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Authors: Taiwo, Temitope M, and Ogunbode, Timothy O

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Understanding Environmental Consequences of Quarry Operations: Residents' Perception Study in the Neighbourhood of a Quarry in Osun state, Nigeria

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Temitope M Taiwo and Timothy O Ogunbode 

Environmental Management and Crop Production Unit, College of Agriculture, Engineering and Science, Bowen University, Iwo, Nigeria.

ABSTRACT: Investigation on human perspective on the impacts of quarry activities on the natural environment remains limited. This study gauged residents' perceptions of the ecological consequences of quarry operations. A meticulously structured questionnaire was dispensed among 214 households, chosen at random, in the vicinity of Sanlong Quarry within Obaagun community, Ifelodun Local Government Area, Osun State, Nigeria. The dataset underwent analysis utilising both descriptive and inferential statistics. Results indicated a predominance of female respondents, constituting 77.6%, with 65% aged 41 years and above. Moreover, 74.2% had been residents in the study area for no less than 7 years, and 62.6% resided within 1 km of the quarry site. A substantial 74.3% (159 residents) regarded quarry operations as detrimental to their environment, with 72.2% attributing this to machine vibrations. Kaiser-Meyer-Olkins and Bartlett's tests affirmed the factorability of the dataset at a 77.5% significance level ($P < .005$). Factor analysis revealed 7 variables, encompassing 79.19% of residents' perceptions of the environmental impact of quarry operations. These variables included the loss of farmlands (21.35%), degraded farmland (15.06%), vibrations from heavy machines affecting buildings (10.64%), flyrock debris from rock blasting damaging roofs, and the destruction caused by trucks and heavy machinery on rural roads (8.57%). Additionally, wildlife displacement (8.33%) and respondents' perception of the quarry's duration of operation (8.00%) were identified. These findings suggest that quarry operations exert a significant influence on the livelihood of the Sanlong quarry neighbourhood. It is imperative for stakeholders to address this situation through relevant policies, particularly those that enhance the well-being of the community and hold the quarry company responsible for the damages inflicted on various environmental resources. Nonetheless, further study is recommended to validate or otherwise the current findings.

KEYWORDS: Quarry operations, environment, neighbourhood's perception, Sanlong Quarry Limited, Obaagun, Nigeria

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CORRESPONDING AUTHOR: Timothy O Ogunbode, Environmental Management and Crop Production Unit, College of Agriculture, Engineering and Science, Bowen University, P/M. B 284, Iwo, Osun 232, Nigeria. Email: timothy.ogunbode@bowen.edu.ng

Introduction

The sustenance of human welfare and livelihood is intricately linked to various activities such as agriculture and trading, among others. However, in developing countries like Nigeria, the contribution of the quarry industry remains minimal.¹ Quarrying, which encompasses the removal of overburden, drilling, blasting, and rock crushing for diverse applications, plays a pivotal role in meeting the manifold needs of society.^{2,3} Its importance is underscored by the multifaceted benefits it offers, ranging from employment opportunities and income generation to government revenue, fostering allied businesses, supplying raw materials to the construction industry, and contributing to ornamental purposes. In economic terms, quarrying has been a cornerstone for many nations, and Nigeria is no exception. Melodi and Ogunyemi⁴ documented the contribution of quarry activities to Nigeria's GDP, indicating N62.39 billion by the end of 2023, according to the Central Bank of Nigeria.⁵ Statista¹ further highlighted that rock mining alone accounted for 0.89% of Nigeria's gross domestic product (GDP). Beyond the macroeconomic impact, quarrying supports the livelihoods of a considerable number of individuals who are directly engaged in operations. These individuals take on various roles, including machine operators, drivers, account clerks, managers, supervisors and casual labourers. Moreover, a plethora of businesses in quarry neighbourhoods, such as petty

trades, cafeterias, food vendors, motor repairers and vulcanisers, thrive by catering to the needs of the quarry workers. All these underscores the vital role played by the quarrying industry in the economic landscape of the nation.

