Quantifying Potential displacements and Land-use Conflicts in Mining Regions

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Abstract: - Quantifying and assessing the spatial interactions between prospective mining and existing local communities’ land use interests can identify and mitigate potential displacements and conflicts between the mining industry and local communities in developing countries. A case study has been conducted at the emerging Ghana’s North-west gold province. Geographic Information Science (GIS), techniques from regional science, and Participatory Rural Appraisal (PRA) tools have been integrated and used to analyse land cover data and socioeconomic activities across 55 villages. The study finds a minimum of 90 and a maximum of 4576 hectares of cultivable lands potentially displaced in the study villages. This has a cumulative effect on manufacturing, wholesale and retailing industries that form the diversity of enduring local economies. The findings of this study will enhance local communities’ empowerment, and benchmark indicators for removing uncertainties and land use conflicts.

Key-words: - villages, mining, conflicts, land use, rural, communities, socioeconomic, displacement

1 Introduction

The mineral resource sector is considered as an asset through which Africa’s quest for industrialisation and development can be obtained. However, the prospects of developing these assets are creating land use conflicts between local communities and the mining industry. Lack of information disempowers local communities from engaging companies and government in peaceful negotiations on resource development. Decision makers also grant new approvals without understanding the realities on the ground. This increases the trends of conflicts between the mining industry and local communities in developing countries. Development of mechanisms for managing these conflicts has been a governance and international policy elusion.

The needs and demand of African rural communities at present are food security, livelihood, and infrastructure[1]. However, African governments assert that the current needs can be obtained through a reinvestment from the mineral resource sector [2]. This implies compromises of land resources. The economy of African rural communities is based on land resources and related industrial and commercial enterprises. It is evident in Africa that most violent conflicts are associated with mineral and other land resources. To mitigate such conflicts, it is necessary to identify the potential impacts of mining on rural livelihood and rural land resources.

Four fundamental causes of conflicts between communities and the industry have been identified. These range from the distribution of royalties, survival of small-scale mines, land use and resettlement [3]. Land use conflicts have been recognised as the most difficult to manage in corporate-community issues [4]. These have negative impacts for both communities and companies. For communities, land use conflicts may lead to stagnation of economic and social development. For the companies, conflicts with local communities have led to the temporary and sometimes permanent close down of projects [4, 5]. It is estimated that corporate-community conflicts have cost over 80% of management working time used in dispute negotiations [6]. This is equivalent to US$ 20 million per week for an operating mine, and about US$ 10, 000 per day of an exploration company [6].

Hilson [5] finds communication gap as an important factor in company-community conflicts. Lack of information and communication about the
spatial extents and impacts of the industry’s interests contribute to uncertainties, communities’ anxiety and resistance. Communities need information about the extent of their land that has been leased to companies. Failure to get answers for their anxieties, tensions and uncertainties leap into violent conflicts [7]. However, most African countries lack spatial information and village maps for an efficient policy decision making and management of rural resources [8]. As in many developing countries in Asia and Latin America, the mining sector policy in most African countries entrench compulsory extraction of mineral resources found, whether on or above or beneath the surface [9, 10]. This implies that while customary lands are recognised, their rights end where they conflict with national interests. Therefore, concessions are often granted without consideration for the futures of rural livelihoods. As a result, conflicts escalate when the industry’s activities interfere with villages’ land use activities. To manage these conflicts requires consultations and mediation tools [11]. Nonetheless, no study has analysed and quantified the extent of land occupation, and the impact of the industry’s interests on the socioeconomic activities of rural populations. To this end, this paper aims to develop a strategy that will enhance the availability and use of information for informed decision making on village resources. Specifically, the paper seeks to: (1) generate spatial data to build a common knowledge base that is accessible to all stakeholders, (2) analyse the spatial interactions between company activities and local communities’ socioeconomic activities, and (3) assess and predict the socioeconomic and community impacts of new proposals on rural communities and potential conflicts. This can facilitate meaningful negotiations between local communities on one hand and companies and governments on another hand.

