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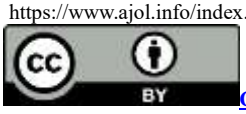

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Original Research

ENVIRONMENTAL AND SOCIAL ECONOMIC IMPACTS OF SAND AND GRAVEL MINING ON RIVER NJORO- NAKURU COUNTY: ASSESSING THE DRIVERS OF SAND AND GRAVEL MINING

[1]JAMES Ngatia *and* **[2]JAPHET Kipng'eno**
[1]Department of Geography, Mount Kenya University *and* [2]Department of Geography, Kampala International University

Email: [1]royalkurj@gmail.com, *and* [2]japhetkipngeno2013@gmail.com

ABSTRACT
Sand and gravel mining in Nakuru County, Kenya, plays a vital role in supporting livelihoods and infrastructural development but poses significant environmental and socio-economic challenges. This study examines the drivers, impacts, and regulatory gaps associated with sand and gravel extraction along the Njoro River, a critical ecosystem linked to Lake Nakuru. Using a mixed-methods approach, including surveys, interviews, and field observations, the research explores the economic motivations behind mining, such as employment opportunities and poverty alleviation, alongside its environmental consequences, including riverbank erosion, biodiversity loss, and water pollution. Findings reveal that weak regulatory enforcement and limited community involvement contribute to unsustainable practices, threatening long-term ecological balance. The study underscores the urgent need for policy reforms, stricter oversight, and community-based management strategies to ensure sustainable resource utilization. By bridging the gap between economic development and environmental conservation, the study recommends that county governments, in collaboration with national agencies such as the National Environment Management Authority (NEMA), formulate comprehensive policies and legal frameworks specifically addressing sand and gravel mining.

Keywords: *Sand and gravel mining, Environmental impacts, Socio-economic drivers, Sustainable resource management, Njoro River.*

BACKGROUND TO THE STUDY
The backdrop of the study made it clearly clear that the mining of sand and gravel is a worldwide activity that takes place in both developed and developing countries all over the world. This was made abundantly clear after the research was conducted. Because water is the major means by which these two natural resources are carried and deposited, they are often gathered from aquatic settings, such as rivers, lakes, and beaches. This is because water is the principal route by which they are transported. However, the activity of sand and gravel mining is supported by numerous positive factors (Jonah, et al., 2015; Narh, 2016). According to Mingist and Gebremedhin (2016), the extraction of these two commodities is straightforward and can be carried out locally by making use of equipment that is easily available and does not need the miners to spend a considerable amount of money to obtain. In this age of rapid expansion, people have begun to concentrate their attention on rivers and floodplains as a substantial source of sand and gravel for the purpose of

constructing or to fulfill the increasing demand for urbanization, (Devi, et al., 2015). According to this research, people have begun to focus their attention on rivers and floodplains. It was reported by Narh (2016) and Aromolaran (2012) that there has been an increase in the mining of sand and gravel in the Dormaa District of the Brong Ahafo Region and Ogun State in Nigeria. This information was derived from the respective sources. This procedure is carried out in order to provide the building industry and the road sector with the raw materials that are required for their operations. The extraction of sand results in the production of resources that may be used for the construction of a wide range of infrastructure projects, such as residential structures, roadways, railway lines, walkways, dams, landscaping, and other enhancements. In the same way that diamonds are in high demand in the construction business, sand is a natural resource that is in high demand in the construction industry. Sand is a fundamental raw material and component of a broad range of building materials, such as cement, mortar, tile, brick, glass, adhesives, ceramics, sandpapers, and many more. Sand is also used in the production of construction materials. The building sector is another business that is related with sand because of its use. Per Devi and Rongmei (2015), it is also used in the plastic industry, as well as in the processing of chemicals and metals, and in the filtration of water. In addition, it is utilized in the plastic industry. As a result of this, sand and gravel are used to a significant degree in the manufacturing and construction industries; in the absence of these resources, these businesses would be forced to discontinue the manufacture of their products (Gavriletea, 2017). The results of a study that was carried out by Monforton and Windsor (2018) indicate that the annual use of sand and gravel as a construction material is expected to be comparable to around 10 billion tons throughout the whole world. According to the findings of the study that has been carried out, it is incontestable that the need for sand and gravel is consistently increasing. According to Kori and Mthanda (2012), this is because the construction sector needs this kind of materials in order to function properly. On the other hand, Hemalatha et al. (2005) state that there is no alternative to the use of sand as a building material. This demonstrates that the utilization of sand is continuing and does not discriminate in any way.

