Effects of Noise Pollution on Residential Property Value in Enugu Urban, Nigeria

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Abstract
One of the persistent environmental issues today is high noise levels in residential areas especially in the developing countries. There are several unorganized informal sector activities such as recreational, road traffic, household and religious activities, operation of power generating sets, incompatible uses in space among others that are the sources of noise pollution in residential areas. A number of empirical studies have been carried out on the impact of noise on residential property values. However, one finds it very difficult to ascertain whether noise pollution affects residential property value in Enugu Urban. The aim of this study is to ascertain whether noise pollution has significant influence on residential rental values in the study area. The study has discovered that residential properties affected by noise pollution have lower rental value compared to those unaffected by 3.1% of its rental value. The study has provided some insight to guide property buyers or users, investors, property managers, and valuers as regards property transactions. The study has suggested that property value spatial index of noise pollution in the study area can be built and use as a guide for urban management strategy to achieve sustainable development.

Keywords
noise, pollution, residential property, environment, traffic, property value

Introduction
One of the persistent environmental issues today is high noise levels in residential areas especially in the developing countries of the world like Nigeria. Residential land-use generates noise pollution like other land-uses. This is because of the numerous human activities that take place in this zone such as unorganized informal sectors, recreational, religious coupled with noise from activities, operation of power generating sets and incompatible uses of space. These activities have been found in numerous literatures to abate high sound levels of noise which are injurious to city dwellers. Interruption of speech (Jin & Nelson, 2010), disruption of sleep (Elmenhorst et al., 2019; Kim et al., 2012) as well as health issues such as cardiovascular disease like hypertension (Münzel et al., 2014). In developed nations, several efforts are being made in a bid to control noise levels in residential neighborhoods. To this end, the (Department of Housing and Urban Development [HUD] United State), recommends the following standards: 49 dB—clearly acceptable, 65 dB—normally acceptable, and 76 dB—clearly unacceptable, while Japan’s threshold is 50 dB. Surprisingly, the developing country like India implements 55 dB limit. While in Nigeria, residential areas fall in the category of “clearly unacceptable” zone of the United State. Oyedepo (2012) posits that there is no legal framework on which noise can be abated in Nigeria and her citizenry are yet to come to terms with the present and future impacts of noise pollution on the environment. This implies that noise pollution control and management is weak in Nigeria. This poor attitude to noise pollution affects safety, comfort, and property value in residential areas. However, some residents in some residential neighborhoods may tend to disregards pollution in their neighborhood with the view that noise is a temporal pollution. Some other reasons why some residents prefer to continue to reside in noisy neighborhood are affordable rents, availability of property, proximity to place of work, other neighborhood conditions, and sometimes cultural diversity. However, this is not a general consensus, some people take environmental factors into account in decision-making as regards where to rent or buy property to reside.

Even though studies on noise pollution and other environmental disamenities on property value have been extensively

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undertaken around the world, such as Akinjare et al., 2011; B. T. Anderson et al., 2008; Cohen & Coughlin, 2008; Collins & Evans, 1994; Palmquist, 1982; Smith & Huang, 1993; Szopinska et al., 2020 such a study have little carried out in Nigerian and especially in Enugu property market. In this regards, one finds it very difficult to ascertain whether noise pollution affects property value in Enugu urban or not. Our argument is that residential property value is a function of its characteristics such as its bedrooms, plot size, age, aesthetic, municipal services, economic situation, nature of sales, or rental trend within the neighborhood. Noise pollution level is also a function of distance from the source and has an inverse relationship with residential property value. Noise pollution within a neighbooughd may be similar, its level and impact on each property may differ from one property to another. In this regards, the impact of noise pollution may then be taken into account in the determination of residential property value.

Huh and Shin (2018) believed that wise policy on noise pollution to be sustainable, it requires information on the monetary value of noise level. It is presumed that properties affected by noise and other environmental pollutions show a lower value compared to those not affected. Consequently, noise pollution as one of the environmental problems is crucial in the determination of residential value including other factors like demand and supply, legal and economic situations. This study aimed to ascertain whether noise pollution could have effect on residential rental values in Enugu Urban. Second to assess the level of effect of noise pollution and other property components on residential rental values in Enugu Urban.

### Sources of Noise Pollution in the Environment

Sources of noise pollution can be broadly classified according to land-use patterns, namely: residential/household, commercial, industrial, transportation, recreational, and public/institutional. Noise sources in residential neighborhoods are classified into two major groupings: point sources and line sources (Ijaiya, 2014; Obiefuna et al., 2013; Okedere & Elehinafe, 2016).

Table 1 shows the two major sources of noise in residential neighborhood. 1 to 13 represents point sources, while 14 to 16 represent line sources. Point sources of noise pollution are sounds encountered in our daily life which are produced spherically spreading in all direction, such as generator, electronic device, and so on. The line sources are sound that spread cylindrically that is spreading across double the area and the sound intensity half as that of a train, aircraft, or vehicle noise. Among all the sources of noise pollution, traffic noise is considered the most disturbing in residential areas. This arises as a result of deterioration of the road system, air pollution, traffic congestion, and vehicle ownership in Nigeria are now on a high scale (Ukonze et al., 2020). Wang et al. (2017) showed that noise levels from transformers in residential neighborhood were obviously greater than the normal noise train metro station. This normally brings discomfort for human living in the area. The question is what other economic effects of noise pollution are there on real estate?

