Assessment of Road Junctions' Noise Levels in Yenagoa Metropolis, Nigeria Using Geographic Information Systems

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Abstract: The study examined the spatio-temporal variation of traffic noise levels along major roads in Yenagoa City, Bayelsa State, Nigeria. Road junctions were sampled randomly for noise data using noise meters in the morning, afternoon and night. Descriptive and inferential statistics was used to test the significant difference in the spatio-temporal traffic noise levels. Spatial variability mapping of noise and noise risk zones were derived using inverse distance weight interpolation method. Findings showed that road junctions with higher noise level included Berger, Along Berger-Imgbi Junction, Swali Roundabout, Swali Market, Lambert Junction, Imgbi Junction, Ekeki, Okaka, Biogbolo, Opolo, Tombia Roundabout, Akenfa and Ede-Epie while the lower noise level was found in Oxbow Lake Junction, Oxbow Lake, Berger Bayelsa Palm Road, Bayelsa Palm and Lambert Eradiri Roundabout. Findings also showed that 33.3% of the road junctions were tolerable and 33.3% were lowly risked to noise pollution while only 6.1% was moderately risk. Moreover, noise level was highest on Wednesdays and the least was observed in Saturday. Findings also revealed that the mean traffic noise level in the morning was 66.9 dB (A), afternoon 69.9 dB (A) while in the night was 66.1 dB (A). The overall traffic noise risk levels revealed that 20.9% of Yenagoa City were safe, 39.4% were tolerable, 34.4% were lowly risked while 5.3% were moderately risked. Okaki, Oxbow Lake, Bayelsa Palm, and Agudama-Epie were safe, Prosco, INEC, Akenpai, Nikton and Igbogene were tolerable, Akenfa, Berger, Swali Roundabout and Swali Market were lowly risked while Tombia Roundabout, Ede-Epie, Opolo, and Biogbolo were moderately risked. There was a significant difference in the spatial ($F_{0.05}$ =11.415, $p<0.05$) and temporal traffic ($F_{0.05}$ =7.823, $p<0.05$) noise levels in Yenagoa City. The study recommended that people residing or working in the moderately noise risked zones should use ear-protection aids to reduce the effects of noise in their health systems.

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1. Introduction

Noise pollution is an environmental phenomenon in Nigeria which displeases and disrupts the normal activities of human life. According to Mansouri *et al.* (2006) in Oyedepo and Saadu (2008), noise pollution is a bye product of urbanization which is recognized as a major problem for the quality of life in urban areas. However, vehicular noise pollution is the collective sound energy emanating from motor vehicles which may consists of road surface and tire friction, engine/transmission, aerodynamic, and braking elements. Vehicular noise levels are functions of the amount of traffic on the road, fastness of the vehicles that are travelling and the compositions of the vehicles (trucks, tractor, trailer, passenger buses, motorcycles). Rode *et al.* (2014) reported that mobility and accessibility have been described as the cornerstone of urban economic activities and of all, transportation is the bedrock on which this cornerstone is built. The daily movements of people and goods which involves mechanically automated mediums such as vehicles, motorcycles etc. have their attendant problems in the environment. Apart from the emission of pollutants such as carbon monoxides, hydrocarbons etc which reduce the ambient air quality of the area (Rode *et al.*, 2014), noise pollution is another environmental problems induced into the environment by automobiles. However, considering the connectivity of vicinity, transport routes could result to an increase in noise volume generated. Noise therefore is considered a growing health threat, and if left unchecked could result to hazardous conditions (Oyedepo, 2013); because noise pollution determines the quality of life in urban areas all over the world. Oyedepo (2013) viewed that noise in cities, especially along main arteries has reached disturbing levels as residences far from noise sources and near silent secondary roads are currently at the mercy of traffic noise, hence, people prefer to live in places far from noisy urban areas. Chakraborty and Basu (2015) reported that more people are exposed to noise hazards from motor vehicles than any other single source of noise. Horsfall and Spiff (2013) noted that noise pollution can interfere with sleep. Godson et al (2009) reported that noise caused tiredness and lack of concentration among secondary schools in Ibadan,

Nigeria. According to Goines and Hagler (2007), noise interferes with sleep, concentration, communication and reaction. Kukreja (2009) reported that high intensity noise cause high blood pressure and increase heart rate as it disrupts the normal blood flow. World Health Organization (1999) concluded that noise has been associated with cardiovascular health problems, and there is a relationship between long term noise exposure above 67-70dB (A) and hypertension while Oyedepo (2013) reported that noise causes reduction of productivity and mis-understanding of what is heard. Sources of noise pollution are numerous and these include household equipment (Olayinka and Abdullahi, 2008; Horsfall and Spiff, 2013), big machines in industries (Kukreja et al, 2004); road traffic (Santra, 2001; Obafemi and Eludoyin, 2012; Chakraborty and Basu, 2015); mobile line (Godson et al, 2009); and agricultural machines (Suresh, 2007).

In Nigeria, the problem of noise pollution is wide spread and several studies have reported that noise level in metropolitan cities exceeds specified standard limits. A study by Ugwuanyi et al (2013) conducted in Markudi, Nigeria found that the noise pollution level in the city was about 3dB (A) to 10dB (A) above the recommended upper limit of 82db (A). Anomohanran et al (2013) also found that the peak noise level at road junction in Abraka, Nigeria to be 100 dB (A). This noise level is higher than the recommended level 60dB (A) for industrial and residential areas. Igboroje *et al.* (2013) investigated the level of noise pollution in selected industrial locations in Benin City, Nigeria. The average ambient noise level in sawmills, electro-acoustic market and food processing industrial areas was determined to be above 90dB (A). This noise level is well above the healthy noise level of 60 dB (A). Meanwhile, Hagler (2007) reported that noise above 80dB is consistently associated with decreased helping behaviour and increased aggressiveness. It seems that Nigerian Government and her citizenry appear not to be conscious of the generation of noise in the metropolitan setting can be viewed in the light of the city planning disorderliness and the increasing number of vehicular traffic in the face of urban growth and development. In addition, Obafemi and Eludoyin (2010) studied the spatial analysis of noise pollution in Port Harcourt metropolis. Obafemi and Eludoyin (2012) monitored noise pollution level along road arteries away from the dominant city-centre in Port Harcourt.

Studies on noise levels in urban cities in Nigeria such as Olayinka and Oyedepo (2013), Igboroje *et al.* (2013), Ugwuanyi *et al.* (2013), Obafemi and Eludoyin (2010; 2012) and Anomohanran *et al.* (2013) did not involve vehicular noise study and the spatial variability mapping of noise. According to Horsfall and Spiff (2013), major vehicle noises are of concern to occupants of the vehicle and to persons living or working near highways. No study has revealed the variation of vehicular noise in Yenagoa City in different road junctions at different times of the day. The present study therefore investigated the spatio-temporal analysis of vehicular noise in Yenagoa City with a view to determining the noise risk zones within the metropolis.

2. Materials and Methods

Study Area

The study area is Yenagoa City, Bayelsa State of Nigeria. Yenagoa City is located within latitude 4º 51' N and 5º 22' N and longitudes 6º 12' E and 6º 33' E. Generally, study area is a lowland area characterized by tidal flats and coastal beaches, beach ridge barriers and flood plains. The network of rivers, creeks, lakes and other riverine relief features such as cliffs and lagoons are the dominant relief features of the area. The study area experiences tropical equatorial type of climate. Rain occurs generally every month of the year with heavy downpour with annual rainfall of about 2200mm. The mean monthly temperature is in the range of 25^0C to 31^0C. The hottest months are December to April. Relative humidity is high throughout the year and decreases slightly in the dry season. The vegetation included the fresh water swamps, rainforest and mangrove. The major soil types in the state are young namely shallow, poorly drained soils and acid sulphate soils.

