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Environmental and Socio-economic Impacts of Sand Mining in Selected Coastal Communities along the Western Rural-Freetown Peninsular in Sierra Leone

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Abstract This study examines the environmental and socio-economic impacts of sand mining in three selected coastal communities (Hamilton, John Obey and Laka) along the Western Area Rural-Freetown peninsula in Sierra Leone. Coastal sand mining poses significant environmental and social problems. It damages ecosystems, increases coastal erosion and vulnerability to storms, threatens biodiversity, and can lead to social issues like corruption and violence. The study employed a quantitative cross-sectional perception survey-based research design. A simple random sampling technique was used to representatively select 666 community respondents including heads of households, community leaders, sand miners, sellers, and transporters. A combination of Statistical Package for the Social Science (SPSS) and Excel Software Package were employed. A multinomial logistic regression (MNL) model was used to analyse the data. Findings reveal that the determinants of respondents' perceived knowledge on the negative impacts of sand mining were mainly demographic attributes including age ($p<0.001$), marital status ($p<0.001$), family size ($p<0.001$), and monthly household income ($p<0.001$). The findings further revealed that accident ($p<0.001$), community conflicts ($p<0.001$), drug abuse ($p<0.001$), and knowledge of negative effects of sand mining ($p<0.001$), exhibited a negative significant impact of sand mining. The determinants of respondents' perceived knowledge on the positive impacts of sand mining indicated that occupation has a positive and significant impact on sand mining. The benefits of utilizing sand in the communities ($p<0.001$) and benefits of sand mining ($p<0.001$) had a negative significant impact on sand mining. It is recommended that increased awareness on the negative impacts of coastal sand mining coupled with the implementation of environmental policies could help to mitigate some of the negative environmental impacts.

Keywords: *coastal, sand mining, negative impacts, positive impacts, Freetown*

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1. Introduction

Sand mining, which is the process of removing sand and gravel, is becoming a problem for the environment as a result of the growing need for sand in building and industry. Sand mining or 'sand dredging' is a growing industry that has long supported industrialization, housing, general construction, and urbanization worldwide [1,2,3,4,5] Sand mining, among other natural aggregates represent the main source of construction aggregates used throughout the world [6,7,8,9]. Sand is mostly obtained from coastal settings, including dunes, beaches, and bluff areas, as well as riverine ecosystems, which are the primary suppliers of sand for many coastal locations. The rapid increase in urbanization and development of large-scale infrastructure projects are driving increasing demands for construction materials globally. United Nations Environment Program UNEP [6] estimated that between 32 and 50 billion tonnes of sand and gravel are extracted globally each year with demand increasing, especially in developing countries [10]. Sand is regarded as a "provisioning ecosystem service" resource. According to Massellink and Gehrels [11], the coastal system is the area of the Earth's surface that is directly impacted by natural phenomena such as winds, tides, waves, and currents. A highly specialized collection of habitats can be found along coasts, which mark the spatial transition between continental and marine environments [12]. The evolution of these systems is due to the current interplay between flora, water, sand, and other external forces [13]. Among the planet's most dynamic landscapes are the coasts, which may be found in all latitudes. Coasts are among the most dynamic environments on Earth, found at all latitudes and resulting from the integration of several important ecosystems, such as beaches, dunes, and cliffs. These geomorphic regions have historically been analyzed as discrete and unique settings, but they are actually integrated systems that require management [14]. Due to its strategic location between the sea and the land, the coast is considered an environmental hotspot that offers a variety of environmental services, including regulation (e.g., sediment storage, environmental quality, [15], provision (e.g., bioindicators of pollutants), [16], ecological support [17], and cultural services (e.g., recreational opportunities, spiritual enhancement), [18].

However, the process of sand mining activities, whether small or large scale, are inherently destructive to the natural environment chiefly because sand is considered and being grouped into nonrenewable resource [19]. Sand mining is considered destructive due to its increased impact on coastal erosion and the introduction of artificial structures that impede the movement of sand in the ocean, loss of aquatic biodiversity, alteration of coastal shorelines, and a source of ecological destabilization [5,20,21] [22,23,24]. Mined ecosystems recover very slowly, if at all, because current extraction rates surpass natural sand replenishment rates [25,26]. Coastal habitats are negatively impacted and altered by the mining process, whether it is occurring immediately at the coast or in upstream river sources. Ecosystems and water quality at mining sites and nearby areas are directly impacted by coastal sand mining. These effects frequently have detrimental effects for benthic plants and animals [27,28]. The loss of fisheries and the extinction and destruction of aquatic life are two effects on biological resources that pose issues for people whose livelihoods depend on fishing. In addition to decreasing the variety of species that can be found in these aquatic environments, this process can lead to erosion, contaminate water sources, and damage coastal vegetation [29]. Sand mining will always have disastrous and, for the most part, irreversible impacts in the absence of legislation, oversight, and regulation.

