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Spatio-Temporal Variability and Sensitivity Analysis of Environmental Noise Risk Across Landuse Types in South-South States, Nigeria

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***Abstract*— *This study examined the spatio-temporal variability and analyzed the sensitivity of environmental noise risk across landuse types in South-South States. Experimental research design was employed where direct field measurement was done at sampled locations including motor parks, markets, road junctions and industrial hubs in the morning, afternoon, and evening hours within the study areas using SONIK-SE power sound level meter. The ANOVA statistical tool was used to evaluate the spatial and temporal variations in noise levels across landuse types at different times of the day. The result showed that the mean noise levels ranged from 76.0 ± 2.5 dB in Cross River to 92.8 ± 3.1 dB in industrial zones of Rivers. Industrial areas recorded the highest averages: Rivers (92.8 ± 3.1 dB), Delta (87.0 ± 2.8 dB), Edo (85.7 ± 2.9 dB), and Bayelsa (84.6 ± 2.7 dB), while Akwa Ibom and Cross River remained below the WHO 85 dB threshold (83.5 ± 2.5 dB and 78.9 ± 2.6 dB, respectively). Residential zones ranged from 62.4 ± 2.1 dB in Cross River to 71.9 ± 2.3 dB in Rivers. Transport zones averaged 74.2 ± 2.4 dB to 84.9 ± 2.7 dB, above the 70 dB limit, while commercial zones ranged from 69.2 ± 2.2 dB to 80.5 ± 2.8 dB. Temporal patterns revealed diurnal increases, with F-values from 28.4 to 120.5 ($p \leq 0.005$), this indicated significant variation from morning to evening. The findings highlighted widespread acoustic stress linked to industrialization, traffic congestion, and poor urban planning. The study therefore, concludes that noise pollution in the south-south region poses significant public health risks, and therefore necessitates stricter regulations, enforcement of zoning laws, noise monitoring, and community-based mitigation programme*.

***Keywords*— *Noise Risk, Variability, Landuse Types, Assessment, Environment*.

I. INTRODUCTION

Environmental noise is the sound generated from all sources without taking cognizance of its devastating effect on both man and the environment. Accordingly, noise is defined as the spread of sound that has a negative impact on the physiological and psychological well-being of humans and animals. Noise pollution is one of several types of pollution widely acknowledged as a serious issue affecting quality of life in urban places around the world (Oloruntoba *et al*., 2012; Okeke & George, 2015; Oviasogie, 2020). On the other hand, the World Health Organization (2018), describe noise pollution as one of the most significant environmental risks to mental health. The effects of noise pollution on humans are numerous depending on the sound intensity and length of time of exposure to the sound. These include interference with verbal communication; temporary or permanent hearing damages/loss; physiological and psychological changes; hypertension; insomnia and going to sleep late; blood pressure changes; behavioural changes; emotional changes; irritability, stress, anxiety; and reduction in working efficiency (Ugwuanyi *et al*., 2004; Okeke and George, 2015; Omubo-Pepple *et al.,* 2010; Ahamad *et al.,* 2006, Kaushik and Kaushik, 2008; Bronzaft, 2000; WHO, 2005). Noise pollution within residential neighbourhoods is a product of numerous other activities other than those normally expected, especially with the mixed and interwoven uses to which residential landuse is put. FEPA (1992) reported that most industrial estates exist alongside or close to residential areas, whereas exposure to industrial and other forms of noise can induce hearing loss and other pathological changes in the affected population. Similarly, Obafemi (2006) noted that noise was regarded as an ordinary unwanted sound but has in contemporary time become a nuisance which contributes immensely to the degradation of the urban environment.

Noise is usually intrusive, potentially causing discomfort, stress, and adverse health effects and traffic, industrial operations, and social interactions are major sources of this auditory disruption. The impact is often magnified in densely populated urban settings where sound levels can become harmful (Onuu & Onuu, 2020; Eze *et al.,* 2021). In many developing countries, including Nigeria and particularly major cities in the South-South, noise pollution is a typical characteristic basically due to uncontrolled urbanization, ineffective noise abatement strategies, poorly enforced planning laws, public enlightenment including low level of awareness of health risk associated with noise. Thus, noise pollution has become a serious environmental problem, with researches showing scholarly evidence of its consequences more damaging than water and air pollution. Noise pollution

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has essentially become an integral component of urban living in most African settings and has become more significant as cities urbanized and more densely populated (Olukanni *et al.,* 2022). Land-use types – such as industrial zones, transport corridors, commercial districts and residential neighbourhoods influence both generation and exposure patterns of noise. Against this background, this study attempt to examine the spatio-temporal variability and and analyze the sensitity of noise risk across different landuses in the South-South region (Figure 1)

II. MATERIALS AND METHODS

The study sought to assess the spatio-temporal variation in the magnitude and level of noise risk associated with different land uses particularly industrial, residential, transport and commercial. The SONIK-SE power sound level meter was used to obtain noise level pertaining to different land uses at the selected noise stations across the study area. The noise readings for this study was obtained at road junctions, market places, event centers, motor parks, residential areas and industrial sites in the morning (8:00–11:00 a.m.), afternoon (12:00–3:00 p.m.), and evening (4:00–7:00 p.m.) for a period of 6 months according to the procedure itemized by (Maheswaran & Visagavel, 2014). The average noise levels across the major land use categories, residential, commercial, industrial, transportation were first computed and then inferential statistics was used accordingly. The Analysis of Variance (ANOVA) was employed to test the extent of variation in noise levels across different land uses and times of the day in consonance with studies such as Omubo-Pepple *et al*. (2013) and Suleiman and Shuaibu (2020), who demonstrated that this technique is appropriate for comparing multiple groups with environmental data. Again, based on significant variation in the ANOVA, a Duncan Multiple Range Test (DMRT) was conducted to identify the specific land use category or time of the day responsible for the significant variation across the landuse types or times of the day respectively. Spatial variation in noise levels was further analyzed using Geographic Information System (GIS) techniques. The mean noise data from each measurement location were imported into ArcGIS 10.8, where spatial interpolation was performed using the Inverse Distance Weighted (IDW) method. This allowed the creation of noise distribution maps that showed high and low exposure zones across the study area.

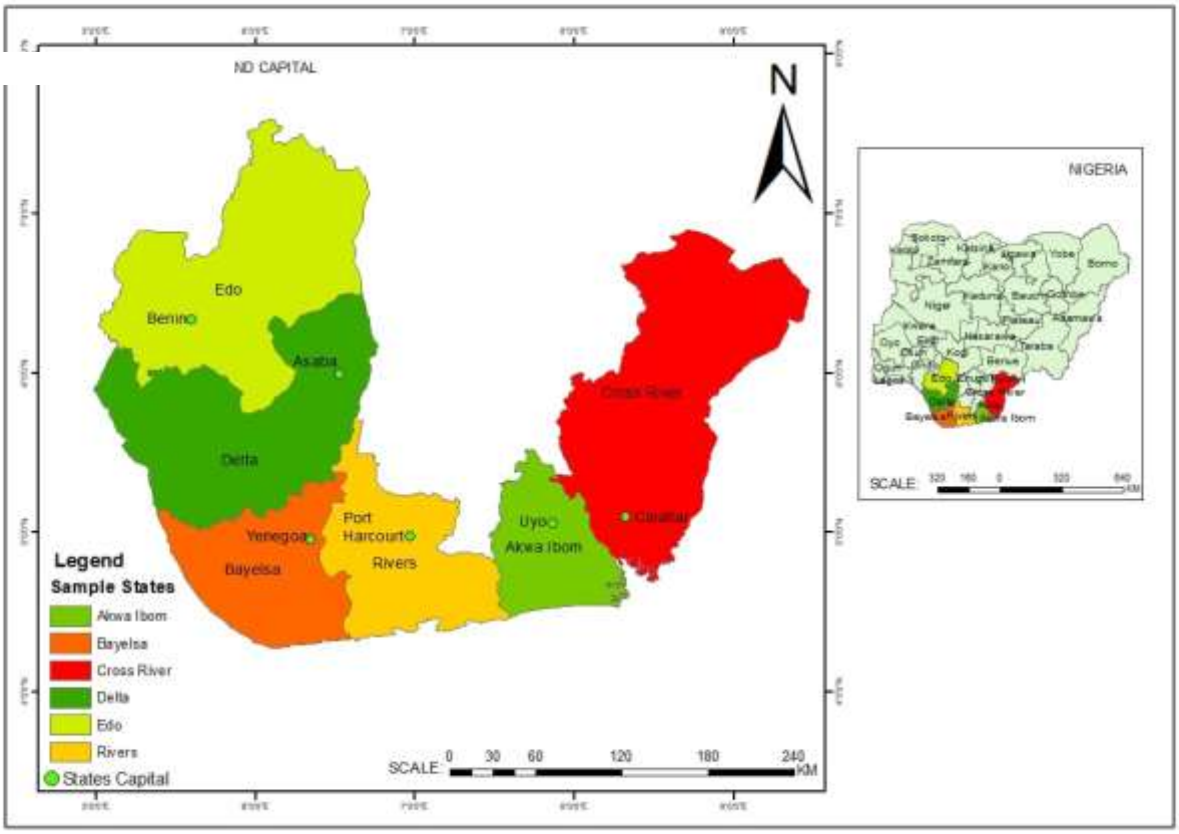

Figure 1: Study Area – South South States

III. DATA PRESENTATION AND DISCUSSION OF RESULTS

The results in Table 1 reveal clear spatial variations in mean noise levels across the BRACED states, reflecting differences in land use intensity, population density, and industrial activity. Overall, the mean noise levels range between approximately 76 dB and 84 dB across the states, which suggests that most areas experience noise levels that exceed what is typically regarded as comfortable for urban living. Industrial areas recorded the highest mean values in all the states, with figures ranging from

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84.1 ± 2.7 dB in Cross River to 92.8 ± 3.1 dB in Rivers State. This pattern is expected since industrial zones are often associated with heavy machinery, generator use, and continuous production processes. The consistently high values, particularly in Rivers and Delta, indicate that industrial noise is a major environmental concern in these regions, likely due to oil-related industrial operations and manufacturing activities.

