Assessing Land Degradation in Amansie West District: A Surface Mined Area in Ghana

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Abstract

The Amansie West District is characterized by extensive land degrading activities. The district has become a nexus for vast illegal small-scale mining activities, thus affecting the sustainability of other land uses. It is thus imperative, that the land use land cover (LULC) trends over the years be monitored. This would aid assessment of changes over time and their future impacts on resources in the district. The study examined the LULC changes in the district with surface mining as a driver of change. Landsat images of 30m resolution for 1986, 2004, and 2015 were taken for Amansie West District in the Ashanti Region of Ghana. The images were classified using the Maximum Likelihood Classification. Verification was done using 200 ground truth points collected on-site and from Google Earth. The results showed changes in the Spatio-temporal distribution of LULC in the District over 30 years (1986–2015). The dominant LULC changes are from forest to farmland and farmland to mines for 30 years. In addition, there were losses from farmland to mines from 2004–2015. Farmland and forest were the dominant LULC types of the study area which made up 54.6% and 43.6% respectively for 1986, and likewise 54.4% and 22.3% for 2015. However, the forest cover was reduced drastically by 21.3% in 2015. The main drivers of land degradation were farmland from 1986–2004 and mines from 2004–2015. The study emphasizes the need for local-level studies by exposing the extent of the damage for effective future land use management.

Introduction

LULC changes fueled by anthropogenic activities, to meet basic needs of food, shelter, and clothing contribute to natural resource degradation (Dewan & Yamaguchi, 2009; Lambin, Geist, & Lepers, 2003; Ouedraogo et al., 2010). LULC change detection with the help of Remote Sensing and Geographic Information System (GIS) techniques; is very essential to various stakeholders of natural resources (Yeboah, Awotwi, Forkuo, & Kumi, 2017). Like all other developing countries, Ghana depends on its natural resource base for economic development (Mensah & Okyere, 2014). This has had several consequences on environmental quality and productivity. In a bid to bridge the gap between the needs of the human populace and environmental quality, sustainable development goals (SDGs) were enacted and accepted globally to serve as guides for action. Over the years, forested lands have been cleared for infrastructural development, settlements, industries, and agriculture (Braimoh & Vlek, 2004; Lambin et al., 2003; Ouedraogo et al., 2010)

However, in recent years surface mining has become a major threat to environmental quality since the advent of the investment code in 1986 (Peprah, 2002). The goal of the code was to attract foreign investors and enhance economic diversity from total dependence on a few primary commodities exports. This led to the complete modification of the mining sector and surface mining was given the liberal foundation to operate through tax exemptions and holidays (Peprah, 2002). This modification enhanced the sprawl in mining. However, contrary to expectations, the contributions of mining to economic growth are minimal, reflected least in mining communities. The Provisional 2017 Annual Gross Domestic Product published by the Service (2014); shows a higher gross domestic product (GDP) of 5.9% for mining and quarrying. However, oil was the major contributor with a percentage of 5.6; with mining contributing only 0.3%. Agriculture, on the other hand, had a GDP of 18.3% with crops, livestock, forestry, and logging, and fisheries contributing 14.2%, 1.8%, 1.1%, 1.9%, and 1.2% respectively. Though industrial contribution to GDP (25.5%) is higher than agriculture, all subsectors of agriculture have percentage GDP values that far exceed that of mining. Thus, the exploitation of natural resources like gold, bauxite, and aluminum, though essential to human livelihoods and national economic growth, cannot serve as substitutes for food resources (Ocansey, 2013; Rios, 2021).

Aside from its shortfall in contributing to economic development, surface mining (mostly illegal) has directly affected various natural resources and human livelihoods. Land degradation predominates illegal small-scale mining operations; since miners work without a permit, have no concessions of their own, and operate uncontrollably (Aryee, Ntibery, & Atorkui, 2003) with no obligation in regards to environmental quality and safety; since such activities are unmonitored. Large tracts of forested lands have been cleared indiscriminately due to illegal mining activities (Baah, Foli, Gikunoo, & Gidigasu, 2022). Natural resources like forest lands have been cleared, extraction of minerals along major river bodies Obodai, Adjei, Odai, and Lumor (2019) making it unfit for human consumption and lands mined left without reclamation (Ocansey, 2013). Many small-scale farmers are left without a source of livelihood. Most farmers sell their farms for mining since it is more lucrative, and others do so out of fear of their farms being destroyed by illegal small-scale miners; at no cost (Bach, 2014).

The Amansie West District has a total employed population of 57,887 of which 34,279 (59.2%) are into agriculture, forestry and fishing; and 9,546 (16.5%) are into mining and quarrying. With agriculture as the dominant economic activity (employs 21,755 of a total household number of 29, 359) in the Amansie West District Darfour and Rosentrater (2016), it is needful that the rate of land degradation is given prior attention. The occupation in the district is largely land-based. Agriculture, forestry, fishing, mining, and quarry alone employs 75.7% of the population. However, since land is fixed, it is scarce. Thus, multiple uses of the land would mean reducing the area covered or prioritizing one use over another.

