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Original Research Article

Determining the Impacts of Stone Quarry Works On Riparian Vegetation of River Molo in Rongai Sub-County, Nakuru County, Kenya

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Abstract

The contribution made by stone quarrying to the Gross Domestic Product (GDP) in many countries globally is enormous. Whether small or large-scale, stone quarrying is inherently disruptive and can cause detrimental effects on the fragile riparian vegetation. This research therefore, aimed at determining the status of riparian vegetation between 2000- 2023 along river Molo and establishing the effects of stone quarry works on riparian vegetation. A descriptive survey design was adopted where 404 household heads were randomly sampled from a total of 35,545 households in Visoi, Soin and Mosop wards. 15 key informants were purposively sampled for interviews. Questionnaires, interview schedules and Geographical Information System (GIS) and Remote sensing (RS) instruments were used in data collection. The obtained data was analyzed using SPSS (Version 25), ArchMap and remote sensing (time series) to analyze changes in riparian vegetation using the Normalized Difference Vegetation Index (NDVI). The findings revealed a significant decline in riparian vegetation attributed to land use changes driven by poor agricultural practices and quarrying activities. The five purposively selected quarries were found to be located between 49 - 330 meters away from the river, where one was abandoned with no sign of reclamation, thus directly affecting the health and integrity of the riparian vegetation. It was also noted that massive heaping of quarry overburden and deep excavation accelerated felling of trees, reduced natural regeneration and increased soil erosion. These findings will be useful to inform the best quarrying practices to reduce detrimental impacts on riparian vegetation and a foundation for policy development in quarrying sector at county and national level.

Keywords: Geographical Information System, Normalized Difference Vegetation Index, Riparian Vegetation, Quarrying

INTRODUCTION

Quarrying is a common land use activity that involves the extraction of building materials such as stones, sand, and gravel. Globally, most established quarries produce either dimension stones or aggregate (Umar, 2022). Dimension stones are natural, structural and decorative building blocks used in the construction industry (Gonçalves and Margarido, 2015). However, traditional architecture; (the use of mud and wood to build houses) is fast disappearing due to neglect of culture and increased urbanization where most people in both rural and urban

setups are now embracing stone-built houses (Ikudayisi and Odeyale, 2021).

Substantial increase in natural stone extraction has been witnessed over the last decade owing to the increased construction activities worldwide (Awoke, 2019). Although quarrying is associated with poverty (Asante, Abass and Afriyie, 2014), most rural residents derive their daily income from quarrying activities. Sayara, (2016) also found that quarrying of stones contributed to 5.5 % gross domestic product (GDP) in Palestine in 2015.

In Sub-Saharan Africa, quarrying activities have expanded without adequate regulatory frameworks, leading to severe degradation of riparian ecosystems (Nartey et al., 2012). This is largely attributed to rapid urbanization and the demand for construction materials have exacerbated the environmental impacts of quarrying.

In areas such as East Africa, riparian zones have been significantly altered due to extensive quarrying, threatening the livelihood of communities dependent on these ecosystems for water and agriculture (Lameed& Ayodele, 2010). Land degradation aggravated by quarrying activities have rendered relatively large land as derelict (Omondi et al., 2021). Similarly, intensive land uses such as agriculture, construction and quarrying negatively affects riparian vegetation and results to decline in riparian vegetation species (Koskey et al., 2021).

Riparian zones are dynamic ecosystems that form at the interface of a landscape's aquatic and terrestrial components. They are shaped by complex interactions between river system biophysical components such as hydrology, geomorphology, and vegetation (Rusnák et al., 2022). Healthy riparian forests are essential to the maintenance of water quality and biological integrity in surface water systems, and their destruction often leads to subsequent degradation of adjoining aquatic ecosystems (Naiman, 1997).

According to Statista (2022) quarrying and mining industry contributed 91.8 billion to the Kenya's economy in 2021 which is a substantial increase from 68.9 billion in 2018. However, Eshiwani, (2007) noted that most quarrying activities in Kenya are carried out unsustainably, indiscriminately and uncontrollably escalating more negative impacts on riparian systems and the total environment. This finding corroborates with other research done by Mwaura, (2013) and Kosgey, (2021).

Nakuru County is endowed with enormous natural resources such as the scenic Lake Nakuru Park, Mau Forest complex, valuable rocks, geothermal resources, river ecosystems and other resources. However, these resources have been experiencing anthropogenic pressure such as stone quarrying particularly along riparian areas like the Ndarugu and Malewa rivers hence leading to riparian vegetation stress and increased sedimentation in Lake Naivasha, Lake Nakuru and other local water bodies (Mwaura, 2015). The water quality and aquatic life have been affected hence indirectly affecting local communities who rely on these resources for fishing and agriculture.

Rongai Sub- County is known to have many quarries especially along the R. Molo ecosystem which traverses through Kuresoi, Molo, Rongai, Mogotio and Baringo south Sub-Counties. These quarries are not well regulated and mapped hence accelerating unsustainable quarrying methods. Public participation as an approach for environmental management has been limited and not well coordinated exacerbating serious degradation (Mwangi et al., 2020). Thus far, there is need to strike a balance between enhancing quarry activities to improve people's livelihoods and improving the environment through holistic approaches (Dar et al., 2023).

Statement of the Problem

The contribution made by stone quarrying activities to the improvement of livelihoods in Africa is enormous (Mingate and Mohammed, 2016). The demand for building materials such as dimension stones and aggregate have been growing day by day exerting pressure on natural resources.

Despite of the existing policies in place to control quarrying activities, illegal quarrying activities have been taking place thus, causing detrimental effects on environment, particularly in riparian ecosystems. Additionally, there is little knowledge on the effects of quarrying activities on the delicate riparian vegetation which play a vital role in ecosystem functioning and health.

