Spatial Assessment of Impacts of Artisanal and Small-scale Mining on Land Cover and Environment, Batourri, Eastern Cameroun

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ABSTRACT

Artisanal and small-scale mining affects the quality and components of the environment in the Batouri area in different ways. Activities interfere with air, soil, water, fauna and forest resources. This study seeks to assess the impacts of mining on the environment using a combination of spatial analysis, questionnaires administration and Leopold’s grid of impact assessment. The impacts of mining on physical environment include air pollution by emission of dusts and fumes from engines, soil and subsoil degradation by earthworks and release of wastewater containing chemicals from companies. Destruction of habitats; decrease in quantity of forested area since the arrival of mining companies have been observed. Aquatic fauna is threatened by high turbidity and death of fishes. Government bodies must ensure permanent monitoring and environmental audit to check the compliance of mining companies and their activities with regulations.

Keywords:
- Artisanal and Small-scale mining
- Spatial analysis
- Environment
- Impacts
- Batouri

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Évaluation spatiale des impacts de l'exploitation minière artisanale et à petite échelle sur la couverture terrestre et l'environnement, Batouri, Cameroun oriental

Résumé en Français

L'exploitation manière artisanale et semi-mécanisée affecte la qualité et toutes les composantes de l'environnement à Batouri de différente manière ; les activités interfèrent avec l'air, le sol, l'eau, la faune et la forêt. Cette étude vise à analyser les impacts de l'exploitation minière sur l'environnement. L'approche méthodologique est constituée de la combinaison de l'analyse spatiale, les enquêtes par questionnaires et la grille d'identification des impacts de Leopold. Les impacts des activités minières sur l'environnement impliquent la pollution de l'air par les émissions des poussières et des fumées par les engins ; la dégradation du sol et sous-sol par le terrassement et les rejets d'eaux polluées contenant les produits chimiques. La destruction de l'habitat et la réduction des superficies forestières sont prononcées depuis l'arrivée des compagnies minières. La faune aquatique est menacée par une grande turbidité et la mort des poissons. Les autorités gouvernementales doivent prendre des mesures pour un monitoring et audit environnemental régulier pour s'assurer de la conformité des compagnies minières aux normes.

Mots clés :
- Exploitation manière artisanale et semi-mécanisée
- Analyse spatiale
- Environnement
- Impacts
- Batouri

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1. INTRODUCTION

Artisanal mining in the Batouri area is related to a number of environmental impacts. Deforestation and land degradation amount others constitute the dominant environmental impacts. Artisanal gold mining activities involves the creation of roads and paves through small-scale logging. The exploitation phase leads to the digging of open pits which are generally left opened after the mining process. This constitute animal traps and health hazards (Funoh, 2014). The environmental impacts of small-scale mining have been studied worldwide; the main impacts are deforestation and land degradation. (Labonne and Gilman 1999; Hentschel, 2002; Hentschel 2003; Tieguhong et al., 2009).

The interaction between the environmental components and mining processes results to a lot of impacts that affect both the environment and humans. There is a need for proper monitoring of pollution level and forest degradation and deforestation in the Kadey Division in order to apply proper remediation strategies.

2. LOCAL GEOLOGY

Gold production in eastern Cameroon began in 1934 and by 1951 a total of 2265 kg had been produced (Gazel & Gerard 1954), mainly from alluvial workings. This official production is thought to represent only a small proportion of the gold produced because many small-scale miners kept no records of output, and production. Gold in the Batouri area occurs in structurally controlled discordant NE – SW trending quartz veins and veinlets hosted by sheared metagranites and remnants of a gneissic basement (Suh et al., 2006).

3. MATERIAL AND METHODS

3.1 Questionnaire Administration

35% of households were assessed using questionnaires as shown in table 1

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of households</th>
<th>Number of questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONGO-NAM/Pater (Exploitation site)</td>
<td>142</td>
<td>26</td>
</tr>
<tr>
<td>KAMBELE II (Boucareau : Households)</td>
<td>105</td>
<td>30</td>
</tr>
<tr>
<td>KAMBELE II (Djoungou : Exploitation site)</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>247</strong></td>
<td><strong>86</strong></td>
</tr>
</tbody>
</table>

Source: BUCREP: 3rd RGPH in Cameroon in 2010 and field work
3.2 In-depth Interview

The identified authorities of the area to whom interviews were conducted included; the Delegate of Mines of Batouri, the manager of CAPAM and the divisional delegates of the Environment, Water and Energy of subdivision Division); the chief of the mining company METALICON and a local chief.