2 Materials and Methods
2.1 Study area
In the context of natural resource endowment and mineral resource development in particular, Ghana is considered a benchmark indicator for resource-based development and industrialisation in Africa. The country’s Medium Term Development Policy Framework aims to achieve structural transformation of the economy through modernised agriculture and mineral resources [12]. Agriculture and mining contribute more than half of Ghana’s gross domestic products (GDP). Agriculture sector employs more than 60% of the labour force and over 80% of rural households [13]. Progress in other non-agricultural sectors of the economy is slow. However, the mining sector continues to grow with new approvals granted in areas that have not had mining sector experiences before. This implies bringing more land from other uses into mineral exploration and mining. Previously, mining sector activities concentrated in the Southern fringes of Ghana. Recent discoveries of viable quantities of mineral deposits in the three Northern Savanna regions of the country have given a different meaning to this land use phenomenon [14, 15].

The regions in the Northern Savanna are the most poorest in Ghana [16]. Traditionally, the economy of these regions is largely driven by agriculture. During fieldwork, it was observed that the agriculture sector employs over 90% of rural populations in these regions. Al-Hassan and Poulton [17] find that communities that are highly dependent on agriculture in the three Northern regions are the most poorest. As a result of this, rural communities are diversifying their livelihood opportunities from agriculture to off-farm and non-agricultural activities [18]. The diversifications include petty trading, wood carving, gardening, and Shea processing. DFID [19] find that whereas agro-based industries and tourism hold the key to breaking poverty hikes in the three Northern regions of Ghana, the requisite capital to raise these industries to sustainable levels may flow from the mineral resource sector. Land is the only asset for rural economic diversification in this area. Thus, the introduction of mining sector activities in a village landscape has the potential to change village’s economic base and lifestyle. It is, therefore, important to develop a strategy that can assess and quantify the socioeconomic activities of local communities and the impacts that the emerging mining industry activities will have on them. Hence, the focus of this study is on the emerging Ghana’s North-West Gold Province in the Upper West Region (UWR).

2.2 Data collection and preparations
Due to lack of up to date spatial data in the area, data for this study were collected during fieldwork. Two field visits were done from December, 2013 to February, 2014 and December, 2014 to February, 2015. The objectives of the fieldwork were to: (1) take inventory of land use and livelihood activities in local communities, (2) map spatial extents of land
use activities across village space and, (3) source existing data covering communities’ biophysical and socioeconomic activities. These objectives were pursued in three stages: community entering, data collection, and data validation. The purpose of the community entering was to explain the objectives of the study to district assemblies of study communities; identify sample communities with the assemblymen of lead villages used to name exploration and mining leases (ELs) by companies. The purpose was also to explain the objectives to the sample villages and to seek their consent. Overall, the district assemblies and the villages supported the study.

Agriculture and Forest suitability map for the study area was obtained from the Soil Research Institute (SRI) of the Council for Scientific and Industrial Research (CSIR). The map has been developed by SRI based on an extensive soil inventory and physiographic analysis of the landscape. Details of the survey methods used in developing the map can be found in Adu [20]. The suitability map was digitized in ArcMap and used together with the ELs and land use sketch maps of the villages to identify areas of potential displacements and impacts.

The Centre for Remote Sensing and Geographic Information Services (CERSGIS) in the University of Ghana has developed a land cover scheme applicable in all the ecological zones in Ghana. The scheme has been developed in conformity with the USGS land cover mapping system and has been used to develop a land cover map of Ghana. Details of the algorithms used in developing the scheme can be found in Agyapong, et al. [21]. Land cover data developed from this scheme have been obtained from the Department of Geography and Resource Development, University of Ghana, and used for tree density analysis in this study.

2.2.1 Sampling
A multi-stage sampling technique was employed in this study. First, the company with exploration and mining interest in the study area was identified. The tenement map for exploration and mining activities was downloaded from the company’s website. The map was geo-referenced in the Universal Transverse Mercator (UTM) projection system. The ELs together with drill-holes in the tenement map were uploaded onto ArcMap and digitized. The ELs and drill-holes have been named after the villages in which they are located. The names of these villages were then used for a purposive and cluster sampling of villages in the ELs that were under active exploration activities. The sampling was pruned down to villages within same electoral area in the district assembly system. Another criteria was that villages that share kinship ties within the ELs were also considered in the sampling. The purpose for these criteria used is that land is communally owned and managed by kinship ties among the tribes in the area. Issues relating to land in one community affects a host of other communities otherwise not considered as mining communities [22]. Also, under the decentralisation system, community development programs are generally channelled through the district assembly. The district assembly comprises of members elected from these communities to represent their development interests.

