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Geospatial analysis of the impact of abattoir activities in Karu, Abuja, Nigeria

Elizabeth Rizga Jackson [1,*], Felix Ndukson Buba [2], Vivian Aaron Ibrahim [1], Epsar Philip Kopteer [1], Udya Aniya [1], Kamila Abba Tukur [1], Augustine Abah Odeh [1], Sumaiyat Kpanja Abdullahi [1], Binta Ahmad [1], Jibatswen Agbutsokwa Hosea [1] and James Adah John [1]

[1] *National Space Research and Development Agency (NASRDA), Abuja, Nigeria.*
[2] *African Regional Centre for Space Science and Technology Education- English (Arcsste-E), Ile-Ife, Osun State, Nigeria.*

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Abstract

Meat is a worldwide staple food item obtained mostly from animal farms after killing and preparation in abattoirs or slaughter houses, and it has played a significant role in human ill-health and death due to the intake of improperly processed and unwholesome meat. Abattoir operations generate numerous waste and microbial organisms that pollute the environment. This poses serious threat to human health and quality of life. Most abattoirs in Nigeria are characterized by poor design, obsolete facilities and a deteriorating environment. The challenges posed by Karu abattoir activities and management of its residential neighborhood have become a source of concern. This study aims to analyze the impact of abattoir activities in Karu, Abuja, Nigeria with the specific objectives to assess the effects of Karu abattoir activities on its residential neighborhoods and to determine the level of compliance to regulations for establishing abattoirs. A descriptive cross-sectional study was conducted using a semi-structured, interviewer-administered questionnaire. Eighty (80) households within the abattoir neighborhoods were interviewed. Data obtained were analyzed using the statistical software for social sciences (SPSS). Water sample was collected and analyzed in the laboratory and air quality was also collected through the European Center for Medium Range Weather Forecast database and the area of interest was extracted using ArcGIS 10.8 software. The average mean value of the pollutant shows Sulfur dioxide (SO_2) being the highest pollutant in the atmosphere around the study area both during dry and wet seasons with values of 2.53m/cm^3 and 1.49m/cm^3 respectively. Nitrogen monoxide (NO) is the lowest pollutant in the atmosphere having values of 1.68m/cm^3 and 0.36m/cm^3 respectively. The presence of coliform in the well water at the study area provides evidence of recent faecal contamination. More than half (53.7%) of the respondents reported that there is an inadequate water supply facility and sourced their water from the tap (64.6%) and disposed of their waste water in the nearby stream. More than two-thirds (77.6%) of the abattoir workers reported that there are adequate veterinarians and other health officers and a routine post-mortem examination is adequate in the abattoir. The study showed that the abattoir lacks infrastructure and compliance with slaughter practices and regulations.

Keywords: Abattoir; Karu; Turbidity, Suitability; Criteria; Respondents

1. Introduction

Meat is a worldwide staple food item obtained mostly from animal farms after killing and preparation in abattoirs or slaughter houses, and it has played a significant role in human ill-health and death due to the intake of improperly processed and unwholesome meat [1]. Due to a lack of suitable sanitary facilities for the treatment of animal waste in abattoirs, meat production has resulted in contamination and degradation of the soil, air, and water, resulting in an unattractive and nauseous environment. Poor environmental sanitation and food hygiene practices have been linked to the spread and severity of diarrhea [2]. According to current estimates, around 1.4 billion episodes of diarrhea occur yearly in children under the age of five, resulting in 123 million clinic visits and 9 million hospitalizations worldwide,

* Corresponding author: Elizabeth Rizga Jackson

resulting in a loss of 62 million disability-adjusted life years [3]. Environmental and health concerns about abattoirs and meat processing factories, as well as inadequate meat inspection services and the public's subsequent consumption of unwholesome meat, have become important sources of worry for both industry stakeholders and the general public [4].

An abattoir is a government-approved and registered facility for the sanitary slaughtering and inspection of animals, as well as the processing, preservation, and storage of meat products for human consumption, while the slaughtering of animals produces significant meat supplies and useful by-products such as leather, skin, and bones [5], [6]. Processing activities can lead to pollution of the environment and other health risks, which can end up endangering animal and human health [7]. The primary goal of meat inspection and abattoir sanitation is to prevent spoilage, meat-borne disease, and infection, and minimize the opportunity for microorganisms, particularly pathogens, to get access to the meat [8]. Abattoir operations result in the generation of numerous waste and microbial organisms that pollute the environment and pose a serious threat to human health and quality of life. Sadly, most abattoirs in Nigeria are characterized by poor design, obsolete facilities, and a deteriorating environment. Abattoir waste affects air quality, agriculture, potable water supplies, and aquatic life. These pose risks to human health [9]. The common disease-causing organisms have been reported by researchers in slaughtered animals and abattoir wastes in Nigeria. Heaps of abattoir waste are common sight in most abattoirs in Nigeria as well as the study area which constitute serious environmental and public health hazards. Wastes are unavoidable elements of the ecosystem, and they appear in solid, liquid, and gaseous forms. Waste management is one of the obligations entrusted to humans as the most intellectual creatures for the goal of supporting and guaranteeing a healthy environment [10]. To avoid epidemic outbreaks, the foul odors, dust, smoke, and wastes emitted by these facilities must be effectively controlled. The challenges posed by poor abattoir waste management on the public and quality of life in Nigeria have become a source of concern in recent times. Sanitation is the practice of promoting good health by preventing humans from coming into contact with waste dangers [11], [12]. The primary purpose of the food processing industry is to supply consumers with safe, healthful, and appropriate food, and microbial control is critical to achieving this goal [13], [2].

In Nigeria, the National Environmental Sanitation Policy identified market and abattoir hygiene as one of the key government policies to address the enormous problems of environmental sanitation in abattoirs, which include inappropriate waste disposal, insufficient water supply, and gross insufficiency of sanitary facilities, which result in poor sanitation defecation, congestion, and meat exposure to flies, pollutant and rodents [14], [15]. In Nigeria, sanitary issues are linked to bad abattoir planning, the emergence of illegal abattoirs (including slaughter slabs), a lack of suitable utilities such as portable water, and insufficient road networks institutional regulations, enforcement, and monitoring, as well as corrupt and egregious behavior by government-appointed abattoir supervisors [16], [17].

The only economical method of monitoring the prevalence of zoonotic illnesses in Nigeria is abattoir meat inspection [15]. The essential purpose for both ante-mortem and post-mortem examinations at slaughterhouses for protection remains the same in the field of public health before being butchered, the animals are placed in the lairage for 24-72 hours during inspection [18]. Meat inspection aids in the detection of certain livestock diseases, the prevention of the spread of diseased meat that could cause disease in animals and humans, and the assurance of product profitability in the local market [19]. The results of meat inspection at the slaughterhouse, along with appropriate patterns, indicate potential risks from unsafe meat obtained from animal carcasses at the slaughterhouse, which can be mitigated by strict ante mortem inspection of animals before slaughter and post-mortem inspection of meat and offal after slaughter. As a result, the sanitary state and compliance with slaughter practices in Karu Abattoir, Abuja Municipal Area Council, Federal Capital Territory, Nigeria, were assessed in this study.

This study will generate data and strategies for proper environmental management in Karu abattoir and other similar facilities in Nigeria. This goes a long way towards a cleaner and healthier environment. Also, this study would provide insights into the opportunities inherent in compliance to rules and regulations governing the establishment of abattoir

This study aims to analyse the impact of abattoir activities in Karu, Abuja, Nigeria with the specific objectives to assess the effects of Karu abattoir activities on its residential neighborhoods and to determine the level of compliance to regulations for establishing abattoirs

1.1. Study Area

1.1.1. Location, Extent, and Population

Karu is a satellite town in Abuja Municipal Area Council, about 14.1 kilometers east of the Federal Capital City as shown in Figure 1. It is located between latitudes 8^0 59’ 38.6” N and 9^0 01’ 39.6” N and longitudes 7^0 33’ 17.19” E and 7^0 34’ 49.61” E. It has a surface area of around 275km2 and it is roughly 7km northeast of the Federal Capital City (FCC), which is located off the Abuja–Keffi expressway. It is bordered to the north by Nyanya, to the south by Jikoyi, to the west by

Kugbo, and to the east by Mararaba (in Nasarawa State). The inhabitants of the Town are Gbagiyi, Gwandara, Hausa and are predominantly farmers, traders, and public servants [20]. Karu Abattoir was established in 1997, before then, it was located in Garki, almost within the centre of the central business district of the FCT. Due to the amount of waste, it was generating especially in terms of air pollution and waste mismanagement it was relocated to Karu in 1997. Before that time, local people slaughtered animals using a slaughtering slab under the supervision of Sarkin Fawa appointed by the Karu village local chief. Sarkin Fawa is in charge of the butchers, as well as all other aspects of the slaughterhouse, including revenue collection. Animals were slaughtered in an unsanitary slab, prompting the FCT Administration and Rural Development Secretariat to intervene to improve the slaughter slab, as well as take over processing and meat inspection to ensure that meat presented for sale is wholesome and fit for human consumption. Karu Abattoir currently serves the entire Abuja Municipal Area Council.

FCT has six area councils which include, the Gwagwalada area council, Kuje area council, Kwali area council, Abaji area council, Bwari area council, and Abuja municipal area council, where the study area is located (see Figure 1). The FCT is bordered in the north by Kaduna State, South-east by Nasarawa State, southwest by Kogi State, and in the west by Niger State. The Karu Urban Area Is majorly located in the Nigerian state of Nasarawa, but with some parts stretching into the boundaries of the Federal Capital Territory (FCT). It has an area of 40,000 hectares (400 km^2) [21]. Despite a lack of up-to-date statistics, the urban areas in and around Karu are known to be some of the fastest-growing in Nigeria. Therefore, the current population of Karu Local Government area is likely to be far higher than the last census count which put the population at over 1.1 million [22] Figure 1 and 2 Map of Study Area.

1.1.2. Climate, Topography and Vegetation

The tropical savanna climate of central Nigeria prevails in the Greater Karu Urban Area, with rainy and dry seasons alternating. The rainy season lasts from April to November. Because of its location on the windward side of the Jos Plateau and in the zone of rising air masses, the Urban Area receives a lot of rain. The annual total rainfall ranges between 1100 and 1600 mm. The elevation is 360 meters (1,180 ft). The FCT falls within the Guinean forest-savanna mosaic zone of the West African sub-region. Patches of rainforest, however, occur in the Gwagwa plains, especially in the rugged terrain to the southeastern parts of the territory, where a landscape of gullies and rough terrain is found. These areas of the Federal Capital Territory (FCT) form one of the few surviving occurrences of the mature forest vegetation in Nigeria. Abuja. The study areas are very close to the Federal Capital City Abuja, which is well-developed; therefore, there are no wild animals. This is due largely to intense pressure put on land, which is increasing by the day as a result of migration to the FCT from other parts of the country. Vegetation of the area is also affected by these developments. The original thick vegetation cover is fast giving way to open areas due to rapid developments in housing infrastructure.

1.1.3. Drainage System

In Nigeria, numerous abattoirs dispose of their effluents directly into the streams and waterways without any type of treatment and the butchered meat is washed by the same water. There was an open space used as lairage which lacks drainage, concrete floor and scattered with cow dung. Waste water from abattoirs could harbour bacteria some of which are pathogenic. The contamination of water from rivers or land by effluent of abattoir could cause a pronounced health and environmental hazard. Karu abattoir lacks an adequate drainage system, when the rain comes, the abattoir becomes extremely muddy, smelling to the high heavens as the rains wash animal dung and bones into neighbouring houses, since it does not have a proper drainage system. Faeces is washed to the road nearby, making it impossible for residents to get by without waddling in the thick mud of faeces.

