

Assessment of Land Use and Land Cover (LULC) Changes along the MRT-6 Corridor in Dhaka Using Multi-Temporal Satellite Data

Pias Pal*, Md. Ibrahim Khalil, Swe Kya Waiy Marma, Mahiman Zinnurain, M. Afzal Hossain and Md. Sabbir Hosen

Department of Civil Engineering, Dhaka University of Engineering & Technology, Gazipur, Bangladesh

ABSTRACT

The development of metro rail infrastructure plays a significant role in shaping urban land use and accelerating urban growth in rapidly developing cities. This study analyzes the spatio-temporal changes in land use and land cover (LULC) within the MRT-6 station buffer zones in Dhaka, Bangladesh, in the period between 2021 and 2025. Satellite-based GIS and remote sensing techniques were used to classify LULC into four major categories: built-up area, vegetation, open land, and water bodies. Multiple MRT-6 stations were analyzed to gain an insight into patterns of urban transformation. These findings demonstrate that built-up areas in most station buffer zones increase significantly in the period between 2023 and 2025, following the introduction of the metro. Concurrently, vegetation, open land, and water bodies have been diminishing gradually, demonstrating the conversion of land by the growing infrastructure and business activities. Notably, Kazipara recorded the highest built-up area in 2021 at 1.79 km², increasing further to 1.85 km² by 2025, while Uttara South recorded the lowest built-up coverage in both years, starting at just 0.19 km² in 2021 and 0.47 km² in 2025, reflecting urban growth along the corridor. The results indicate that the availability of metro promotes residential and commercial development, increases land value, and accelerates urban expansion. Altogether, MRT-6 has led to the tremendous urban change in its route. Although the metro system provides a way of sustainable transportation and reduces traffic congestion, it also causes environmental pressure due to the decrease in the natural land cover. The study highlights the importance of integrating transportation planning with land use management to help in balancing and sustainable development of urban centers in Dhaka.

Keywords: Land Use Land Cover (LULC), Dhaka Metro Rail, Geographic Information System, Transit Oriented Development.

1. INTRODUCTION

Urbanization in developing countries has been increasing rapidly, with the number of people living in urban areas expected to rise from about 2.0 billion in 2000 to nearly 5.5 billion by 2050 [1]. This rapid population growth puts significant pressure on land resources and often leads to environmental problems, inefficient transportation systems, and unplanned urban expansion [2]. With the growth of the population, cities are growing at a rate that is outpacing the population growth of the country, which is a sign of poor land development. Despite the necessity of sustainable development, rapid urban development poses significant challenges that should be properly planned and addressed to achieve balanced urban development [2], [3]. Rapid urbanization in megacities poses significant challenges, especially in the transport systems and sustainable planning of land use [4], [5]. Urbanization and human activities brought about changes in land use and land cover (LULC) that greatly influence climate, biodiversity,

and environmental quality [6]. Simultaneously, the increasing number of vehicles contributes to traffic congestion, air pollution, and ineffective land use patterns, generating severe environmental and social issues [7]. Thus, the need to come up with efficient and sustainable transportation systems has become critical in enhancing the living conditions and economic performance of urban life [8]. Dhaka Mass Transit Company Limited (DMTCL) is a key player in changing urban transportation in Dhaka under the MRT Line-6 project [9]. Launched as part of the Strategic Transport Plan (STP) and running since 2022, MRT-6 already serves a route of around 20.1 km with 16 stations between Uttara and Motijheel [10], [11]. It aims to reduce severe traffic congestion and provide a fast, reliable, and environmentally friendly public transport system to the increasing population [12]. MRT-6 is a component of a multi-phase metro network that enhances urban mobility and connectivity and meets the growing transportation demands as a result of the rapid