Transportation facilities play crucial role in the level of noise pollution within a neighborhood and are gathering great serious environmental issues. There are growing degree of discontentment within urban residential neighborhood characterized by traffic congestions and high traffic concentration (Tapia Grandoso, 1998; Hamid et al., 2012). Tapia Grandoso (1998) believes that the more the number of motor vehicles on the road, coupled with its condition, use of horns and alarms indiscriminately affects the quality of the environment. However, Abumere et al. (1998) observed that in Nigeria, the urban informal sector provides the bulk of the total internally generated revenue for the Local Government Areas and, moreover, accounts for over 70% of the urban employment in the country. Low-income urban dwellers do not use their dwelling units solely for residential purpose but for other purposes of commercial activities to support their income (Onyebueke, 2001). Despite socio-economic benefits of urban informal businesses, there is a flip side of value reduction and human health risks. For instance, informal urban business play a part in causing deteriorating effects on feeble housing situation, environmental issues, health hazard, and poor residential quality. The hallmark is that the informal sector activities contribute greatly to noise pollution especially in residential areas as this is where this sector often strives.

Apart from sources of noise from transportation, supplementary sources of noise within neighbooods include

| S/N | Point sources of residential/neighborhood noise                                      |
|-----|--------------------------------------------------------------------------------------|
| 1   | Telecom base stations                                                                |
| 2   | Generators                                                                           |
| 3   | Electronic devices                                                                   |
| 4   | Home Based Enterprises/informal activities                                          |
| 5   | Religious worship                                                                    |
| 6   | Social activities                                                                    |
| 7   | Commercial activities                                                                 |
| 8   | Railway services                                                                     |
| 9   | Airport services                                                                     |
| 10  | Domestic/household activities                                                        |
| 11  | Recreation                                                                          |
| 12  | Public/institution                                                                  |
| 13  | Honking                                                                              |
| 14  | Traffic                                                                             |
| 15  | Honking                                                                              |
| 16  | Mobile HBEs                                                                          |

| S/N | Line sources of residential/neighborhood noise                                      |
|-----|--------------------------------------------------------------------------------------|
| 14  | Traffic                                                                             |
| 15  | Honking                                                                             |
| 16  | Mobile HBEs                                                                          |

Source. Ijaiya (2014).
However, it is important to note that other continents, generation is an important determinant of real estate values. An additional source of noise is from religious activities within neighborhoods. Indeed this emerging environmental problem is ravaging the third-world countries. This noise pollution emanating from religious activities is as a result of proliferation of religious houses which is born out of the fact that there is freedom of worship. However, this activity is done without consideration on the environmental effects on the people. It is a common practice that one finds religious activities around any available open spaces, uncompleted buildings, hotels, warehouses, and old cinema (Akintaro, 2014). Noise sources emanate from the use of loudspeakers, call for prayers, singing, and preaching. But then when it comes to limiting noisy religious signal, they often meet strong resistance (Crochet, 2016).

However, existing legislations on noise control do not specify limits for residential and other land uses in Nigeria, and as such noise control is yet to receive the full attention it deserves in this part of the world (Ijaiya, 2014). The few laws and regulatory provision on noise pollution in the country seem to have aloof aims, although these are bogged down by the lack of proper implementation. Another challenge to effective noise control in the country is the huge gaps in the legal, institutional, and management standards between evolving local standards in the country. For instance, the noise threshold by the former Federal Environmental Protection Agency in Nigeria (Federal Environmental Protection Agency [FEPA], 1990), recommended 90 dB for a maximum of 8 hours (Oloruntoba et al., 2012; Umeh & Uchegebua, 1997). This deviates significantly from the 55 dB benchmark for noise impact in residential areas as approved by the “World Health Organization (WHO), the World Bank, and Organization for Economic Cooperation and Development” (Schomer, 2001).

**Effects of Noise Pollution on Property Value**

Urban areas have a high concentration of economic, social, and political activities due to high population as such leads to high level of noise exposures to its residents. Over the years, there have being several studies on noise pollution especially traffic noise (rail, aircraft, and motor vehicles). Despite the growing concern by property investors, valuers, property managers and occupants on the factors that affect property value, noise pollution happens to be a contemporary issue. Noise from traffic is one of the major environmental problems in Europe (Szczepeńska et al., 2015), and noise pollution is an important determinant of real estate values. However, it is important to note that other continents, countries, and cities are not an exception. Guijarro (2019) found that traffic noise relate to price of residential properties negatively while distance of buildings to the traffic area has a positive effect. In a study carried out by Zulkifili (1995), properties situated in proximity to industrial area may cause environmental issues such as noise and traffic congestion, which make the area less attractive to property investors and drop in land value (Lentz & Wang, 1998). This implies that environmental factors are considered in relation to physical, psychological, and economical factors affecting property values. Therefore, noise pollution is one of the externalities considered as a determinant environmental factor that can also affect the value of a property.

A study carried out in the United States which focused on the degrading effects of airport noise on property value, reported that noise pollution emanating from nearness to airport is termed as “long-term or permanent” disturbance that inflict harmful and deteriorating environmental condition that reduces property value (Anon, 2004; Bell, 1997). Similar studies that focus on aircraft noise and property include: Collins & Evans, 1994; Diaz-serrano, 2006; Praag et al., 2005; Stansfeld et al., 2005; Walters, 1975. These studies used market data to estimate the shadow price of noise. The general finding is that properties closer to source of noise pollution have lower sale prices. Again, Palmquist (1982) investigated the effect of highway noise on residential value and used Repeat Sale Analysis (RSA) as a method to indicate that properties located nearer to source of noise pollution have lower sale prices. In a similar study, B. T. Anderson et al. (2008) examined the “effect of road and railway noise on property prices” with emphases on residential value. They concluded that road noise pollution has a larger negative impact on the property price than railway noise. Cohen and Coughlin (2008) did a study on “the effects of airport noise and proximity on housing prices” and the finding was that properties situated near “noisy areas (70–75 dB) sold for 20.8% less than properties situated in less noisy areas (<65 dB).” This finding was a confirmation of Walters (1975) who focused on train noise in centring on the direction and particular time of the day of noise exposure and its relative effect on property value in Memphis, Tennessee area. The method used was hedonic pricing model based on the premises that the value of each individual property is a function of its characteristics. The result of the study was that noise pollution from a rail road crossing has a significant impact on residential property values, but not on commercial properties. The finding of the study affirmed that commercial property values are not significantly affected by noise pollution in the sampled neighborhood. The reason could be that commercial properties are prone to noise as most of the activities carried out there are noise related. Bellinger (2006) used residential properties sold during a 24-year period from 1980 to 2004 to measure the impact of horn noise on the property values. The finding showed a 4.2% decrease in sales values for each additional 10 dB of added noise exposure. Showing
an inverse correlation between an increase in sound and a decrease in housing property value.

