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An Analytical Perspective to Evaluate the Noise Level and Respective Spatial Noise Mapping Induced by Metro-Rail Movement in Dhaka City

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Abstract:- Metro rail systems, which provide efficiency and speed, have revolutionized urban travel. However, the subsequent influence on environmental acoustics, notably noise pollution, needs further examination. This study evaluates noise pollution from the Dhaka metro rail along an 11.7 km segment, focusing on 27 monitoring points across commercial, mixed, and residential areas. Sampling on working and non-working days, representing a three-shift day, revealed average morning noise levels during working days (72 dB to 78.7 dB), increasing in the afternoon (76.2 dB to 83.6 dB), and peaking in the evening (80.8 dB to 89 dB). On non-working days, morning levels ranged from 69.1 dB to 73.1 dB, with afternoon and evening levels at 75.2 dB to 81.6 dB and 75.2 dB to 84 dB, respectively. Identified noise levels at specific locations underscored the need for managing metro rail-induced noise pollution, especially in commercial zones during working days. To address this issue, the research recommends implementing noise reduction measures and planning strategies to minimize disturbances in sensitive areas, ensuring a sustainable and harmonious urban environment.

Keywords:- *Noise Pollution, Metro Rail, GIS, Urban Pollution, Environmental Impact.*

I. INTRODUCTION

Noise, derived from the term "nausea" meaning undesirable sound, is a significant form of pollution that affects the environment in which we live. It arises from diverse sources and propagates through a medium, typically air, ultimately resulting in physiological and psychological effects on individuals who perceive it (Guha *et al.*, 2020). The surrounding environment is increasingly susceptible to various types of pollution, with noise pollution being recognized as a prominent contributor. By understanding the origin, transmission, and impact of noise, we can grasp its adverse consequences on both our physical and mental well-being (Croy, Smith and Waye, 2013). In numerous cities, road traffic noise stands out as the primary source of noise pollution. Despite this, rail transport remains a highly advantageous mode of transportation that is utilized regardless of seasons or weather conditions (Grubliauskas *et al.*, 2014). However, with the ongoing construction of railway lines to foster environmentally friendly transportation alternatives and address traffic congestion, the prevalence of rail noise has surged. This increase in rail noise has emerged as a significant concern within urban environments (Chan and Lam, 2008). Residences located in close proximity to metro-rail tracks often experience complaints from the local population due to the noise pollution caused by metro-rail(Bunn and Zannin, 2016). The sound and vibration caused by metro-trains contribute significantly to the overall noise pollution in the surrounding area, causing inconvenience and disturbance to those living nearby(Yan *et al.*, 2020). Addressing this issue and finding suitable solutions to minimize the impact of train noise and vibration on residential areas is crucial for mitigating the negative effects of metro-rail noise pollution. With the rapid pace of urbanization and industrialization, Dhaka City has undergone a significant increase in noise levels, becoming a hotspot for noise pollution (Razzaque *et al.*, 2010). This detrimental environmental issue poses a serious threat to the well-being of the city's inhabitants. Along the metro rail area and the associated major roads, numerous essential organizations, offices, hospitals, educational institutions, and residences are situated, making it a crucial hub for urban and national connectivity (Haq *et al.*, 2012). Consequently, this area witnesses a wide range of activities and attracts a large number of people who gather to participate in various events. Considering the significance of this area and the multitude of activities taking place, the effects of metro rail noise pollution on the well-being of individuals and the overall urban environment demand careful examination and effective mitigation strategies. Objectives of the study are,

- To quantify and assess the levels of noise pollution generated by the metro rail system in different areas of Dhaka City.
- To evaluate the impacts of metro rail noise pollution on the physical and mental well-being of residents living in close proximity to the rail tracks.

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II. MATERIALS AND METHODS

The study was conducted mainly about the measurement of noise generated from the Metro Rail Transit established in the Dhaka city. The data was collected through the primary data collection process where the level of noise was measured at different locations along the MRT-system.

