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Analysing influence of abandoned mining sites on land use land cover and the terrain in Jos, Nigeria

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ABSTRACT

This research used Geospatial techniques in analysing the influence of abandoned mining sites on Land Use Land Cover (LULC) and the Terrain in Jos South, Nigeria. Thus, the objectives were to determine how the abandoned mining sites relate to the neighbouring land use and analyse the topography of the terrain in the neighbourhood of the degraded sites. The study analysed abandoned mining (land degraded) sites using multi-sensor satellite imageries of Landsat 8 (2016), SPOT 5 (2012), and SRTM DEM data of the study area. Maximum Likelihood Supervised classifications of land cover and land degradation features using Landsat 8 and SPOT 5 imageries were carried out to determine the area of land that had been affected by mining-induced activities. Finally, detailed terrain analyses such as slope and aspect were carried out. The results of the LULC classification revealed a total land cover of 512.10km^2 with mine ponds occupying about 10.01km^2. Terrain analyses revealed that the spatial location of the degraded sites is irrespective of the terrain because most of the degraded sites occurred because of mining activities; which can be done whether at high or low land. It was however suggested that certain land uses such as block industries, water treatment plants, and fish farms should be sited around the seasonally inundated mine pond.

1. INTRODUCTION

Henssen (2014) defined land as an area of the surface of the earth together with the water, soil, rocks, minerals, and hydrocarbons beneath or upon it and the air above it. It embraces all things which are linked to a fixed area or point on the surface of the earth. Components of land include the soil, vegetation, groundwater, air, wildlife. Each of these components plays a substantial role in bestowing a quality on the land through their interaction with one another (Christopher, 2015).

Proper mining started on the Jos Plateau as far-off as 1902 through Tin and Columbite as the foremost targets (Gyang and Ashano, 2009). The Tin Mining industry on the Jos Plateau has triggered widespread manmade environmental damage, with gigantic tracks of pastoral land systematically ruined in the pursuit of minerals. These activities have negative consequences on the land and hence have instigated environmental degradation in quite a lot of parts of the study area. Some of these dangers affected the environment resulting in land degradation, devegetation, water, and air pollution.

Related researches have been carried out in the past (Jonathan and Joshua, 2013; Edun and Davou, 2013; Adedeji *et al*., 2014; Igbokwe *et al*., 2008; Haruna and Solomon, 2011; and Owolabi, 2020). These research attempts mostly centred on the evaluation of the effects of post-mining activities and gully erosion on the environment.

Bearing in mind the importance of sustainability of any land and the environment in general, and also the rate at which the abandoned mining sites in the study area are affecting the LULC and terrain, this research analysed the influence of Abandoned Mining Sites on Land Use Land Cover and Terrain in the study area, to proffer solutions on how suitable restoration, reclamation, or rehabilitation can be carried out.

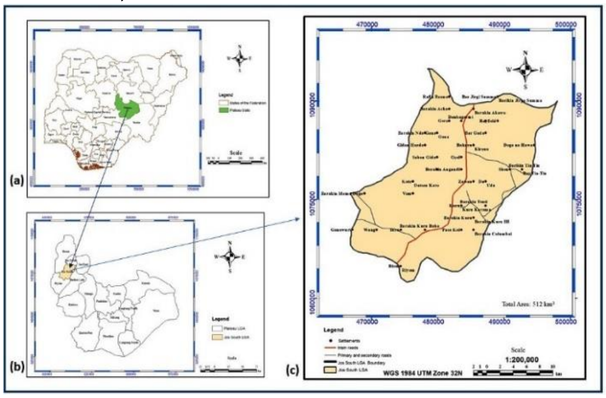

Figure 1: (a)Nigeria (b)Plateau State (c) Jos South LGA (the study area)

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The study area (shown in Figure 1) is the Jos South Local Government area which bounded by Latitude (9°34'22"N to 9°54'40"N) and Longitude (8°39'55"E to 8°59'13"E). It covers a total area of 512 km^2. It has a cool climatic condition known as mountain climate. 18°C is the average mean daily temperature, reaching up to 36^0C.