H. Anderson et al. (2010) examined sound that has relative impact on property value. They compared road and rail noise, using noise threshold of 45 dB and distance to the nearest road or railway station, paying attention more to the source of sound that is most harmful to property value. Using hedonic regression principle, they argued that the time of day the noise pollution occurs should differently matter for residents and ultimately property value, as much road traffic occurs during rush hour and the day time, while rail traffic is more evenly distributed. “In controlling for noise level on properties within 150 meter to the roads,” they discovered that there was no effect of distance in property value. But they established an impact on rail with higher decibel. Wilhelmsson (2010) explained the effects traffic noise pollution has on the value of single family house. The explanation is based on the assumption that negative externalities are capitalized into house values using “hedonic price method.” The result of the study showed that there is substantial negative effect on housing values.

The main noise pollution which affects property values follow from development in transportation, and it is regarded as devalue of property value, “Noise and Property Value (Part 1)” (2004). Levkovich et al. (2016) assessed the effects of highway development on housing prices where transportation projects where going on in the east of Netherlands. The study adopted repeated sales model specification and controlling for neighborhood effects. The goal of the study was to examine the housing price trends in the municipalities around the two newly developed highways in the Netherlands. The results of the study showed that where there is a change in accessibility, it results in significant positive effect on the price of housing in nearby area. However, the result further showed that increase in “noise pollution and traffic intensity levels result in a decrease in price of houses.” Hamid et al. (2012) discovered that property investors would consider environmental quality as an imperative element in property transactions affected by water and noise pollutions in eastern Netherlands. Shen et al. (2017) have argued that a well transit-oriented development will enhance and improve the comfort and safety of movement within neighborhood and hence increase the willingness to pay for real estate properties near the vicinity. Beimer and Maening (2017) found that the effects of flight noise compared to road noise have a significantly higher negative effect than road and rail. Huh and Shin (2018) used contingent valuation method to analyze economic value of noise in South Korea. The result of the study showed that about 80% of the respondents are willing to pay for a “noise policy.” Bravo-Moncayo et al. (2017) used artificial neural network to predict willingness to pay for assessment of noise pollution and find out that is reliable and accurate. However, Ryu et al. (2017) used autoregressive model spatial error model and ordinary least square models to analyze effects of urban form on road traffic noise exposure in South Korea. While Shen et al. (2017) used hedonic price method to study effects of bus transit oriented development and the study showed that bus transit-oriented development have a positive effects on the value of adjacent homes, especially those within 500-meter radius. Also, Guijarro (2019) used hedonic method to show that both distance and daily volume of traffic are significantly related to the price of residential property. The study finds out that traffic-related variables can influence residential property price. That is the distance between a residential house and the nearest traffic measurement has a positive effects on price meaning that at 1 km away from the traffic measurement point results to an average increase of .07%. Ozdenerol et al. (2015) used the speed and volume values of traffic flow as input to the noise model using geographical information system (GIS). The study shows that traffic nuisance has a negative effect on house value. This implies that with an increase in traffic volume, it leads to further decrease in house prices. In studying the effects of reversal when reduction in noise has taken place, Nakakeeto et al. (2017) investigated the impact of noise Barrier wall on the market value of adjacent residential value in 12 counties in Washington State, USA. The result shows that noise barrier wall increases price of residential properties within 300 meters by 15.24%. This implies that there is the impact decrease as the distance from the noise barrier increase. To verify that residential properties located along busy route at Kujawska street in Poland (Szopinska et al., 2020), housing price vary with acoustic zone but difference in price in the area are not statistically significant. This does not mean noise pollution has no negative effects on property values but from subjective view point of the valuer or user of the property it has.

Papi and Hallemen (2004) have argued that urban traffic noise pollution has adverse economic consequence by reducing the values of real estate. Burgess and Macpherson (2016) believed that noise pollution in the environment within homes result from road traffic noise especially from vehicles. In simulating car traffic noise on real estate rents, Kuehnel and Moeckel (2019) found that real estate price decrease at 0.4% per dB(A) and 9.6% for high noise–level areas, which confirmed the result of earlier study by Huang et al. (2017) on acoustic amenities on high-rise building along transportation routes. This study provides a reference point for building and road designers. Wen et al. (2020) postulated that urban roads traffic generates noise and air pollution thereby resulting in a disamenities effects on surrounding residential property value. However, the result of the study showed that road traffic has effects on property value; especially on the floor level of high-rise properties.

In recent times, especially in Nigeria, Fernandez et al. (2011) observed that property owners, investors, and users have made great effort to find out the basic factors that influence residential property prices, because demand for housing quality goes along with other environmental consideration within such neighborhoods. A situation that tends to
influence house pricing when compared to similar structures in another neighborhood. Armah et al. (2010) quantified religious noise exposure in urban residential neighborhoods in the Cape Coast metropolis of Ghana and found that most (77% and 86%) of the residential locations recorded noise levels that were above the Ghana Environmental Protection Agency maximum permissible limit for day and night, respectively. Oyetunji et al. (2018) assessed locational effects of religious campsite on property value in Lagos Nigeria and found that the presence of the campsite pose serious traffic congestion, noise, and air pollution on its surrounding environment which in turn has significant impact on property values. Although, the study failed to quantify the level of the effects of noise pollution on property values. Wokekoro (2020) revealed that noise pollution negatively impacts property values. The study recommends the development and enforcement of noise abatement measures to improve urban neighborhood quality and increase property values.