➢ *Study Area*

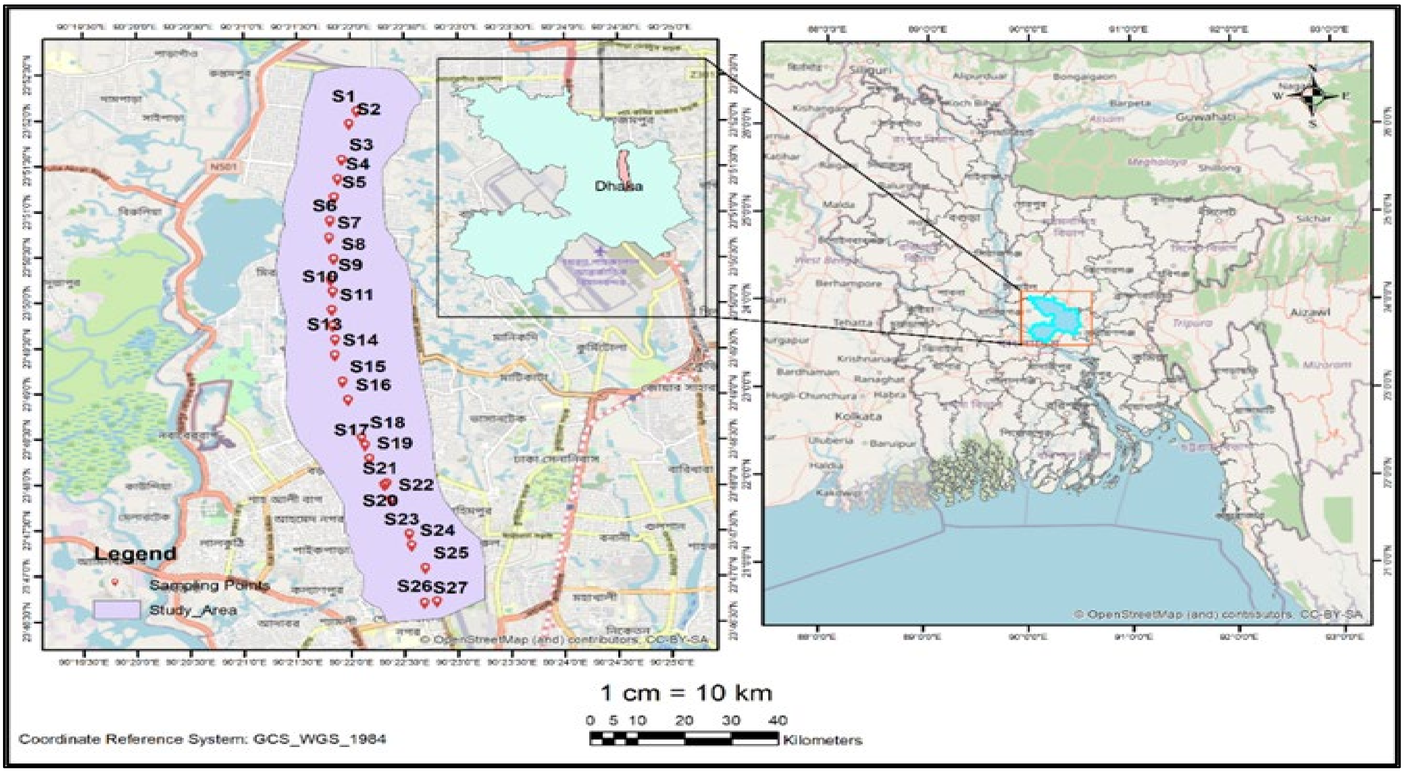

Fig 1 Study Area

This study was conducted in Dhaka, the capital of Bangladesh which is the center of the country with a huge rush and the geographic coordinate is 23° 48' 39.8016" N (latitude) and 90° 24' 27.3888" E (longitude). The study was undertaken to analyze the performance of the Dhaka Metro MRT-6, the first phase of the Dhaka Metro. The study was conducted from Uttara North to Agargaon, with the latitudes of 23° 48' 39.8016" N and 90° 24' 27.3888" E. The metro has a length of 11.73 km and a transit capacity of 60 thousand people per hour. The track operates 12 trains with 6 coaches and 9 interval points to maintain the load of citizens. 27 different points and their parameters were considered for analysis, considering attributes in three different circumstances of a day.