This research seeks to ascertain the status of R.Molo riparian vegetation between 2000-2023 and determine specific impacts of stone quarrying in Rongai Sub-County on the riparian ecosystem. Moreover, the study will blend field surveys, Geographical information systems and remote sensing to acquire accurate and useful data.

Research Objectives

1. To determine River Molo riparian vegetation status between 2000- 2023 in Rongai Sub- County, Nakuru County.
2. To establish the perceived effects of stone quarry works on R. Molo riparian vegetation in Rongai Sub-County, Nakuru County.

RESEARCH METHODOLOGY

Study area

The study was undertaken in Rongai Sub-County,

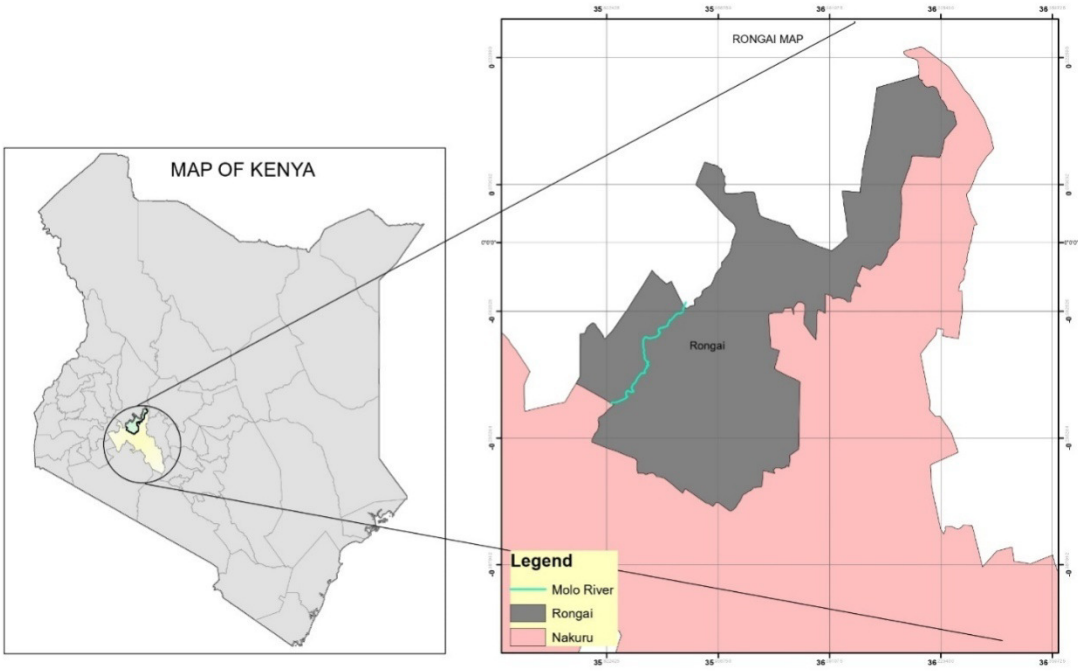

Figure 1. Study Area Map

located in Nakuru County, Kenya. It is situated along the A104 road and the railway line connecting Nakuru to Uganda with a geographical area of 988 km^2. The Geographical Positioning System (GPS) of the study area were between 0° 3'0.41"S, 35°57'16.17"E and 0°11'50.04"S, 35°50'1.60". The sub-county has an elevation of about 1,912 meters characterized by favorable climate with varied topographical elevations. Figure 1

Research Design

The study adopted a descriptive survey design that portrayed peoples' opinions and the researcher's observations. The design was also useful in drawing conclusion of the study.

Target Household Population

The study targeted 35,545 households in Visoi, Soin and Mosop wards. These wards were purposely selected because River Molo flows through them, and the primary quarries of interest are situated within their boundaries.

Sampling Procedures and Sample Size

The researcher used random sampling technique in selecting 404 head of households to be engaged during questionnaire survey process and 15 key informants who were purposively selected for interviews. The sample size was arrived at by using Yamane formula (1967) as follows:

$$n = \frac{N}{1+N\,(e\text{^}2)}$$

$$= \frac{35{,}545}{1+35{,}545(0.05)\text{^}2}$$

***n*= 404**

Where;

n- Sample size

N- Target population

e- Confidence level (0.05)

Proportionate sampling method was employed to determine the head of households' sample for each ward as shown below:

Visoi -14904/35545*100=**169**

Soin- 10184/35545*100=**116**

Mosop- 10457/35545*100=**119**

The chiefs, public health officer, environment officer from Nakuru County and NEMA official were selected because they were knowledgeable about quarrying activities in the area. Table 1

Research Instruments

structured questionnaires were administered to 404 head of households in Visoi, Soin and Mosop wards to capture their views. Additionally, key informant interview schedule, Geographical Information System and Remote

Table 1. Key Informants

Key Informants	
Chiefs	12
NEMA Official	1
Public health officer	1
Environment Officer	1
Total	15

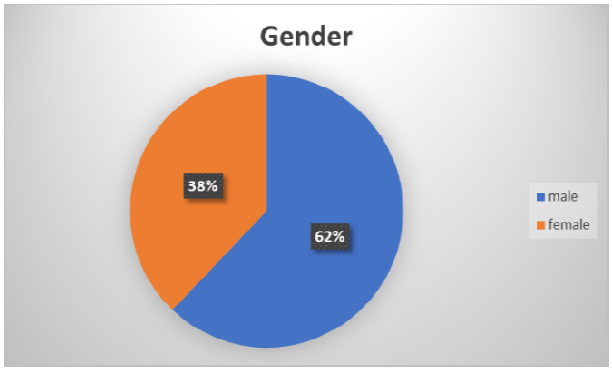

Figure 2. Gender

sensing were used to acquire relevant data for analysis.