In Ghana and in the Amansie West in particular, several studies have considered surface mining in relation to health, environmental impacts such as the degradation of land, air and water resources, socio-economic activities and livelihoods of mining communities using surveys. Surveys though efficient are prone to biases based on the respondent’s interest. With no or very little quantitative data on the changes in land use land cover in the district, this study employs the use of satellite images to assess the spatio-temporal changes in LULC and the effects of surface mining on other LULC types in the Amansie West District over a 30-year period. The study not only measures the area of each cover but exposes the major drivers of change. This would serve as action pointers to all stakeholders to help reduce the rate of change over covers that are fast dwindling by finding a common ground between consumption and preservation.

Materials And Methods

Study area

Location, Size, Climate, And Vegetation Of Amansie West District

The Amansie West District (as seen in Fig. 1) lies in the south-western part of the Ashanti Region within latitudes 6º 35 and 6º 51 North and Longitudes 1º 40 and 2º 056º28   N. The district covers a land area of 1,364sq.km; which is about 5.4% of the total land area of Ashanti Region (Baffour-Kyei, Mensah, & Owusu, 2018). The District shares boundaries with Atwima Nwabiagya and Atwima Mponuah to the west, Bekwai

Municipality, Amansie Central, and Obuasi Municipal to the east, Atwima Kwawhoma to the north, and Upper Denkyira and Bibiani to the south. It also serves as a regional boundary between Ashanti Region on one side and Central and Western on the other side. Some of the towns in the district are Pakyi No. 1 and 2, Esaase, Essuowin, Antoakrom, Manso Abore, Brofoyedru, Yaw Henekrom with Manso Nkwanta as its capital (Fig. 1). The population of the district was 134,331 representing 2.8% of the populace in the Ashanti Region as of 2010.

Climate, Vegetation, And Soil

The climate of the district is the Wet Semi-Equatorial type. It is characterized by a bimodal rainfall regime with the major rainy season occurring between March and July, while the minor rainfall season occurs between September and November. Mean annual rainfall ranges between 855mm and 1,500mm. The average number of rainy days for the year is between 110 and 120 days. The months, December to March is usually dry with high temperatures, early morning mist/fog, and cold weather conditions. Temperatures are generally high throughout the year with a mean monthly temperature of about 27ºC.

The vegetation is mainly of the rain forest type and exhibits moist semi-deciduous characteristics. This makes the land very fertile and suitable for the cultivation of food and cash crops such as cassava, rice, maize, cocoa, citrus, oil palm, and citronella grass among others. The district has four main forest reserves. They include; the Oda River Forest Reserve, Apanprama Forest Reserve, Jimira Forest Reserve, and Gyeni River Forest Reserve. The activities of the people in the district by way of poor farming methods and illegal mining and logging have destroyed the primary forest. There are six key soil types in the district. These are Bekwai-Oda Compound Association, Ahawam-Kakum-Chichiwere Association, the Mim-Oda Compound, the Bekwai-Zongo-Oda Complex, NyanooTinkong Association, and the Kobeda-Eschiem-Subinso-Oda Complex (Aborah, 2014).

Processes Used

In assessing the land degradation of the district, several steps were undertaken (Fig. 2). These give in detail the processes undertaken in identifying the LULC changes of the Amansie West District.