These studies provided some helpful information for improving the valuation of properties in environmentally sensitive areas. It has shown that location of residential properties and subsequent their surroundings are one of the main determinants of its market value. The siting of residential property near any source of noise pollution is subject to several effects in terms of economic loss and social and physiological well-being of the people. The literature also assists in the planning of urban areas as the information on environmental variables would help policymakers in the area of development plans and infrastructural provision.

Methodology

The study area is Enugu Urban, which is the capital city of Enugu State in the south-eastern part of Nigeria. It is located at the foot of the Udi Escarpment. Enugu is an inorganic city developed out of the discovering of coal in 1909, which led to the building of port in Port Harcourt in the southern Nigerian and the rail line running from Port Harcourt to Enugu, 240 km and extend to Northern Nigeria. After the completion of railroad in 1916; Enugu urban developed rapidly leading to become one of the most developed cities in Nigeria. The population of Enugu is estimated to be 779,000 as at 2020 by the World Statistical Data. Land ownership is communal, but individuals can acquire land for property development. The city is witnessing rapid property development. The predominant types of properties are blocks of flats, tenement, bungalow, semi and detached houses.

To examine the effects of noise pollution on residential property rental value, we collected two types of data. The property specific data and the noise pollution related data. These data are actual market rental value on properties and noise data from survey within the neighbourhoods. The noise pollution data were collected in two major ways: through direct noise pollution data capture using digital noise meter to determine the level of decibel and the use of structured questionnaire aimed at eliciting the perception of the people. Direct field data capture was conducted with the aid of a digital noise meter to acquire noise descriptors at the various logging stations (see Figure 1), using remote sensing to pick strategic data collection. The house-specific data were collected through survey of residential houses within the neighborhoods. The data on property value were the actual market rent on the properties. Total of 240 residential properties were surveyed. The data obtained for each type of property are total number of floors in the building, number of bedrooms, number of bathroom, condition, age of property, plot size, mean noise level, and distance to source of noise as shown in Table 3

Ideally the market capital values are to be used but are hard to obtain as there are no records of sales transaction, even if it exist it does not reflect the actual transaction with bid to evade capital gain tax and valuations are unsatisfactory substitutes. This rental data suffice in that if the market is in equilibrium and the capitalized rate is constant, the rate of change in capital value is the same as the rate of change in the rent. The study purposively adopted five data capture stations in five out of the 18 residential neighborhoods in Enugu metropolis in the proportion of 4:3:2 for the high-, medium-, and low-density categories, respectively, due to accessibility. Table 2 shows the selected residential areas and density types.

The 45 logging stations (spots where noise levels were captured using noise meter)—five in each of the nine neighborhoods and their coordinates were selected on a digital map of Enugu obtained using Google Map. In determining the noise incidence in Enugu, the study considered both the point sources and line sources. Noise reading from both line sources includes traffic noise while point sources include noise from residences, loudspeakers, and religious centers. In addition, each logging session observed noise descriptors such as the minimum noise level, maximum noise level, and average noise level. The data captured also recorded other noise descriptors from the logging stations such as intervals (morning 8.00 am–10.00 am, afternoon 2.00 pm–4.00 pm, and night 8.00 pm–10.00 pm) and weekdays from Monday to Friday in all the selected neighborhoods. Each point was logged for a period of 5 minutes to ensure data stability. The noise receiver was located at 1 meter above ground level of each property. A purposive sample of 360 copies of questionnaire was distributed across the nine neighborhoods, necessitating the administration of eight questionnaire to housing units around the 45 logging stations in the city. The copies of questionnaire were filled on-the-spot and returned.

Description of the Statistical Techniques Used

The thematic research of the assessment of the effects of environmental disamenities (air, water, and noise) pollution dates back to (R. J. Anderson & Crocker, 1971; Freeman, 1974; Ridker & Henning, 1967). These studies used properties data
in multiple regressions modeling of residential values. The conclusion of these studies using multiple regressions is “that all things being equal, if similar property sells for less the closer they are to the source of disamenity, the difference in price is interpreted as the market discount attributed to the source of the problem.” That is to say hedonic model can be used to test for the effect of noise pollution on property values. The model stated that “housing market is regarded as a differential product comprising a number of characteristics \((x_1, \ldots, x_n)\) such as property and neighborhood characteristics.”

Thus, \(X = (x_1, x_2, \ldots, x_n)\) \hspace{1cm} (1)

The market price of each property is related to the characteristic of the property. The determination of residential value of the property is the combination of the characteristics in a model. That is,
where $Y$ is residential value, $x_i$ represents housing characteristics of and $\varepsilon$ denote error term. This means that the rent or value that an individual resident pay for improving the noise level in extra unit of housing characteristic determine the willingness to pay or the marginal price.

Let say the model for property value is as follows:

$$Y = \alpha + \beta X_i + \varepsilon$$

where $Y$ is the observable value of the property, $X_i$ is the characteristics of the property $\alpha$ is the regression intercept (Constant), $\beta$ is the coefficient of the characteristic of the property.

This hedonic model is applicable only when the people are aware of the existence of environmental pollution, and are free to choose an alternative accommodation in the property market if they exist. If not the important relationship with residential values would not be perceived by the residents. The common method to determine the effects of environmental pollution is by estimating percentage or Naira (dollar) change in residential value with respect to the level of pollution involved. Thus separating a particular component of value such as proximity to noise source or pollution is a standard procedure in property valuation. (Smith & Huang, 1995)

In this study, we used proximity of a residential property to the source of noise pollution and measure this effect on property rental value using the hedonic model. The variables used in the study are shown in Table 3.

The data collected were recorded in a database using “Statistical Package for Social Sciences” (SPSS v.20). T-Test was used to test differentials between the existing noise levels within the various neighborhoods and the permissible limit. One-way analysis of variance (ANOVA) was used to test for differentials among the various residential neighborhoods because this technique compares the means between the groups of interest and determines whether any of those means are significantly different from each other. In analyzing the effects, two models were used as equation (3). The first model includes the noise level as one of the explanatory variables, while the second exclude it. That is the first model act as control model.

