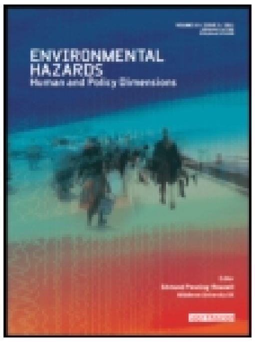

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ENVIRONMENTAL HAZARDS
Human and Policy Dimensions

Mapping of noise risk zones derived from religious activities and perceptions in residential neighbourhoods in the Cape Coast metropolis, Ghana

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Ambient noise levels emanating from religious activities in residential neighbourhoods are an emerging environmental problem that educes little attention from enforcement agencies and policy makers in Ghana. This paper set out to quantify religious noise exposure in urban residential neighbourhoods in the Cape Coast metropolis of Ghana. Subjective annoyance levels of residents in selected communities were determined. Noise risk zones were mapped using ARCGIS 9.3 software and surface interpolation for the data was carried out using inverse distance weighting. The results show that most (77 and 86 per cent) of the locations recorded noise levels that were above the Ghana Environmental Protection Agency maximum permissible limit for day and night, respectively. Pearson's correlation coefficient for day and night noise exposure shows strong association (0.714) at the 0.01 level. There is variability in the levels of noise for both day and night, which are rather high (standard deviation = 7.59477 and 7.94022, respectively). Generally, levels of noise exposure correlated with levels of annoyance of residents, except that the highest noise exposure was not recorded in the community where the annoyance level of residents was highest. Residential neighbourhoods within the study area largely experienced safe to tolerable levels of religious noise, although 5 per cent were within the high-risk zone. Given that the selected residential areas have high population densities, even when the dispersion of noise risk is spatially limited, it affects a large number of people who belong to different socio-economic classes.

Keywords: environmental hazard; geographical information systems; interpolation; religious noise exposure; risk zones

1. Introduction

Ambient noise is an environmental problem. Consequently, ambient noise is often used interchangeably with environmental noise. The Ghana Environmental Protection Agency (EPA) describes noise pollution as the sleeping volcano of environmental issues lagging behind air and water pollution on the political agenda. As a result of alarming proportions of noise levels, the Ghana EPA has mounted a vigorous public education campaign to draw the attention of the Ghanaian public to the harmful effects of noise. It has also declared 14 April of every year as 'Noise Awareness' day. The Ghana EPA had set the ambient noise level guidelines in residential areas with negligible or infrequent transportation at 55 decibels (dB) from 0600 to 2200 h and at 48 dB from 2200 to 0600 h. It asserts that noise levels above 45 dB impair sleep while noise levels of 70 dB lead to emotional upset, irritability and other tensions. Any noise level above 90 dB may cause damage to the ear either temporarily or permanently. Noise can affect the

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circulatory, digestive and nervous systems, and even vision. In response to several complaints of noise-making in residential settings, the EPA has reiterated the need to implement the EPA Act (490) of 1994 to improve and enhance the effectiveness of the agency and the district, municipal and metropolitan assemblies in the enforcement of rules on noise pollution. A section of this act mandates the EPA to issue notice in the form of directives, procedures or warnings to any other person or body for the purpose of controlling the volume, intensity and quality of noise in the environment. However, it is unclear how many community-level religious organizations are aware of this regulation. It is also unclear how many such institutions are aware of the penalty for violating this regulation.

The building of religious meeting places in residential neighbourhoods is widespread in Ghana compared to the number of residential buildings per locality. This could be attributed to the fact that the regulations governing land-use planning were either not in place or not enforced. There are three broad categories of noise, namely transport noise, occupational noise and neighbourhood noise (Kumar De and Kumar De, 2005). Hitherto much attention has been accorded to transport and occupational noise. Lately, however, the attention of the public is being drawn particularly to noise from religious establishments in residential neighbourhoods. In this paper, we refer to this kind of noise as *religious noise*. In this context, religious noise may be defined as any unwanted, unpleasant sound that emanates from religious activities. The components of religious noise could be related in this paper as mosque call, ringing of church bells, clapping of hands, loud prayers, chanting, singing, mobile preaching, drumming and dancing in churches, and the use of loudspeakers and microphones in mosques and churches. According to Constable (2010), attempts at regulating religious noise date back to medieval times. The Ghana EPA has demonstrated its disapproval of such noise-making in residential neighbourhoods by directing that environmental impact assessments of religious meeting places to be sited in residential neighbourhoods must necessarily account for the intended noise levels that will ensue from the operations of such facilities.

