ASSESSMENT OF THE LEVELS OF NOISE POLLUTION IN NORTH BANK MARKET, IN MAKURDI USING GIS TECHNOLOGY

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Abstract
Noise pollution has become a major environmental challenge in rapidly growing urban areas, especially in markets where commercial activities, traffic and human interaction are intense. This study assessed the levels and spatial distribution of noise pollution in North Bank Market, Makurdi, Benue State, using Geographic Information System (GIS) technology. Noise levels were measured at nineteen strategic locations during morning, afternoon, and evening periods using a digital sound level meter, while questionnaires were administered to capture public perception. The measurements were analyzed statistically and integrated into ArcGIS for spatial mapping and hotspot identification. Results showed that the average noise level in the market was **65 dB**, exceeding recommended limits set by the World Health Organization and national guidelines. Hotspots were concentrated along major road corridors, market entrances, and densely populated trading zones, especially during peak activities. The findings reveal that noise pollution poses potential risks to public health and urban liveability. The

study recommends strict noise regulation, continuous monitoring, improved market planning, and public awareness as effective mitigation strategies. GIS proved to be a valuable tool for visualizing noise dynamics and supporting environmental decision-making in urban markets.

Keywords; Noise pollution, Geographic Information System (GIS), Spatial analysis, Sound level meters, Environmental concern, Noise hotspots.

1. Introduction

Noise pollution has become a significant environmental concern, particularly in urban areas where commercial activities thrive. In markets, the convergence of human activity, traffic, and mechanical noise contributes to high levels of noise pollution. Noise pollution is an increasingly prevalent environmental issue that poses significant threats to public health, well-being, and quality of life, especially in urban areas. According to WHO, noise pollution is unwanted or harmful sound that disrupts the natural balance of the environment, noise pollution is often a byproduct of human activities, including traffic, industrial operations, and commercial enterprises. In densely populated regions, such as markets, the cumulative effects of these sounds can create an environment that not only hinders communication and relaxation but also contributes to stress-related health problems. Noise pollution affects physical and mental health, contributing to stress, hearing loss, and decreased quality of life (Smith et al., 2022).

The North Bank Market in Makurdi, Benue State, serves as a critical hub for commerce and trade, attracting numerous vendors and customers daily. This bustling market environment is characterized by a high concentration of activities that generate significant noise, from vendors calling out their wares to the constant movement of vehicles. Despite its economic importance, there has been little systematic assessment of noise pollution levels within this area, leaving residents and local authorities unaware of its potential impacts. The World Health

Organization (WHO) define noise pollution as any noise above 65 decibels (dB). Noise that is above 75 dB can be harmful. Noise above 120 Db can be painful. Overall, this study emphasizes the importance of addressing noise pollution in urban settings to foster a more sustainable and health-conscious community. Geographic Information Systems (GIS) provide powerful tools for analyzing spatial data, enabling researchers to visualize and assess environmental issues such as noise pollution effectively. By integrating noise level measurements with GIS technology, this project aims to map the distribution of noise pollution in North Bank Market, identify primary sources, and assess the implications for public health and urban planning.

This study will not only fill the existing knowledge gap regarding noise pollution in the North bank market but also contribute to the development of effective noise management strategies for North bank. Understanding the extent and impact of noise pollution is vital for policymakers, urban planners, and the community, as it enables the formulation of targeted interventions that can mitigate negative effects of noise pollution on health and enhance the overall quality of life in the area. Statement of problems for assessment of noise pollution levels in North Bank Market, Makurdi, Benue State, using GIS: are as followsing

There is a lack of comprehensive data on current noise pollution levels in North Bank Market, making it difficult to assess the extent and sources of noise pollution accurately. High levels of noise can lead to noise pollution which can adversely affect the health and well-being of market vendors and visitors, leading to issues such as hearing loss, stress, and sleep disturbances, which have not been sufficiently studied in this area. The environmental consequences of sustained noise pollution, including its effects on local wildlife and community quality of life, have not been explored, leading to a gap in knowledge about the broader ecological impact. Without proper assessment, urban planners may struggle to implement effective noise mitigation strategies in the market area, leading to ongoing

issues for residents and businesses. There may be limited awareness among stakeholders, including local authorities and the community, about the implications of noise pollution and the need for effective monitoring and management. The potential of Geographic Information Systems (GIS) in mapping and analyzing noise pollution levels has not been fully utilized in this region, hindering effective decision-making and resource allocation. To achieve this, aim the following objectives are needed

To measure noise pollution levels at different locations within North Bank Market, To identify major sources of noise pollution, to analyze the spatial distribution of noise pollution using GIS tools, to provide recommendations for noise reduction strategies.