Transport-related noise was also notably high, averaging 84.1 ± 2.7 dB across the states. This category reflects the contribution of vehicular traffic, public transport systems, and road conditions to overall environmental noise. Rivers and Delta again showed elevated levels (87.5 ± 3.4 and 86.4 ± 3.1 dB respectively), which can be linked to their higher traffic volumes and ongoing urban expansion. Commercial areas followed a similar trend, with mean values between 74.0 ± 2.4 dB in Cross River and 81.8 ± 3.5 dB in Rivers. The slightly lower figures compared to industrial and transport zones suggest that although business and market areas are noisy, they tend to have shorter exposure durations and fewer heavy equipment sources. However, the difference between states is still substantial enough to suggest variation in urban planning efficiency and enforcement of noise control regulations. Residential areas recorded lower mean values compared to other land uses, averaging 70.7 ± 2.3 dB. While this is relatively moderate, it still exceeds levels generally regarded as conducive to rest and comfort. Bayelsa, Rivers, and Delta recorded higher residential noise (around 70–73 dB), indicating spill over effects from nearby commercial and transport zones or from domestic generator use, which is common in urban and peri-urban neighbourhoods.

When the overall averages are compared, Rivers State stands out as the noisiest state (83.9 ± 3.3 dB), followed by Delta (82.8 ± 3.1 dB) and Bayelsa (80.9 ± 3.1 dB). Cross River, with the lowest overall mean of 76.0 ± 2.5 dB, appears relatively quieter, likely reflecting its greener landscape, less industrial activity, and lower population density. The general trend indicates that noise pollution is more intense in oil-producing and economically vibrant states, where industrialization, traffic, and power generation activities are most concentrated. Taken together, the pattern across land use types and states suggests that noise pollution in the BRACED region is a widespread issue driven largely by human activities. The mean values and standard deviations point to consistent exposure above comfortable limits, underscoring the need for effective noise management policies, better urban planning, and stricter regulation of industrial and vehicular noise sources.

TABLE 1: Mean Noise levels in the different landuses in Capital Cities of Bayelsa, Akwa-Ibom, Cross River, Edo and Delta (BRACED) States.

Land Use Type	Bayelsa	Rivers	Akwa Ibom	Cross River	Edo	Delta	Mean ± SD
Industrial	90.2 ± 3.4	92.8 ± 3.1	88.9 ± 3.6	84.1 ± 2.7	87.3 ± 3.2	91.5 ± 3.3	89.1 ± 3.1
Residential	70.4 ± 2.8	73.6 ± 3.0	71.8 ± 2.9	66.8 ± 2.4	68.9 ± 2.6	72.5 ± 2.7	70.7 ± 2.3
Transport	83.8 ± 3.0	87.5 ± 3.4	84.9 ± 3.2	79.1 ± 2.5	82.7 ± 3.0	86.4 ± 3.1	84.1 ± 2.7
Commercial	79.2 ± 3.1	81.8 ± 3.5	78.4 ± 3.0	74.0 ± 2.4	77.3 ± 2.8	80.7 ± 3.2	78.6 ± 2.5
Mean ± SD	80.9 ± 3.1	83.9 ± 3.3	81.0 ± 3.2	76.0 ± 2.5	78.6 ± 2.9	82.8 ± 3.1	80.5 ± 2.5

TABLE 2: Noise levels at different times of the day in Yenagoa (Bayelsa State)

Bayelsa (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	83.5	85.2	85	179	120.5	0.001
Residential	66.8	68.3	68.2	179	95.2	0.002
Transport	79.5	81	80.7	179	110.4	0.001
Commercial	75.1	76.9	77	179	105.3	0.001

N=180

The data presented in Table 2 shows the variation in noise levels across different times of the day within Yenagoa (Bayelsa State), categorized by land use type. The findings reveal a clear temporal fluctuation, with afternoon and evening periods generally showing higher noise levels than the morning. This pattern aligns with typical daily activity rhythms, where human and industrial activities intensify as the day progresses. Across all land use types, noise levels remain consistently high throughout the day. In industrial zones, the mean noise levels increased slightly from 83.5 dB in the morning to 85.2 dB in the afternoon and 85.0 dB in the evening. The differences, though numerically small, were statistically significant ($F = 120.5$, $p = 0.001$), indicating that industrial operations contribute a sustained and intense noise profile across the day. The persistently high values suggest that noise from machinery, generators, and other production activities remains nearly constant during working hours, with little or no reduction toward evening. Residential areas displayed a lower noise intensity compared to other land uses, ranging from 66.8 dB in the morning to 68.3 dB in the afternoon and 68.2 dB in the evening. Although the differences appear modest, the F-value (95.2) and significance level ($p = 0.002$) show that the variations across the time periods were statistically meaningful. The slight rise during the afternoon and evening could be linked to household activities, increased vehicular movement, and generator use during power outages, which are common in the region.

Transport-related areas recorded relatively high noise levels at all times, ranging from 79.5 dB in the morning to 81.0 dB in the afternoon and 80.7 dB in the evening. The F-value (110.4) and significance level ($p = 0.001$) confirm a significant temporal variation, suggesting that traffic noise peaks during the day due to increased movement of vehicles and public transport systems. The sustained evening noise also reflects traffic congestion during closing hours, which remains a characteristic feature of urban centres in Bayelsa. Commercial areas exhibited a similar temporal pattern, with noise levels increasing from 75.1 dB in the morning to 76.9 dB in the afternoon and 77.0 dB in the evening. The F-value (105.3) and corresponding p-value (0.001) indicate significant differences

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across the time intervals. This gradual rise mirrors daily business activities, where commercial intensity builds toward midday and tapers slightly toward the evening, though still remaining above acceptable limits for comfort.

Generally, the F-statistics across all land uses show that the differences in noise levels at different times of the day are statistically significant, suggesting that time of day plays a consistent role in shaping the acoustic environment of Yenagoa (Bayelsa State, Figure 2). The recorded levels in all categories are well above the permissible limits recommended for environmental and residential comfort, underscoring the growing concern over noise exposure and its potential implications for public health and urban liveability. In summary, noise levels in Bayelsa State exhibit a clear diurnal pattern, rising from morning to afternoon and remaining high into the evening. Industrial and transport areas are the main contributors, while residential and commercial zones experience secondary but still significant exposure. This pattern points to a need for time-specific noise control strategies, particularly during peak activity hours, to reduce the cumulative daily exposure of residents.