Interestingly, notwithstanding the adverse effects that noise could potentially confer on individuals, the perceptions of residents on the desirability or otherwise of religious noise in Ghanaian communities are mixed. While some residents have indicated their annoyance about the phenomenon, others maintain that regardless of the levels of religious noise they still consider it to be very desirable. This dichotomy indicates that perceptions of individuals in residential neighbourhoods regarding noise levels are subjective. We chose to study noise from religious institutions because according to the Ghana EPA, they are growing more rapidly than other sources of pollution. Not much has been done in Ghana on any scale to quantify and map noise risk zones based on religious activities. In this sense, this paper is original. The objective of the study was therefore to measure the levels and distributions of religious noise in residential neighbourhoods and to ascertain the perceptions of residents of the noise levels generated by religious activities in these communities.

Specifically, the study set out to:

- measure the levels of religious noise in selected communities in the Cape Coast metropolis;
- compare the levels of religious noise measured in the selected communities to the Ghana EPA maximum permissible day and night noise levels for residential neighbourhoods;
- compare the levels of religious noise exposure with the perceptions of residents;
- construct noise maps and zone the residential neighbourhoods as safe, tolerable, low risk, moderate risk and high risk, based on their exposure to variable noise levels.

2. State of knowledge on noise pollution

What any individual considers as noise depends on many variables, among them one's background, mood and occupation. Location and hearing ability are also important determinants, as are time of the day, the duration and volume of a sound, and other factors (Berglund and Lindvall, 1995; Chiras, 2001). In comparison to other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on humans and of dose–response relationships as well as a lack of defined criteria (Berglund et al., 2000). Yet, there is growing international consensus on what constitutes unacceptable noise levels. The World Health Organization (WHO) and the Organisation for Economic Co-operation and Development (OECD) have led the field regarding data collection and the development of assessments of the effects of exposure to environmental noise. Unlike many other environmental problems, noise pollution continues to build up, attended by a mounting number of complaints from affected individuals. According to Berglund and Lindvall (1995), on the whole, people are characteristically exposed to several noise sources, with road traffic noise being the foremost source. Population growth, urbanization and to a large extent technological development are the central driving forces, and future enlargements of highway systems, international airports and railway systems will exacerbate the noise problem.

From a global perspective, the growth in urban environmental noise pollution is increasingly problematic because it involves direct and cumulative adverse effects on health. It also adversely affects future generations by degrading residential, social and learning environments, with analogous economic losses. Consequently, noise is not just a local problem, but a global issue that affects everyone (Lang, 1999; Sandberg, 1999) and calls for precautionary action in any environmental planning situation. Noise has miscellaneous effects on humans. It interrupts conversations with family, friends and co-workers, causing increased tension – not only because the sufferer cannot understand what is being said, but also because deafened individuals may talk annoyingly loud. In residential neighbourhoods, noise has profound effects on sleep. It prevents individuals from falling asleep as soon as desired or may keep them from sleeping at all (Smith and Enger, 1998). It may wake individuals during the night or may alter the quality of sleep, leaving them irritable (Chiras, 2001). Apart from depriving people of sleep and deafening them, it is also linked to a variety of other ailments, ranging from nervous tension and headaches to neuroses (Klæboe et al., 2008). It may also cause blood vessels to constrict (which reduces blood flow to key body parts) and sometimes causes seizures in epileptics (Smith and Enger, 1998). Persons affected by noise could potentially suffer from gastric spasms, nausea and peptic ulcers (Murthy, 2008). It affects developing embryos and impairs the development of the central nervous system of unborn babies. It may also cause increased heart rate and raised blood pressure by increasing the level of cholesterol in the blood. It causes dilation of the eye pupil, defective eyesight and defective colour vision (Murthy, 2008). However, it is essential to state that these adverse effects only set in with very high levels of pollution.