Review existing literature on the health impacts of noise pollution to correlate findings with local conditions. Assess community awareness and perceptions of noise pollution through surveys or interviews. Develop recommendations for noise reduction measures based on the findings, targeting policymakers and community stakeholders. Obtaining accurate noise measurements can be affected by factors such as weather conditions, equipment limitations, and the presence of intermittent noise sources, leading to potential inconsistencies. Noise levels can fluctuate significantly based on time of day, events, and market activity, making it challenging to capture a representative snapshot of noise pollution. The effectiveness of GIS analysis relies on the availability and accuracy of spatial data, which may be limited or outdated in certain areas, impacting the overall analysis. The success of surveys and interviews may depend on community willingness to participate, which could result in biased or incomplete data regarding perceptions of noise pollution. Health Impact Analysis: While the project will explore health implications, establishing direct causal relationships between noise pollution and health outcomes may be complex and require longitudinal studies. Limited funding and time may restrict the scope of data collection and analysis, potentially affecting the depth and comprehensiveness of the findings. Findings from the North

Bank Market may not be applicable to other areas with different noise dynamics, limiting the broader applicability of the results

2. Literature Review

This section reviews existing studies on noise pollution and its health impacts, emphasizing research that utilizes GIS for spatial analysis. Literature review on the assessment of noise pollution levels in urban markets, exactly focusing on the use of GIS Technology. Noise pollution is a growing concern in urban areas, particularly in bustling markets where traffic and human activity converge. (Adamu & Bello, 2023). Understanding noise levels is vital for public health and urban planning. Noise pollution affects physical and mental health, contributing to stress, hearing loss, and decreased quality of life (Smith et al., 2022).

Nigerian & Regional Case Studies

Several Nigerian studies illustrate the application of GIS to urban noise mapping and the characteristics of market/ CBD noise:

Makurdi (Wurukum & North Bank) — According to field research that evaluated noise levels in the Wurukum and North Bank locations of Makurdi, it was observed that values frequently surpassed the NESREA and WHO permitted limits for daytime and nighttime noise levels. The main local sources and spatial distribution of excessive noise zones are documented, and recorded LAeq values are compared to standards. As an empirical baseline for the North Bank Market, this is immediately pertinent.

Ota (Ogun State) — Oyedepo (2019) provided a comprehensive GIS-based workflow that includes instrumentation, averaging techniques (LAeq), and the use of ArcGIS for interpolation and map creation in order to analyze and map noise in an urban region in Ota. For Nigerian urban noise mapping, that work is regularly referenced as a useful methodological guide.

Bariga (Lagos), Zaria (Kaduna State), Abuja, Abakaliki — Multiple studies applied similar GIS workflows (point sampling + interpolation) and consistently found market and major road corridors produce LAeq values above recommended residential/commercial levels; many recommend noise zoning, traffic management, and public-awareness interventions. These case studies show portability of methods and recurrent findings (markets and motor parks as hotspots).

Key empirical patterns across studies

- Market zones and major junctions often register the highest LAeq levels in the city.
- Diurnal variability is pronounced: daytime peaks correspond with market hours and traffic; night noise can still exceed residential limits in buffer zones.
- Interpolation accuracy improves with higher sampling density near heterogeneous source clusters (markets, junctions).
- Many studies highlight the need to combine measurements with source inventories (vehicle counts, generator use, loudspeaker presence) to interpret spatial patterns and design interventions.

Geographic Information Systems in Noise Studies

In the early 1960s, Roger Tomlinson, who is frequently referred to as the "father of GIS," created what is generally considered to be the first functional geographic information system (GIS) in Canada. Developed for the Canadian government's land inventory project (the Canada Land Inventory) in Ottawa, Ontario, the system was called the Canada Geographic Information System (CGIS). Sources claim that CGIS was created in 1963 and went into use later (by 1968 or the early 1970s). More generally, when computer processing, spatial data, and mapping requirements came together in the 1960s, the area of GIS started to take shape.

GIS technology has emerged as a powerful tool for environmental monitoring, allowing for spatial analysis and

visualization of noise data. It facilitates the integration of various data sources, enhancing the understanding of noise pollution patterns (Johnson et al., 2021). Recent studies have demonstrated the effectiveness of GIS in mapping noise levels in urban settings (Nguyen et al., 2023). In Nigeria, studies have highlighted noise pollution levels in urban markets. For instance, a study by Okafor et al. (2023) assessed noise in markets across Enugu, employing GIS to visualize noise hotspots. Similarly, research in Lagos showed significant correlations between traffic density and noise pollution levels, underscoring the utility of GIS in urban noise assessments (Ogunleye, 2022).

Recent assessments in various markets have revealed noise levels exceeding acceptable limits, particularly during peak hours (Ibrahim & Sadiq, 2023). In Makurdi, preliminary studies suggest similar trends, with noise levels influenced by market activities and traffic flow (Audu & Ibrahim, 2023). Data collection in developing regions often face challenges such as limited resources and infrastructure (Akinyemi & Ojo, 2023).

3. Methodology

Study Area

Makurdi Local Government Area has a population of 300,000 persons (NPC, 2006). It lies between latitudes 7°40´N 7°53´N of the equator and between longitudes 8°22´E, 8°35´E of the Greenwich Meridian (Hilakaan and Ogwuche, 2015). The total area of Makurdi is 34,059 km2 (13,150 Sq.Mi).