Data Analysis

Geographical Information System (ArchMap) and Remote sensing (time series analysis) and Normalized Difference Vegetation Index (NDVI) were employed to analyze spatial data to determine R.Molo riparian vegetation status and the effects on riparian vegetation. Statistical Packages for Social Sciences (SPSS version 25) was also used to analyze qualitative data using descriptive statistics.

RESULTS AND DISCUSSIONS

Demographic Information

Gender

As depicted in the chart below, male constituted 62% out of the total respondents and 38% represented women. This disparity is largely attributed to the fact that most household heads in the study area were malehence affecting decision-making processes regarding land use and environmental management. Figure 2

Educational level

The research's findings showed that 45% of the respondents attained secondary education. Respondents who were privileged to attain tertiary education were 39% and 16% only got primary level education. Figure 3

Higher education levels are often associated with greater environmental awareness and advocacy for sustainable practices. Educated individuals are more likely to understand the long-term consequences of quarrying on riparian ecosystems and advocate for measures to protect these vital areas (Xie et al., 2019).

Occupation

Respondents were distributed in different occupations where 110 (32%) were farmers, 85 (25%) business people, 79 (23%) casual labourers, 31 (9%) teachers and 38 (11%) in other occupations as shown in figure below. Many casual laborers in the area found employment in quarrying sector owing to the many existing quarries. Figure 4

Additionally, the dry climatic conditions in the area limited most farmers to engaging in farming activities only during the rainy seasons, prompting them to seek alternative sources of income in quarrying sector to support their families.

River Molo Riparian Vegetation Status Between 2000-2023

ArcMap GIS software was used to analyze the land use and land cover classification of Rongai Sub- County.

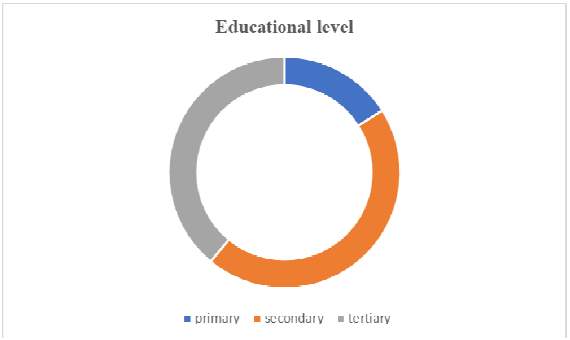

Figure 3. Educational Level

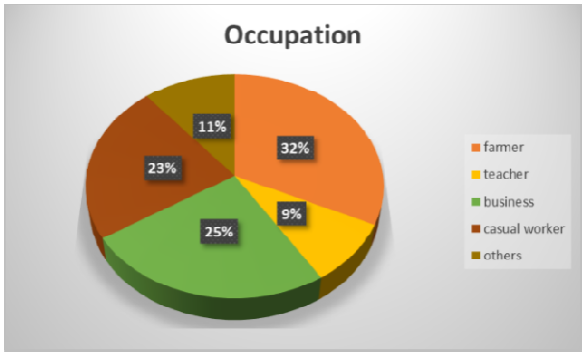

Figure 4. Occupation

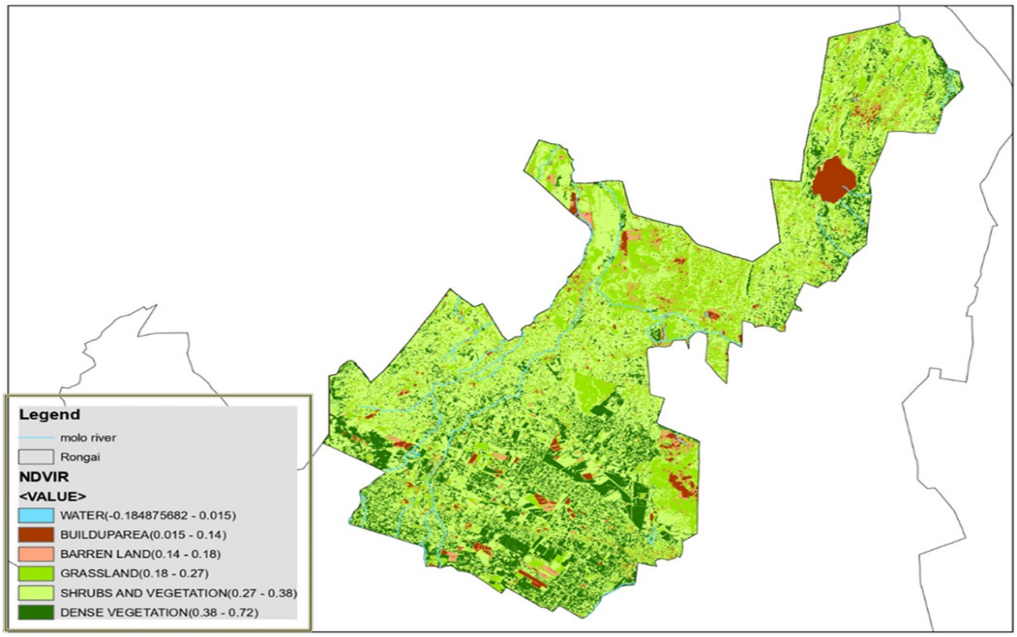

Figure 5. Rongai Land Use map

LANDSAT data comprising of administrative boundaries, Hydrology, topography and other geographical features were acquired from U.S Geological Survey website. Geoprocessing tasks such as overlaying, clipping, layering, mosaicking and image classification were performed which yielded Rongai Sub- County land use and land cover map as shown in Figure 5 above.