A geographical information system (GIS) is being used to monitor and forecast noise pollution patterns in many countries around the globe. It has been widely used in environmental modelling and analysis, including noise pollution monitoring in the global north. GIS could be an indispensable tool for noise analysis and management even in developing countries such as Ghana, although its potential remains largely unexplored. In addition to its powerful capabilities in spatial database development, spatial data processing, managing and modelling, it provides visualization and map-making tools that can be used to effectively present the spatial variability of noise intensity.

3. Materials and methods

3.1. Study area

This includes a location map with (i) the central region in Ghana, West Africa, and (ii) the study area, Cape Coast, with sampled communities.

3.2. Data collection

The study was carried out in residential neighbourhoods in 10 suburbs of Cape Coast where the density of places of worship is high (Figure 1). The areas sampled were Amamoma, Apewosika, Kokoado, Kwaprow, Chapel Square, Royal Lane, Antem, Abura, Esuekyir and Kakumdo. The communities were selected based on parameters such as density of religious activities, human density, location and sociodemographics. The fieldwork encompassed two tasks: measurement of outdoor noise levels and assessment of risk perception of residents in each community. First and foremost, a Garmin Etrex hand-held global positioning system (GPS) was used to obtain the coordinates of the residence of the respondents and the churches and mosques within each community. A precision-grade sound level meter RION NL-22 (Higashimotomachi, Tokyo, Japan) was used to measure the noise levels generated from the churches, mosques and residences of the respondents. The device conforms to International Electrotechnical Commission 61672-1:2002. The instrument was calibrated by an internal sound level calibrator before making measurements at each site. *L*Ai (A-weighted instantaneous sound pressure level) measurements were recorded at intervals of 30 s for a period of 30 min, giving 60 readings per sampling location. This procedure was carried out for day (0600–2200 h) and night (2200–0600 h) measurements. The A-weighted equivalent sound pressure level (*L*Aeq), the daytime average sound level (*L*D), the day–night average sound level (*L*DN), the noise pollution level (*L*NP) and the traffic noise index (TNI) were consequently computed. The noise produced from