3.3 Geospatial Analysis and Remote Sensing

Through Erdas Imagine software, the supervised classification enabled forest and land cover estimation. The ArcGIS environment allowed the production of maps. The global evolution and the rate of dynamism have been calculated using the formula (model Dirzo, 1990): \[ r = \frac{1}{100} \left( 1 - \left( \frac{A1 - A2}{A1} \right) \right) \]

3.4 Environmental Assesment Method (Leoplod's Matrix)

Leopold's matrix was used to identify the various impacts of mining activities on physical, biological and socioeconomic variables of the environment.

4. RESULTS AND DISCUSSIONS

4.1 Land cover dynamism 2002-2014 in Batouri

From (A) 2000 to 2014 (B), the rainforest changed from 377227 (58.44%); ha to 371044 (57.49%), ha corresponding to a decrease of 6183 ha. The secondary forest/agriculture varied from 128460.6 ha (19.90%); to 131742.39 ha (20.41%), corresponding to an increase of 3281.79 ha. Forest/savannah mosaic changed from 106490 (16.50%); to 46969.3 Ha (7.28%). The rural complex: shown a variation from 26908.3 (4.17%) to 89140.9 Ha (13.81%) and built-up areas from 6380.22 (0.99% to 6560.19 Ha (1.02%) as shown in Table 2. The arrival of mining companies (METALICON and Cameroon Inc.) in the Batouri area in 2011, witness a decrease in rainforest surface area (6183 ha). The companies destroy the rainforest in favour of their settlement and agricultural farm lands (secondary forest) by the indigenous people. Eventually, through shifting cultivation, the area will also become young forest and rural complex for habitations.
4.2 Impact on the Physical Environment

4.2.1 Soil subsoil related issues

Soil and land degradation; modification of the subsoil fertility through earthwork and excavation, movement of machines and vehicles, development of driveways and maintenance of machines (spills) are some of the impacts of mining on the physical environment in the Batouri area as shown in Plate 1.
Table 2: Land Use and Land Cover Change in Batouri 2002-2014

<table>
<thead>
<tr>
<th>Classes of Interest</th>
<th>Areas 2002</th>
<th>%</th>
<th>Areas 2014</th>
<th>%</th>
<th>Global variability</th>
<th>Annual variability</th>
<th>Global change rate</th>
<th>Annual change rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainforest</td>
<td>377227</td>
<td>58.4</td>
<td>371044</td>
<td>57.4</td>
<td>-6183</td>
<td>-515.25</td>
<td>-0.96</td>
<td>-0.08</td>
</tr>
<tr>
<td>Secondary forest/Agriculture</td>
<td>128460.6</td>
<td>19.9</td>
<td>131742.3</td>
<td>20.4</td>
<td>3281.79</td>
<td>273.48</td>
<td>0.51</td>
<td>0.04</td>
</tr>
<tr>
<td>Forest/Savanna mosaic</td>
<td>106490</td>
<td>16.5</td>
<td>46969.3</td>
<td>13.8</td>
<td>-59520.7</td>
<td>-4960.06</td>
<td>-9.22</td>
<td>-0.77</td>
</tr>
<tr>
<td>Rural complex</td>
<td>26908.3</td>
<td>5.17</td>
<td>89140.9</td>
<td>27.8</td>
<td>62232.6</td>
<td>5186.05</td>
<td>9.64</td>
<td>0.80</td>
</tr>
<tr>
<td>Urban area/Built-up</td>
<td>6380.22</td>
<td>0.99</td>
<td>6569.53</td>
<td>1.02</td>
<td>189.31</td>
<td>15.78</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>645466.1</td>
<td>2</td>
<td>645466.1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Derived from Landsat images 2002 and 2014

Plate 1: Effects of mining operations on soil in Batouri with A indicating oil products in METALICON; B indicating discharge of oil on the soil in Cam Inc.; C indicating the digging of holes (METALICON) and D indicating the deposit of materials on land and water.
4.2.2 Water Environment

Decrease in freshwater availability, turbidity and stagnant water in open pits are the dominant water related impacts on the environment in the area. These open pits filled with water usually constitute a trap for animals and even cause death (8 persons per year) to humans (Plate 2). The mining activity usually involves a change or modification of the water course which usually cause floods in farm lands and may also pollute drinkable water resources. Pumping of water to the gold washing tables and out of opened pits during excavation also impact the water resource in the area. Another health related issue in the area is the accumulation of mine tailings. Infiltration of water within these tailings usually reacts with remobilized minerals in them, resulting in the formation of acid water and arsenide release. This acid water and arsenide are very dangerous as it may enter drinkable water courses leading to health problems.

