Sahel Journal of Geography, Environment & Development Vol. 2 No. 2 December, 2021

ISSN: Online: 2756-536X www.saheljournalofgeography.com.ng Print: 2756-5378

Effects of Artisanal and Small-scale Mining on Land Use and Land Cover in Awe, Nasarawa State, Nigeria.

Madaki, J. A.[1], Suleiman Y. M.[1], Yahaya, T. I.[1] and Waziri, N. M.[2]

[1]Department of Geography, Federal University of Technology Minna, Niger State. Nigeria.

[2]Department of Geology, Federal University of Technology, Minna, Niger State. Nigeria.

Corresponding author's e-mail: josemadaki@gmail.com

ABSTRACT

Land use and land cover impact on the local, regional and global environment. Therefore, this paper assessed the effects of artisanal and small-scale mining on land use and land over (LULC) in Awe, Nasarawa State. Specifically, the objectives of study entailed a time series analysis of LULC between 1986, 1996 and 2006 using LandSat 4 TM, LandSat 7 ETM$^+$ and LandSat8 (OLI). Major land use classes used to determine changes in land use/ cover are built-up area, vegetation, farmlands, mining pits and water bodies. These were classified using the Maximum Likelihood Classifier. Results obtained are summarised using descriptive statistics and presented in tables and charts. The results show that major changes were observed in the built-up area, mining area and farmland land use and land cover types. Findings showed an upward trend in built-up areas from 157km^2 (6.3%) in 1986 to 371 km^2 (14%) in 1996, 413 km^2 (16%) in 2006 and 616.5 km^2 (24%) in 2016. Similarly, mining areas increased from 5.23km^2(0.21%) in 1986 to 18.15km^2 (0.71%) in 1996, 34.191km^2 (34.2%) in 2006 and 105.3km^2 (4.1%) in 2016. However, farmlands declined consistently from 1445.5km^2 (57%) in 1986, 1002.5km^2 (37%) in 1996, 954km^2 (37%) in 2006 and 751.8492km^2(29.3%) in 2016. It is concluded that land use and land cover changes as well as uncontrolled mining activities contribute to the existing environmental deterioration in the study area. Therefore, there is a need to implement and enforce sustainable mining methods, effective monitoring of mining activities through strict adherence to the country's EIA standard and proper management of land resources.

Keywords: Artisanal, Geographic Information System, mining, resources.

1. INTRODUCTION

Mining is a major economic activity in many developing countries and has attracted much attention worldwide as many people are involved in it and several economies are affected by it (Alvarez-Berríos *et al.,* 2015; Dougherty, 2011). The 1990s saw significant shifts in global investment flows in mining, resulting in changes in national regulatory frameworks in over 90 countries worldwide (Alvarez-Berríos *et al.,* 2015; Dougherty, 2011). However, mining is seen as a blessing or a curse depending on how an area, group, community or country is impacted by the activities and processes of exploitation of the resource in question (Kitula, 2006).

An estimated 13-20 million men, women, and children from over 50 developing countries are directly engaged in the artisanal mining sector (Hilson, 2002). The conservation of forests is also a great concern as many artisanal mining operations take place in and around forests that are home to a vast number of biodiversity. One assessment indicates that almost three-quarters of active mining and exploratory sites overlap with high conservation value and high watershed stress areas (Ford *et al.,* 2010). It has also been reported that some mining operations also work within environmentally protected areas (Ford *et al.,* 2010). During mining activities, large vegetation is cleared and huge pits dug to obtain the rocks rich in mineral resources (Ford *et al.,* 2010; Nzunda, 2013). The continuous extraction of natural resources leads to the direct loss of the forest, damage to the forest land and removal of fertile topsoil layers, resulting in the shortage of fuel wood, grazing areas and increase in soil erosion and air pollution (Nzunda, 2013). This situation negatively affects people living within the mining areas (Nzunda, 2013). Furthermore, the dumping of waste rocks in un-mined environments cause disturbances to the surrounding ecosystem, affecting the area's biodiversity and changing the area's natural topography (Kitula, 2006; Nzunda, 2013).