2. METHOD

2.1 Reconnaissance field survey and Ground truthing

Ground truthing and signature extraction were carried out before the supervised maximum likelihood classification of the merged imagery.

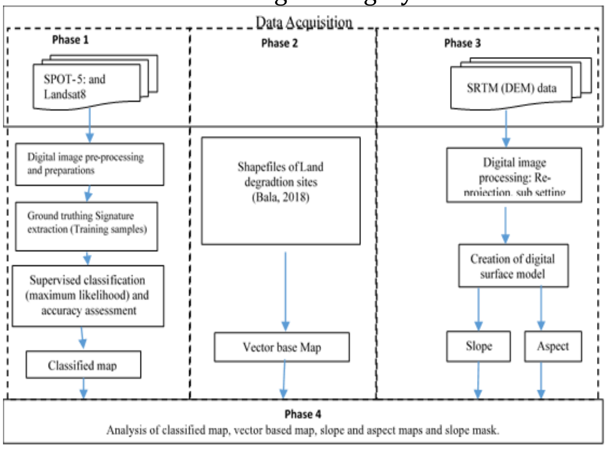


Figure 2: A flow diagram of the steps used in the research (after; Bala, 2018)

2.2 Materials Used

A description of different types of data sets dataset utilised for this research is given in Table 1.

Table 1: Datasets and their sources:

DATA NAME	RESOLUTION	DATA DATE	DATA SOURCE	PURPOSE	DESCRIPTION
SPOT 5	2.5 m	7/12/2012	Office of the Surveyor-General of the Federation	LULC mapping and analysis	3 bands multispectral image: NIR, red and green
Landsat 8: OLI and TIRS	15, 30& 100m	11/2/2016	http://www.glovis.usgs.gov/	Collateral data for LULC mapping	11 bands multispectral image
Digital Elevation Model (DEM)	20 m in both H and V directions	-	Office of the Surveyor-General of the Federation	Terrain visualization and analysis	A raster DEM covering the study area.
Vector files of land degraded sites	-		Bala, 2018	Extracting the land degraded sites	shapefiles
Study area vector file	-	-	National Centre for Remote Sensing, Jos	To demarcate the study area	Jos South local government boundary shapefile

2.3 Image Classification

The merged SPOT 5 and Landsat 8 multispectral images were classified instead of classifying SPOT5 alone because the Landsat 8 is dated 2016 whereas SPOT5 is dated 2012, hence it will be more current to employ both for the classification (Olumide, 2007).

The six (6) identified classes are shown in Table 2.

Table 2: A description of the six adopted land classes

Training sample	Code	Color assign	Description
Mine pond	1	Blue	Land surface occupied by stagnant water body without tributaries which are caused as a result of excavation/mining of earth material e.g. lake
Settlement	2	Red	Commercial, industrial, residential places, etc.
Bare exposed Rocks	3	Gray	Land consisting of rocky and stony materials.
Farmland	4	Lemon	Land occupied or related to agriculture or farming activities.
Bare degraded land	5	Yellowish	A bare surface that consists of exposed excavated earth surface material with no vegetation.
Vegetation	6	Light green	Shrubs and other vegetation that is not used for farming activities.

2.4 Analyses of Terrain in the Neighbourhood of the Abandoned Mining Sites

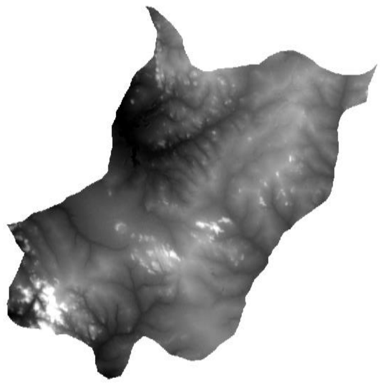


Figure 3: A subset of DEM of the study area

The DEM data scene was clipped to match the study area (see Figure 3). The slope was calculated for each cell in raster images (ESRI, 2017a). Thereafter, the slope and aspect maps were generated based on Eqn. 1 and 2 (ESRI, 2017b).

$$Percent\ of\ slope = (Rise \div Run) \times 100 \quad \text{(Eqn. 1)}$$

$$Degree\ of\ slope, \theta = \tan^{-1}(Rise \div Run) \quad \text{(Eqn. 2)}$$

3. RESULTS

3.1 Analyses of Land Use Classification in the Neighbourhood of Degraded Area

The overall map accuracy and the Kappa coefficient accuracy were 77.82% and 73.16% respectively.