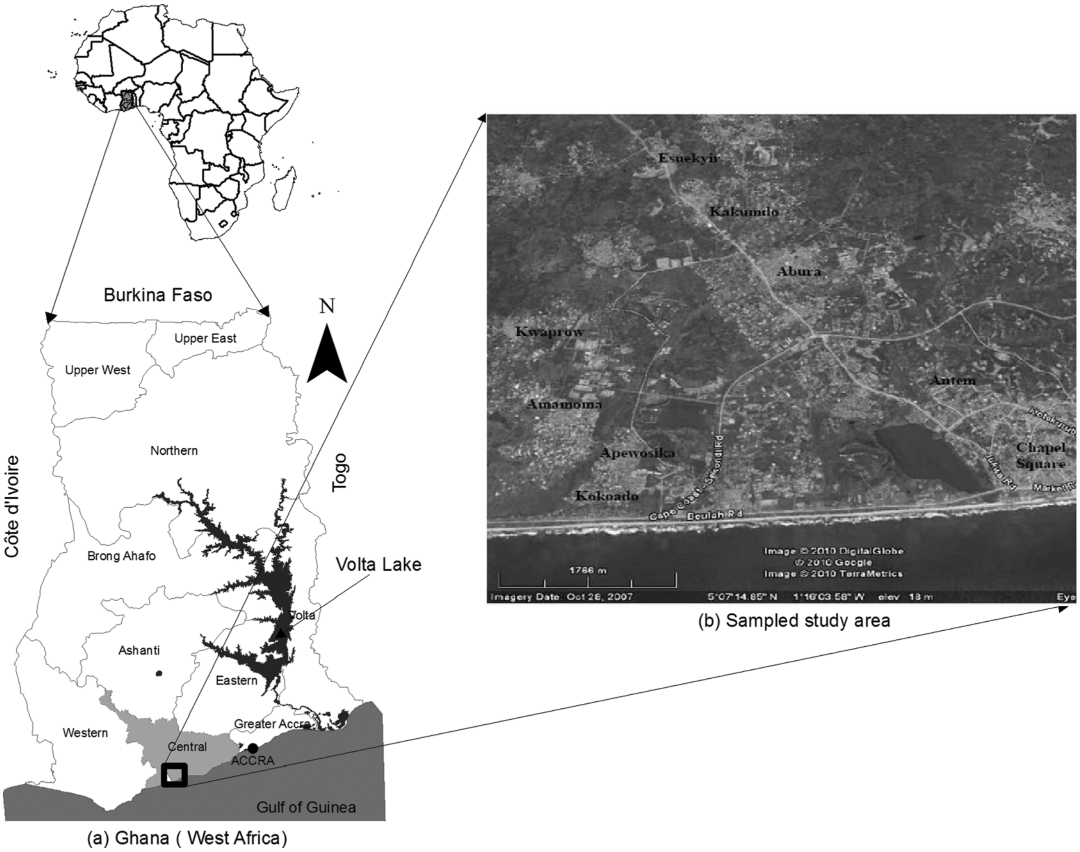

FIGURE 1 Location map with (a) the central region in Ghana, West Africa, and (b) the study area, Cape Coast, with sampled communities

these sources was compared with the ambient noise level guidelines (Table 1) of the Ghana EPA to verify compliance. For each location the noise levels were recorded for low and peak values, and the average noise level was computed. This was done in cognisance of the fact that noise is transient and that noise levels within localities will be varying all the time. The obtained values represented the exposure values of the same site.

Secondly, qualitative data were collected by administering a semi-structured questionnaire (designed to obtain demographic and noise perception-related information) to individuals living within a 100 m radius of a church or mosque. It must be stated that the study emphasized the evaluation of a single noise source: religious activities. Some respondents filled in the questionnaire on their own while others were interviewed. The study population included people of both sexes within the age group of 13–70 years and capable of providing authentic information for the study. In all, 179 respondents were interviewed (Figure 2). Although 200 prospective respondents were contacted, 21 declined to be interviewed. Individuals who declined to be interviewed claimed either lack of interest or time. The churches and mosques were selected by convenient sampling technique. Selections were based on those that could be accessed within the time, material and financial resource limit.

The questionnaires comprised 25 questions divided into two main sections. The first section contained general sociodemographic questions about the respondent's age, gender, employment, home ownership, length of residence, daily duration of stay at home, house structure and orientation of living room/bedroom windows, among others. The second section included noise-related questions, in which noise irritation arising from religious noise was measured using one international standardized scale, which was created following the International Commission on the Biological Effects of Noise (ICBEN) method: a five-point Likert scale ('extremely annoyed' = 5, 'very annoyed' = 4, 'moderately annoyed' = 3, 'slightly annoyed' = 2 and 'not at all annoyed' = 1). Questionnaires were checked

TABLE 1 Ambient noise-level guidelines of the Ghana EPA

Zone	Description of area of noise reception	Permissible noise level dB (A)	
		Day (0600–2200 h)	Night (2200–0600 h)
A	Residential areas with negligible or infrequent transportation	55	48
B1	Educational (school) and health (hospital) facilities	55	50
B2	Area with some commercial or light industry	60	55
C1	Area with some light industry, place of entertainment, or public assembly and place of worship such as churches and mosques	65	60
C2	Predominantly commercial areas	75	65
D	Light industrial areas	70	60
E	Predominantly heavy industrial areas	70	70

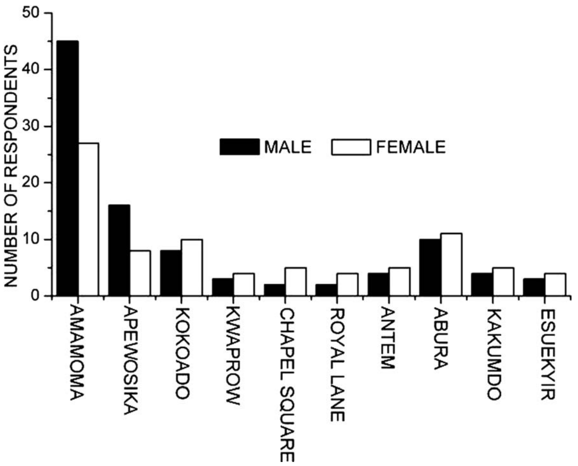

FIGURE 2 Number of respondents by gender sampled in each community

for completeness and internal consistency at the close of each day. Questionnaires were then sorted, numbered and data-coded before entering data into SPSS (version 17) software. Descriptive statistics of the data were then computed.