This map categorized the land uses into different

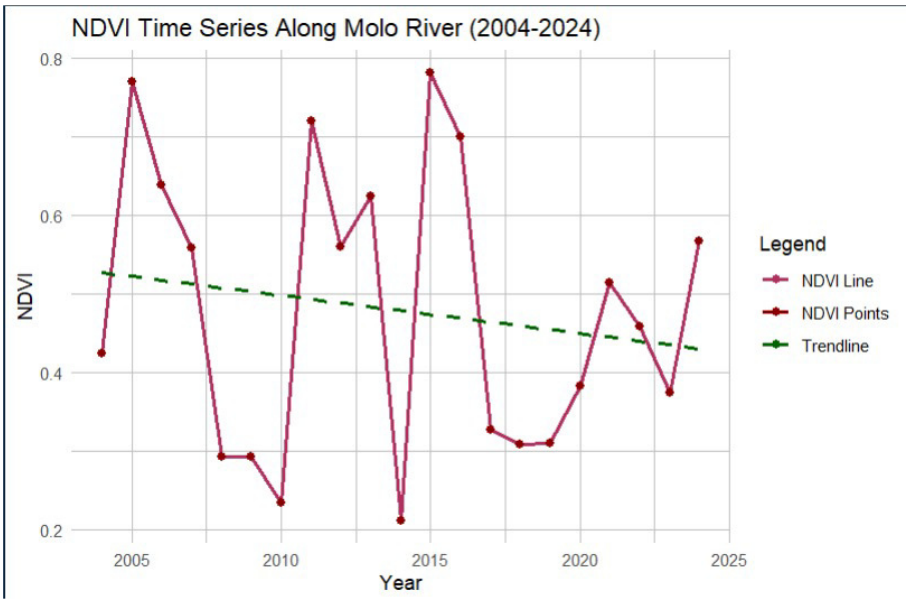

Figure 6. NDVI Analysis (2000-2023)

types based on their NDVI values, which reflect the density and health of vegetation. The categories included water, built-up areas, barren land, grassland and agriculture, shrubs and sparse vegetation and dense vegetation. From the map, it is also evident that there were barren areas along the riparian zone of River Molo indicating human interference including farming and quarrying activities.

Ren, Wang & Li (2019) study emphasized that human activities, such as agriculture and quarrying, significantly affect the structure and function of riparian ecosystems leaving the land exposed, hence corroborating with the results above.

The analysis of satellite imagery from 2000 to 2018 did not reveal substantial evidence of quarrying activities. However, a notable change was observed between 2019 and 2023, coinciding with the introduction of modern stone cutting machines. This suggests that the recent adoption of advanced quarrying technologies has accelerated the pace and scale of stone extraction in the study area during the 2019-2023 period.

Normalized Difference Vegetation Index Time Series Along River Molo

The NDVI data was obtained through timeseries analysis of satellite imagery between 2000-2023. The imagery was subjected to hyperspectral analysis using ArcMap with huge focus on variation in reflectance, topography and vegetation along River Molo.

Figure 6 above shows the down sloping trendline suggesting a decline in NDVI between the timeframe. The decline is largely attributed to agriculture and stone quarrying activities along the riparian areas of River Molo. These findings are consistent with the results recorded by Ruto, Musila, Limbua, Kinyanjui and Kaigongi (2023) which indicated that anthropogenic activities (grazing, crop farming and quarrying) fragmented riparian forests, resulting in reduced NDVI values.

Perceived effects of stone quarry work on R. Molo riparian vegetation

During field visit and observation, the researcher also established that all the five quarries were active except Q1 which had been abandoned. However, the researcher did not establish as to why the quarry was abandoned. Remote sensing using google earth pro established that Q1 was the leading in area of coverage with a total of 3.74 Ha and Q2 being the least with 0.48 Ha. Moreover, Q5 recorded the lowest proximal distance to the river with 49.48 meters whereas Q2 was the furthest with proximal distance of 324.42 meters. This was a clear indication that the ongoing quarrying activities were directly affecting riparian vegetation found along River Molo. According to EMCA, (2015) highly impactful activities such as quarrying should undergo through comprehensive environmental Impact Assessment study before operationalization. EIA expert should undertake a comprehensive screening process to establish the proximity of the proposed quarry to the riparian areas and recommend whether to proceed or look for an alternative site. Table 2

The figure above shows the extent of stone extraction in Q3 and Q4 where existing trees and shrubs were uprooted to pave way for extraction processes. It was

Table 2. Sampled Quarries

S/No	Name	GPS Coordinates	Area coverage (ha)	Proximity to the River(meters)	Status
1.	**Q1**	0°2'3.56"S 35°57'43.73"E	3.74	91.92	Inactive
2.	**Q2**	0° 2'26.96"S 35°57'31.81"E	0.48	323.42	Active
3.	**Q3**	0° 2'59.24"S 35°57'14.27"E	1.10	78.73	Active
4.	**Q4**	0° 3'49.32"S 35°56'24.53"E	1.32	49.99	Active
5.	**Q5**	0° 4'7.96"S 35°56'15.66"E	1.49	49.48	Active

also noted that deep cuts were existing showing no adherence to sustainable extraction methods as prescribed by NEMA. The researcher also observed a lot of dust emissions emanating from quarry operation which significantly affected photosynthesis by blocking stomata in plant leaves.