Although sand and gravel are used in the building industry and other industries that are closely related with it, there is also the economic reason for the extraction of these two commodities (Krausmann 2009). Sand and gravel are both used in the construction sector. Pegg (2016) and Mobtaker and Osanloo (2014) arrived to the conclusion that mining offers a significant contribution to the alleviation of poverty and the growth of the economy as a result of their study on the direct relationship between the extraction of sand and the elimination of poverty. According to Blachowski (2015), the exploitation of these two resources acts as a stimulant for the expansion of commercial and economic activity. Not only does it bring in money, but it also provides a contribution to the general economic prosperity of people and society as a whole (Salifu, 2016). For instance, Agyemang (2018), Peprah (2013), and Narh (2016) claim that the mining of sand and gravel provides opportunities for individuals to earn a livelihood so that they may support themselves. Sand loaders, truck drivers, truck owners, landowners, food vendors, and other personnel who offer services associated to the industry are included in this group of people. These points of view are given more weight as a consequence of the findings of the study that was carried out by Afriyie and colleagues (2016) on the investigation of the Galamsey business. The findings of the study led the researchers to the conclusion that there is a movement of individuals departing from agricultural regions and areas of unemployment to work in the mining industry in Ghana. These individuals have a propensity to seek refuge or employment in the mining business, namely in the sand and gravel industry, when there are a greater number of people who are without jobs.

This is because sand mining creates a significant amount of income for landowners, truck drivers, and other persons who are engaged in the process of sand and gravel mining (Musah, 2009; Mensah, 1997). This is the reason why this is the case. People are motivated to urge their social networks to join in the activity of sand and gravel mining since the activity does not need any specialized talents or equipment. This is because the money that they obtain from this business is what drives them to do so.

Sand is a mineral that is used to maintain the environment, works as a buffer against extreme tidal waves and storms, and provides a home for a range of marine creatures and species. Sand is also a crucial component since it is used to conserve the ecosystem. Unfortunately, there has been no research carried out in this specific location, which is unfortunate since the goal of the present study is not to investigate this particular region. At the global level, Lawal (2011) suggests that the mining of sand and gravel is crucial to the expansion of a large number of countries all over the world. This is a proposition concerning the international level. According to a study that was published by the United Nations in 2018 on the subject of commodity trade, it was anticipated that the entire value of stone, sand, and gravel imports for the year 2010 would amount to $40.3 billion. Countries such as China, Singapore, Italy, Germany, and the Netherlands were the ones that imported the most quantity of their respective goods.

According to worldwide Construction Perspectives (2012), it is estimated that the global value of the construction or sand industry would reach 12 trillion United States Dollars annually in the year 2020. This figure is comparable to around 13 percent of the global GDP. Taking all of this into consideration, it is clear that the construction or sand business is expected to become significant in the next years. As a result, it is almost hard to argue against the significance of sand mining to the development of economies in countries all over the world. Regarding this matter, it is impossible to disregard it. At the local level, some persons who see the changes in the economic position of individuals who are doing business in the mining sites are lured to enter the mining sector. This is because the mining industry is a lucrative industry. Despite the fact that this sector has a detrimental impact on the environment, there is a potential that it will motivate more individuals to join the sand mining industry. This is because the demand for goods and services at such mining sites by sand miners gives opportunities for a higher number of people to engage in a range of commercial activities in the surrounding region. This is the reason why this is the case. Because of this, the process of mining for sand and gravel is paired with a wide variety of activities that are not sustainable. These variables vary from the people's skewed perception of the fleeting economic and development accruals that this company obtained to the fact that this corporation enjoyed temporary benefits. There are a big number of individuals all over the globe who find job in the mining of sand and gravel. This is a major source of employment. It provides job chances to people of society who are now without work, as well as revenue to sand contractors and truck drivers, as well as to governments (Asha, 2011). In addition, it provides income to governments. In accordance with the findings of Mattamana et al. (2013), it is a multifaceted industry that offers advantageous services to thousands of people all over the globe. Sand, gravel, and crushed stone are the most mined resources on Earth (Bendixen et al., 2021). As a consequence of the indiscriminate extraction of these materials, there will come a time when the demand for natural sand and gravel will exceed the rate at which they are replaced by nature (Sverdrup, et al., 2017). This will occur as a result of the extraction of these materials without any discrimination.