Overall, 55 villages have been sampled across 5 districts. The communities are: Bulituo, Eggu, Oli, Sukpare, and Zan in the Wa West district; Berendari, Butele, Gabilee, Konne, Musama, Mwindaale, Nanga-Wuchema, Nieri, Sabiili, Tangasia, Tanduori, Turi-Dari, Vuuyiri, Yaro, and Yiziri in Nadowli-Kaleo district; Gbetuol, Guoripuo, Kakala, Kul-Ora, Kpannyaga, Kunzokala, Orifane, Tambore, Tampoe, Tanzire, Tikpe, Tie, Tuolung, Wuling, Yagha-Baapari, Yagha-Gbaani, Yagha-Kusoglo, and Yagha-Tohaa in Jirapa district. The rest are: Bompari, Buree, Danko, Dazuuri Baapari, Dazuuri Dabozeri, Naayirbog, Naburnye, Toto, Sorgoun, Yagra, Yagra Tangzu, and Zinpen in Lawra district; Nandom district; and Lambussie Karni district. However, fieldwork was completed in all the villages except the Kokoligu and Kokoligu Gbantakuri in Nandom district. This was due to challenges in accessing these communities.

2.2.2 Focus group discussions and participatory Mapping
In each village, leaders and village groups were identified and invited to participate voluntarily in focus group discussions and participatory mapping activities. Identifiable individuals and groups were village chiefs, priests, community youth association, village unit committee, and women association. Other village experts such as experienced farmers and hunters were also engaged in the focus group and sketch mapping. These individuals and groups have knowledge about the villages’ development objectives and land use patterns. There was at least one representative from each of these groups.
making a maximum of 10 participants in each focus group and participatory mapping session in each village. The sessions lasted for a maximum of 6 hours and a minimum of 3 hours. In total, 53 sessions were held with a maximum of 530 participants in the field data collection activities. Examples of discussions questions are: “Which livelihood opportunities exist in the village in respect of Animals, plant materials, rock minerals, and soils harvested for food, clothing, medicines, sacrifice; shelter, tools, and rent”’; “How much land area is used or occupied by existing and previous livelihood activities in the village landscape”? Places where these activities are conducted were sketched on cardboards for transcription onto ArcGIS. Each session was moderated by the researcher but, the sketch mapping activities were mostly led by the assemblyman of each village. Data generated include village population, economic activities, and land use extent maps.

2.2.3 Data Validation
At the end of focus group discussions and mapping sessions, transect walks were conducted around the features indicated on the sketched maps. The coordinates of these features were taken using a hand-held GPS with 5 metres positional accuracy. The transect walks were mostly led by the village youth and the assemblymen. Overall, the village land use extents were georeferenced base on the last farmlands along the North, East, South and West cardinal points. It is important to emphasise that these were not supposed to create village boundaries maps. This issue was extensively discussed at each village, during the community entering process, and was widely accepted before the study was permitted to proceed. The sketched maps were uploaded onto ArcGIS and registered with the respective GPS coordinates for each village. The registered maps were taken back to the villages for validation. There was over 90% acceptance of the accuracies of the geo-referenced maps. The sketched maps were then digitized and are used in this study to represent the land use extents of the villages (Fig. 1).

The 2010 population and economic activity data of 20 villages were obtained from the Ghana Statistical Service (GSS). These data were used to cross-validate the field generated population and economic activity data using the annual intercensal rate of increase. There was over 95% agreement between these data. So it was convincing to go with the rest of the population data obtained directly from the local communities.