The municipality comprises eleven council wards namely; Agan, Mbalagh, North-Bank 1, North-Bank 2, Market Clerk, Central South Mission, and Ankpa/Wadata, Bar, Modern Market, Fiidi and Walomayo wards. North Bank Market is located in a densely populated area, characterized by various vendors, street traders, and vehicular traffic. The market's activities include trading, loading and unloading goods, and public interactions, all of which contribute to noise levels.

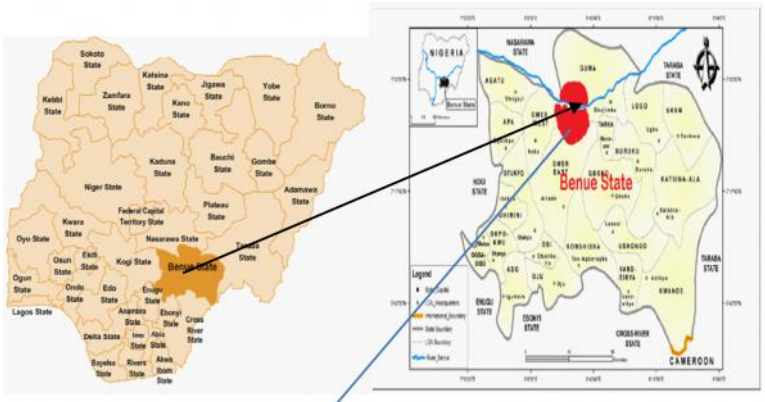

Fig 1.1 Map of Nigeria (Google)

Fig 1.2 Map of Benue state (Google)

Fig 1.3 Map Showing Study Area (Google)

3.1 Study Design

This study employs a mixed-methods approach, combining quantitative measurements of noise levels with qualitative data from surveys. The sound level meter used is 3M 1100 TYPES shown below

3M 1100 TYPES

Plate 1; Digital sound level meter

3.2 Field Measurements:

Equipment: A digital sound level meter (3M 1100 TYPES) A hybrid approach combining real-time noise measurement and GIS mapping provides comprehensive insights into noise distribution (Eze et al., 2024).

1. Preparation Before Measurement

1. Inspect the Device
   Ensure the SLM is working and the microphone is not blocked or damaged.
2. Install Batteries / Charge
   Make sure the meter has enough power for field use.
3. Use a Windscreen
   If measuring outdoors, place the foam windscreen on the microphone to avoid wind noise.
4. Calibrate the Meter

Use an **acoustic calibrator (94 dB or 114 dB at 1 kHz)**.
Insert the calibrator on the microphone, turn it on, and adjust the SLM until the reading matches.

2. Taking a Measurement (Step-by-Step)

1. Hold the meter at arm's length (1–1.5 m above ground) and away from your body to avoid reflection.
2. Point the microphone toward the noise source (usually 0° orientation).
3. Stand still and avoid talking or movement noise.
4. Turn on the SLM and allow 2–5 seconds for stabilization.
5. Take the reading:
   Note the instant dB or use Max/Min/Leq (Equivalent Continuous Noise Level) depending on your study.
6. Record the values, including:
   Time, location (GPS if needed for GIS), weighting (dBA), response setting, and reading.

3. **After Measurement**

Turn off the meter and save or download data (if it has data-logging).

Remove batteries if storing for long.

Keep the device clean and dry.

4.**Best Practices**

Take multiple readings (e.g., every 5–10 minutes) and compute an average.

Avoid measuring in rain, strong wind, or close to walls/ vehicles (avoid sound reflections).

For environmental studies, measure during:

Morning peak

Afternoon

Evening

3.3 Data Collection

Table 1; showing the various place of noise

S/n	Location	Morning 8am (dB)	Afternoon 12pm (dB)	Evening 4pm (dB)	Average (dB)
1.	Bamako street	59.9	60.2	60.0	60.0
2.	Grinding Lane	64.3	70.7	69.0	68.0
3.	Grain Lane	54.9	60.7	57.8	57.8
4.	Meat Lane	55.4	60.0	57.7	57.7
5.	General hospital Road	55.8	59.7	57.6	57.7
6.	Ecwa church	56.7	60.7	61.7	59.7
7.	Village mkt i	52.7	75.7	74.7	67.9
8.	Village mkt ii	61.7	74.9	75.8	70.8
9.	Village mkt iii	66.0	69.9	72.9	69.0
10.	Goat mkt	58.7	71.0	72.7	67.7
11.	Old Otukpo Rd i	60.7	74.6	72.7	70.7
12.	Old Otukpo Rd ii	61.8	77.9	72.6	70.7
13	Old Otukpo Rd iii	62.8	75.9	70.1	69.3
14	NASME Junction	60.6	72.9	75.6	69.7
15	Rice Mill	62.7	72.6	72.8	69.3
16	Yam Lane	56.7	60.7	59.6	59.0
17	Plastic Lane	53.6	59.0	52.7	55.0
18	North Bank Park	53.7	70.9	72.7	66.0
19	North Bank Park Gate	65.6	70.7	73.8	70.0