However, amidst the economic prosperity associated with quarry activities, there has been a noticeable paucity of attention given to their environmental repercussions, particularly concerning the residents^{6,7} and the natural environment in proximity. The impact on human health is a critical concern, particularly for workers operating heavy machinery and those residing near the quarry sites.⁸⁻¹¹ The health implications are diverse, encompassing hearing challenges, accidents resulting from machine operations, and injuries caused by stones and gravels during the processing phase. Compounding these issues, Gerhardsson et al¹² highlighted the development of heart problems among workers due to vibrations from the machinery. The heavy vibrations generated by these machines have also been reported to affect the structural integrity of residential buildings in the vicinity, leading to the displacement of original dwellers, predominantly farmers.^{13,14}

In addition to the immediate health concerns, the impact of quarry operations extends to agricultural lands in the surrounding areas. Farmlands are often abandoned due to the disruptions caused by quarry operations, leading to adverse experiences



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for farmers in adjacent areas.^{15,16} The consequences are far-reaching, affecting not only the livelihoods of those directly involved in agriculture but also the broader food supply chain. The environmental impact is not confined to land-based concerns; it also extends to watersheds. Misra,¹⁷ Miliša et al¹⁸ and Eruke et al¹⁹ highlighted the adverse effects on water quality, yield, accessibility, and availability in various watersheds. The ecological ramifications are significant, impacting the delicate balance of local ecosystems and posing challenges for communities dependent on these water resources.

Furthermore, the deplorable condition of roads connecting quarry sites to major trunks has been noted, primarily attributed to the transportation of heavy-duty vehicles carrying products from quarries.²⁰ This creates a ripple effect on infrastructure, impacting both local and regional connectivity. In the context of sustainable development, particularly Sustainable Development Goal 11 (SDG 11), which aims to make cities and human settlements inclusive, safe, resilient, and sustainable, there is a pressing need to address the challenges posed by quarry activities. The United Nations has been actively involved in fostering global collaboration to achieve this goal. Bendixen et al²¹ highlight the importance of international cooperation through platforms like the United Nations, where countries share best practices, research, and resources, fostering a collective approach to urban development. Various global partnerships have emerged, involving governments, non-governmental organisations, businesses, and local communities, all working towards common urban sustainability goals.²² These collaborations often result in innovative solutions, such as the adoption of green technologies and resilient infrastructure, contributing to the realisation of SDG 11. Given the multifaceted nature of the impact of quarry activities, understanding the human perspective on their environmental impact becomes imperative. The views of those directly affected provide valuable insights into the intricate challenges associated with quarry operations. It is from this perspective that the current investigation was initiated, with the primary aim of comprehending the environmental impact of quarry operations through the lens of the local population. The specific objectives of this investigation are twofold. Firstly, to understand the economic benefits of quarry operations to the Osun State neighbourhood. This entails examining the direct and indirect economic contributions of quarrying to the local community, assessing employment opportunities, income generation, and the overall economic well-being of residents. Secondly, the investigation aims to explore the significant impacts of quarry activities on the environment, as perceived by the local population. This involves delving into the qualitative aspects of environmental impact, considering factors such as health, agriculture, water resources, and infrastructure.

In conclusion, while quarry activities have undeniably played a crucial role in contributing to the economic landscape of Nigeria and many other nations, the environmental repercussions, particularly on human health and safety and

the surrounding ecosystem, cannot be overlooked. Sustainable development requires a holistic approach that considers the economic benefits alongside the environmental and social costs. Through understanding the human perspective on the environmental impact of quarry operations, policymakers and stakeholders such as the quarry industry management, quarry workers, regulators and residents can formulate informed strategies to mitigate the challenges associated with quarrying while ensuring the well-being of both the community and the environment.