2.3 Analysis
2.3.1 Normalized units/life cycle thinking
The land use maps of the villages have been overlaid with the ELs maps in ArcMap to identify areas of overlaps and potential displacement (Fig. 2). The areas of overlaps have then been used to estimate specific village land use and associated livelihood activities that will be affected by the emerging developments. There are no existing models to use for analysing such problems. Therefore, the study used normalised units and life cycle thinking approaches [23] to develop models for answering the questions in this study. These are expressed as following to determine the potential displacement of livelihood activities in the villages:

\[
\text{Cultivable lands}_v - S = \left( \text{EL}_v \cap \left( \text{AF}_{v} \cap \text{T}_{v} \right) \right) - \left( \text{EL}_v \cap \left( \text{AF}_{v} \cap \text{T}_{v} \right) \right)
\]

Where: 
- \(S\) = displacement; 
- \(EL\) = Exploration and mining Lease; 
- \(A\) = Area; 
- \(j\) = village 
- \(AF\) = unsuitable Agriculture and Forest land;
The total area of village land use extents is estimated as:

$$T = \text{total area of village land use extents}$$

Average number of trees is estimated as:

$$\text{AvNT}_{y,j} - S = \left[ \sum \text{EstNT}_{yj\text{ELj}} \right]$$

Average Shea tree density is calculated as:

$$\text{AvShea}_{y,j} - S = \left[ \sum A_{ELj} \times (\text{AvSheaDens}) \right]$$

Estimated number of Shea trees potentially displaced in each village is:

$$\text{EstNShea}_{y,j} - S \times \text{AvNFPT} \times \text{MFW}$$

The types of crop farming systems practiced in the area make every unit of land important for cultivation in the villages [24]. The AFu has been excluded from the villages cultivable lands since it might not have much value for agriculture. It has also been excluded from the ELs because the analysis needed to compute the overlaps of spatial units of agricultural value. The EL intersection AFu could be residual for the mining industry’s activities. Thus, the estimated potential cultivable lands displacement is the total area of ELs in each village excluding the concurrent overlaps of ELs, AFu and villages’ land use extents.

The tree density per land cover type per EL has been calculated using the mean values of the range of trees per hectare in each land cover type. Thus, the average tree density per land cover type within the EL multiplied by the area of the land cover in the EL. Therefore, the estimated number of trees potentially displaced in each village is the sum of the estimated number of trees per land cover type within the overlaps of villages land use extents and ELs. Similarly, the estimated Shea tree displacement is the sum of the estimated average Shea tree density within the overlaps of ELs and villages land use extents. The average Shea tree density per hectare has been calculated using the estimated minimum number of Shea trees in the Northern Savanna of Ghana, $9.4 \times 10^6$ [25]. This figure has been divided by the total area of the Northern Savanna, 77,670 km$^2$, to obtain Shea tree density for the study villages. The mean Shea fruit weight and average number of fruits per tree have been obtained from the findings of Yidana [25]. These have been multiplied by the estimated number of Shea trees potentially displaced to obtain the amount of fruits potentially displaced in each village.

### 2.3.2 Principal component analysis (PCA)

The village major livelihood activities inventoried have been aggregated into industry categories known as the Principal Components (Table 1). This was done using the International Standard Industrial Classification (ISIC) system developed by the United Nations (UN) statistics division. The ISIC provides a universal standard format for the detailed aggregation and analysis of all economic activities in a locality based on a consistent internationally agreed concepts and definitions. The activities are put into a hierarchical, four-level-structure of mutually exclusive categories. The highest level categories are labelled as sections. The sections are coded with alphabets. The sections are then subdivided into divisions; also coded with two-digit numerals. The next lower level is group with three-digit code. The last level is class with four-digit code. For instance, “Agriculture/forestry/fishing” is (section A), “Manufacturing” is (section C), “Mining and Quarrying is (section B), “Wholesale and retailing” is (section G). But, the industries have some location congruence with each other. This determines the clustering and dispersal of economic activities in a location. Therefore, the location association of pairs of industries was calculated.
Table 1 showing Principal Components and industry categories of livelihood activities at the villages

<table>
<thead>
<tr>
<th>Activities</th>
<th>Principal Components/Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AGRICFF</td>
</tr>
<tr>
<td>Cropping</td>
<td>A0111</td>
</tr>
<tr>
<td>Gardening</td>
<td>A0113</td>
</tr>
<tr>
<td>Shea butter processing</td>
<td></td>
</tr>
<tr>
<td>Pito brewing</td>
<td></td>
</tr>
<tr>
<td>Petty Trading</td>
<td></td>
</tr>
<tr>
<td>Food processing</td>
<td></td>
</tr>
<tr>
<td>Wood carving</td>
<td></td>
</tr>
<tr>
<td>Weaving and basketry</td>
<td></td>
</tr>
<tr>
<td>Pottery and ceramics</td>
<td></td>
</tr>
<tr>
<td>Sand/clay/gravel Quarry</td>
<td></td>
</tr>
<tr>
<td>Haunting</td>
<td>A017</td>
</tr>
<tr>
<td>Livestock keeping</td>
<td>A0141/44</td>
</tr>
<tr>
<td>Firewood/Charcoal Burning</td>
<td></td>
</tr>
</tbody>
</table>