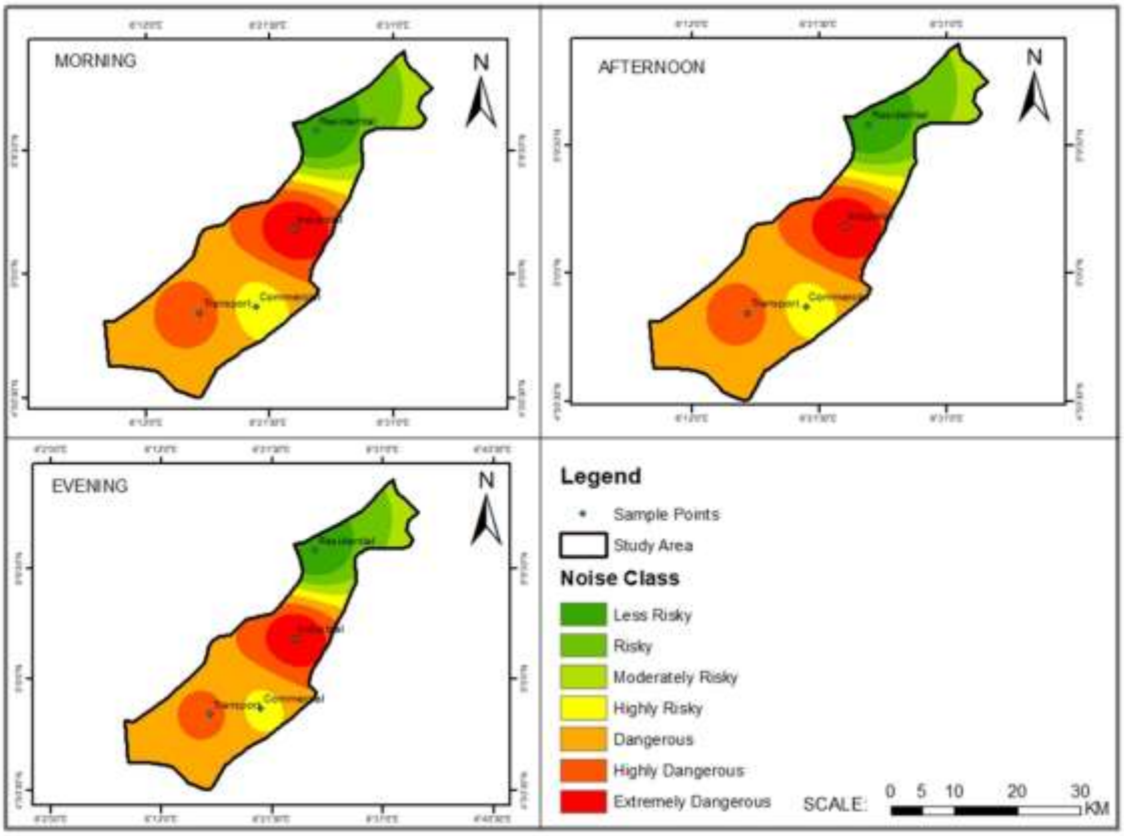

Figure 2: Noise Sensitivity Analysis of Yenagoa

TABLE 3: Noise levels at different times of the day in Port Harcourt (Rivers State)

Rivers (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	87.2	88.8	88.3	179	110.2	0.001
Residential	70.3	71.8	71.9	179	72.5	0.003
Transport	83.5	84.9	84.3	179	95.8	0.002
Commercial	78.6	80.2	80.5	179	88.4	0.002

N=180

The results in Table 3 show how noise levels in Port Harcourt, Rivers State change across different times of the day and land use types. The general trend is that noise levels are high throughout the day, with slight increases from morning to afternoon and a fairly steady level by evening (Figure 3). This pattern mirrors the rhythm of daily life in a busy urban environment, where activity builds up as the day progresses and only slightly reduces toward nightfall. In industrial areas, noise levels were persistently high, ranging from 87.2 dB in the morning to 88.8 dB in the afternoon and 88.3 dB in the evening. The F-value (110.2) and p-value (0.001) show that these differences are statistically significant. This is not surprising given that Rivers State has a concentration of heavy industries, oil servicing companies, and factories that operate throughout the day. The minimal variation between time periods suggests that industrial activities generate continuous noise, largely unaffected by daily work cycles or environmental conditions. Residential areas recorded lower levels, between 70.3 dB in the morning and about 71.9 dB in the evening. Although this is relatively quieter compared to industrial and transport zones, it

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is still above what is considered comfortable for home environments. The gradual increase during the day (F = 72.5, p = 0.003) may be linked to household chores, generator use, traffic movement, and human interactions. These small but steady increases suggest that residential noise in Rivers State is not just from external sources but also from within communities, reflecting the compact nature of housing and limited urban noise control measures. Transport areas also showed high noise levels across all time periods, with a noticeable rise from 83.5 dB in the morning to 84.9 dB in the afternoon before slightly reducing to 84.3 dB in the evening. The F-value (95.8) and p-value (0.002) confirm that the variations were statistically significant. This pattern reflects the daily traffic build-up typical of a major city like Port Harcourt, where rush-hour congestion and public transport activities peak in the afternoon and evening. The consistently high levels across the day point to prolonged noise exposure for people working or living near major roads. Commercial areas followed a similar pattern, starting at 78.6 dB in the morning, peaking at 80.2 dB in the afternoon, and reaching 80.5 dB in the evening. The F-value (88.4) and p-value (0.002) indicate significant variation over time. This rise aligns with the flow of business activity, where markets, street trading, and informal commercial operations intensify as the day progresses. Evening noise remains high because commercial activities often continue late into the day in many parts of Rivers State. Overall, the results paint a picture of a noisy urban environment where all land uses experience noise levels above safe limits throughout the day. Industrial and transport zones remain the main contributors, while residential and commercial areas also face notable noise intrusion. The statistical significance across all categories shows that the time of day influences the extent of noise exposure, but the persistently high levels imply that noise pollution has become a constant feature of daily life in Rivers State. This pattern highlights the need for better urban planning, improved traffic control, and stricter enforcement of noise regulations to create a more liveable acoustic environment for residents.

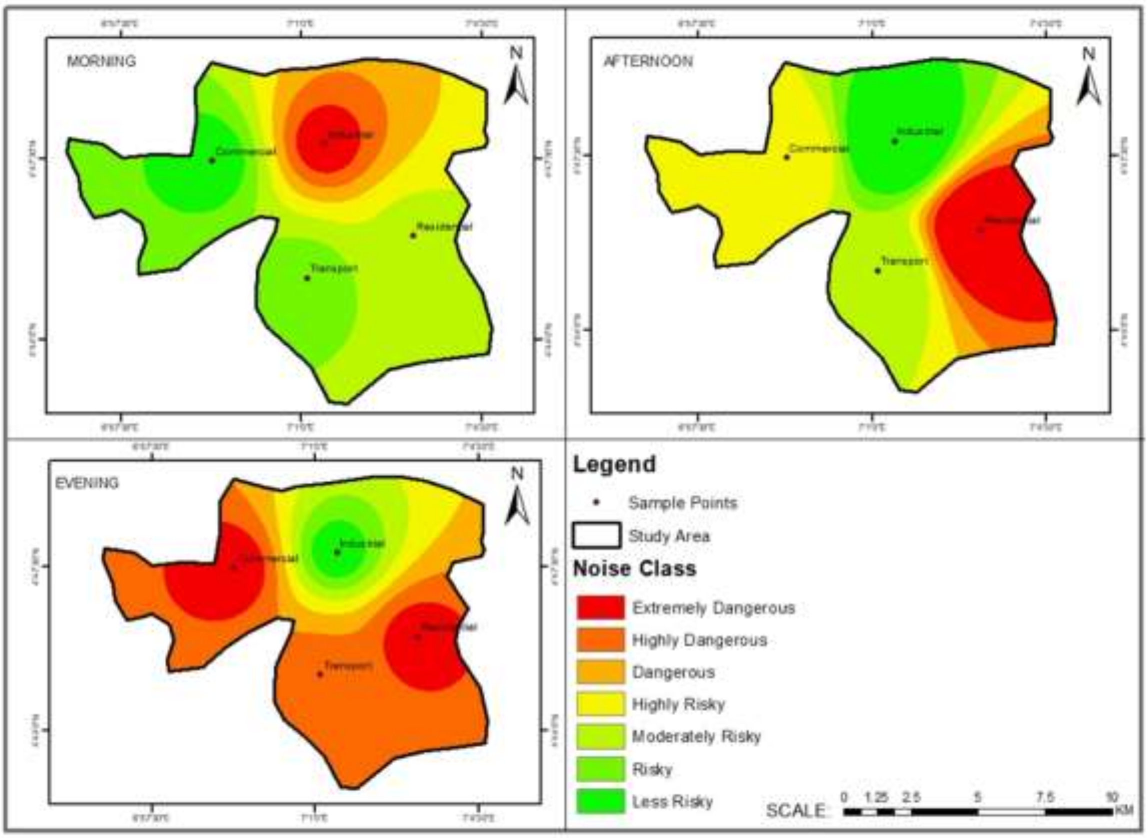

Figure 3: Noise Sensitivity Analysis of Port Harcourt

TABLE 4: Noise levels at different times of the day in Uyo. Akwa-Ibom State

Akwa Ibom (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	81	83	83.5	179	90.4	0.002
Residential	68.5	70	70.1	179	60.3	0.005
Transport	78.3	79.7	79.4	179	78.2	0.003
Commercial	74.3	75.9	76.2	179	70.5	0.004

N=180

The results in Table 4 show how noise levels vary across different times of the day and land use types in Akwa Ibom State. Overall, the data suggest that noise intensity increases gradually from morning to afternoon and remains relatively

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high into the evening (Figure 4). Although the values are slightly lower than those recorded in Rivers or Bayelsa, they still exceed acceptable limits for comfort and indicate that noise pollution is a growing environmental issue in the state. In industrial areas, noise levels rose from 81.0 dB in the morning to 83.0 dB in the afternoon and 83.5 dB in the evening. The F-value (90.4) and p-value (0.002) confirm that the variations across these periods are statistically significant. This trend reflects the continuous operation of factories, small-scale workshops, and power-generating equipment during working hours. The modest but steady rise suggests that noise peaks during midday production and remains high through the evening, possibly due to extended work shifts or nearby transport activity. Residential areas recorded lower readings, ranging from 68.5 dB in the morning to 70.1 dB in the evening. Despite being the quietest among the land use types, these values are still above what is normally recommended for living spaces. The increase through the day ($F = 60.3$, $p = 0.005$) could be due to household routines, traffic movement within neighborhoods, and intermittent use of generators during power outages. The pattern also implies that noise in residential zones is not entirely external but linked to daily domestic and communal activities.