Method of Study

Study area

Sanlong Quarry Limited is a private quarry company situated along Ire/Ikirun Road, Obaagun, a suburban community of Ikirun, the headquarters of Ifelodun Local Government Area in Osun State, Nigeria (Figure 1). Sanlong was established in 2019 when it received government licencing to mine and process rock resources in the state. Since its inception, rock mining has been actively conducted, resulting in various quarry products such as rock stones for construction, gravels, stone dusts, stones of different sizes, polished rocks, among others. The workforce at the site comprises approximately 100 individuals, including both casual and regular workers in roles such as drivers, managers, cashiers, secretaries, machine operators, health workers, security personnel and others. Casual workers encompass labourers and gardeners. The machinery in use includes crushers, rock breakers, trucks, and other equipment. Sanlong Company has contributed to the growth of other small-scale business outlets, including food vendors, petty trading, health services and more. However, the quarry activities have resulted in adverse effects such as building cracks, roof damages, and health hazards, among other concerns.¹⁹

Briefs on Sanlong Quarry Limited

This study was carried out at Sanlong Quarry Limited located in Obaagun town, a suburb of Ikirun, the headquarter of Ifelodun Local Government Area (LGA) of Osun State, Nigeria. The land was previously used for small scale quarry business. In the year 2018 the industry was licenced and is now managed by Sanlong Quarry Company, a Chinese Corporation. The quarry's exact size couldn't be determined from the records on hand. However, an unofficial source indicated that the Sanlong quarry might cover approximately 15 hectares, acquired from different families through purchases. Details about the operational licence issued by the government to the quarry company were also unavailable in the records. These details are likely considered sensitive by the company and were inaccessible due to time constraints at the relevant ministry. The company also revealed that rock blasting occurs nearly every day to meet the demand for their products, considering the availability of rock resources. Obaagun is an ancient town that is richly blessed with rock resources. It is situated in the

