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Environmental and socio-economic impacts of mining on local livelihood in Sierra Leone: The case of sierra diamond limited in Tongo field

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Abstract

Despite its contributions to the country's development, the mining sector in Sierra Leone has been attributed to a multitude of impacts. This study aims to explore the environmental and socio-economic impacts of mining on local livelihood. Three independent variables are used i.e. environmental, economic and socio-cultural impacts of mining. A total of 300 respondents from three communities at the Tongo field mining area are used in this current study. Moreover, confirmatory factor analysis (CFA) using AMOS version 24 was mainly used to analyze the data. The results from the structural equation model (SEM) indicate that economic benefit and socio-cultural benefits of mining activities have significantly influence the local livelihood of community members around the mining area. However, the environmental impacts of mining activities are consequential for the local livelihood of the community. Hence, the study recommends some policies to help mitigate the environmental damage.

Keywords: Environmental impact, economic impact, socio-cultural impact, local livelihood

1. Introduction

Despite being the backbone of many economies in developing countries, mining operations, no matter the scale, are disruptive to the environment (Measham *et al*., 2013; Oviir & Utouh, 2010) [13, 12]. It contributes to indiscriminate vegetation loss, degradation of farmland (Boadi *et al*., 2016) [2], and river sedimentation (Bansah *et al*., 2018) [1]. The destruction of the environment caused by mining operations is mainly as a result of inappropriate mining practices. With an expansion in mineral production regionally and globally, sustainable mineral resource production becomes a significant challenge, and hence there is an increasing need for sustainable environmental management (Jain, & Jamali, 2016) [9]. The environmental dangers posed by mining and its related health and safety repercussions for staff and surrounding communities are related to lack of awareness, financial limitations, inadequate technology, and ineffective environmental law (Hilson, Hilson & Pardie,2007; Hentschel, 2001) [8, 7]. Sustainable mineral production is essential for the protection of natural resources and in many countries around the world (Dubi ´nski, 2013) [3].

Sierra Leone is one of the countries richly endowed with abundant natural resources in the world. Such resources include diamonds, gold, rutile, bauxite, platinum, iron ore, fish, etc. The country was in 2010, the world’s 10th largest producer of diamonds (2010 Minerals Yearbook Sierra Leone) while earlier on, in 2007, the country was the 7th largest producer of diamonds in the world. Although best-known for diamonds, Sierra Leone is also the world’s third largest producer of rutile. Furthermore, according to Africa Minerals Limited (AML), the country, the Tonkolili project to be specific, was confirmed to have one of the largest iron ore deposits in the world. In addition to this, Sierra Leone’s coastal waters are known to have the largest numbers of fish as well as the largest species of fish in West Africa.

Mining and quarrying provide a livelihood for more than 82,000 people and directly or indirectly employ about 3 percent of the total labor force in Sierra Leone (Statistics Sierra Leone, 2016) [15]. Mineral exports, mainly iron ore, diamonds, bauxite, rutile, and gold contributed 2.7% to the national Gross Domestic Product (GDP) and accounted for 91.1% of exports in 2016 (SLEITI, 2016). The most prominent among the mining companies in Sierra Leone are Octea Mining Company, Kono. Kono district-primarily mining diamond, Sierra Rutile Limited, Rutile, Bonthe district–mining rutile and SL Mining Company, Lunsar, Port Loko district–mining iron ore. The economy remained largely dependent on large-scale mining of rutile (Titanium oxide), diamond, and bauxite. Rutile and bauxite are mined predominantly by large mining firms, while the alluvial nature of the diamond and gold deposits suggest that they are open to both artisanal miners and larger mechanized companies.

Although the exploitation of mineral resources is now considered to be one of the chief causes of pollution and environmental degradation in Sierra Leone, there is growing realization that mining activities can be undertaken in a fashion whereby economic

Contributions are maximized, social conditions are improved, and damages to the environment are minimized. The majority of the country's mining ventures are involved in the extraction of iron ore and other minerals from these mining companies in the regions. Notwithstanding the widespread documentation of increased mineral production within these regions, minimal analysis has been undertaken to determine the impacts associated with the expansion of activities. The findings of this work would therefore complement those by other researchers and government in the formulation of policy with regards natural resources and local livelihood.