Plate 2: Water pollution process in Kambellé II. Discharge of wastewater by an “industrial mining company” (METALICON) (A); discharge of wastewater by an artisanal miners (B); open pit from artisanal mining (C) and the deviation of water bed by artisanal miners (D).
4.2.3 Air environment

Dust emissions, noise and air pollution through earthwork, movement of machines and vehicles and energy power supply affect the air quality in Batouri. In Kambellé II, both artisanal and small scale gold mining affect the quality of air via dust and fumes from rock crushing machines (Plate 3).

Plate 3: Sources of air pollution from field observations, 2016. Air pollution by engines (A); “industrial mining” (METALICON) (B); air pollution by artisanal mines (C) and fumes from engine used by an artisanal miner to squash rocks (D)

4.3 Impacts on the Biological Environment

Deforestation is caused by earthwork and excavation, development of driveways, construction of buildings and clearance as shown on Plate 4 Trees have been cut down in Kambellé II by METALICON and in MONGONAN by Cam Inc.
4.3.1 Fauna

The destruction of wildlife habitats and aquatic fauna is caused by oil spills and chemicals release in Batouri. The local people complained several times about the death of fishes in water bodies (Delegate of Water and Energy, 2016). Out the 89 households interviewed in the location, more than 50 confirmed that there is a decrease in the number of fishes in water bodies in Batouri.

Plate 4: Deforestation in Batouri Area observed at Kambellé II (A) and Mongonam (B)

Plate 5: Impacts of mining on aquatic habitats. An engine leaking oil directly into water course (A) and a massive growth of weeds downstream of the river Djingou (B).
4.3.2 Security and Health

Abandoned sites and open pits lead to the increase of mosquitoes and diseases (malaria). Another impact is the lack of drinking water and increase in waterborne diseases. Body pain, skin diseases and malaria constitute the general complain of local people according to a medical doctor interviewed, (the owner of a medical centre in Kambellé II who preferred to be anonymous). The most affected population are Bororo and Malian who collect their water directly from wells and rivers. There is also a recurrence of early pregnancy in the area (personal communication, medical Doctor, 2016). Health is very precarious in Kambellé II. There is acute shortage of social infrastructures such as schools and hospitals. This makes the level of education to be very low in the area. The proliferation of gold mining activities in the area attracts a certain categories of people, namely, children and women (Plate 6). This makes them to be the most affected by health impacts. There are at least 8 deaths every year caused either by people who fall in open pit and drown or through landslides (Nzika, 2016). Malaria, diarrhoea, typhoid, pneumonia and amoeba are the diseases that affect most people in mine sites in Batouri subdivision. It has also been mentioned that in the process of exploitation, the companies acquire large areas of forest that lead to population displacement.

Plate 6: Open pits and mining activities in Mongonan (A) and abandoned open pits leading to mosquitos (B) and categories of people involved in mining activities : men, women and children (C).
5. CONCLUSION

The rate of change of the rainforest and secondary forest are respectively -0.08% and 0.51%. built-areas including mining settlement shown an increase of 0.03%; it can therefore be concluded that in Batouri, artisanal and small-scale mining, developed both by local miners and companies had led to deforestation. Turbidity and poor quality of water resources expose people around mine site area to some water related diseases. Protection of environment and people in the area require some management strategies including: control and monitoring of deforestation and its evolution; a review of the law or current mining code should be performed. The operator must develop and submit an EIA and an Environmental and Social Management Plan to ensure the protection of the environment during and after the gold mining. For the excavations, holes, land degraded, and sites affected by the activities; proper measures are needed for their maintenance and restoration. Mining activities in the area require the supervision of an interdisciplinary team where the role and actions of different stakeholders are clearly stated. The state must ensure permanent monitoring, compliance and control of mining by a regular environmental audit of each mining company.

6. ACKNOWLEDGMENT

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7. REFERENCES


8. ADDITIONAL READINGS


9. KEY TERMS AND DEFINITION

Spatial analysis refers to the analysis of land use data, usually from aerial photographs or satellite images. It provides information on interactions across space and how variables affect each other over time and space.

Land use and land cover change (LUCC) refers to a conversion from one class to another, for example from grassland to cropping.

Artisanal and small-scale mining refers to all exploitations aimed at extracting and concentrating minerals using manual methods and procedures with the use of little or no mechanization. (Cameroon Mining Code, 2001)