The increase in global demand for mineral resources such as byrates, gold, diamond, bauxite and coal have stimulated new mining industries, including multinational companies and small-scale miners throughout the world (Bury, 2004). For example, mining activities in various forest belts are likely to increase in Ghana as the global demand and prices increase (Alvarez-Berríos *et al.,* 2015). Accurate information is therefore needed on the rate and impact of mining activities on forest areas since these activities occur within remote forests and affect biodiversity (Alvarez-Berríos *et al.,* 2015). Protecting the environment is one of the critical global challenges for humans due to factors such as population increase, depletion of natural resources and pollution (Study and Zanjan, 2009). The unplanned changes in land use have become a major problem because of the absence of logical planning and consideration of environmental impacts (Study and Zanjan, 2009).

For the past decades, Remote Sensing (RS) and Geographic Information System (GIS) technologies have been vital tools for mapping the Earth's features, studying environmental changes in time and space and managing natural resources. This gives the most accurate means of measuring the extent and pattern of the changes at a particular landscape over time (Kumar and Pandey, 2013). This technology affords a practical means of analysing the changes in the land use pattern at mine sites at inaccessible places. It has also become possible to get a synoptic coverage of a larger area cost-effectively and repetitively (Nzunda, 2013). Assessing land use and land cover change has become a central component in the current strategies for managing natural resources and monitoring environmental changes (Mark and Kudakwashe, 2010). Land cover change detection has been found applicable in land use change analysis, especially in assessing the extent of deforestation in a particular area. Therefore, the focus of this research is to assess the effects of artisanal and small-scale mining activities on land use and land cover changes in Awe, Nasarawa State, Nigeria. Specifically, the objectives include assessing the extent of land use and land cover changes from multi-temporal LULC data (1986, 1996, 2006 and 2016) and establishing a relationship between changing land use/cover change and effects of mining in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

The geographical entity known as Nasarawa State came into existence in October 1996 (Binbol and Marcus, 2010). It is located in the middle belt region of Nigeria and lies between latitude 7° 45' and 9° 25' N and between 7° 29' and 9° 37' E. It shares boundaries with Kaduna State in the North, Plateau State in the East, Taraba and Benue States in the South, Kogi and Federal Capital

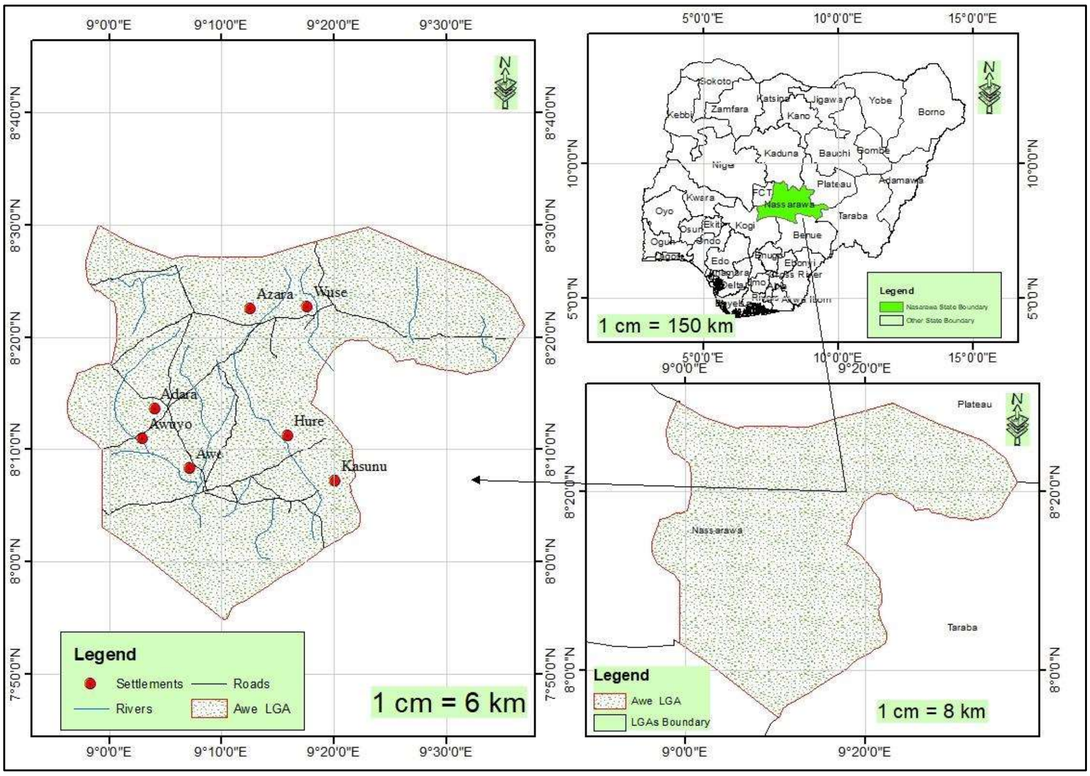

Figure 1: Geographical Location the Study Area
Source: *Nigeria Geological Survey Agency (NGSA), 2019.*