*Corresponding author's email: piaspal102@gmail.com

urbanization [13]. Under the system, it is anticipated that land use patterns and urban development will be affected greatly along the corridor [14]. It is vital to analyze the relationship between the transport systems and patterns of land use because integrated planning is required to achieve sustainable urban development [15]. Efficient public transportation systems like MRT-6 can reduce emissions, minimize congestion, and support economic growth by improving accessibility. In addition, MRT-6 facilitates sustainable mobility through a decrease in the use of personal vehicles, which is significant in terms of climate change and resource limitations. Nevertheless, the intensive urbanization process still exerts pressure on the natural resources and ecological balance in Dhaka [16]. Although this has happened, the effects of MRT-6 on land use patterns and environmental dynamics have not been adequately investigated. This paper examines the construction and operation stages of MRT-6 and its influence on surrounding areas. In particular, it looks at the spatio-temporal changes in LULC within 0-800 m buffer zones along the MRT-6 corridor in the years 2021, 2023, and 2025. The study aims to assess how MRT-6 influences urban growth and land use transformation and to support sustainable urban planning and policy-making in rapidly growing megacities like Dhaka.

Understanding the spatial extent of urban transformation around metro corridors is increasingly important for evidence-based planning. By comparing pre-operation, initial operation, and post-operation phases, this study provides a more granular perspective on how metro accessibility drives localized land use shifts. The outcomes are expected to contribute valuable empirical evidence for transport and urban planners, helping guide future infrastructure decisions and land use policies.

2. LITERATURE REVIEW

The role of urban transit systems has been growing in significance as it has increased the level of accessibility and made urban living a better experience. Land use and transportation planning have become a common practice in controlling uncontrolled urban sprawl that has been brought about by overreliance on personal vehicles [18]. This combined method is believed to be an efficient way of reducing adverse environmental and social impacts and encouraging sustainable city growth [19]. Transit-oriented development (TOD) can be viewed as an important factor in enhancing the economic development of metropolitan regions and their livability. TOD was introduced by Peter Calthorpe in the late 1980s and focuses on high-density,

mixed-use development around transit stations, and facilitates access to workplaces and services via walking and cycling. Though there were not many considerations on accessibility in early TOD models, this has been enhanced over the years [20]. The growth of the metro rail has also helped in making urban areas more alive and economically active, as land values grow with the growth of urban areas, and commercial activities are more likely to occur around transit corridors [21].

In the context of Dhaka, Metro rail systems like MRT-6 have greatly enhanced accessibility and urban mobility. But environmental and social issues can be generated through such a large-scale infrastructure development. It has been found that this type of project can cause habitat destruction, deforestation, soil erosion, and urban heat island (UHI) effects, which harm the ecological balance. Furthermore, the activities of metro construction can lead to the enhancement of metal pollution, which can be a threat to human health [22]. Another significant issue is the uneven development, where the regions nearer to the metro stations are likely to have a better economic growth than those that are farther away, thus creating spatial inequalities. Moreover, the increased accessibility and lowered traveling expenses could stimulate development in the regions that were less reachable in the past, which could lead to urban sprawl and demographic shifts.

Despite these challenges, metro lines like MRT-6 have a significant impact on the growth and socio-economic development of the city in terms of connectivity and supporting growth based on TOD. The high population densities and mixed-use development promoted by the compact city concept are facilitated by efficient public transportation systems that promote the concept of compact cities in controlling urban sprawl. Additionally, MRT-6 increases the comfort of passengers and promotes the connection to other means of transport, which is a part of a multimodal urban transport system. Therefore, sustainable urban development will need improved integration of transport and land-use planning, infrastructure optimization, and encouragement of sustainable mobility options to maximize the benefits of MRT-6 in Dhaka [17]. No prior study has examined station-level LULC changes within buffer zones along the MRT-6 corridor.