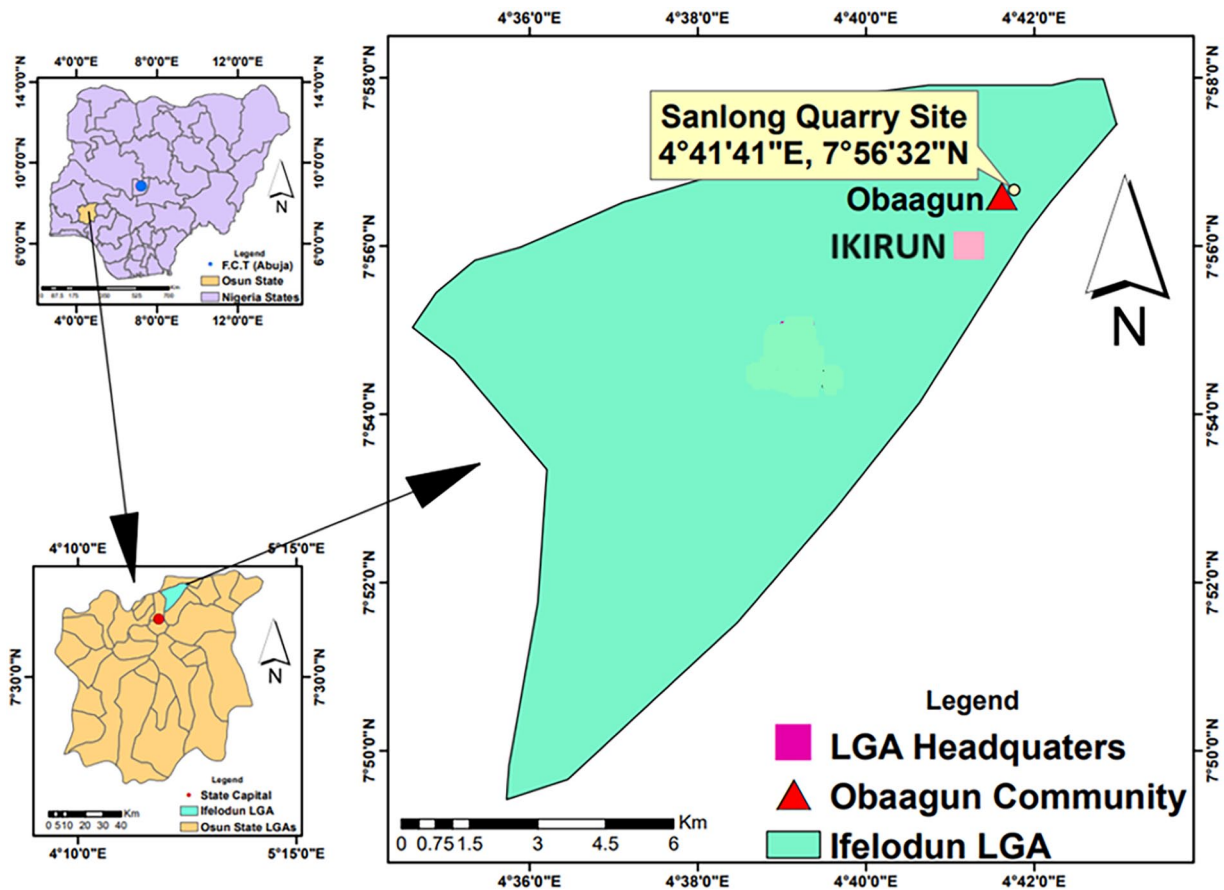


Figure 1. Map showing the location of Sanlong Quarry site at Obaagun, Osun state, Nigeria.

tropical rain forest of Southern Nigeria. Obaagun town has latitude $7^{\circ}55'43''\text{N}$ and longitude $4^{\circ}40'32''\text{E}$. The town has an elevation of 400 m (1312 ft). The whole population of Obaagun encompasses inhabitants of Ikirun (Isale Ikirun), Oke-Iba, Eweta and Iree. According to the 2006 census, Obaagun had a population of 21 543. Obaagun is an historical town surrounded by mountains dominating the areas which include Gbogi- gboole hill, Aofe hill, Igbolamu hill. Obaagun is predominantly inhabited by the Yoruba tribe and the most practiced religions are Christianity and Islam. In Obaagun, farming is conducted both for personal and commercial purposes, and consists of cash crops such as yam, cassava, maize, palm trees, cocoa and kolanuts. In this town, farming is mostly practiced both food and cash crops like yam, cassava, maize, palm trees, cocoa, kolanuts among others are largely cultivated. Some people also venture into gaari, oil palm production, bead making and, soap and honey production. Other occupations in Obaagun include carpentry, mechanic, steel and iron works, panel beating, fashion designing, painting, transportation services among others.

Sampling Techniques

The investigation applied a careful approach to formulate the dataset, primarily utilising a well-structured questionnaire for data collection. A random selection process was employed to choose 214 households, for the survey. The sample size was

determined by the limitations in time and available resources. The sample frame consisted of the adults who are 85% farmers living in the neighbourhood of the quarry site and 80% (80%) of the survey was conducted in the evening time each day so that the respondents would have come back home from their various farms and businesses. It is important to note, however, that potential biases were acknowledged in the sampling design, particularly, in the randomisation process. The questionnaire comprised 2 sections: Section A, which included questions regarding the respondent's occupation, age, length of residency in the area, family size, among other demographics. The second section contained structured questions focussing on the respondents' perspectives regarding the impact of quarry operations in their locality. The variables derived from these structured questions were subsequently subjected to analysis.

Data collection

The questionnaire consisted of 2 sections. The first section concentrated on gathering respondent details, encompassing information such as age, gender, level of education, occupation and family size. The second section comprised structured questions addressing the perception of the respondents on the environmental impact of quarry operations. in the study area. The administration of the questionnaire was a collaborative effort involving the authors and 4 assistants, ensuring a comprehensive

and robust data collection process. Nonetheless, it is crucial to recognise the potential biases inherent in both the sampling design and data collection methods, as these could impact the accurate interpretation of the study results. Major constraints encountered during data collection was associated with the incidences of rainfall during the survey which hinders mobility and the challenge of respondents' availability in the course of the survey because some of them could have departed their homes for their various businesses. Even when it was done in evening, some households could not be surveyed as planned.