territory in the West. The state has a total landmass of 27,138.8 km^2 and an estimated population density of about 67 persons per km^2 (Mamman *et al.,* 2000). Awe Local Government Area of Nasarawa State has an altitude of 181.5m above sea level (Obaje *et al.,* 2006)**.** Awe is characterized by sub-humid tropical climate (Binbol, 2007; Lyam, 2000) with two distinctive rainfall seasons with the wet season beginning from April and lasting still the ends in October (Lyam, 2000). The rainfall in the area ranges from about 1100mm to 2000mm with 90% of the rainfall within the months of May to September. The rainfalls usually come with thunderstorms and high intensity at the onset and towards the termination of the rainfall season (Lyam, 2000).

The mean annual temperature is high with the highest temperature recorded from January to March. A single maximum temperature is achieved in the month of March when maximum temperatures can reach 39°C. Minimum temperature on the other hand can drop to as low as 17°C in December and January. Rainfall ceases by the end of October when a further decline in temperature in the area is made possible in November/December by the coming of the harmattan winds. The relative humidity in the study area rises from February to a maximum of about 88% in July. Steady rains commence in April, when the relative humidity will be at about 75%. During this period, the southern part of the state comes under the influence of the humid maritime air mass. The study area is geomorphologically within the upward Awe formation which consists of transitional sandstone, shale, siltstone and limestone and the fluviatile sandstone of the Keana Formation. The Azara area forms part of the north-eastern limb of the Keana anticlinorium. The barite deposit in Azara occurs as hydrothermal veins within the cretaceous Keana sandstone of the middle Benue Trough (Benkhelil, 2000; Obaje*et al.,* 2005).

The predominant soil parent materials in the area are derived from cretaceous sandstones, siltstone, shale, limestone and ironstone of undifferentiated basement complex. These rocks are frequently overlain by gravely lateritic iron pans probably formed in the late tertiary era associated with concretion gravels and accumulation of alluvial deposits in rivers flood plains. The climatic phenomena and rock grade have yielded different soil types (Chaanda *et al.,* 2010). In the study area, the vegetation type is dominantly characterized by the southern Guinea Savanna and some elements of the northern Guinea Savanna (Chaanda *et al.,* 2010). The vegetation is derived from temperate deciduous woodland which existed centuries ago, interspersed with thickets, grassland tree savannah, and fringing woodland or gallery forests along the valleys. (Aboki *et al.,* 2007). The dominant woody species in this area include *terminalialaxiflora, albiziazygia, ficus exasperate, ficussyncomorous, khayasenegalesis, tarmarindusindica* (tsamiya*), parkiabiglobosa (*doruwa), *vitellariapradoxa (kadanya, or* shear butter*), vitexdoniana (*dinya*), Annona sengalensis* (Aboki *et al.,* 2007). The major crops produced include yam, cassava, melon, guinea corn and other grains in large quantities for both consumption and trade. A substantial number of nomads reside in the area and are the main suppliers of milk, butter, hides and skin. The indigenous people are mainly farmers and the Hausas are petty traders. The Ibo and Yoruba are mainly traders in utensils, automobiles and building materials.

2.2 Data Collection and Analysis

2.2.1 Assessment of Land Use and Land Cover Changes

The Land use and land cover change in Awe between 1986, 1996 and 2006 and 2020 was determined using remotely sensed data and GIS for changes of the four time periods. Table 1 summarizes the characteristics of the imageries used for the study.