2. Research Hypothesis

Impact on Livelihood

Livelihood itself is a broader concept to study. Therefore, in the present research, the sustainable livelihood (SL) framework of DFID was adopted to define and analyze the diverse impacts of mining on rural livelihoods. While, employing the SL framework, the present research started unfolding the vulnerable context of livelihood i.e. mining.

In spite of lots of social cost, mining has brought an economic gain for the villagers. Its introduction has brought positive impact on financial capital. During pre-mining period the households' average annual income was low, but it has gone up for working communities nowadays (Pearce *et al*., 2019). Prior to the introduction of mining projects the entire occupational scenario of the affected villages was agro-based. The forest resources were also another major source of income for them. However, with the introduction of mining agriculture, which was a major source of livelihood, is mostly replaced by non-farm activities. The loss of biodiversity due to pollution and mining activities has disturbed the livelihood pattern of mining affected villagers. Even the source of incomes has become more or less mining centric in the post mining period. While the diversified source of income has lost its importance in post mining period, the assured source of income from mining sector has increased the purchasing and investing capacity of the villagers. There are various forms of business nurtures in the mining villages. While some have rented out their tractors and vans, some run hotels, pan shops, grocery shops and cycle repair shops, and some are engaged in the vegetable business. Some households in the mining villages have indulged in income-generating activities such as drivers, helpers in tractors, tailors, blacksmiths, barbers, contractors, etc. In lieu of the above, we propose the following hypotheses:

H_1: Economic impact of mining has significant positive effect on the local livelihood

H_2: Socio-cultural impact of mining has significant positive effect on the local livelihood

Despite its contributions to the development of the country, mining has witnessed potential negative impact on natural. Because of mining, the natural environment is degrading day by day. Emission of coal dust and waste particles during transportation, loading, unloading, blasting, etc. is making life impossible. Even the usual temperature tends to increase. Water bodies such as ponds, tube-wells and open wells are getting polluted very frequently. The continuous release of waste water into the nearby rivers is not only responsible for the pollution of water bodies; rather it is the central reason behind the prevalence of varieties of water and air borne diseases. Likewise, the natural vegetation is decaying frequently. The households who had their primary income from the natural resources like fishing, and haunting have lost their livelihood. Even the loss of grazing land is compelling them not to possess any livestock.

H_3: Environmental impact of mining has significant negative effect on the local livelihood

3. Materials and Methods

3.1 Study Area

Tongo, also known as Tongoma, is a diamond mining town and the second largest city in Kenema District, (after the city of Kenema) located in the Eastern Province of Sierra Leone. Tongo is about twenty seven miles to Kenema. The population of the 60-sq.-mile city is 44,376 (2009). The town is the seat of the Tongo Diamond Field, one of the largest diamond-producing areas in Sierra Leone. The city of Tongoma is ethnically and religiously diverse. The city is home to a significant number of most of the country's ethnic groups and attracts people from all parts of Sierra Leone, due to the rich diamond mining in the area. The Tongo Mine Development combines kimberlite dyke-hosted diamond resources on two adjacent mining licences that cover over 134 km2 and host 11 identified diamondiferous kimberlites. It is subject to a Tribute Mining Agreement between the two mining licence holders, these being Newfield's subsidiary company, Sierra Diamonds Limited, and Octéa Mining's subsidiary company, Tonguma Limited. Consequently, the Sierra Diamonds Limited operating in Tongo field (area highlighted red in figure 1) has been the central focus of this study.