➢ *Sound Level Meter*

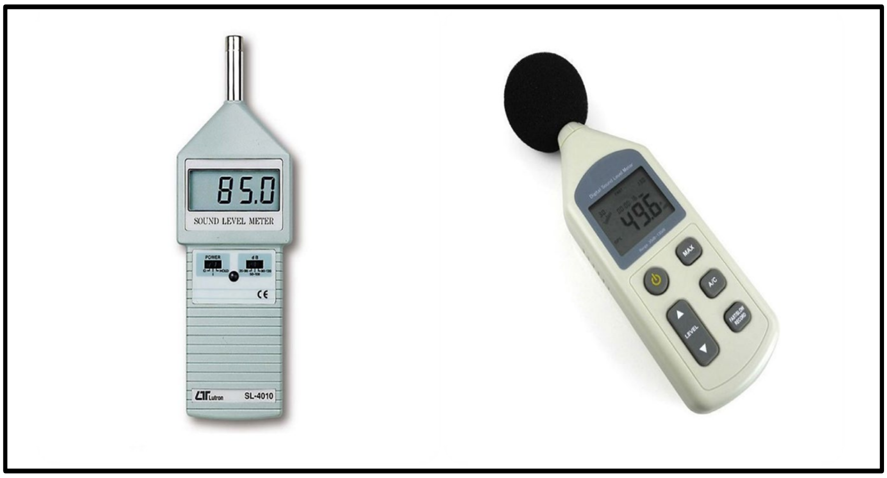

Fig 2 Sound Level Meter

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For this study two sound level meters were used for data collection process. One of them was the Lutron SL-4010 and the other was AR824 Digital Sound level meter. Sound level meters must adhere to international standards like IEC 61672 - 1, which define signal processing as applying frequency and temporal weightings to the signal. This standard dictates the application of frequency and temporal weightings to the signal, guaranteeing a standardized and accurate measurement of sound levels.

➢ *Data Collection Method*

The data collection process spanned from 8 AM to 8 PM, encompassing the varying periods of Morning, Afternoon, and Evening. To derive a representative average, the mean of the collected data was computed. A three-shift approach was adopted to optimize data accumulation, providing a comprehensive understanding of noise levels throughout the day. Additionally, a decibel calculator was integrated into the methodology to ascertain the precise decibel levels recorded.

➢ *Noise Analysis Software*

The extracted data was processed and cleaned using the MS Excel software to provide robust data for analysis. This step aimed to ensure the robustness of the dataset for subsequent analysis. The processed data underwent further scrutiny with the assistance of ArcGIS 10.8.2. Leveraging the IDW (Inverse Distance Weighted) method within the ArcGIS platform, spatial mapping was executed. This involved extracting and consolidating preserved point data from targeted spots. The utilization of ArcGIS facilitated the creation of a map layout, providing a visual representation of noise distribution across the metro rail zones in Dhaka City.

III. RESULT AND DISCUSSION

Disputed project reflects the Metro rail Noise consideration of Dhaka city and the activity was conducted by accumulating sample data from 27 different locations.

A. *Measured Noise Level*

Table 1 provides us with an overview of sampling points and the average noise levels on working and non-working days.

Table 1 Measured Noise Level on Working and Non-working Days

Sl. No.	**Location**	**Zone**	**Noise Level on Working Days (dB)**			**Noise Level on Non-working Days (dB)**		
			Morning (8-10) a.m.	**Afternoon (1-3) p.m.**	**Evening (6-8) p.m.**	**Morning (8-10) a.m.**	**Afternoon (1-3) p.m.**	**Evening (6-8) p.m.**
S1	Uttara North	Mixed	70.6	72.3	76.9	68.9	74.5	75.8
S2	Block C1, Uttara	Residential	66.9	71.2	78.9	65.8	77.7	76.7
S3	Uttara Center	Residential	69.3	79.8	77.1	69	78.1	76.1
S4	Uttara R.M.T	Residential	71.1	75.8	77.7	65.6	79.1	76.6
S5	Itd Transport Office	Residential	72.1	72.6	75.4	69.4	72.4	69.5
S6	Uttara South	Residential	71.6	73.1	77.7	67	67.5	63.7
S7	Uttara South Station	Residential	72.7	73.9	79.1	70.2	71.5	69
S8	Mirpur	Mixed	72.4	73.3	81.7	70	67.5	70.9
S9	Mirpur Cantonment	Residential	72.4	74.6	81.4	66.2	71.6	71.4
S10	Cantonment School and College	Mixed	73.2	75.6	84.7	63.9	75.3	73.2
S11	National Defense College	Mixed	75.6	75.5	85.5	62.5	73.9	77.1
S12	Arong, Mirpur	Commercial	73.5	75.8	80.7	66.4	74.8	74
S13	Pallabi Station	Commercial	75.2	81.3	91.5	66.5	88	85.3
S14	Pallabi	Commercial	71.6	77.5	88	69.8	77.6	81
S15	Mirpur 11 Station	Commercial	74.1	80.7	86.2	68.7	76	73.6
S16	Mirpur 11	Commercial	73.4	81.5	88.5	68	78.9	87
S17	Mirpur 10	Commercial	76.7	83.9	89.2	70.2	80	82
S18	Mirpur 10 Station	Commercial	90.8	93.4	93.4	83	91.9	91.8
S19	Shenpara	Mixed	78	82.2	90.1	74.7	80.3	85.1
S20	Kazipara Station	Mixed	76.9	82.5	89.1	72.7	81.7	86
S21	Kazipara	Mixed	75.4	75.8	86.6	72.5	75.8	81.9
S22	Kazipara Jame Mosjid	Residential	74.3	79.9	89.1	73	74	84.8