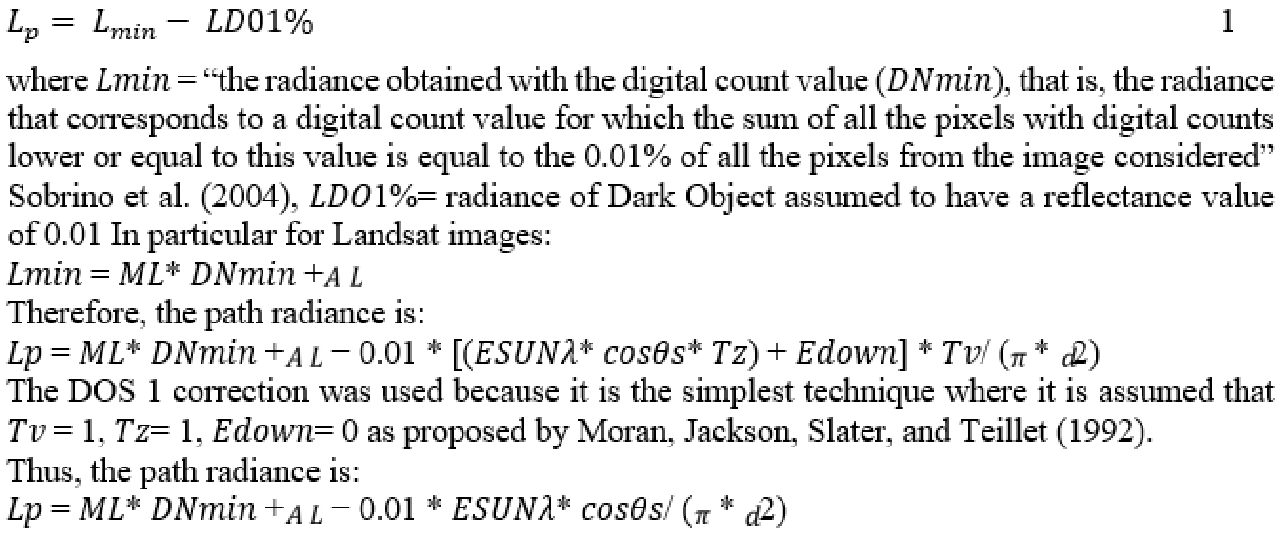
Data Set Availability And Acquisition

The cloud-free images available were downloaded from the United States Geological Survey (USGS) website (http://earthexplorer.usgs.gov/). Landsat images of 30m resolution for 1986, 2004, and 2015 were used as inputs for the classification and analysis of LULC change. The images comprised of Landsat 5 TM, Landsat 7 ETM + and Landsat 8 OLI_TIRS.

Image Pre-processing

Geometric and radiometric corrections were executed on the raw images, in preparation for image analysis. The Landsat 7 ETM + image was gap filled with the respective gap mask for each band. According to Sobrino, Jiménez-Muñoz, and Paolini (2004), the Semi-automatic Classification Plugin (SCP) in QGIS was used for atmospheric correction on the images, by converting the image data from Digital Numbers (DN) to Top of

Atmosphere (TOA) reflectance, and then modified by the Dark Object Subtraction 1 (DOS 1), an image-based technique using the Eq. 1:



$$L_p = L_{min} - LD01\% \qquad 1$$

where $Lmin$ = "the radiance obtained with the digital count value ($DNmin$), that is, the radiance that corresponds to a digital count value for which the sum of all the pixels with digital counts lower or equal to this value is equal to the 0.01% of all the pixels from the image considered" Sobrino et al. (2004), $LDO1\%$= radiance of Dark Object assumed to have a reflectance value of 0.01 In particular for Landsat images:

$Lmin = ML* DNmin +_{A\,L}$

Therefore, the path radiance is:

$Lp = ML* DNmin +_{A\,L} - 0.01 * [(ESUN\lambda* \cos\theta s* Tz) + Edown] * Tv/ (\pi * d^2)$

The DOS 1 correction was used because it is the simplest technique where it is assumed that $Tv = 1$, $Tz= 1$, $Edown= 0$ as proposed by Moran, Jackson, Slater, and Teillet (1992).

Thus, the path radiance is:

$Lp = ML* DNmin +_{A\,L} - 0.01 * ESUN\lambda* \cos\theta s/ (\pi * d^2)$

The respective bands were stacked to form a composite and a district shapefile was overlaid on the images and clipped to form a subset.

Table 1 List of Landsat images used

Satellite	Sensor ID	Resolution(m)	Acquisition Date	Path/ Row
Landsat 5	TM	30m	29th December, 1986	194/56
Landsat 7	ETM+	30m	2nd February, 2004	194/56
Landsat 8	OLI_TIRS	30m	29th December, 2015	194/56

Image Classification

The pre-processed images were classified using the Image classification tool. An Iso-cluster unsupervised classification was done on the pre-processed Landsat images to give a general overview of the various LULC classes. Training samples were created for each class and used as input for the Maximum Likelihood classification (Fig. 2), based on reference data from field surveys and Google earth (Congedo, 2019).

Accuracy Assessment

The Kappa index was used to assess the accuracy of the 2015 map. The LULC classes were used as strata in stratified random sampling, to aid assess accurately rare classes like mine and agriculture. To report site-specific errors, 200 points were collected from the field and Google earth Pro to compute the error matrix for the classified maps. Based on the error matrix table, the users' accuracy, producers' accuracy, and overall accuracy were calculated.

Change Detection

The change analysis was carried out using the post-classification land cover change tool under the SCP. In addition, the percentages and areas covered by the individual classes were generated through the classification report tool. This gave statistical evidence on areas of change and no change over the 30-years.

Table 2
LULC types and their description

LULC type	Description of LULC type
Forest	Dense forested areas (forest reserves), sparse forest, trees, shrubs, bushes
Farm	Agricultural lands
Settlement	Villages, towns, cities, roads, bare areas
Mines	Areas with large- and small-scale mining, stagnant water from mining

Results

The Overall accuracy was 0.85 ± 0.05 (Table 3). The Kappa value was 0.79. The producer’s and user’s accuracy for the individual LULC types have percentages between 78–95 and kappa values between 0.83–0.85.