Source; Field survey (2025)

Plate 2 showing the study area

Table 2; showing the coordinate of noise spot

S/n	Location	Coordinates(E)	Coordinates(N)
1.	Bamako str	449801.997	857170.921
2.	Grinding Lane	449834.761	857183.515
3.	Grain Lane	449866.998	857207.924
4.	Meat Lane	449900.932	857255.228
5.	General hospital Rd	449911.271	857290.751
6.	Ecwa church	450041.420	857427.276
7.	Village mkt i	449996.089	857249.256
8.	Village mkt ii	450029.091	857326.850
9.	Village mkt iii	450051.213	857385.252
10.	Goat mkt	450071.580	857220.067
11.	Old Otukpo Rd i	449990.327	857083.883
12.	Old Otukpo Rd ii	450038.058	857168.883
13	Old Otukpo Rd iii	450120.688	857259.857
14	NASME Junction	449959.355	857023.930
15	Rice Mill	449894.986	857105.073
16	Yam Lane	449879.383	857135.008
17	Plastic Lane	449900.461	857223.677
18	North Bank Park	449962.702	857108.037
19	North Bank Park Gate	449905.075	857083.012

Surveys:

One hundred (100) questionnaires were distributed to gather information of noise sources from vendors and customers.

From the questionnaire distributed it was observed that;

Table 3; showing the percentage of questions asked in the questionnaire

S/N	DESCRIPTION	PESENTAGE %
1.	Higher age of vendors and customers. (36 - 45)	50 %
2.	Gender (female)	70%
3.	Role (Majority are customers).	60%
4.	Duration of stay in the market (more than 8 hrs)	70%
5.	Kind of noise encounter (vehicle traffic)	70%
6.	How do you rate scale of noise in the 1- 5 (Moderate)	60%
7.	Time of the day the noise most disruptive (Afternoon)	60%
8.	How does the noise affect your experience in the market (no impact)	60%
9.	Have you ever experienced any health issues attribution to noise exposure (NO)	95%

Field Survey (2025)

Plate 3 : Georefrence map of the study area

3.3 GIS Tools

Table 4: Showing Coordinates of point obtained during Ground trusting

POINT	NAME	EASTING	NORTHING
1	**BAMAKO STR**	**449801.997**	**857170.921**
2	**GENERAL HOSIPITAL JUNCTION**	**449911.271**	**857290.751**
3	**ECWACHURCH JUNCTION**	**450041.420**	**857427.276**
4	**NASME JUNCTION**	**449959.355**	**857023.930**

Source; Field survey

The above coordinates were used for geo-referencing
Geo-referencing a map in ArcGIS 10 involves assigning spatial coordinates to a raster image or a scanned map, so it can be aligned with other spatial data. Here's a step-by-step guide on how to Geo-reference a map using ArcGIS 10.8

Geo-referencing the Map

1. Open ArcMap: Launch ArcMap and create a new map document.
2. Add the raster image: Add the raster image of the map to the map document.
3. Start the Geo-referencing Wizard: Click on the "Geo-referencing" tab in the ribbon and select "Geo-referencing Wizard."
5. Select the datum and coordinate system: Choose the datum and coordinate system that matches the map's projection.
6. Add control points: Identify recognizable features on the map, such as intersections or landmarks, and add control points to these locations.
7. Enter the control point coordinates: Enter the coordinates for each control point, either by typing them in or by using a GPS device.
8. Run the geo-referencing process: Click "OK" to run the

geo-referencing process. ArcGIS 10 will use the control points to transform the raster image into a geo-referenced map.

Refining the Geo-referencing

1. Check the geo-referencing accuracy: Verify the accuracy of the geo-referencing by checking the residual errors for each control point.
2. Adjust the control points: If necessary, adjust the control points to improve the geo-. referencing accuracy
3. Re-run the geo-referencing process: Re-run the geo-referencing process to update the transformation.

Saving the Geo-referenced Map

1. Save the geo-referenced map: Save the geo-referenced map as a new raster dataset.
2. Export the map: Export the geo-referenced map in a suitable format, such as a GeoTIFF or a JPEG.

3.4 Spatial Analysis

Noise Spot : Identify areas with excessive noise levels and correlate them with market activities and traffic patterns.

