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21st November 2019

Integrating Multispectral Satellite Imagery for Monitoring Land Use and Land Cover Changes in Gatumba Mining Landscape, Rwanda
Study area

Location of the study area. It covers 31,243 Hectares

- Area characterised by extensive opencast mining.
- Gatumba region is rich in mineral resources such as coltan, cassiterite, wolfram and gemstones.
1. Background and Research problem

- Mining activities in Gatumba region are still inadequately developed and the surrounding environment suffers from artisanal and small scale mining practices.

- Lack of proper environmental protection regulations.

- Soil erosion, barren waste rock dumps, and polluted rivers.
2. Research Objectives

The main objective of this study was to analyse the spatio-temporal pattern of land use/land cover changes by determining the main driving forces behind Gatumba landscape deterioration over the period of 1999 to 2015 using multi-temporal Landsat data and to assess the associated environmental impact using qualitative instruments.

The specific research objectives are:

• To analyze the spatial temporal land use/ land cover change induced by mining activities in Gatumba region from 1999 until 2015,

• To determine the driving forces of mining activities and associated land use/ land cover changes in Gatumba region during the period of 1999 until 2015,

• To evaluate environmental impacts of mining activities in Gatumba region.
3. **Data collected:** Remote sensing data

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>Resolution</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat TM</td>
<td>1999</td>
<td>30m</td>
<td>USGS to create land use/land</td>
</tr>
<tr>
<td>Landsat ETM+</td>
<td>2008</td>
<td>30m</td>
<td>USGS</td>
</tr>
<tr>
<td>Landsat OLI/TIRS</td>
<td>2015</td>
<td>30m</td>
<td>USGS</td>
</tr>
<tr>
<td>Aerial Photography</td>
<td>1974</td>
<td>2m</td>
<td>RNRA</td>
</tr>
<tr>
<td>Aerial Photography</td>
<td>2008</td>
<td>0.25m</td>
<td>RNRA</td>
</tr>
<tr>
<td>Aerial Photography</td>
<td>2014</td>
<td>0.50m</td>
<td>RNRA</td>
</tr>
<tr>
<td>Topographic map</td>
<td>1988</td>
<td>1/50,000</td>
<td>RNRA</td>
</tr>
<tr>
<td>Mineral map</td>
<td>1982</td>
<td>1/250,000</td>
<td>RNRA</td>
</tr>
</tbody>
</table>

3. Data collected: truth ground data and training samples

631 ground truth data: 282 points for vegetation; 212 points for bare soil and built up; 133 points for the forest cover and 4 points represented water bodies.
3. Methodology

- Landsat 7 ETM+ (1999),
- Landsat 5 TM (2008),
- Landsat 8 OLI/TIRS (2015)


Classified map with 4 land use/cover classes 1999, 2008, 2015

Classified map 1999, 2008, 2015 with 5 land use/cover classes

A) Layer Stacking, B) Pan-sharpening, C) Subset

Supervised classification: Pixel based approach by Maximum Likelihood algorithm

Training data

Verification data (A)

A) Accuracy assessment: Overall accuracy & Kappa statistics, B) Post image classification.

Vectorized Mining areas for 1999, 2008 & 2015 (B)

Change detection: Time spans matrix


Classified map (2008, 1999, 2015) with 4 land use/cover classes

Classified map (2008, 1999, 2015) with 5 land use/cover classes

3. **Data collected:** Questionnaire administration

- The field observation and questionnaire survey helped to investigate the driving forces of mining activities and the associated environmental impacts.

- Key informants interview facilitated by a Questionnaire:
  - Local leaders at the level of Sector and severally Cell,
  - Elderly people in the area,
  - Working/actual miners,
  - High level managers and miners who used to work in Gatumba region before 2015.
4. Results (1): Trends and pattern of land use/cover in Gatumba

<table>
<thead>
<tr>
<th>Classes</th>
<th>1999 Area in Km²</th>
<th>2015 Area in Km²</th>
<th>Change in</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining area</td>
<td>0.85</td>
<td>0.91</td>
<td>0.06</td>
<td>Increase</td>
</tr>
<tr>
<td>Water body</td>
<td>2.93</td>
<td>2.92</td>
<td>0.01</td>
<td>Increase</td>
</tr>
<tr>
<td>Bare soil and Built up</td>
<td>29.59</td>
<td>9.35</td>
<td>60.67</td>
<td>Increase</td>
</tr>
<tr>
<td>Forest</td>
<td>197.61</td>
<td>62.49</td>
<td>195.82</td>
<td>Decrease</td>
</tr>
<tr>
<td>Crop and Vegetation</td>
<td>100</td>
<td>100</td>
<td>0.00</td>
<td>Total</td>
</tr>
</tbody>
</table>

Total change: 68.42%
4. Results (2): Driving forces of mining activities in Gatumba region

- Economic factor: Good price of minerals
- Human Interaction
- Social factor: Lack of other work that pay sufficiently
- Hydrological factor: Water availability
- Morphological factor: Shallow mineralized pegmatite
- Mineralogical factor: Wide spread mineralized pegmatites
- Gatumba region: History and Locality
4. Results (3): Environmental impacts of mining activities at Gatumba
4. Results (4): Implications of future mining activities on environment at Gatumba mining landscape

- Already the current environment is damaged primary due to mining activities,
- If no proper and serious measures taken and by which will be monitored to be implemented, the nature will turn in chaotic,
- Rivers will continue to be deviated, polluted more to cause diseases, inundations and soil erosion,
- The magnitude of deforestation will increase to induce crops damages and soil erosion accompanied by landslides.
5. Conclusion

- The study highlighted explore the use of hybrid remote sensing based classification methods strengths to monitor mining landscape degradation.

- Results revealed the main driving factors of mining activities, in turn, will form the basis of policy options/decisions for mining sector.

- The study results also can be taken as validation tool for locating mining sites and environmental protection and policies formulation.
Thanks for your attention!