The data sets from LandSat 4 TM, LandSat 7 ETM$^+$ and LandSat8 (OLI) were selected based on the date of acquisition and availability. The images were of the same season; free from cloud cover and have the same identifiable features to prevent bias in the data. This gives uniform radiometric and spectral characteristic which help reduce or prevent seasonal variations in the spectral reflectance of the land cover data-sets (Nzunda, 2013). Also, the imageries were geo-referenced to the coordinate system of the study area, i.e. WGS84 projection; UTM zone 32N. Idrisi Terrset was used to develop

Table 1: Characteristics of the Images used for the Study

Date of Acquisition	Sensor	Path	Row	Multispectral Band	Thermal Band	Spectral Range (micrometers)	Spatial Resolution (pixel spacing)	Source
1986	TM	188	54	1to5 and 7	6	10.45-12.45	30	glovis.usgs.gov
1996	TM							glovis.usgs.gov
2006	ETM+	188	54	1to5 and 7	6	10.45-12.45	30	glovis.usgs.gov
2020	OLI and TIRS	188	54	1to7 and 9	10 and 11	10.60-12.51	30	glovis.usgs.gov

land use and land cover maps for the study area, while ArcGIS 10.3 was used to develop, display, and process the location maps.

The methods used to process the imageries for this study were image extraction of study area of interest (AOI), image restoration/pre-processing, image enhancement and image classification. Since the imageries acquired were already geo-referenced from the World Geodetic System (WGS84), they were re-projected to the coordinate system of the study area, i.e. Universal Transverse Mercator (UTM) zone 32 North for Nigeria using ArcGIS version 10.8. Radiometric restoration removes or suppresses the degree of spectral differences from each detector, distorting the imagery. These distortions are striping, scan line drop-out and atmospheric haze (Jensen, 2014). The scan lines in the imagery were removed using the gap-fill method in ArcGIS version 10.3. Image enhancement deals with modifying or improving the quality of the imagery, making it more suitable as perceived by humans. In order to improve the visibility of the imagery, a colour composite for the imageries was established using Landsat TM bands 4, 3 and 2 (i.e. Near-infrared, Red and Green), which gave a false colour composite. The imageries were then classified using the supervised classification method. This method involves extracting land cover information from the imagery, mostly referred to as clustering. The main objective for classification was to produce land cover classes that resemble the actual land cover types on the earth surface (Kashaigili and Majaliwa, 2010).

A total of five land use categories were adopted for the study. The supervised classification was based on the use of a Maximum likelihood classification scheme with five (5) land use and land cover classes (built-up area, vegetation, farmlands, mining pits and water bodies). Results obtained are summarised using descriptive statistics.

3. RESULTS AND DISCUSSION

3.1 Land Use and Land Cover Changes (1986-2016)

Figures 2, 3, 4 and 5 are classified LULC cover maps of the study area, while Table 2 shows the statistics derived from the classifications. The results show that the dominant land use/land cover in 1986 is farmland. It covered about 1445.4km^2 (58%) of the area. This is followed by vegetation which covers an area of 861.144 km^2 (34.53%) of the total landmass of the area. Most of the vegetation cover can be found in

Table 2: Land use and land cover Distribution of Awe (1986, 1996, 2006 and 2016)

LULC	1986		1996		2006		2016	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Built-up	157.554	6.32	371.6793	14.50	413.4087	16.13	616.5117	24.06
Vegetation	861.1443	34.53	1136.942	44.36	1127.579	44.00	1055.744	41.20
Farmland	1445.425	57.95	1002.483	39.12	954.0045	37.23	751.8492	29.34
Mining pit	5.2578	0.21	18.1557	0.71	34.191	1.33	105.3369	4.11
Water body	24.7887	0.99	33.282	1.23	33.3045	1.23	32.9949	1.29
Total	2562.4629	100	2562.4629	100	2562.4629	100	2562.4629	100