STATEMENT OF THE PROBLEM

The mining of sand and gravel in Nakuru County, Kenya, is a critical economic activity that supports livelihoods, construction, and infrastructure development. However, this activity is largely unregulated, leading to significant environmental degradation, including riverbank erosion, loss of biodiversity, and water pollution, particularly in ecosystems dependent on the Njoro River. Despite its socio-economic benefits, the unchecked extraction of these resources poses long-term risks to both the environment and the sustainability of local communities.

The study identifies a gap in understanding the key drivers behind sand and gravel mining in Nakuru County, as well as the lack of effective policies to manage its environmental and socio-economic impacts. The absence of stringent regulations and community-based management strategies exacerbates the problem, resulting in indiscriminate mining practices that threaten water sources and ecosystems.

This research aimed to address these issues by examining the drivers of sand and gravel mining, assessing its environmental and socio-economic consequences, and proposing sustainable management solutions to balance economic needs with ecological preservation.

STUDY MAIN OBJECTIVE

The study aimed to examine the drivers of sand and gravel mining in Nakuru County, Kenya.

SCOPE OF THE STUDY

The scope of this study encompasses an examination of the environmental and socio-economic impacts of sand and gravel mining activities in Nakuru County, Kenya, with particular focus on the Njoro River ecosystem. Geographically, the research is limited to mining sites along the Njoro River and its confluence with Lake Nakuru, areas that represent significant extraction zones while also serving as critical habitats. The study investigates three key dimensions: the economic and social drivers promoting mining activities, including employment opportunities and livelihood sustenance; the environmental consequences such as riverbank erosion, biodiversity loss, and water quality degradation; and the existing regulatory framework governing resource extraction. Methodologically, the research employs a mixed-methods approach involving surveys, interviews, and field observations with key stakeholders including local miners, community members, environmental officers, and county government officials. The temporal scope covers recent mining practices and their cumulative impacts, without extending into long-term predictive modeling. This bounded approach enables a focused analysis of current mining dynamics while providing actionable insights for sustainable resource management in Nakuru County.

Resource Dependence Theory (RDT)

Resource Dependence Theory (RDT) was developed by Jeffrey Pfeffer and Gerald R. Salancik in their 1978 book. RDT helps to address gaps left by the preceding theory, particularly concerning the relationship between miners and the available resources, as well as the influence of external factors on organizational behavior. The theory posits that an organization's success depends on its ability to acquire, control, and utilize critical external resources more effectively than its competitors. It emphasizes how organizations manage dependencies and navigate power dynamics in response to external environmental pressures. According to Pfeffer and Salancik (1978), it is founded on the concept that resources are indispensable to the achievement of organisational goals, and that the ability to get access to and exercise control over resources is the foundation of power

within the organisation in question. In accordance with RDT, it is necessary to use vigilant tactics in order to preserve open access to resources.

In the context of this research, the fast urbanisation and other associated infrastructure that is experienced in Nakuru County results in an inadequate quantity of natural resources such as sand and gravel for the building of homes and other infrastructure in order to satisfy the requirements of the growing population. But in order to extract these two resources in a sustainable manner, it is necessary to collaborate with rural communities and form alliances with them. This, in turn, makes it possible for rural people to generate revenue from sand gravel, which can be used to support their lives. When residents in Nakuru County assume responsibility for the management of sand and gravel resources, they will be able to govern and manage these resources in a way that is both sustainable and appropriate. This, in turn, results in the mining and use of sand and gravel in the County carried out in a responsible manner. It further lowers their exploitation and the detrimental entrenched consequences that it has on the ecosystems that are dependent on the water sources that are damaged by the extraction of sand and gravel. One of the most important aspects of these activities is the idea of power, which determines who has control over these essential resources (Ulrich & Barney, 1984). In this research, the power is considered to originate from the community rather than from the large, well-known firms or organisations that have a tendency to have a significant amount of influence over the mining of sand and gravel in Nakuru County.