The degradation that affected different land cover types was determined by overlaying the land cover data with the vector files of the abandoned mining sites. Special attention was paid to land cover classes that coincided with degraded areas such as inundation and bare degraded land because such areas represent land cover types that were likely to have been affected by degradation.

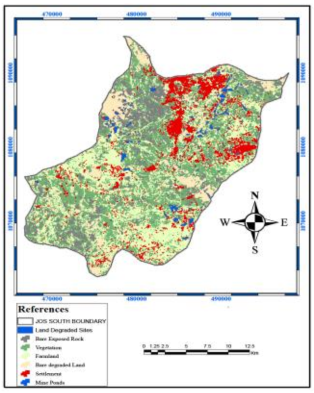
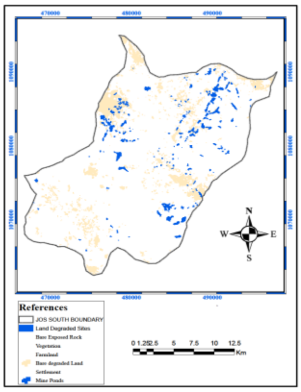



Figure 4: Land cover map; Figure 5: Relationship between Bare Degraded land and Abandoned mining sites

In Figure 4, the settlement areas were concentrated in the central upper part of the area and are shown in red colour. Similarly, the mine ponds (degraded) were dispersed all over the area characterizing where mining activities are taking place. Again, the presence of rocky covers indicated that the study is characterized by steep terrain. Farmlands and vegetation covers are found all over the area and are displayed in light green and green.

In Figure 5, the relationship between bare land cover and degradation is that this land cover is not much influenced by degradation because rock outcrops do not get easily eroded or excavated, except where quarry activities (blasting and crushing) are carried out turning this land cover to big gullies and inundated due to rainfall.

Table 3: LULC distribution of the fused imagery

LULC CLASS	AREA (Km^2)	AREA (%)
Mine pond	10.0052	1.95
Settlement	35.7792	6.99
Exposed Rock Outcrop	212.809	41.56
Farmland	92.9401	18.15
Bare degraded land	38.4006	7.50
Vegetation	122.163	23.85
TOTAL	**512.0971**	**100**

Source: (Geomatic Department, ABU Zaria, 18/6/2018)

Mine ponds and bare degraded lands account for a total of 9.45%, these are the most obvious land degraded covers with less economic activities going on (Table 3).

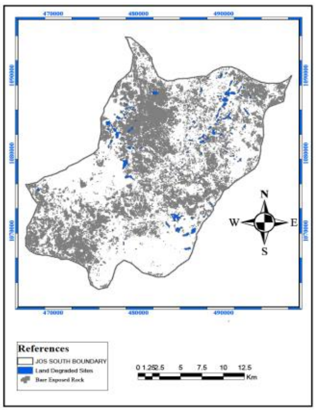
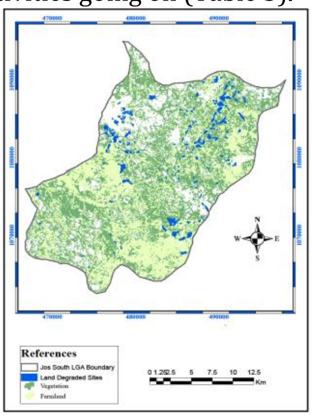



Figure 6: rock outcrop & Abandoned mining sites; Figure 7: Vegetation, Farmland &Abandoned mining sites

The rock cover in Figure 6 is largely spread across the area and covered a total of 41.56%. This land cover could be referred to as degraded areas because it is barren and agricultural activities are seldom carried out. Some areas are turned into quarry areas where rocks are blasted and crushed for economic purposes.