3. METHODOLOGY

3.1 Study Area

The study area is MRT Line-6 within Dhaka, which is among the busiest and fastest-growing megacities. MRT-6 was the first metro railway to be opened in Bangladesh,

aimed at alleviating traffic congestion and enhancing urban mobility. It is a path that links Uttara North and Motijheel and has a distance of 20.1 km, which passes through 16 stations at strategic areas in the city [9], [10]. These are the Uttara North, Uttara Center, Uttara South, Pallabi, Mirpur-11, Mirpur-10, Kazipara, Shewrapara, Agargaon, Bijoy Sarani, Farmgate, Karwan Bazar, Shahbagh, Dhaka University, Secretariat, and Motijheel. It started serving partially (between Uttara North and Agargaon) in December 2022 and was expanded fully to serve Motijheel in 2023 [9]. This phased development significantly improved accessibility and connectivity, making the corridor suitable for analyzing urban transformation. Fig. 1 explains that an 800 m buffer was applied around each of the stations in order to investigate the immediate impact. This distance is an average walking distance in a transit-oriented development study [11]. The change in LULC is determined in the years 2021, 2023, and 2025 to study the trend of growth of the urban areas as a result of the metro.

3.2 Materials

Sentinel-2 satellite images from 2021, 2023, and 2025 were used to examine land use and land cover changes along the MRT-6 corridor in Dhaka. The images have a spatial resolution of 10 m, which made them suitable for identifying the main land-cover features of the study

area. Before classification, the images were aligned through image-to-image registration to maintain spatial consistency. Radiometric and geometric corrections were also carried out to reduce atmospheric and sensor-related errors. All images were projected using the WGS 84 datum and UTM Zone 46N so that changes between the selected years could be compared accurately. Finally, the study area was classified into four main categories: built-up area, vegetation, open land, and water bodies, based on their spectral characteristics.

3.3 Methods

Buffer zone analysis was applied to assess the impact of MRT-6 on urban growth and land cover change. A 0-800 m buffer was established at all the stations to examine the immediate effect of the metro infrastructure. Multi-temporal satellite data were analyzed using GIS tools, including geo-referencing and subsetting. The supervised classification method, Maximum Likelihood Classification (MLC), was used to classify the images into four LULC types: built-up area, vegetation, open land, and water bodies. Buffer zones were superimposed on 2021, 2023, and 2025 LULC maps to evaluate the changes over the years. Classification accuracy was assessed using reference samples to evaluate the reliability of the classified LULC maps.