Results and Discussion

The result of the study shows that majority of the participants in the survey were above 40 years, representing 40.3% and those who attended high education were 48.3%. This means that the information provided by the participants are reliable and can be used for generalization.

Table 4 shows that noise level is low among the low-density and high within the high-density neighborhoods. This means that the noise level within low-density neighborhoods are within World Health Organization permissible limits of 55 dBA for residential areas and within United State Department of Housing Urban Development recommended limit of 49 dBA and tolerable at 65 dBA. However, noise levels in other neighborhoods are above the recommended and tolerable dBA levels in residential areas. This reveals that there is high noise level in Enugu Urban, and this could affects social, economical, and physiological aspects of human beings and physical features.

Table 5 shows the effects of noise as perceived by the residents in the neighborhoods. It shows that noise pollution is mostly felt during the time of relaxation 36.7%, conversation 31.4% and the least is during the time of sleeping 2.8%. To confirm the time in which noise pollution often occurs the respondents believed that it is daily representing 83.9 1% and frequent 56.1%. The feeling of the residents about the noise pollution is that it is very annoying 56.4% and they perceived that the entire neighborhood is noisy 59.1%. This implies that the residents perceived the neighborhood as noisy, and it could affect their economic and social and physiological aspect of life. This result is consistent with studies of Elmenhorst et al. (2019), Jin & Nelson (2010), Kim et al. (2012), and Münzel et al. (2014), which showed that noise pollution interrupt speech, disrupt sleep as well as adversely affect health of the people such cardiovascular disease like hypertension and heart diseases.

The regression results of the study are shown in Table 6. It indicated that the $F$-value is 24.648, and the models were statistically significant in explaining the factors that influence residential rental values in the study area. It also showed a low level of $R^2 = 0.461$ (46.1%). This implies that there are several variables that could influence the value of residential property value in the study area that were not included in the model. The goal of the study did not intend to include all variables, but particular interest was on noise pollution. On the starting point of $t$-values except for a few variables such as NBR, PLOT, and CD, all variables can be said to be statistically significant determinants of residential rental values including the variables for noise which is the subject matter of the study. The model then is

$$P = \alpha + BTBLG + \beta NBR + \beta BATH + \beta CD, AGE, \beta PLOTS, \beta dB + \beta DISTR + \varepsilon$$

To verify the relationship between noise pollution level and property value (annual rental value paid). We examine the effect of property distance to noise pollution source at a mean distance of 8.4 meters and standard deviation of 3.6. In doing this, we sought to test whether the regression coefficient of noise level is significantly different from 0. We compared: $\beta$ dB -0/standard error of $\beta$ dB with percentage point of the $t$ distribution: that is $T$-test of difference = 0 (vs $\neq$ 1). The result shows that $t$-value is = 2.17, $p$ value = 1.86. Since the $p$ value at 0.05 is less than $T$-value, noise level is statistically significant. This means that there are
differences between noise levels and rental values paid by residents in the study area. The overall results is that (based on the regression coefficient), the higher the noise level, the lower is the market value of the property compared to a comparable property sited in a neighborhood with lower noise level.

If Table 6 is compared with Table 5 it shows clearly that noise pollution could have more impact on property value. The $R^2$ adjusted for Table 5 is .473 (47.3%). Using the overall coefficient of determination ($R^2$ adjusted) to determine the impact of noise pollution, the result shows (.473−.442 = .031) (3.1%). This means that the differential disamenity of noise level in the study area is 3.1%. Specifically, using only the coefficient of noise level which is 4.035 (4.035%) which is absent in the control model as shown in Table 5, indicates that noise pollution affects property value by 4.035%. However, all variables used in the estimate as shown in Table 5 are significant except NBR and CD and PLOTS which are same with equation 4. The results of the study are in line with results of previous studies (Szczepańska et al., 2015; Guijarro, 2019; Kuehnel & Moeckel, 2019) that noise pollution affect the price of residential properties negatively and form an important determinate of real estate values. An addition, the result is not different from the findings of Armah et al (2010) while quantify effects religious noise exposure on residential property values in Ghana. Oyetunjii et al. (2018) on location of religious campsite on property value in Lagos, Nigeria. These studies demonstrated that noise exposure affects property values negatively and also affects other sectors of the economies, social, and physiological such as traffic congestion on highways, accidents, health issues (hypertension, depression, stress, and loss of hearing) leisure.

Table 7 shows the residential rental value schedule for the study area. The effects of noise on residential rental value are assumed to be restricted to each other. The dominant types of property in the study area are block of flats and bungalow where average rental value with low noise pollution level is N 600,000 per unit of flat per annum and N 550,000 per unit of bungalow per annum with high noise pollution N 500,000 each per annum. The environmental disbenefits that eroded property value for both types of property are N 50,000 per unit per annum. However, based on the result of the study that noise pollution is 3.1% reduction on the rental value of residential property in the study area as it is shown in column 5 of Table 8. The return is not different from Wokekoro (2020) which revealed that noise pollution reduces rental value by 2.7% of mean rental value in Port Harcourt, Nigeria. The study support the conclusion by Oloruntoba et al. (2012) that noise pollution affects quality of life, causing serious health and social problems and suggested that there should be noise level standard in Nigeria for residential neighborhood, rather than using current 8 hour standard of 90 dB which is recommended for industrial layouts.