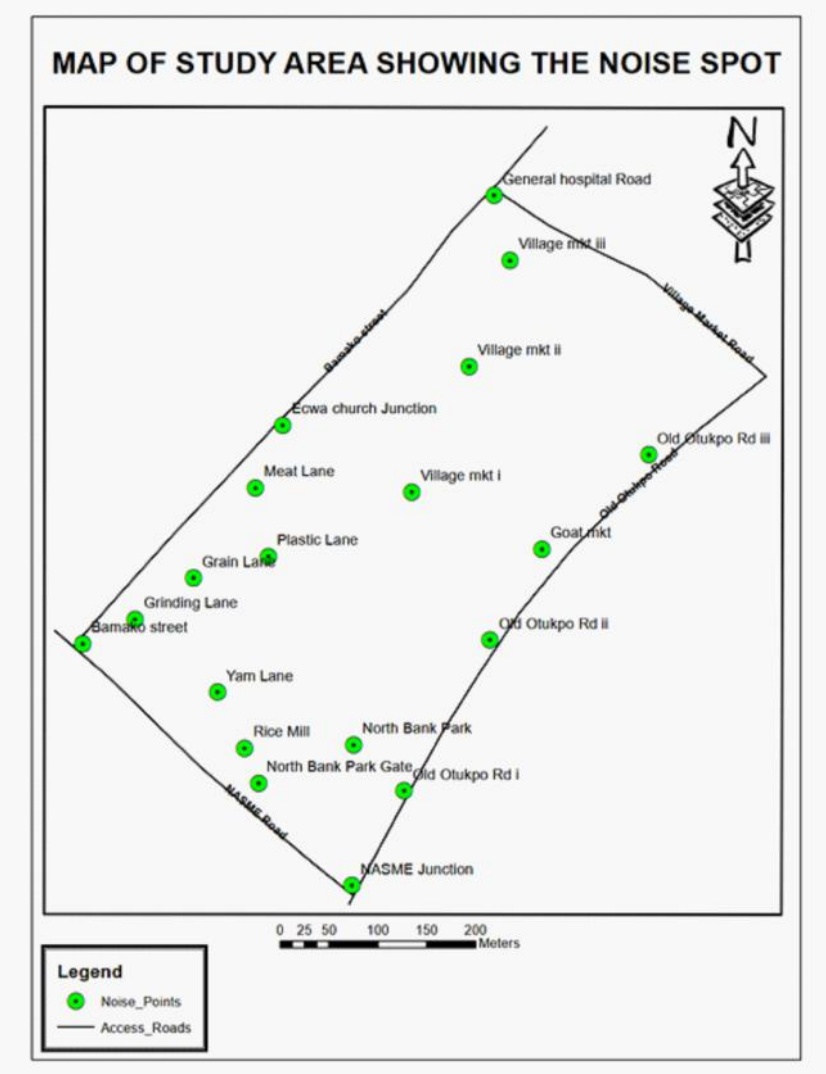

Plate 4 Map of North-bank market showing the noise spot

4. Data Analysis

4.1 Statistical Analysis

Calculate descriptive statistics (mean, median, and mode) for noise levels across different locations.

Mean = Average Sum of all Measurement/ Number of Measurement.

Average sum of all measurement = = 65.00 db.

Medium = first sort the measurement sorted measurement; 60.0, 68.0, 57.8, 57.7, 57.7, 59.7, 67.7, 70.8, 69.0, 67.7, 70.7,70.7, 69.3, 69.7, 69.3, 59.0, 55.0, 66.0, 70.0.

Medium = 65.06 db

Mode = 57.7, 70.7, and 69.3,

Summary of results

a. Mean sound level 65.00 db.

b. Medium sound level 65.00 db.

c. Mode sound level 57.7 db, 70.7 db, and 69.3 db,

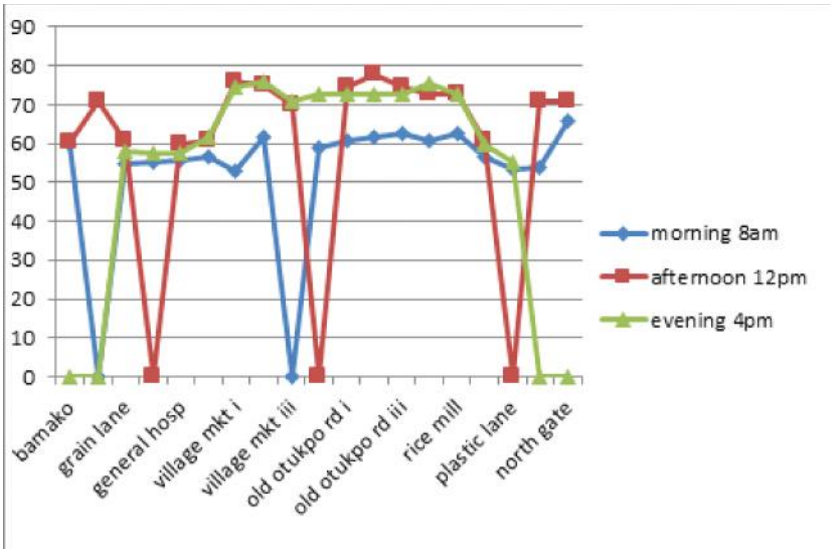

Fig 1 : level of noise in the Morning, Afternoon and Evening

Source; Field survey (2025)