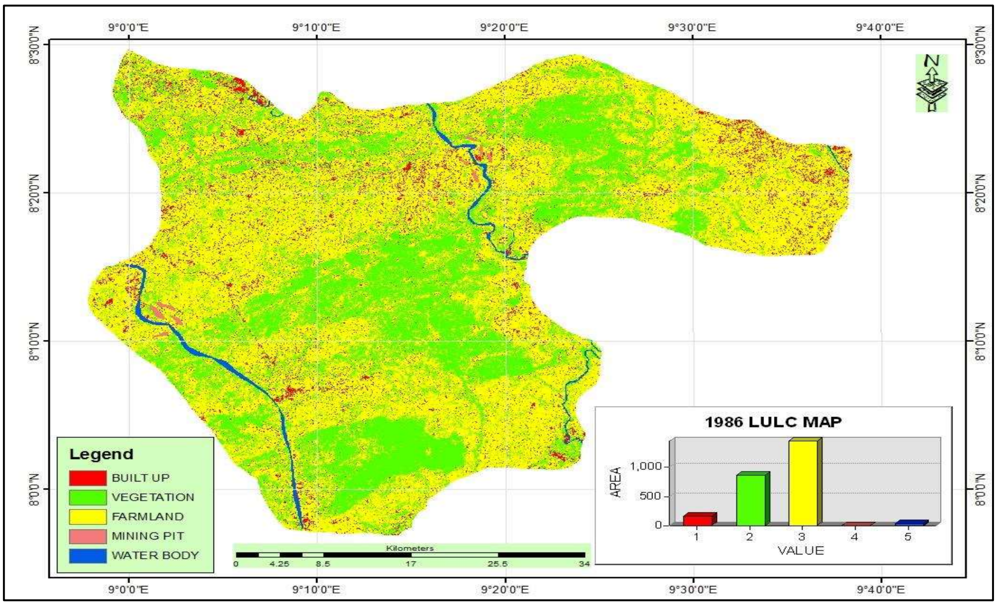

Figure 2: Land Use and Land Cover Classification (LandSat 4 TM, 1986)

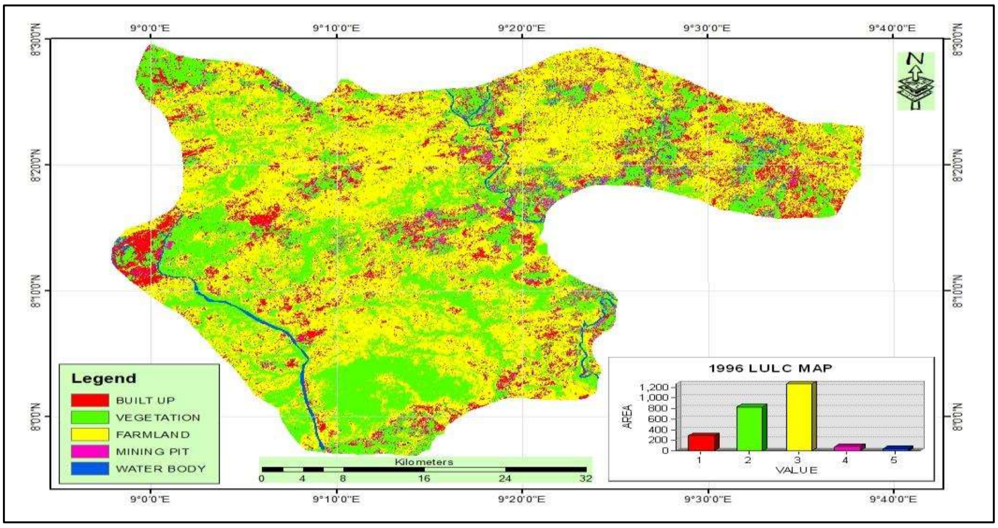

Figure 3: Land Use and Land Cover Classification (LandSat 4 TM, 1996)

the northeastern, central, and southern parts of the study area.

The built-up areas accounted for about 157.6 km^2 (6.32%) and were concentrated around the eastern and western banks of the river. Also, mining pits occupied 5.2578 km^2 (0.21%) while water bodies covered 24.7887 km^2 (0.99%). In 1996, farmland area increased to 1263.2km^2, vegetation occupied 826.9 km^2, while built-up areas increased to 289.2 km^2. Mining pits and water bodies covered about 79.35 km^2 (3.17%) and 40.314 km^2 (1.61%) respectively. However, 2006 witnessed a drastic decrease in farmland areas (954km^2) and vegetation land use (1127.5 km^2), indicating a decrease in farming activities. The built-up area and