RESEARCH METHODOLOGY

Research Design

Researchers used a descriptive research strategy for this investigation. The study's goal of gathering participant perspectives on the effects of sand and gravel mining on the Njoro River and its dependent ecosystems in Nakuru County provides the basis for this qualitative categorisation. According to Mayoh and Onwuegbuzie (2015) and Marshall and Rossman (2016), phenomenological research relies on a descriptive research design that allows for the reporting of participants' lived experiences. This approach takes into account their opinions, perceptions, and knowledge in order to get a better understanding of the research topic. The research team achieved this by conducting in-depth interviews with study participants and administering a standardised questionnaire to gauge their level of familiarity with the subject matter. Participants' perspectives, attitudes, and levels of understanding about the phenomena of sand and gravel mining and its effects on the Njoro River and other ecosystems in Nakuru County, Kenya, will be better understood via the use of in-depth interviews (Bailey, 2014). Indicators of the independent variable that could be examined and evaluated using descriptive study design were the following: drivers of sand and gravel mining, local community management measures, and the problems encountered in the pursuit of sustainable sand and gravel mining. Poor water quality, biodiversity destruction, deforestation, and soil erosion were the dependent variables, and the research went on to detail how these indicators affected those indicators.

STUDY LOCATION

This research focused on the mouth of the Njoro River in Nakuru County. One possible location for sand and gravel mining is Lake Nakuru, to which this river flows as a tributary. The mining of sand and gravel in Nakuru County is economically significant for the miners, the surrounding villages, and the large-scale building corporations. Locals benefit from the mining industry's direct and indirect job prospects. Some of the county's rivers are drying up, threatening the extinction of

other ecosystems that rely on them, and some of those ecosystems are already dead. In light of this tragic fact, more community-based actions may be necessary to reduce the indiscriminate extraction of the two resources. This is mainly due to the lack of study on the responsibilities of local authorities and communities in relation to sustainable sand and gravel mining in the region, as well as the fact that the surrounding communities have not made any efforts to promote such mining. In order to meet the building needs of the whole Rift valley area, sand and gravel are mined continuously throughout the year.

Target Population

The goal of the project was to collect reliable data on how sand and gravel mining affected the ecosystems around the Njoro River mouth, Lake Nakuru, and the ecosystems that relied on the river from a diverse and equal sample of people in Nakuru County. Table 1 below shows the many parties that may have legal authority to supervise and safeguard the environment from environmental deterioration, as well as those directly or indirectly engaged in the sand and gravel mining sector.

Table 1: Target Population

Target Group	Target Population	Percentages
Miners	100	30%
Local Community Members	150	45%
Environmental Officers (NEMA)	15	5%
Constructors	50	15%
County Government Officials	15	5%
Total	**330**	**100%**

Source: Nakuru County (2024)

As shown in table 1 above, the study's target population consisted of 330 participants, including miners, residents of the local community, environmental officers (NEMA), builders, and representatives of the Nakuru County administration. The rivers and ecosystems impacted by the sand and gravel mining industry in Nakuru County served as the study's sample unit or unit of analysis.

Sample Size Determination

The study adopted the Yamane formula to calculate the sample size as shown below;

$$n = \frac{N}{1 + Ne^2}$$

Were

N = Target population (330)
e = Margin of error (5 %)
n = Sample Size

After replacing the values, the formula becomes;

$$n = \frac{330}{1 + 330\ (0.05)^2} = 181$$

The study used a sample of 181 respondents.