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S23	Sheurapara Station	Commercial	91.1	93.2	93.5	88.9	92.3	92.6
S24	Sheurapara	Commercial	77.7	83.5	86.9	76.2	75	85.7
S25	West Karfol, Taltola	Residential	77.8	84.9	90.7	75.3	84.9	88.6
S26	Agargaon	Mixed	74.1	84	88.7	75.3	81.9	84.9
S27	Agargaon Station	Commercial	82.4	85.5	92	73	81.8	87.4

B. Spatial Distribution of Noise Level on Working Days

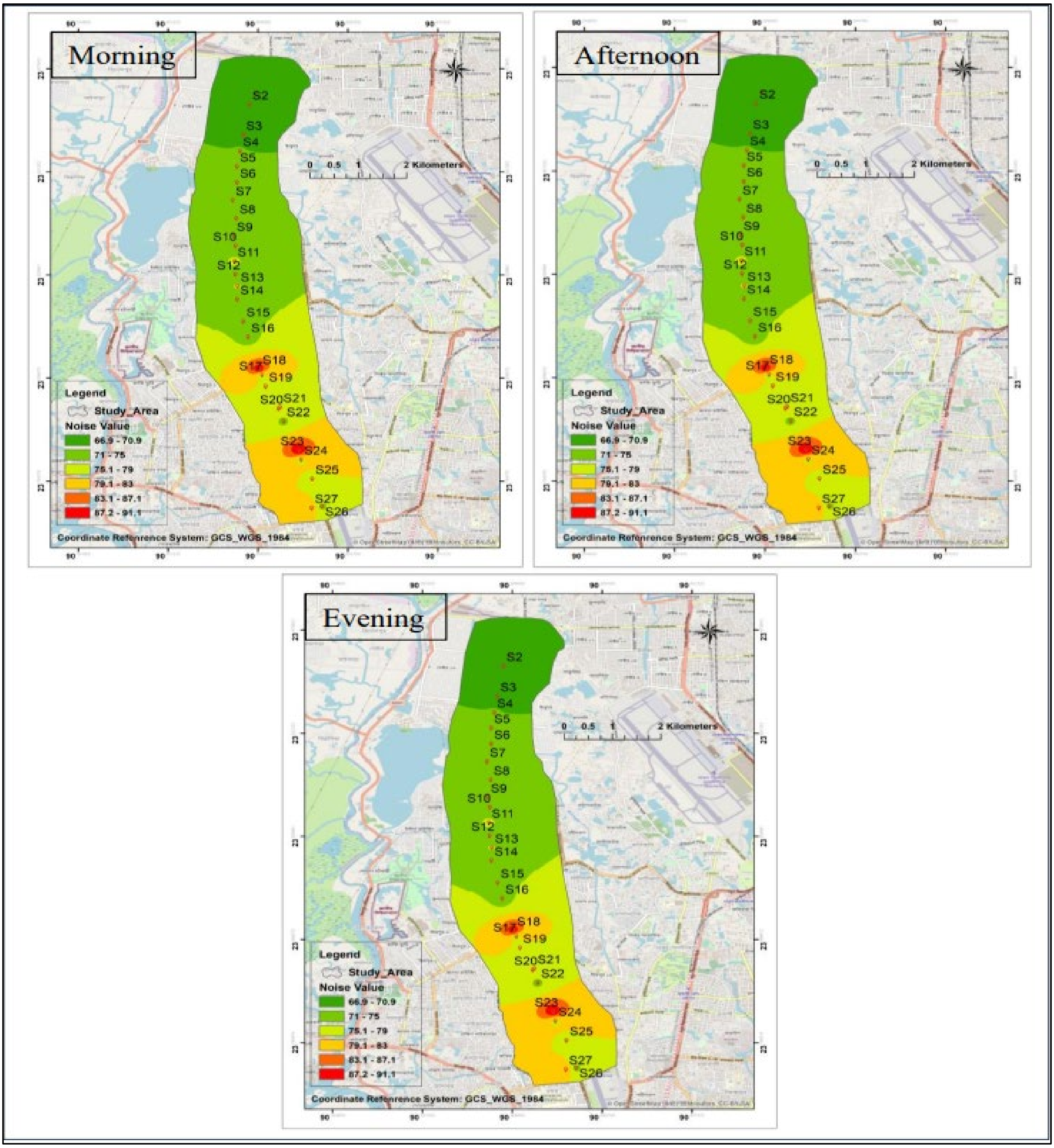

Fig 3 Spatial Distribution of Noise Level on Working Days

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The noise levels on working days were thoroughly examined using advanced GIS-based interpolation techniques, providing a comprehensive understanding of noise characteristics in Mixed, Residential, and Commercial areas. In the morning hours the Commercial Zone emerged as a focal point, exhibiting the highest morning noise at 88.9 dB. In contrast, the Residential Zone had lower levels (65.6 dB to 73.0 dB), and the Mixed Zone fell in between (62.5 dB to 75.3 dB). During the afternoon Commercial Zone had the highest noise (75.8 dB to 93.4 dB), while the Residential Zone had quieter levels (71.2 dB to 84.9 dB) and the Mixed Zone ranged from 72.3 dB to 84.0 dB. In the evening The Commercial Zone showed the highest evening noise (80.7 dB to 93.5 dB), the Residential Zone had lower levels (75.4 dB to 90.7 dB), and the Mixed Zone fell between these extremes (76.9 dB to 89.1 dB).