Table 3
Accuracy assessment of the 2015 classified map

Class	Reference Totals	Classified Totals	Number Correct	Producer’s Accuracy (%)	User’s Accuracy (%)	Kappa
Settlement	30	36	27	90	78	0.85
Forest	25	25	21	84	86	0.85
Farm	69	68	61	87	95	0.84
Mine	76	71	62	82	93	0.83
Total	200	200	171			
Overall Accuracy	85.5%					
Kappa Value	0.79					

The major LULC classes for the years (1986, 2004, and 2015) studied in the Amansie West district are settlement, forest, farmland, and mines (Fig. 3). The results of the raw error matrix presented in Table 2 include the user and producers’ accuracy and the kappa statistics. The maps give a visual representation of the change in the LULC of the area for the three years used. A change map was created for 1986–2004 and 2004–2015 in other to ascertain the actual changes (in area, km^2) from one class to another for all the four classes (Figs. 4 and 5). The change map showed the unchanged class and a change from each class to the three other classes (Figs. 4 and 5).

The values derived from quantification is illustrated in bar charts (Figs. 4 and 5). The chart shows a change from one LULC type to another. In terms of inflows mine recorded the least, followed by settlement, forest and then farmland for 1986–2004 (Fig. 4). However, in 2004–2015, settlement recorded least followed by forest, mine and farmland. In all instances, farm gained more mostly as a result of losses from forest. However, in 2004–2015, there's a drastic rise in mine area from farms (Fig. 5). In 1986–2004, the sum of all losses to other classes (illustrated in columns; Fig. 4) from settlement was 6.06 km^2, forest was 242.39 km^2, farmland was 108.17 km^2 and mines was 13.26 km^2. This shows high losses in forest, followed by farmland, mines and settlement. The sum of all gains from other classes (illustrated in rows; Fig. 4) to settlement was 22.18 km^2, forest was 85.59 km^2, farmland 250.05 km^2 and mines was 12.06 km^2. This shows high gains in farmland, followed by forest, settlement and mines. Actual gains within the period (Gains – losses) was settlement 16.12 km^2, forest − 156.8 km^2, farmland was 141.88 km^2, mines were − 1.2 km^2. Thus, within the period, settlement and farmland increased in area while forests and mines reduced. A critical look at Fig. 4 in comparison with other LULC types shows higher losses from all other classes to farmland.

In 2004–2015, the sum of all losses to other classes (illustrated in columns; Fig. 5) from settlement was 16.65 km^2, forest was 179.71 km^2, farmland was 304.17 km^2 and mines was 6.64 km^2. This shows high losses in farmland, followed by forest, settlement and mines. The sum of all gains from other classes (illustrated in rows; Fig. 4) to settlement was 40.19 km^2, forest was 81.65 km^2, farmland 163.71 km^2 and mines was 221.62 km^2. This shows high gains in mines, followed by farmland, forest, and settlement. Actual gains within the period (Gains – losses) was settlement 23.54 km^2, forest − 98.06 km^2, farmland was − 140.46 km^2, mines were 214.98 km^2. Thus, within the period, settlement and mines increased in area while forests and farmland reduced. A critical look at Fig. 5 in comparison with other LULC types shows higher losses from all other classes to mines except forest.

Settlements increased consistently over all the years, forest decreased consistently, farms increased in 2004 but declined in 2015 and mines decreased in 2004 but increased drastically in 2015 (Table 4). Thus, the area for the two-year periods for settlement is positive, forest is negative, farms positive in 1986–2004 and negative in 2004–2015 and mines negative in 1986–2004 and positive in 2004–2015 (Table 4). Positive representing gains and negative representing losses.

Settlements increased steadily in area from 8.8 km^2, 25 km^2, 51.4 km^2 for 1986, 2004 and 2015 respectively (Table 4). Settlements increased by 42.6 km^2 at the end of the 30 years (Table 4). Some areas of forest (6.12 km^2) and farms (50.74 km^2) were also converted to settlements from 1986 to 2015 (Figs. 4 and 5).

Forest on the other hand decreased consistently over all the years with an area of 523.3 km^2, 366.4 km^2, and 267.8 km^2 for 1986, 2004, and 2015 respectively (Table 4). Forest area converted to mine for the three years was 21.59 km^2. Farms increased by 11.8% over the 1986–2004 period and decreased by 12% in 2004–2015 (Table 4). Farm area converted to forest was 163.46 km^2 over the 30-year period. Mines decreased between 1986 and 2004 by 0.02% and increased drastically between 2004 and 2015 (Table 4). Mine area converted to farm was 12.1 km^2 over the three-year period.