In real property market, the interaction of the market forces of demand and supply factors determine the general outcome, which are equilibrium price and quantities (Ball et al., 1998). In the perspective of this study, property market price performance is one of those indicators that this study tries to verify. In the free market economy, price is the indicating factor especially in terms of investment opportunities. That is to say, the values of property have a close relationship with investment opportunities in terms of investment returns or benefits. The theory is that where the market can sustain property value, it will encourage the demand for property ownership and investment. This is because it will provide an opportunity for favorable returns to the property owner. The argument of this study is that environmental pollution weighed down such opportunities. Negative capitalization of residential rental value into capital value reflects in the reduction in residential rental value estimate. This signifies deprivation of the effects of environmental pollution on property markets. The issue is that most valuers do not take this into account in valuation of property as they may be unaware of the disamenity caused by environmental pollution especially noise. This sign must be conveyed to the general public as a mean of urban economic analysis and management strategies mostly as it relates to property management and valuation.

**Conclusion**

The study has put bare that residential properties affected by noise pollution have lower rental value compared to those unaffected by 3.1% of its rental value. It has offered some insight that buyers or users should consider environmental factors as an important factor in property transaction especially noise pollution. For property managers and valuers this is a factor that they need to take into consideration in negotiation and valuation exercises. The study suggested that property value spatial index of environmental pollution in the study area can be created and used as an indicator for the level of urban management strategy to achieve sustainable development. Neighborhoods with high noise pollution on residential rental value can be graded as unsuitable
residential areas because of loss in property value due to noise pollution. Besides, the finding of this study, it may also be used as way of compensating social gain from those living in a less environmentally polluted neighborhood by local government areas. Local government authority may use this finding as a basis for assessing property tax or levy to raise more revenue to finance environmentally polluted neighborhoods.

As regard urban management strategy, to achieve sustainable neighborhoods with high effect of noise pollution on residential value can be graded as unsuitable neighborhood. In this way, measures can easily be put in place by property owners, users, and the government to address the issue. As this study has demonstrated, the option is to reduce the level of noise pollution on residential areas, as it has negative impact on the value of the property and the residents. This calls for review of environmental standards or regulation especially as it relates to the sector of informal activities that takes place within residential neighborhoods in our towns and cities.

**Table 5.** Effects of Noise as Perceived by the Respondents.

| Items                  | Frequency | Percent | Valid percent | Cumulative percent |
|------------------------|-----------|---------|---------------|--------------------|
| Valid                  | 10        | 2.8     | 2.8           | 2.8                |
| Sleep                  | 29        | 8.1     | 8.1           | 10.9               |
| Relaxation             | 132       | 36.7    | 36.7          | 47.6               |
| Conversation          | 113       | 31.4    | 31.4          | 79                 |
| Working at home        | 76        | 21.1    | 21.1          | 100.1              |
| Total                  | 360       | 100.0   | 100.0         |                    |

**Table 6.** Estimates of Regression Result Including Noise Level.

| Model | Unstandardized coefficients | Standardized coefficients |
|-------|-----------------------------|---------------------------|
|       | B                            | SE                        | Beta          | T     | Sig.  |
| 1     | (Constant) −492.033          | 164.677                   | −2.988        | 0.003 |
|       | TBLG 61.2                   | 17.061                    | 0.266         | 3.587 | 0.000 |
|       | NBR −5.201                  | 18.049                    | −0.02         | −0.288| 0.774*|
|       | BATH 102.403                | 16.711                    | 0.456         | 6.128 | 0.000 |
|       | CD −7.245                   | 13.091                    | −0.03         | −0.553| 0.58* |
|       | AGE 5.942                   | 1.729                     | 0.168         | 3.436 | 0.001 |
|       | PLOTS 0.172                 | 0.143                     | 0.06          | 1.2   | 0.231*|
|       | dB 4.035                    | 1.86                      | 0.107         | 2.17  | 0.031 |
|       | DISTR 8.008                 | 3.888                     | 0.102         | 2.06  | 0.041 |

*Not significant at α = 0.05.

**Table 7.** Rental Value of House With Low and High Noise Pollution.

| Type of property | Type of accommodation (bedroom) | Average rental value with low dB level ₦ ('000) | Average rental value with high dB level ₦ ('000) | Effects of Noise @ 3.1% ₦ ('000) |
|------------------|---------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------|
| I                | 2                               | 3                                            | 4                                            | 5                             |
| Blocks of flat   | 3                               | 600                                          | 500                                          | −18.6                         |
| Bungalow         | 3                               | 550                                          | 500                                          | −17                           |
| Tenement         | 1                               | 120                                          | 150                                          | −3                            |
| Semi-detached    | 4                               | 800                                          | 1000                                         | −24.8                         |
| Detached         | 5                               | 1200                                         | 1500                                         | −37.2                         |
Table 8. Estimates of Regression Result Excluding Noise Level.

|                  | Unstandardized coefficients | Standardized coefficients |
|------------------|------------------------------|---------------------------|
|                  | B                            | SE                        | Beta          | T      | Sig.  |
| (Constant)       | -260.71                      | 96.50142                  | -2.702        | 0.007  |
| TBLG             | 70.54169                     | 16.47063                  | 0.306889      | 4.283  | 0.000 |
| NBR              | -8.74787                     | 17.23167                  | -0.03295      | -0.508 | 0.612 |
| BATH             | 93.98977                     | 16.3309                   | 0.418244      | 5.755  | 0.000 |
| CD               | -1.14862                     | 12.79756                  | -0.00468      | -0.09  | 0.929 |
| AGE              | 5.416046                     | 1.673508                  | 0.15311       | 3.236  | 0.001 |
| PLOTS            | 0.219462                     | 0.13933                   | 0.076568      | 1.575  | 0.117 |
| DISTR            | 12.23143                     | 2.647258                  | 0.222612      | 4.62   | 0.000 |

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References

Abumere, S. I., Arimah, B. C., & Jerome, T. A. (1998). The informal sector in Nigeria’s development process (Research Report No. 1). Development Policy Centre.

Akinjare, O. A., Adelegan, V. A., Ajayi, A., & Oyewole, S. O. (2011). Monetary implication of environmental disamenity on housing investment in Ojota Scenerio Lagos State: The ojota scenerio. Mediterranean Journal of Social Sciences, 2(2), 135–145.