Perceived Impacts of Stone Quarrying on Riparian Vegetation

Strong majority of 87%of respondents perceived stone quarrying as having a negative impact on riparian vegetation of River Molo. Additionally, 13% of respondents did not see stone quarrying as detrimental to the riparian vegetation in the study area as shown in figure 8 below. Table 3

Weighted Average = 4.615

The survey results showed a strong consensus among respondents regarding the environmental impacts of stone quarrying on riparian vegetation of River Molo. Table 3 above indicate a weighted average = 4.615 for all the four statements. Statement one on changes on riparian vegetation cover recorded a mean of 4.78 and a standard deviation (SD) of 0.60 suggesting a very high perception that quarrying significantly changes vegetation cover along the river.

Statement two on reduction in natural regeneration of riparian vegetation scored a mean of 4.20 and SD of 1.14 hence falling below the weighed mean. This therefore implied a high perception on reduced natural regeneration of riparian vegetation as a result of stone quarrying.

The third statement on felling of riparian trees recorded a mean of 4.92 and a SD of 0.32 indicating a very high perception that quarrying leads to the removal of trees near the riparian areas. Lastly, the fourth statement on soil erosion scored a mean of 4.56 and a SD of 0.65 showing high perception that quarrying resulted to soil erosion which greatly affected riparian vegetation health and growth.

Additionally, all fifteen (15) key informants confirmed that most of the quarries fell trees to allow space for expansion and the overburden generated were heaped unsustainably affecting the rate of natural regeneration of treesparticularly grasses and low-lying herbaceous plants. Similarly, quarrying activities led to chlorosis (loss or reduction of chlorophyll leading to yellowing of leaf) in plants corroborating to the findings by Moilinga and Athian, (2023) which concluded that quarrying activities led to the destruction and removal of local vegetation, particularly grasses and low-lying herbaceous plants in Mount Korok in South Sudan.

Similarly, a study by Kibii (2020) found that 79.6% of respondents noted that original vegetation cover and trees had been destroyed affecting the availability of animal fodder due to quarrying activities in Tuluongoi, Baringo county. Furthermore, Omondi *et al.,* (2020) documented how the extraction of materials led to the creation of deep gullies and barren landscapes, which negatively impacted local ecosystems and biodiversity in Lake Victoria Basin. Another study by Muthee (2017) in Kenya's central highlands indicated disruption of key riparian species through soil erosion.

The findings are also supported by Kamran & Siddique (2020); Shah & Sah (2018 who found that quarrying activities led to reduced vegetation, soil erosion and felling of trees which appeared to be the immediate repercussions of quarrying. In the contrary, Ogunbode and Ifatimehin (2013) in Nigeria suggested that application of stone quarrying best practices could mitigate all related environmental damage especially along riverine areas.

Taken together, these findings suggest that stone quarrying has had detrimental effects on the riparian vegetation, leading to deforestation, disruption of natural ecological processes, soil degradation, and reduced

Figure 7. Pictorial Representation of Q3 and Q4

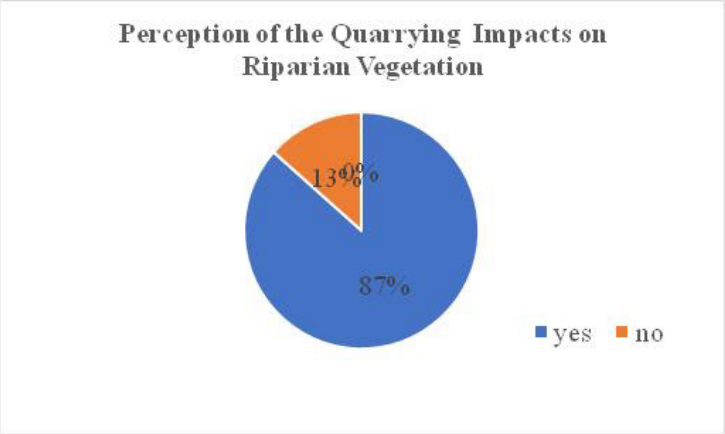

Figure 8. Pie Chart Showing Perception of the Quarrying Impacts on Riparian Vegetation

Table 3. Household Head's Perception Towards the Impacts of Stone Quarrying on Riparian Vegetation

Statement	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)	Mean	Standard Deviation	Perception
Quarrying leads to changes in riparian vegetation cover.	0.58	2.04	0	13.12	84.26	4.78	0.6	Very High
Quarrying reduces natural regeneration of vegetation.	4.37	9.33	2.92	29.15	54.23	4.2	1.14	High
Quarrying results in the felling of riparian trees.	0	0.58	0	5.83	93.59	4.92	0.32	Very High
Quarrying contributes to soil erosion.	0.29	1.46	2.92	32.94	62.39	4.56	0.65	High

natural regeneration among riparian vegetation communities.

CONCLUSION

Based on the findings, the NDVI of the riparian vegetation along river Molo is gradually declining as a result of quarrying activities and other land use activities in the area. The proximity of the quarries to the river and the mode of extraction have accelerated destruction of riparian vegetation hence resulting to change in riparian vegetation cover, felling of trees, reduced regeneration and soil erosion.

RECOMMENDATIONS

❖ Ensure rehabilitation and reclamation of quarry sites after decommissioning to promote enhanced landforms and vegetation cover.

❖ Planting of trees and grass to reduce soil erosion and enhance riparian ecosystem functioning

❖ Promote public education and sensitization on the impacts of stone quarrying on riparian vegetation.

❖ Enactment of Nakuru County quarrying laws to regulate establishment of quarries and mode of extraction and proper disposal of quarry overburden and other wastes.

Conflict of Interest

No conflict of interest in the publication of this article

Ethical Consideration

The researcher obtained an introductory letter from Kabarak University and thereafter sought a research permit from the National Commission of Science, Technology and Innovation. The permit was then

presented to the chiefs of the respective areas and the key informants before undertaking the study.