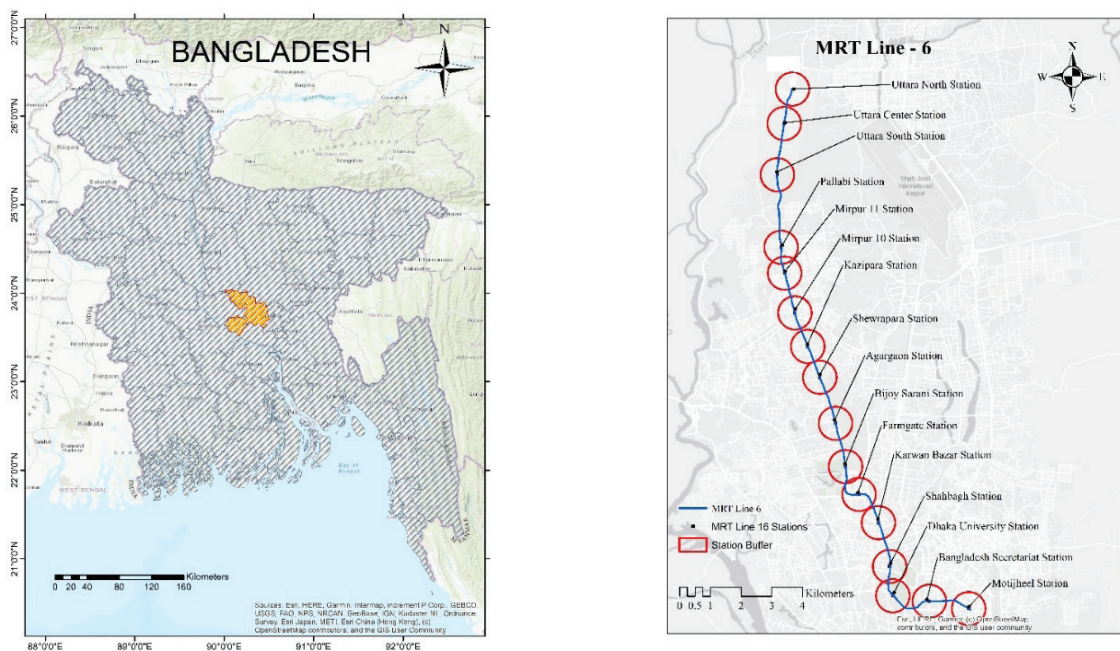


Fig. 1: Study Area (MRT LINE-6)

4. RESULT AND DISCUSSION

4.1 Temporal Changes in LULC along MRT-6 Corridor

Table 1 presents the land use and land cover conditions within the 0-800 m buffer zones of the MRT-6 stations for 2021, 2023, and 2025. The results show an overall increase in built-up land, together with a gradual decline in vegetation, open land, and water bodies. Considering the summed values of all station buffers, built-up land increased from 16.65 km² in 2021 to 19.73 km² in 2025, representing an increase of 3.07 km² or 18.46%. During the same period, vegetation decreased from 8.21 km² to 6.61 km², showing a decline of 19.53%. Open land fell from 5.21 km² to 4.27 km², while water bodies decreased from 2.17 km² to 1.61 km². These changes represent reductions of 17.95% and 25.91%, respectively. The results suggest that much of the new built-up development occurred through the gradual conversion of vegetation and open land. At the same time, vegetation has been decreasing gradually in most of the stations, implying that the growing development force is converting the green areas into urban land use. This fall is further visible in the central stations, where the population density, land demand, and development of infrastructure are a bit more noticeable. In addition, a reduction in open land is also present in several stations. This means that previously unused land, unoccupied land, or land that was put to ineffective use is now being converted to residential premises, commercial areas, and facilities that support the infrastructure. The reduction in water bodies in some of the areas is minimal, and compared to other categories of land use, the reduction is not much. This means that urbanization is majorly happening through vegetation and open land conversion, and water bodies are comparatively less affected. They are, however, relatively stressed due to human activities in the environment. Minor intrusion at the edges of the water can also be observed in some of the stations, which can be regarded as environmental issues of long-term concern if this trend continues.

Overall, the table indicates that there is a progressive shift in the natural and semi-natural land covers to the built-up land covers within the period 2021 to 2025. The other interesting observation is that an expansion in the built-up areas is more pronounced after 2023, which corresponds to the operational phase of MRT-6-Kazipara, which had the highest built-up area of 1.79 km² in 2021, further increased to 1.85 km² by 2025, while Uttara South remained the least urbanized, rising modestly from 0.19 km² to 0.47 km². This means that enhanced access and

connectivity have played a key role in development activities in and around the stations. In general, the observed changes reveal that there exists a close and direct correlation between the development of the metro and the transformation of land use.

4.2 Spatial and Graphical Representation of LULC Changes

Fig. 2 illustrates the percentage variation of different land use and land cover (LULC) classes over the study period. The results clearly indicate a consistent increase in built-up areas, accompanied by a progressive decline in vegetation cover, open land, and water bodies. This pattern confirms that urban expansion within the study area is predominantly occurring through the conversion of natural and semi-natural land covers. The GIS-based LULC maps for 2021, 2023, and 2025 (Fig. 3) further offer a clear spatial interpretation of these temporal changes. The maps demonstrate a continuous and spatially concentrated expansion of built-up areas along the MRT-6 corridor. This expansion is particularly prominent in and around centrally located stations, where enhanced accessibility and higher economic attractiveness have contributed to intensified land development.

A more detailed observation is evident at Uttara North station (Fig 4), where comparative analysis of LULC maps reveals a pronounced transformation over time. Built-up land has expanded substantially, while vegetation and open land have experienced notable reductions. This indicates that even peripheral urban zones are undergoing accelerated land use transformation, primarily driven by improved metro connectivity and associated urban development pressures.