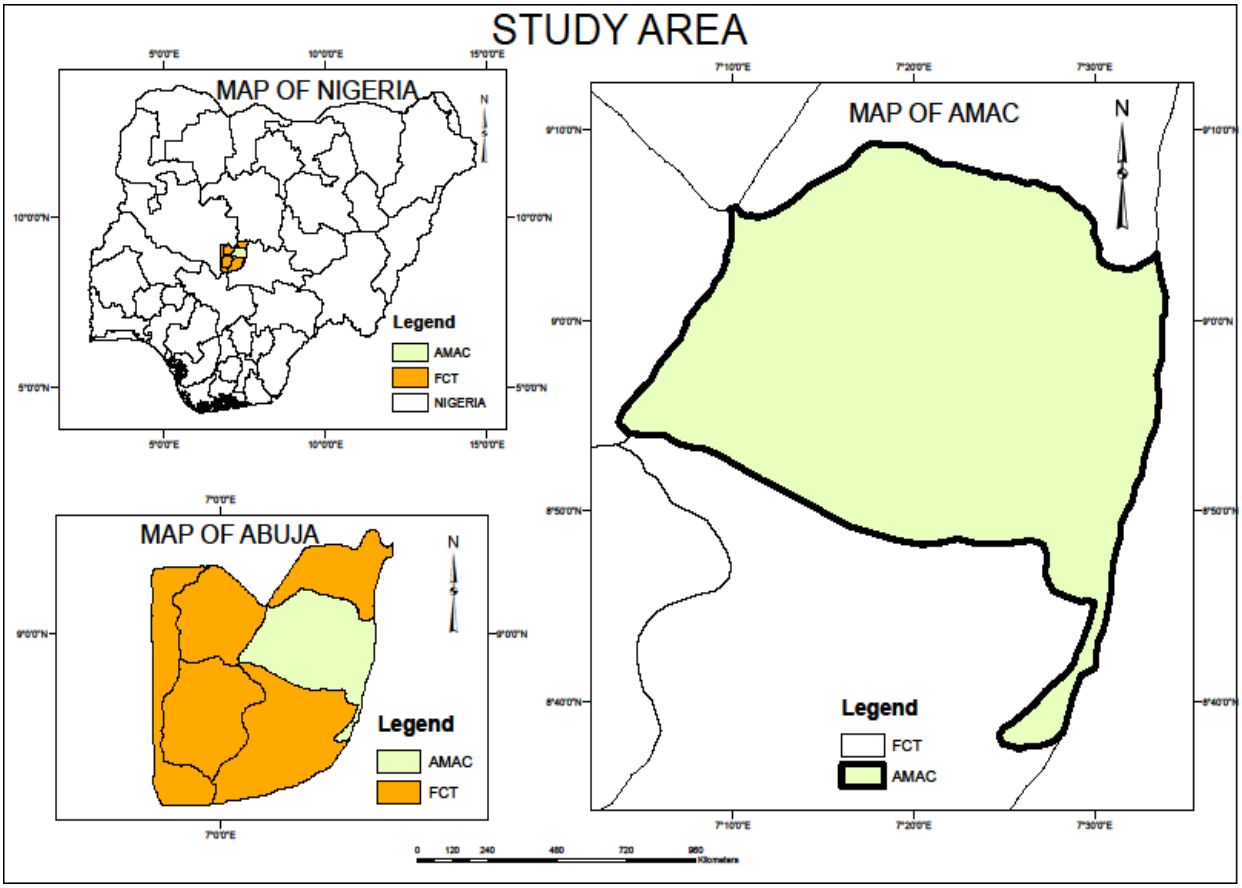

Figure 1 Study Area Map

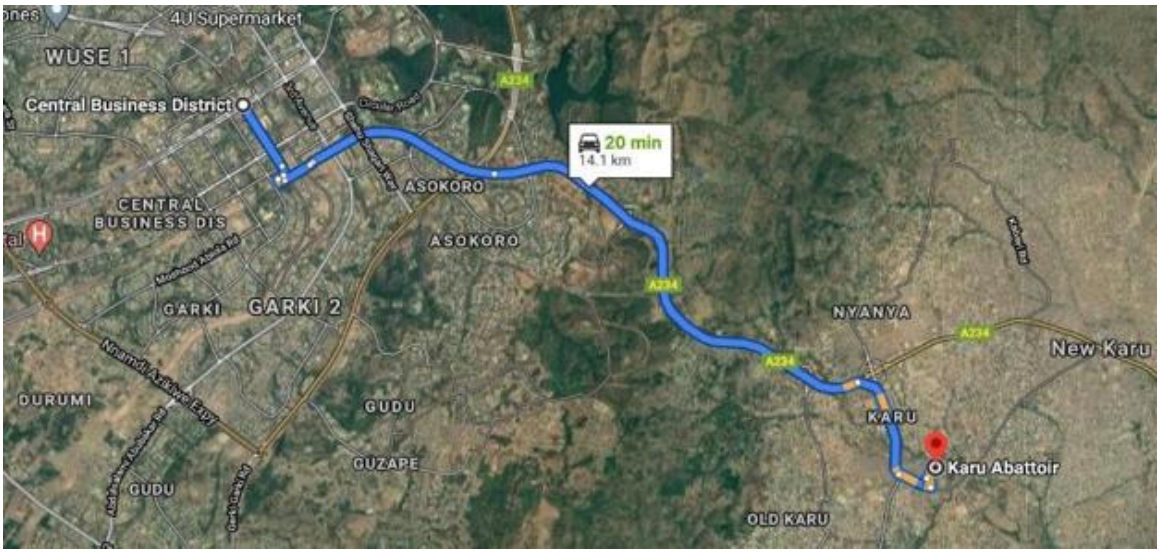

Figure 2 Location of Study Area from the Central Business District, Abuja (FCT).

2. Materials and method

2.1. Research Design

Data used in the study include primary and secondary data collected from various organizations, literature, and individuals. The primary data from the field survey was collected through 80 houses in the study area, to determine the biomass potentials of the abattoirs. Data were also collected using interviews; onsite observations; and use of

questionnaires. In addition, a Global Positioning System (GPS) receiver (Handheld GARMIN 76S) was used in the field survey to determine the geographical co-ordinate of the abattoir houses for geo-coding in the data analysis.

2.2. Data Requirement for the Impact of Abattoir Activities on the Residential Neighborhood.

A structured questionnaire with two sections was used to collect data: Gender, age, marital status, educational level, employment status, house status, average hours spent at home, and time spent in the region were all collected in Section A. Section B included questions about the impact of abattoirs on residential areas, such as many symptoms and diseases that may be linked to slaughterhouse activities through airborne, waterborne, or pollution exposure. Other questions included whether they suspect the diseases are linked to abattoir hazards, the number of people affected in a house and their ages, the kind of health assistance they seek when infected with any kind of disease, their comfort with the presence of abattoirs in their surroundings, source of their drinking water, insect and flies' disturbances, blockage of gutters or drainages by abattoir effluents and what they benefit from with the abattoir being in their neighborhood. Eighty (80) questionnaires were systematically distributed across eighty residences but however, due to a non-response rate of sixty-four (64) copies of the questionnaire were employed for analysis at the end of the survey. Monthly concentrations of total column Nitrogen dioxide, Methane, Nitrogen Oxides, Sulphur dioxide, and Carbon monoxide in molecules/cm2 for 2020 were downloaded from the archives of CAMS ECMWF Near-real- time datasets. Water sample was also collected from the well within the abattoir. In addition, a Global Positioning System (GPS) receiver was used in the field survey to determine the geographical co-ordinate of the abattoir houses for geo-coding in the data analysis and site suitability which is a critical step in determining the location of abattoir was carried out in the study area using the power of Geographical Information System (GIS) technology

2.3. Data Requirement for Compliance with Abattoir Rules.

A semi-structured, interviewer-administered questionnaire was used to elicit information on the socio-demographics, knowledge about the abattoir sanitation, water supply and waste management, sanitary facilities, hygiene status, and safety and precautionary measures in the abattoir. The instrument was pre-tested from a group similar to the main study group. Each question was translated into the local language (Hausa) for those who could not read English, to help the respondents to give true and accurate answers. Other materials related to abattoir and environmental matters were also used to achieve the result.

2.4. Data Requirement for Abattoir Site Suitability

All GIS operations and map development were carried out using ArcGIS 10. Political boundary map layer, road network layer, and Land Use and Land Cover (LULC) map acquired from Landsat images are among the GIS-based thematic maps utilized in the suitability map's construction.

2.5. Data Analysis

2.5.1. Method of Data Analysis for the Impact of Abattoir Activities on the Residential Neighborhood

For demographic analysis, the information gathered was statistically analyzed. The analyses were also completed using the statistical software for social sciences (SPSS) for data analysis and hypothesis testing. The t-test statistic was used to assess the null hypotheses I-III, which sought to determine the significant differences between the two variables. For the study, an alpha of 0.05 level of significance was employed to support or reject the hypotheses.

2.5.2. Air Quality Analysis

For the air quality analysis, monthly concentrations of total column Nitrogen dioxide, Methane, Nitrogen Oxides, Sulphur dioxide, and Carbon monoxide in molecules/cm2 for 2020 were downloaded from the archives of CAMS ECMWF Near-real-time datasets (https://apps.ecmwf.int/datasets/data/camsnrealtime/levtype=sfc/). ECMWF is the European Centre for Medium-Range Weather Forecasts. The datasets downloaded in NetCDF formats were converted to a raster layer using the 'Make NetCDF Raster Layer' tool in ArcGIS 10.8 software, and then extracted to the area of interest.

2.5.3. Water Quality Analysis

Laboratory analysis of water was conducted to determine the physical, chemical, and biological parameters of the Karu abattoir water

Turbidity

Determination of the water turbidity was done using a Lovibond turbid direct meter. 10mls of the water sample was added to a cuvette (sample cell). The meter is set to zero-unit NTU nephelometric turbidity unit. The sample was inserted into the sample hold, the red button is pressed and the turbidity of the water was read on the screen.

Conductivity, Total Dissolved Solids and Temperature

Determination of conductivity, total dissolved solids and temperature using a multimeter that measures the parameters. 100mlsof the water sample was measured in a beaker, the probe of the meter was lowered into the water and the results were read from the screen of the meter.

PH

PH meter was first calibrated with buffer 7, after which the sample's PH was read using the probe and the PH meter. The abattoir water sample PH was determined using 1mil of bromothymol blue added into a test tube containing 10ml of the water sample. The result was read using a comparator plate.

Alkalinity

Determination of the water alkalinity was carried out using the following reagents:

a. Alkalimetric as the titrate b. Methyl orange as the indicator

Two (2) drops of the indicator were added to 100ml of the water samples, the solution was titrated against the alkalimetric reagent to an orange endpoint. The total alkalinity was multiplied with total hardness as the multiplication factor to convert to mg/l.

Chloride Ion

Chloride ion was determined using the following reagents:

a. Silver nitrate as the titrate b. Potassium dichromate as the indicator

Three (3) drops of the indicator (potassium dichromate) was added to a 100ml of the water sample, the solution was titrated against the silver nitrate reagent to give a yellow-colored solution as the end point.

Iron, Manganese, Sulphate, Phosphate, Nitrate and Nitrite

Determination of Iron, Manganese, Sulphate, Phosphate, Nitrate and Nitrite using HACH spectrophotometer and the various parameter reagent pillows. The spectrophotometer is powered and programmed to read the irons according to their various wavelength of absorption. 10ml 0f the water sample is added into a cuvette and a sachet of the reagent pillow is also added following the manufacturer's guide on contact time. Distilled water was used to zero the equipment before taking the sample reading.

Total Hardness

the following reagents were used to determine the total hardness of the water sample,

(a). Disodium (Na2), Endothelium-Dependent Dilation (EDD), Ethylenediamine teraacetic acid (EDTA) as titrant
(b). K-10 buffer to stabilize the water PH (c). Eriochrome Black-T as indicator

The EDTA is added into a burette, 100ml of the water sample is added into 250ml conical flask, 1ml of the K-10 reagent is added to the and three (3) drops of the indicator was added. The solution was titrated against the EDTA to a light blue color as the end point, the value of the total hardness was obtained by multiplying the burette reading by 20 which is the conversion factor to mg/l.

Bacteriological Analysis

The determination of coliform was achieved using these two stages;

Stage one (presultive test); 10ml of the water sample in the test tube was heated before covering them. The 10ml of the water was disposed into 5 Macartney bottles containing 10ml of lactose-bought media which were all labeled and placed into the incubator for 24hrs and the presence of coliform was determined.

Stage two; After coliform presence has been determined the water sample is incubated in the incubator for another 24 hours to determine the presence of other bacteria.

2.6. Data Analysis for Compliance with Abattoir Rules

Data were analyzed using the Statistical Package for Social Sciences, version 20.0. The data were analyzed using descriptive statistics such as mean and standard deviation. The results were presented in tables.