Noise level data were collected from 32 points (42.1%) out of 76 points of road T-junctions and intersections in Yenagoa City in the morning (7-9am), afternoon (12-2pm) and evening (7-9pm) for two weeks. The latitudes and longitudes of these points were tracked with the use of global positioning system (GPS) to facilitate spatial variability mapping. Spatial variability map of Yenagoa around the road junctions was done in ArcGIS 9.3 with the use of Inverse Diverse Weighted (IDW) interpolation method. This helps to understand the noise levels of the unsampled locations and to determine the areas in square kilometers of low and high noise levels in Yenagoa metropolis in relation to traffic noise level. The analysis therefore was used to classify the noise risk zone in Yenagoa City into safe (0-<65 dB(A)), tolerable (66-71 dB (A)), low risk (71-76 dB (A)), moderate risk (76-81 dB (A)), high risk (81-86 dB (A)) and extremely high risk (<86 dB (A)) (Iaaly-Sankari *et al.*, 2010). Descriptive analysis was used to explain the mean noise levels in the selected locations at different times of the day. Analysis of variance (ANOVA) was used to test the significant variation in the noise level among the selected T-junctions at different times of the day.

3. Results

Spatial variation of traffic noise level in Yenagoa Metropolis

The traffic noise levels at different road junctions in Yenagoa City in the morning, afternoon and evening revealed that the mean noise level was above 70 dB (A) in the morning in Berger, Along Berger – Imgbi Road, Swali Roundabout, Lambert junction, Imgbi junction, Ekeki, Okaka, Biogbolo, Opolo, Okutukutu School road, Tombia roundabout, Akenfa, Akenpai, Ede-Epie and Prosco. However, the noise was excessively high in Tombia Roundabout with mean value of 81.1 dB (A) and Ede-Epie with 80.8 dB(A). Road junctions like Oxbow Lake junction, Oxbow Lake, Berger Bayelsa Palm Road, Bayelsa Palm had noise level ranging from 53.3 to 58.0 dB (A) and the minimum noise level in the morning was observed in Oxbow Lake with a mean value of 53.3 dB (A).

Table 1: Spatial variation of traffic noise level in road junctions in Yenagoa Metropolis

Locations	Morning	Afternoon	Night	Total Mean±SD
	Mean±SD	Mean±SD	Mean±SD	
Berger	**78.9±8.6**	**72.1±8.6**	64.5±8.5	**71.8±10.1**
Along Berger – Imgbi	**72.8±3.9**	**72.9±5.5**	68.4±8.3	**71.4±6.2**
Along Berger – Imgbi Junction	69.8±6.4	68.1±6.1	**56.4±11.2**	64.8±9.8
Imgbi Roundabout	67.7±6.7	68.2±5.7	61.8±5.8	65.9±6.4
Imgbi Roundabout – Swali	65.8±3.7	61.2±11.5	**59.7±12.4**	62.2±9.7
Swali Roundabout	**75.3±2.9**	**75.3±2.3**	64.8±16.1	**71.8±10.3**
Swali Market	**76.5±4.6**	**78.6±2.5**	69.7±10.6	**74.9±7.5**
Swali – Oxbow Lake Road	65.9±11.8	62.1±7.9	62.3±17.6	63.4±12.4
Oxbow Lake Junction	**58.0±9.6**	**55.7±6.0**	62.5±11.9	**58.8±9.4**
Oxbow Lake	**53.3±5.1**	**48.7±9.2**	**52.0±9.8**	**51.3±8.1**
Berger Bayelsa Palm Road	**56.1±6.0**	**56.3±7.7**	**48.6±2.2**	**53.6±6.5**
Bayelsa Palm	**57.6±5.3**	**58.2±4.9**	**51.3±5.4**	**55.7±5.8**
Lambert Eradiri Roundabout	64.5±10.9	**58.1±9.7**	**54.2±11.6**	**58.9±11.0**
Hospital	65.4±5.3	67.1±4.8	69.2±7.6	67.2±5.9
FRSC	67.0±11.4	61.6±10.0	67.5±9.8	65.4±10.2
Lambert Junction	**74.1±2.7**	67.5±1.6	69.7±4.8	**70.4±4.2**
Imgbi Junction	**72.6±10.8**	69.7±8.8	**73.5±7.0**	**71.9±8.6**
Ekeki	**78.0±6.0**	**79.1±3.9**	**78.2±0.7**	**78.5±3.9**
Okaka	**76.1±5.1**	**72.9±4.4**	68.2±12.2	**72.4±8.2**
Nikton	67.1±12.9	67.1±13.4	**70.8±6.3**	68.3±10.2
INEC	67.3±9.8	65.1±6.7	69.4±6.3	67.3±7.5
Biogbolo	**74.8±5.0**	**72.3±2.5**	**76.7±2.7**	**74.6±3.8**
Opolo	**76.5±5.1**	**73.8±5.8**	**76.4±3.6**	**75.5±4.8**
Okutukutu School Road	**75.8±4.6**	**70.0±5.3**	62.0±15.6	69.3±10.9
Tombia Roundabout	**81.1±0.8**	**79.0±2.8**	**76.6±4.9**	**78.9±3.6**
Akenfa	**73.7±5.1**	**70.9±3.7**	68.1±13.3	**70.9±8.4**
Agudama-Epie	68.9±6.0	65.8±5.0	64.2±15.4	66.3±9.6
Akenpai	**71.9±6.6**	68.0±3.6	68.7±11.1	69.5±7.4
Okaki	66.8±11.5	60.5±10.6	63.2±8.4	63.5±10.0
Igbogene	67.7±5.4	65.7±3.3	**71.4±1.5**	68.3±4.3
Ede-epie	**80.8±3.4**	**59.3±8.5**	**79.8±1.8**	**73.3±11.3**
Prosco	**71.0±5.1**	68.7±4.7	63.9±9.3	67.9±7.0
Kpansia Market	67.9±4.6	66.3±7.0	65.7±8.5	66.7±6.5

F= 11.416; p=0.001

In the afternoon, noise levels was 70.0 dB (A) and above in Berger, Along Berger-Imgbi, Swali Round about, Swali Market, Ekeki, Okaka, Biogbolo, Opolo, Okutukutu School Road, Tombia Round about and Akenfa; but the higher noise level was discovered in Swali Market with a mean value of 78.6 dB (A), Ekeki with a mean value of 79.1 dB (A), Tombia roundabout with a mean value of 79.0 dB (A). The lower noise level in the afternoon was observed in junctions like Oxbow Lake junction (55.7dB (A)), Oxbow Lake (48.7 dB/A), Berger Bayelsa Palm Road (56.3 dB (A)), Bayelsa Palm (58.2 dB/A), Lambert Eradiri Roundabout (58.1 dB (A)) and Ede-Epie (59.3 dB (A)).

In the night, higher noise level was recorded in Imgbi junction (73.5 dB (A)), Ekeki (78.2 dB (A)), Nikton (70.8 dB (A)), Biogbolo (76.7 dB (A)), Opolo (76.4 dB (A)), Tombia Roundabout (76.6 dB (A)), Igbogene (71.4 dB (A)), and Ede-Epie (79.8 dB (A)) while lower noise level was found in Along Berger-Imgbi Junction (56.4 dB (A)), Imgbi Roundabout-Swali (59.7 dB (A)), Oxbow Lake (52.0 dB (A)), Berger Bayelsa Palm Road (48.6 dB (A)), Bayelsa Palm (51.3 dB (A)), and Lambert Eradiri Roundabout (54.2 dB (A)).

The total mean noise levels reveals that junctions with higher noise level included Berger (71.8 dB (A)), Along Berger-Imgbi Junction (71.4 dB (A)), Swali Roundabout (71.8 dB (A)), Swali Market (74.9 dB (A)). Lambert Junction (70.4 dB (A)), Imgbi Junction (71.9 dB (A)), Ekeki (78.9 dB (A)), Okaka (72.4 dB (A)), Biogbolo (74.6 dB (A)), Opolo (75.5 dB (A)), Tombia Roundabout (78.9 dB (A)), Akenfa (70.9 dB (A)) and Ede-Epie (73.3 dB (A)) while the lower noise level was found in Oxbow Lake Junction (58.8 dB (A)), Oxbow Lake (51.3 dB (A)), Berger Bayelsa Palm Road (53.6 dB (A)), Bayelsa Palm (55.7 dB (A)) and Lambert Eradiri Roundabout (58.9 dB (A)). Thus, the road junction with the highest noise level was Tombia Roundabout and the least was Oxbow Lake.

Analysis shows that 27.3% of total road junctions in Yenagoa City had noise intensity less than 65.0 dB (A) while 33.3% each had classes from 65-70 dB (A) and 33.3% also had classes from 71-76 (Table 2). However, road junctions with intensity of noise from 77-81 dB (A) were 6.1% (Table 2). This shows that 33.3% of the road junctions to be tolerable and low risk to noise pollution while only 6.1% had moderate risk. There was no road junction having high noise risk (76-81 dB (A)) and extremely high risk (76-81 dB/A).