Akintaro, O. A. (2014). Perceived effect of noise generated by religious houses on the health of people of Osun State, Nigeria. Journal of Education and Practice, 5(19), 91–95.

Anderson, B. T., Ruane, A. C., Roads, J. O., Kanamitsu, M., & Salvucci, G. (2008). A new metric for estimating local moisture cycling and its influence upon seasonal precipitation rates. Journal of Hydrometeorology, 9, 576–588. https://doi.org/10.1175/2007JHM968.1

Anderson, H., Jonsson, L., & Ogren, M. (2010). Property prices and exposure to multiple noise sources: Hedonic regression with road and railway noise. Environmental and Resource Economics, 45(1), 73–89.

Anderson, R. J., & Crocker, T. D. (1971). Air pollution and residential values. Urban Studies, 8(3), 171–180.

Anon. (2004). Airport noise and residential property value, aviation noise law.

Armah, F. A., Odoi, J., Yawson, D. O., Genesia, T. Y., Afrifa, E. A., & Pappoe, N. M. (2010). Mapping of noise risk zones derived from religious activities and perceptions in residential neighbourhoods in the Cape Coast metropolis. Ghana, Environmental Hazards, 9(4), 358–368.

Bell, R. (1997, January 9). Airport diminution in value [Report Submitted to Orange County Board of Supervisors]. Federal Register, 63(6).

Bellinger, W. K. (2006). The economic valuation of train horn noise: A US case study. Transportation Research Part D: Transport and Environment, 11(4), 310–314.

Bravo-Moncavo, L., Naranjo, J. L., Garcia, I. P., & Mosquera, R. (2017). Neural based contingent valuation of road traffic noise. Transportation Research Part D: Transport and Environment, 50, 26–39.

Burgess, M., & Macpherson, J. (2016). Overview of Australian road traffic noise policy. Acoustic Australian, 44, 227–234.

Cohen, J. P., & Coughlin, C. U. (2008). Spatial hedonic models of airport noise, proximity, and housing prices. Journal of Regional Science, 48(5), 859–878.

Collins, H. M., & Evans, R. (1994). The third wave of science studies: Studies of expertise and experience. Social Studies of Science, 32, 235–296.

Crochet, S. (2016). About noise in religious context: Religious communication perspective. Cover Age: Journal of Strategic Communication, 7(1), 28–42.

Diaz-Serrano, L. (2006, September). Housing satisfaction, home-ownership and housing mobility: A panel data analysis for twelve European Union countries (IZA Discussion Paper No. 1160)."
https://www.iza.org/publications/dp/2318/housing-satisfaction-homeownership-and-housing-mobility-a-panel-data-analysis-for-twelve-eu-countries
Elmenhorst, E. M., Griefahn, B., Rolny, V., & Basner, M. (2019). Comparing the effects of road, railway, and aircraft noise on sleep: Exposure–response relationships from pooled data of three laboratory studies. *International Journal of Environmental Research and Public Health, 16*, 1073.

Federal Environmental Protection Agency. (1990). *National interim guidelines and standard for industrial effluents, gaseous emission, and hazardous waste in Nigeria*. Federal Environmental Protection Agency.

Fernandez, R. A., Anderson, J. B., Wellner, J. S., & Hallet, B. (2011). Timescale dependence of glacial erosion rates: A case study of Marinelli Glacier, Cordillera Darwin, southern Patagonia. *Journal of Geophysical Research, 116*, 1–18.

Freeman, A. M. (1974). Air pollution and property values, a further comment. *Review of Economics and Statistics, 56*, 554–556.

Guijarro, F. (2019). Assessing the impact of road traffic externalities on residential price values: A case study in Madrid, Spain. *International Journal of Environmental Research and Public Health, 16*(24), 5149.

Hamid, A., Iman, M., & Gan, C. (2012). *Community loss of residential value from water and noise pollution*. https://www.semanticscholar.org/paper/COMMUNITY-LOSS-OF-RESIDENTIAL-VALUE-FROM-WATER-AND-IMAN-GAN/827452123fec48ae8b6cc098fb3d812f5282ee92

Huang, B., Pan, Z., Liu, Z., Hou, G., & Yang, H. (2017). Acoustic amenity analysis for high-rise building along urban expressway: Modeling traffic noise vertical propagation using neural network. *Transportation Research Part D: Transport Environment, 53*, 63–77.

Huh, S. Y., & Shin, J. (2018). Economic valuation of noise pollution control policy: Does the type of noise matter? *Environmental Science and Pollution Research, 25*, 30747–30658.

Ijiyia, H. (2014). The legal regime of noise pollution in Nigeria. *Beijing Law Review (BLR) China University of Political Science and Law, China*, 5(1), 1–6.

Jin, S., & Nelson, P. B. (2010). Interrupted speech perception: The effects of hearing sensitivity and frequency resolution. *Journal of the Acoustical Society of America, 128*(2), 881–889.

Kim, M., Chang, S. I., Seong, J. C., Holt, J. B., Park, T. H., Ko, J. H., & Croft, J. B. (2012). Road traffic noise: Annoyance, sleep disturbance, and public health implications. *American Journal of Preventive Medicine, 43*, 353–360.

Kuehnel, N., & Moeckel, R. (2019). Impact of simulation-based traffic noise on rent prices. *Transportation Research Part D: Transport Environment, 78*, 102191.

Lentz, G. H., & Wang, K. (1998). Residential appraisal and the lending process: A survey of issues. *Journal of Real Estate Research, 15*, 11–40.

Levkovich, O. R., Rouwendal, J., & Marwijk, A. V. (2016). The effects of highway development on housing prices. *Transportation, 43*(2), 379–405.

Münzel, T., Gori, T., Babish, W., & Basner, M. (2014). Cardiovascular effects of environmental noise exposure. *European Heart Journal, 35*, 829–836.

