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Environmental and Social Implications of Mixed Land use in Zambia: A Case Study of Makeni Area, Lusaka

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Abstract:- This study aimed to explore the Environmental and Social Implications of mixed land use in Makeni, Lusaka, focusing on three specific objectives: understanding the social implications, determining environmental impacts, and assessing the management of mixed land use in the area. Employing a mixed-methods approach, the research incorporated both qualitative and quantitative data collection and analysis, utilizing secondary and primary data. The sample size of 385 participants included 375 occupants of commercial and residential properties in Makeni and 10 key informants from relevant environmental agencies. Findings indicated that mixed land use in Makeni had positive effects on housing prices, accessibility to social amenities, and property costs. It also contributed to improved road infrastructure and building quality, with limited evidence of increased social problems. However, diverse opinions among respondents suggested varying perceptions. Air sampling revealed concerning levels of carbon monoxide from industries, surpassing allowable limits, while noise levels exceeded WHO recommendations in residential areas. Water analysis was not conducted due to closed systems or lack of effluent discharge. Regarding the management of mixed land use, the study highlighted a lack of awareness among participants about implementation guidelines, indicating a need for increased awareness efforts. Some participants, however, were knowledgeable, suggesting potential advocates for knowledge dissemination. The study also revealed uncertainty among participants about challenges associated with mixed land use management, emphasizing the need for further exploration and understanding of these issues.

Keywords:- *Mixed Land Use, Awareness, Environmental and Social Implications, Pollution.*

I. INTRODUCTION

The vibrant streets of Makeni in Lusaka exemplified the concept of mixed land use, where residential and commercial spaces coalesced, reflecting the intricate interplay between urban growth, environmental considerations, and social dynamics. This exploration delved into the environmental and social consequences of mixed land use in Lusaka, using the Makeni case study as a focal point. Beyond this Zambian enclave, the research uncovered insights into how well-managed mixed land use could propel sustainable progress, serving as a model for harmonizing communities with the natural world. Globally, the position of residential and commercial properties has become a prevalent practice in modern urban planning, with mixed land use associated with both positive and negative implications that can either foster or hinder sustainability. The term "mixed land use" was defined as combining different land uses within a specific area, deviating from segregating them into separate zones. This approach in urban planning created vibrant, diverse, and sustainable communities by integrating residential, commercial, industrial, recreational, and institutional uses in close proximity. The Makeni case study thus served as a microcosm, shedding light on the broader global trend and the potential benefits and challenges associated with mixed land use.

A. Statement of the Problem

Mixed land use is believed to have many socio-economic benefits such as urban vitality, reduced mobility costs, social cohesion, and effective use of utilities (Anderson, 2000) [1]. However, mixed land use has potential to pose environmental and social challenges in some instances. If not enforced to optimum level of correct typology mixed land use would hamper the quality of life as it would attract undesired traffic and visitors creating noise and safety issues. Makeni Area possessed characteristics of mixed land use and hence the need to investigate environmental and social implications of mixed land use in Lusaka.

B. Research Questions

- What are the social implications of mixed land use in Zambia?
- How has mixed land use in Zambia affected the environment?
- How is mixed land use managed in Zambia?

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C. Study Objectives

➢ *Main Objective*

The main objective of the study was to investigate environmental and social implications of mixed land use in Lusaka.

➢ *Specific Objectives*

- In order to attain the main objective, this study focused on the following specific objectives:
- To ascertain how mixed land use affects socio-economic development in Zambia;
- To determine the impact of mixed land use on the environment in Zambia; and
- To ascertain management options of mixed land use in Zambia.

➢ *Justification of the Study*

This study is of immense benefit as it draws insights into the environmental and social implications of mixed land use in Lusaka, specifically Makeni. It was expected that results of this study would be beneficial to policy formulation and decision-making regarding land use in Zambia. This would enable relevant stakeholders to enhance measures to protect the environment and social livelihoods of communities. The findings of this proposed research would able to add to the existing body of knowledge related to mixed land use.

➢ *Scope*

The research was confined to mixed land use in Makeni Area in Lusaka.

II. MATERIAL AND METHODS

A. Empirical Review

➢ *Mixed Land use in Asia*

Beijing faces challenges arising from high demand for land amid its limited availability due to a rapidly growing population. To address this, mixed land use has been considered a potential solution. (Tang, 2021) [2] conducted a study in Beijing, focusing on the evaluation of mixed land use and its impact on housing prices. The research relied on secondary data from sources like Gaode Map POI, Open Street Map, and housing price data. While the study site around the sixth road in Beijing was deemed suitable for capturing relevant characteristics, the paper lacked clarity on the criteria for selecting this location. Six land use types were identified, and 29 Points of Interest (POI) types representing these uses were selected for the study. However, the paper did not explicitly state its objectives, although the headings in the results section hinted at potential objectives. Findings revealed high mixed land use around the sixth ring, initiated by the community rather than government policy. The study emphasized the need for policy guidance to control land use. Additionally, the degree of land mixture had an impact on housing prices, but other factors, including location and structural characteristics of residential communities, were found to play a significant role. The study suggested the importance of considering multiple factors, such as proximity to amenities and transportation networks, in assessing housing prices in mixed land use arrangements.

Jingyi's (2018) [3] study conducted in Shanghai explores the complex relationship between mixed land-use planning, urban facilities, and property prices. Using quantitative methods, the research constructs an extensive database encompassing housing prices and land use in Shanghai. The study significantly contributes to existing research on consumer cities, mixed land-use, property valuation, and housing prices, offering valuable insights into the ongoing discourse surrounding land market reform in China. Notably, the research provided a quantitative analysis of the effectiveness of Shanghai's current land use structure, evaluating the willingness-to-pay for mixed land-use. The study identifies factors contributing to the distortion of land structure, including an oversupply of industrial lands targeting foreign investors and inefficiencies in the public land market.

Another important study worth noting is that which was conducted by (Chen, et al., 2022) [4] on mixed land use plays a pivotal role in fostering the efficient and intensive utilization of land resources, igniting endogenous development capabilities within rural areas. This study zeroes in on Pingba Village in Chongqing as the focal point for research. Field visits and interviews facilitated the acquisition of comprehensive data encompassing the land use status and socio-economic aspects of rural settlements in the area for the year 2021. The land use categories within these rural settlements were further subdivided based on their dominant functions, which paved the way for the creation of a mixed land-use measurement system tailored to rural settings.

The study identified two key findings: firstly, rural settlements in the research area exhibited a medium level of mixed land use with notable spatial variations. Secondly, the research emphasized the pivotal role of natural environmental factors in determining mixed land use levels and resulting spatial patterns. Socio-economic variables, including resident population and average household income, were identified as influential drivers, alongside rural tourism resources and policies promoting homestead agglomeration. The study sheds light on the complex interplay of environmental and socio-economic factors shaping mixed land use in rural settlements (Chen, et al., 2022) [4]. The study underscores the importance of mixed land use as a catalyst for rural revitalization.

Bahadure and Kothakar (2015) [5] wrote an article of Assessing Sustainability of mixed-use neighborhoods through Resident’s travel behaviorand perception. The article assesses the sustainability of mixed-use neighborhoods in Nagpur, India, focusing on residents' travel behavior and perceptions. The study, involving 12 neighborhoods, lacks clarity on the inclusion method, utilizing simple stratified sampling with a total sample size of 360. Findings suggest that areas with a high mix of land use exhibit more sustainable features in residents' travel behavior, such as shorter trip lengths and reduced vehicle ownership and expenses. Despite methodological shortcomings, the study highlights social

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benefits like secure communities and environmental advantages, including reduced greenhouse gas emissions due to proximity, encouraging eco-friendly transportation means like cycling and walking.