2.7. Data Analysis for Site Suitability

Suitability analysis involves the search for the best location of one or more facilities to support some desired function, it is the process to determine whether the land resource is suitable for a particular purpose. Before the spatial analysis was performed to choose a site, siting criteria/factors were evaluated for their applicability for selecting areas based on environmental and socio-economic factors. The site suitability was assessed using equation below:

$Si = \sum WiXi$

Where Wi is the weighted score of the factor, Xi is the suitability rank of the factor, S is the suitability value for each factor and i is factor i. In selecting suitable sites using a weighted score model, the input factors were selected, some constrained (i.e., unsuitable areas blacked out.), standardized (i.e., factor attributes classified and ranked), and weighted (i.e., assigned weights to the factor) before combining them

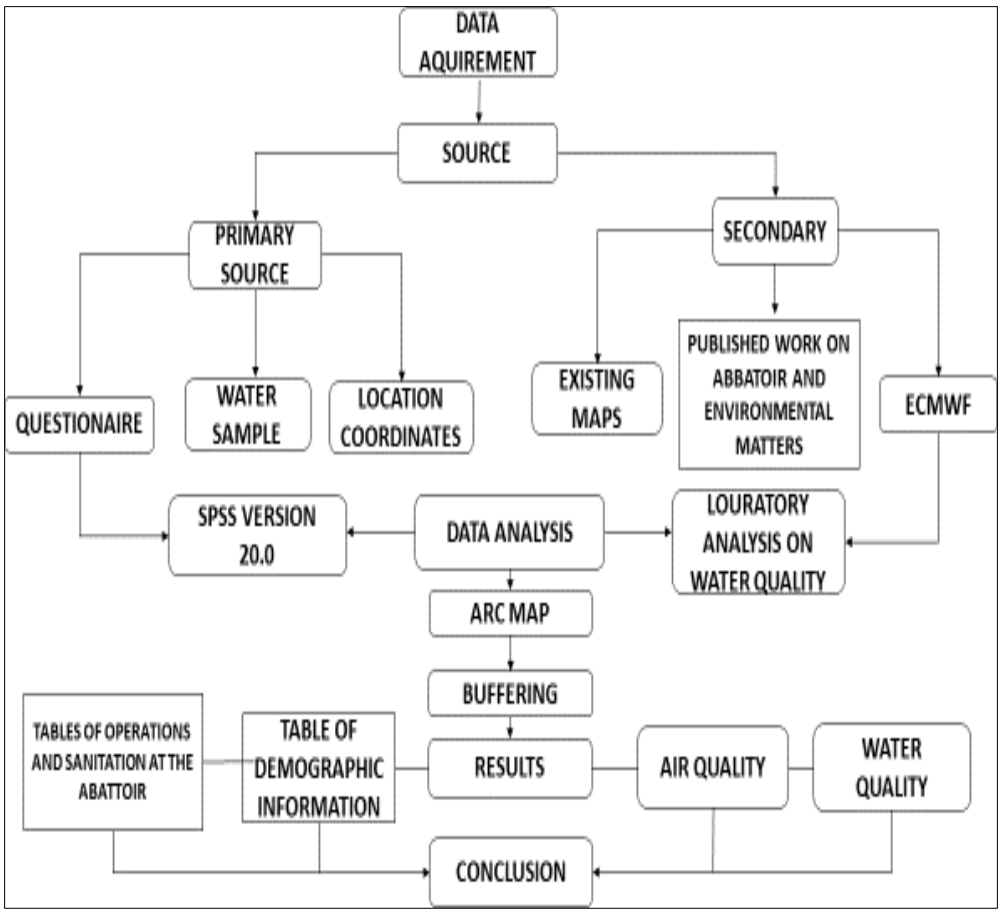

Figure 3 Methodology Workflow

3. Results and analyses

3.1. Results of the impact of abattoir activities on the residential neighborhood.

3.1.1. Demographic characteristics of the respondents (n=64)

Table 1 Sex of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	27	42.2	42.2	42.2
	Female	37	57.8	57.8	100.0
	Total	64	100.0	100.0	

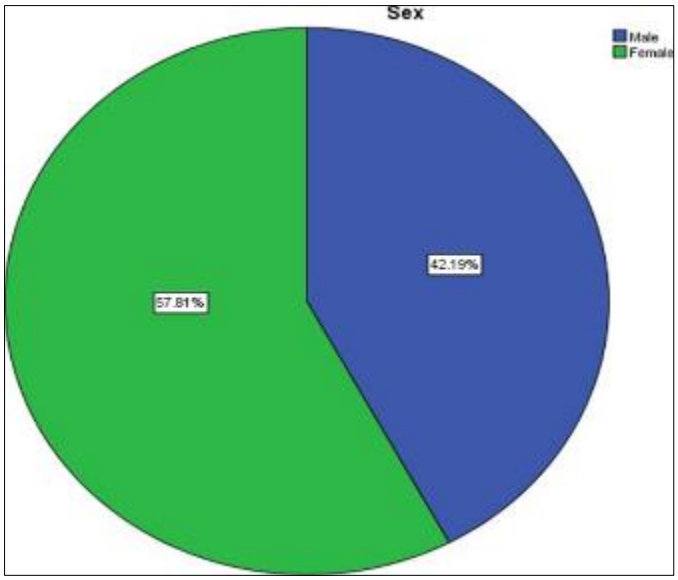

Figure 4 Sex of the Respondents

Table 2 Age of the Respondents

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Between 20-30	17	26.6	26.6	26.6
	Between 31-40	22	34.4	34.4	60.9
	Between 41-50	16	25.0	25.0	85.9
	Between 51-60	6	9.4	9.4	95.3
	Over 60	3	4.7	4.7	100.0
	Total	64	100.0	100.0	

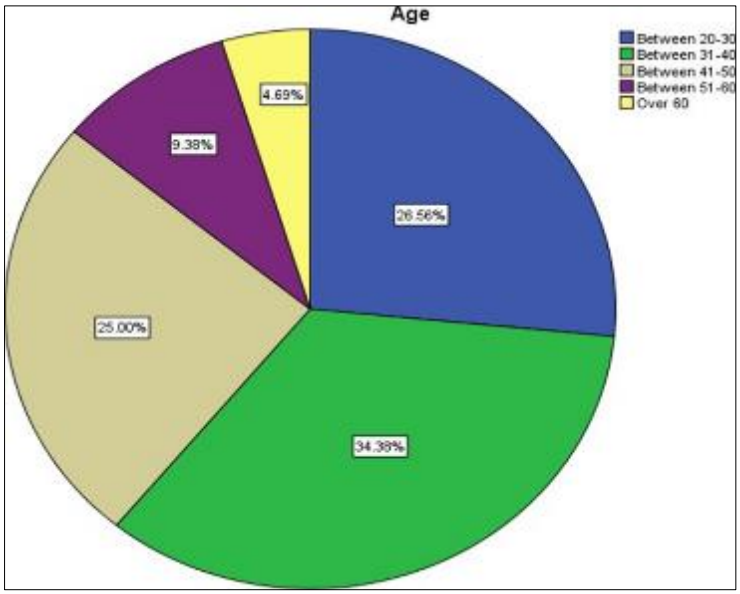

Figure 5 Age of the Respondents

Table 3 Marital Status of the Respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	41	64.1	64.1	64.1
	Single	14	21.9	21.9	85.9
	Divorced	4	6.3	6.3	92.2
	Widow/Widower	5	7.8	7.8	100.0
	Total	64	100.0	100.0	

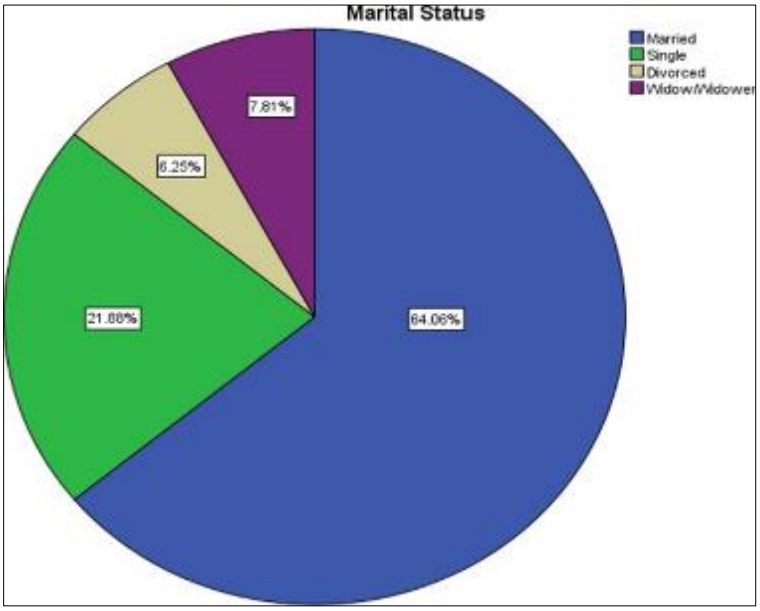

Figure 6 Marital Status of the Respondents

Table 4 Level of Education of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	1	1.6	1.6	1.6
	Secondary	18	28.1	28.1	29.7
	Tertiary	45	70.3	70.3	100.0
	Total	64	100.0	100.0	

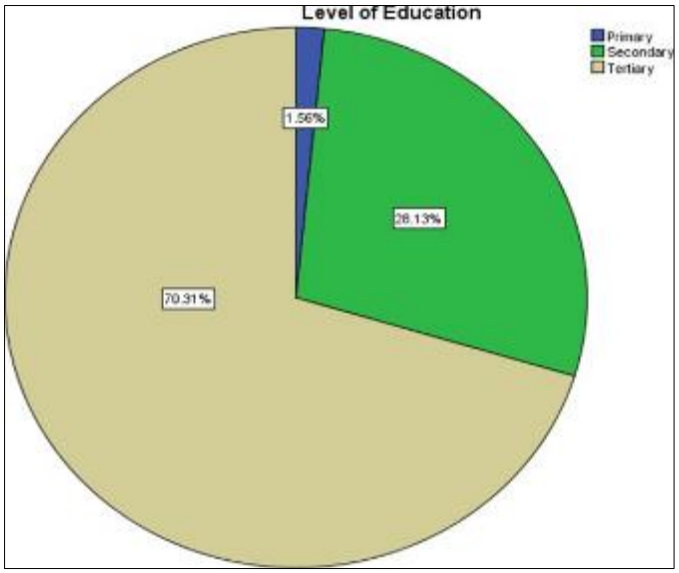

Figure 7 Level of Education of the Respondents

Table 5 Employment Status of the Respondents

		Frequency	Percent	Valid percent	Cumulative Percent
Valid	Employed	22	34.4	34.4	34.4
	Unemployed	15	23.4	23.4	57.8
	Self Employed	27	42.2	42.2	100.0
	Total	64	100.0	100.0	

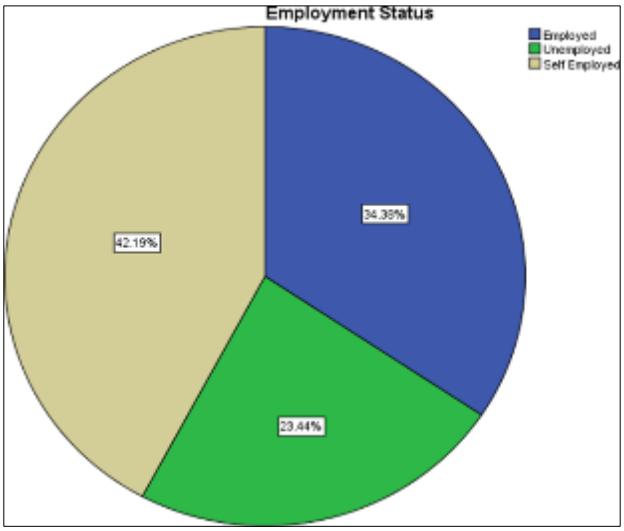

Figure 8 Employment Status of the Respondents

Table 6 Duration of Respondents in the Study Area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 years	24	37.5	37.5	37.5
	Between 5-10 years	32	50.0	50.0	87.5
	Between 10-15 years	5	7.8	7.8	95.3
	Over 15 years	3	4.7	4.7	100.0
	Total	64	100.0	100.0	