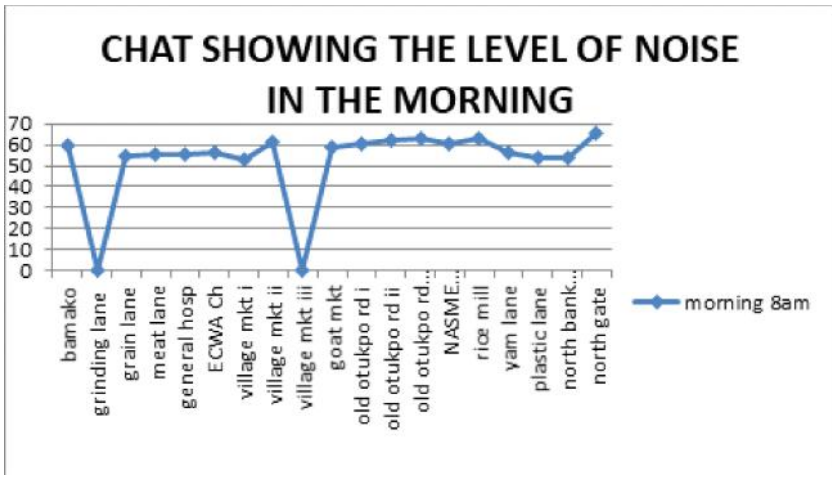

Fig 2 : level of noise in the morning
Source; Field survey (2025)

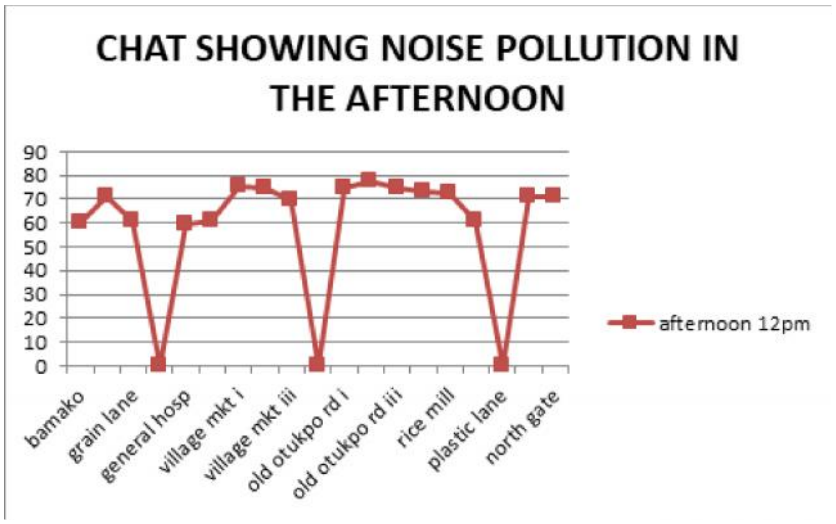

Fig 3: level of noise in the Afternoon
Source; Field survey (2025).

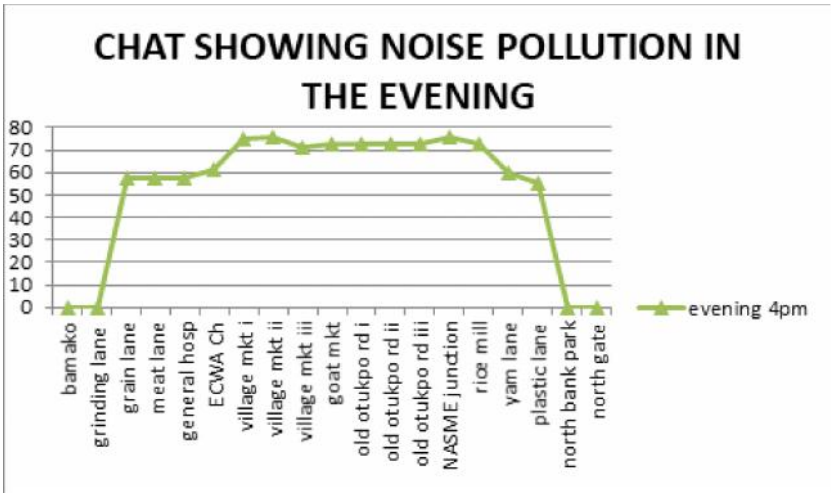

Fig 4: level of noise in the Evening
Source; Field survey (2025)

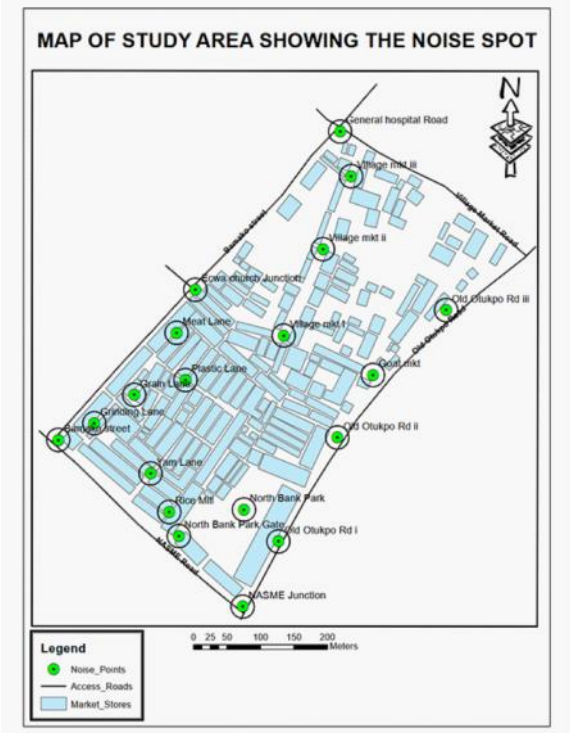

Plate 5 Map of North-bank showing the hotspot area of noise.