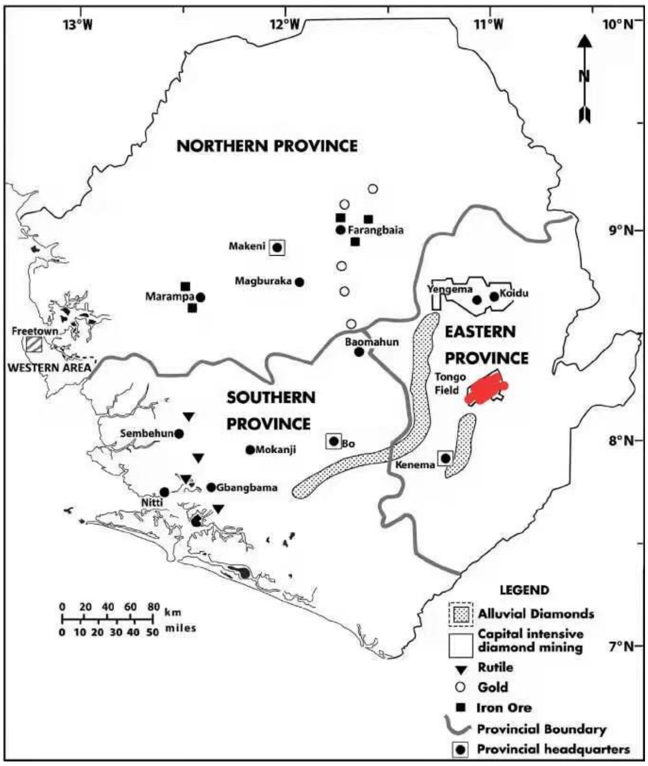

Fig 1: Map of Study Area

3.2 Data Collection and Analysis

Data for this research were collected through household questionnaire survey. The researcher administered structured questionnaires to 300 respondents selected from households in three communities around the mining area using a systematic random sampling technique. Only one respondent was picked in each household to represent the entire household members.

Local participants approved the research team, and permission was given by the community authorities to conduct the research in the three communities. Before administering the household questionnaire, three field assistants were recruited and trained on the study objectives and the administration of the questionnaire. On completion of the training, the questionnaire was pre-tested on 10% (30 out of 300) of the respondents in the 3 three selected communities around the mining area. This helped us to verify the validity and reliability of the data as it was collected. Results from the pre-test were used to review and update the questions. The questionnaire consisted of items that were measured on a five-point scale (1= strongly disagree, 5=strongly agree). Aspects covered in the questionnaires were socioeconomic characteristics of the respondents, Economic, Environmental and Socio-cultural effects of diamond mining on local livelihood. All the items in the constructs were sourced from the literatures. Economic impact was measured with four items, environmental impact was measured with five items socio-cultural impact was measured with four items and local livelihood was measured with five items.The questionnaires were administered via face-to face by the research assistants and posting the answers that are thereafter imported into the SPSS and AMOS software for accurate analysis of the data.

3.3 Data Analysis

In this paper, the data gathered was analyzed using the structural equation modeling (SEM) technique. SEM is a powerful statistical technique that consists of two main parts of analysis, namely measurement model and structural model (Hair *et al.*, 2010; Kline, 2011; Zainudin, 2012). The confirmatory factor analysis (CFA) measurement model demonstrates the relationships between response items (observed variables) and their underlying latent constructs (variables). On the other hand, the structural model demonstrates the correlational and causal dependencies between the environmental and socio-cultural effects of mining and local livelihood improvement.

4. Results and Discussion

4.1 CFA Measurement of the Research Model

The assessment of Confirmatory Factor Analysis (CFA) measurement model was performed simultaneously using the pooled measurement model method (Zainudin, 2012). This method determines the unidimensionality, validity and reliability of investigated latent variables in a single model. Table 1 reports the results of unidimensionality, validity and reliability of the constructs.

Table 1: Validity and reliability results

Latent Constructs	Cronbach Alpha	Construct Reliability (CR)	AVE
Economic Impact	0.874	0.935	0.846
Environmental Impact	0.815	0.951	0.832
socio-cultural Impact	0.882	0.966	0.795
Local Livelihood	0.913	0.983	0.884

The unidimensionality is achieved through the items deletion process for low factor loadings. In this paper, the established scales were used to operationalize all latent construct. All latent constructs had achieved undimensionality with factor loading for an item is greater than 0.60. In this paper, two types of validity were tested, namely convergent validity and construct validity. The convergent validity was assessed through Average Variance Extracted (AVE). The value of AVE should be 0.50 or higher to achieve convergent validity (Fornell & Larcker, 1981). The results indicate that the values of AVE for each construct was higher than 0.50. Therefore, all investigated constructs had achieved the convergent validity. This indicates that all items that measure a particular construct have a high percentage of shared common variance. On the other hand, the construct validity is achieved when the fitness indices accomplish the required levels. In this paper, all fitness indices for the measurement model had achieved the required levels as follows: CFI > 0.90, TLI > 0.90, RMSEA < 0.08, and the ratio of χ^2/df is less than 5.0. Therefore, all investigated constructs are truly captured the theoretical constructs. In this paper, the reliability was assessed through internal reliability and construct reliability (CR). The internal reliability is achieved when the Cronbach's Alpha value is higher than 0.70. As shown in Table 1, the values of Cronbach's Alpha for each construct is greater than 0.70. Thus, all latent constructs had achieved the internal consistency. The construct reliability assesses the reliability of the measurement model in measuring the intended latent constructs. A value of CR is greater than 0.60 is required in order to achieve the construct reliability. As shown in Table 1, the values of CR for each constructs are greater than 0.60. Thus, all investigated latent constructs had achieved the construct reliability.