➢ *Mixed land Use in Japan*

In Japan, a study was conducted by (Sioen, Terada, Sekiyama, Yokohari, & Makoto, 2018) [6] on Resilience with Mixed Agricultural and Urban Land Uses in Tokyo, Japan. Urban agriculture presents an opportunity to bolster the resilience of urban neighbourhoods, particularly in times of natural disasters, by ensuring a local supply of fresh food. However, empirical evidence supporting this concept remains limited. To address this gap, this study introduces a novel methodology aimed at identifying agricultural production patterns within urban areas. It achieves this by quantifying self-sufficiency rates in vegetable weight and key nutrients. Leveraging a geographic information system (GIS) for spatial grid cell analysis, the research explores the existing and potential self-sufficiency levels across various land use patterns in Tokyo.

In a comprehensive examination encompassing 1,479 grid cells, the study scrutinizes the dominant land use and the distribution of 49,263 agricultural plots, leading to the classification of six distinct land use patterns. The outcomes reveal that Tokyo currently maintains a self-sufficiency rate of 4.27% for fruits and vegetables, with the potential to increase this figure to 11.73%. Additionally, the analysis extends to the nutritional self-sufficiency of specific nutrients, with vitamin K exhibiting the highest rate at 6.54%, followed by vitamin C at 3.84%, and vitamin A at 1.92% (Sioen, Terada, Sekiyama, Yokohari, & Makoto, 2018)[6]. Notably, the study also assessedd the resilience of peri-urban areas concerning aggregated risks and population density. This resilience is attributed to the amalgamation of agricultural and urban land uses within these areas. Overall, the research offers valuable insights into the capacity of urban agriculture to enhance resilience in urban settings, especially in the face of potential disruptions like natural disasters. This study presents a compelling study that addresses a significant knowledge gap regarding the role of urban agriculture in bolstering the resilience of cities (Sioen, Terada, Sekiyama, Yokohari, & Makoto, 2018) [6].

➢ *Indian Practices of Mixed Land Uses*

As per guidelines, mixed use is to be carefully allowed along with the compatible uses only. The approaches for promoting mixed use development can be by increasing intensity of land use, increasing diversity of land use or integrating segregated uses. The key parameters for integration of different uses can be: The functional and physical integration of different uses such as Residential, Commercial – Retail & service and Public Semi Public, offices; Integration of three or more significant revenue producing uses. In an urban space, mixed use development can be planned at selected locations, such as a) City or town centres comprising the commercial and civic core of town and cities, b) Inner city areas and c) Peri-urban locations and greenfield sites in urban fringes (URDPFI, 2014) [7].

➢ *Practice in Delhi*

In 2006, the mixed-use regulation was introduced in Delhi to curb the unauthorized operation of numerous commercial establishments in residential areas. While the Master Plan allowed certain mixed-use in designated areas, its implementation faced challenges. The blending of commercial activities disrupted the peaceful residential fabric, causing issues like traffic congestion and encroachments. Limited infrastructure and narrow roads could not cope with the added load, making residential areas less walkable. Despite collecting conversion charges, essential services like parking were neglected. Difficulty in obtaining trade licenses left shops vacant, fostering antisocial activities. Noise and pollution regulations were lacking, impacting the environment, and housing affordability suffered due to rental competition (Chitlangia, 2015) [8].

➢ *Practice In Pune*

In Pune's Development Plan 2007-2027, there was no distinct Mixed Land-use zone, but mixing was allowed in various zones under specific norms, emphasizing predominant use. Land-use was categorized based on the main function, and certain uses depended on road width. Predominantly residential areas permit commercial activities like clinics and offices. Commercial zones allowed residential uses. While this flexibility ensured good access to services, unregulated visitor numbers alongside residents would lead to potential negative impacts. This study in Pune evaluated mixed-use trends and their effects using models in a specific locality.

➢ *Mixed Land Use Models*

To comprehend the impact of mixed uses on their surroundings, a classification based on typology was employed, considering parameters like social, economic, temporal, and physical mix. Social mix involved aspects of income, tenure, and lifestyle, economic mix included industrial and commercial activities, physical mix considered land use, amenities, and open spaces, while temporal mix involved the 24-hour economy, shared premises, and street markets. This classification extended to different scales such as building, street, and ward levels, assessing multifunctional dynamics in various urban contexts (Thwaites, 2007)[9].

Rowley's model of mixed-use models outlines the parameters based on which the mixed land uses could be categorized. Rowley’s Model for Mixed Land use Typology: As per this study mixed-used development was essentially an aspect of the internal texture of settlements. The physical form of mixed-use development was a function of urban texture, setting, and location. Aspects of mixed land uses considered in this study were: urban texture comprises of grain, density, and permeability. Activities and land use within mixed-use projects generated different degrees of vitality. Time dimension as different uses produced activity on varying time schedules (Rowley, 1996)[10].

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B. Review of Theory

➢ *Spatial Mismatch Theory*

Theory Spatial mismatch as a hypothesis first emerged after the exploration and analysis of the reasons behind the vanishing of employment opportunities away from the poverty-stricken areas of black ghettos. This hypothesis states that the blacks' access to jobs is restricted and harder than their white counter parts because of the residential arrangement of the blacks that is further away from the work places. Even though the concept of spatial mismatch theory emerged first in 1968, the cause and root of 14 concentrated poverty and segregation can be traced back to the end of civil war in 1865 (Massey and Denton, 1993) [11].

These studies and theories provided valuable insights into the complexities and implications of mixed land use in various urban contexts.

C. Data Collection Techniques

This study involved mixed methods, where both qualitative and quantitative methods were used to collect data. Quantitative data were collected using a survey questionnaire closed-ended question. Qualitative data was collected through interviews with key informants from the Zambia Environmental Agency and Lusaka City Council. To determine the impact of mixed land use, the study employed experimentation in which samples of emissions air were collected and analysed using portable air emissions sampling equipment.

D. Primary Data

This study employed structured questionnaires administered to occupants of commercial and residential property of Makeni Area to collect data. The questionnaires had both closed and open questions. Additionally, the study engaged key informants from the Zambia Environmental Management Agency and the Lusaka City Council. Furthermore, the study employed experimentation to determine the impact of mixed land use on ambient air quality in the study area.

E. Secondary Data

Document review was employed to collect data from secondary sources such as published books, and reports, both electronic and hardcopies. Secondary data will offered the study an opportunity for triangulation, in which the findings from both interviews and the questionnaire survey, were corroborated to arrive at conclusions.

- Sample Size and Sampling Method
- Sample Size

A sample size of 385 was arrived at using the formula for sample size determination at 95% confidence interval and margin of error at 5%:

n = [(Z^2 * p * (1 - p))/E^2]

Where:
n is the required sample size.
Z is the Z-score corresponding to your desired confidence level.
p is the estimated proportion of the population.
E is the desired margin of error.

Therefore, the sample size was calculated as follows:

$$\eta = \frac{1.96^{2\times 0.5\times 0.5}}{0.05^2}$$

$$\eta \approx 384.16$$

Since there cannot be a fraction of a person in a sample, 384.16 is rounded up to the nearest whole number to ensure your sample size is at least 385.Therefore, a sample size of 385 for this study to achieve a 95% confidence level with a 5% margin of error, using an estimated proportion (p) of 0.5, which represents the maximum variability (0.5 for maximum variance) when estimating sample size for an unknown population proportion

The total sample size is 385 participants. The sample size consisted of 375 occupants of both commercial and residential properties in Makeni Area. Convenience sampling was used to select commercial and residential occupants, who were potential participants.

Key informants from the Zambia Environmental Agency and Lusaka City Council were engaged through interviews.

F. Data Analysis

Quantitative data were analysed using Statistical Package for Social Sciences to establish the social impacts of mixed land use from the direct and indirect affected persons. On the other hand, qualitative data were analysed using thematic analysis.

G. Limitations of the Study

Makeni Area of Lusaka has patches of residential areas and commercial facilities which predominantly are into quarrying. Therefore, this study conveniently focused on impacts of mixed land use on socio-economic development and the environment using air quality analysis and noise level assessment.