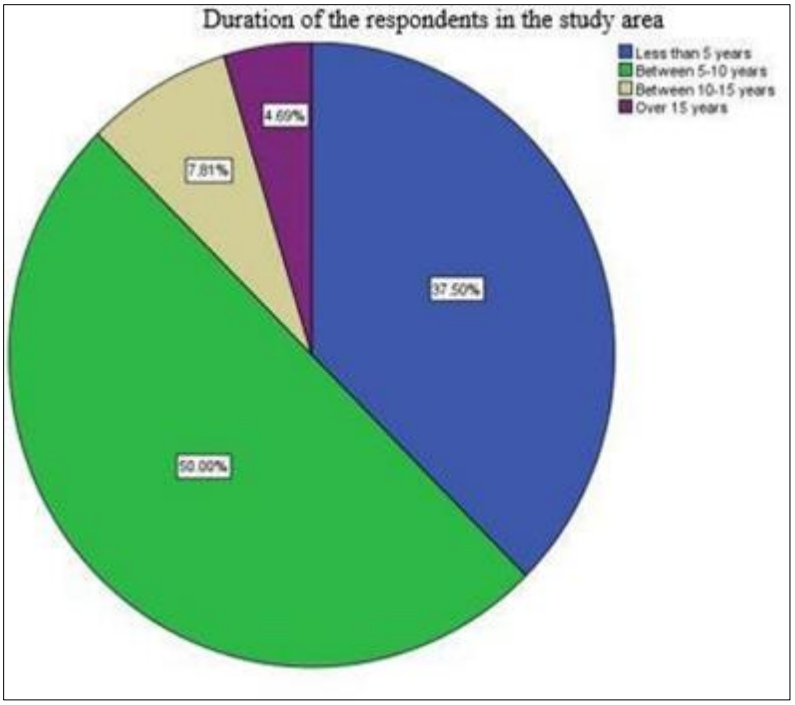

Figure 9 Duration of Respondents in the Study Area

Table 7 Residential Status of the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Personal	20	31.3	31.3	31.3
	Rented	43	67.2	67.2	98.4
	No comment	1	1.6	1.6	100.0
	Total	64	100.0	100.0	

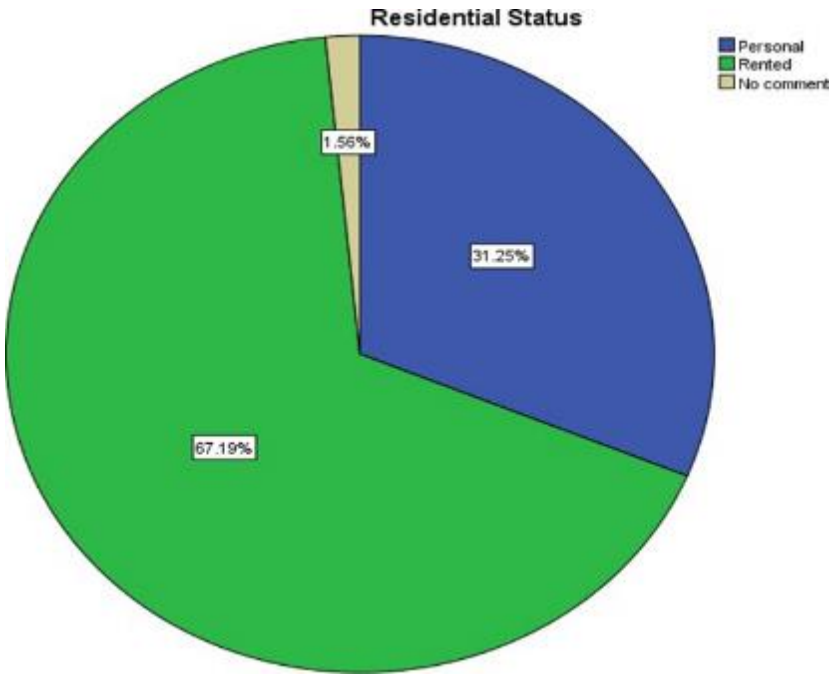

Figure 10 Residential Status of the Respondents

Table 8 Number of Hours Spent at Home by the Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6-10hrs	52	81.3	81.3	81.3
	10hrs and above	12	18.8	18.8	100.0
	Total	64	100.0	100.0	

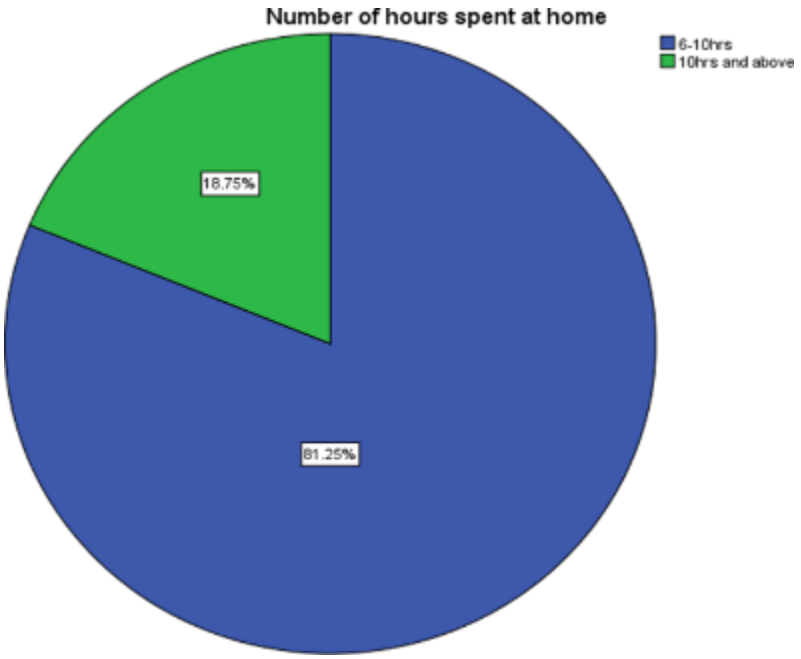

Figure 11 Number of Hours Spent at Home by the Respondents

Table 9 Main Source of Water for Domestic Use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Public kiosk	33	51.6	51.6	51.6
	Yard connection	24	37.5	37.5	89.1
	House connection	7	10.9	10.9	100.0
	Total	64	100.0	100.0	

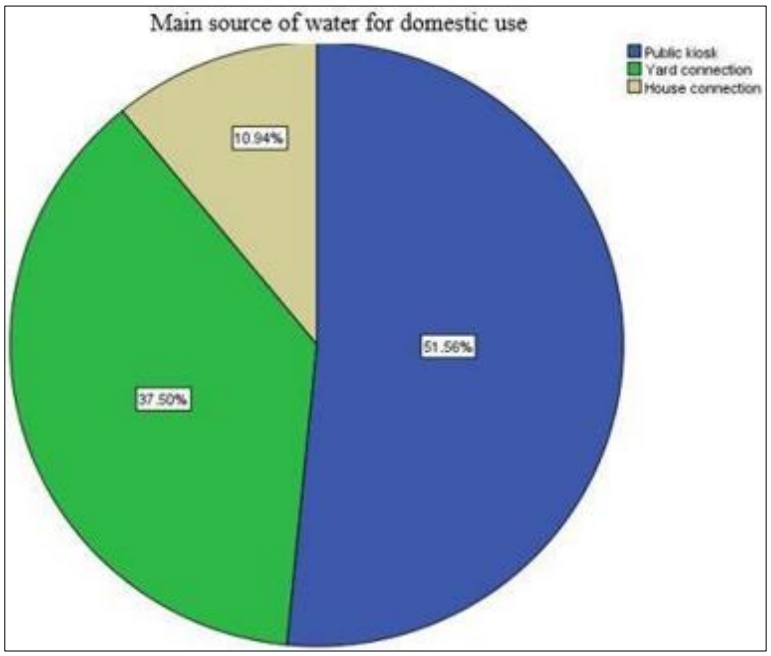

Figure 12 Main Source of Water for Domestic Use

Table 10 Usage of River Water for Domestic Chores

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	64	100.0	100.0	100.0

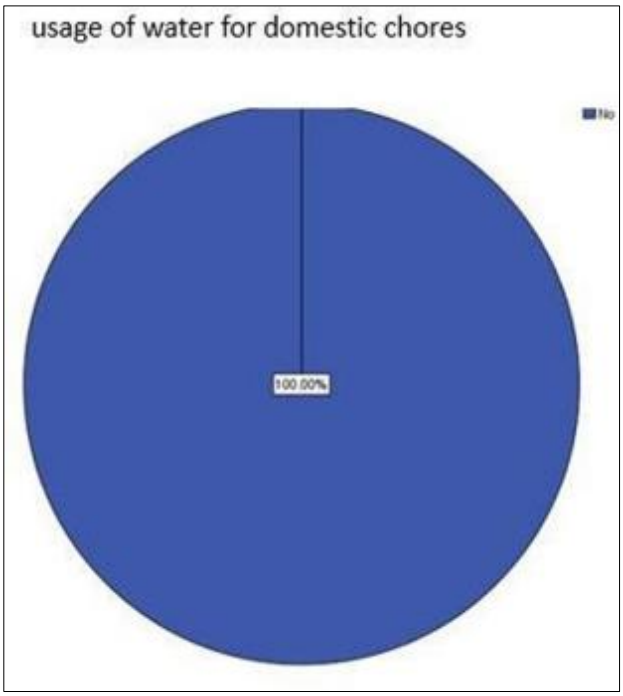

Figure 13 Usage of River Water for Domestic Chores

3.1.2. The Effect of Abattoir Activities on the Residential Neighborhood

Table 11 Health Problems Experienced by Households Last Year

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diarrhea	9	14.1	14.1	14.1
	Intestinal worms	3	4.7	4.7	18.8
	Skin irritation	10	15.6	15.6	34.4
	Other (specify)	12	18.8	18.8	53.1
	None	30	46.9	46.9	100.0
	Total	64	100.0	100.0	

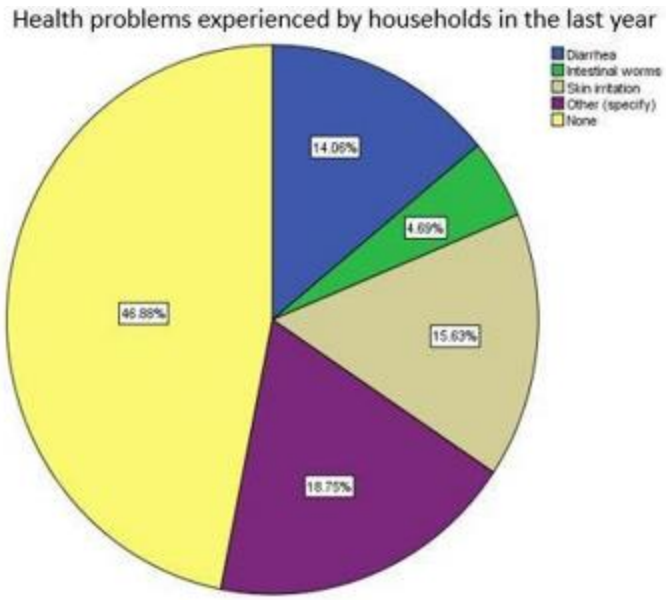

Figure 14 Health Problems Experienced by Households Last Year

Table 12 Other Health Problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Respiratory issue	7	10.9	41.2	41.2
	Heart disease	1	1.6	5.9	47.1
	Malaria	5	7.8	29.4	76.5
	Teething	2	3.1	11.8	88.2
	Typhoid	1	1.6	5.9	94.1
	High blood pressure	1	1.6	5.9	100.0
	Total	17	26.6	100.0	
Missing	System	47	73.4		
Total		64	100.0		

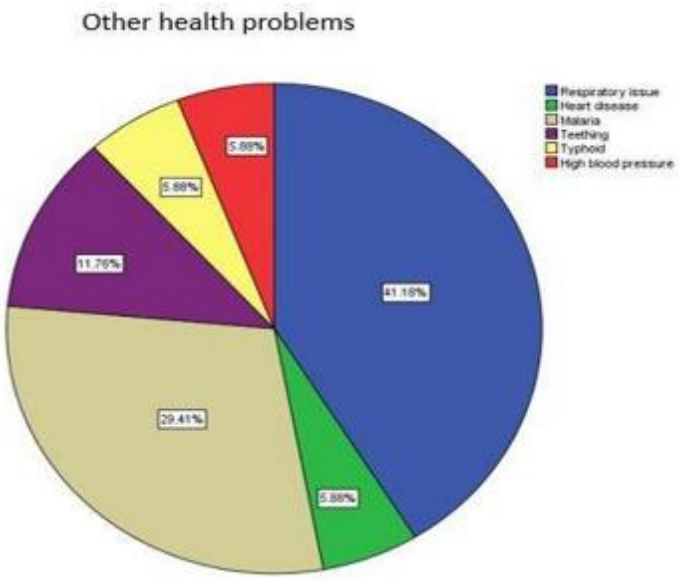

Figure 15 Other Health Problems

Table 13 Reasons for the Health Problems Complained Above

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low water quality	11	17.2	35.5	35.5
	Poor hygiene	11	17.2	35.5	71.0
	Do not know	9	14.1	29.0	100.0
	Total	31	48.4	100.0	
Missing	System	33	51.6		
Total		64	100.0		