Table 2: Traffic Noise Intensity in Yenagoa City

Intensity of Noise (dB (A))	Frequency	Percentage (%)
Less than 65.0	9	27.3
65-70	11	33.3
71-76	11	33.3
77-81	2	6.1
82-86	0	0
Greater than 86	0	0
Total	33	100

Temporal variation of traffic noise level in Yenagoa Metropolis

Table 3 presents the traffic noise levels across the days of the week in Yenagoa City. On Monday, the noise level, the range of noise level was 46.7-85.3 dB (A) and the mean noise level was 71.4 dB (A), in the afternoon, mean noise level was 69.1 dB (A) while in the evening, the mean noise level was 64.0 dB (A). On Tuesday, the mean noise levels in the road junctions in the morning in Yenagoa City was 70.7 b (A), afternoon 67.7 dB (A) and in the evening was 68.8 dB (A). On Wednesday, the noise level was highest in the morning (72.7 dB (A)) and least in the afternoon (67.7 dB (A)). On Thursday and Friday, the analysis shows that the mean noise level was higher in the morning while the least was observed in the evening. On Saturday, the mean noise level was highest in the afternoon (62.7 dB (A)) and the least was observed in the night (64.9 dB (A)). Generally, the total mean value of noise level was highest on Wednesday and the least was observed in Saturday. Generally, the noise level was highest in the morning and except Tuesday, Wednesday and Saturday, noise level was least in the night in road junctions of Yenagoa City (Figure 1).

The mean noise level in the morning with a mean value of 66.9 dB (A), afternoon had 69.9 dB (A) while in the night, it was 66.1 dB (A) (Table 4). The least noise level was found in the night while the highest noise level was observed in the afternoon.

Table 3: Traffic noise levels during the week per daytime in Yenagoa City

Days	Morning		Afternoon		Night		Total Mean Noise
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD	
Monday	46.7-85.3	71.4±8.6	37.7-81.4	69.1±8.8	40.7-78.8	64.0±11.3	68.2±10.1
Tuesday	49.7-83.0	70.7±8.3	49.7-82.0	67.7±7.9	42.9-78.3	67.8±8.9	68.8±8.5
Wednesday	55.1-82.1	72.7±7.1	44.4-79.6	68.6±8.5	46.5-81.6	69.6±9.1	70.4±8.4
Thursday	48.1-83.2	69.6±9.7	45.1-78.9	65.1±9.1	34.0-82.2	61.5±15.0	65.4±11.9
Friday	50.3-85.6	69.7±10.0	49.4-86.3	67.9±9.1	42.3-82.3	66.7±11.8	68.1±10.4
Saturday	42.9-81.0	65.3±11.2	42.5-81.5	62.7±11.6	41.4-81.8	66.6±11.7	64.9±11.6

(F=7.823, p=0.001)

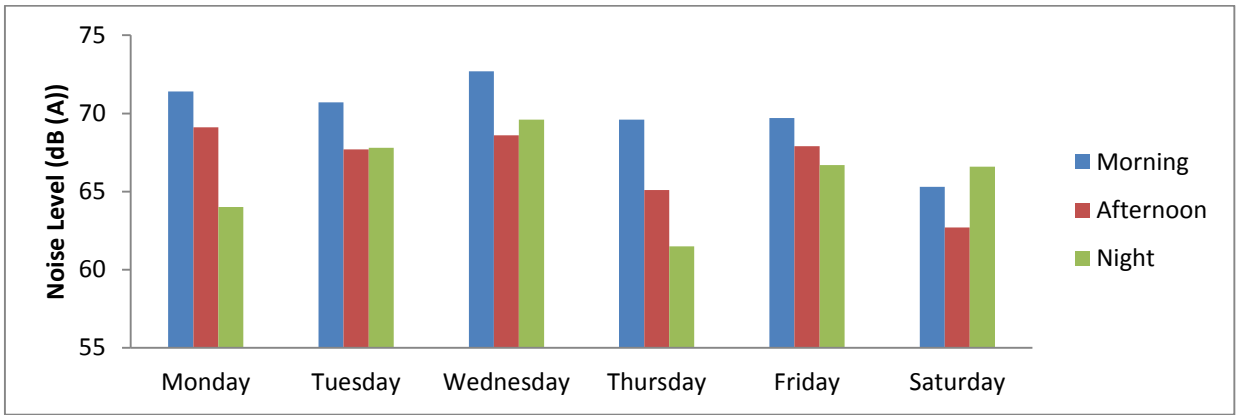

Figure 1: Variation of noise levels at different days of the week

Table 4: Traffic noise level in road junctions in the morning, afternoon and evening

Time of the day	Minimum	Maximum	Mean±SD
Afternoon	37.70	86.30	66.8±9.4
Morning	42.90	85.60	69.9±9.5
Night	34.00	82.30	66.1±11.6

Spatial variability of traffic noise levels in the morning in Yenagoa City

The spatial variability of traffic noise level and the isonoise (places of equal noise level) in the morning in Yenagoa City is shown in Figure 2 and Figure 3. The noise level was highest around Tombia junction, Berger, Okaka and Swali. The noise level was mild at Okaki, Igbogene, INEC and Kpansia areas. More than 60.0% of Yenagoa City experienced noise level between 70.6 dB (A) and 75.2 dB (A) in the morning (Table 5).

Table 5: Traffic noise level variation in the morning in Yenagoa City

Noise Levels (dB (A))	Area (Sq km)	Percentage (%)
53.4-61.0	4.8	2.9
61.1-65.4	7.4	4.5
65.5-68.6	16.4	9.9
68.7-70.5	21.0	12.7
70.6-72.1	34.1	20.6
72.2-73.5	38.0	23.0
73.6-75.2	22.2	13.4
75.3-77.4	16.8	10.2
77.5-81.1	4.5	2.7
Total	165.2	100.0

Table 6: Traffic noise level variation in the afternoon in Yenagoa City

Noise Levels (dB (A))	Area (Sq km)	Percentage (%)
48.7-58.8	3.5	2.1
58.9-61.7	7.3	4.4
61.8-64.1	8.6	5.2
64.2-66.2	14.5	8.8
66.3-67.8	28.7	17.4
67.9-69.0	46.7	28.3
69.1-70.5	42.0	25.4
70.6-73.1	12.2	7.4
73.2-79.1	1.8	1.1
Total	165.2	100.0