AGRICFF: Agriculture/Forestry/Fishing; MINQUA: Mining and Quarrying; MANUF: Manufacturing; WRETAIL: Wholesale and retailing

2.3.3 Location Association (La)

The La model has been adopted and used in this study to understand the spatial correlations between different categories of livelihood activities based on industry types. The question was whether there is location affinity between any pair of industry activities such that the displacement of one industry will automatically affect another. The following is the La model used:

\[
La = 100 - \left( \sum_{k=1}^{n} \frac{|E_{ij1...ijn} - E_{ij1...ijn}|}{2} \right)
\]

(6)

I and l = industry types; \( La \geq 60 \); means higher degree of association

\( La < 60 > 50 \); evidence of association

\( La \leq 50 \); weak association

j = reference area (village)

The expected value of La to establish the location affinity between a pair of industries is \( La > 60 \) [26]. An La between 50 and 60 is evident that there is a location affinity between the pair of industries. But that relationship might not be strong such that the displacement of one affects the other. Implicitly, an La < 50 shows weak relationships between any pair of industries in a location. But to further explain the binding forces between industries, the Input-Output (I-O) table was used.

2.3.4 Input-Output (I-O) model

The I-O model (Leontief model), developed by Leontief [27], analyses the significance of clusters of industries in a location. The model explains the demand and supply relationships between any pair of industries at a given time. To understand this, the model uses an N\^{}n matrix in table 2 below to show the flow of goods and services from one industry into others. Column two indicates the demand for the output x of industries 1 to n by industries 1 to N in column six. C indicates the final demand for the output of industries in column two and X is the total output of industries in the rows. Y is the total inputs of each industry in the columns. For instance, in a village setting, household constitute labour input to the agriculture industry. Part of the output of the agriculture sector in turn is consumed domestically by the household and part of it is supplied to the Wholesale and retail industry as an input for the market. Profits and market returns are reinvested on farms to provide further input for the Wholesale and retail industry. However, the origin and flow of the inter-industry dependence needs to be determined to understand the degree of specialisation of villages in the production and supply system. To determine this, the co-efficient of specialisation model was used.
Table 2: Input/output flow table for one location  Adopted from Yankson [28]

<table>
<thead>
<tr>
<th>Supply Sector</th>
<th>Industry 1</th>
<th>2</th>
<th>3</th>
<th>N</th>
<th>C</th>
<th>Total X</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$x_{11}$</td>
<td>$x_{12}$</td>
<td>$x_{13}$</td>
<td>$x_{1n}$</td>
<td>$x_{C1}$</td>
<td>$X_1$</td>
</tr>
<tr>
<td></td>
<td>$x_{21}$</td>
<td>$x_{22}$</td>
<td>$x_{23}$</td>
<td>$x_{2n}$</td>
<td>$x_{C2}$</td>
<td>$X_2$</td>
</tr>
<tr>
<td></td>
<td>$x_{31}$</td>
<td>$x_{32}$</td>
<td>$x_{33}$</td>
<td>$x_{3n}$</td>
<td>$x_{C3}$</td>
<td>$X_3$</td>
</tr>
<tr>
<td></td>
<td>$x_{n1}$</td>
<td>$x_{n2}$</td>
<td>$x_{n3}$</td>
<td>$x_{nn}$</td>
<td>$x_{Cn}$</td>
<td>$X_n$</td>
</tr>
<tr>
<td></td>
<td>$v$</td>
<td>$v_1$</td>
<td>$v_2$</td>
<td>$v_3$</td>
<td>$v_n$</td>
<td>$Y$</td>
</tr>
<tr>
<td>Total</td>
<td>$y$</td>
<td>$Y_1$</td>
<td>$Y_2$</td>
<td>$Y_3$</td>
<td>$Y_n$</td>
<td></td>
</tr>
</tbody>
</table>