The researcher and the research assistant sought the consent of respondents before administering questionnaires and interviews by briefing them on the purpose of the study and seeking their consent to participate. The researcher adequately assured all respondents of their data protection and privacy by restricting data access to authorized personnel only and ensuring that all the data were securely discarded after the completion of the study.

REFERENCES

"Mining and Quarrying Impacts." Environmental Science: In Context. . Retrieved January 24, 2022 from Encyclopedia.com: https://www.encyclopedia.com/environment/energy-government-and-defense-magazines/mining-and-quarrying-impacts

Akanwa, A. O., Okeke, F. I., Nnodu, V. C., &Iortyom, E. T. (2017). Quarrying and its effect on vegetation cover for a sustainable development using high-resolution satellite image and GIS. Environmental earth sciences, 76, 1-12.

Ali, E. (2020). Geographic information system (GIS): definition, development, applications & components. Department of Geography, Ananda Chandra College. India.

Antunes, R., & Tia, M. (2018). Cement Content Reduction in Concrete Through Aggregate Optimization and Packing: A Sustainable Practice for Pavement and Seaport Construction. Mix Sustentável, 4(3), 25-32.

Aronson, J., C., Floret, LeFloc'h, E., Ovalle, C. and R., Pontanier.1993. Restoration and rehabilitation of degraded ecosystems in arid and semi-arid lands. A view from the South. Restoration Ecology 1:8-17.

Asante, F., Abass, K., & Afriyie, K. (2014). Stone quarrying and livelihood transformation in Peri- Urban Kumasi. J. Res. Humanities and Soc. Sci. 4(13), 93-197.

Assad, E. A. and Jordan, H. (1994). Karst terraces and Environmental aspects, journal of Environmental Geology, 23: 228-237.

Azad S. A and Ashish M (2006). The stone quarrying industry around Deli impact on workers and the environment, michigan, lansing publishing

Basu, S., Orr, S. A., &Aktas, Y. D. (2020). A geological perspective on climate change and building stone deterioration in London: Implications for urban stone-built heritage research and management. Atmosphere, 11(8), 788.

Bertalanffy, L. (1950). An Outline of General System Theory. The Journal for Philosophy of Science; Vol 1.

Bhattacharya, R. K., Chatterjee, N. D., & Das, K. (2022). Assessment of Habitat Quality in Quarried Reach of Alluvial River. River Health and Ecology in South Asia: Pollution, Restoration, and Conservation, 251-280.

Careddu, N. (2019). Dimension stones in the circular economy world. Resources Policy, 60, 243-245.

Clare, S. and G. Sass (2012). Riparian lands in Alberta: Current state, conservation tools, and management approaches. Edmonton, Alberta. Fiera Biological Consulting Ltd. Report #1163

Dar, S. A., Ganie, D. H., Teeli, J. I., & Bhat, S. U. (2023). A policy approach for sustainable governance of sand mining activities in NW Kashmir Himalayas. The Extractive Industries and Society, 13, 101204.

Dosskey, M. G., Vidon, P., Gurwick, N. P., Allan, C. J., Duval, T. P., & Lowrance, R. (2010). The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association, 46(2), 261-277. https://doi.org/10.1111/j.1752-1688.2010.00419.x

El-Gammal, M. I., Ali, R. R., & Samra, R. A. (2014). NDVI threshold classification for detecting vegetation cover in Damietta governorate, Egypt. Journal of American Science, 10(8), 108-113.

Endalew, A., Tasew, E., &Tolahun, S. (2019). Environment and Social Impacts of Stone Quarrying: South-Western Ethiopia, in Case of Bahir Dar Zuria Wereda Zenzelma Kebele. Int. J. of Res. Enviro. Sci., 5(2), 29-38. http:// dx.doi.org/10.20431/2454-9444.0502005

Eshiwani, F. (2014). Effects of quarrying activities on the environment in Nairobi County: a case study of Embakasi district (Doctoral dissertation, University of Nairobi).

Gandhi, G. M., Parthiban, B. S., Thummalu, N., & Christy, A. (2015). Ndvi: Vegetation change detection using remote sensing and gis–A case study of Vellore District. Procedia computer science, 57, 1199-1210.

Goel, A. K., Gomez de Silva Garza, A., Grué, N., Murdock, J. W., Recker, M. M., &Govinderaj, T. (1996). Towards designing learning environments. I: Exploring how devices work. In C. Fraisson, G. Gauthier, & A. Lesgold (Eds.), Intelligent tutoring systems: Lecture notes in computer science. Berlin: Springer-Verlag.

Gonçalves, M. C., &Margarido, F. (2015). Materials for construction and civil engineering. Cham, Switzerland: Springer.

Green, J. A., Pavlish, J. A., Merritt, R. G., &Leete, J. L. (2005). Hydraulic impacts of quarries and gravel pits. Minnesota Department of Natural Resources, Division of Waters. Prepared for the Legislative Commission on Minnesota Resources.

Halwenge, J. A. (2015). Dust pollution and its health risks among rock quarry workers in kajiado county, Kenya (Doctoral dissertation, Kenyatta University).

Hamza, S., & Kanyama, A. (2016). Challenges of Addressing Environmental Problems due to Quarrying Operation in Uwandani Ward, Pemba. World Journal of Social Science Research, 3(3).

Harrell, J. A., &Storemyr, P. (2009). Ancient Egyptian quarries—an illustrated overview. Geological Survey of Norway Special Publication, 12, 7-50.

Hassan, I. A. (2022). Assessment of the Socio-Economic and Health Impact of Quarrying on the Inhabitants of Kenta Logemo Village in Odeda Local Government Area, Ogun State, Nigeria.

Hawe, E. S. (2005). Riparian Buffer Zones: Functions and Recommended widths.