The sample is distributed as shown in Table 2:

Table 2:Sample Size Distribution

Target group	N	Proportion (Ni/N)*100	n	Sampling Procedure
Miners	100	30	55	Simple Random
Local Community Members	150	45	82	Simple Random
Environmental Officers	15	5	8	Purposive
Constructors	50	15	27	Purposive
County Government Officials	15	5	8	Purposive
Total	**330**	**100**	**181**	

Source: Researcher (2022)

Participants in the research were organised into a wide variety of clusters, which are shown in Table 2. To ensure the credibility of the results of the research and to facilitate their further generalisation, this is done in order to ensure that a substantial and diverse representation of the respondents is obtained. In light of this, the total number of respondents for the whole research is 181, and they are spread out over all of the study clusters. It is believed that this sample size is appropriate since it encompasses significant regions of participants in the field of sand gravel mining. These participants have the potential to provide the necessary data for the research, which were then analysed in order to create the results.

Data Collection Instruments

Questionnaire, interviews, and examination of documents were the three methods of data collecting that were used in the research. Creswell (2007) and Cozby and Bates (2012), who maintain that using more than one instrument helps to avoid various ethical issues in research, particularly bias, because it helps to cross-check the findings for the authenticity of the data that was gathered; it also emphasizes the importance of validity and reliability of the study, were used as a source of inspiration for the selection of these three instruments. This point is reaffirmed by Kumar (2014) and Mugenda and Mugenda (2003), who state that questionnaires and interview schedules are the primary methods of data collecting for qualitative research. This is due to the fact that these methods are designed to compile a variety of perspectives contributed by participants.

FINDINGS

Response Rate

The study aimed to assess the environmental and socio-economic impacts of sand and gravel mining on Njoro River in Nakuru County, Kenya. A sample size of 181 participants was selected to provide insights into the various aspects of sand and gravel mining, including its drivers,

impacts, community collaboration, and sustainable management challenges. During the data collection phase, a total of 172 responses were received. The response rate of this study was significant, reflecting the participants' willingness to engage and share their experiences and perceptions regarding mining activities in the area. Specifically, the response rate in terms of frequency was 172, representing the number of individuals who completed the survey out of the targeted sample size of 181. In terms of percentage, the response rate was approximately 95.03%, calculated by dividing the number of responses (172) by the total sample size (181) and multiplying by 100. This high response rate of 95.03% indicates a robust level of engagement from the community, providing a reliable data set for analyzing the environmental and socio-economic impacts of mining activities on the Njoro River ecosystem. Additionally, this response rate strengthens the credibility of the study findings, as it reflects the views and concerns of a substantial portion of the targeted population.

The drivers of sand and gravel mining

Based on the results of the first goal, which was to investigate the determinants of sand and gravel extraction in Nakuru County, numerous significant elements were found. The research revealed that sand and gravel mining offers job opportunities to local residents, with a mean of 3.9826 and a standard deviation of 1.25411. The mean of 3.8256 and a standard deviation of 1.44847 indicate that the notion of individuals engaging in economic operations inside mining zones to sustain their livelihoods is acknowledged as a significant motivator. Respondents mainly agreed that sand and gravel mining had enhanced the living conditions of local residents in the area, shown by a mean of 4.0349 and a standard deviation of 1.30628.

Mining was further recognised as a source of employment for miners and nearby communities, with a mean of 3.9709 and a standard deviation of 1.32200. The survey revealed a mean of 2.6395 and a standard deviation of 1.55532 regarding the assertion that licenses for sand and gravel mining are issued to anybody in the county, which elicited conflicting answers, reflecting diverse perspectives of the county's regulatory policies.

Moreover, with a mean of 3.9128 and a standard deviation of 1.34576, the research revealed that sand and gravel mining has reduced other criminal activities in the area, since youngsters are engaged in the mining sector. Poverty, with a mean of 3.9419 and a standard deviation of 1.36673, was recognised as a key factor influencing sand and gravel mining in the region. The ease and affordability of mining were emphasised, with a mean of 4.0058 and a standard deviation of 1.27732, suggesting it is seen as an attainable economic endeavour.

Conversely, with a mean of 4.0698 and a standard deviation of 1.25926, the survey determined that mining was seen as the most marketable economic activity. Furthermore, with a mean of 4.1919 and a standard deviation of 1.22515, sand and gravel mining are identified as the most uncontrolled activity in the county, underscoring worries about its insufficient monitoring.