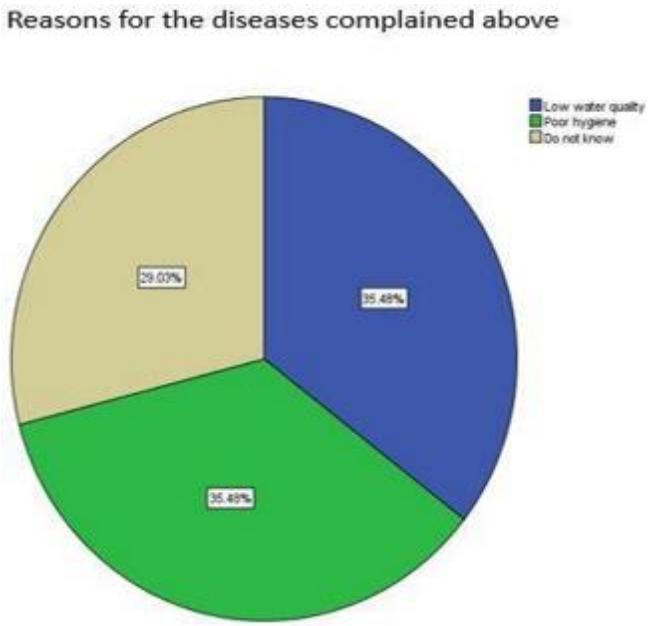

Figure 16 Reasons for the Health Problems Complained Above

Table 14 Number of People Affected in a Household

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	6.3	11.4	11.4
	1-3	30	46.9	85.7	97.1
	4-6	1	1.6	2.9	100.0
	Total	35	54.7	100.0	
Missing	System	29	45.3		
Total		64	100.0		

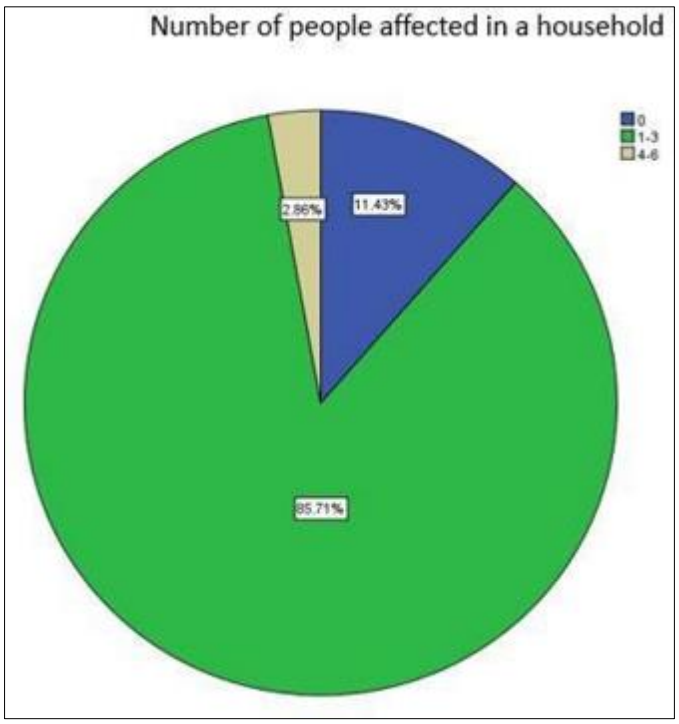

Figure 17 Number of People Affected in a Household

Table 15 The Age of Affected Household Members

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5 years	6	9.4	17.1	17.1
	6-10 years	12	18.8	34.3	51.4
	11-15 years	4	6.3	11.4	62.9
	16-20 years	4	6.3	11.4	74.3
	20 years and above	9	14.1	25.7	100.0
	Total	35	54.7	100.0	
Missing	System	29	45.3		
Total		64	100.0		

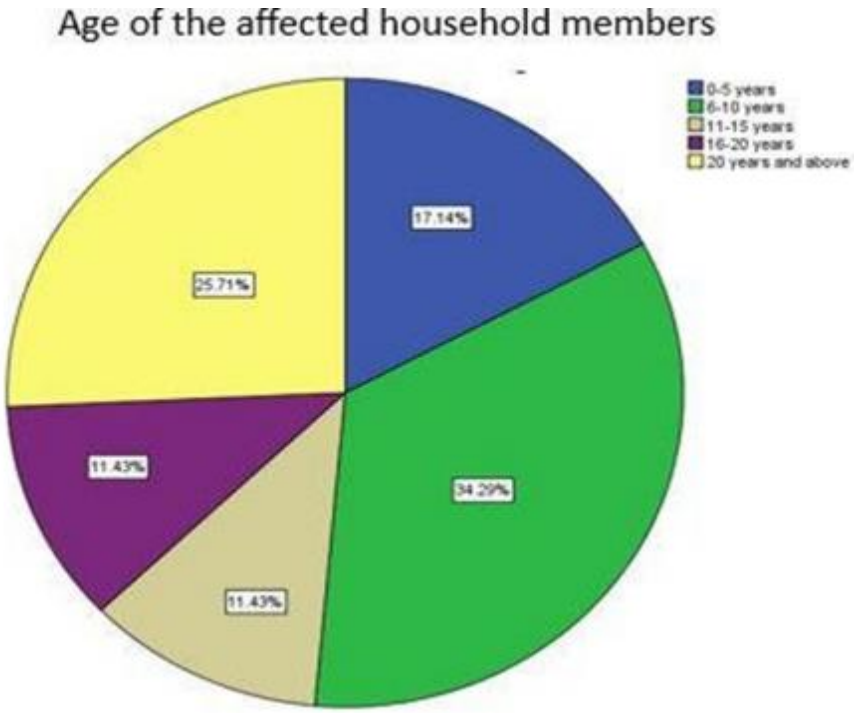

Figure 18 Age of the Affected Household Members

Table 16 The kind of health assistance when infected with the diseases mentioned above

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Go to the dispensary/hospital	7	10.9	20.0	20.0
	Buy medication in a shop	26	40.6	74.3	94.3
	None	2	3.1	5.7	100.0
	Total	35	54.7	100.0	
Missing	System	29	45.3		
Total		64	100.0		

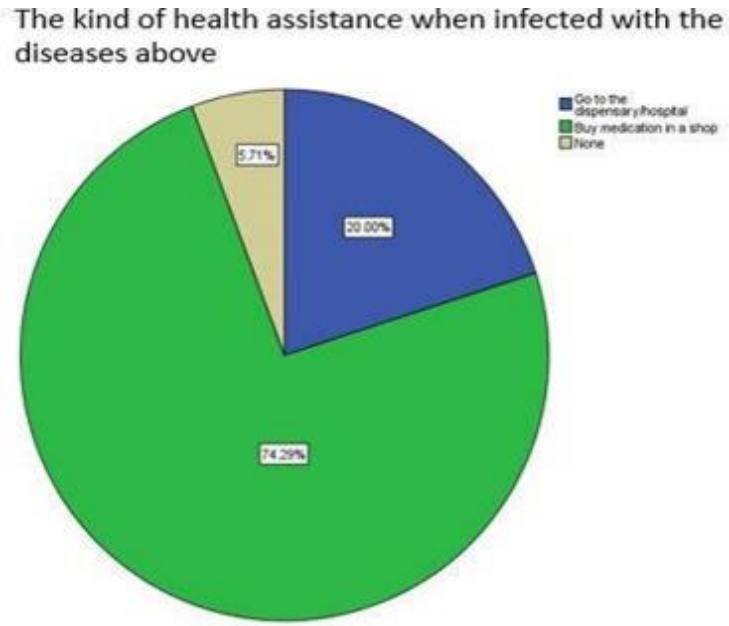

Figure 19 kind of health Assistance they Seek when Infected

Table 17 Their concern for the abattoir being in the neighborhood

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	41	64.1	64.1	64.1
	No	19	29.7	29.7	93.8
	Do not know	4	6.3	6.3	100.0
	Total	64	100.0	100.0	

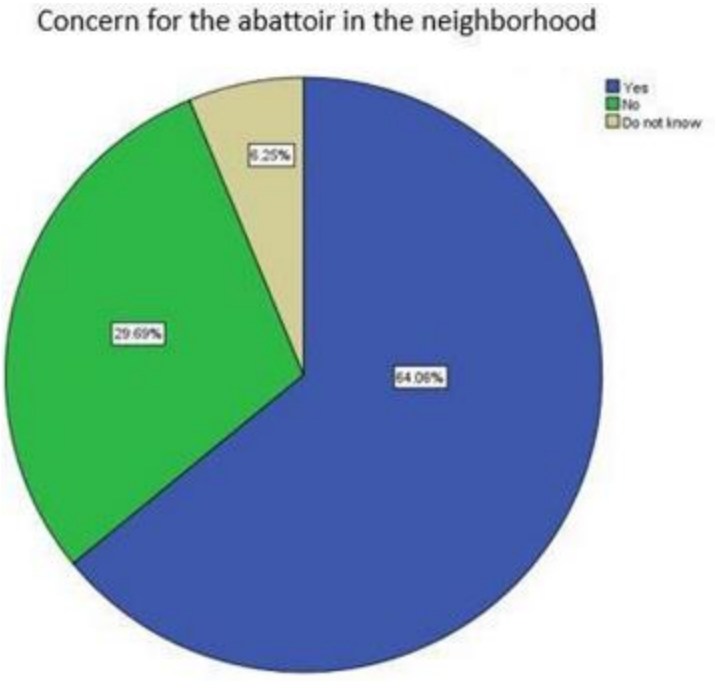

Figure 20 Concern for Having the Abattoir in the Neighborhood

Table 18 Number of Concerns About the Abattoir in the Neighborhood

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Lots of smoke and odour	1	1.6	2.4	2.4
	Odour	8	12.5	19.0	21.4
	Flies	1	1.6	2.4	23.8
	Smoke, flies and odour	5	7.8	11.9	35.7
	Smoke	20	31.3	47.6	83.3
	Touts around and smoke	2	3.1	4.8	88.1
	Insecurity	1	1.6	2.4	90.5
	Drug dealers	2	3.1	4.8	95.2
	Very busy	1	1.6	2.4	97.6
	Drugs	1	1.6	2.4	100.0
	Total	42	65.6	100.0	
Missing	System	22	34.4		
Total		64	100.0		

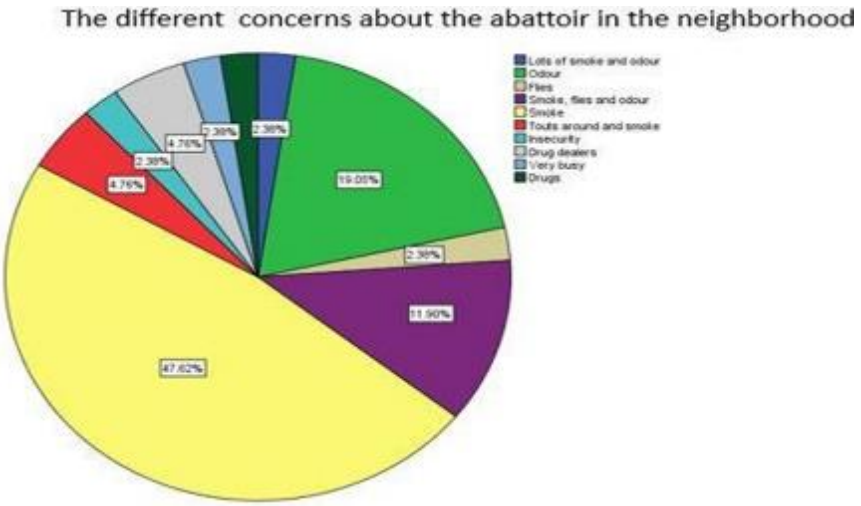

Figure 21 Number of concerns they have for having the abattoir in the neighborhood