C. Spatial Distribution of Noise Level on Non-Working Days

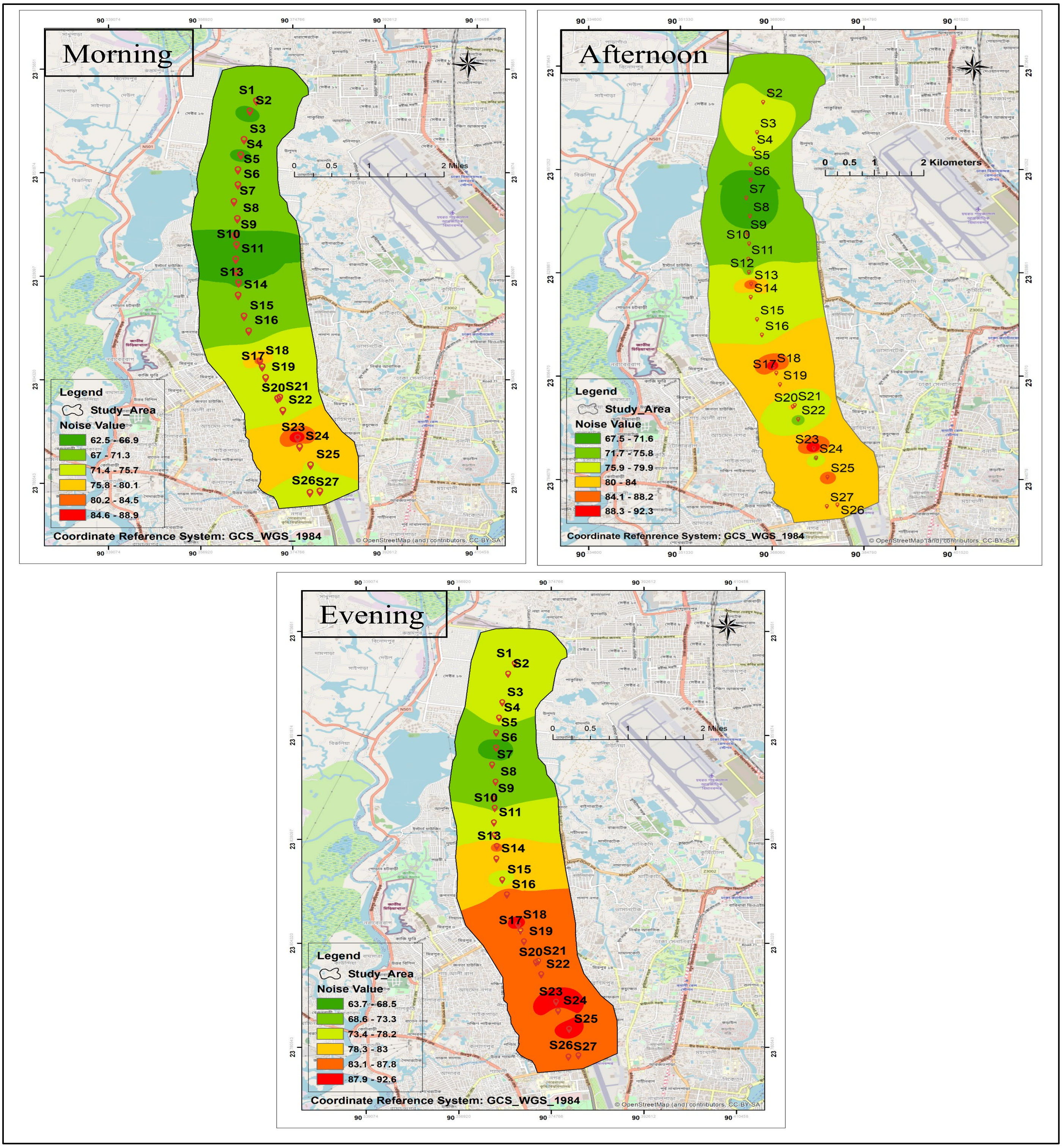

Fig 4 Spatial Distribution of Noise Level on Non-Working Days

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Utilizing advanced GIS-based interpolation techniques, spatial maps vividly depict the morning, afternoon, and evening noise fluctuations on non-working days across Mixed, Residential, and Commercial zones. In the morning, the Commercial Zone records the highest noise levels (66.4 dB to 88.9 dB), with the Residential Zone ranging from 65.6 dB to 75.3 dB and the Mixed Zone falling between (62.5 dB to 75.3 dB). During the afternoon, the Commercial Zone exhibits peak noise levels (75 dB to 92.3 dB), while the Residential Zone ranges from 67.5 dB to 84.9 dB and the Mixed Zone falls between (67.5 dB to 81.9 dB). In the evening, the Commercial Zone again experiences the highest noise levels (75 dB to 92.3 dB), with the Residential Zone ranging from 67.5 dB to 84.9 dB and the Mixed Zone falling between (67.5 dB to 81.9 dB).