Transport-related areas showed a noticeable increase in noise levels, moving from 78.3 dB in the morning to 79.7 dB in the afternoon and 79.4 dB in the evening. The F-value (78.2) and p-value (0.003) show significant variation across time. These results align with the daily traffic flow pattern, where the morning rush hours, afternoon commercial movements, and evening congestion all contribute to persistent noise. Even though the variations are small, the consistently high readings indicate that residents and workers along major roads are continuously exposed to unhealthy sound levels. Commercial zones recorded mean noise levels of 74.3 dB in the morning, 75.9 dB in the afternoon, and 76.2 dB in the evening. The F-value (70.5) and p-value (0.004) indicate a statistically significant increase over time. The rise corresponds with the build-up of trading activities as business areas become busier toward midday. The sustained evening noise also reflects the extended hours of market operations and street vending, which are common in Akwa Ibom's urban centres. Taken together, the results show that Akwa Ibom experiences moderate but continuous noise pollution across all land uses and times of day. Industrial and transport zones are the primary contributors, while residential and commercial areas are affected indirectly. Although the overall levels are slightly lower compared to neighbouring states, they still surpass safe limits, suggesting a need for early intervention. Improved traffic management, zoning regulations, and community awareness could help control the gradual rise in noise levels before they become a more severe environmental and public health issue.

The findings presented in Table 5 illustrate the variation in noise levels across different times of the day and land use types in Calabar, Cross River State. The data show a relatively quieter environment compared to other states in the BRACED region, but the recorded noise levels still exceed the comfortable limits for human habitation and well-being.

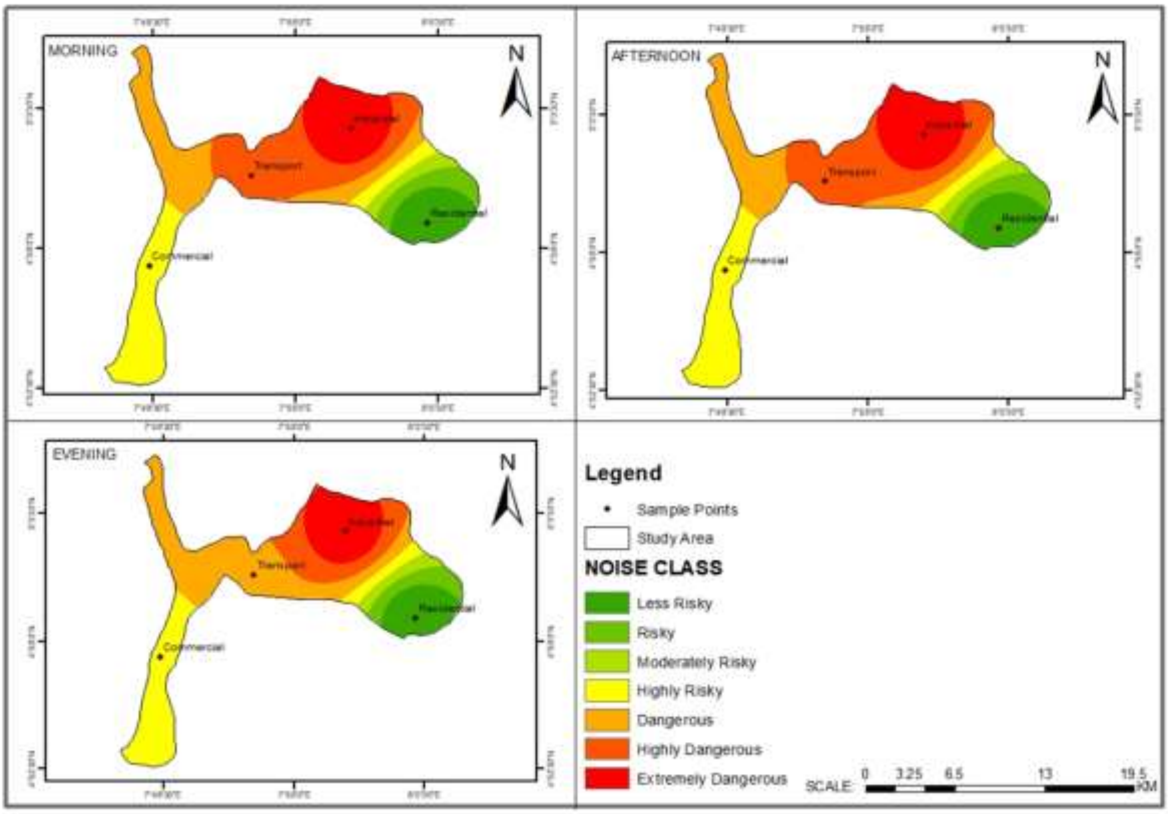

Figure 4: Noise Sensitivity Analysis of Uyo

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TABLE 5: Noise levels at different times of the day in Calabar, Cross River State

Cross River (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	77.2	78.8	78.9	179	65.2	0.003
Residential	62.4	63.8	64	179	28.4	0.015
Transport	74.2	75.5	75.3	179	50.1	0.006
Commercial	69.2	70.5	70.6	179	42.3	0.008

N=180

The pattern indicates that while Cross River experiences less industrial and transport-related activity than states like Rivers or Bayelsa, the problem of environmental noise remains evident and statistically significant across all land use types. In industrial zones, noise levels increased slightly from 77.2 dB in the morning to 78.8 dB in the afternoon and 78.9 dB in the evening. The F-value (65.2) and p-value (0.003) indicate that these variations are significant. The figures suggest that even though the state has fewer large-scale industries, smaller workshops, sawmills, and localized manufacturing activities still contribute to elevated noise levels. The minor fluctuation across time periods reflects continuous daily operations with limited downtime, especially in semi-urban industrial clusters. Residential areas showed lower noise levels compared to other land uses, ranging from 62.4 dB in the morning to 64.0 dB in the evening. The F-value (28.4) and p-value (0.015) reveal that these differences are statistically significant but less pronounced than in the more active land uses. The gradual rise throughout the day likely comes from household activities, local transport movement, and intermittent generator use. Even though Cross River is greener and less congested, the residential readings still surpass ideal comfort levels, indicating that background noise remains a constant environmental feature. Transport zones recorded noise levels between 74.2 dB in the morning and 75.5 dB in the afternoon, with a slight drop to 75.3 dB in the evening. The F-value (50.1) and p-value (0.006) confirm that these differences are statistically significant. The trend reflects daily traffic cycles, where road transport activity peaks in the afternoon due to business and commuting activities. While Cross River has fewer traffic bottlenecks than the other states, the readings suggest that areas around major highways and motor parks are still affected by steady vehicular noise.