Table 19 Idea About the Quality of Effluent Discharged from the Abattoir

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	18	28.1	28.1	28.1
	No	38	59.4	59.4	87.5
	Do not know	8	12.5	12.5	100.0
	Total	64	100.0	100.0	

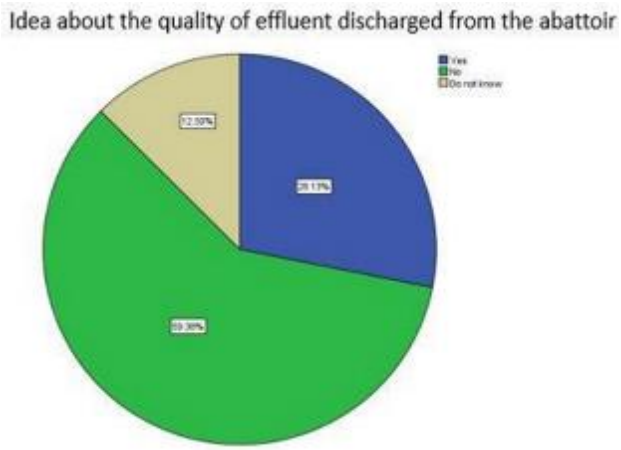

Figure 22 The Ideas they Have About the Quality of Effluents Discharged from the Abattoir

Table 20 The Different Effluents Discharged from the Abattoir

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dirty water	10	15.6	27.0	27.0
	Blood and intestinal content	5	7.8	13.5	40.5
	Blood	5	7.8	13.5	54.1
	Blood and animal faeces	9	14.1	24.3	78.4
	Abattoir waste	8	12.5	21.6	100.0
	Total	37	57.8	100.0	
Missing	System	27	42.2		
Total		64	100.0		

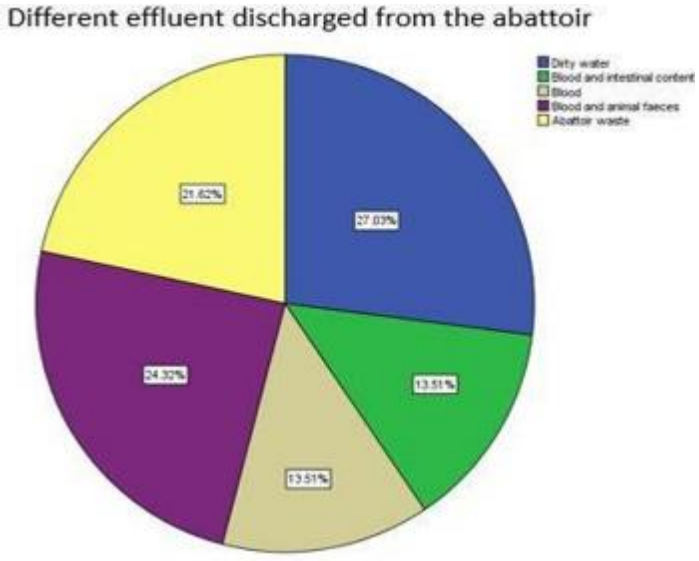

Figure 23 Different Effluents Discharged from the Abattoir

Table 21 Benefits of Having an Abattoir in the Neighborhood

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes. If yes, how	19	29.7	29.7	29.7
	No	42	65.6	65.6	95.3
	Do not know	3	4.7	4.7	100.0
	Total	64	100.0	100.0	

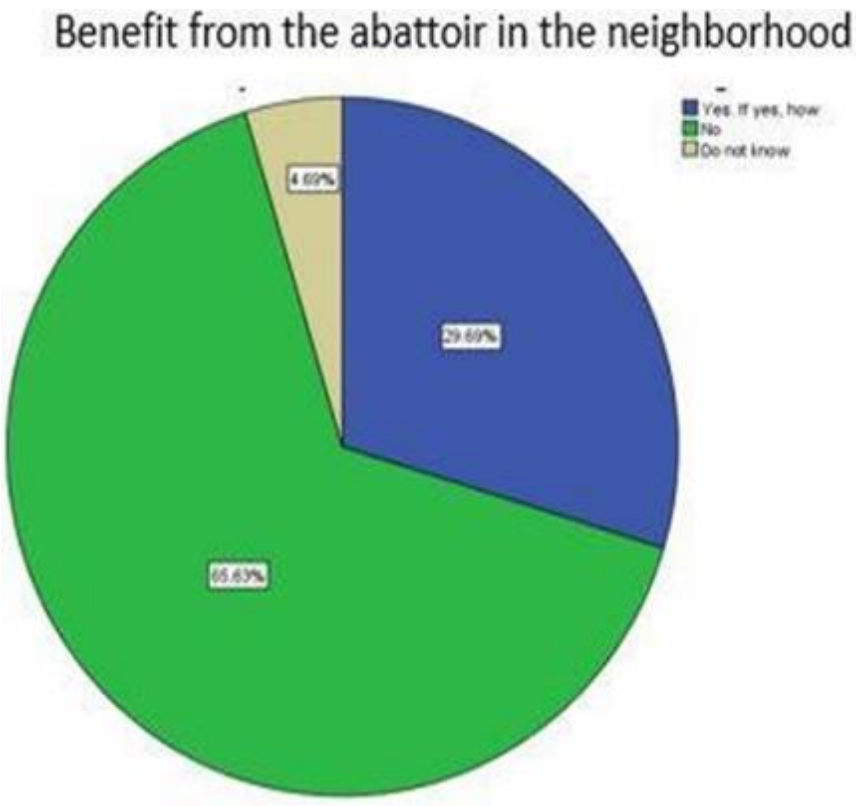

Figure 24 Benefits of having an Abattoir Within the Neighborhood

Table 22 Number of benefits for having the abattoir in the neighborhood

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Close proximity to buy meat	3	4.7	13.6	13.6
	Security	9	14.1	40.9	54.5
	Employment	8	12.5	36.4	90.9
	Buying meat	2	3.1	9.1	100.0
	Total	22	34.4	100.0	
Missing	System	42	65.6		
Total		64	100.0		

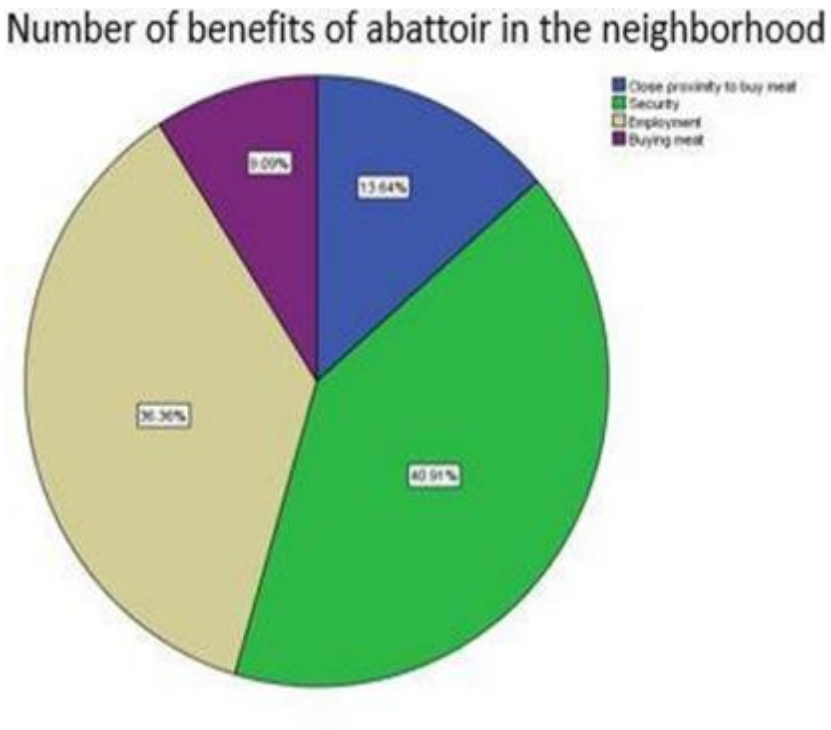

Figure 25 Number of benefits for having the abattoir in the neighborhood

3.1.3. Air quality

Table 23 Monthly concentrations of air pollutants at the Abattoir in 2020

Units: molecules/cm^2								
Month	Location	Longitude	Latitude	NO2	CH4	NO	SO2	CO
Jan	Abattoir	7.579077	9.01151	2.75	3.00	2.10	4.06	3.17
Feb	Abattoir	7.579077	9.01151	1.98	2.15	1.48	2.91	2.27
Mar	Abattoir	7.579077	9.01151	1.65	1.53	1.01	2.11	1.61
Apr	Abattoir	7.579077	9.01151	1.27	1.38	0.84	1.93	1.42
May	Abattoir	7.579077	9.01151	1.04	1.09	0.57	1.65	1.12
Jun	Abattoir	7.579077	9.01151	0.82	0.84	0.32	1.37	0.88
Jul	Abattoir	7.579077	9.01151	0.86	0.84	0.26	1.46	0.91
Aug	Abattoir	7.579077	9.01151	0.85	0.91	0.36	1.46	0.96
Sep	Abattoir	7.579077	9.01151	0.82	0.82	0.31	1.42	0.88
Oct	Abattoir	7.579077	9.01151	0.90	0.90	0.35	1.58	0.99
Nov	Abattoir	7.579077	9.01151	1.39	1.14	0.55	1.77	1.19
Dec	Abattoir	7.579077	9.01151	1.88	1.68	1.03	2.42	1.77

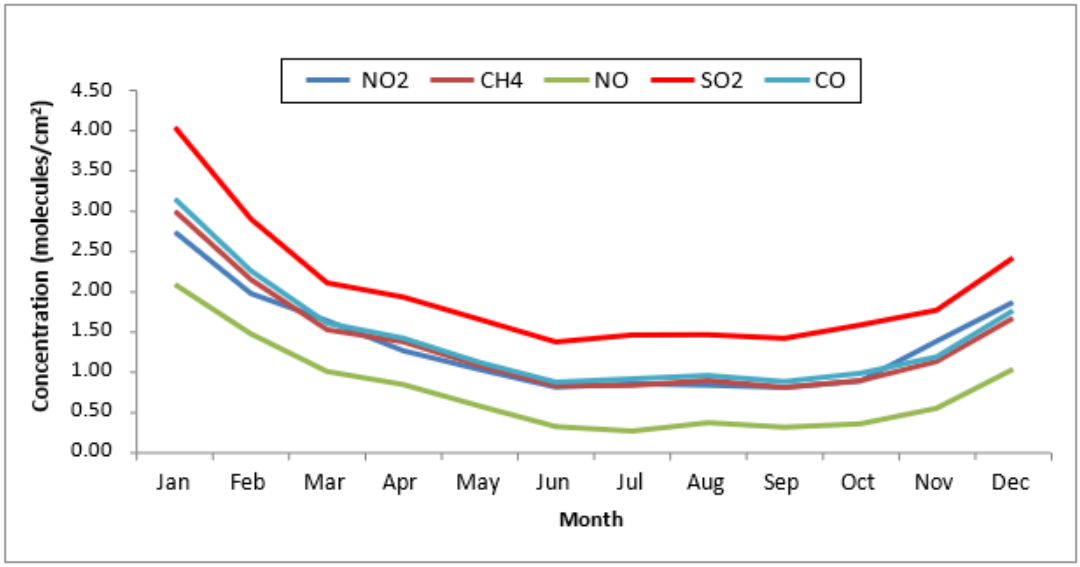

Figure 26 Monthly variation of air pollutants concentrations at the Abattoir (7.579077°N, 9.01151°E)

Concentration of Pollutants in Dry Season (November – April)

Nitrogen dioxide (NO_2) = 1.39 + 1.88 +2.75 +1.98 + 1.65 + 1.27 = 10.92/6 =1.82m/cm^3

Methane (CH_4) = 1.14 + 1.68 + 3.00 + 2.15 + 1.53 + 1.38 = 10.88/6 = 1.81m/cm^3

Nitrogen monoxide (NO) = 0.55 + 1.03 + 2.10 + 1.48 + 1.01 + 0.84 = 7.01/6 = 1.68m/cm^3