$\sum V = \sum C$;  C-final demand for the output of each industry;  X-total output of each industry;  V-household sector contribution (in terms of labour);  Y-total value of inputs used

2.3.3 Location Quotient (LQ)

The LQ model is used to measure the degree of specialisation of a location in the production of goods and service. It is also used to predict potential changes in a local economy when a new activity is introduced [29]. It is expressed as a ratio of ratios in the following equation:

$$\left( \frac{E_{ij}}{E_j} \right) \div \left( \frac{E_{ij}}{E_i} \right)$$  \hspace{1cm} (7)

$E$ = Employment;  $i$ = industry;  $j$ = small reference area (village)

$J$ = Larger reference area (district);  $LQ < 1$ means production is less than local demand;  $LQ = 1$ implies production is subsistence;  $LQ > 1$ is production beyond local demand

Usually, employment figures are used to compute the LQ. The number of people engaged in an industry ($i$) in a smaller location ($j$) is normalised by the total number of people engaged in all other industries including industry ($i$) in the same smaller location ($j$). Then, the same computation is done again but with employment figures from the larger location wherein the smaller location is situated. The results from the smaller location is then normalised with that of the larger location. In this study, the smaller location ($j$) is the village, and the larger location ($J$) is the district. The LQ for all the industries identified in the villages is computed. To demonstrate that a location is able to meet its local demand for the output of an industry and is able to supply beyond its vicinity, the LQ should be greater than 1. An LQ equal to 1 means that production in that particular industry is subsistence and not for supplying to the market. An LQ less than 1 implies that a particular location is in deficit of the output of that industry and would always be in demand to satisfy local requirements.

3 Results and Discussions

Fig 2 shows the overlaps between the ELs and the villages’ land use extents. It can be seen from the results that some villages would have to be relocated. Especially so in the Nadowli-Kaleo and Jirapa districts where mining licenses have been granted. The affected villages are Nanga-Wuchema, Tangasia, and Yiziri in the Nadowli-Kaleo district. And in the Jirapa district only Orifane will immediately be affected. However, in-case of mine expansion in the current concession, Kpannya, Guoripuo, together with Orifane in the Jirapa district will have to be relocated. With intensification in exploration, villages’ cultivable lands will be interfered with (Fig 3).
Eggu, Zan, and Sukpare in the Wa West district will be affected, whereas Butele, Turi-Dari, Niiri and Berendari in the South of Nadowli-Kaleo will be affected. Except Tampoe, almost all the sample villages and surrounding communities in the Jirapa district will be affected by an intensification of exploration activities. Except Bompari, Yagra and Toto, all the sample villages in the Lawra district will be affected by exploration disturbance and future mining considerations. Billaw and Banwon in the Lambussie Karni district are no exception to the disturbance of the mining industry activities. This has negative implications for the manufacturing and wholesale and retail industries. Activities like food processing, ‘Pito’-brewing, and petty trading derive their inputs from cultivable lands in the agriculture industry.

Fig 4 shows the quantity of trees that will potentially be displaced in each village. Billaw in the Lambussie Karni district will have the highest number of trees displacement. This may is because it is covered by the close wooded Savanna land cover type.