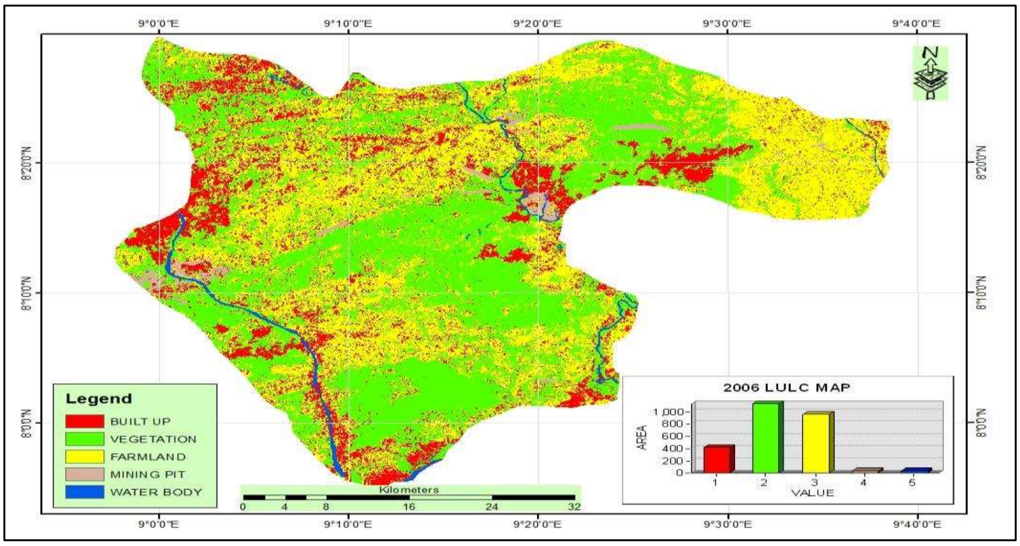

Figure 4: Land Use and Land Cover Classifification (LandSat 7 ETM+ , 2006)

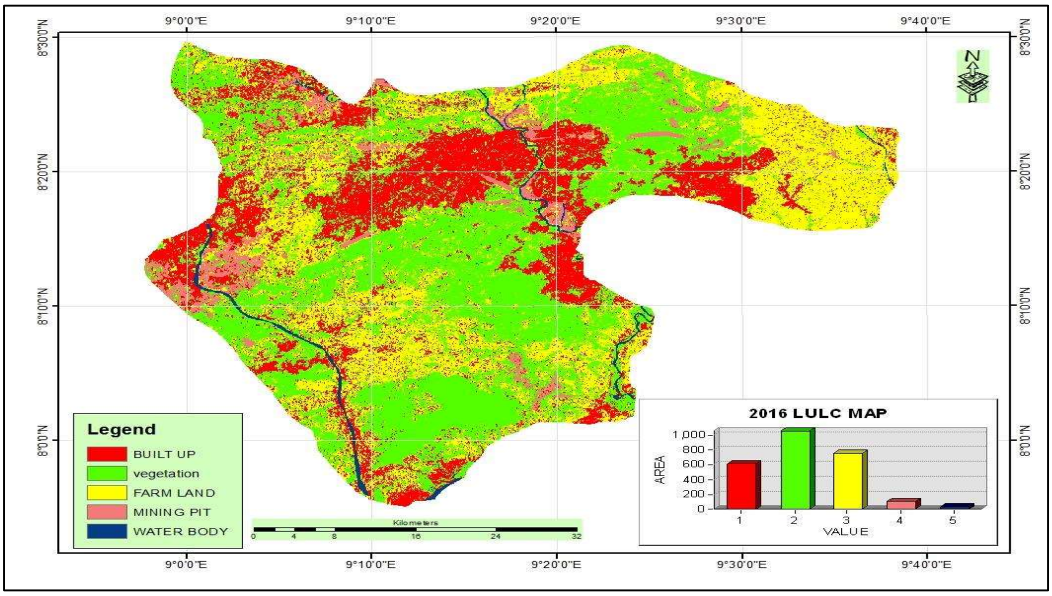

Figure 5: Land Use and Land Cover Classifification (LandSat8 OLI, 2016)

mining pits maintained a consistent gain at 413 (16%) and 34km^2 (1.33%).

