62	25	721.35	35	612.22	29