In Figure 7, farming activities make the topsoil susceptible to erosion. This results in gulling as witnessed in many parts of the areas. Also, some farmlands have been disturbed due to tin mining activity. Also, large portions of the vegetation cover are cleared annually for farming purposes and searching for minerals, resulting in vegetation degradation, deforestation, and severe damage.

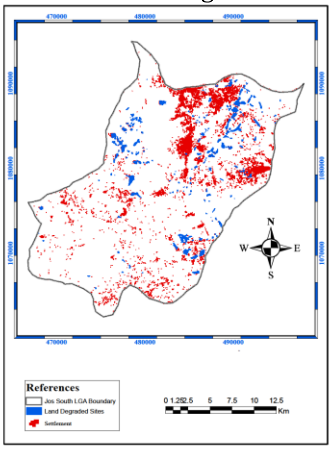


Figure 8: Relationship between Settlements and Land degraded sites

In Figure 8, settlements are not properly planned; some houses are built indiscriminately near the abandoned mine pits without due consideration to dangers such may posit. Most of the area is rocky hence houses cannot be constructed easily.

3.2 Analyses of the Terrain in the Neighbourhood of the Degraded Sites

The high elevation of the area contributes to land degradation because when heavy rainfalls, water moves from the upstream carrying sediments down the lowland. The resultant high overflow on the steep slopes aggravates soil erosion and ultimately causes the land cover to depreciate resulting in degradation of the area.

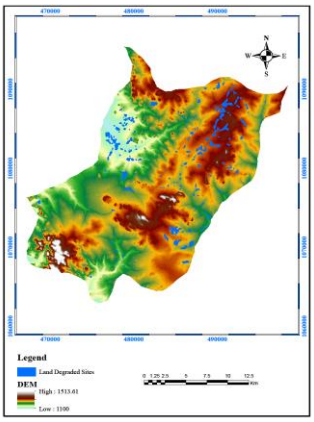
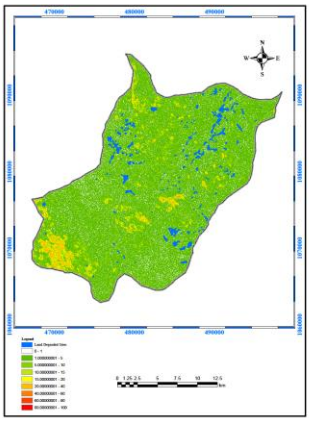
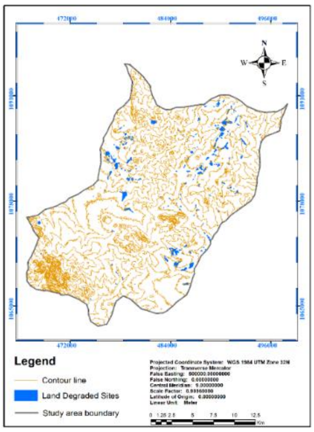



Figure 9: Overlay Maps (Degraded Sites & DEM); Figure 10: Slopes derived from DEM

Figure 9 is the overlay of the digitized degraded sites on the elevation model. This revealed the abandoned mining ponds spread randomly in the study area. It can be observed that the spatial location of the sites is irrespective of the elevation.

The slope map in Figure 10 shows the configuration of the terrain in terms of depth and height. It implied that land covers with depths (e.g. derelict ponds) have slope values of 0 to 0.99, which further describes that the study area is characterized by excavated surfaces, gully, and abandoned mines that have become derelict ponds (filled with water and stagnant).



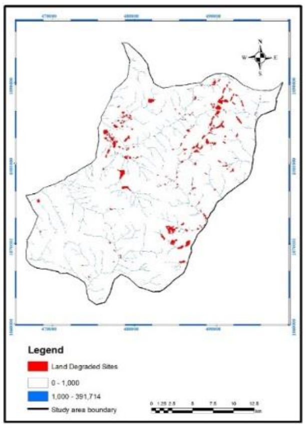


Figure 11: Degraded sites overlaid on contours; Figure 12: Degraded sites overlaid on the flow accumulation

From Figure 11, the spatial location of the sites is irrespective of the contour values as some sites are located on a steep slope while others are on a gentle slope.