The results of LULC classification in 2016 indicate that major changes are in the built-up area, farmlands and mining pits. Vegetation land use type remains the most dominant land use and the land cover type, covering an area of 1055.7 km^2 (41.2%) in 2016, farmland occupied an area of 751.8 km^2 (29.34%) while the built-up area increased to 616.5km^2(24.06%), a gain of 211.2km^2(8.25 %) within the study period. This may be attributed to the conversion of other land use and land cover types to build-up due to influx of people. Similarly, gains were recorded in mining pits as the areal coverage increased to 105.3km^2(4.11%) in 2016.

3.2 Spatial Distribution of Mining Sites in the Study Area

The spatial distribution of mining sites in the study area is shown in Figure 6. The mining sites also correspond with degraded lands in the study area. The specific locations include Abuni and Azara mining sites, Saunin Sarki where Baryte is mined, Sohon Rami (glass), Vein 17 (Baryte and iron), River Wuse site (Baryte), Akiri mine (Baryte with shoots of copper, charcoal and salt), Vein 2 (iron abandoned), Vein 18 extension (Baryte abandoned), Vein 1 (mix of Baryte and sandstone) while kanji copper site is abandoned. This agrees with the work of Atayi *et al*., (2016) on the effects of large-scale mining on land use and land cover changes in the Brong-Ahafo Region of Ghana. Their findings indicate a high level of land degradation due to ASM activities.

Similarly, the consistent increase in the built-up areas and mining pits and decrease in vegetation land use and land cover type is indicative of increased human population and economic activities such as mining (Atayi *et al*., 2016). Though mining activities have been found to boost a country's economy, these activities however, result in environmental degradation (Nzunda, 2013; Atayi *et al*., 2016) through excessive vegetation clearance. The findings are in agreement with Opoku-Ware (2010); Pandit, (2011); Kumi-Boateng *et al.,* (2012) and Nzunda, (2013), who concluded that increase in populations, mining activities and the changes in the land use/land cover were mutually related to each other.

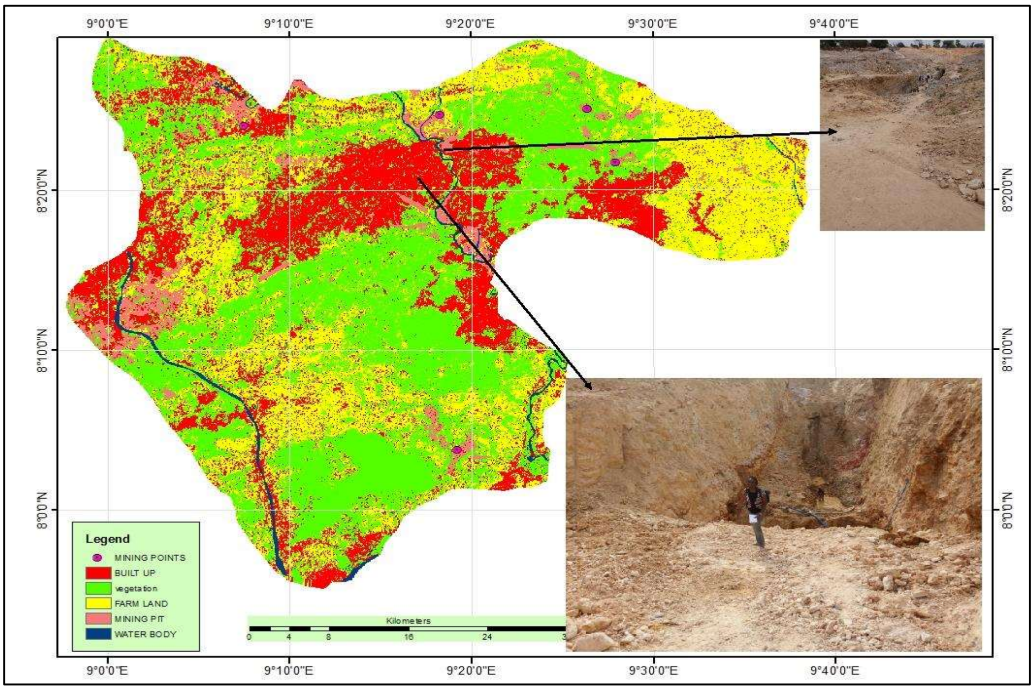

Figure 6: Geo-Tagged image of degraded lands in the study area.