In Sierra Leone, the details of the environmental, social and economic geologic importance of the extraction of sand are completely unclear. The appropriate assessment of environmental and socio-economic impacts is often a hard task because the impacts appear after a long period of time. The primary challenge is the need to implement a comprehensive strategy in the planning and management of these resources. The illegal extraction in most coastal areas also aggravates the situation. Therefore, the aim of this study is to assess the environmental and socio-economic impacts of sand mining on selected coastal communities along the Western Rural Peninsular Freetown, Sierra Leone.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in three selected communities (Hamilton, John Obey and Laka), situated along the Freetown peninsula, Western Area Rural District where sand mining is highly undertaken (Figure 1). The communities fell within the Western Area Rural District which is one of the fourteen districts in Sierra Leone. The Western Area Rural District has a population of 442,951 [30]. Hamilton is located in the Western Area of Sierra Leone. It is known for its diverse community and historical significance with coordinates 08° 22′ 59.98″ N and 13° 13′ 00.01″ W. With a mix of urban and rural areas, Hamilton offers a unique blend of culture, tradition, and modernity. The community is home to various landmarks, schools, businesses, and residential areas, making it a bustling hub of activities like fishing and sand mining in the region. John Obey is a town in Sierra Leone known for its beautiful beaches and vibrant community, located along the Atlantic Ocean (8°14′43.8″N 13°09′51″W). John Obey offers stunning views and is a popular destination for both locals and tourists looking to relax by the sea. Laka beach is known for its pristine beauty and tranquil surroundings (8°20′N 13°04′W**).** Located along the Atlantic Ocean, Laka Beach offers soft golden sands, clear blue waters, and stunning panoramic views. The beach is known for a range of activities such as sunbathing, swimming, beachcombing, and taking leisurely walks along the shore.

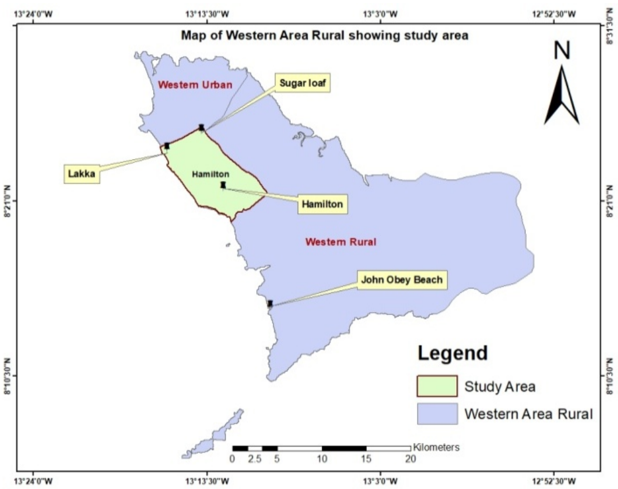

Figure 1. Map of three selected sites along the western rural peninsular, Freetown, Sierra Leone

2.2. Research Design and Data Collection

The study was a perceptive cross-sectional survey based research which employed quantitative analytical frameworks. The field work for primary data collection was conducted between February and – April 2022. The study used primary data drawn from a field survey of the selected coastal communities and sand miners using a structured questionnaire with appropriate design. The structured questionnaire contained three sections. Section A consisted of the demographic characteristics of the respondents, Section B comprised the drivers of sand mining and the socio-economic impacts of sand mining, Section C consisted of questions on the environmental impacts of sand mining and Section D consisted of the respondents' perception on the effects, impacts, benefits and mitigation measures of negative effects of sand mining in the Freetown.

2.3. Sampling Techniques and Sample Size Determination

This study firstly employed purposive sampling to select those respondents and locations identified to be directly associated with sand mining and most suitably meet the criteria for the purpose of this study and hence contacted as primary data sources for the needed information. The respondents included sand miners, sand miner's household heads, and other key stakeholder groups (chiefs, members of community development committees, sand sellers, and sand transporters). The study purposively identified the three communities (Hamilton community, John Obey and Lakka) in the Western Area Rural with predominant coastal sand mining. A simple random sampling was employed to select from each of the respondent groups, identified as elementary sampling units for data collection.