3.3. Data handling and processing

GPS noise locations, noise level readings (minimum, maximum and average) per location and time of noise reading were input in ARCGIS 9.3 software. Surface interpolation for the data was carried out using inverse distance weighting (IDW). IDW interpolation determines cell values via linearly weighted combinations of a set of sampling points. The methods provide an accurate weighted interpolated surface grid. IDW interpolation employs the Tobler law by estimating unknown measurements as weighted averages over known measurements at nearby points, giving the greatest weight to the nearest points (Longley et al., 2005). More specifically, denote the point of interest as x, and the points where measurements were taken as x_i, where i runs from 1 to n, if there are n data points.

Denote the unknown value as $z(x)$ and the known measurements as i. Give each of these points a weight d_i, which will be evaluated based on the distance from x_i to x. Then the weighted average computed at x is

$$\sum w_i z_i / \sum w_i$$

The interpolated value is an average over the observed values, weighted by w (the inverse squares of distances):

$$\frac{\sum_{i=1}^{n} m_i/d_i^2}{\sum_{i=1}^{n} 1/d_i^2}$$

This means that the weight given to a point drops by a factor of 4 when the distance to the point doubles (or by a factor of 9 when the distance triples). For the purpose of spotting noise risk zones in Cape Coast metropolis, the following noise evaluation criteria were used, resulting in five risk zones (Table 2).

TABLE 2 Noise risk evaluation criteria

Intensity of noise in dB	Zones
Up to 65	Safe
66–71	Tolerable
71–76	Low risk
76–81	Moderate risk
81–86	High risk

4. Results and discussion

4.1. Noise levels in selected communities

Noise exposure from 16 churches and six mosques in the 10 communities within Cape Coast was determined. Kokoado Methodist Church produced the lowest noise level during the day while Abura Tijaniya mosque recorded the highest noise during the day for the entire study. Also, Amamoma Methodist Church recorded the lowest noise while Amamoma main mosque produced the highest noise during the night. The noise levels from mosques were generally higher than the levels of noise from churches. However, the duration of noise exposure due to mosques in all cases was shorter than the duration of noise exposure due to churches. The average duration of noise exposure for mosques was 5 min while that for churches was 30 min. Consequently, noise exposure due to mosques and that due to churches could be considered as acute and chronic, respectively. The results of the highest and lowest noise levels produced by churches/mosques for both day and night in each community are presented in Table 3.

4.2. Compliance of noise exposure to Ghana EPA maximum ambient noise permissible limits

Five churches/mosques representing 23 per cent produced noise within the EPA limit for day. The churches in this category were relatively smaller and new with few members, and so did not use many musical instruments such as loud-speakers and microphones as compared to older churches. Likewise, mosques within the group did not use loudspeakers for mosque calls but only their natural voices. Three churches recorded noise levels within the EPA noise limit for night, representing 14 per cent. However, most (77 per cent) of the churches/mosques recorded noise levels that were above the EPA maximum permissible limit for day. Eighty-six per cent of the churches/mosques recorded noise levels above the EPA maximum permissible limit for night. Only one mosque produced noise levels within the maximum limit for day; the rest (five) were above the maximum noise exposure limit for both day and night. Table 4 shows the descriptive statistics for noise exposure measured during day and night in the selected communities.

Pearson's correlation coefficient for day and night noise exposure shows strong association (0.714) at the 0.01 level. There is variability in the levels of noise for both day and night, which are rather high (standard deviation = 7.59477 and 7.94022, respectively).

In the *t*-test for equality of means the *p*-value was found to be 0.000, which is less than the α-value of 0.05 (Table 5). This implies that there is a significant difference in the average levels of noise exposure during day and night, implying that these differences are statistically significant at the 5 per cent level.