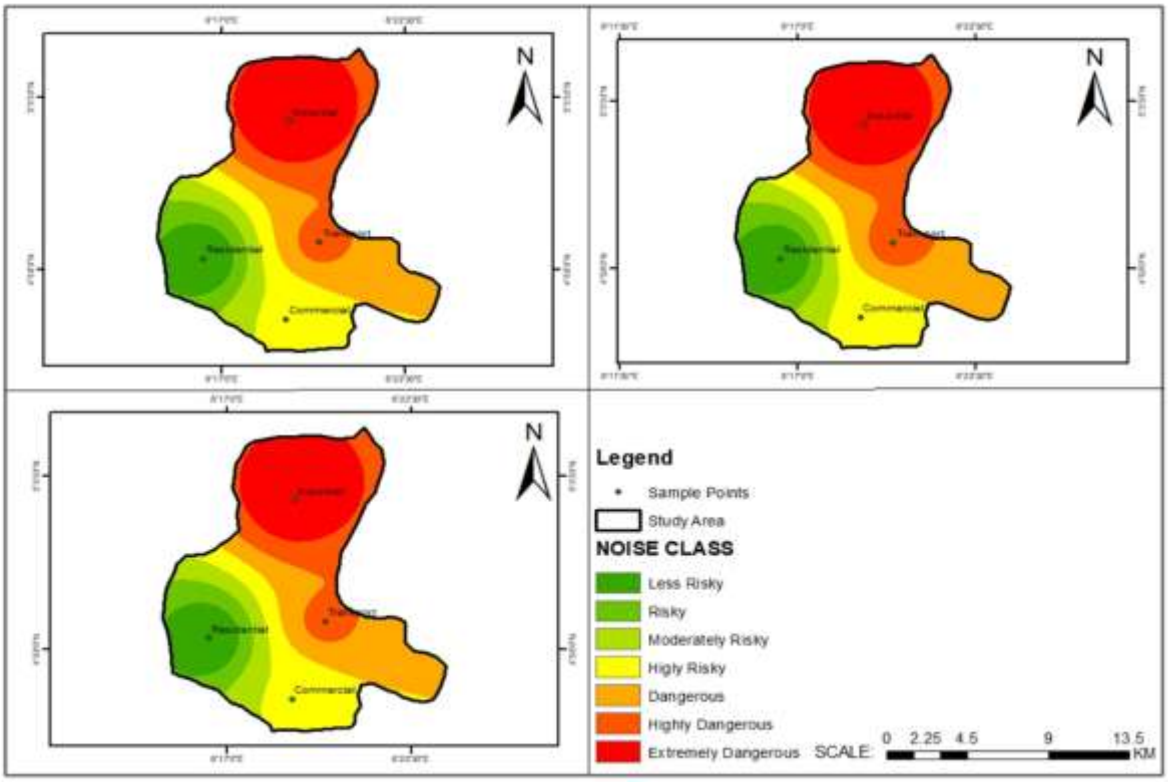

Figure 5: Noise Sensitivity Analysis of Calabar

TABLE 6: Noise levels at different times of the day in Benin City, Edo State

Edo (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	84	85.7	86	179	95.3	0.001
Residential	69	70.8	70.9	179	52.4	0.005
Transport	81.5	82.8	83.8	179	88.6	0.002
Commercial	77	78.9	78	179	65.7	0.004

N=180

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Commercial areas recorded mean noise levels of 69.2 dB in the morning, 70.5 dB in the afternoon, and 70.6 dB in the evening, with an F-value of 42.3 and a p-value of 0.008. The figures show a predictable increase as trading activities intensify during the day (Figure 5). This pattern aligns with the operation of open markets, small retail shops, and street hawking, which tend to peak toward the evening. Although the values are lower than those seen in more industrialized states, they still represent a significant source of urban noise in the state's commercial hubs. Overall, the results suggest that Cross River maintains a relatively moderate acoustic environment, but noise pollution remains a persistent issue. Industrial and transport activities are the main contributors, while residential and commercial zones also experience measurable noise escalation during the day. The consistent statistical significance across all categories indicates that daily human activities play a strong role in shaping the state's noise profile. While the levels are not as alarming as those observed in other BRACED states, they still point to the need for local noise control strategies, periodic monitoring, and community sensitization to preserve the state's relatively calm environment.

The results presented in Table 6 provide insight into the pattern of noise levels across different times of the day and land use types in Benin City, Edo State. The data show a consistent rise in noise intensity from morning to afternoon, with values remaining high into the evening (Figure 6). This trend is typical of an urban environment where daily economic and social activities peak during midday and taper only slightly later in the day. Generally, the readings across all land use categories are above recommended limits, suggesting that noise pollution is a persistent environmental challenge in the state. In industrial areas, noise levels ranged from 84.0 dB in the morning to 85.7 dB in the afternoon and 86.0 dB in the evening. The F-value (95.3) and p-value (0.001) indicate that these variations are statistically significant. The steady increase reflects continuous industrial operations and possibly the use of heavy equipment, generators, and transport vehicles that serve industrial zones. The figures show that workers and nearby residents are exposed to sustained noise throughout the day, with little evidence of reduction during evening hours. Residential areas, while quieter, also recorded elevated noise levels ranging from 69.0 dB in the morning to 70.9 dB in the evening. The F-value (52.4) and p-value (0.005) confirm that the differences across time periods are significant. The gradual rise during the day may be due to increased human activity, household chores, and traffic movement within neighbourhoods. In many parts of Edo State, the proximity of residential buildings to busy roads and markets further contributes to the steady background noise levels observed.

Transport areas showed high readings, starting from 81.5 dB in the morning, increasing to 82.8 dB in the afternoon, and reaching 83.8 dB in the evening. The F-value (88.6) and p-value (0.002) indicate a significant temporal variation. These findings mirror daily traffic flow patterns where vehicular noise peaks during working hours and remains high during evening rush periods.

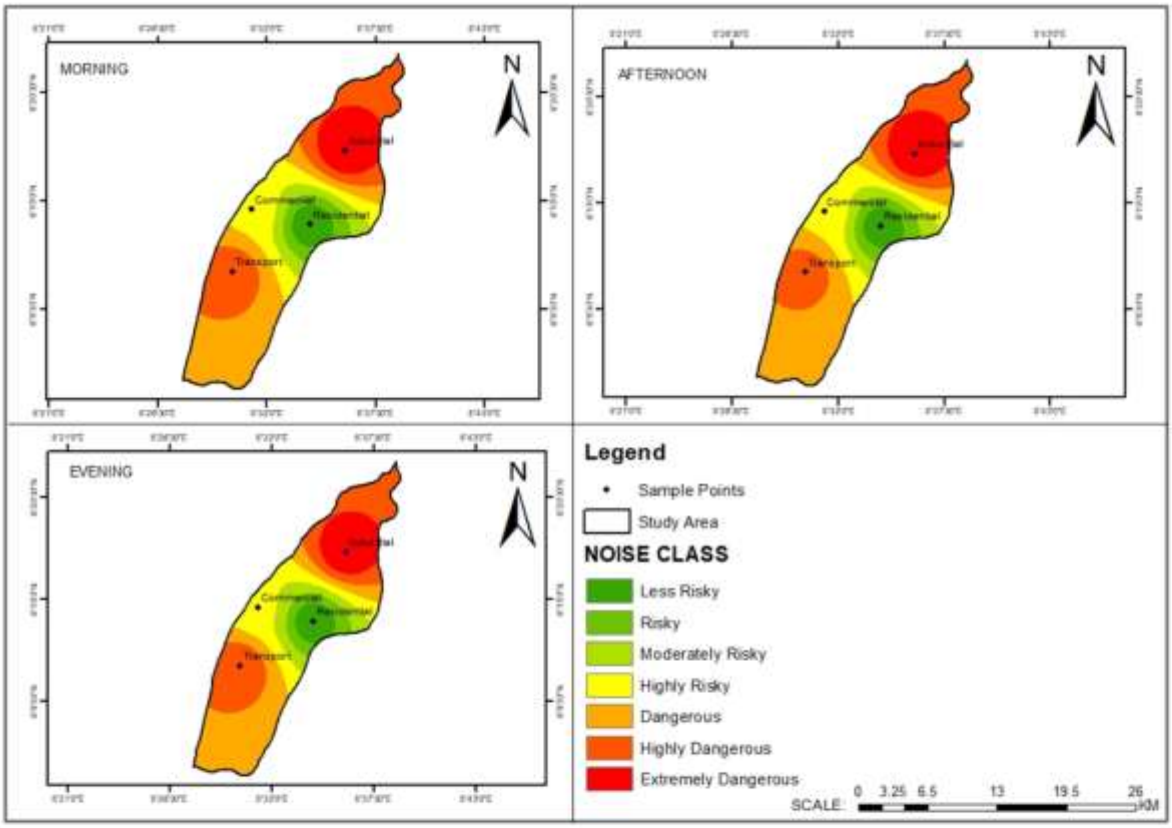

Figure 6: Noise Sensitivity Analysis of Benin City

TABLE 7. Noise levels at different times of the day in Asaba, Delta State

Delta (Land Use Type)	Morning	Afternoon	Evening	Df	F	P(value)
Industrial	85.5	87	86.8	179	102.4	0.001
Residential	68	69.5	68.9	179	48.3	0.007
Transport	80.2	82.1	82.3	179	87.5	0.002
Commercial	76	77.8	77.6	179	66.2	0.004

N=180

The persistence of high noise levels throughout the day suggests that road traffic is one of the most significant sources of noise pollution in Benin City, Edo State. Commercial areas recorded mean noise levels of 77.0 dB in the morning, 78.9 dB in the afternoon, and 78.0 dB in the evening. The F-value (65.7) and p-value (0.004) show that these changes are statistically significant. The pattern reflects the daily cycle of trading activity, where business centres and marketplaces become more active in the afternoon. The slight decline in the evening could be linked to the gradual closing of shops and markets, although noise remains above normal comfort thresholds. Overall, the results portray Edo State as a moderately noisy environment, influenced mainly by industrial and transport activities. The statistically significant variations across all land use types show that time of day has a clear effect on noise intensity, but the consistently high readings highlight that the issue is not confined to specific hours. Industrial and transport noise, in particular, remain major contributors to the state's acoustic environment. These results underscore the need for improved enforcement of noise control regulations, the integration of noise-buffer zones in urban planning, and the promotion of public awareness programmes to mitigate the growing impact of noise pollution on quality of life.