The number of respondents was proportional and dependent on the size (land/coverage area) of sand mining communities targeted in this study. Thus, for a representative sample of respondents from the sand mining communities, the study grouped the three communities into two, the larger community, Hamilton as one and the other two relatively smaller communities (John Obey and Lakka) as another. The study used standard statistical sample size formula developed by de Vaus [31] in agreement with Saunders et al. [32], which is mostly used in social research surveys, to determine the representative minimum sample size. The formula is used with relevant information from various reliable sources at the 95% confidence level (CL) and 5% margin of error. The statistical formula is as shown below:

$$\mathbf{n = p \times q \{Z/(e)\}^2}$$

Were,

n = Minimum sample size required,

p = Proportion belonging to the specified category

q = Proportion not belonging to the specified category (1- p)

Z = The Z-value corresponding to the level of confidence required (1.96 at 95% CL)

e = Margin of error required

Generally, sand mining in Sierra Leone at community level, especially in the rural areas is largely driven by poverty to generate livelihoods for inhabitants. So, information used for the proportion of people in poverty or not has been sourced from the Statistics Sierra Leone population and Housing Census report of 2015. The report reveals a national estimate of 68.3% of poverty level in the country. This was considered as the proportion belonging to the specified category, because the study communities though based in rural areas, but are almost infused into the country's capital of Freetown and Western Area Urban. Using the above information, a minimum sample size of 333 was determined for Hamilton and same for the other two communities grouped together as one location, making a total of 666 respondents. However, there was an actual 98% response rate (650 respondents). The distribution is presented in Table 1.

Table 1. Target population and sample population of the study participants

Location	Category	Sample
Hamilton community	Sand miners	(173)
	Households	(100)
	Stakeholders	(60)
John Obey and Lakka	Sand miners	(160)
	Households	(97)
	Stakeholders	(76)
Total		666

2.4. Analysis of Socio-environmental Data

The Statistical Package for the Social Science (SPSS) and Excel Software Package were used to analyze and assess the significance of residents' perception of the impacts of sand mining in the district. They were also used to determine homogeneity of respondents from different sand mining communities and to assess the significance of the impacts of sand mining on peoples' livelihoods. The negative and positive impacts of sand mining were explored using the multinomial logistic regression (MNL) model. The MNL model was specified as follows:

Letting P j (j = 1,2,3) be the probabilities of a respondents being in each negative or positive impact and assuming that j = 1 is the reference category, the multinomial logit model showing the relative probabilities of being in the three participation categories as a linear function of X ki for the i th household, according to Greene [33], is estimated as:

$$\mathbf{\ln \log (P_j/P_1) = \log (P_j/P_1) = \beta_{0j} + \beta_{1j} X_{1i} + \ldots + \beta_{kj} X_{ki} + u_{ji}}$$

For j = 2, 3 and i = 1, 2...n respondents

where: ln = the natural logarithm (or log e),

P 1 = the probability of the respondents being in the reference category (negative/positive impacts);

β kj are the MNL coefficients to be estimated and,

X ki is the k th explanatory variable explaining the i th respondents.

3. Results and Discussion

3.1. Demographic Attributes of Respondent in the Study Area

The findings showed that majority of the respondents involved in sand mining in the sampled area were male (90.9%), while 9.1% of the respondents were female. Most (52.2%) of the miners had experience of 6-10 years in sand mining. For the age category, majority of the respondents (54.8%) were in the ages of 19-35 years, while 1.8% and 2.0% of the total sampled population were the lowest obtained for the ages of ≤18 years and ≥ 60 years, respectively (Table 2). The presence of different age groups that are involved in the sand mining activity with youths being the majority among the workers particularly as sand loaders are excessive dependent on the socio-economic conditions of local communities. Similarly, sand mining has been recorded to provide employment for youth as drivers and loaders and it also serves as a source of income to individuals who mine and sell sand [34]. Most of the respondents (47.7 %) did not go through any formal education while 1.1% of the respondents went through Technical/vocational education. Majority of the respondents (46.9%) were engaged in sand mining as their main occupation, while 2.9 % of the respondents were engaged in Agriculture. Sand mining activities in these areas was believed to have been driven by urbanization forces. Research has shown that population growth is one of the elements that promote sand mining because as the population expands, so does the demand for jobs, which promotes increased dependence on the exploitation of natural resources [35, 36]. According to Dacosta & Mathada [37], the majority of respondents to a survey done in the Limpopo Province's Nzhelelele River believed that sand mining provided an economic benefit.