TABLE 3 Day and night noise exposure in selected communities

Community	Church/mosque			
	Day		Night	
	Lowest noise level (dB)	Highest noise level (dB)	Lowest noise level (dB)	Highest noise level (dB)
Amamoma	Mosque close to excellence hostel (65)	Main mosque (79)	Methodist (57)	Main mosque (80)
Apewosika	Methodist (79)	Pentecost (81)	Catholic (70)	Pentecost (71)
Kokoado	Methodist (59)	Baptist (67)	Methodist (57)	Baptist (69)
Kwaprow	Apostolic (75)	Mosque (76)	Apostolic (74)	Mosque (79)
Chapel Square	Methodist (76)	Methodist (76)	Methodist (73)	Methodist (73)
Royal Lane	Catholic (72)	Catholic (72)	Catholic (70)	Catholic (70)
Antem	ELMT (61)	Mosque (82)	Assemblies of God (70)	Mosque (78)
Abura	Calvary (65)	Tijaniya mosque (85)	Calvary (63)	Tijaniya mosque (79)
Kakumdo	Assemblies of God (69)	Baptist (71)	Assemblies of God/Baptist (70)	
Esuekyir	Winners chapel (61)	Methodist (74)	Winners chapel (60)	Methodist (75)

TABLE 4 Descriptive statistics of noise exposure in selected communities

	N	Range	Minimum	Maximum	Mean	Standard deviation	Variance	Skewness		Kurtosis	
								Statistic	Standard error	Statistic	Standard error
Day	120	35.00	50.00	85.00	67.7583	7.59477	57.681	−0.061	0.221	−0.739	0.438
Night	118	30.00	50.00	80.00	63.8051	7.94022	63.047	0.027	0.223	−0.919	0.442

TABLE 5 Test for equality of means

	Mean	Standard deviation	Standard error mean	95% Confidence interval of the difference		*t*	df	*p*-value
				Lower	Upper			
Day−night	4.09322	5.88056	0.54135	3.02111	5.16533	7.561	117	0.000

4.3. Noise exposure levels vs. perceptions of residents

When respondents were asked whether they considered the noise from churches and mosques as a nuisance or not, 48.3 per cent answered in the affirmative and 51.7 per cent answered in the negative. Many of the respondents (45 per cent) were annoyed about the noise produced from church/mosque activities, while a significant number (42.2 per cent) were indifferent. Quite interestingly, 1.1 per cent of the respondents regarded the noise as good. It is worth stating that although Abura Tijaniya mosque produced the highest level of noise during the day (85 dB) for the entire study, this level of noise exposure did not necessarily translate into high levels of annoyance of residents. The general feeling of residents living proximally to this mosque was indifference. This could be attributed to the fact that they were all Muslims and so found this noise rather functional. It is also probable that since the duration of noise exposure for mosques was very short, residents in this community could accommodate it even though it was very loud. Amamoma methodist church recorded the lowest noise level for night (57 dB) for the entire study. However, most residents in the community felt the noise was very annoying. This could be attributed to the fact that although it is the lowest noise exposure, it persisted for a longer duration; consequently, residents considered it a nuisance. These findings support the work of Berglund et al. (2000) and Lercher et al. (2002), who indicated that the capacity of a noise to induce annoyance depends on many of its physical characteristics, including sound pressure level and spectral characteristics, as well as variations of these properties over time. However, annoyance reactions are sensitive to many non-acoustic factors of a social, psychological or economic nature, and there are also considerable differences in individual reactions to the same noise (Pinto and Mardones, 2009; Tsai et al., 2009).

Peak noise for churches was recorded during weekends while peak noise for mosques was recorded at dawn. Sixty-six per cent of respondents were of the opinion that noise from churches/mosques should be stopped or minimized, while 32.22 per cent indicated that there was no need for such an action. A further 1.67 per cent were non-committal.

Although 66.7 per cent of the respondents advocated that the noise should be stopped or minimized, 67.8 per cent did nothing about the noise produced from church/mosque activities, 6.7 per cent reported to appropriate authorities and 22.8 per cent took other measures to reduce religious noise. Also, people who took other measures and those who reported to the appropriate authorities were relatively more numerous in groups that were aware that the Ghana EPA enforces noise regulations than those who were not aware.

4.4. Noise mapping and noise risk zones

Figures 3(a) and (b) show the spatial distribution of noise risk zones emanating from religious activities.