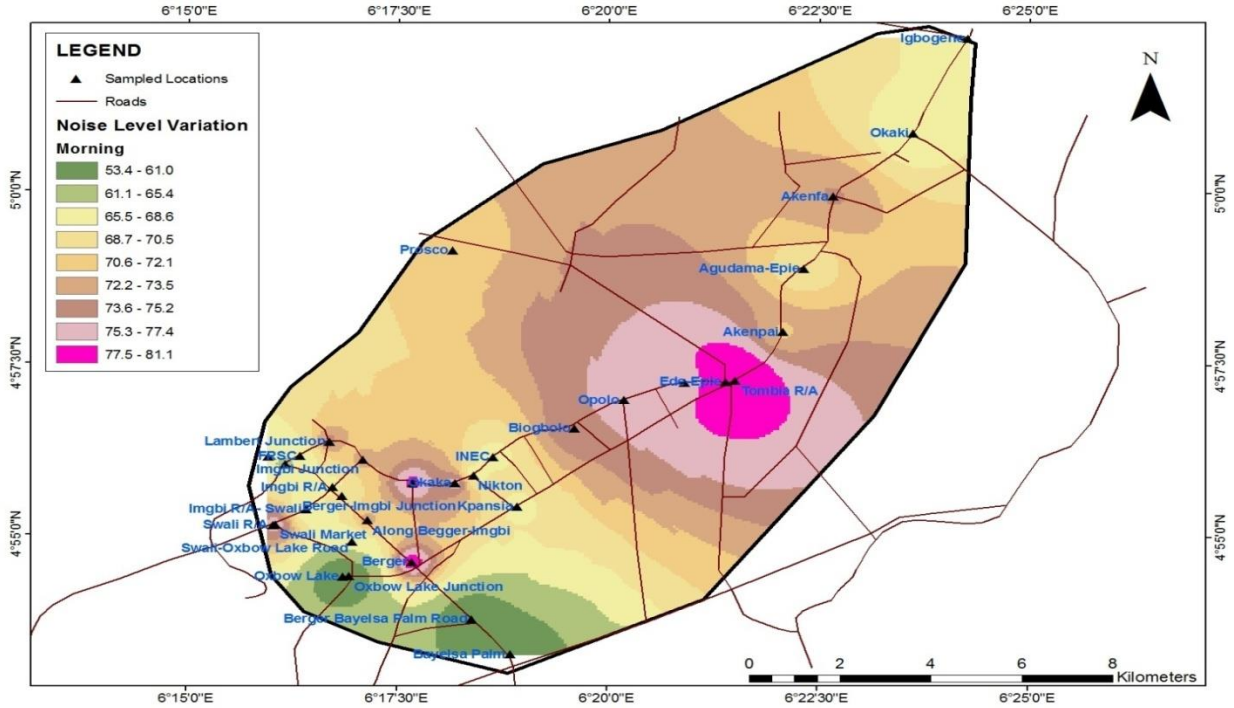

Figure 2: Spatial traffic noise level variation in the morning

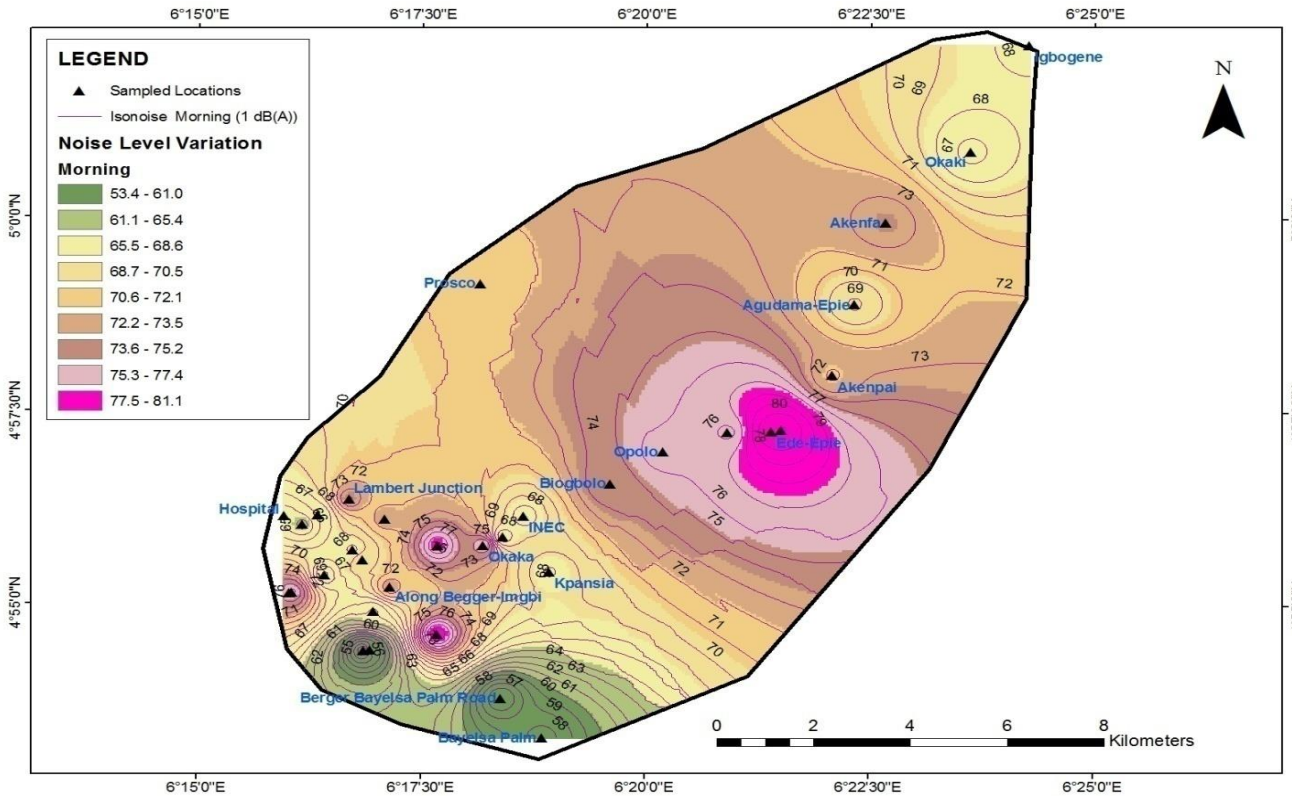

Figure 3: Traffic Isonoise in the morning in Yenagoa City

Spatial variability of traffic noise levels in the afternoon in Yenagoa City

Analysis shows that traffic noise levels in the afternoon in Yenagoa City was highest in Tombia roundabout, Opolo, Okaka and Swali area while the least was gotten in areas like Berger Bayelsa Palm R/about, Oxbowlake and Bayelsa Palm (Figure 4; Figure 5). It is shown that 53.7% of the Yenagoa City was within the noise brackets of 67.9 and 70.5 dB (A) (Table 6).