3.2. Perceived Knowledge on the Effects, Impacts, Benefits and Mitigation Measures of the Negative Effects of Sand Mining

Majority (57.4%) of the respondents in the study areas were aware of the effects of sand mining, while 42.6% of them had no knowledge of the effects of sand mining (Table 3). This is consistent with the research conducted in Vietnam which reported that most of the respondents were aware of the effects of sand mining [38]. Majority (71.5%) of the positive impacts of sand mining, of which, 30.6%, 22.2%, 18.8% of them enumerated its usefulness as raw materials, provision of employment, and income generation, respectively, while the remaining opined that they have no idea (Table 3). Research that supported sand mining and demonstrated its economic advantages revealed that the majority of respondents believed that sand mining produced jobs and provided local communities with a higher revenue [38,39,40]. Among the respondents, 50% felt that sand mining was bad while the remaining 50% considered it beneficial as they perceived themselves capable of dealing with the environmental problems associated with sand mining. Research have revealed that people viewed environmental issues as a serious issue that took precedence above higher incomes where illicit sand mining caused erosion and landslides, making the impacted areas unusable [36].

The perception of majority (56.5%) of the respondents opined that they lack knowledge of the negative impacts of sand mining. However, some of the negative impacts highlighted by the remaining respondents included species loss and flooding (5.1%), flooding and loss of mangrove vegetation (8.8%), loss of vegetation (3.2%), traffic congestion (2.9%), increase water pollution (19.8%), and accident (3.7%). These findings corroborate the view that illiteracy, lack of infrastructure and socio-economic factors contribute to the lack of knowledge among relevant stakeholders [41,42,43]. The equilibrium between humans and the natural resources is no longer reached through the actions heading towards modernization. There is increased deforestation due to the growing population and this affects sand mining activity. The increasing deforestation aimed at developing infrastructure, livelihood change, land degradation, flooding, erosion, threat to buildings and water pollution are some of the impacts of sand mining in the studied communities. The current findings agree with the view that illegal and indiscriminate sand mining cause changes in river channel, land degradation, flooding, erosion, threat to buildings and water pollution [44,45,46]. These changes affect agriculture that also contributes to climate change through deforestation during land preparation, resulting in climate change [47,48,49,50]. The mitigation measures to combat negative impacts of sand mining based on the indigenous knowledge of respondents included avoidance of sand mining (33.4%), followed by long period closure (27.7%), education (15.8%), skills enhancement (14.9%), and effective monitoring (8.2%). Majority (57.4%) of the respondents opined that their communities do not benefit from sand mining. However, the benefits of sand utilization, based on the indigenous knowledge of respondents, included (57.4%), filling roads (12.3%), construction of buildings (11.2%), and community development (19.1%) (Table 3).

Table 2. Demographic Attribute of Respondents in the study area

Variable description	Category	Frequency	Percentage	Cumulative (%)
Age	18 years and below	12	1.8	1.8
	Between 19-35 years	356	54.8	56.6
	36-59 years	269	41.4	98.0
	60 years and above	13	2.0	100.0
Gender	Male	591	90.9	100.0
	Female	59	9.1	9.1
Marital status	Married	439	67.5	67.50
	Single	211	32.5	100.00
Religion	Islam	482	74.2	74.2
	Christianity	168	25.8	100.0
Education	No-formal	310	47.7	47.7
	Primary	295	45.4	93.1
	Secondary	38	5.8	98.9
	Technical/vocational	7	1.1	100.0
Family size	1-5 dependents	445	68.5	68.5
	6-10 dependents	153	23.5	92.0
	11 dependents and above	42	6.5	98.5

Variable description	Category	Frequency	Percentage	Cumulative (%)
	None	10	1.5	100.0
Experience	Less than 5 years	299	46	46.0
	6-10 years	339	52.2	98.2
	11 year and above	12	1.8	100.0
Occupation	Trading	106	16.3	16.3
	Fishing	181	27.8	44.2
	Sand mining	305	46.9	83.2
	Civil servant	39	6.0	97.1
	Agriculture	19	2.9	100.0
Alternative livelihood	Charcoal burning	480	73.8	73.8
	Trading	133	20.5	94.3
	Stone mining	37	5.7	100.0
Monthly household income	Below Le 500	57	8.8	8.8
	Le 600-1000	134	20.6	29.4
	Le 1100-1500	88	13.5	42.9
	Le 1600 and above	371	57.1	100.0