D. Temporal Variation of Noise Level on Working Days

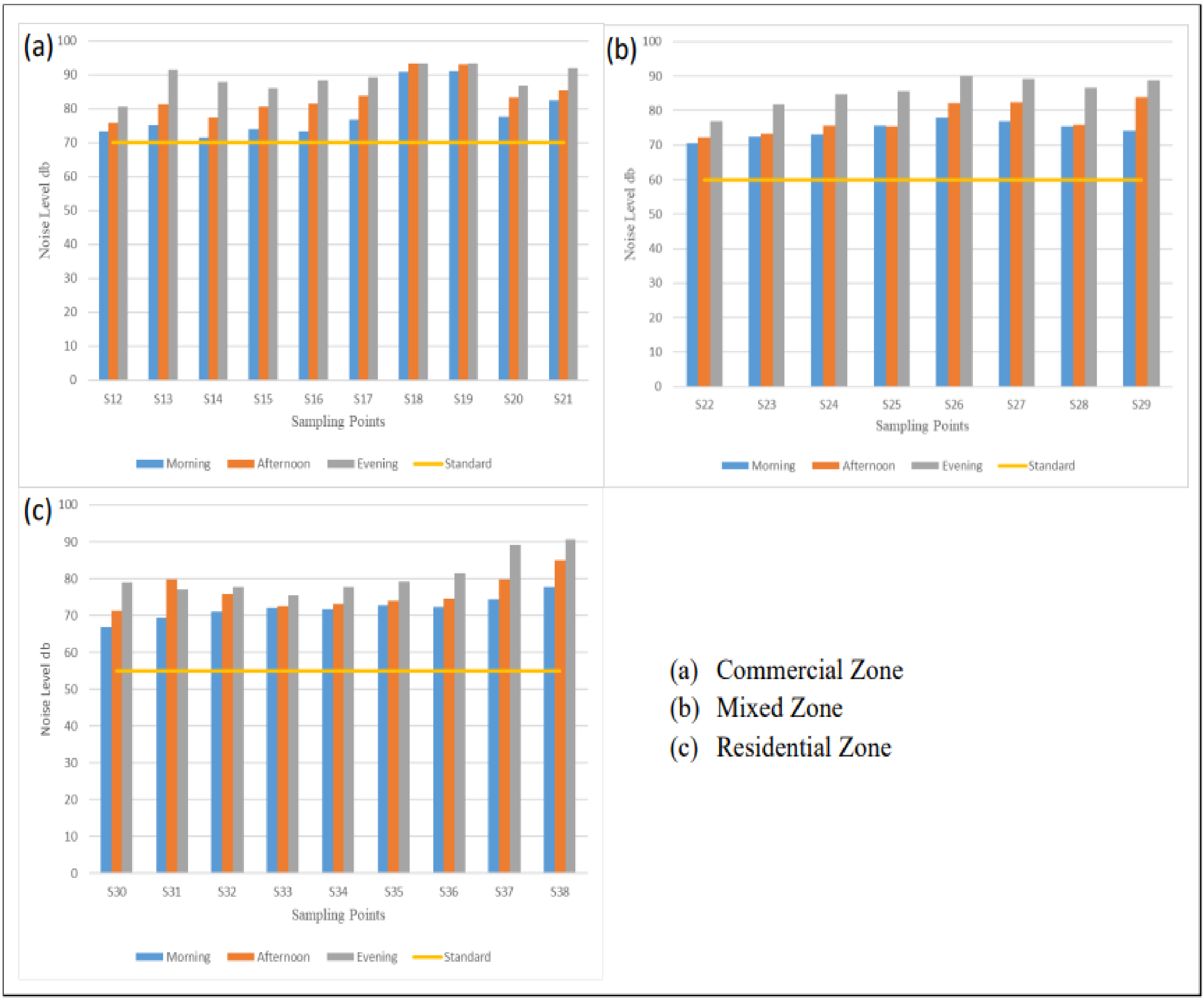

Fig 5 Temporal Variation of Noise Level on Working Days

The temporal analysis of noise levels on working days reveals dynamic patterns across different zones in Dhaka City. In commercial zones, morning noise spans a wide range (71.6 dB to 91.1 dB), indicating the dynamic nature of early-hour noise pollution. Afternoons exhibit a more stabilized but heightened soundscape (75.8 dB to 93.4 dB), while evenings record the highest levels (80.7 dB to 93.5 dB), likely due to increased commercial activities. Exceedance of the standard noise level for commercial areas (70 dB) raises concerns about well-being. In mixed zones, morning levels (70.6 dB to 78 dB) indicate moderate to higher pollution, with afternoons (72.3 dB to 82.5 dB) showcasing a persistent but stabilized soundscape. Evenings record the highest levels (76.9 dB to 90.1 dB), raising concerns about residents' well-being as compared to the standard noise level for mixed zones (60 dB). Residential zones exhibit morning levels (66.9 dB to 77.8 dB) indicating moderate to higher pollution, with afternoons (71.2 dB to 84.9 dB) showing a stabilized but persistent soundscape. Evenings reveal the highest levels (75.4 dB to 90.7 dB), emphasizing the urgency of addressing noise pollution for residents' well-being, especially considering consistent exceedance of the standard noise level for residential areas (55 dB).

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E. Temporal Variation of Noise Level on Non-working Days