Table 3: The drivers of sand and gravel mining

	N	Min	Max	Mean	Std. Deviation
Sand and gravel mining provide employment to the locals	172	1.00	5.00	3.9826	1.25411
People carry business activities in the mining zones to earn a living	172	1.00	5.00	3.8256	1.44847
Sand and gravel mining has uplifted the standards of living of the local communities in the region	172	1.00	5.00	4.0349	1.30628
Sand and gravel mining is the source of employment to the miners and local communities in the region	172	1.00	5.00	3.9709	1.32200
Permit for sand and gravel mining is given to anybody who wants to do mining activity in the county	172	1.00	5.00	2.6395	1.55532
Sand and gravel mining has lessened other acts of crime in the in the region since the youths are busy in the mining industry	172	1.00	5.00	3.9128	1.34576
Poverty is the greatest driver of sand and gravel mining in the region	172	1.00	5.00	3.9419	1.36673
Is the simplest and less costly economic activity and job	172	1.00	5.00	4.0058	1.27732
Is the most marketable economic activity	172	1.00	5.00	4.0698	1.25926
It is the most less regulated activity in the County	172	1.00	5.00	4.1919	1.22515
Valid N (listwise)	172				

Source: Field Data, (2024)

Guided by the first objective that sought to investigate the key drivers behind sand and gravel mining in Nakuru County, the study performed a qualitative analysis and identified several economic motivations and regulatory gaps that encourage the growth of this industry. The findings highlight that the sand economy is not only a source of self-employment but also serves as a backbone for various sectors, including construction and hospitality. The study revealed a complex interplay of economic incentives and policy gaps that contribute to the ongoing mining activities.

> **County Official 1** emphasized the economic benefits of sand mining: *"The sand economy significantly contributes to self-employment. It supports not just the individuals directly involved in mining but also industries such as building, construction, and hospitality."* This underscores the role of mining as a critical livelihood strategy in Nakuru County, suggesting that the drive for economic survival is a key motivator for locals engaging in mining activities.

> Regarding the regulatory environment, **County Official 2** highlighted the absence of rules governing mining activities: *"Anyone can engage in sand mining since there is no regulation currently in place to control it."* This lack of oversight suggests that the

ease of entry into mining, due to the absence of restrictive policies, serves as a major driver. The official further added, *"Proper regulation of the mining activities is needed, but for now, the lack of policies makes it a free-for-all industry."* This finding implies that the sector's growth is propelled by the unregulated environment, where individuals can easily exploit natural resources for economic gain.

Additionally, **County Official 4** pointed out the role of machinery in facilitating mining activities: *"The use of heavy machinery makes the extraction process easier and faster, which is why it is so common. However, there should be stricter regulations on the type of equipment allowed to prevent environmental damage."* This concern reveals that sand mining is not only driven by economic incentives but is also accelerated by the availability of machinery that enables more extensive extraction.

The findings indicate that the perceived economic benefits of the sand economy, combined with weak regulatory frameworks, drive individuals and businesses to engage in mining activities. This situation creates an environment where mining is seen as an accessible economic activity with minimal barriers to entry.

CONCLUSION OF THE STUDY

The study concludes that the main drivers of sand and gravel mining in Nakuru County include the need for employment, business opportunities, and improved living standards. The mining activities are perceived as marketable and accessible, largely due to the lack of regulation and oversight. However, the mixed responses on permit regulations indicate an environment where the enforcement of policies may be inconsistent. Therefore, the mining industry in Nakuru County is primarily driven by socio-economic factors, which have implications for both community development and environmental sustainability.

STUDY RECOMMENDATIONS

The study recommends that county governments, in collaboration with national agencies such as the National Environment Management Authority (NEMA), formulate comprehensive policies and legal frameworks specifically addressing sand and gravel mining. These policies should include clear guidelines for sustainable mining practices, permit allocation, and environmental impact assessments. Additionally, the study suggests implementing strict enforcement mechanisms to ensure compliance with these regulations.

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