4.3 Impact of MRT-6 on Urban Development

The findings of this study have clearly indicated that MRT-6 has had an enormous impact on urban development along its route. Increased access and speed in connectivity have stimulated residential and commercial activity, which has resulted in observable changes in land use within the buffer zones throughout the study period. Much of the developed growth has occurred through the transformation of vegetation and undeveloped land. This implies that the transport infrastructure contributes significantly to the development of the patterns of urban growth. It is more significant in central stations like Farmgate, Karwan Bazar, and Motijheel, where the intensity of development is high due to more economic activity and a higher land value. In contrast, peripheral stations show relatively slower but steady transformation.

Environmentally, MRT-6 has both positive and negative impacts. On the one hand, it will contribute to the sustainable transportation process and help to reduce the problem of road traffic congestion. However, it may also cause the urban heat island effect, loss of biodiversity, and an ecological imbalance unless well managed. Generally, the results indicate the significance of land

use and transport planning that is integrated. Strategies such as Transit-Oriented Development (TOD) play a vital role in balancing urban development and environmental preservation. The accuracy assessment showed that the overall classification accuracy ranged from 80% to 90%, indicating acceptable reliability of the classified LULC maps.

Table 1: LULC distribution within MRT-6 station buffer zones (2021, 2023, and 2025)

Station	2021				2023				2025			
	Water body (Sq.km)	Vegetation (Sq.km)	Buildup (Sq.km)	Open land (Sq.km)	Water body (Sq.km)	Vegetation (Sq.km)	Buildup (Sq.km)	Open land (Sq.km)	Water body (Sq.km)	Vegetation (Sq.km)	Buildup (Sq.km)	Open land (Sq.km)
Uttara North	0.2114	0.5592	0.4747	0.765	0.1958	0.5466	0.5713	0.6989	0.1529	0.394	0.8685	0.5949
Uttara Centre	0.2201	0.4389	0.3563	1.003	0.2074	0.4171	0.4213	0.97	0.1868	0.4054	0.4794	0.9392
Uttara South	0.6867	0.4565	0.1944	0.6829	0.6539	0.3911	0.2982	0.6704	0.5588	0.3143	0.4679	0.6695
Pallabi	0.129	0.3216	1.3247	0.2421	0.0907	0.3	1.3809	0.2312	0.0591	0.2915	1.4745	0.1862
Mirpur-11	0.0257	0.256	1.653	0.0879	0.0258	0.2163	1.6914	0.079	0.0108	0.1417	1.814	0.0443
Mirpur-10	0.0379	0.2647	1.5982	0.1095	0.0289	0.2461	1.6416	0.0962	0.0277	0.2399	1.6549	0.0948
Kazipara	0.03	0.1185	1.7876	0.0779	0.0195	0.1065	1.8308	0.0504	0.0136	0.096	1.8529	0.0477
Shewrapara	0.2603	0.3325	1.201	0.2166	0.2274	0.3171	1.263	0.2113	0.117	0.143	1.5793	0.1711
Agargaon	0.0911	0.7433	0.6176	0.584	0.0848	0.6944	0.6799	0.5733	0.0833	0.6722	0.7512	0.517
Bijoy Sarani	0.1106	0.8261	0.6224	0.452	0.10951	0.7749	0.6817	0.4414	0.1073	0.7193	0.7626	0.4219
Farmgate	0.035	0.4058	1.3549	0.2134	0.0338	0.3898	1.4439	0.1513	0.0315	0.3581	1.4827	0.1398
Karwan Bazar	0.0932	0.2388	1.6038	0.0845	0.0702	0.2221	1.6986	0.0316	0.0975	0.2104	1.6937	0.0187
Shabbag	0.0707	0.947	0.8424	0.1508	0.062	0.8351	1.0268	0.0887	0.0543	0.8151	1.0611	0.08304
DU	0.0492	1.2044	0.4674	0.2897	0.0488	0.9985	0.7235	0.2414	0.0405	1.0004	0.7792	0.1916
Bangladesh Secretariat	0.0535	0.6239	1.2064	0.1267	0.0276	0.5251	1.3916	0.066	0.0115	0.4948	1.3798	0.1244
Motijheel	0.07	0.4749	1.3467	0.1193	0.068	0.3317	1.5758	0.0477	0.0585	0.3123	1.6235	0.0266