Data analysis

The analytical phase encompassed both descriptive and inferential statistical assessments. Basic attributes of the respondents were presented in form of percentages and tabulation. Factor Analysis (FA) was chosen for this analysis due to its ability to identify underlying factors or dimensions within a dataset and to determine the variables that contribute most significantly to residents' perceptions of the environmental consequences of quarry activities. The statistic has been successfully used to achieve this same purpose by Ogunbode et al,²³ Ogunbode et al²⁴ and Sigudla and Maritz.²⁵ A dataset is 'factorable' indicated that it can be decomposed or factorised to reveal underlying structures or latent variables that explain patterns within the data. In conducting FA, Kaiser-Meyer-Olkin (KMO) measure and Bartlett's tests were in the first instance determined. The 2 tests are both statistical tools commonly employed in the field of factor analysis, a statistical technique used to identify underlying relationships among variables. According to Rossoni,²⁶ the KMO measure assesses the suitability of data for factor analysis by evaluating the adequacy of the sample size and the correlations among variables. A high KMO value (typically ranging from 0 to 1) indicates that the data is well-suited for factor analysis. On the other hand, Bartlett's test examines whether the observed correlation matrix significantly differs from an identity matrix, which assumes no correlation between variables. A significant result in Bartlett's test suggests that the variables are interrelated, providing justification for conducting factor analysis. In essence, these tests serve as diagnostic tools to ensure the reliability and validity of the data before delving into the more intricate process of factor analysis, enhancing the robustness of the subsequent findings. The Eigen value criterion was employed with a minimum threshold set at 1.000. Any variable that did not meet this stipulated threshold was consequently deemed irrelevant and excluded from consideration as a significant viewpoint in the explanation of human perception of the impacts of quarry activities in the environment.

Results and Discussion

Demographic attributes of the respondents

The examination of respondent demographics as shown in Table 1 unveiled a distinct gender distribution, with the female

Table 1. Pooled demographic attributes of the respondents.

CATEGORISATION	DISTRIBUTION	
	SAMPLE SIZE	% OF TOTAL IN THE CATEGORY
A Gender		
Male	48	22.4
Female	166	77.6
B Age		
18-30 y	67	31.3
31-40 y	8	3.7
41-50 y	96	44.9
over 50 y	43	20.1
C Length of stay in the study area		
1-3 y	40	18.9
4-6 y	15	6.8
7-9 y	73	34.1
>9 y	86	40.1
D Level of education		
No formal education	72	33.6
Primary education	19	8.9
Secondary education	99	46.3
Tertiary education	24	11.2
E Occupation		
Trading	94	43.9
Teaching	10	4.7
Farming	62	29.0
Others	48	22.4
F. Distance to the quarry site		
<500 m	79	36.9
501 m to 1 km	55	25.7
1-2 km	43	20.1
2-3 km	22	10.3
>3 km	15	7.0
G View on quarry site		
Unfriendly	159	74.3
Not friendly	37	17.3
Null	18	8.4
H Perceived negative impacts		
Dusty environment	23	10.8
Loss of farmland	45	21.0
Loss of wildlife	11	5.1
Heavy vibration effects on buildings and ill-health	135	63.1

Source: Authors' fieldwork, 2023.

Table 2. Factors extracted by FA and their respective characteristics.

S/NO	VARIABLE NAME	RCM VALUE	EIGEN VALUE	% VARIANCE	% CUMULATIVE
1.	Loss of farmland	82.1	2.042	21.345	21.345
2.	Environmental degradation	77.5	1.811	15.063	36.408
3.	Building wall cracks or collapse	77.9	1.556	10.644	47.052
4.	Effect of flyrocks on roofs	70.7	1.459	9.104	56.156
5.	Road damage	81.8	1.362	8.568	64.724
6.	Loss of wildlife	68.9	1.319	8.330	73.054
7.	Period of site operation	85.7	1.105	6.136	79.191

Abbreviation: RCM, rotated component matrix.