Figure 3(a) shows that, during the day, religious noise levels at Kakumdo are within safe limits while Abura and a greater part of the study area lie within tolerable limits. A small spot that is within the low-risk zone at Abura is associated with the vicinity of the mosque. A greater part

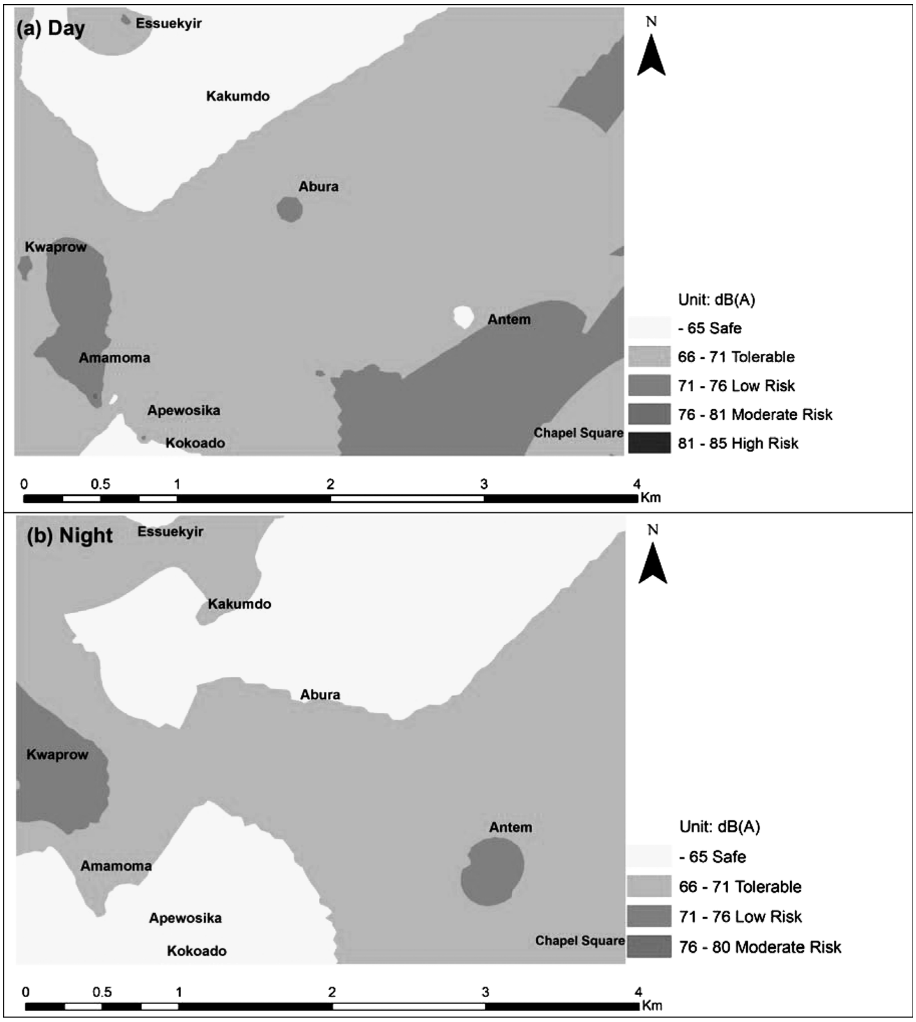

FIGURE 3 Noise exposure level distributions from religious activities in Cape Coast Municipality: (a) day 0600–2200 h and (b) night 2200–0600 h

of the area covering Chapel Square, Royal Lane and Antem lies within a low-risk zone. Kwaprow and Amamoma largely have tolerable to low-risk noise levels, with a small spot at Amamoma (related to the mosque) having moderate-risk noise level. Thus, during the day, religious noise levels within the study largely fall within safe to tolerable limits according to the criteria used, while parts of Amamoma, Kwaprow, Antem and Chapel Square have low-risk noise levels.

Figure 3(b) shows that, at night, the noise risk classification at Essuekyir and Kakumdo changes from safe to tolerable and the dispersion also increases. This could be due to the fact that at night, many sources of noise diminish, thus allowing religious noise to travel farther. Noise levels at Apewosika, Kokoado and a greater part of Abura are within safe limits, while those at Kwaprow and a small portion of Antem are within low-risk limits. In all, religious noise levels are within safe to tolerable limits at night in the study area. Figure 4 shows the percentage of noise risk sites (values in dB (A)).