H. Research Design

The research was a case study. This is because it sought to describe environmental and social implications of mixed land use in Makeni Area in detail and in a contextualised manner. The study endeavoured to bring out deeper insights of the actual implications of mixed land use in Makeni Area.

I. Ethical Consideration

In order for one to undertake a research, one ought to take into account ethical considerations. These ethics are important to the participants and also ensure that the research produces accurate results. The ethics will include; confidentiality, seeking consent, avoiding biasness and

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protecting participant from harm. The present research work does not contain any studies performed on animals/humans subjects by any of the authors. Hence, the research was cleared by the university to conduct the research with conditions with main one being that, All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

III. RESULTS AND DISCUSSION

A. Background Information

The majority of the respondents accounting for a frequency of 216 (56%) were female. On the other hand, the minority of the participants who accounted for a frequency of 169 (44%) were male. As regards age of participants, the majority of the respondents were aged between 18-25 years of age and accounted for 32%. This was followed by those aged between 40-50 years of age and accounted for 27%. Those aged between 29-39 years accounted for 23%. Those that were aged between 51-61years accounted for 13%. Those that were between 62-72 accounted for 3%. The minority of the respondents were aged 75 years of age and above.

The study further revealed that the majority of respondents (43%) of the respondents earned an average income between K4, 001 and K6, 000. This was followed by those that earned and income that was less than K2, 000 (25%). Those that earned K6001 and above accounted for 21% of the total respondents. Those that earned and income of K6, 001 and above accounted for 21% of the respondents. The minority (11%) of the respondents earned between K2001 and K4, 000.

➢ *Social Implications of Mixed Land Use in Makeni Area.*

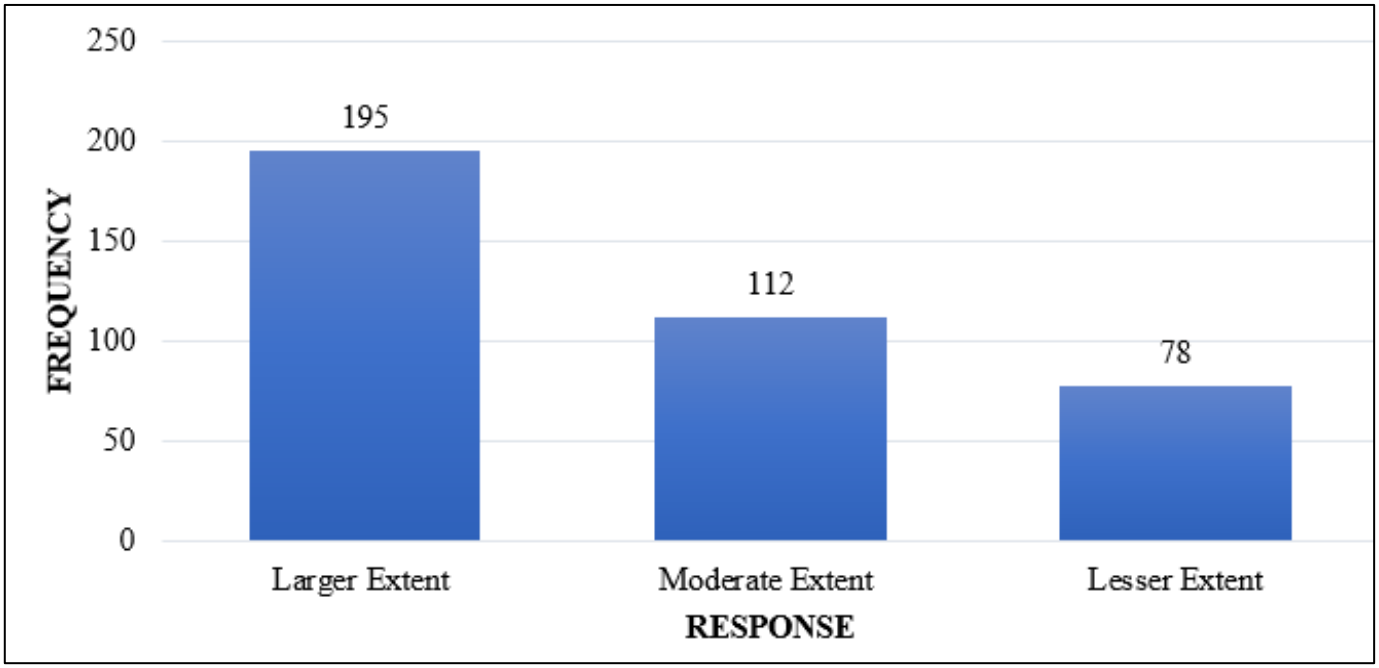

Fig 1: Extent to Which Mixed Land use had Affected Housing Prices
(Source: Field Data, 2023)

The figure above shows the extent to which mixed land use had affected housing prices in Makeni Area. The findings indicated that the majority of the respondents indicated that the mixed land use had affected housing prices to a larger extent as indicated by a frequency of 195 (50.6%). This was followed by those that indicated that mixed land use affected housing prices in Makeni Area to a moderate extent as indicated by a frequency of 112 (29.1%). The minority of the respondents who accounted for a frequency of 78 (20.3%) indicated that mixed land use had affected housing prices to a lesser extent.

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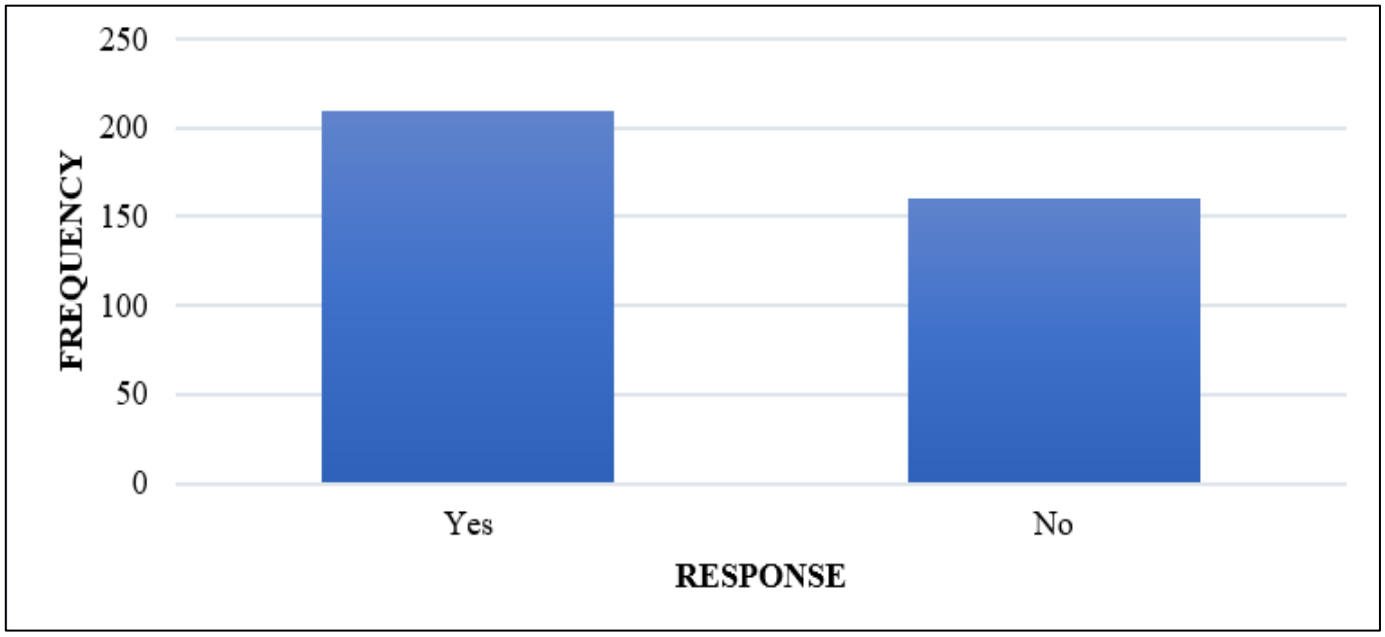

Fig 2: Accessibility of Social Amenities due to Mixed Land Use
(Source: Field Data, 2023).