The next most potentially affected villages are Eggu, Zan, in Wa West; Konne, Nanga-Wuchema in Nadowli-Kaleo; and Banwon in Lambussie Karni districts. Villages in the Jirapa and Lawra districts will the least affected in terms of potential tree removal because of: (1) the land cover types overlying in these areas, (2) the size of land use extents in most of them is relatively small and, (3) they have small area of overlap with ELs. But most of the villages are covered by the open cultivated Savanna woodland; and with or without scattered trees. Tree densities in these land cover types are 6-10 trees/hectare (ha), and 0-5 trees/ha respectively. Tree displacements have negative implications for the supply of inputs to manufacturing and wholesale and retail industries. Activities like wood carving, weaving, firewood and charcoal burning derive their inputs from wild trees. Including potentials of Shea trees displacements (Fig 5), the Shea processing sector will be affected in most of the villages. This is associated with fruits displacement and has an extensive negative livelihood implication for women in these villages. Women in these villages depend on the Shea sector as a major source of income with which they support their families [30]. Fig 6 shows the potential Shea fruit displacement.
The results in Fig 7 show the spatial congruence between pairs of industries in the villages. The results here re-emphasis those in Table 2. Most livelihood activities in these areas are spatially correlated. The presence of one generates the practice of a chain of others in the village. Except the mining and quarrying industry, all the industries have an $La > 60$ with each other. It means that the displacement of any of these industries will affect the source of input or consumption levels of the other industries in the villages. However, all the locations are not equally endowed with resources. Therefore, the results in Fig 8 demonstrate the coefficient of specialisation of all the villages in the production system. Except Banwon, Toto, Turidari, Yagha-Baapari, and Musama, all the other villages have an $LQ > 1$ in agriculture. The implication is that these villages are able to produce enough agricultural products to satisfy local demand, while at the same time been able to send some of the products to the market. Those with $LQ < 1$ are rather deficit in agricultural products and might be dependent on the more abled villages for supplies. Again, except Yagha-Gibaa, Yagha-Tohaan, Nayiribog, Kokoligu Gbantakuuri, Niiri, Naburnye, and Banwon, all other villages have an $LQ>1$ in manufacturing. Toto has the highest $LQ$ of 22.8 in the wholesale and retail industry. The degree of specialisation in the production system across is one of the binding forces that links these villages together in harmony [31].

The potential cumulative impact of conversions of villages’ land and its resources into mining activities is obvious from these results. The models used in this study demonstrate the cyclical flow of resource, particularly at the villages level. Diversifying economies can be threatened with a break in this cycle of inter-industry dependence for cash and inputs. In the event that these conversions further compound livelihood constraints, communities are mostly likely to resist the mining industry activities. Several studies have reported instances where land use conflicts between local communities and exploration and mining companies escalated from resistance into violent conflicts [4, 5, 32]. Lack of communication is usually cited as the main cause. But this study establishes that there can be no efficient communication between local communities and mining companies without equalising the power difference between them.
The industry has several initiatives in place for managing land use issues with communities. A most recent action by the industry is the Community Development Toolkit (CDT) of the International Council for Mining and Metals (ICCM). The CDT has Social Impact Assessment (SIA) module for collecting baseline data when a project reaches concept stages.

However, the local communities cannot differentiate between a feasibility survey and project concept stages of an exploration company. From ground observations during fieldwork, local communities are of the conviction that once a company comes around to prospect and explore for mineral deposits, it means the deposits are worth investing on. Else, companies will not spend so much money and time excavating their land resources and livelihood foundations. Besides, companies may hire consultancies to conduct the baseline studies for them. The risk is that these consultancies may not commit the needed time to apply all aspects of the module in a short period as may be required before mine commissioning.

Also, consultancies may not have adequate knowledge about the diversity of village livelihood activities, and for that matter may under-represent realities on the ground. Furthermore, companies are often reluctant to share data with local communities in order to enhance their capacities for mediation and negotiation processes [4].

Local communities lack the necessary information about the spatial extents of the mining industry’s land use interests in the landscape. For local communities to be able to hold any meaningful negotiations with the industry and governments, they must be empowered with knowledge about the extents of their land and for that matter livelihood activities that would potentially be displaced. This places communities in a better position to understand the futures of their economic fortunes.
The results of this study will empower communities and governments to know what is to be expected and how best to adapt to the expected economic changes. The results can also be used to facilitate a linkage between the numerous resource endowment in the rural landscape for a mutual beneficiation between the local communities, private sector, states, and other partners in a diversified economy. This involves the creation of enabling environment for local communities to provide goods and service for the mining industry. The optimum outcome could be the development of a mining sector that will bring an integrated rural livelihood improvement.

4 Conclusion
The study developed a geographical representation of local communities’ livelihood space. Based on this representation, the overlaps of mining interests upon local space have been identified and measured. The potential displacement of villages livelihood foundations have also been quantified and assessed. Agriculture, whole-sale and retailing, and manufacturing all contribute to the communities’ economy and lifestyle. Villages have both social and trade linkages with neighbouring communities. A displacement of one village’s livelihood can have an extensive impact on other villages that would otherwise not be considered as mining communities. The results of the study will help all stakeholders to prepare for uncertain economic futures of villages.

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