Table 4. Area (km2) and percentages (%) of each LULC class for the 1986, 2004 and 2015 classified maps

	1986		2004		2015			
LULC classes	Area (km^2)	% of distribution	Area (km^2)	% of distribution	Area (km^2)	% of distribution	Changed area in km^2 (1986-2004)	Changed area in km^2 (2004-2015)
Settlement	8.8	0.7	25.0	2.1	51.4	4.3	16.2	26.4
Forest	523.8	43.6	366.4	30.5	267.8	22.3	-157.4	-98.6
Farm	655.6	54.6	797.3	66.4	653.5	54.4	141.7	-143.8
Mine	13.4	1.2	12.2	1.0	228.6	19.0	-1.2	216.4

Discussion

The Overall accuracy was 0.85 ± 0.05 (Table 3) which means that the 2015 classified image is 85.5% in agreement with reality or the actual. Appiah, Forkuo, Bugri, and Apreku (2017) in referencing Chander and Markham (2003) said Kappa values are characterized as < 0 indicating no agreements, 0-0.2 as slight, 0.2–0.41 as fair, 0.41–0.60 as moderate, 0.60–0.80 as substantial and 0.81-1.0 as almost perfect agreement. Thus, the Kappa value of 0.79 shows substantial agreement to the actual as seen in Table 3. Generally, the natural vegetative cover of the area is decreasing as a result of increasing anthropogenic activities as seen in the increases in settlements, farms, and mines (Fig. 3). Activities like mining, agriculture, built environments as observed during site visits are done by humans in meeting their basic needs to the detriment of the natural cover.

The increase in settlements in the district would be a result of migration for agricultural and mining purposes (Fig. 3). As more people gain knowledge of the mineral deposits present, they tend to build their homes temporarily around the area for easy and consistent access to the minerals thus creating communities (Fig. 3a and 3c).Tenkorang and Osei-Kufuor (2013) confirm that mining activities lead to migration into mining areas or communities. Osei, Yeboah, Kumi, and Antoh (2021) states that in Ghana towns like Konongo, Obuasi, Tarkwa, Kwaebibrem and Nkawkaw have experienced an influx of youth from other towns as a result of mining activities undertaken in these areas. Basommi, Guan, and Cheng (2015) highlight that the migrants put up temporal structures as a place of residence and are usually drifted towards the mine sites. A typical example in the district is in the Essuowin community where the mine site lies miles away from the main community. Thus, the miners with their families, are gradually putting in place infrastructure to make life comfortable; since it is somewhat alienated from the main town. Agriculture is the mainstay of the district, thus seasonally people migrate into the district for farming activities which is typical of most farming communities as seen in the increases in farmlands (Fig. 3a and Fig. 3b). These findings also confirm studies which show that people migrate seasonally into rural areas for farming activities due to the deterioration of soil quality and access to land (Tenkorang & Osei-Kufuor, 2013).

The losses in forest lands, 256 km^2 (Table 4) was mostly due to farms (Fig. 3a and Fig. 3b). Forest lost 19.68% and 13.27% of its area to farms in 1986–2004 (Fig. 4) and 2004–2015 (Fig. 5) respectively. As population increases and people settle, the demand for food in meeting nutritional needs increases; thus, people tend to engage in agricultural activities which require changes in land use, since most lands in times past were forested. People tend to clear forest lands to make way for agriculture (Baah-Ennumh & Forson, 2017); causing changes from forests to agriculture (Fig. 3b); since forested lands were seen as fertile grounds for cultivation. A study by Mahmood, Malik, and Hussain (2010) showed the demands of population led to the clearing of more lands for agricultural purposes, settlement, lumbering, mining, construction, livestock grazing, intensive agriculture, industrial activities, human habitation, and other activities that disturb the ecosystem. Though forests experienced losses generally (Fig. 3), the losses from forest to farms were significantly higher than all other classes. A study by CILSS, (2016) showed similar results that more than a third of the forest cover in West Africa was lost to make way for farms and settlements in 1975. Gibbs et al. (2010) also had similar results, in a study conducted across the tropics, around 1980–2000. He found out that more than half of agricultural lands sprang at the expense of intact forests and 28% from disturbed forests.

The gains in farms within the period were mostly at the expense of forest. Farms contributed to 12.69% and 6.61% of the 13.1% and 12.2% forest decline (Table 4); experienced within 1986–2004 and 2004–2015 respectively (Figs. 4 and 5). This is mostly due to increases in population in the district. In 2000, the population of the district was 108,273 as compared to 134, 331 recorded during the Population and Housing Census conducted in 2010. This shows a 19% increase in the populace of the district over ten-year A study conducted by Schueler, Kuemmerle, and Schröder (2011) showed that about 12.3% (730 ha) of all land in the Bogoso–Prestea concession was converted from forest to farmlands A study conducted in West Africa showed that with an increase in population and so many new families to feed, farm areas were doubled between 1975 and 2013 (Forest, 2017).