The figure above shows how accessible social amenities were because of mixed land use. The figure shows that the majority who accounted for a frequency of 210 (55%) indicated that social amenities such as schools, recreational facilities and health facilities were accessible due to mixed land use. The minority of the respondents indicated that social amenities were not accessible due to mixed land use and accounted for a frequency of 175 (45%).

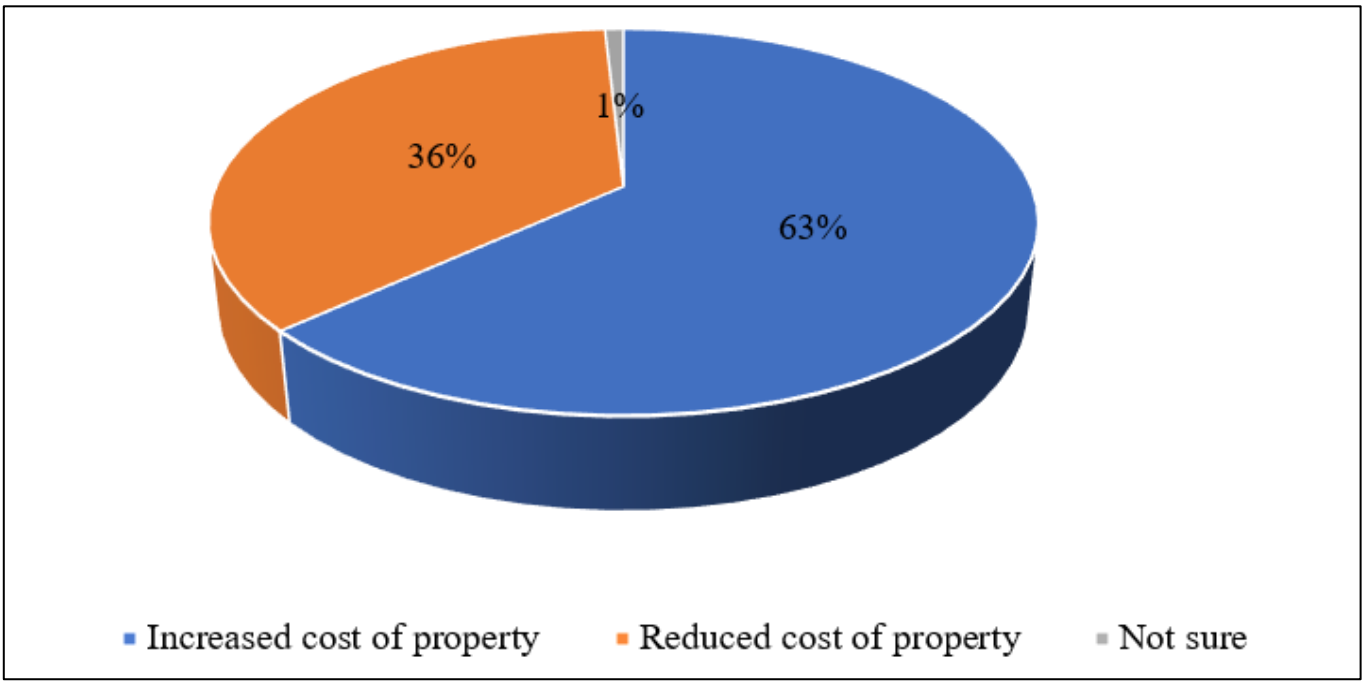

Fig 3: Impact of Land Use in Property Prices
(Source: Field Data, 2023)

The figure above shows the impact of land use in Makeni Area. The findings of the paper revealed that the majority of the respondents who accounted for a frequency of 242 (63%) indicated that mixed land use increased the cost of property in Makeni Area. This was followed by those that indicated that land use has led to reduced cost of property as accounted by 139 (36%). The minority of the respondents representing a frequency of 5 (1%) indicated that they were not sure.

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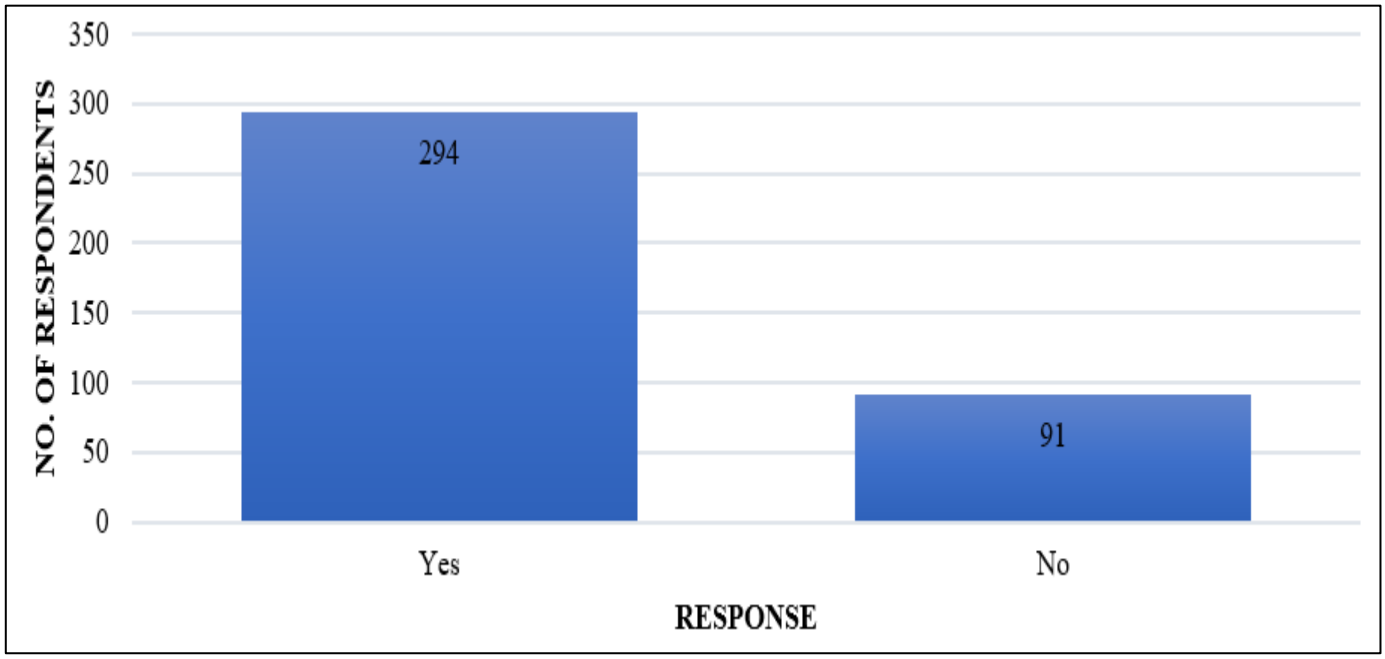

Fig 4: Improved Quality of Road Infrastructure/Buildings due to Mixed Land
(Source: Field Data, 2023)

The majority of the respondents indicated that mixed land use in Makeni Area had improved quality of road infrastructure/buildings as indicated by a frequency of 294. The minority of the respondents indicated that mixed land use had not improved quality of road infrastructure/buildings and these accounted for a frequency of 91.