Sulfur dioxide (SO_2) = 1.77 + 2.42 + 4.06 + 2.91 + 2.11 + 1.93 = 15.2/6 = 2.53m/cm^3

Carbon monoxide (CO) = 1.19 + 1.77 + 3.17 + 2.27+ 1.61 + 1.42 = 11.43/6 = 1.90m/cm^3

Concentration of Pollutants in Wet Season (May – October)

Nitrogen dioxide (NO_2) = 1.04 + 0.82 + 0.86 + 0.85 + 0.82 + 0.90 = 5.29/6 = 0.88m/cm^3

Methane (CH_4) = 1.09 + 0.84 + 0.84 + 0.91 + 0.82 + 0.90 = 5.4/6 = 0.9m/cm^3

Nitrogen monoxide (NO) = 0.57 + 0.32 + 0.26 + 0.36 + 0.31 + 0.35 = 2.17/6 = 0.36m/cm^3

Sulfur dioxide (SO_2) = 1.65 + 1.37 + 1.46 + 1.46 + 1.42 + 1.58 = 8.94/6 = 1.49m/cm^3

Carbon monoxide (CO) = 1.12 + 0.88 + 0.91 + 0.96 + 0.88 + 0.99 = 5.74/6 = 0.96m/cm^3

3.1.4. Water quality

Table 24 Parameters of Water Quality Analysis (Physical, Chemical and Biological**)**

S/NO	WATER ANALYSIS PARAMETERS (PHYSICAL)	RESULTS OF WATER QUALITY ANALYSIS	PERMISSIBLE LIMIT (WHO)	NSDWQ
1	Turbidity	2.39µs	5NTU	-
2	Temperature	26.3ºC	30ºC	30ºC
3	Total dissolve solids	239mg/l	1500mg/l	500mg/l
4	Conductivity	299µs/cm^3	1250µs/cm^3	1000 µs/cm^3

S/NO	CHEMICAL PARAMTERS	RESULTS OF WATER QUALITY ANALYSIS	PERMISSIBLE LIMIT (WHO)	NSDWQ
1	pH	7.4	6.5 – 8.5	6.5 – 8.5
2	Alkalinity	172mg/l	100mg/l	200mg/l
3	Sulfate (SO_4^{2-})	9mg/l	400mg/l	100mg/l
4	Chloride ion content Cl^-	31.24mg/l	250mg/l	250mg/l
5	Iron (Fe)	0.06mg/l	0.3mg/l	0.3mg/l
6	Phosphate (PO_4^{2-})	0.26mg/l	6.5mg/l	-
7	Nitrate (NO_3^-)	1.9mg/l	50mg/l	50mg/l
8	Nitrite (NO_2^-)	0.044mg/l	50mg/l	50mg/l
9	Total hardness	152mg/l	500mg/l	100mg/l
10	Manganese (Mn)	0.1mg/l	0.5mg/l	1.0mg/l

S/NO	(BIOLOGICAL) PARAMETERS	RESULTS OF WATER QUALITY ANALYSIS	PERMISSIBLE LIMIT (WHO)	NSDWQ
1	Coliforms	15.8mg/l	Nil/100mg	Nil
2	Enterobacter Aerogene	9.0mg/l	Nil/100mg	Nil

3.1.5. Results on Abattoir Operations and Sanitation Based on Compliance with Rules and Regulations

Operations and sanitation at the abattoir

Table 25 Operational awareness about the Karu abattoir's sanitation

Variables	Frequency	Percentage
Adequacy of the abattoir		
Yes	59	86.8
No	9	13.2
Availability of lairage		
Yes	55	80.9
No	13	19.1
Carrying out the ante-mortem activities		
Yes	47	71.2
No	19	28.8
Adequacy of toilet facility		
Yes	47	69.1
No	21	30.9
Adequacy of waste disposal facility		

Yes	16	33.3
No	32	66.7
Adequacy of water supply facility		
Yes	30	44.8
No	37	55.2
Availability of health personnel		
Yes	52	77.6
No	15	22.4
Carrying out environmental sanitation activities		
Yes	61	89.7
No	7	10.3
Routine Post-mortem examination		
Yes	62	91.2
No	6	8.8
Conversion of waste to wealth		
Yes	44	91.7
No	4	8.3
Current disposal methods		
Open dumping	50	73.6
Land filling	9	13.2
Composting	9	13.2

Table 26 Water Supply and Waste Management in Karu Abattoir

Variables	**Frequency**	**Percentage**
Sources of water supply		
Tap water	31	64.6
Borehole	17	35.4
Availability through the year		
Yes	40	87
No	6	13
Water treatment		
Chlorination	21	87.5
Exposure to sunlight	3	12.5
Satisfaction with quantity of water supply		
Yes	23	48.9
No	24	51.1
How often is the disposal of waste		

Once in a day	45	95.7
Once in a week	2	4.3
Disposal of wastewater		
Into the drainage	47	100

Table 27 Availability of Sanitary facilities in Karu Abattoir

Variables	**Frequency**	**Percentage**
Accommodation (office)		
Yes	41	85.4
No	7	14.6
Cleaning and repair room		
Yes	18	37.5
No	30	62.5
Water supply facilities		
Yes	44	91.7
No	4	8.3
Toilet facilities		
Yes	47	97.9
No	1	2.1
Hand washing facilities		
Yes	11	23.4
No	36	76.6
Refuse /waste bin		
Yes	44	91.7
No	4	8.3
Drainage		
Yes	44	91.7
No	4	8.3
Cold room		
Yes	3	6.3
No	45	93.7
Cloak room		
Yes	11	25.0
No	33	75.0
Sterilizer		
Yes	10	20.8
No	38	79.2

Slaughter-bay		
Yes	40	83.3
No	8	16.7
Electricity		
Yes	40	83.3
No	8	16.7
First Aid box		
Yes	2	4.2
No	46	95.8
Laboratory		
Yes	1	2.1
No	47	97.9
Lairage		
Yes	45	93.8
No	3	6.2
Bleeding room		
Yes	15	31.9
No	32	68.1
Flaying section		
Yes	30	62.5
No	18	37.5
Eviscerating room		
Yes	17	35.4
No	31	56.6
Hoists		
Yes	18	37.5
No	30	62.5

Table 28 Personal hygiene and safety practices in Karu Abattoir

Variables	Frequency	Percentage
Is there any employed cleaner in the abattoir		
Yes	47	97.9
No	1	2.1
How often is the cleaning done		
Once in a day	41	85.4
Twice in a day	7	14.6
Washing of hand after each operation		

Yes	59	98.3
No	1	1.7
How often		
Frequently	44	68.8
Seldom	8	12.5
When I remember	2	3.1
When I want to eat/pray	10	15.6
Wearing of PPE		
Yes	53	89.8
No	6	10.2
Boot		
Yes	63	96.9
No	2	3.1
Overall cloth		
Yes	60	92.3
No	5	7.7
Nose mask		
Yes	11	19.0
No	47	81.0
Hand gloves		
Yes	47	72.3
No	18	27.7
Cleaning of cutting materials		
Yes	62	100
Cleaning materials		
Water only	29	46.0
Water and detergent	23	36.5
Water, sterilizer and detergent	11	17.5
Operation system for slaughtering		
Line	48	80.0
Booth	1	1.7
Don’t know	11	18.3
Materials for roasting		
Kerosene	2	4.3
Tyre	11	23.4
Wood	34	72.3
Attendance of public health education programme on abattoir operation		
Yes	33	52.4
No	30	47.6

3.1.6. Results for abattoir site suitability

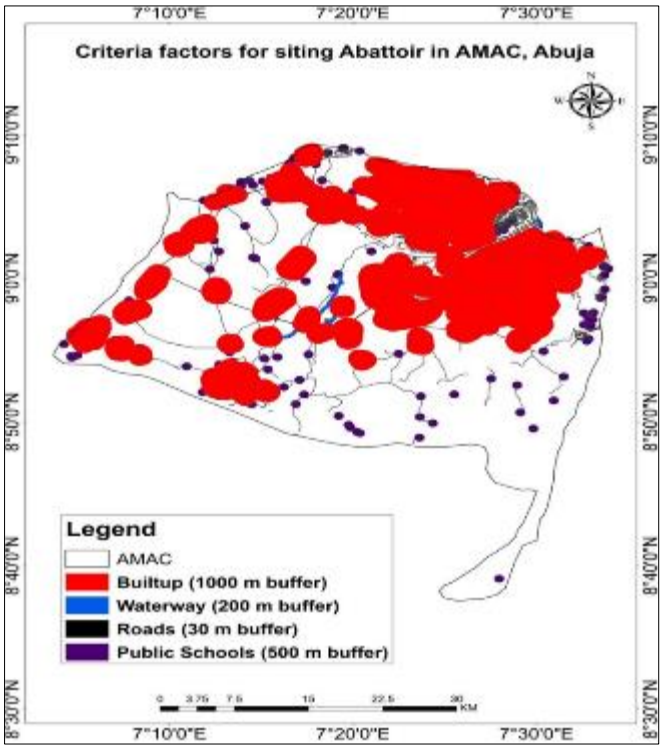

Figure 27 Map showing the criteria factors for siting abattoir in AMAC, Abuja

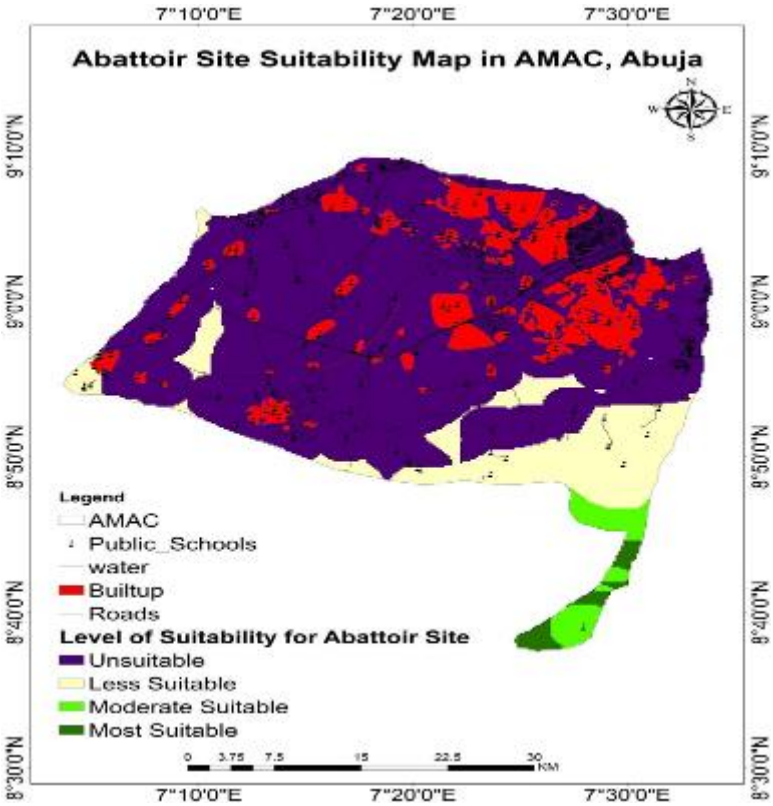

Figure 28 Map showing Abattoir site suitability in AMAC, Abuja

3.2. Demographic characteristics of the respondents (n=64)

From the demographic analysis, 57.81% of the respondents were females and 42.19% were male. Their ages range between 20- 30 years (26.56%), between 31- 40 years (34.38%) from 41 -50 years where about 25% and 9.38% were above 60 years. 64.06% were married, 21. 88% were single, 7.81% widows/widowers, and 6.25% were divorced. 70.31% had tertiary certificates, 28.13% had secondary certificates, and 1.56% with primary certificates. 42.19% were self-employed, 34.38% were employed and 23.44% were unemployed. 37.50% of the respondents lived within the neighborhood for less than five (5) years, 50% lived between five (5) to ten (10) years, 7.81% lived between ten (10) to fifteen (15) years and 4.69% lived over fifteen (15) years within the Karu abattoir neighborhood. 31.25% of the respondents lived in their houses, 67.19% in rented apartments, and 1.56% had no comment. 81.25% spend six (6) to ten (10) hours at home while 18.75% spend 10 hours and above at home. 51% of the respondents use water from public kiosks for their domestic chores, 37.50% use water from yard connections, and 10.94% have water connected to their houses. 100% of the respondents had no business with the Karu River water for any domestic chores (See Table 1 and Figure 4).