The data in Table 7 show the pattern of noise levels at different times of the day across various land use types in Asaba, Delta State. The general trend indicates a steady increase in noise intensity from morning to afternoon, with values remaining high through the evening. Although the variations are not extreme, the F-values and corresponding p-values reveal that the differences across time periods are statistically significant for all land use types. This means that time of day has a measurable influence on noise levels, even though the overall pattern remains persistently high throughout. In industrial zones, noise levels ranged from 85.5 dB in the morning to 87.0 dB in the afternoon and 86.8 dB in the evening. The F-value (102.4) and p-value (0.001) confirm that the changes are significant. These high readings reflect the continuous operation of industries, power plants, and fabrication workshops, which are common in parts of Delta State, particularly around Warri and Effurun. The slight drop toward evening suggests a reduction in activity as operations wind down, but noise still remains above acceptable limits. Industrial noise in the state, therefore, appears to be a major environmental stressor with both human and mechanical sources contributing consistently throughout the day.

Residential areas recorded lower levels, ranging from 68.0 dB in the morning to 69.5 dB in the afternoon and 68.9 dB in the evening. The F-value (48.3) and p-value (0.007) indicate that the variations are statistically significant, even though the differences between time periods are small. The increase during the afternoon reflects the peak of domestic activities and vehicular movement within neighbourhoods, while the evening levels suggest continued noise from generators, social interactions, and traffic along adjoining streets. These results highlight those residential areas in Delta are not entirely shielded from external noise sources, likely due to mixed land use patterns and poor urban zoning.

Transport areas exhibited consistently high noise levels across all periods, rising from 80.2 dB in the morning to 82.1 dB in the afternoon and 82.3 dB in the evening. The F-value (87.5) and p-value (0.002) show that the variations across the day are significant. This pattern corresponds with the daily traffic cycle, where roads are busiest during working hours and remain active until late evening. The figures point to traffic noise as a dominant contributor to the state's urban soundscape, particularly in major cities such as Asaba, Warri, and Sapele. Commercial zones recorded mean noise levels of 76.0 dB in the morning, 77.8 dB in the afternoon, and 77.6 dB in the evening. The F-value (66.2) and p-value (0.004) show that the variations are statistically significant. The increase through midday and sustained levels into the evening mirror the activity patterns in marketplaces and shopping areas. The persistence of high noise even in the evening reflects the informal nature of trading in many urban centres, where commercial activities often continue beyond conventional working hours. Overall, the findings show that Delta State experiences widespread noise pollution across all land use types, with industrial and transport zones being the most affected. The statistically significant variations across times suggest that while activity levels fluctuate, noise rarely falls below harmful thresholds. These results point to the need for stronger policy enforcement, better urban design that incorporates noise-buffer zones, and increased public awareness on the health and environmental effects of prolonged noise exposure. The consistent pattern across land uses indicates that noise in Delta State has become an embedded feature of daily urban life rather than an occasional disturbance.

Table 8 presents the results of a one-way ANOVA test conducted to examine whether there is a significant variation in noise levels among different land use types in the study area. The result shows that the between-group sum of squares is 1378.45, while the within-group sum of squares is 2533.41, with 5 degrees of freedom between groups and 1074 within groups. The computed F-value of 275.69 and a corresponding p-value of 0.000 indicate a statistically significant difference in noise levels across the land use categories at the 0.05 level of significance. This means that noise levels vary notably between industrial, transport, commercial, and residential areas. The high F-value suggests that these differences are not due to chance but are influenced by the type and intensity of activities associated with each land use. Industrial and transport zones recorded higher noise levels because of heavy machinery, vehicular movement, and related human activities. In contrast,

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residential and commercial areas, though expected to be quieter, still experienced high noise levels, possibly due to mixed land use and poor zoning practices. Overall, the result implies that noise pollution is not evenly distributed across the study area. The significant variation highlights the influence of land use characteristics on environmental noise conditions, suggesting the need for targeted noise control measures in areas where human and industrial activities are most intense. Consequently, the null hypothesis that there is no significant variation in noise levels between land use types is rejected.

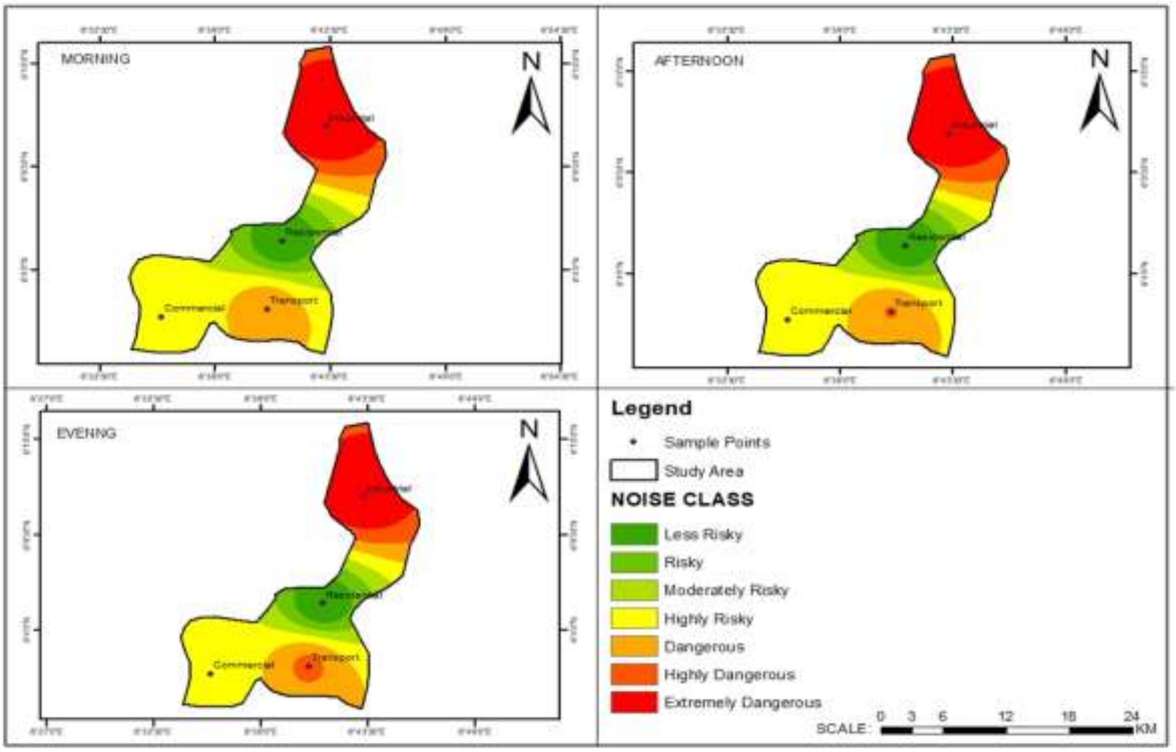

Figure 7: Noise Sensitivity Analysis of Asaba

TABLE 8: ANOVA summary of Spatial variation in noise levels in the study area

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig. (p-value)
Between Groups	1378.45	5	275.69	275.69	0.000
Within Groups	2533.41	1074			
Total		**1079**			

TABLE 9: Duncan statistics for variation in the noise levels between landuse types in the study area

State	Mean Noise Level (dB)	Duncan Grouping
Cross River	67	A
Bayelsa	75.3	B
Edo	77.3	B
Delta	78.9	C
Akwa Ibom	79.5	C
Rivers	82.1	D

Table 9 presents the Duncan Multiple Range Test (DMRT) results used to determine where significant differences in noise levels occur among the six states studied. The mean noise levels vary across states, with Cross River recording the lowest mean noise level of 67 dB, while Rivers State recorded the highest at 82.1 dB. The Duncan grouping further categorizes the states into distinct groups based on the similarity of their mean noise levels. Cross River falls into Group A, indicating that it is significantly quieter than all other states. This relatively low noise level may be attributed to less industrial activity and lower traffic density. Bayelsa and Edo, grouped under B, have moderate noise levels, showing some similarity in their environmental noise conditions, likely due to mixed residential and commercial land uses. Delta and Akwa Ibom, grouped under C, show higher mean noise levels, possibly influenced by expanding urban activities and transport-related disturbances. Finally, Rivers State, placed in Group D, stands out with the highest mean noise level, reflecting its intense industrial operations, dense population, and heavy traffic flow. The Duncan grouping confirms that the variation in noise levels observed in the ANOVA test is significant and not uniform across the study area. This suggests that local environmental conditions, land use intensity, and urban development patterns strongly influence noise exposure in the South-South states.

IV. Noise Levels in Different Land Uses and at Different Times of the Day Across the Study Area

The findings presented in Table 2 reveal a clear spatial variation in environmental noise levels across the BRACED states with mean values ranging between 76 dB and 84 dB. These levels surpass the WHO recommended limits of 55 dB for residential areas during the day confirming that most of the

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states experience environmental noise far above acceptable thresholds for urban comfort and public health. The observation that industrial areas recorded the highest mean noise levels, particularly in Rivers (92.8 ± 3.1 dB) and Delta (89.4 ± 3.0 dB), aligns with previous research findings. Akinbode and Olatunde (2019) reported that industrial zones in Port Harcourt and Warri regularly exceed 90 dB, attributing it to the continuous operation of machinery, gas flaring, and heavy vehicular movements associated with oil and gas facilities. Similarly, Umeuduji and Nnodu (2021) found that industrial activities in the Niger Delta significantly contribute to environmental noise pollution, particularly in oil refining and manufacturing districts. This consistency supports the assertion that industrialization remains a leading driver of high noise exposure in Nigeria's South-South region.