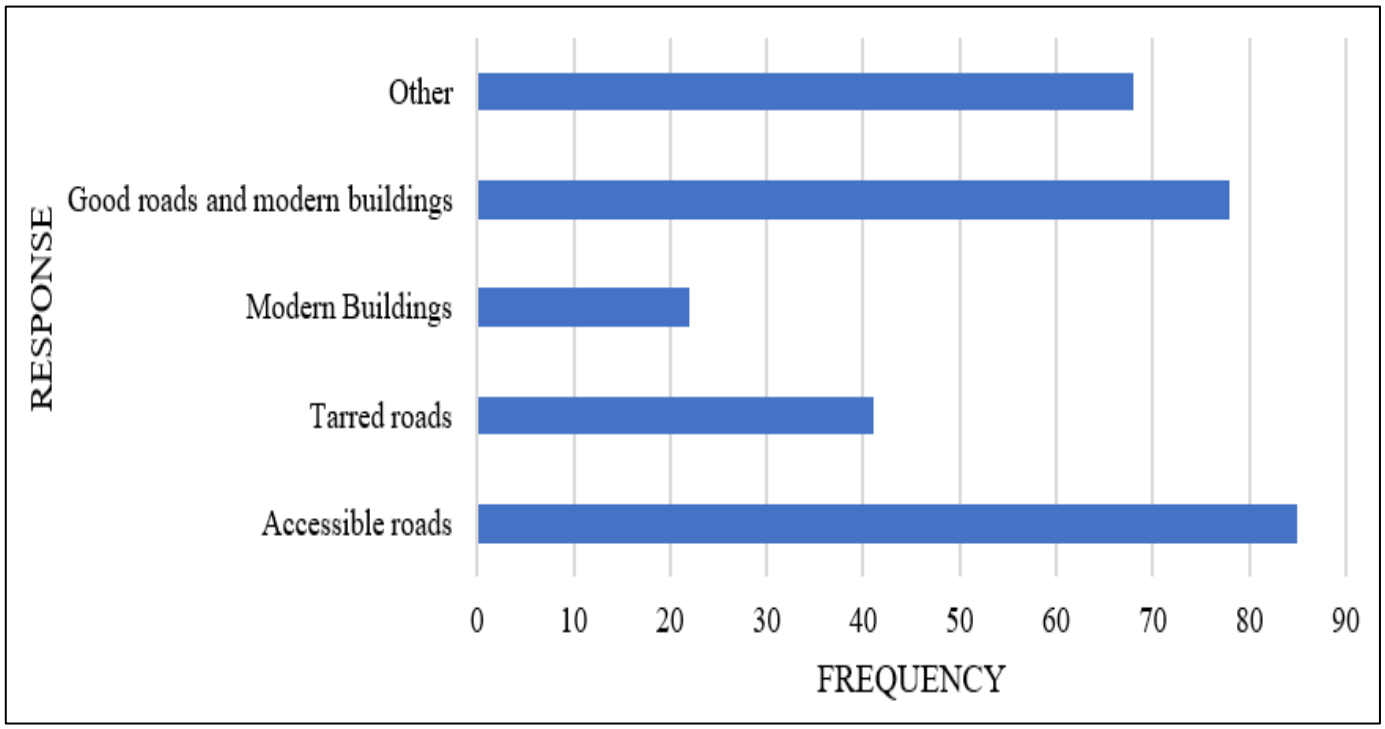

Fig 5: Reasons for the Results
(Source: Field Data, 2023)

For those that indicated that mixed land use had improved quality of road infrastructure/buildings, they indicated that companies around Makeni Area conducted maintenance of roads in order for their motor vehicles to access markets easily and also bring in materials.

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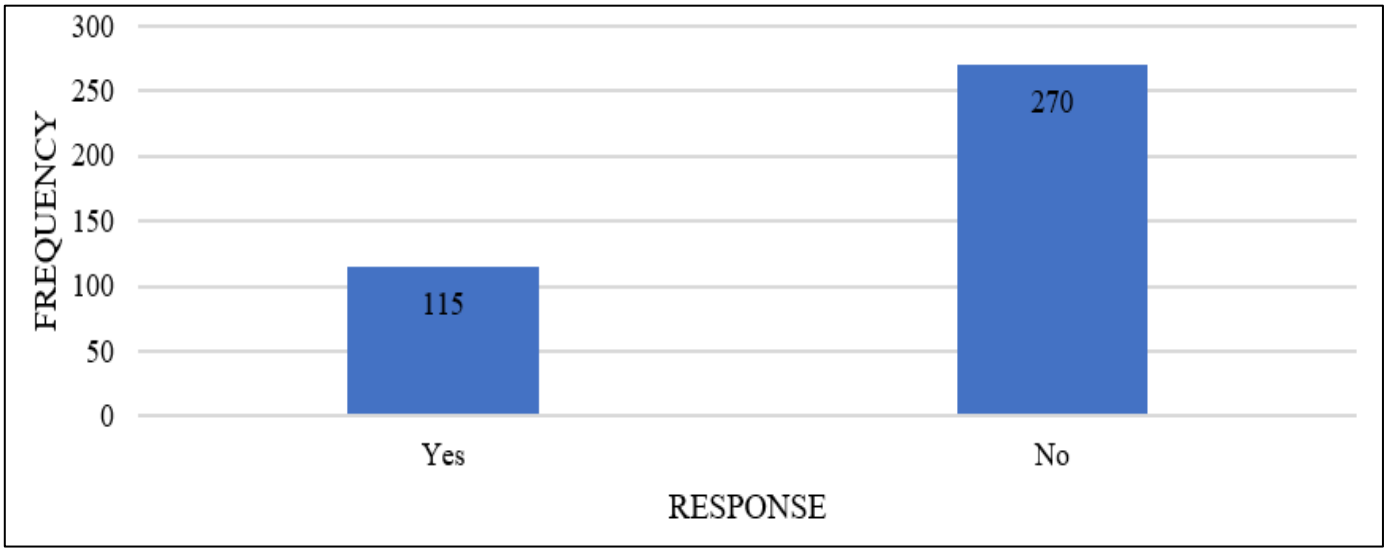

Fig 6: Mixed Land Use Increased Social Problems
(Source: Field Data, 2023).

The figure above shows the responses from participants when asked whether land use in Makeni Area had increased social problems. The findings showed that the majority of the respondents who accounted for a frequency of 270 indicated that mixed land use had not increased social problems while the minority of the respondents who accounted for a frequency of 115 indicated that mixed land use had increased social problems.

➢ *Environmental Implications of Mixed Land Use in Makeni Area.*

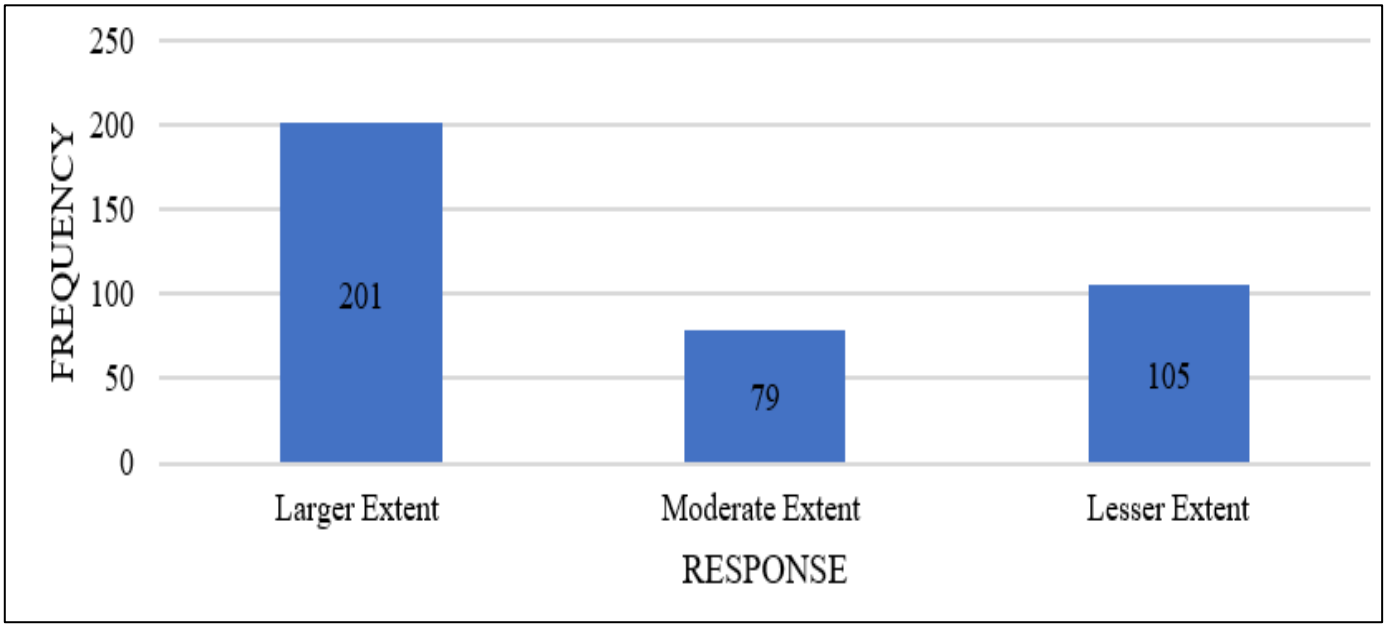

Fig 7: Extent Mixed Land Use had Affected the Environment
(Source: Filed Data, 2023)