Ibrahim, M. H. (2007). Sectoral effects of ringgit depreciation shocks. Journal of Economic Development, 32(2), 135.

Ikudayisi, A. E., &Odeyale, T. O. (2021). Designing for cultural revival: African housing in perspective. Space and Culture, 24(4), 617-634.

Ilyas, M., & Rasheed, F. (2010). Health and environment related issues in stone crushing in Pakistan. South Asia Network of Economic Research Institutes (SANEI), 10-18.

Jiao, Y., Peluso, P., Shi, J., Liang, T., Stitzer, M. C., Wang, B. & Ware, D. (2017). Improved maize reference genome with single-molecule technologies. Nature, 546(7659), 524-527.

Joseph, L. (2022). Impacts of Traditional Extraction of Building Materials on Biodiversity Conservation and Livelihoods of Residing Communities in Mwanza City-Tanzania.

Kamran, A., & Siddique, S. (2020). Environmental impacts of quarrying: A case study of riparian ecosystem degradation in Pakistan. Journal of Environmental Management, 250, 109-120. https://doi.org/10.1016/j.jenvman.2020.109120

Kangogo, J. (2020). Quarry collapses, Kills two in Baringo. The star.

Retrieved from. https://www.the-star.co.ke/news/2020-04-22-quarry-collapses-kills-two-in-baringo/

Karisa, C. (2010). A negotiated framework for rehabilitation of riparian zones in Nairobi City: the case of Mathare River Valley (Kenya).

Kenya Bureau of Statistics. (2019). Household and Census Survey. Nairobi. Kenya: The Government Printer.

Kibii, C. (2020). Social and Environmental effects of Stone Quarrying in Tuluongoi Sub Location, Tenges Division, Baringo County (Doctoral dissertation, University of Nairobi).

Kigomo, J. N., Kuria, M. N., Gatama, S., & Waweru, E. M. (2018). Evaluation of land and vegetation degradation indicators in Kiang'ombe Landscape, Mbeere North, Kenya. Journal of Research in Forestry, Wildlife and Environment, 10(1), 74-84.

Koskey, J. C., M'Erimba, C. M., &Ogendi, G. M. (2021). Effects of Land Use on the Riparian Vegetation along the Njoro and Kamweti Rivers, Kenya. Open Journal of Ecology, 11(11), 807.

Lameed, G. A., & Ayodele, A. E. (2010). Effect of quarrying activity on biodiversity: Case study of Ogbere site, Ogun State Nigeria. African Journal of Environmental Science and Technology, 4(11), 740-750.

Langer, W. H. (2001). Potential Environmental Impacts of Quarrying Stone in Karst - A Literature Review.

Macdonald, S. E., Landhäusser, S. M., Skousen, J., Franklin, J., Frouz, J., Hall, S., ... &Quideau, S. (2015). Forest restoration following surface mining disturbance: challenges and solutions. New Forests, 46, 703-732.

Mahapatra, T. (2023). Environmental, social and health impacts of stone quarrying in Mitrapur panchayat of Balasore district, Odisha. International Journal of Science and Research Archive, 8(1), 678-688.

Mandal, I., & Pal, S. (2020). COVID-19 pandemic persuaded lockdown effects on environment over stone quarrying and crushing areas. Science of the Total Environment, 732, 139281.

Matheus, L. (2016). Proposal for modernization of blasting works in Austin Detonator Powder Service Company.

Matunda, J.M. (2015). Sustainable Management of Riparian areas in Kenya: A Critique of the Legislative Framework Governing the Protection of Sustainable Management of Riparian Zones in Kenya. Unpublished Master of Laws degree (LLM) Environmental law, University of Nairobi

Ming'ate, F. L. M., & Mohamed, M. Y. (2016). Impact of stone quarrying on the environment and the livelihood of communities in Mandera County, Kenya. Journal of Scientific Research and Reports, 10(5), 1-9.

Mirzabaev, A., Wu, J., Evans, J., García-Oliva, F., Hussein, I. A., Iqbal, M. H., ... &Weltz, M. (2019). Desertification

Moilinga, P. T., &Athian, M. R. (2023). Impacts of Stone Quarrying on Local Vegetation in Mount Korok Area, Juba, Central Equatoria State, South Sudan. In New Insights Into Protected Area Management and Conservation Biology. IntechOpen.

Muhoma, R. A. (2014). Factors influencing youth employment through involvement in the milk value chain: a case of Rongai/Nakuru sub-counties, in Nakuru county Kenya (Doctoral dissertation, University of Nairobi,).

Muthee, K. (2017). The effects of quarrying on riparian ecosystems in Kenya's central highlands. African Journal of Environmental Science and Technology, 11(8), 415-422. https://doi.org/10.5897/AJEST2017.2380

Mwangi, J., et al. (2020). The role of public participation in managing environmental impacts of quarrying in Nakuru County. Journal of Environmental Studies, 30(2), 221-234.

Mwangi, S. N. (2014). An assessment of environmental impacts of quarrying activities in Ndarugo Area, Kiambu County. Bachelor Degree Project, Kenyatta University, Kenya.

Mwaura, F. (2015). Impact of quarrying on riparian ecosystems in Nakuru County, Kenya. Environmental Management, 55(3), 492-500.

Mwaura, S.K., 2013. The Effects of Sand Harvesting on Economic Growth in Kenya with a case study of Machakos County: International Journal of Sciences and Entrepreneurship 1 (5), 342-350.

Naiman, R.J. and Decamps, H. (1997) The Ecology of Interfaces: Riparian Zones. Annual Review of Ecology and Systematics, 28, 621-658.