Thus, according to the criteria used, residential neighbourhoods within the study area largely experience safe to tolerable levels of religious noise. This notwithstanding, some of the areas (22 per cent) are cumulatively exposed to moderate- to high-risk noise levels during both day and night. It is important to note that the selected residential areas have high population densities; as such, even when the dispersion of noise risk is spatially limited, it affects a large number of people who may belong to different socio-economic classes. This means that the exposure to religious noise could have differential impacts on the economy of Cape Coast and Ghana as a whole, depending on the proportion of residents within different social classes. For example, a huge number of students and workers at the University of Cape Coast live at Kwaprow and Amamoma, and exposure to religious noise in these neighbourhoods could significantly affect productivity at the university.

4.5. Policy implications

The government policy framework underpins noise management. Lacking an appropriate policy framework and adequate legislation, it is difficult to maintain an active or successful noise management programme (Berglund et al., 2000). A policy framework could encompass transport, planning, development and environmental policies. The goals are more readily achieved if the interconnected government policies are compatible, and if issues that traverse diverse areas of government policy are coordinated. In this case, emphasis has to be put on synergizing planning, development and environmental components of the policy framework.

The appropriate departments within the metropolitan, municipal and district assemblies must consult all relevant stakeholders, particularly residents, with respect to the land-use planning implications of religious noise, as appropriate, regarding the community structure plan, the neighbourhood structure plan, subdivision and development application stages of the planning process. It is not uncommon that in developing countries such as Ghana, there is usually a lack of appropriate statistical information to produce noise exposure estimates. Nevertheless, where action is essential to lower the noise levels, the absence of comprehensive information should not put off the development of interim noise exposure estimates (Berglund et al., 2000). Fundamental information about the exposed population, noise source and other relevant factors can be used to calculate provisional noise exposures. These can feed into the drafting and implementation of provisional noise management plans. The preliminary exposure estimates can be revised as more accurate information becomes available.

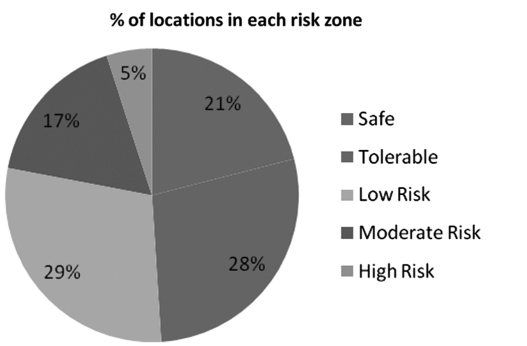

FIGURE 4 Distribution of locations in each noise risk zone

5. Conclusion

Religious noise exposure in urban residential neighbourhoods in the Cape Coast metropolis of Ghana was quantified in this study. Likewise, subjective annoyance levels of residents in selected neighbourhoods were studied. Noise risk zones were mapped using ARCGIS 9.3 software and surface interpolation for the data was carried out using IDW. More than three-fourths (77 per cent) and approximately four-fifths (86 per cent) of the sampled locations recorded noise exposures above the Ghana EPA maximum permissible ambient noise limit for day and night, respectively. Pearson's correlation coefficient for day and night noise exposure shows strong association (0.714) at the 0.01

level. There is variability in the levels of noise for both day and night, which are rather high (standard deviation = 7.59477 and 7.94022, respectively). However, noise exposure for day was generally higher than that for night. Noise exposure correlated with level of annoyance of residents, except that the location that recorded the highest noise exposure did not correspond to a high annoyance of residents within the vicinity. Noise risk zones showed that residential neighbourhoods within the study area are largely exposed to safe to tolerable risks of religious noise. Given that the selected residential neighbourhoods have high population densities, even when the dispersion of noise risk is spatially limited, it affects a large number of people belonging to different socio-economic classes. This would suggest the need to consult all relevant stakeholders, particularly residents, with respect to the land-use planning implications of religious noise, as appropriate, regarding the community structure plan, the neighbourhood structure plan, subdivision and development application stages of the planning process. One of the implications of this study relates to environmental justice. While some individuals who are highly sensitive to noise may have the means to avoid living in noisy areas, not everyone can pay for living in relatively quieter neighbourhoods. Moreover, some highly sensitive individuals may also bear a greater burden of risk, such as elderly persons and children who may be more exposed to daytime noise. Not only should new residents be protected from defectively planned new development, attention should also be given to populations presently experiencing the greatest burden of risk. Moreover, noise mitigation, including noise management, has to be vigorously pursued, and in each case the policy implications have to be evaluated for efficiency.

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