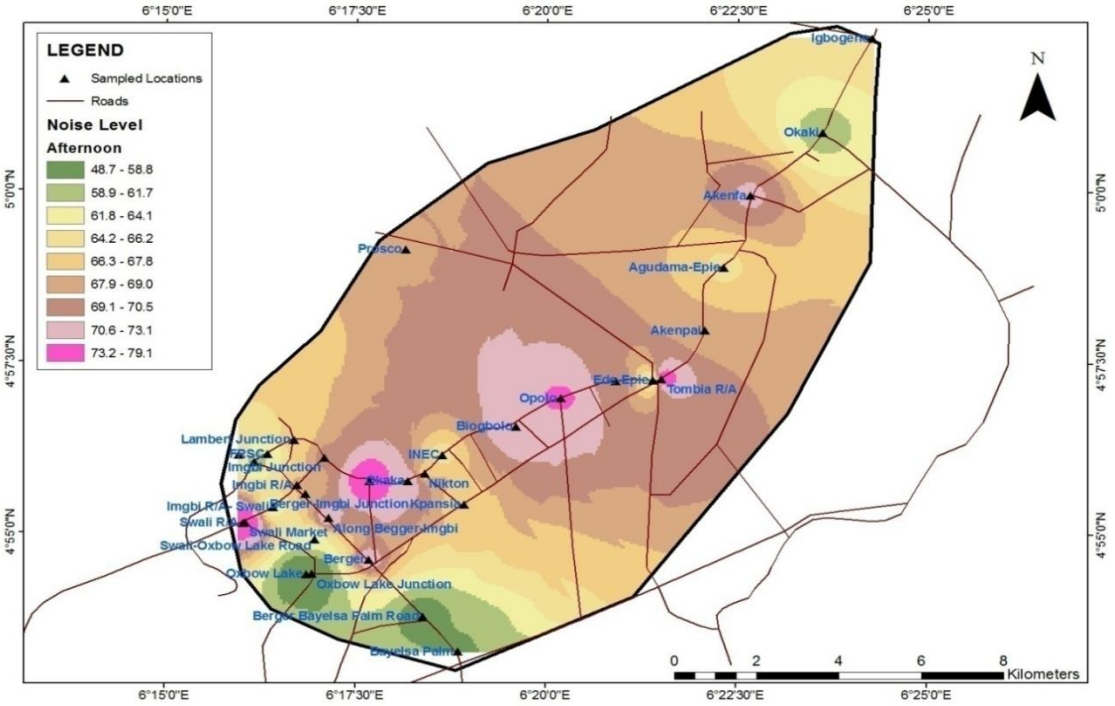

Figure 4: Spatial traffic noise level variation in the afternoon

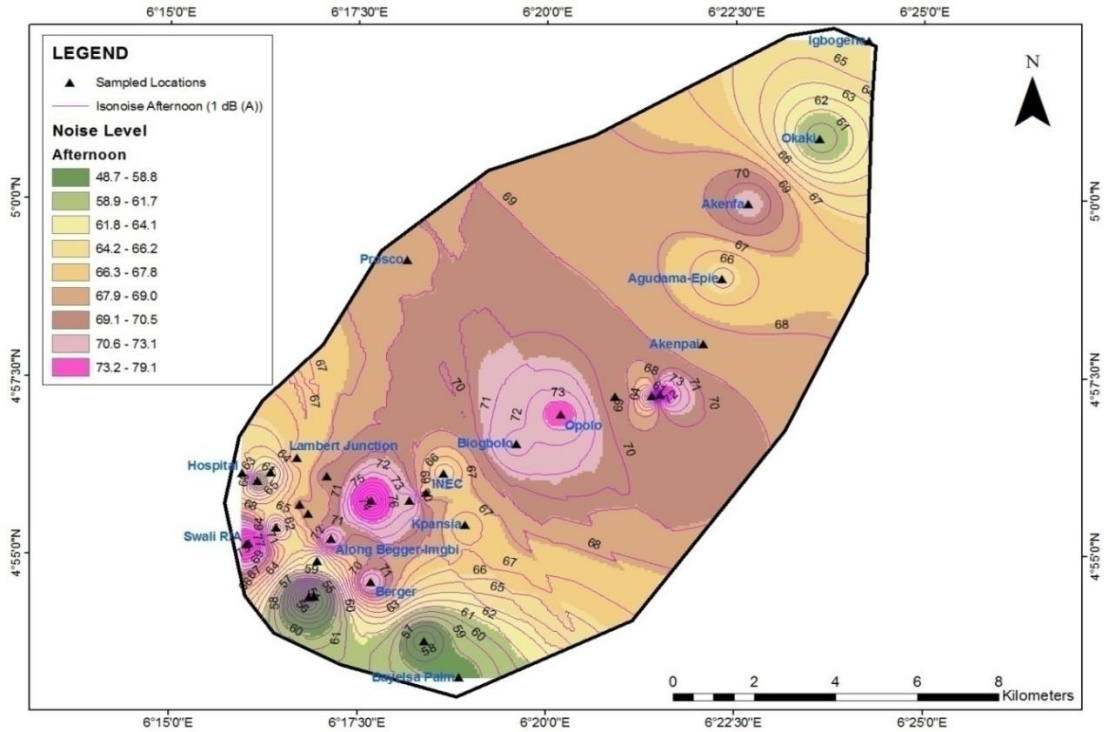

Figure 5: Traffic isonoise in the afternoon in Yenagoa City

Spatial variability of traffic noise levels in the night in Yenagoa City

The spatial variability of traffic noise level and the traffic Isonoise in the night in Yenagoa City is shown in Figure 6 and Figure 7 respectively. It is shown that in the night the noise level was very high around Tombia junction, Opolo, Biogbolo and Okaka. The noise level was low around Oxbow Lake and Bayelsa Plam. It is also recorded that about 71.3% of Yenagoa City experienced noise level between 63.7 dB (A) and 71.4 dB (A) in the night (Table 7).

Table 7: Traffic noise level variation in the night in Yenagoa City

Noise Levels (dB (A))	Area (Sq km)	Percentage (%)
48.6-55.8	4.1	2.5
55.9-60.4	7.8	4.7
60.5-63.6	8.9	5.4
63.7-66.1	18.3	11.1
66.2-68.0	36.3	22.0
68.1-69.6	34.6	21.0
69.7-71.4	28.4	17.2
71.5-73.8	19.5	11.8
73.9-79.6	7.3	4.4
Total	165.2	100.0

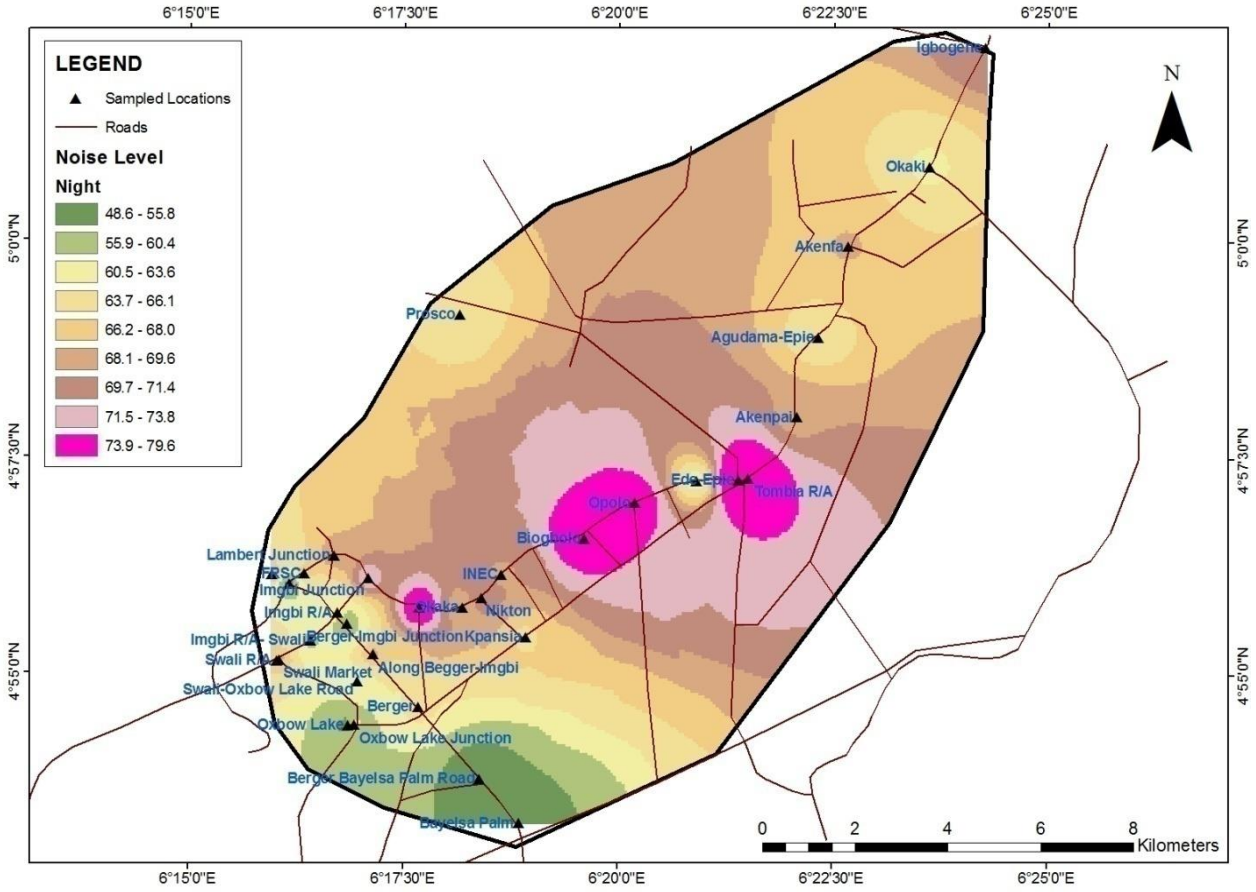

Figure 4.6: Spatial variation of traffic noise levels in the night in Yenagoa City