Table 3. Respondents' perception on the effects, impacts, benefits and mitigation measures of negative effects of sand mining

Variable description	Category	Frequency	Percentage	Cumulative (%)
Effects of sand mining	Yes	373	57.4	57.4
	No	277	42.6	100.0
Positive impacts	I don't know	185	28.5	28.5
	Employment	144	22.2	50.6
	Income generation	122	18.8	69.4
	Raw materials	199	30.6	100.0
Negative impacts	I don't know	367	56.5	56.5
	Species loss and flooding	33	5.1	61.5
	Flooding and loss of vegetation	57	8.8	70.3
	Loss of vegetation	21	3.2	73.5
	Traffic congestion	19	2.9	76.5
	Increase pollution	129	19.8	96.3
	Accident	24	3.7	100.0
Mitigation measures	Skills enhancement	97	14.9	14.9
	Education	103	15.8	30.8
	Long period closure	180	27.7	58.5
	Avoid sand mining	217	33.4	91.8
	Effective monitoring	53	8.2	100.0
Community benefits	Yes	277	42.6	42.6
	No	373	57.4	100.0
Benefits of sand	Raw materials	373	57.4	57.4
	Filling roads	80	12.3	69.7
	Building purposes	73	11.2	80.9
	Community development	124	19.1	100.0

3.3. Determinants of Respondents' Perceived Knowledge on the Negative Impacts of Sand Mining

Multinomial logistic regression analysis was estimated to respondents' perceived knowledge on the negative impacts of sand mining in the studied communities (Table 4). The results indicate that demographic attributes such as age ($p<0.001$), marital status ($p<0.001$), family size ($p<0.001$), and monthly household income ($p<0.001$) show a negative significant impact on sand mining (Table 4). The findings further reveal that accident ($p<0.001$), community conflicts ($p<0.001$), drug abuse ($p<0.001$), and knowledge of the negative effects of sand mining ($p<0.001$), exhibited a negative significant impact on sand mining. Environmental protection agency officers are most likely to influence the decision of sand miners to use other type of adaptation strategy to cope with the adverse impacts of climate change on their sand mining activities. Socioeconomic factors have been identified as the primary drivers of coastal sand mining, including low environmental awareness among communities, immense profit margins, easy access to the coast, and inadequate employment [51,52,53]. Whatever the motivations behind sand mining, it is obvious that the failure of environmental rules being enforced by legally mandated authorities like the Environmental Protection Agency (EPA) is mostly to blame for the practice's current pervasive nature. Thus, raising public awareness and regulating resource extraction are imperative in order to support the stakeholders in developing policy to control sand mining activities along the coast. The study findings also highlight that gender ($p<0.001$), educational background ($p<0.001$), experience ($p<0.026$), and prostitution ($p<0.033$) have a positive significant impact on sand mining. Hence, John Obey community has a negative significant (p<0.001) impact on sand mining (Table 4). This implies that being from a certain area (community) where sand mining occurs influences the negative impacts on sand mining.

Table 4. Multinomial logistic regression estimates for negative impacts of sand mining

Parameter	Coefficient	SE	t(621)	t pr.	P>z
Constant	-0.751***	0.0577	-13.01	<.001	0.472
Age	-0.008	0.006	-1.19	0.233	0.992
Gender	0.070***	0.013	5.53	<.001	1.072
Marital status	-0.044***	0.006	-7.28	<.001	0.957
Religion	0.002	0.006	0.41	0.681	1.002
Educational background	0.022***	0.005	4.81	<.001	1.022
Family size	-0.025***	0.005	-4.78	<.001	0.976
Experience	0.019*	0.008	2.23	0.026	1.019
Occupation	0.006	0.003	1.58	0.115	1.006
Alternative livelihood	0.003	0.005	0.54	0.591	1.003
Monthly household income	-0.008*	0.003	-2.46	0.014	0.992
Positive and negative effects	0.046	0.026	1.76	0.079	1.047
Negative effects of sand mining	-1.024***	0.011	-90.93	<.001	0.359
Accident	-0.037***	0.005	-7.41	<.001	0.964
Community conflicts	-0.047***	0.003	-15.71	<.001	0.954
Prostitution	0.007*	0.003	2.13	0.033	1.007
School drop outs	0.006	0.005	1.26	0.208	1.006
Drug abuse	-0.027***	0.005	-5.37	<.001	0.973
Insecurity	-0.004	0.005	-0.74	0.458	0.996
Flooding	-0.026	0.023	-1.15	0.252	0.974
Road traffic	0.017	0.011	1.63	0.103	1.017
Locations John Obey	-0.313***	0.029	-10.99	<.001	0.732
Locations Lakka	-0.188***	0.019	-9.96	<.001	0.828

*** = values statistically significant at 0.01 probability level, ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level Base category: Hamilton, Number of observations: 650.