Nakakeeto, G., Pope, J. C., Rahamy, S. M., & Asare, E. (2017, February 4–7). *The impact of highway noise barrier on the house price of neighborhoods* [Paper presentation]. Southern Agricultural Economic Association Annual Meeting, Alabama, TX, United States.

Noise and property value (Part 1). (2004). *Noise & Vibration World Wide*, 35(2), 10–12. https://doi.org/10.1260/0957456041217234

Obiefun, J. N., Nwilo, P. C., Atagbaza, A. O., & Okolie, C. J. (2013). Spatial changes in the wetlands of Lagos/Lekki Lagoons of Lagos. *Nigeria, Journal of Sustainable Development*, 6(7), 123–133. https://www.researchgate.net/publication/ [accessed May 11 2020]

Okedere, O. B., & Elechinae, F. (2016). Particulate pollution from diesel generators of mobile telecommunication industries in Lagos Nigeria. *UNIOSUN Journal of Science, 1*(1), 37–40. https://www.researchgate.net/publication/327437586

Oloruntoba, E. O., Ademola, R. A., Sridhar, M. K. C., Agbola, S. A., Omokhodion, F. O., Ana, R. E. E., & Alabi, R. T. (2012). Urban environmental noise pollution and perceived health effects in Ibadan Nigeria. *African Journal of Biomedical Research, 15*, 77–84.

Onyebuwe, V. U. (2001). Denied reality, retarded perception or inaction? *Cities, 18*(6), 419–423.

Oyedepo, O. S. (2012). Noise pap: Tool for abating noise pollution in urban areas. *Scientific Reports, J*(185), 1–14.

Oyetunji, A. K., Olukolajo, M. A., & Omorogbe, H. (2018). Assessment of the locational effect of religious campsite development on proximate property values. *Confluence Journal of Environmental Studies, 12*(1), 44–52.

Ozdenerol, E., Javadnejad, F., Hun, Y., & Anipova, A. (2015). The impact of traffic noise on housing values. *Journal of Real Estate Practice and Education, 18*(1), 35–53.

Palmquist, R. B. (1982). Measuring environmental effects on property values without hedonic regressions. *Journal of Urban Economics, 12*(3), 333–347.

Papi, J., & Hallemann, B. (2004). *Road traffic noise the road sector’s perspective*. The European Union Road Federation.

Prang, V., Bernard, M. S., & Barbara, E. B. (2005). Using happiness surveys to value intangibles: The case of airport noise. *The Economic Journal, 115*(500), 224–246.

Ridker, R. G., & Henning, J. A. (1967). The determinants of residential property values with special reference to air pollution. *The Review of Economics and Statistics, 49*(2), 246–257.

Ryu, H., Park, I. K., Chun, B. S., & Chang, S. I. (2017). Spatial statistical analysis of the effects of Urban form indicators on road-traffic noise exposure of a city in South Korea. *Applied Acoustic, 115*, 93–100.

Schomer, P. (2001). *Assessment of noise Annoyance [White paper]*. Schomer and Associates.

Shen, Q., Xu, S., & Lin, J. (2017). Effects of bus transit-oriented development (BTOD) on single-family property value in Seattle metropolitan area. *Urban Studies, 55*(13), 2960–2979.

Smith, V. K., & Huang, J.-C. (1993). Hedonic models and air pollution: Twenty-five years and counting. *Resources Economics, 3*, 381–394.

Smith, V. K., & Huang, J.-C. (1995). Can markets value air quality? A meta-analysis of hedonic property value models. *Journal of Political Economy, 103*(1), 209–227.

Stansfeld, S. A., Berglund, B., Clark, C., Lopez-Barrio, I., Fischer, P., Öhrström, E., Haines, M. M., Head, J., Hygge, S., van
Kamp, I., & Berry, B. F. (2005). Aircraft and road traffic noise and children’s cognition and health: A cross-national study. *The Lancet, 365*, 1942–1949.

Szczepańska, A., Senetra, A., & Wasilewicz-Pszczółkowska, M. (2015). The effect of traffic noise on the prices of residential property—A case study of the polish city of Olsztyn. *Transportation Research Part D: Transport Environment, 36*, 167–177.

Szopinska, K., Krajewska, M., & Kwiecien, J. (2020). The impact of road traffic noise on housing prices–Case study in Poland. *Real Estate Management and Valuation, 28*(2), 21–36.

Tapia Granados, J. A. (1998). Reducing automobile traffic: An urgent policy for health promotion. *Revista Panamericana de Salud Pública, 4*, 227–41. https://doi.org/10.1590/s1020-49891998000400003. PMID: 9608812

Ukonze, F. I., Nwachukwu, M. U., Okeke, D. C., & Jiburum, U. (2020). Determinants of vehicle ownership in Nigeria. *SAGE Open, 10*, 3–13. https://doi.org/10.1177/2158244020922970

Umeh, L. C., & Uchegbu, S. N. (1997). *Principles and procedures of Environmental Impact Assessment (EIA)*. Computer Edge Publishers.

Walters, A. A. (1975). *Noise and prices*. Oxford University Press.

Wang, P., Wang, Y., Zou, C., & Guo, J. (2017). A preliminary investigation of noise impact within metro station in the urban city of Guangzhou, China. *Environmental Science and Pollution Research, 24*, 11371–11382.

Wen, H., Gui, Z., Zhang, L., & Hui, E. C. M. (2020). An empirical study of the impact of vehicular traffic and floor level on property price. *Habitat International, 97*, 102132.

Wilhelmsson, M. (2010). The impact of traffic noise on the values of single-family houses. *Journal of Environmental Planning and Management, 43*(6), 799–815.

Wokekoro, E. (2020). An assessment of the effect of noise pollution on rental values of properties in Nigeria. *MOJ Ecology & Environmental Sciences, 5*(5), 206–209.

Zulkifli, I. (1995). Is there a positive side to stress? *World Poultry Services Journal, 51*, 63–76.