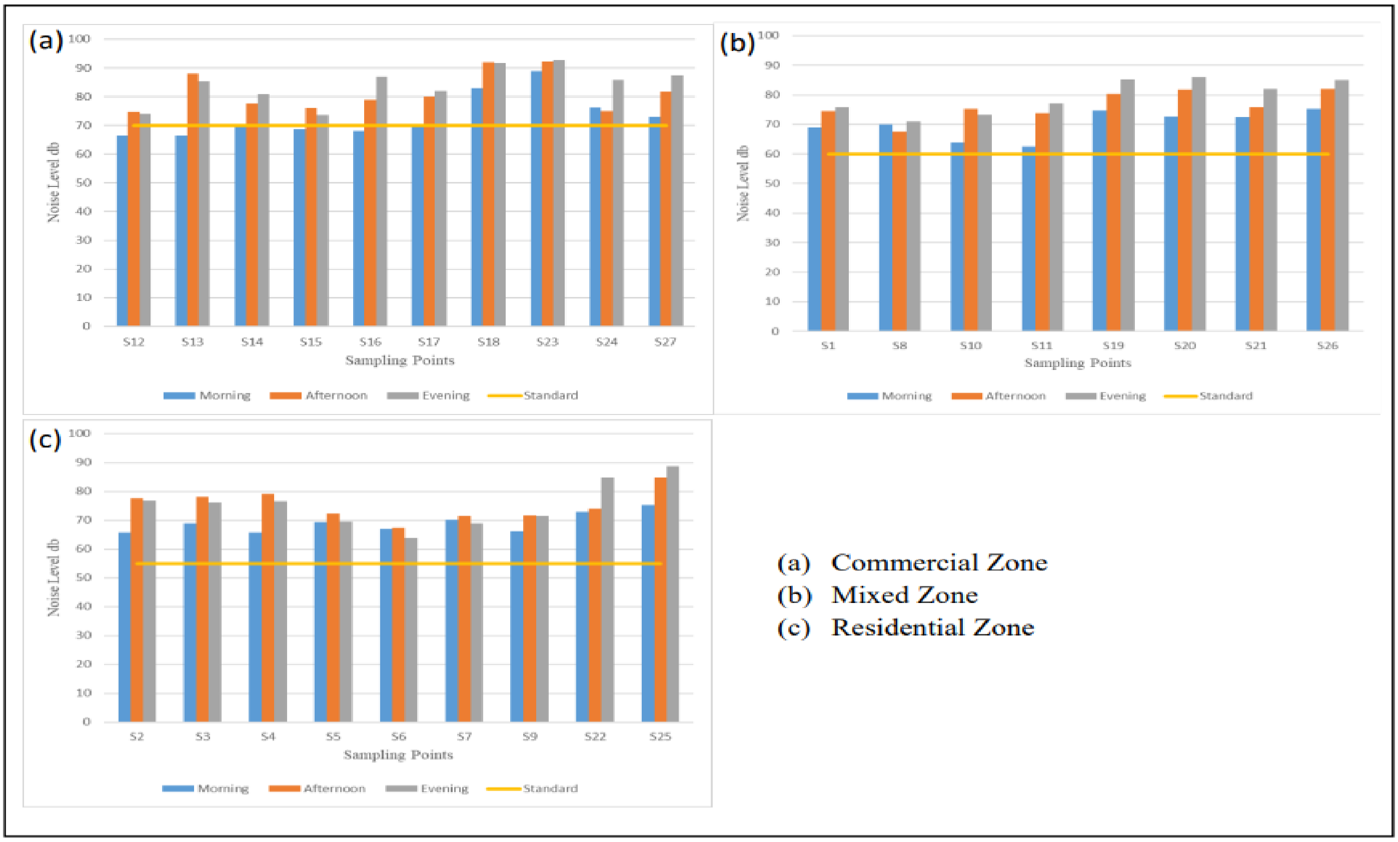

Fig 6 Temporal Variation of Noise Level on Non-working Days

The analysis of noise levels during non-working days reveals significant variations in commercial, mixed, and residential zones in Dhaka City. In the commercial zone, morning noise (66.4 dB to 88.9 dB) indicates moderate to high pollution, escalating in the afternoon (74.8 dB to 92.3 dB) and peaking in the evening (73.6 dB to 92.6 dB), consistently exceeding the standard (70 dB). This raises concerns for residents' health, particularly during afternoon and evening hours. The mixed zone exhibits moderate morning pollution (62.5 dB to 75.3 dB), escalating in the afternoon (67.5 dB to 81.9 dB) and peaking in the evening (70.9 dB to 86 dB), consistently surpassing the standard (60 dB). In the residential zone, mornings indicate moderate pollution (65.6 dB to 75.3 dB), slightly increasing in the afternoon (67.5 dB to 84.9 dB), and peaking in the evening (63.7 dB to 88.6 dB), consistently exceeding the standard (55 dB). This underscores the urgent need for effective noise control measures, especially during the afternoon and evening, to ensure residents' well-being and tranquility on non-working days.

IV. CONCLUSION

The project on metro rail noise levels has provided valuable insights into the impact of metro operations on the surrounding environment, specifically on noise pollution in different areas. The measured noise values on both working and non-working days were analyzed for morning, afternoon, and evening periods at commercial, mixed, and residential sites. Throughout the study, it was observed that noise levels were consistently higher during the working day compared to non-working days. Additionally, the noise levels tended to be higher in commercial areas, followed by mixed areas, and then residential areas. During the working day, the morning noise levels ranged from 78.7 dB in commercial sites, 74.5 dB in mixed sites, and 72 dB in residential sites. In