gender comprising a significant majority at 77.6%. Notably, 65% of these women were aged 41 years and above, reflecting a substantial representation of mature individuals in the study. This prevalence of female respondents was linked to the cultural norms of the Yoruba people, who traditionally assign domestic caregiving roles to women. Females are often expected to stay indoors, taking care of their children while engaging in home-based petty trading. In contrast, males typically occupy roles in farming and other vocations. Furthermore, the study deliberately included respondents who had resided in the study area for a minimum of 7 years, aiming to gather insights from individuals with a comprehensive understanding of the local environment. This intentional selection criterion was set to ensure that respondents could provide nuanced perspectives based on their experiences. The 7 years was deemed arbitrarily adequate to gain a profound understanding of the terrain and the changes brought about by quarry activities.²⁷ The educational background of the respondents displayed a diverse spectrum, with 33.6% having received no formal education, 8.9% completing primary education, 46.3% reaching the secondary level, and 11.2% attaining tertiary education. To maintain inclusivity, the investigation harboured no bias against educational levels. Field assistants played a crucial role in facilitating the participation of respondents with no formal education or those who faced challenges in reading or writing. Occupationally, the respondents were engaged in various fields, with 43.9% working as traders, 4.7% in the teaching profession, and 29.0% involved in farming. The category labelled 'others', constituting 22.4%, encompassed respondents participating in diverse occupations not explicitly listed as options, including vulcanisers, painters, carpenters, health workers, and more. Geographically, the distribution of respondents around the quarry site revealed that 62.6% resided within 1 km, while 20.1%, 10.3%, and 7.0% were situated 1 to 3 km, 3 to 4 km and 4 km and above away from the quarry site, respectively. Concerningly, 74.3% of all respondents perceived the quarry site and its activities as unfriendly to human livelihood, while 17.3% held a contrary view. Within the majority who perceived the unfriendliness, 63.1% attributed their

negative sentiments to the adverse effects of vibrations on their buildings and the resulting health concerns.

Residents' perception of the ecological impact of Sanlong Quarry

The results of Factor Analysis (FA) are presented in Table 2. The findings reveal the identification and extraction of 7 factors that account for a total variance of 79.191% in the residents' viewpoints on quarry activities. The primary factor, as per the Rotated Component Matrix (RCM), is the loss of farmlands attributed to quarry activities (QA). This viewpoint has the highest variance among the extracted variables, with a given value of 2.042% and a %age variance of 21.345% out of the total 79.191% explained. The loss of farmlands due to quarry activities has been substantiated by previous studies,^{28,29} highlighting the challenges faced by farmers in cultivating land near the quarry site. This perspective didn't come as a surprise, considering that a significant portion of the respondents (29%) are farmers. Moreover, throughout the survey, it was observed that many respondents engage in farming alongside other occupations to make ends meet.

Following closely in significance is the residents' perception of degraded farmland in the vicinity of the quarry site, ranking second among the extracted factors. This factor, with an eigenvalue of 1.811 and a variance proportion of 15.0637%, underscores concern about suspended particles adversely affecting farmland, leading to increased heavy metal concentration.^{29,30} The perspectives of the respondents on this issue likely originate from the critical role of agricultural practices in the region. Their acute awareness of land resource quality is probably influenced by their active engagement in farming activities.

The impact of heavy machinery, used in processes such as blasting, crushing, and polishing rocks, on the structural integrity of buildings constitutes the third significant factor. This viewpoint, expressed with an eigenvalue of 1.556 and 10.644% variance, highlights the vulnerability of settlements constructed mainly with clay bricks to the effects of quarry operations. Chu and Karr³¹ had equally reported similar observations caused by

quarry operations. The majority of buildings in rural communities in Nigeria, as well as in many other African countries, are constructed using non-durable materials, making them fragile and prone to collapse when exposed to high vibrations such as those generated by heavy quarry machines.³²

The fourth factor is the unprecedented number of flyrocks resulting from rock blasting and crushing often resulting in damaging building roofs. It has eigen value of 1.459 and offered a variance of 9.104%. This challenge from quarry sites was raised by Nartey et al¹⁶ and Umar and Oriri.³³ The psychological and emotional effects of these occurrences, coupled with their contribution to existing health challenges in the community, underscore the multifaceted impact of quarry operations. Continuing on the same note, the detrimental impact of fly rocks, particularly on the buildings of many respondents, is a concern they are acutely aware of. They understand that most of these buildings have weak roofing and inadequate structural strength to withstand numerous and unpredictable fly rocks resulting from rock blasting.