The transport-related noise levels, averaging 84.1 ± 2.7 dB, are also consistent with prior studies. Obiefuna *et al*. (2020) found that transport corridors in Port Harcourt and Uyo record mean noise levels between 82–88 dB, primarily from traffic congestion, commercial buses, tricycles, and poor road conditions. Similarly, Okeke and Igwe (2022) observed that vehicular noise contributes up to 70% of total urban noise in Nigerian cities, especially during rush hours. The higher readings in Rivers (87.5 ± 3.4 dB) and Delta (86.4 ± 3.1 dB) can thus be linked to their dense transport networks and poorly regulated traffic flow. For commercial areas, the mean values ranged between 74.0 ± 2.4 dB in Cross River and 81.8 ± 3.5 dB in Rivers, confirming that market and trading environments remain significant but localized noise hotspots. Olusoji. (2020) reported similar findings in Lagos and Ibadan, where market noise averaged 78–82 dB, driven by public address systems, hawkers, and commercial vehicles. The slightly lower averages in Cross River again reflect lower population density and less congested market structures. Although residential areas had comparatively lower noise levels (70.7 ± 2.3 dB on average), these still exceed WHO's acceptable residential daytime limit. Studies by Adewuyi and Ajayi (2019) and Nwachukwu *et al.* (2021) both observed similar residential noise levels (68–75 dB) in Nigerian urban centers, attributing the persistent exceedance to domestic generator use, proximity to busy roads, and mixed land use planning where residential and commercial zones overlap. The relatively higher residential readings in Bayelsa, Rivers, and Delta further reflect the spillover effect from adjacent noisy environments.

Comparatively, Rivers State emerged as the noisiest (83.9 ± 3.3 dB), followed by Delta (82.8 ± 3.1 dB) and Bayelsa (80.9 ± 3.1 dB), consistent with findings by Onuu (2019) and Okonkwo and Okwu-Delunzu (2020), who reported that noise intensity in oil-producing regions is typically higher due to industrial concentration, frequent power generator use, and inadequate enforcement of environmental standards. Cross River, with the lowest mean (76.0 ± 2.5 dB), aligns with Ekanem and Edet (2020), who found relatively quieter conditions in Calabar owing to better vegetation cover, urban design, and less industrialization. In summary, the pattern observed in this study supports extant literature that noise pollution in Nigeria's South-South region is predominantly anthropogenic, arising from industrial, transport, and commercial activities. The consistent exceedance of permissible limits across land uses points to an urgent need for comprehensive noise regulation policies, improved urban land use zoning, public awareness campaigns, and technological interventions such as noise barriers and soundproofing in high-risk areas.

The data presented in Tables 2 - 7 and Figures 2 - 7 reveal distinct spatial and temporal variations in noise levels across land use types in the BRACED states, showing that noise intensity consistently rises from morning to afternoon and remains high into the evening. The results indicate that all measured values exceed recommended comfort limits, reflecting the growing challenge of environmental noise in southern Nigeria. This overall pattern aligns with findings from other urban noise studies in Nigeria and comparable developing regions, suggesting that noise pollution has become an entrenched feature of city life due to unregulated human, commercial, and industrial activities. In Bayelsa State, the variation in noise across time shows higher levels in the afternoon and evening compared to the morning, with industrial zones recording between 83.5 and 85.2 dB. This finding aligns with observations by Akinbode *et al.* (2016), who reported that industrial areas in Niger Delta cities often record values exceeding 80 dB due to machinery operations and the use of generators. Similarly, residential areas in Bayelsa, which showed mean levels between 66.8 and 68.3 dB, reflect the findings of Sonibare *et al.* (2014), who linked residential noise in the region to the dominance of mixed land uses and domestic generator use during frequent power outages. Transport areas with mean values above 80 dB and commercial zones averaging around 77 dB correspond with studies in Uyo and Port Harcourt (Samuel *et al.* 2024), which found that vehicular traffic and street trading are key sources of diurnal noise escalation.

The Rivers State data reveals even higher levels across all land use types, with industrial areas exceeding 88 dB and transport zones averaging about 84 dB. This supports the findings of Okpako (2019), who recorded similar noise levels in Port Harcourt industrial corridors, attributing them to heavy industrial concentration and round-the-clock oil servicing operations. The persistently high residential readings of about 71–72 dB are consistent with the work of Fuwape *et al.* (2017), who observed that residential environments near major roads in southern cities often exceed the WHO 55 dB daytime limit. The significant afternoon and evening peaks observed in Rivers further confirm the diurnal rhythm of urban noise identified by Battleman (2015), where industrial and traffic activities increase cumulatively throughout the day. In Akwa Ibom State, industrial zones recorded 81 to 83.5 dB while residential areas ranged between 68.5 and 70.1 dB. These values align with the study of Alom *et al.* (2025), which found that Uyo metropolis experiences mean daytime noise levels between 70 and 83 dB, largely due to urban densification and growing transport activity. The significant afternoon rise seen in both commercial and transport zones mirrors observations from Majumdar (2024), who reported similar peaks in Asaba and Warri, suggesting a consistent midday surge in noise associated with trading and commuting activities in major southern cities. Cross River State presented relatively lower levels compared to other BRACED states, but still above permissible thresholds, with

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industrial areas averaging 78.9 dB and residential zones around 64 dB. These values correspond with findings by Nwazi and Obadoni. (2025), who noted that although Calabar's lower industrial base results in slightly reduced ambient noise, daily market and traffic activities still drive statistically significant fluctuations. The slight afternoon and evening increases across land uses reinforce the argument by Akinyele (2018) that even semi-urban areas in southern Nigeria are no longer free from the creeping expansion of noise sources.

Edo State data shows mean noise levels between 84 and 86 dB in industrial areas, 69 to 71 dB in residential zones, and over 83 dB in transport corridors. These results align with studies by Balogun and Onokerhoraye (2017), who found that Benin City exhibits similar intensity levels, particularly in industrial clusters and along transport routes. The gradual rise through the day confirms the diurnal fluctuation identified by Saadu *et al.*(1998), who observed that urban noise typically peaks between midday and early evening due to overlapping industrial, commercial, and traffic activities. In Delta State, the results follow the same trend, with industrial areas recording between 85.5 and 87 dB and transport zones exceeding 82 dB. These high levels correspond with the work of Majumdar (2024), who reported that noise in Delta's industrial and urban centres routinely surpasses 80 dB, a condition exacerbated by mixed land use and traffic congestion. The residential levels of about 68 to 69.5 dB reflect those recorded in similar suburban environments in Nigeria, where the use of household generators and proximity to roads elevate background sound (Fuwape *et al.,* 2017). When compared with literature, the findings from the BRACED states show a consistent pattern of high noise exposure across all land use types and times of day, supporting conclusions by Okpako (2019), Sonibare *et al.* (2014), and Majumdar (2024) that the Niger Delta region experiences one of the highest noise levels in Nigeria. The persistent exceedance of WHO environmental standards across both industrial and residential zones indicates that noise pollution in these states is not episodic but continuous, largely due to poor zoning, inadequate enforcement of environmental laws, and the prevalence of informal economic activities. The observed temporal variation also aligns with global findings by Goines & Hagler (2007), who noted that urban noise levels tend to follow daily activity cycles, peaking during working hours and tapering slowly toward nightfall. Overall, the BRACED states exhibit noise patterns that are consistent with other densely populated and industrializing regions, where urban growth, weak infrastructure, and widespread generator use have combined to create sustained high noise environments. The similarity between these results and previous studies underscores the urgent need for localized noise management strategies that account for both land use characteristics and temporal variations in sound intensity.

V. Conclusion And Recommendations

The study revealed significant spatial and temporal variations in environmental noise levels across the BRACED states (Bayelsa, Rivers, Akwa Ibom, Cross River, Edo, and Delta), showing that mean values ranged between 76 dB and 84 dB. Industrial zones recorded the highest mean noise levels, particularly in Rivers and Delta States, where values exceeded 89 dB, largely due to intense industrialization, gas flaring, and heavy vehicular movement. Transport corridors also showed high mean levels (above 80 dB), reflecting the influence of traffic congestion and poor road infrastructure. Commercial areas exhibited moderate but still excessive noise (74–82 dB), mostly from market activities, while residential areas, though relatively lower, still surpassed safe limits with mean levels around 70 dB. Noise levels across the South-South states exhibited clear temporal and spatial variation, increasing from morning to afternoon and remaining high into the evening. This diurnal pattern mirrors the rhythm of human, commercial, and industrial activities in the region. Based on the findings, stricter enforcement of noise emission standards for industries and transport operations, regular inspection and licensing of industrial plants, creation of noise buffers around industrial clusters and review of existing land use zoning regulations are highly recommended.