In the 1986–2004 period, farms had significant gains from the forest but declined mostly due to losses to mines in 2004–2015. Out of the 18% gained by mines, 15.97% were losses from farmlands. These drastic losses from farms to mines as seen in Fig. 5 are a result of most farmlands being sold out for illegal small-scale mining activities. A study by Ocansey (2013) shows huge losses in farms to mines leading high cost and standard of living. To build local agricultural capacity, the Amansie West District Unit (AWDADU) of MOFA in the district put in six interventions namely the Millennium Villages Project (MVP), Unleashing the Power of Cassava in Africa (UPoCA), Care or Cadbury Cocoa Partnership Programme, Ghana Sustainable and Competitive Cocoa Project, Cocoa-Hi Tech Programme and Block Farming. However, illegal mining activities have taken over the 2010 block farm. Results from a study conducted by Stemn, Amoh, and Joe-Asare (2021) showed farmers sold farmlands for mining since it was more lucrative. A survey conducted in the district by Bach (2014) reiterates this fact with a recorded annual income of GHC 750 for farmers compared to GHC 5000 paid when farms are sold for mining, which amounts to almost 6.5 years of the farmers’ income. Thus, farmers with multiple farms sell one of their farms while farming on the other. However, some farmers are forced to sell their farmlands Ocansey (2013) for fear of their farms being destroyed by galamsey’ operators upon failure to comply and are given meager compensations for farmlands deemed infertile, mostly as a result of the pollution of water from nearby lands that have already been sold for mining (Bach, 2014). However, findings from Owusu-Ansah and Smardon (2015) suggest that, on a national level, crop production had not suffered extremely from the resource curse effect due to; acreage expansion induced by government initiative, investment in agricultural infrastructure, incentives and credits, which sustained higher crop output over the years. Moreover, expansion in some major crops in non-active large-scale mining zones appeared to offset the loss of cultivated lands in actual mining zones. They proposed that launching the economic recovery program (ERP), structural adjustment program (SAP) ERP/SAP resulted in a mining boom. More agricultural lands were converted for mining operations, which triggered the policy agenda for acreage expansion and production of certain major food crops to compensate for crop production loses, resulting in significant improvement in the production of most major crops; like cassava, plantain and yam. They argue that their findings support the hypothesis that 'resource curse' occurs only conditionally, and may be offset by proactive policies and sufficiently good institutions. However, they raised a concern on the fast pace at which virgin lands are lost and its policy implications especially in this 21st century when the world is advocating for sustainable development, reduction in atmospheric carbon and suffering from increases in extreme climatic events.

The losses in mines were mostly due to farms within 1986–2004. It was deduced from Fig. 4 that 0.95% of the area covered by mines were converted to farms between 1986 and 2004. It should be noted however that, though some raster signatures are computed as mines in 1986 and 2004 (Fig. 3a and 3b), the possibility of the absence of such mine areas may exist since surface mining activity, mostly 'galamsey' sprouted in the district in 2013 as seen in Google Earth Images. The Bonteso mine commenced in the ninety's legally but was liquidated in 2004 since it did not oblige to Environmental Protection Agency (EPA) standards. These areas classed as mines are possibly bare lands. These areas were classified as mines since mines and bare lands have similar spectral signatures. This scenario is buttressed in 2004–2015, with the changes from mines to farms reducing drastically to 0.75 km^2. As the population increased, lands became scarce, and thus gradually the shifting cultivation and fallow system of farming died out to the adoption of more advanced methods like agroforestry, mixed cropping, intercropping systems, etc.

Settlements comprise bare lands, open spaces, tarred and untarred roads. Thus, there is the possibility of these bare areas (Figs. 4 and 5) within settlements being converted to other land uses like farms. The conversion from settlements to the forests could be due to the closing up of the forest canopy near bare lands. Thus, causing changes from settlements in 1986 to forest in 2004 and 2015. A study by Yeboah et al. (2017), states that bare areas within built-up areas could appear as other LULC classes in subsequent years since they might have been put to some form of use. Some areas of forest (6.12km^2) and farms (50.74 km^2) were also converted to settlements from 1986 to 2015 (Figs. 4 and 5). This would be due to increases in population and proximity to farming areas. Over the years, people have settled in various places forming communities as a result of the availability of certain resources (firewood, food, medicine, shelter, etc.). These basic needs cause people to settle in such areas for proximity. The rise in population increases the demand for the land resource for shelter or housing purposes and thus serves as a contributing factor for the changes from forests and farms to settlements (Braimoh & Vlek, 2004).

The changes from forest to mine (21.59 km^2) for the three years would be because mineral deposits are usually embedded in forest lands and the water used in galamsey activity mainly passes through the borders of the district where the major forest cover lies. The canopy of the trees makes the water invisible. However, the bid for clear water leads to encroachment along forest borders since it is an easier alternative. According to Obodai et al. (2019), galamsey activities occur along major rivers in Ghana due to easy access to clear water for gold extraction, releasing heavy metal and sediments into the river. Several studies reiterate this fact, by discussing the devastating impacts of galamsey activities on water quality in mining areas or communities (Ocansey, 2013; Peprah, 2002). Also, large tracts of forested lands have been cleared indiscriminately by illegal mining activities Stemn et al. (2021) since most minerals are embedded in forest lands. Hence, the changes from forest to mine, since there is easy access to the mineral and water for its extraction thus leading to encroachment along the borders.