4. CONCLUSION

The study assessed the effects of artisanal and small scale mining on land use and land cover in Awe, Nasarawa State, Nigeria. The study focused on land use and land cover changes between 1986 and 2016. The results showed that the dominant land use and land cover changes were in the built-up area and mining areas. Findings showed an upward trend in built-up areas from 157km^2 (6.3%) in 1986 to 371 km^2 (14%) in 1996, 413 km^2 (16%) in

2006 and 616.5 km^2 (24%) in 2016. The mining pits increased consistently and occupied 105 km^2 in 2016. It is concluded that land use and land cover changes as well as uncontrolled mining activities contribute to the existing environmental deterioration in the study area. Therefore, there is a need to implement and enforce sustainable mining methods, effective monitoring of mining activities through strict adherence to the country's EIA standard and proper management of land resources.

REFERENCES

Alvarez-Berríos, Nora, L and Mitchell Aide, T. (2015) Global demand for gold is another threat for tropical forests. *Environmental Research Letters*. 10 (1), 014006.

Anderson, J. R. (1976). *A land use and land cover classification system for use with remote sensor data*. (9), 64. US Government Printing Office. Washington, D.C. P.

Apam, S (2014). *Impacts of Small Scale Mining on Rural Livelihoods: The Case Study of Amansie West District-Ashanti*. Doctoral Dissertation, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Atayi, J., Kabo-bah, A and Akpoti, K (2016). The effects of large-scale mining on land use and land cover changes using remotely sensed data 1. *International Journal of Science and Nature*. 7, 724-733.

Binbol, N. L and Marcus, N. D. (2010). Geography of Nasarawa State: A Study of Flora and Fauna.

Bridge, G (2004). Contested terrain: mining and the environment. *Annu. Rev. Environ. Resour.*, 2(9), 205-259.

Bury, J. (2004). Livelihoods in transition: transnational gold mining operations and local change in Cajamarca, Peru. *Geographical Journal*, 170 (1), 78–91.

Dougherty, M. L. (2011). The global gold mining industry, junior firms, and civil society resistance in Guatemala. *Bulletin of Latin American Research*, *30* (4), 403-418.

Ford, J. D., Pearce, T., Prno, J., Duerden, F., Ford, L. B., Beaumier, M and Smith, T. (2010). Perceptions of climate change risks in primary resource use industries: a survey of the Canadian mining sector. *Regional Environmental Change*. 10 (1), 65-81.

Hilson, G. (2002). Small-scale mining and its socio-economic impact in developing countries. *Natural Resources Forum.* 26, (1), 3-13.

Jensen, J.R. (2014) Introductory Digital Image Processing (3rd edition). New Jersey, USA: A Remote Sensing Perspective.

Kashaigili, J.J. and Majaliwa, A.M. (2010). Integrated assessment of land use and cover changes in the Malagarasi river catchment in Tanzania. *Physics and Chemistry of the Earth*, Parts A/B/C, 35(13), 730–741.

Kitula, A. G. N. (2006). The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District. *Journal of cleaner production*, *14*(3), 405-414.

Kumar, A. and Pandey, A. (2013) Evaluating Impact of Coal Mining Activity on Landuse / Landcover Using Temporal Satellite Images in South Karanpura Coalfields and. *International Journal of Advanced Remote Sensing and GIS*. 2(1), 183–197.

Mark, M. and Kudakwashe, M. (2010). Rate of Land-Use/ Land-Cover Changes in

Shurugwi District, Zimbabwe: Drivers for Change. *Journal of Sustainable Development in Africa*, 12(3), 107–121.

Nzunda, H. P. (2013). *Impacts of mining activities on land cover and forest stock in Mbozi district, Mbeya region*, Tanzania. Doctoral dissertation, Sokoine University of Agriculture.

Opoku-Ware, J. (2010). *The social and environmental impacts of mining activitieson indigenious communities: The case of Newmont Gold (Gh) limited (Kenyasi) in Ghana.* Master's thesis, Universitetet i Agder, University of Agder.

Pandit, S. (2011) Forest Cover and Land Use Changes: A Study of Laljhadi Forest (Corridor) Far-Western Development Region, Nepal. Tribhuvan University.

Study, A.C. and Zanjan, O.N. (2009). Evaluation and forecast of human impacts based on land use changes using multi-temporal satellite imagery and GIS: A case study on Zanjan, Iran. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 38(2), 548–55