Nyaguthii, D., Armoson, B &Kitala, P. (2019). Knowledge and risk factors for foot and mouth disease among small scale dairy farmers in endemic setting.

Nyakeniga, A. C. (2009). An assessment of environmental impacts of stone quarrying activities in Nyambera Location Kisii County. A research project report submitted to Kenyatta University.

Ogunbode, C. A., &Ifatimehin, O. O. (2013). Mitigating environmental impacts of quarrying through sustainable practices in Nigeria. Int. J. Environ. Sci. Develop. 4(5), 306-310. https://doi.org/10.7763/IJESD.2013.V4.388

Omondi, G. O., Otieno, A. C., Tonui, K. W., & Otieno, J. (2021). Quarrying and Land Degradation in Nyakach Sub County, Kenya. Int. J. Earth Sci. Knowledge and Applications, 4(1), 69-78.

Onyango, D. O., & Opiyo, S. B. (2021). Riparian community perceptions of the extent and potential impacts of watershed degradation in Lake Victoria Basin, Kenya. Limnologica, 91, 125930.

Patel, P. G., Mishra, K., & Kumar, S. (2016). Challenges in implementing quarrying laws for sustainable practices: A case study. J. Environ. Manag. 182, 635-642. https://doi.org/10.1016/j.jenvman.2016.08.001

Qasrawi, H. (2014). The use of steel slag aggregate to enhance the mechanical properties of recycled aggregate concrete and retain the environment. Construction and Building Materials, 54, 298-304.

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. Biological Conservation, 141(10), 2417-2431. https://doi.org/10.1016/j.biocon.2008.07.014

Ren, Y., Wang, D., & Li, X. (2019). Impacts of human disturbances on riparian herbaceous communities in a Chinese karst river. Nature Environment and Pollution Technology, 18(4), 1107-1118.

Robertson, T. (2012). Mathusian Moments: Global population growth and birth of American environmentalism. New Brunswick; Rutgers Univerity Press.

Rusnák, M.; Goga, T.; Michaleje, L.; ŠulcMichalková, M.; Má˘cka, Z.; Bertalan, L.; Kidová, A. Remote Sensing of Riparian Ecosystems. Remote Sens. 2022, 14, 2645. https://doi.org/10.3390/rs14112645

Ruto, D. K., Musila, F. M., Limbua, P. G., Kinyanjui, J. M., &Kaigongi, M. M. (2023). Effects of land use on the riparian vegetation in Mau Forest Complex in Kenya. Global Ecology and Conservation, 46, e02624.

Sayara, T. (2016). Environmental impact assessment of quarries and stone cutting industries in Palestine: Case Study of Jammain. Journal of Environmental Protection and Sustainable Development, 2(4), 32-38.

Shah, M. A., & Sah, J. P. (2018). Environmental impact assessment of stone quarrying in the Indian subcontinent: Felling of trees and destruction of riparian vegetation. Environmental Monitoring and Assessment, 190(4), 240-250. https://doi.org/10.1007/s10661-018-

6642-3

Singh, T. N., &Anbalagan, R. (2018). Rehabilitation of quarries for enhanced ecological balance and biodiversity. Environmental Earth Sciences, 77(6), 1-12. https://doi.org/10.1007/s12665-018-7538-5

Şirin, E., Bonduà, S., &Elkarmoty, M. (2021). Environmental and economic optimization for block cutting of dimension stones in a limestone quarry. Resources Policy, 74, 102396.

Southwick, S. J. (2005). Building on a Borrowed Past: Place and Identity in Pipestone, Minnesota. Ohio University Press.

Stolz, N. (2021). Geological Survey of New South Wales: New South Wales–a great place to explore. Preview, 2021(213), 17-21.

Tanko A (2007). "Environmental concerns, assessment and protection procedures for Nigeria's oil industry" Centre for Development studies and the school of Geography, Geol. Environ. Sci., BUK, Nigeria.

Twerefou, D. K., Tutu, K., Owusu-Afriyie, J., & Adjei-Mantey, K. (2015). Attitudes of local people to mining policies and interventions. International Growth Centre, Ref: E-33107-GHA-1.

Umar, H. A. (2020). Evaluation of Suitability of Some Selected Basement Complex Rock Exposures for Dimension Stone Quarry in Southwestern Nigeria (Doctoral dissertation, Kwara State University (Nigeria).

Vandana, M., John, S. E., Maya, K., &Padmalal, D. (2020). Environmental impact of quarrying of building stones and laterite blocks: a comparative study of two river basins in Southern Western Ghats, India. Environmental Earth Sciences, 79, 1-15.

Ventura, D., Bonifazi, A., Gravina, M. F., Belluscio, A., &Ardizzone, G. (2018). Mapping and classification of ecologically sensitive marine habitats using unmanned aerial vehicle (UAV) imagery and object-based image analysis (OBIA). Remote Sensing, 10(9), 1331.

Walser, G. (2002). Economic impact of world mining.

Wangela, S. W. (2019). Effects of Dimension Stone Quarrying Activities in Ndarugo Area of Kiambu County, Kenya (Doctoral dissertation, University of Nairobi).

Waqas, M., Tariq, S. M., Shahzad, M., Ali, Z., & Saqib, S. (2015). Performance Measurement of Surface Mining Equipment by Using Overall Equipment Effectiveness. Pakistan Journal of Science, 67(2).

Warhurst, A., & Noronha, M. L. (Eds.). (1999). Environmental policy in mining: Corporate strategy and planning. CRC Press.

Waweru, S. W., Njoroge, J., &Adimo, A. O. (2018). Management status and perception of post quarried sites in Ndarugu Kiambu, Kenya.

Yamane, T. (1967). Sampling Formula. E-Book www albookez com.