The damage inflicted by trucks and heavy machinery on rural roads emerges as the fifth significant factor, with an eigenvalue of 1.362 and a %age explanation of 8.568%. This aligns with the observations of Umar and Oriri,³³ highlighting the disruptions caused to rural communities' connectivity by the transportation activities associated with quarries. The road networks in rural areas across Africa rank among the poorest globally. These rural roads are often in poor condition, only passable during dry seasons.³⁴ They are narrow, lacking tar to resist water erosion and are ill-equipped to handle heavy traffic, particularly the trucks transporting quarry products to high-demand urban centres.

Furthermore, the sixth factor involves the displacement of wildlife due to the operations of heavy machines, with an eigenvalue of 1.319 and 8.330% variance. This underscores the disturbance caused by quarry operations to the local ecosystem, impacting wildlife that serves as a source of food for rural dwellers. The work of Chu and Karr³¹ also corroborated this finding as 1 of the consequences of quarry activities in human environment. The importance of wildlife to rural residents cannot be overstated, as it serves as a vital protein source for them, with rural hunters actively seeking bushmeat.³⁵ However, wildlife thrives in environments free from noise and vibrations,^{36,37} conditions typically absent in quarry sites due to the use of heavy machinery in their operations.

Lastly, the residents' perception of the time of operation at the quarry site is the seventh significant factor, with an eigenvalue of 1.105 and 6.136% variance. This suggests that the timing of quarry activities has negative implications for the neighbourhoods, as residents report experiencing shocks, noise, and hearing challenges caused by quarry machines. Similar findings were reported by Pona et al.³⁸ Also, Umar and Oriri³³ identified the discomfort that are often caused on the livelihood of the residents in the neighbourhood by various heavy quarry machines while being operated and so called for possible relocation of the people. Due to the

demand for various quarry products, quarry operations such as blasting and grinding are carried out to meet this demand, often without considering the implications of these activities on the comfort and well-being of the surrounding neighbourhood.³⁹⁻⁴¹ Consequently, this situation can lead to the abandonment of the area at times.^{15,42} The findings of this study resonate with the works of Adetiloye and Nenuwa,^{43,44} who observed similar negative impacts on residents in Ikere-Ekiti, Nigeria. Residents often advocate for the relocation of quarry operations to less populated areas to alleviate the disturbances experienced in their localities.

However, the extracted variables accounted for 79.19% of the variance in the respondents' perception of the ecological effects of quarrying. The remaining 40.809% is too substantial to be disregarded and needs consideration in future research. The 11 variables that were not identified or extracted by Factor Analysis are as follows: (i) Noise pollution; (ii) Air pollution; (iii) Water pollution; (iv) Soil erosion; (v) Loss of valuable plants; (vi) Tension initiation; (vii) Sudden shocks; (viii) Aggravation of pre-existing ill-health; (ix) Motor accidents; (x) Causes of landslides; and (xi) Vibration effects.

Limitations of the Research

Conclusion and Recommendation

The investigation into the environmental impact of Sanlong Quarry activities in Obaagun, Osun state, Nigeria, adopted a local community-centric approach. Results revealed a predominant female demographic at 77.6%, mainly aged 41 years and above. Factor analysis identified 7 key variables from the 14 analysed, explaining 79.7% of the community's perception of their environment. These variables encompassed issues like the loss of farmlands (21.35%), degraded farmland (15.06%), vibrations affecting buildings (10.64%), among others. The implications suggest that quarry operations have imposed substantial hardships on the community's sustainable living. It is imperative for stakeholders to address this through implementation of the existing quarry-associated policies⁴⁵ and review those policies that need to be in line with the global practice in quarry operations, particularly those prioritising community welfare. Also, policies compelling quarry companies to be accountable for the damages and degradation inflicted on various environmental resources may be inevitable to serve as a probable succour and relief for the quarry regions. However, similar research in other quarry regions is recommended to enable comparisons of the perceptions so that holistic solutions to the challenges can be instituted for sustainable living.

Author contribution

TMT: Conceptualisation; Project administration, Investigation, Formal analysis Writing the draft and editing; TOO: Conceptualization, supervision. Data curation, Investigation, Review and Editing.

ORCID iD

Timothy O. Ogunbode  <https://orcid.org/0000-0003-1515-825X>

Data Availability

Data will be made available on request

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