4.2 Environmental and Socio-Economic effects of mining and local livelihood improvement

In this paper, the relationship between economic, environmental and socio-cultural effects of mining and local livelihood improvement was examined using structural model procedure (Zainudin, 2012). As shown in Table 2, the results of structural model demonstrated that the fit indices had achieved the required level (χ^2=250.284, χ^2/df =2.215, TLI=0.967, IFI = 0.973, CFI=0.984, and RMSEA=0.046).

Table 2: Model fit Indices

χ^2	χ^2/df	TLI	IFI	CFI	RMSEA
1129.998	3.098	0.967	0.973	0.984	0.046

The result in table 3 indicates that the probability of getting a critical ratio as large as 3.854(β = .690, CR = 3.854, p = .000) in absolute value is 0.000. In other words, the regression weight for Economic impact of mining in the prediction of local livelihood development is significantly different from zero at the 0.001 level (two-tailed). Thus, H_1 was supported. This indicates that Economic impact of mining has a positive effect on local livelihood development.

Similarly, the probability of getting a critical ratio as large as 17.500 (β = .070, CR = 17.500, p = .000) in absolute value is 0.000. In other words, the regression weight for socio-cultural impact of mining in the prediction of local livelihood development is significantly different from zero at the 0.001 level (two-tailed). Thus, H_2 was supported. This indicates that Economic impact of mining has a positive effect on local livelihood development.

However, the probability of getting a critical ratio as large as 8.211(β = -.156, CR = 8.211, p = .000) in absolute value is 0.000. The regression weight for Environmental impact of mining in the prediction of local livelihood development is significantly different from zero at the 0.001 level (two-tailed). Thus, H_3 was supported. This indicates that environmental impact of mining has a negative effect on local livelihood in the study area.

Table 3: Unstandardized and standardized regression weight in the hypothesized path model

Hypothesized relationships			Unstandardized Regression Weight Estimate (B)	SE	Standardized Regression Weight Estimate (β)	CR	P
LLI	<---	ECON	0.690	0.179	1.075	3.854	0.000
LLI	<---	ENV	-0.156	0.019	-0.305	8.211	0.000
LLI	<---	SOC	0.070	0.004	0.147	17.500	0.000

Note: ECON: Economic impact, ENV: Environment impact, SOC: Socio-cultural impact, LLI: Local livelihood improvement, S.E.: Standard Error, CR: Critical Ration.

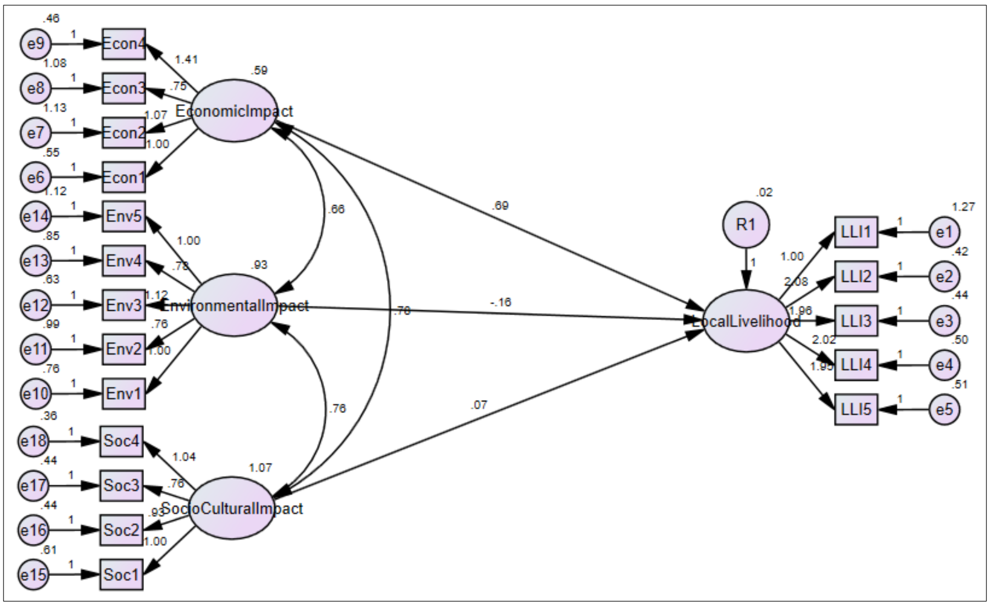

Fig 1: Unstandardized Structural model depicting the influence of economic, environmental and Socio-Cultural on Local Livelihood Improvements