Small scale farmers over the years left deteriorated farmlands to lie fallow to aid soil fertility regeneration. Such lands left over longer periods could return to their forested state. Awareness creation on the impacts of deforestation through the reducing emissions from deforestation and forest degradation (REDD+) program within 2012 and 2015 could have led to the reforestation of such fallow lands. In addition, the changes from farms to forests would be as a result of the cultivation of Citronella introduced by Amansie Resolute in the district in response to environmental needs (Amansie West – Ministry of Food & Agriculture). Studies by Dadson (2016) showed that in small-scale farming systems, farmlands that had lost their fertility due to intensive use and poor farming practices: were left fallow in an attempt to regenerate and restore the fertility of the soil. The changes from mine to farms would be due to reclamation. An example is seen in Brofoyedru, a town in the district, where a mine site after filling, was being used for pineapple cultivation. Though crops cultivated on such lands could be full of chemicals deposits, however, they do exist.

Conclusion

The Amansie West District has experienced vast degradation of land with the major drivers of change being farmland and mines. Farmland recorded the highest gains from all other classes within 1986–2004. Likewise, mines recorded the highest gains from all other classes except forest. Forest still had higher losses to farmland. However, though farmland gained from forest, the losses to mines off-sets the gains thus reducing the area of farmlands from 2004. It can be deduced from the drastic losses from forest and farmland that the vegetative cover of the district is he most vulnerable. A population census done by the Ghana Statistical Service, (2014) in the district, showed that agriculture, forestry and fisheries employed 59.2% of the work force while the mining and quarrying sector employed 16.5%, mostly artisanal mining, making it the second largest source of employment in the district. However, the drastic losses from forest and farmlands show the likelihood of mining overtaking all other sectors which could have dire consequences on employment and the general livelihood of the people. The study recommends future projections of the effects off the major drivers of change on other LULC types as well as the relationship between the loss of the vegetative cover and climatic trends. The study proposes adopting the economic recovery program (ERP), structural adjustment program (SAP) ERP/SAP with a direct focus on environmental sustainability and productivity.

Declarations

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Author Contribution

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Assisted in developing original idea for this research

Study design

Data Acquisition, analysis and interpretation

Drafting of manuscript

Reviewed the manuscript and provided input in writing and finalizing the full manuscript