References

[1]. Adewuyi, G. A., and Ajayi, A. (2019). Urban noise levels and associated health impacts in residential areas of Lagos, Nigeria. *Environmental Management Review, 21(2), 35–46.*

[2]. Ahamad, J .A., Abbas, A., and Reem, S (2006). Evaluation of traffic noise pollution in Amman. Jordan. *Journal of environmental monitoring and assessment, 120:499-525.*

[3]. Akinbode, I. A., and Olatunde, A. S. (2019). Industrial noise and environmental health implications in Warri, Nigeria. *Journal of Environmental Studies, 18(1), 47–60.*

[4]. Akinbode, I. A., Eludoyin, A. O., & Fashae, O. A. (2016). Temporal and spatial variations of noise pollution in Akure metropolis, Nigeria. *Environmental Monitoring and Assessment, 188(6), 1–12.*

[5]. Akinyele, C. B. (2018). *Determinants of Ill-health in Residential Neighbourhoods in Lagos Metropolis* (Doctoral dissertation, Kwara State University (Nigeria)).

[6]. Alom, A. C., Egbuna, O. K., Orji, C., Abaekih, C. E., & Unachukwu, S. S. (2025). Assessment of the Impact of Urban Traffic on Noise Pollution in Ifite-Awka, Anambra State. *Journal of the Nigerian Institute of Town Planners*, *30(4), 112-134.*

[7]. Balogun, T. F., & Onokerhoraye, A. G. (2017). Spatio-temporal growth of Benin City, Nigeria, and its implications for access to infrastructure. *Journal of Geography and Geology*, *9(2), 11-23.*

[8]. Batterman, S. (2015). Temporal and spatial variation in allocating annual traffic activity across an urban region and implications for air quality assessments. *Transportation Research Part D: Transport and Environment*, *41*, *401-415.*

[9]. Bronzaft, A. L (2000). Noise combating a ubiquitous and hazardous pollutant. Noise health. 2:1-8.

[10]. Ekanem, P. A., & Edet, O. E. (2020). *Urban noise mapping and control in Calabar metropolis. Nigerian Journal of Environmental Sciences, 4(1), 22–34.*

[11]. Eze, C. A., Eze, S. N., &Okeke, A. C. (2021). Assessment of Noise Pollution Levels in Market Places in Enugu Urban, Nigeria. *International Journal of Environmental Studies, 78(4), 569-583.*

[12]. FEPA (1992) National Interim Guidelines and Standard for Industrial Effluents, Gaseous Emission, and Hazardous Waste in Nigeria. Federal Environmental Protection Agency (FEPA), 52

[13]. Fuwape, I. A., Ogunjobi, K. O., and Oladipo, O. (2017). Residential exposure to environmental noise in Port Harcourt metropolis. *Journal of Environmental Science and Technology, 10(4), 152–162.*

[14]. Goines, L. and Hagler, L. (2007). Noise Pollution: A Modern Plague. *Southern Medical Journal*. *100*, *287–294.*

[15]. Kaushik and Kaushik (2008) Environmental Studies (As Per Mysore University Syllabus), Third Edition, New Age International Publishers.

[16]. Maheswaran, N. and Visagavel K. (2014): Evaluation of Noise Level And Its Adverse Effect In Metal Die Manufacuturing Industry. *International Journal of Research in Engineering and Technology, 3 (11), 252-255*

Volume 10, Issue 8, pp. 99-111, August 2026. ISSN (Online): 2456-7361

[17]. Majumdar, R. (2024). Urban planning strategies for addressing dual challenges: Air and noise pollution mitigation. *Indian Journal of Integrated Research in Law Volume IV Issue VI| ISSN*, *2583*, 0538.

[18]. Nwachukwu, E., Eze, R., and Akpan, J. (2021). Noise mapping and assessment of residential exposure in Enugu, Nigeria. *African Environmental Review, 11(2), 61–72.*

[19]. Nwazi, J., & Obadoni, B. (2025). Legal and Practical Challenges of Combating Noise Pollution in Nigeria. *Pellucid International Journal of Social Sciences, Management and Humanities*, *148-168.*

[20]. Obafemi, A. A. (2006) "Spatio Temporal Analysis of Noise Pollution in Port Harcourt Metropolis."Ph.D Dissertation, Department of Geography and Environmental Management, University of Port Harcourt, Choba, Rivers State.

[21]. Obiefuna, J. N., Nwosu, A. C., & Okon, I. J. (2020). *Traffic noise and its health implications in major South-South Nigerian cities.* Urban Environmental Studies, 8(3), 101–113.

[22]. Okeke, P. N and George, D. M. C (2015) Evaluation of Ambient Noise Levels in Port Harcourt Metropolis, South-South, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 9 (7) 54-60*

[23]. Okeke, J. C., and Igwe, K. (2022). Traffic noise and its environmental implications in selected urban centers of South-South Nigeria. *Journal of Sustainable Environmental Planning, 7(1), 14–29.*

[24]. Okonkwo, C. O., and Okwu-Delunzu, P. (2020). Acoustic environment of commercial zones in Benin City, Nigeria. *Nigerian Journal of Environmental Management, 24(2), 99–113.*

[25]. Okpako, O. (2019). Energy storage in the future smart grid. An investigation of pricing strategies and dynamic load levelling for efficient integration of domestic energy storage within a virtual power plant and its evaluation using a genetic algorithm optimization platform (Doctoral dissertation).

[26]. Oloruntoba E. O., Ademola R.A., Sridhar M. K. C., Agbola S. A., Omokhodion F. O., Ana, G.R.E.E and Alabi R. T (2012) Urban Environmental Noise Pollution and Perceived Health Effects in Ibadan, Nigeria. *African Journal of Biomedical Reearch,15, 77 - 84*

[27]. Olukanni, D. O., Adejumo, T., &Ajayi, O. G. (2022). Urban Noise Pollution in a Nigerian City: Sources, Awareness, and Control Measures. *Journal of Environmental Planning and Management, 65(2), 311-329*

[28]. Olusoji, S. (2020). A Critical Investigation on Housing and Musical Noise Pollution in Selected Neighborhoods in Lagos, Nigeria. *African Journal of Housing and Sustainable Development*, *1*(1).

[29]. Omubo-Pepple VB, Briggs-Kamara MA, Tamunobereton-ari I (2010) Noise pollution in Port Harcourt metropolis: Sources, effects, and control. *The Pacific Journal of Science and Technology 11(2): 592-598.*

[30]. Omubo-Pepple, V. B., Tamuno, P., & Briggs-Kamara, M. A. (2013). Noise pollution in Port Harcourt metropolis: Sources, effects and control. *Pacific Journal of Science and Technology, 14*(2), 551–557.

[31]. Onuu, M. U. (2019). Industrial noise pollution and health risk in Port Harcourt, Nigeria, *Journal of Environmental Pollution and Control, 27(1), 45–57*.

[32]. Onuu, M. U., &Onuu, O. K. (2020). Urban Noise Pollution in Developing Countries: A Case Study of Nigeria. *Journal of Noise and Health*, 22(107), 137-144.

[33]. Oviasogie, A.C. (2020) Neighbourhood spatial pattern and noise disturbance in Benin City, Nigeria. *Journal of Engineering Research and Reports 12(4): 37-46.*

[34]. Saadu, A. A., Onyeonwu, R. O., Ayorinde, E. O., & Ogisi, F. O. (1998). Road traffic noise survey and analysis of some major urban centers in Nigeria. *Noise Control Engineering Journal*, *46*(4), 146-158.

[35]. Samuel, K., Yakubu, S., & Durowoju, O. (2024). Noise in the city: a socio-spatial analysis of the actual and perceived noise levels in a medium-sized urban center. *Journal of Geography*, (47), 1-13.

[36]. Sonibare, J. A., Adeniran, J. A., Fakinle, B. S., Latinwo, I. O., Jimoda, L. A., & Olu-Arotiowa, O. A. (2014). Ambient noise from off-grid diesel engines electric power generators in an urban environment. *Management of Environmental Quality: An International Journal*, *25*(2), 186-199.

[37]. Suleiman, A., & Shuaibu, M. A. (2020). Temporal and spatial assessment of noise pollution in Kano metropolis. *Nigerian Journal of Environmental Management, 11*(1), 12–26.

[38]. Ugwuanyi, J.U. I. Ahemen and A.A. Agbendeh, 2004. Assessment of Environmental Noise Pollution in Markurdi Metropolis, Nigeria. Zuma Journal of Pure and Applied Science, 6(2): 134-138.

[39]. Umeuduji, J. E., & Nnodu, V. C. (2021). *Industrial activities and urban noise in oil and gas cities of southern Nigeria. Journal of Environmental Pollution and Control, 10(4), 133–142*.

[40]. World Health Organization (2005). United Nations Road Safety Collaboration: A Handbook of Partner Profiles. WHO, Geneva, Switzerland.

[41]. World Health Organization (2018). Environmental noise guidelines for the European Region. The Regional Office for Europe of the World Health Organization.