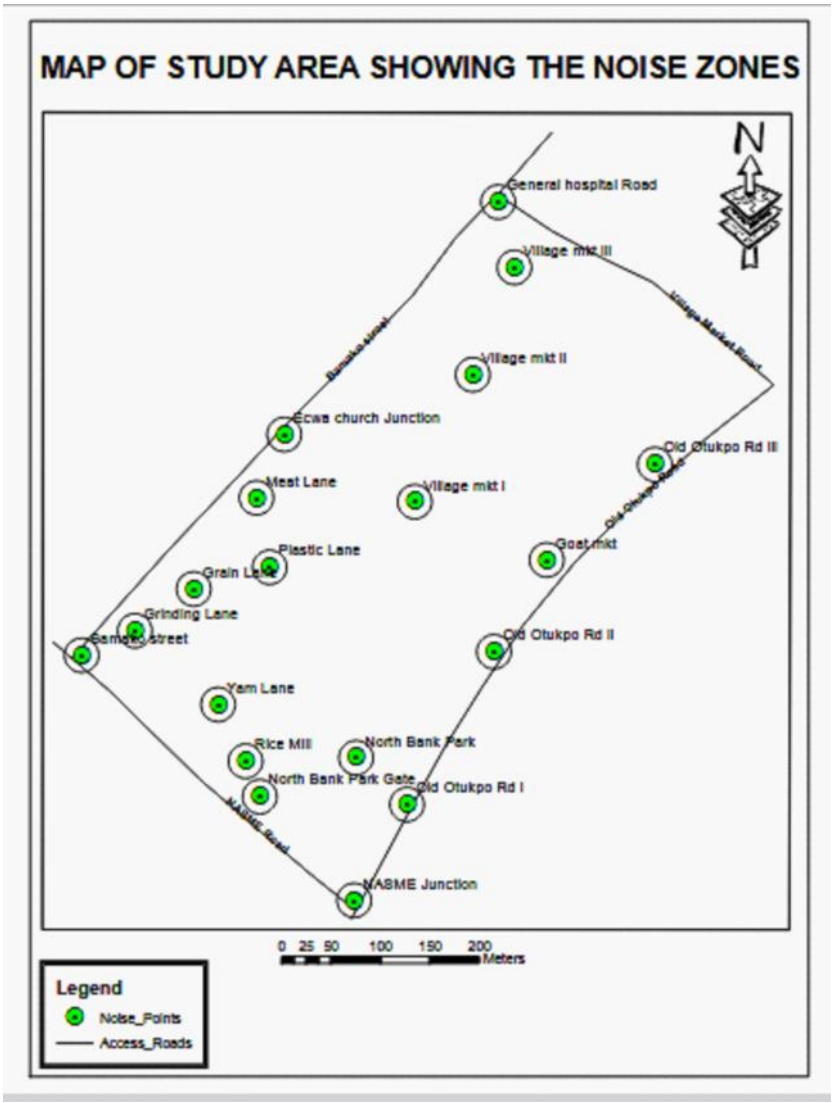

Plate 6 Map Showing the noise zone

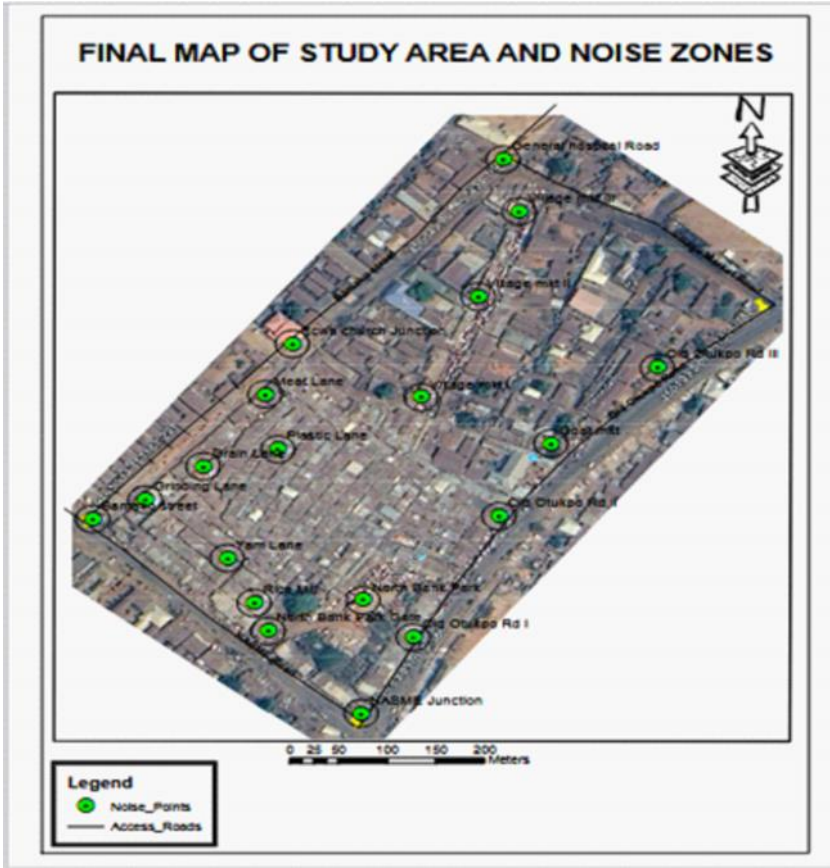

Plate 7 Showing the final map of the study.

5. RESULTS AND DISCUSSION

Results

The results of the study showed that noise pollution levels in North Bank Market were significantly ok which is about **65.00 db** recommended standards by the World Health Organization (WHO) and the Nigerian Federal Ministry of Environment. The highest noise levels were recorded during peak hours, with a maximum value of 52.7 dBA. The noise pollution map showed that the areas with the highest noise levels were located near

the market's entrance and exit points, as well as near the busy roads surrounding the market.

Discussion

A study assessing noise pollution levels in North Bank Market used GIS techniques to map noise levels and identify areas of high noise pollution. The instrument used was 3M 1100 TYPES on Plate 1, plate 2 is the study area, Plate 3 Geo-refrence map of the study area, Plate 4 Map of North-bank market showing the noise spot, Plate 5 Map of North-bank showing the hotspot area of noise, Plate 6 Map Showing the noise zone, Plate 7 Showing the final map of the study.

The noise descriptions for the selected location at respective time of the days are presented in Figure 1, Figure 2, Figure 3, Figure 4. While the noise measurement was carried out and recorded on Table 1. While table 2 showed the coordinate of the selected noise area. The study found that noise levels varied significantly across different locations and times of day, with the highest levels recorded during peak traffic hours. The study indicates that noise pollution is a significant environmental issue in North Bank Market, Makurdi, Benue State. The high noise levels recorded in this study are consistent with previous studies on noise pollution in urban markets. The use of GIS techniques in this study provided a valuable tool for visualizing and analyzing the spatial distribution of noise pollution in the market area.

The study has important implications for public health and environmental policy. The high noise levels recorded in this study can have significant impacts on human health, including hearing loss, cardiovascular disease, and mental health problems.

CONCLUSIONS AND RECOMMENDATION

Conclusions

Therefore, it is essential to implement effective noise pollution control measures in North Bank Market, such as enforcing noise