3.3. The effect of abattoir activities on the residential neighborhood

The health problems experienced by the household members were Diarrhea (14.06%), intestinal worms (4.69%), skin irritation (15.63%) and some diseases other than the ones mentioned where respiratory diseases (41.18%), heart disease (5.88%), teething which was associated to children less than five (5) years of age (11.76%), typhoid (5.88%) and high blood pressure (5.88%). The health conditions above 35.48% reported to be related to low water quality, 35.48% poor hygiene and 29.03% had no idea of the course of their health condition. The ages of the people affected were between zero (0) to five (5) years (17.14%), between six (6) to ten (10) years (34.29%), between eleven (11) to fifteen (15) years (11.43%), between sixteen (16) to twenty (20) years (11.43%) and 25.71% where above twenty (20) years. 20% of the respondents who were affected with one disease or the other seek medical assistance from the dispensary or hospital, 74.29% seek medical assistance over the counter at the pharmacy stores and 5.71% neither visit the hospital nor pharmacy. 64.06% of the respondents have concerns about the abattoir being within the neighborhood and those concerns include lots of smoke (47.62%), flies and odour (11.90%), drug dealers (4.76%), insecurity (2.38%), very busy and noisy (2.38%). 28.13% of the respondents had the idea of the quality of the effluence discharged from the abattoir and those effluence discharge from the abattoir include dirty water (27.03%), blood and intestinal content (13.51%), blood and animal feaces (24.32%) and 21. 62% general abattoir waste. 65.63% of the respondents said they do not benefit from the abattoir being within the neighborhood while 29.69% said they benefit in terms of proximity to buy meat (13.64%), security (40.91%), and employment (36.36%) (See Table 11 and Figure 14).

3.4. Air Quality

The average mean value of the pollutant shows Sulfur dioxide (SO2) being the highest pollutant in the atmosphere around the study area both during dry and wet seasons with values of 2.53m/cm3 and 1.49m/cm3 respectively. Nitrogen monoxide (NO) is the lowest pollutant in the atmosphere having values 1.68m/cm3 and 0.36m/cm3 respectively. During the winter, from time to time, a ridge from the high-pressure system dominates the atmosphere. Accompanied by relatively strong winds, the ridge brings cooler air and carries some pollutants along with it. This implies that those particulate matters or pollutants, for example after it is released from vehicle exhausts and biomass burning, does not rise high enough or it is not transported horizontally for long period to become diluted. With no rain, the dry season worsens the problem because pollutants remain suspended in the air for an extended period. Add to this vehicular and open-burning pollutants, and the situation is exacerbated (See Table 23 and Figure 27).

Even though all pollutants have direct or indirect effects on human health, Sulfur dioxide (SO2) which has the highest value has more effect than others. Sulfur dioxide (SO2) affects the respiratory system, particularly lung function, and can irritate the eyes, and respiratory track and increase the risk of track infection. It causes coughing, mucus secretion and aggravates conditions such as asthma and chronic bronchitis. The major sources of these high particulate matter pollution levels are vehicles and biomass burning. Results from the analysis indicates that high particulate matters were recorded in the month of January which shows a significant trend, decreasing at the onset of raining season and rising as the dry season sets in, giving us an almost U- Shaped like graph (See Table 23 and Figure 27).

3.5. Parameters of water quality at the abattoir

There are three types of water quality parameters physical, chemical, and biological. The results of water quality assessments are shown in Table 3. All the parameter values are below the recommended limits by the Nigerian standards for drinking water quality (NSDWQ) and also the World Health Organization Standard (WHO).

Turbidity, there is no health-based guideline value for turbidity that has been proposed by the NSDWQ; however, it should be below 0.1 NTU for effective disinfection [23]. The permissible limit for WHO 5NTU. But from the result of the analysis 2.39 NTU was realized which is above 0.1 NTU and that shows no effective disinfection. Temperature, from the analysis of water temperature, the NSDWQ agrees with the WHO standard at 30°C which the result from the analysis falls a little below the standard at 26.3°C. As a result, low temperature affects the sedimentation and chlorination processes, as well as the biological oxygen demand (BOD). Total dissolved solids, the value of total dissolve solid was lower than the permissible limit given by NSDWQ 500mg/l and WHO 1500mg/l. Although there is no evidence of any epidemiological reaction at high level of Total solids, but water becomes unpalatable and may lead to corrosion of containers. Consequently, [24] set the highest permissible values of 1500mg/L. The palatability of water with a total solids level of less than 600 mg/L is generally considered to be good. Electrical conductivity, the electrical conductivity of the water fell below the range given by NSDWQ 1000 µs/cm3 and WHO 1250 µs/cm3, which implies that it the water will be unable to pass electrical current. PH, the PH level of the water 7.4 fell within the range of the NSDWQ and WHO at 6.5 – 8.5 respectively. Alkalinity, the high levels of either acidity or alkalinity in water may be an indication of industrial or chemical pollution. The alkalinity of the abattoir ground surface water was 172mg/l a little lower than the permissible limit of the NSDWQ at 200mg/l and higher than the WHO standard at 100mg/l. Sulfate, the value obtained from the analysis is too low at 9mg/l compared to NSDWQ standard at 100mg/l and also WHO at 400mg/l, but there is no significant danger to public health. Chloride ion content, from the result the value of the chloride ions in the water content was 31.24mg/l compared to the standards of NSDWQ and WHO at 250mg/l. Chloride ions Cl^- in drinking water do not cause any harmful effects on public health, but high concentrations can cause an unpleasant salty taste for most people. Iron (Fe) and Manganese (Mn), the iron (Fe) content in the water was of lower at 0.06mg/l compared to the NSDWQ standard at 1.0mg/l and WHO 0.5mg/l. The manganese content was 0.1mg/l compared to the NSDWQ agreeing with the WHO standard at 0.5mg/l. Even though iron (Fe) and manganese (Mn) do not cause health problems, they give drinking water a bitter taste even at very low concentrations. Phosphate. This parameter was analyzed at 0.26mg/l lower than the recommended limit given by the WHO at 6.5mg/l while NSDWQ did not set a specific limit. Phosphates are not toxic to people or animals unless they are present in very high levels causing digestive problems. Nitrate. The content level of Nitrate was 1.9mg/l lower than the permissible level of the WHO guideline value of 50 mg/l as well as NSDWQ. Nitrate is a nitrogenous chemical that, when present in large amounts in our drinking water, can cause a decrease in blood oxygen capacity, shortness of breath, and skin blueness. Nitrite. The nitrite level in the abattoir water was 0.044mg/l, very low compared to the permissible limit of NSDWQ at 3.00mg/l and the limit permitted by WHO is relatively higher at 50mg/l, low amount of nitrite in water is not harmful to public health and it occurs naturally or artificially in groundwater. Hardness; the hardness content of the analyzed water was 152 mg/l higher than the permissible limit of the NSDWQ at 100mg/l and lower than the WHO permissible limit at 500mg/l. The presence of total coliform provides evidence of recent faecal contamination and the detection should lead to further action. It is present in high number in human and animal faeces and rarely found in the absence of faecal pollution. Their presence can also reveal regrowth and possible biofilm function or contamination. They occur in both sewage and natural wastes and can also be excreted with human and animal faeces.

3.6. Operations and sanitation based on compliance with rules and regulations for establishing an abattoir.

According to the outcome of the analysis, the majority of the abattoir's personnel, and the demographics show that the Karu abattoir has a large number of young people (aged 21 to 40). This supported [25] findings that meat handling and retailing need a lot of physical power and are carried out by more energetic and active young and middle-aged men. By the abattoir's entrance, stores were selling unlawful constructions made of wood, as well as an umbrella and canopy, which did not comply with the National Policy on Market and Abattoir Sanitation [14]. Food vendors in the vicinity of the abattoir are unorganized, and the majority operate in unsanitary conditions, exposing the food to flies. There was an open space that was utilized as a lairage, with no drainage, a concrete floor, and cow poo strewn about. The butcher arena was smooth and had drainage, but it lacked a line slaughter system, which is necessary for modern and sanitary killing. Due to careless stunning and unsanitary evisceration, successive animals in each batch were slaughtered on top of animal blood and manure. Some regulations, such as isolation/quarantine and removal of suspected or unhealthy animals, were not strictly enforced by health officers during ante/post-mortem investigations. The butchers were dressed in overalls and boots, but lacked a head covering and hand gloves, in violation of standard animal slaughtering hygiene regulations. Water was obtained from a tap and a borehole, which were satisfactory, but the water did not meet the hygiene standards required to assure the safety and protection of the meat from contamination [26]. Because there was no provision for an overhead storage tank or enough water output points, the “Gwandala women” were forced to work as laborers and bring water for sale from outside the abattoir which is sourced from the borehole. The animals' hides and skins were burned using tyre materials, plastics, and wood, resulting in black smoke that stained their noses, skin, and clothing. The bleeding occurred on the spot with no collection container, and the blood was channeled into the river, polluting water sources. The gut contents are removed at the treatment bay after evisceration on the ground, which is against slaughterhouse sanitary principles (See Table 25).

The Karu abattoir lacks a collection facility for waste products created in the abattoir, such as animal excrement, blood, and hides. The trash was dumped in the open and channeled into a nearby brook. It is illegal to dump wastewater containing blood and animal feces into water bodies such as streams and rivers, as this might accelerate the pace of toxin accumulation. Although suitable toilet facilities were provided, some persons continued to use the lairage and neighboring jungle to practice open defecation, which is not in conformity with the National Policy on Abattoir Sanitation for sanitary behaviors. A significant proportion of butcheries in the Karu abattoirs cleaned their utensils with only water, Because of the fatty nature of the abattoir's output, a constant supply of hot, safe water is essential. The use of hot water and detergent makes cleaning the abattoir floor and equipment simple and effective. The majority of respondents (89.8%) said they wore personal protection equipment (PPE), which includes boots (96.9%), overall clothing (92.3%), and hand gloves (92.3%). (72.3 percent). Everyone was responsible for cleaning the cutting instruments with simple water (46 percent). The majority of respondents (80%) claimed that "line" is being used as a slaughtering operation system. Most (2.3%) engaged in the use of wood as material for roasting the animal in the abattoir (See Table 25).

3.7. Abattoir site Suitability

The analysis on site suitability considered the criteria for siting the abattoir based on socio-economic factors using constraints such as built-up areas, public schools, waterways, and roads, the specification of 1km for residents around the abattoir neighborhood was buffered, 500m for public schools,200m for waterways and 30m for roads. After the analysis, it was seen the location of the abattoir within the Karu abattoir did not meet the given specifications making the neighborhood and its residences vulnerable to the impact of the environmental pollution generated by the abattoir activities (See Figures 28 and 29).

4. Conclusion

The environmental issues linked with abattoirs are extensive and difficult to solve. Diseases caused by a poor waste and sewage disposal system, drinking contaminated water, insufficient vector control, and the general state of the environment all contribute significantly to poor public health and sanitation. Based on the analyzed data of the study, it was revealed that abattoir activities and management have direct and indirect effects on the built-up environment and health of people especially residents of the abattoir vicinity. The regulations on the operations of the slaughterhouse were below the standard requirements and much was needed to be done to improve the system at the facility. Line slaughter systems do not maintain hygiene processes such as butchery utensils such as knives, axe, and other equipment have contaminated diseased carcass due to un-sterilization before being used again. Several environmental criteria and socio-economic factors were considered and used to obtain the land use suitability index map and spatial density map. The final suitability map shows the Most Suitable sites in the study area.

4.1. Recommendations

According to the findings of this study, the Karu abattoir's operations are not environmentally friendly, posing major health and environmental risks to the community's population. As a result, here are some recommendations: Pollution of the air should be avoided by not burning used tyres and using them to roast meat or remove hides from slain animals. Both humans and the ecosystem are harmed by this. The Area Council's government should be proactive in monitoring abattoir operations by conducting routine inspections, including animal and meat supervision, as well as general sanitary inspections, to ensure maximum compliance with global requirements and sanitary regulations and standards governing abattoirs. Built-ups and schools, roads and waterways were mostly situated in an unsuitable locations making them vulnerable to the impact of the pollution generated as a result of abattoir activities, hence, the abattoir should be situated away from residential areas.

Compliance with ethical standards

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No conflict of interest is to be disclosed

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