the afternoon, these values increased to 83.6 dB, 77.7 dB, and 76.2 dB, respectively. Finally, during the evening, the noise levels peaked at 89 dB in commercial areas, 85.4 dB in mixed areas, and 80.8 dB in residential areas. On non-working days, the morning noise levels were comparatively lower, with values of 73.1 dB in commercial sites, 70.1 dB in mixed sites, and 69.1 dB in residential sites. Similarly, the afternoon and evening noise levels decreased to 81.6 dB and 84 dB in commercial areas, 76.4 dB and 79.4 dB in mixed areas, and 75.2 dB and 75.2 dB in residential areas, respectively. Comparing these measured values to the established standards of 70 dB for commercial areas, 60 dB for mixed areas, and 55 dB for residential areas, it is evident that noise pollution exceeds the acceptable levels in several instances, especially during the working day and in commercial zones. The findings highlight the need for effective noise management strategies, particularly in commercial areas, to mitigate the adverse effects of metro rail operations on the surrounding communities. Implementing noise reduction measures, such as sound barriers, sound-absorbing materials, and optimized train schedules, could contribute significantly to minimizing noise levels and enhancing the overall living and working conditions for residents and businesses near metro stations.

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As metro systems continue to expand and evolve, this research serves as a crucial foundation for further studies and the development of sustainable solutions to ensure minimal noise disturbances and a harmonious coexistence between urban transportation infrastructure and the environment.

➢ *Disclosure Statement:*

Conflict of Interest: There are no conflicts of interest, according to the authors. Respect for Ethical Standards: There are no research using human or animal participants in this article.

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