regulations, implementing noise-reducing technologies, and promoting public awareness and education. The results of this study highlighted the significance of noise pollution as an environmental issue in urban markets. The findings of this study have important implications for public health and environmental policy, and emphasize the need for effective noise pollution control measures in North Bank Market.

Recommendation

Immediate Suggestions

1. Enforce Noise Regulations: Make sure that current noise laws are followed and that violators face the appropriate penalties.
2. Noise-reducing Technologies: Implement noise-reducing technologies such as sound barriers, noise-absorbing materials, and noise-reducing pavements.
3. Public Awareness and Education: Organize public awareness programs to educate market users, residents, and stakeholders about the effects of noise pollution and the significance of reducing noise levels.
4. Frequent Noise Monitoring: To track noise levels and pinpoint locations that need remediation, implement a regular noise monitoring program.

Long-Term Suggestions

1. Urban Planning and Design: Include techniques for reducing noise in urban planning and design, such as considering noise reduction when creating marketplaces and other public areas.
2. Infrastructure Development: Make investments in projects like building noise barriers, enhancing road surfaces, and modernizing public transit networks.
3. Alternative Transportation Modes: Promote alternative transportation modes, such as walking, cycling, and using public transit, to minimize the number of private vehicles and accompanying noise pollution.
4. Community Engagement: Work with stakeholders and local communities to increase awareness of noise

pollution and include them in the decision-making process for solutions aimed at reducing it.

GIS-specific Suggestions

1. Update GIS Database: To keep the noise pollution map accurate and current, periodically add fresh noise level data to the GIS database.
2. Integrate with Other Data: To better understand the connections between noise pollution and other pertinent data, such as land use, transportation, and demographic data, integrate the noise pollution data with these other data.
3. Create Noise Pollution Models: Create noise pollution models with GIS and additional data to forecast noise levels in various situations and assess how well various noise reduction techniques work.
4. Visualize Noise Pollution Data: To help in communication with stakeholders and decision-makers, use GIS to create maps and graphs that clearly and understandably represent noise pollution data.

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