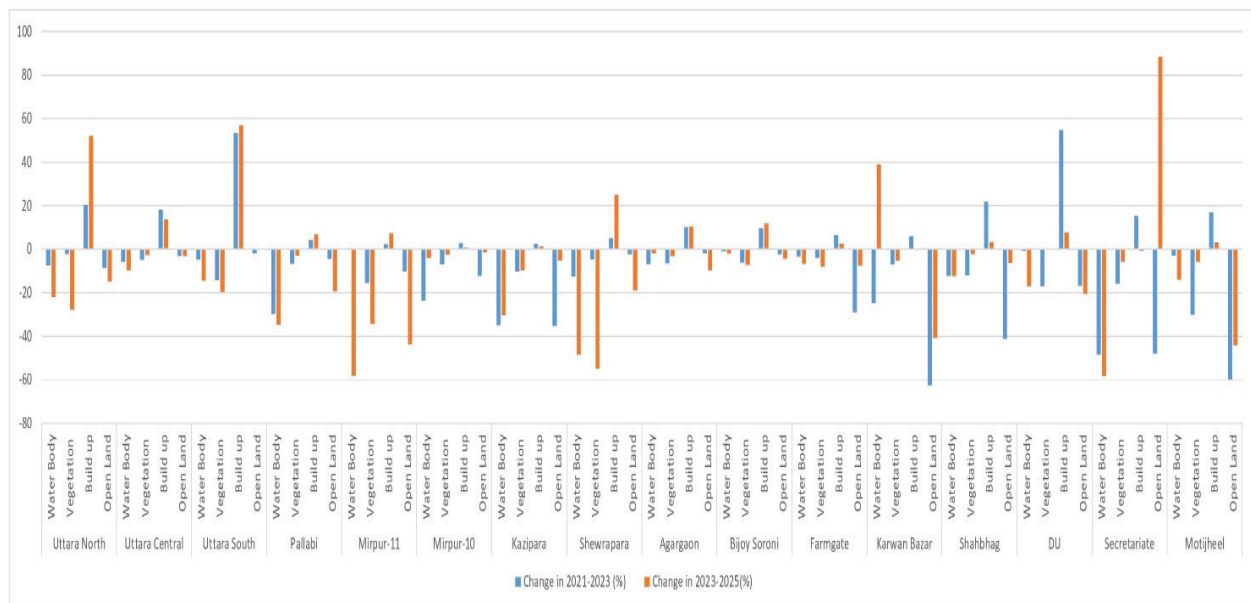


Fig. 2: Percentage (%) change in LULC along MRT-6

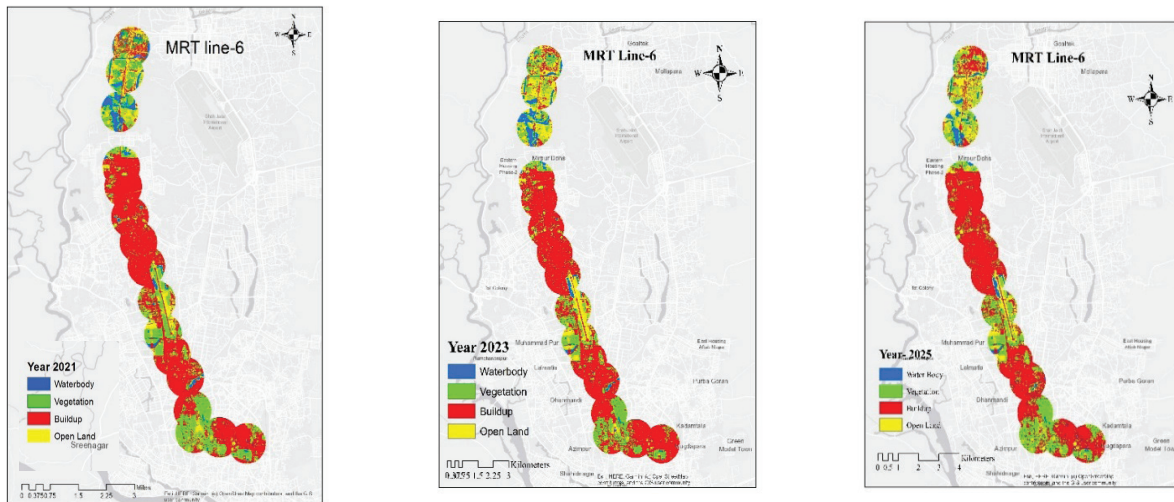


Fig. 3: Spatio-temporal LULC change along MRT-6

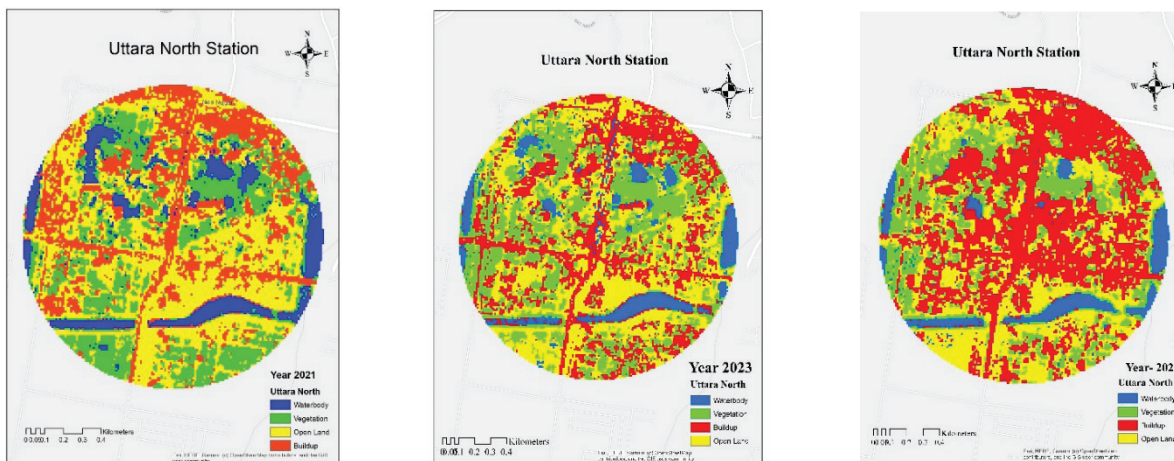


Fig. 4: LULC map of Uttara North Metro station

5. CONCLUSION

This study investigated how land use and land cover changed around the MRT-6 stations in Dhaka between 2021 and 2025. The findings reveal a noticeable shift toward urban development along the corridor. The total built-up area increased from 16.65 km² in 2021 to 19.73 km² in 2025, showing an overall growth of 18.46%. At the same time, vegetation, open land, and water bodies declined by 19.53%, 17.95%, and 25.91%, respectively. The changes were more visible around stations such as Uttara North, Shewrapara, Dhaka University, Motijheel, and Uttara South.

The results suggest that improved accessibility provided by MRT-6 may have encouraged residential, commercial, and infrastructure development near the stations. However, these changes cannot be linked only to the metro rail, as population growth, rising land values, existing urban expansion, and planning decisions may also have played important roles.

This study has some limitations, including the use of only three observation years, 10 m resolution satellite images, overlapping station buffers, and the lack of a control area. Future studies should include longer time-series data, higher-resolution imagery, different buffer

distances, and socioeconomic information. Proper land-use zoning, protection of green spaces and water bodies, and planned transit-oriented development are therefore necessary to achieve balanced and environmentally sustainable growth along the MRT-6 corridor.

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