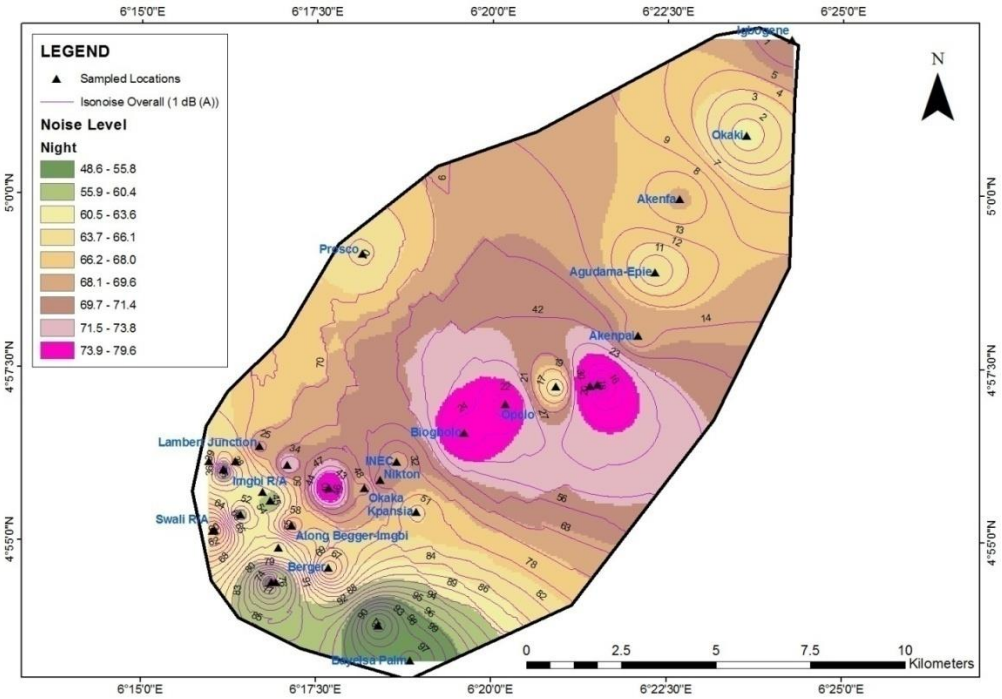

Figure 4.7: Traffic isonoise in the night in Yenagoa City

Overall traffic noise levels in Yenagoa City

Overall analysis of traffic noise levels in Yenagoa City was highest in Tombia Roundabout, Opolo, Biogbolo and Okaka while places like Okaki, Igbogene, Berger and Oxbow Lake area had lower noise level (Figure 8; Figure 9). It was found that noise levels ranging from 67.4 dB (A) to 73.3 dB (A) covered about 73.3% while the least and highest covered only 2.7% and 5.3% of the total area in Yenagoa City (Table 8).

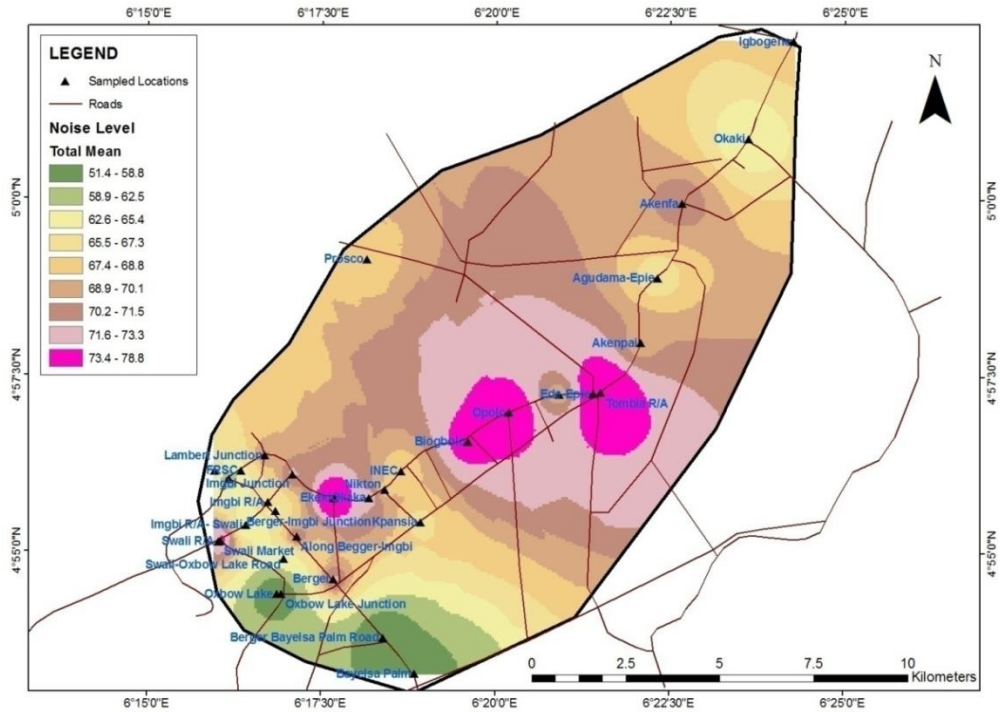

Figure 8: Overall spatial variation of traffic noise levels in Yenagoa City

Table 8: Overall traffic noise level variation in Yenagoa City

Noise Levels (dB (A))	Area (Sq km)	Percentage (%)
51.4-58.8	4.4	2.7
58.9-62.5	7.1	4.3
62.6-65.4	9.1	5.5
65.5-67.3	13.8	8.4
67.4-68.8	27.3	16.5
68.9-70.1	37.8	22.8
70.2-71.5	31.9	19.3
71.6-73.3	25.1	15.2
73.4-78.8	8.7	5.3
Total	165.2	100.0

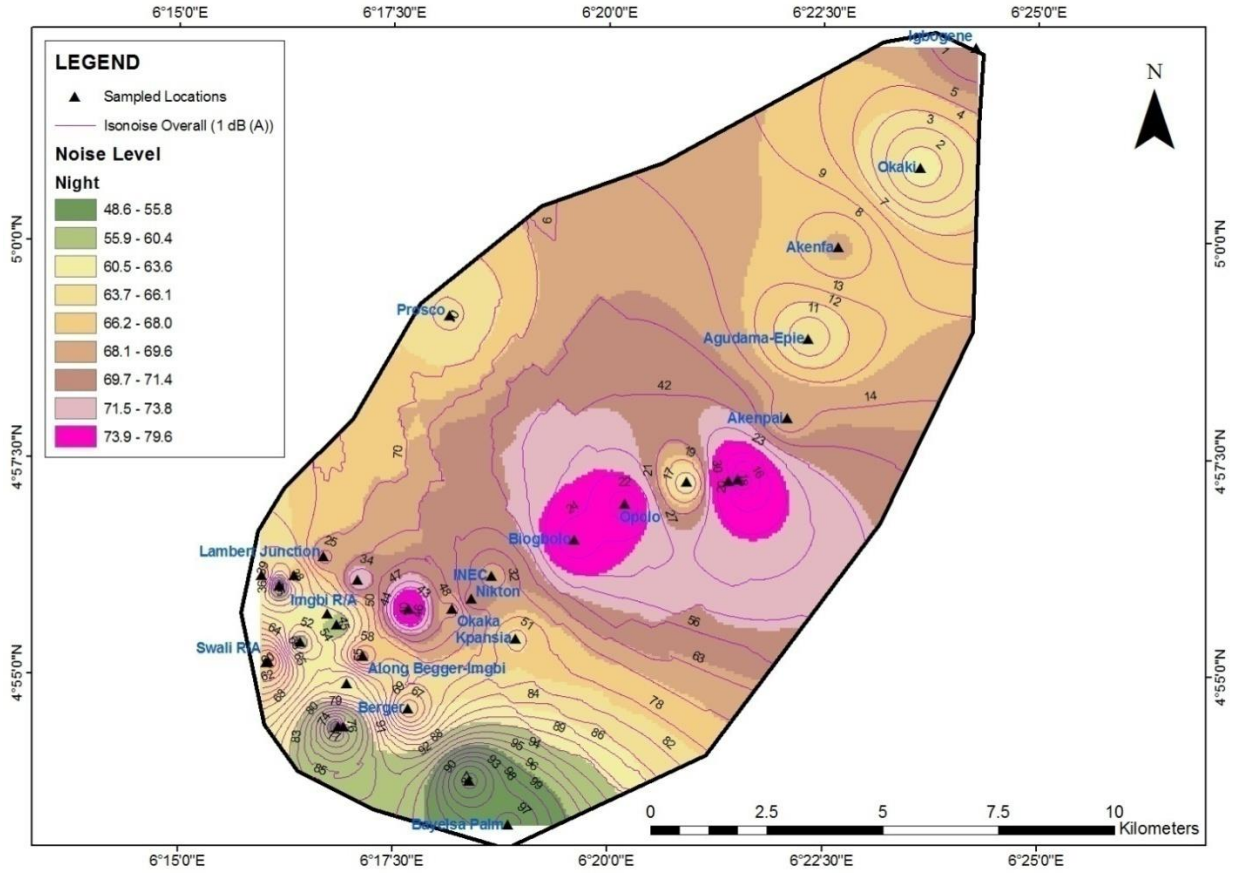

Figure 9: Overall traffic Isonoise in Yenagoa City

Traffic noise risk level in the morning in Yenagoa City

The traffic noise risk levels of road junctions in the morning in Yenagoa City presented in Table 9 shows that 7.7% of the Yenagoa City were safe, 38.9% were tolerable, 38.6% had low risk while 14.9% were moderately risked with noise pollution. No place was found to be neither highly risked nor extremely high risk in the morning. This shows that more than 80% of Yenagoa City were below good for habitation by man with respect to noise pollution in the morning. The moderately noise risk areas included Tombia Roundabout, Ede-Epie, Opolo, Berger, Okaka and Swali Roundabout while the low noise risk areas included Akenpai, Lambert Junction and areas tolerable included Prosco, INEC, and Nikton (Figure 10).