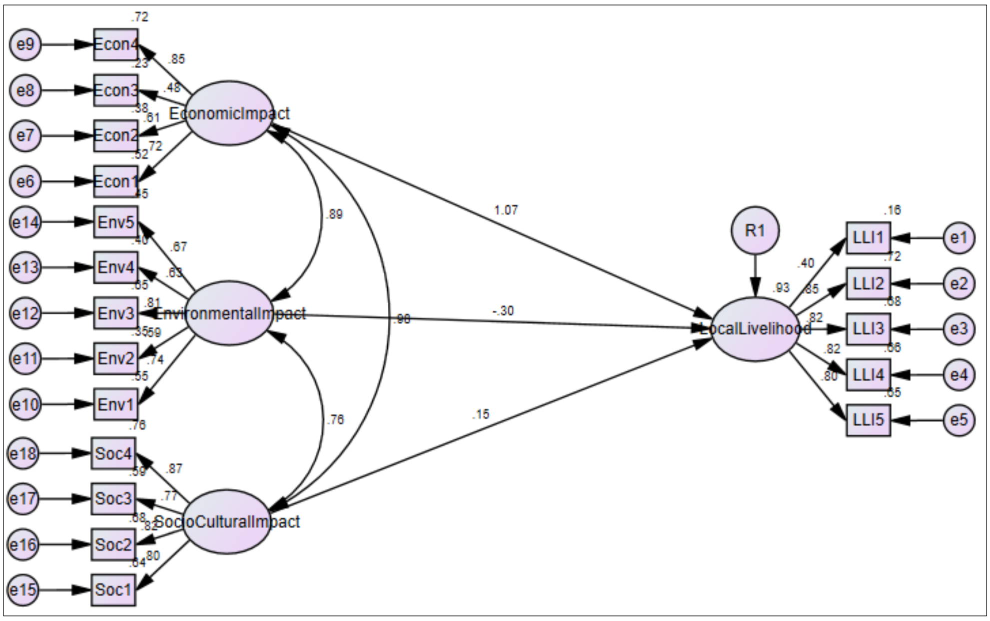

Fig 2: Standardized Structural model depicting the influence of economic, environmental and Socio-Cultural on Local Livelihood Improvements

5. Conclusion and Recommendations

Based on the consequential impact of mining activities, two response measures are imperative. The first builds on the benefits that accrue as a result of the mining activities that are the positive economic and socio-cultural impact of mining on local livelihood. This has been identified as "measures of enhancement". The underpinning rationale connotes the interventions to build the capacity of the mining communities, to optimize social investment by mining investors as well as promote policy measures that fundamentally aim at sustaining benefits from mining activities as well as optimizing the potentials that are associated with mining activities while minimizing environmental risk.

In the area of environmental impact, it is identified that the negativity associated with mining activities needs to be eradicated or reduced. To this, policy measures are to aim at providing policy and regulations to build the capacity of mining activities to be more environmentally friendly and economically efficient.

The Environmental Protection Agency (EPA), the Mineral Agency, and other responsible authorities should address this by intensifying their implementation with a view of ensuring environmental sustainability. Ineffective environmental governance and regulatory mechanism makes it challenging to achieve sustainability. These institutions are required to improve their monitoring activities and to enforce regulatory requirements to mitigate the negative environmental effects of mining in these communities. Strengthened legislation and independent monitoring groups should be commissioned to intervene before environmental and social problems wallow out of control. This is relevant because, considering several attempts and measures, the implications of mining operations have remained a considerable plight, especially for those living in the local communities, and to a larger extent. As a way of enforcing compliance, mining companies should be committed to embarking on: (a) ecological restoration measures, including rehabilitation, reclamation, and restoration measures to be in place to mitigate deforestation and land degradation that have been exacerbated by mining.

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