The figure above shows the responses of participants when asked who about the extent has mixed land use in Makeni Area affected the environment. The responses showed that the majority of the respondents who accounted for a frequency of 201 indicated that mixed land use in Makeni Area affected the environment to a larger extent. This was followed by those participants that indicated that land use had affected the environment to a lesser extent and these accounted for a frequency of 105. The minority of the respondents indicated who accounted for a frequency of 79 indicated that mixed land use in Makeni Area affected the environment to a moderate extent.

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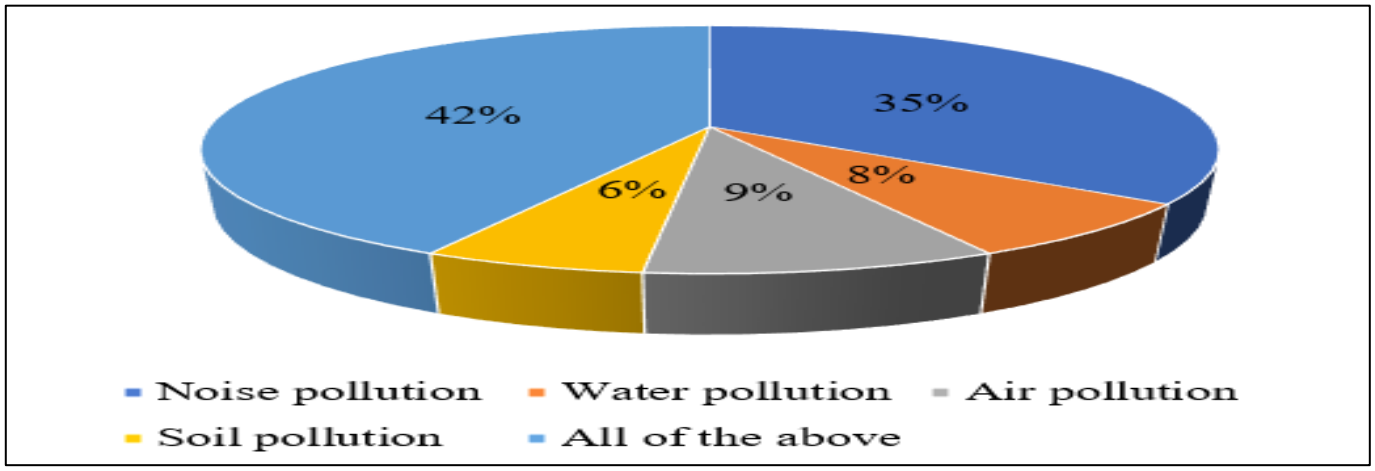

Fig 8: Ways Mixed Land Use had Affected the Environment (Source: Field Data, 2023).

Those that indicated that mixed land use in Makeni Area had affected the environment in Makeni Area and accounted for a frequency of 201 were asked to indicated ways in which mixed land use had affected the environment. The majority of the respondents indicated that mixed land use had caused noise, water and soil pollution and accounted for a frequency of 84 (42%). The minority of the respondents indicated that that mixed land use had caused soil pollution and accounted for a frequency of 12 (6%).

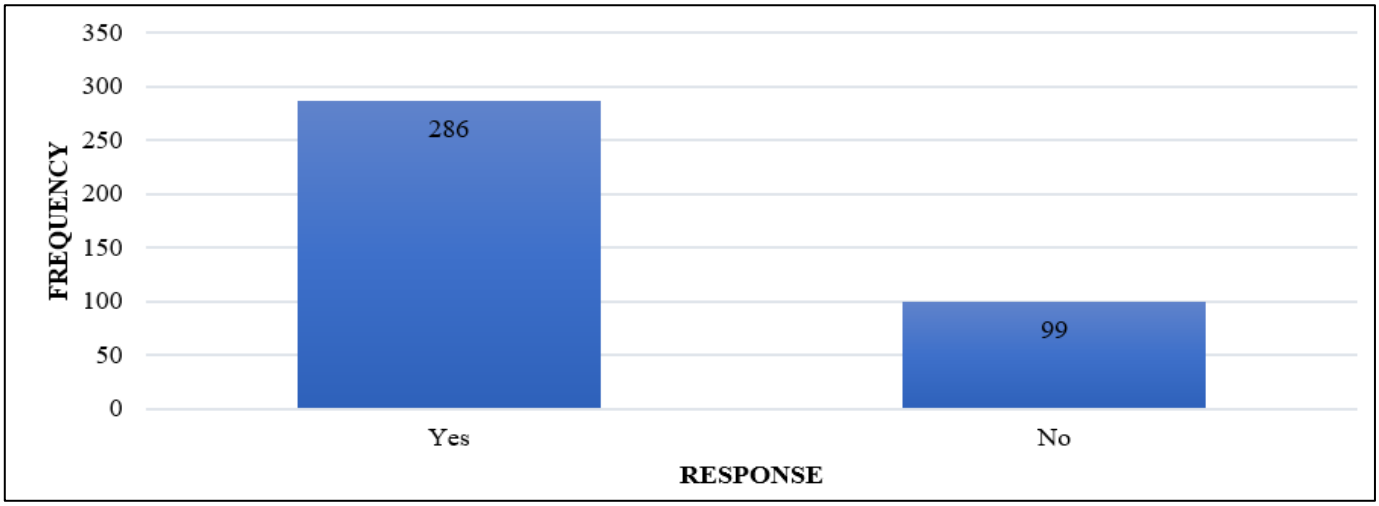

Fig 9: Sustainability of Mixed Land Use
(Source: Field Data, 2023)

The results of the study revealed that mixed land use in Makeni Area was sustainable as indicated by the majority who accounted for a frequency of 286. The minority of the respondents indicated that mixed land use was not sustainable and accounted for a frequency of 99.

B. Results on Air Emission Sampling

Air Emission sampling was conducted on 4 commercial facilities within Makeni Area to ascertain the quality of emission being emitted into the atmosphere. The sampling was done using a calibrated Portable Industrial Combustion Gas & Emissions Analyzer. The results obtained from the exercise are presented in Table 3.

Table 1: Results from Stack: CO Readings Vs ZEMA Limit

Sample	CO (mg/Nm3)	SO2 (mg/Nm3)	NO2 (mg/Nm3)	NO (mg/Nm3)	NOx (mg/Nm3)
Sample 1	198.57125	0	0.36695	2.98686	4.9364
Sample 2	191.12875	0.40898	0.4387	2.98686	5.00815
Sample 3	220.30375	0	0.45715	2.98552	5.02455
Sample 4	217.32625	0	0.451	3.5845	5.93475
Sample 5	206.9075	0.17732	0.53095	3.58316	6.01265
Average	206.8475	0.11726	0.44895	3.22538	5.3833
ZEMA Limits	175	400	-	-	600

(Source: Field Data, 2023)

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The table above shows the results from air emissions (CO, SO2, NO2, No and NOx) from stack 1. The results revealed that the CO emissions in Makeni Area was slightly above the ZEMA Limits of 175 mg/Nm3 for all the 5 samples taken from the stack. However, SO2, NO2, No and NOx were in at acceptable levels as guided by ZEMA.