Table 9: Traffic noise risk level in the morning in Yenagoa City

Noise Risk Level	Area (Sq. Km)	Percentage (%)
Safe	12.69	7.7
Tolerable	64.19	38.9
Low Risk	63.73	38.6
Moderate Risk	24.59	14.9
High Risk	-	-
Extremely High Risk	-	-
Total	165.2	100.0

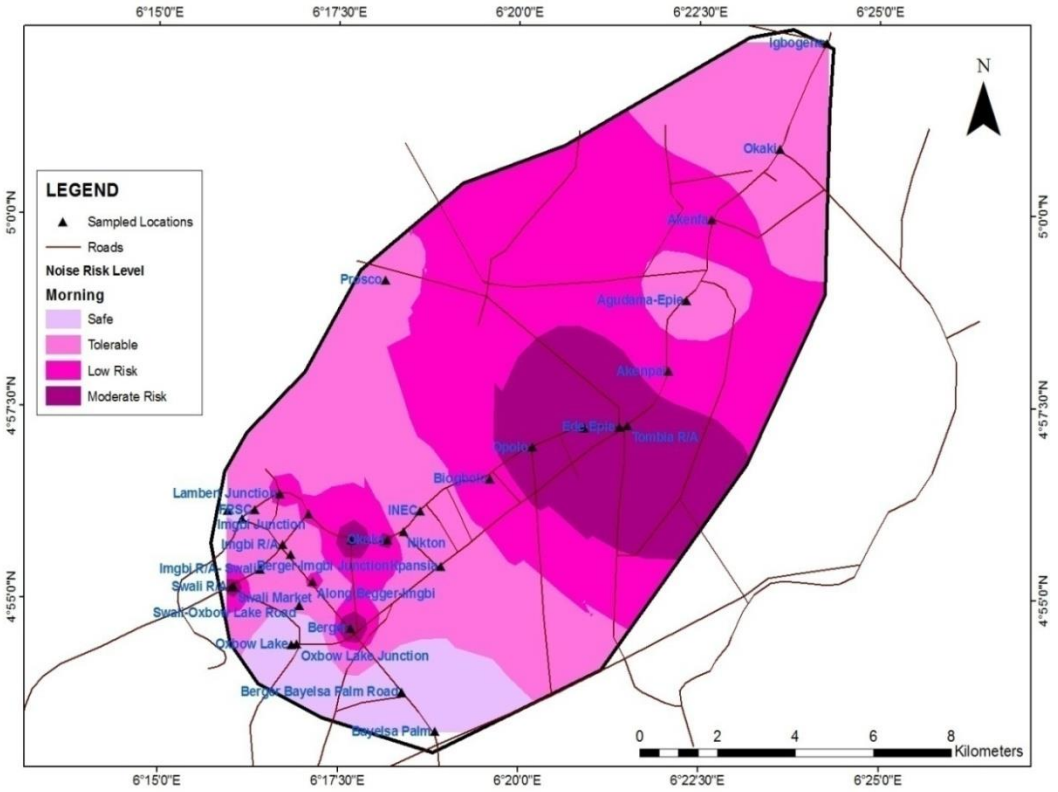

Figure 10: Traffic noise level risk zones in the morning

Traffic noise risk level in the afternoon in Yenagoa City

The traffic noise levels in the afternoon in Yenagoa City presented in Table 10 reveals that 10% of Yenagoa City were safe, 82.4% were tolerable and 7.6% were lowly risked. The analysis also shows that communities like Opolo, Biogbolo, Tombia Roundabout, Akenfa, Berger and Swali are lowly noise risk areas while areas like Akenpai, Prosco, INEC, Ede-Epie were tolerable in the afternoon and Okaki, Oxbow Lake and Bayelsa Palm were safe of noise pollution in the afternoon in Yenagoa City (Figure 11).

Table 10: Traffic noise risk level in the afternoon

Noise Risk Level	Area (Sq. Km)	Percentage (%)
Safe	16.45	10.0
Tolerable	136.19	82.4
Low Risk	12.56	7.6
Moderate Risk	-	-
High Risk	-	-
Extremely High Risk	-	-
Total	165.2	100.0

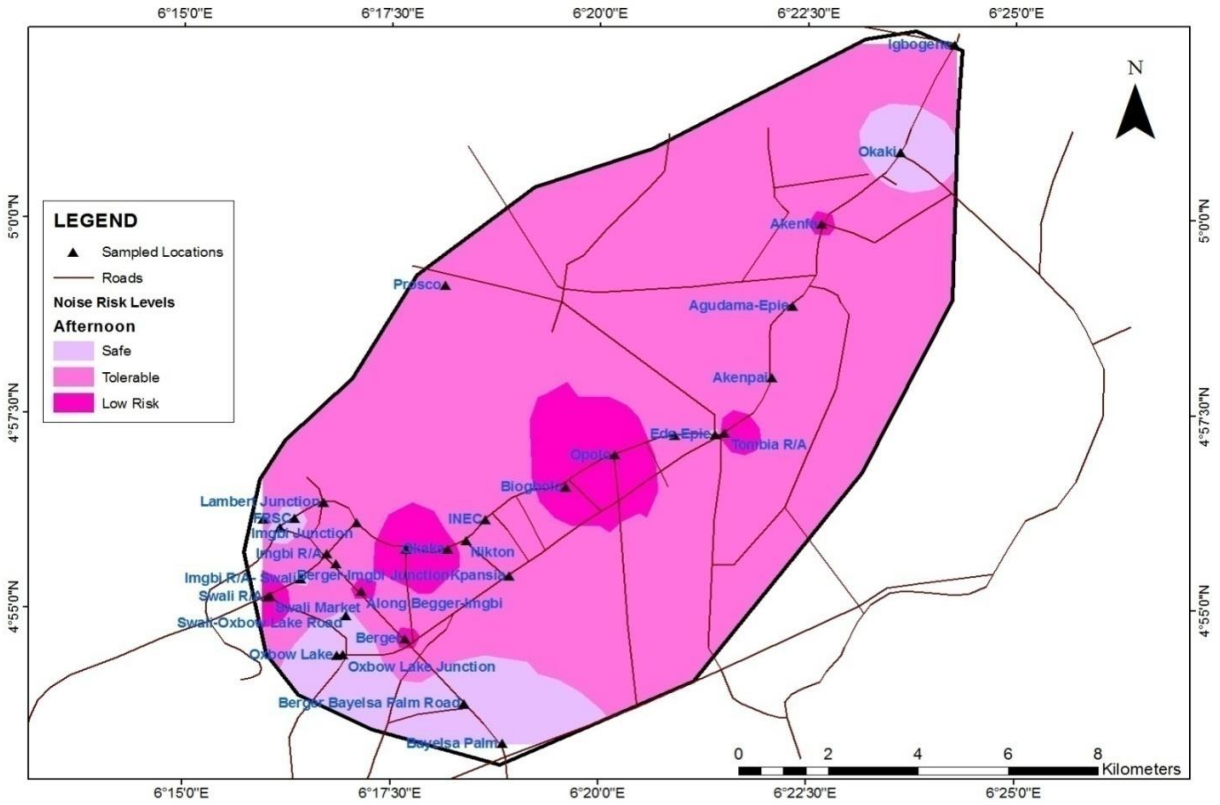

Figure 11: Traffic noise risk level in the afternoon

Traffic noise risk level in the night in Yenagoa

The traffic noise risk levels in the night in Yenagoa City reveals that 22% of Yenagoa City were safe with respect to noise risk levels in the night, 41.7% were tolerable, 35.6% had low risk and 0.7% were moderately risked (Table 11). However, areas such as Okaki, Agudama-Epie, Prosco, Oxbow Lake, and Bayelsa Palm were safe, Akenfa. Lambert junction, Akenfa, Kpansia, and Imgbi junction were tolerable, Opolo, Biogbolo, Okaka and Igbogene were lowly risked while Tombia junction and Ede-Epie were moderately risked (Figure 12).