3.4. Determinants of Respondents' Perceived Knowledge on Positive Impacts of Sand Mining

Occupation has a positive and significant impact on sand mining (Table 5). Thus, John Obey or Laka communities have no significant impact on the positive impacts of sand mining. This implies that being from a certain area (community) where sand mining occurs does not determine the positive impacts of sand mining. Benefits of utilizing sand in the community (p<0.001) and benefits of sand mining (p<0.001) have a negative significant impact on sand mining. Findings indicate that the present meagre benefits from sand mining such as area development, better life from sand harvesting, royalties, taxes and development are insufficient compared to the increasing negative impacts sand mining imposes on the environment such as flooding, insecurity, conflicts. Research has identified coastal sand mining to have several negative social and environmental impacts including coastal erosion, deforestation, livelihood change, land degradation, flooding, threat to buildings and water pollution on the built environment in the coastal areas [51,52,54,55]. The removal of vegetation and destruction of the soil profile during sand mining contribute to habitat destruction and faunal population decrease [35].

Table 5. Multinomial logistic regression estimates for Positive impacts or benefits of Sand Mining.

Parameter	Coefficient	SE	t(621)	t pr.	P>z
Constant	25.9900***	4.49	5.79	<.001	*
Age	0.0291	0.04	0.68	0.495	1.03
Gender	-1.3900	1.25	-1.12	0.264	0.25
Marital status	0.0334	0.06	0.60	0.549	1.03
Religion	0.0003	0.02	0.01	0.988	1.00
Educational background	0.0655	0.06	1.18	0.237	1.07
Family size	0.0084	0.03	0.27	0.787	1.01
Experience	0.0569	0.06	0.95	0.342	1.06
Occupation	0.0613**	0.02	2.60	0.010	1.06
Alternative livelihood	-0.0427	0.04	-1.15	0.253	0.96
Monthly household income	0.0047	0.01	0.40	0.690	1.01
Economic implications of closure of sand mining	-0.6400	1.95	-0.33	0.745	0.53
Perceived solutions	-0.0156	0.02	-0.82	0.413	0.98
Positive and negative effects	-2.1600	1.06	-2.04	0.042	0.12
Community benefits	-19.5800***	1.33	-14.77	<.001	0.00
Benefits of sand mining	-1.7830***	0.05	-37.20	<.001	0.17
Participatory sand mining	-2.4700	2.06	-1.20	0.231	0.08
Area development	0.0206	0.07	0.31	0.754	1.02
Better life from sand harvesting	9.3300	8.04	1.16	0.246	11295.0
Royalties, taxes and development	0.0006	0.02	0.02	0.982	1.00
Location John Obey	2.6600	2.06	1.29	0.198	14.33
Location Lakka	13.4400	7.86	1.71	0.088	685288.0

*** = values statistically significant at 0.01 probability level; ** = values statistically significant at 0.05 probability level; * = values statistically significant at 0.10 probability level; SE=standard error; Base category: Hamilton, Number of observations: 650.

4. Conclusion

The authors conclude that majority of the respondents in the study areas were aware about the economic advantage or the positive impacts of sand mining to be used as raw materials, provision of employment, and income generation. Most sand miners in the peninsula of western rural District lack knowledge on the negative impacts of sand mining. However, flooding, loss of mangrove vegetation, traffic congestion, and water pollution were identified as the major negative impacts of coastal sand mining. Mangrove plants and beaches, which are made to withstand tidal waves, are destroyed by humans' excessive mining of coastal sand. Without due consideration of the precious gift of nature, commercial exploitation for short term gains by pumping out the sand indiscriminately from the rivers, dunes and beaches will destroy the environment. It is recommended that increased awareness on the negative impacts of coastal sand mining coupled with the implementation of environmental policies could help to mitigate some of the negative environmental impacts. Future studies should focus on this, particularly identifying factors that influence the increased awareness of respondents on the negative consequences of sand mining and the extent of these consequences.

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