Table 2: Results from Stack 2

Samples	CO (mg/Nm3)	SO2 (mg/Nm3)	NO2 (mg/Nm3)	NO (mg/Nm3)	NOx (mg/Nm3)
Sample 1	255.105	8.74874	0.52275	15.53998	24.2966
Sample 2	300.35125	12.3981	0.7749	16.13628	25.461
Sample 3	313.74625	11.42856	0.902	19.12448	30.1596
Sample 4	277.43	19.7054	0.9061	23.3093	36.56585
Sample 5	347.68125	18.48418	1.12135	25.10222	39.524
Average	298.86275	14.152996	0.84542	19.842452	31.20141
ZEMA Limits	175	400	-	-	600

The findings of the paper for stack 2 also revealed that the 5 samples obtained for the second point CO was above the ZEMA Limits of 175 mg/Nm3. However, SO2, NO2, No and NOx were in at acceptable levels as guided by ZEMA.

Table 3: Results from Stack 3

Samples	CO (mg/Nm3)	SO2 (mg/Nm3)	NO2 (mg/Nm3)	NO (mg/Nm3)	NOx (mg/Nm3)
Sample 1	464.40125	12.9272	0.95735	16.73258	26.5557
Sample 2	506.07875	11.82324	1.2546	15.53462	25.02025
Sample 3	420.34375	13.39338	1.28945	17.92652	28.71435
Sample 4	420.04625	12.7985	1.40425	17.92518	28.8271
Sample 5	388.78875	18.40982	1.45755	22.11	35.28255
Average	439.93175	13.870428	1.27264	18.04578	28.87999
ZEMA Limits	175	400	-	-	600

Table 5: Results from Stack 3: CO Readings vs. ZEMA Limit (Source: Field Data, 2023)

The findings of the paper further on the third stack indicated that all samples that were collected were far above the ZEMA limits for CO emissions. Just as other stacks, SO2, NO2, No and NOx were below ZEMA limits.

Table 4: Results from Stack 4

Samples	CO (mg/Nm3)	SO2 (mg/Nm3)	NO2 (mg/Nm3)	NO (mg/Nm3)	NO x(mg/Nm3)
Sample 1	967.8475	0	0.67035	5.37608	8.89495
Sample 2	997.32125	0	1.04345	4.77576	8.34965
Sample 3	986.90125	0	1.07215	2.9815	5.6334
Sample 4	814.52875	0	0.9963	1.78622	3.72895
Sample 5	719.56	0	0.8733	1.78756	3.608
Average	897.23175	0	0.93111	3.341424	6.04299
ZEMA Limits	175	400	-	-	600

The findings of the paper further on the third stack indicated that all samples that were collected were far above the ZEMA limits for CO emissions. Just as other stacks, SO2, NO2, No and NOx were below ZEMA limits.

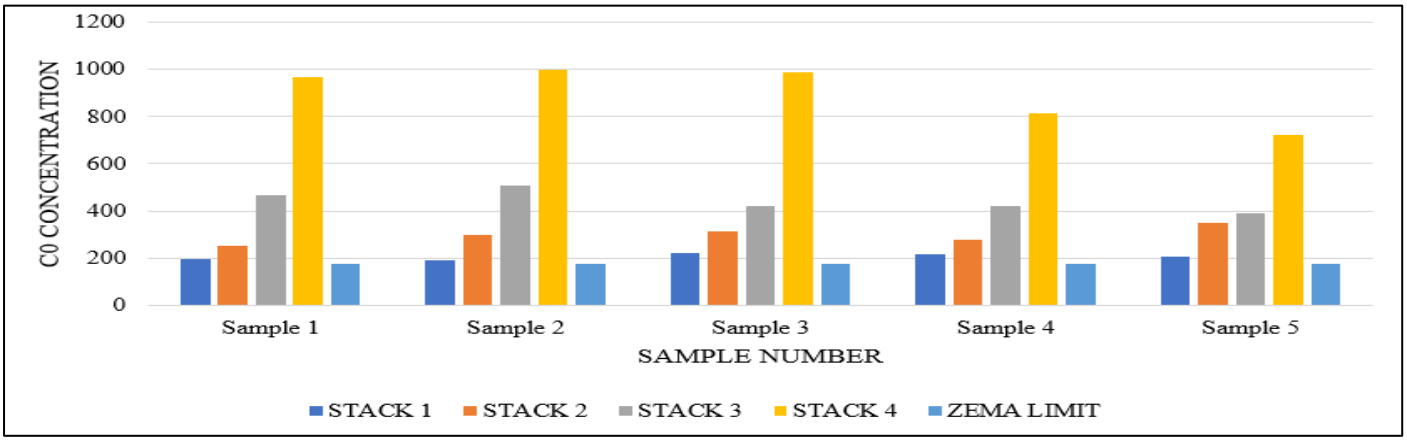

Fig 10: CO Concentration Reading (mg/co3) for four (4) Stacks (Source: Field Data, 2023)

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The bar graph above shows the consolidated results for all the 4 stacks with all the 5 parameters sampled (CO, SO2, NO2, No and NOx) in Makeni Area. The results revealed that the CO emissions in Makeni Area were above the ZEMA Limits of 175 mg/Nm3 for all the 4 sampled points for the four stacks. It was established that Stack 4 had the highest CO emissions among the four points sampled.

➢ *Noise Pollution in Makeni Area.*

Table 5: Noise Pollution in Makeni Area

Reference Point	Distance from ADLA (m)	Min Reading in decibels (dB)	Max Reading in decibels (dB)
	0	66.92	67.8
South Western Direction			
A	30	57.7	59.1
B	60	53.9	54.2
North Western Direction			
A	30	62.5	63.7
B	60	55.5	56.0
South Eastern Direction			
A	30	40	43
B	60	28.5	35.0

NB: Noise limit in residential is 55dB during the day

The noise levels measured were above the WHO guidelines for a residential area.

Upon analysis, it was evident that the noise levels measured at these reference points consistently exceed the recommended guidelines set by the World Health Organization (WHO) for noise levels in residential areas, which are 55 dB during the day. The readings at each reference point, both at 30 meters and 60 meters, surpass this recommended daytime noise level. This suggested a significant issue of noise pollution in the area, which may have adverse effects on the well-being and quality of life of residents. Addressing and mitigating this noise pollution should be a priority to ensure a quieter and healthier living environment for the residents in the affected areas.

The effective implementation of mixed land use for sustainable urban development hinged on the awareness and understanding of guidelines and challenges. In Makeni Area, this study revealed a significant lack of awareness, with 73 percent of respondents being unaware of the guidelines for mixed land use. While 27 percent were aware, the study also explored participants' perceptions of challenges in managing mixed land use, uncovering a considerable frequency (109 respondents) expressing uncertainty about these challenges. This suggested the need for further qualitative research or initiatives to delve deeper into stakeholders' concerns. Those participants acknowledging challenges represented a crucial group whose insights could shape specific solutions for effective mixed land use management in Makeni Area.