Figure 12 shows the stream networks derived from flow accumulations. It is observed that most of the stream networks were connected with the degraded sites which proves the fact that most of the degraded sites are seasonally inundated.

4. DISCUSSION

The high elevation of the area contributes to land degradation which affects the LULC. In addition to elevation, slopes that were affected by degradation were identified because mountain surfaces inherently have steep slopes. The steepness of the slope is significant in the study of land degradation mainly because of the impacts of soil erosion caused by water on the slopes. Most of the degraded sites occurred as a result of mining activities; the major condition or criteria for mining minerals is its availability hence mining activities can be done whether at high or low land.

5. CONCLUSION

The study has effectively analysed the influence of Abandoned Mining Sites on Land Use Land Cover and Terrain in the study area using existing abandoned mining sites vector files, maximum likelihood supervised classification and digital elevation model data. The study revealed that the spatial location of the degraded sites is irrespective of the terrain because most of the degraded sites occurred as a result of mining activities; which can be done whether at high or low land. There are certain appropriate LULC in the neighbourhood that could be utilized productively, for example, block industries, water treatment plants, fish farming, and other economic activities should be sited around the seasonally inundated mine pond, so that they can be more useful.

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REFERENCES

Adedeji, O. H., Adebayo, H. O. and Sotayo, E. I. (2014). Assessment of Environmental Impacts of Inland Sand Mining in Parts of Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies* and *Management, 5*(7).doi:http://www.dx.doi.org/10.4314/ejesm.v7i5 .2Bala, A. (2018) "Geospatial Analyses of Land Degradation Sites in Jos South LGA of Plateau State". M.Sc. thesis submitted to the Ahmadu Bello University, Zaria. Available on http://kubanni.abu.edu.ng/jspui/handle/123456789/11107

Christopher O. A. (2015). Land-Use management. Available on http://www.unaab.edu. ng. Accessed on 17th June, 2015.

Edun, E. O., and Davou, D. D. (2013). Inventory of Abandoned Mine Ponds/Dams on the Jos-Bukuru North-Central Nigeria Using G.I.S and Remote Sensing Technique. *The International Journal of Engineering and Science*, *2*(5): 62-71.

Environmental System and Research Institute (ESRI) (2017a). *How Slope Works.* ESRI ArcGIS Desktop help.

Environmental System and Research Institute (ESRI) (2017b). *How Aspect Works.* ESRI ArcGIS Desktop.

Gyang, J.D, and Ashano, E.C (2009). Effects of Mining on Water Quality and the Environment; a case study of parts of the Jos Plateau, North Central Nigeria. Continental *Journal Environmental Sciences, 3:* 33-42.

Haruna, M.D. and Solomon J.N. (2011). An Assessment of Mining Activities Impact on Vegetation in Bukuru Jos Plateau State Nigeria Using Normalized Differential Vegetation Index (NDVI). *Journal of Sustainable Development, 4*(6). doi:10.5539/jsd. v4n6p150

Henssen, J. (2014). *Basic Principles of the Main Cadastral Systems in the World*. Retrieved from https://www.fig.net/commission7/reports/events/delft_ seminar_ 95/paper2.html. Accessed on 23rd. September, 2020.

Jonathan O. and Joshua B. (2013). Geospatial application in mapping gully erosion sites in Jos, Plateau State, Nigeria. *Journal of Scientific Research and Essay (SJSRE)*, *2* (6): 85-95.

Olumide, M.A. (2007). *Land use and land cover change detection with remote sensing and GIS at metropolitan Lagos, Nigeria (1984-2002).* Leicester, England: ProQuest LLC.

Owolabi, A. (2020). Assessment of Terrain and Land Use/Land Cover Changes of Mine Sites using Geospatial Techniques in Plateau State, Nigeria. *Journal of Mining and Environment (JME), 11(4): 935-948. DOI: 10.22044/jme.2020.9668.18*