Table 11: Traffic noise risk level in the night

Noise Risk Level	Area (Sq. Km)	Percentage (%)
Safe	36.30	22.0
Tolerable	68.86	41.7
Low Risk	58.89	35.6
Moderate Risk	1.15	0.7
High Risk	-	-
Extremely High Risk	-	-
Total	165.2	100.0

Table 12: Overall traffic noise risk level in Yenagoa City

Noise Risk Level	Area (Sq. Km)	Percentage (%)
Safe	34.45	20.9
Tolerable	65.06	39.4
Low Risk	56.90	34.4
Moderate Risk	8.72	5.3
High Risk	-	-
Extremely High Risk	-	-
Total	165.12	100.0

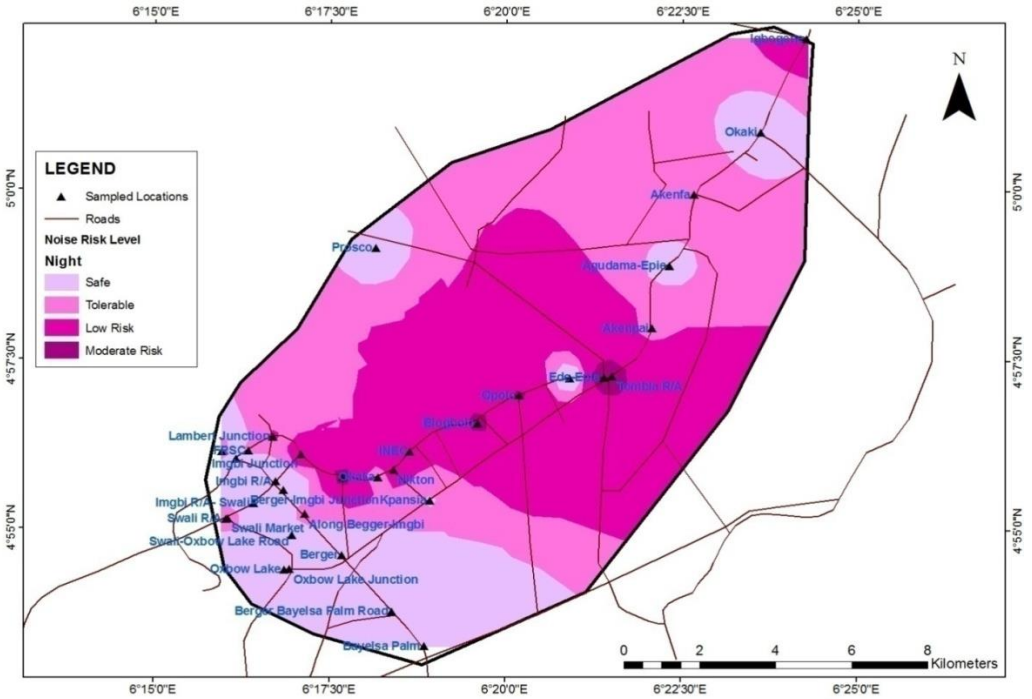

Figure 12: Traffic noise Risk Level in the night in Yenagoa City

Overall traffic noise risk level in Yenagoa

The overall assessment of traffic noise risk zones in Yenagoa City shown in Table 12 reveals that 20.9% of Yenagoa City were safe, 39.4% were tolerable, 34.4% were lowly risked while 5.3% were moderately risked. Nevertheless, the areas such as Okaki, Oxbow Lake, Bayelsa Palm, and Agudama-Epie were safe, Prosco, INEC, Akenpai, Nikton and Igbogene were tolerable, Akenfa, Berger, Swali Roundabout, and Swali Market were lowly risked while Tombia Roundabout, Ede-Epie, Opolo, and Biogbolo were moderately risked (Figure 13).

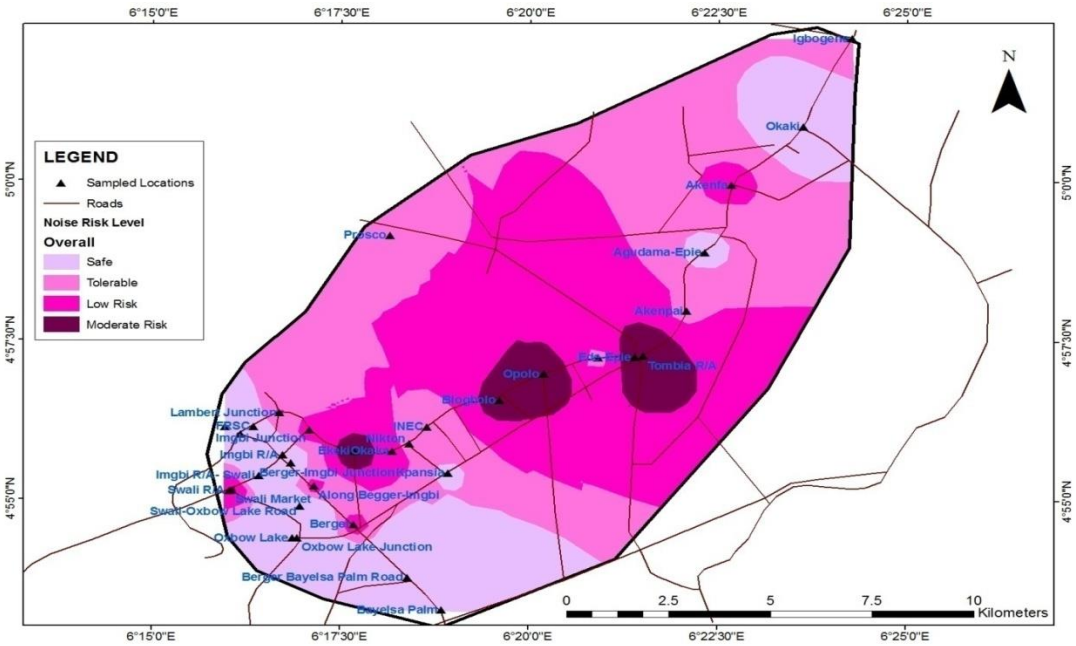

Figure 13: Traffic noise risk level in Yenagoa City

4. Discussions

Findings show that the noise level was above 70 dB (A) in many junctions such as Berger, Swali Roundabout, Ekeki, Okaka, Biogbolo, Opolo, Okutukutu School road, Tombia roundabout, Akenfa, Akenpai, Ede-Epie and Prosco which is above the maximum limit given by the WHO. According to Iaaly-Sankari *et al.* (2012) reported that the sound level of the traffic areas should not be higher than 70% and as a result, the critical health problem in these places may be hearing impairment (Iaaly-Sankari *et al*., 2012). In addition, noise induces hearing loss gradually, imperceptibly, and often painlessly (Corra, 2009). Babisch (2008) and Kaltenbach et al., (2008) quantified the evidence linking chronic noise to adverse health impacts in a dose-effect relationship. A significant increase in the risk of hypertension of 1.14 (95% CI = 1.01-1.29) for a 10 dB(A) difference of aircraft noise during the night (Lnight) was found (Jarup *et al.*, 2008).

The noise levels was generally lower in Oxbow Lake junction, Oxbow Lake, Berger Bayelsa Palm Road, Bayelsa Palm the traffic noise level. This may be due to lower traffic congestion observed in these places. Generally, the noise level in the night was the least among the times of the day. This may be attributed to less activities being carried out in the night by the individuals. Moreover, the higher road traffic noise during the day may be attributed sometimes to other sources of noise levels.

5. Conclusion and Recommendations

The study has revealed the traffic noise levels at different road junctions in Yenagoa City whereby places around Tombia Roundabout, Opolo, Biogbolo and Okaka experienced higher traffic noise pollution while places like Okaki, Igbogene, Berger and Oxbow Lake area had lower traffic noise level. Vehicular noise pollution was highest in the afternoon and least in the night. The noise risk zones in Yenagoa City ranged between tolerable (66-71 dB (A)) and moderately risked (76-81dB (A)). The total mean value of noise level was highest on Wednesday and the least was observed in Saturday. The study therefore recommended that there should be a control of traffic noise level in the areas like Tombia junction, Okaka, Opolo and Biogbolo so that the traffic noise levels in these places will not be extremely high and people residing or working in the moderately noise risked zones are advised to use ear-protection aids like ear plugs, ear-muffs, noise helmets, head phones to reduce the effects of noise in the health of their body system.

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