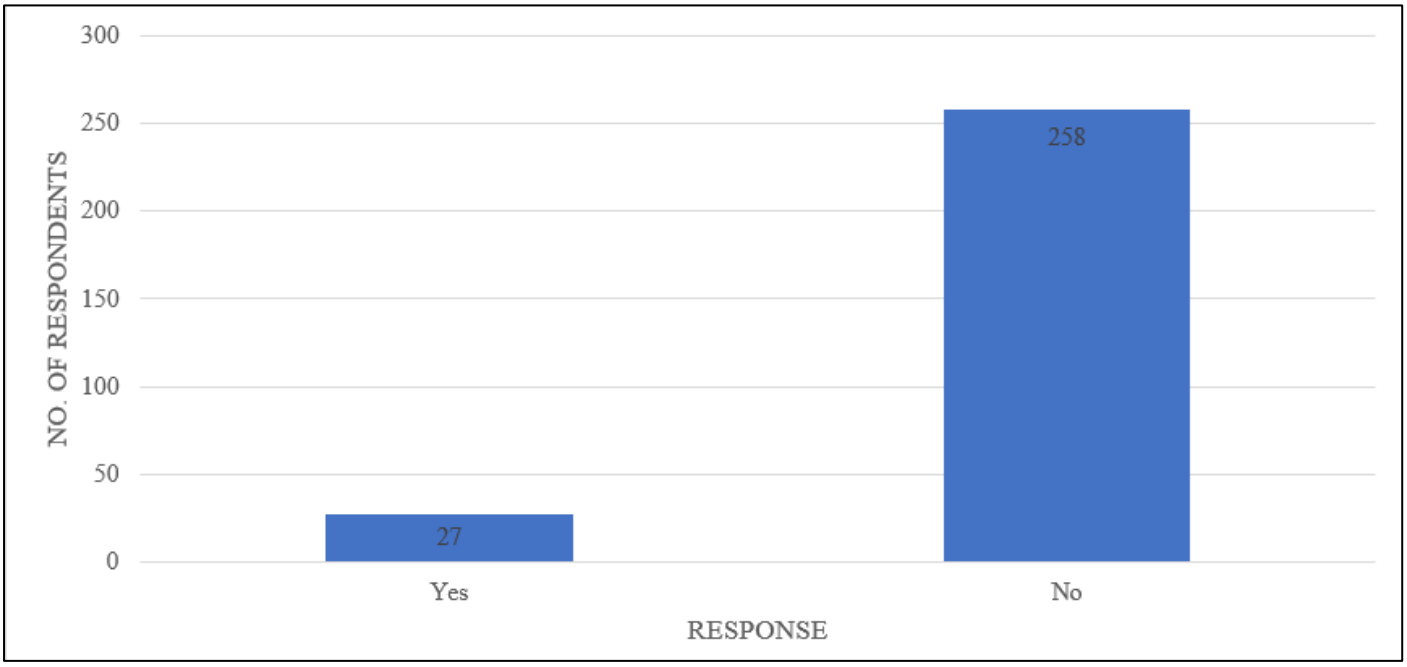

Fig 11: Awareness on the Guidelines for Mixed Land use Implementation
(Source: Field Data, 2023)

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The figure above shows the awareness on the guidelines for mixed land use implementation by participants. The findings of the paper revealed that the majority of the respondents who accounted for a frequency of 258 were not aware about the guidelines for mixed land use while only 27 percent of the participants were aware about guidelines for mixed land use.

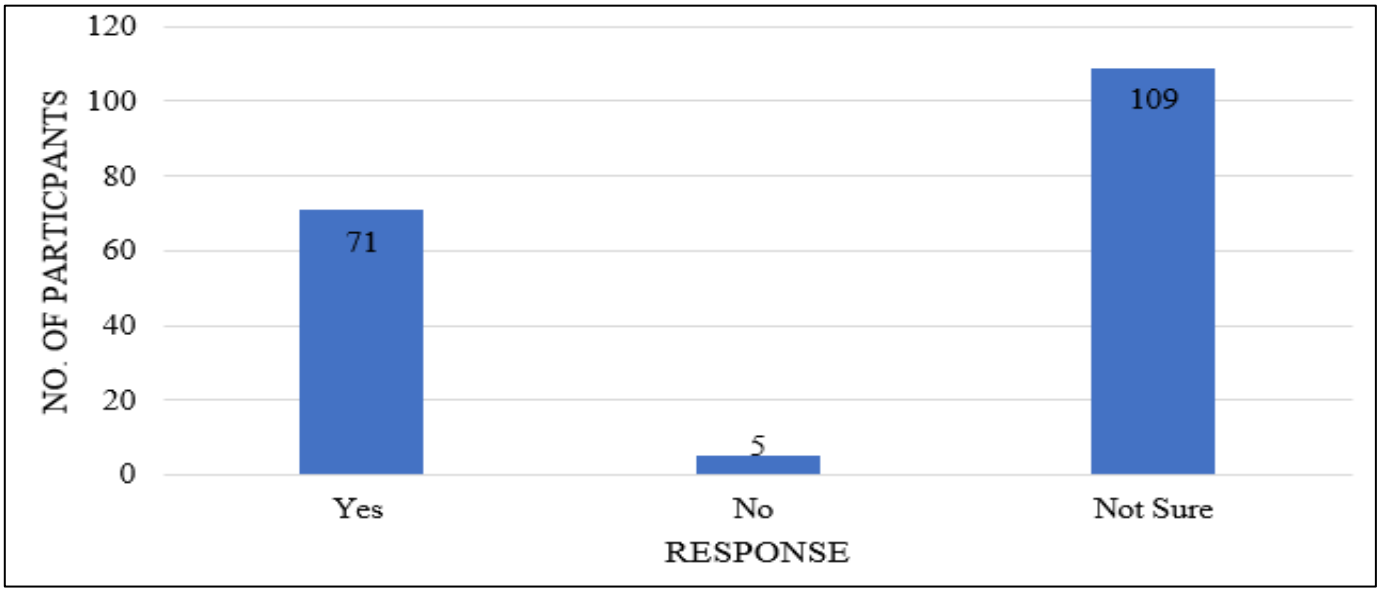

Fig 12: Challenges that are Associated with the Management of Mixed Land use in Makeni Area (Source: Field Data, 2023).

The findings of the paper revealed that the majority of the respondents that accounted for a frequency of 207 109 indicated that there were not sure of the challenges that associated with the management of mixed land use in Makeni Area. This was followed by those that indicated that their challenges that are associated with the management of management of mixed land use in Makeni Area and accounted for a frequency of 171. The minority of the respondents who accounted for a frequency of 7 indicated "No".

IV. CONCLUSIONS

The study in Makeni Area reveals a current lack of awareness about guidelines for mixed land use, emphasizing the need for awareness initiatives and a comprehensive investigation into associated challenges. Addressing this knowledge gap is crucial for fostering sustainable development and enhancing urban planning in Makeni. The findings underline the importance of collaboration among stakeholders, policymakers, and the community to ensure efficient and harmonious implementation of mixed land use practices.

Additionally, the air sampling conducted on four facilities indicates significant air pollution in Makeni, with carbon monoxide consistently exceeding allowable limits, posing risks to human health and the environment. Notably, one facility showed exceptionally high carbon monoxide levels, suggesting potential issues with its pollution control system. Further, the noise levels measured from one of the facilities indicated high levels of noise according to WHO standards.

RECOMMENDATIONS

- Based on the findings of the study on mixed land use in Makeni Area, several recommendations can be proposed to address the identified issues:
- There is need for regulatory bodies to develop and implement awareness campaigns to educate the community about the guidelines and regulations associated with mixed land use.
- There is need for regulatory bodies to establish community forums or workshops to encourage active participation and engagement in the decision-making process related to mixed land use.
- There is a need for Zambia Environmental Management Agency and the local authorities to implement stricter environmental monitoring measures, especially in areas prone to air pollution from industries.
- There is need for the Government to allocate resources for the improvement of road infrastructure and buildings in mixed land use zones to enhance the overall quality of the environment.
- There is need to enhance the coordination amongstate institutions such as local authorities and Government agencies in the planning and management of mixed land use areas.
- By implementing these recommendations, the community in Makeni Area can work towards creating a more sustainable, well-managed, and socially inclusive environment with balanced mixed land use.

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➢ *Recommendations for Future Research*

- This study focused on impacts of mixed land use on socio-economic development and the environment using air quality analysis and assessment of noise from facilities. Future researchers could also consider conducting comprehensive water analysis to assess the quality of water sources in mixed land use areas.

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