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Figures

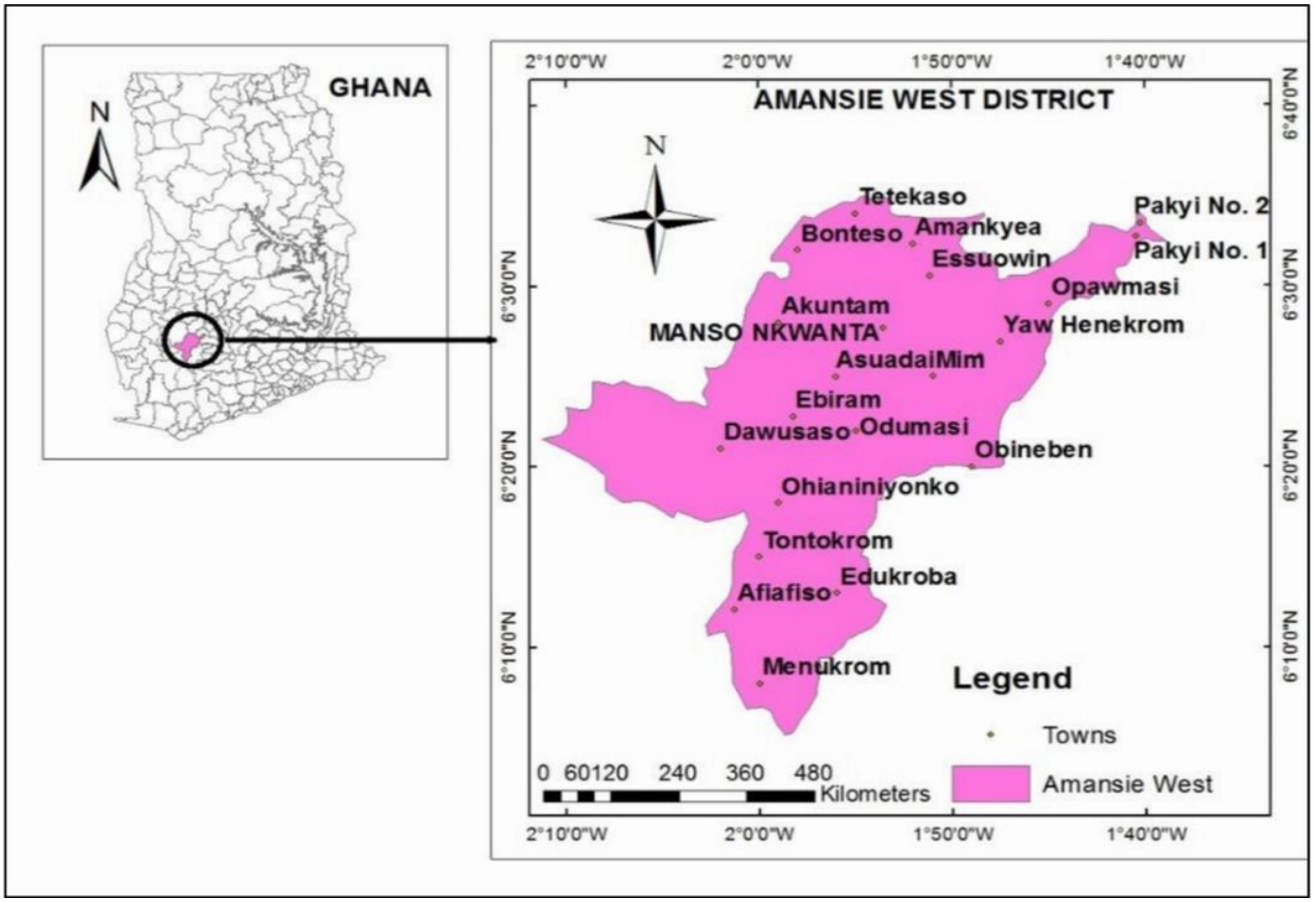


Figure 1

Map showing Amansie West and its towns

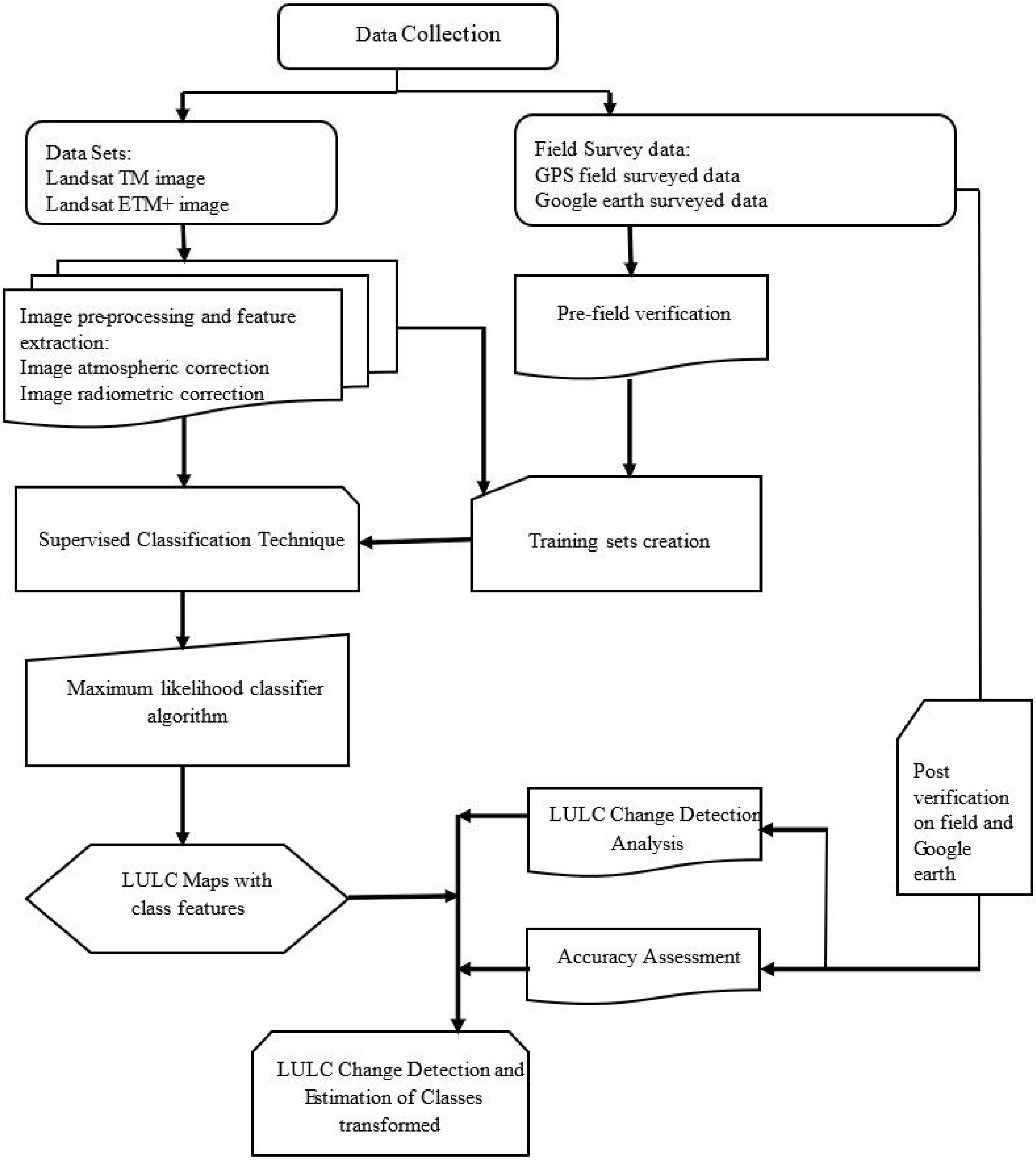


Figure 2

Framework of methods used in LULC change

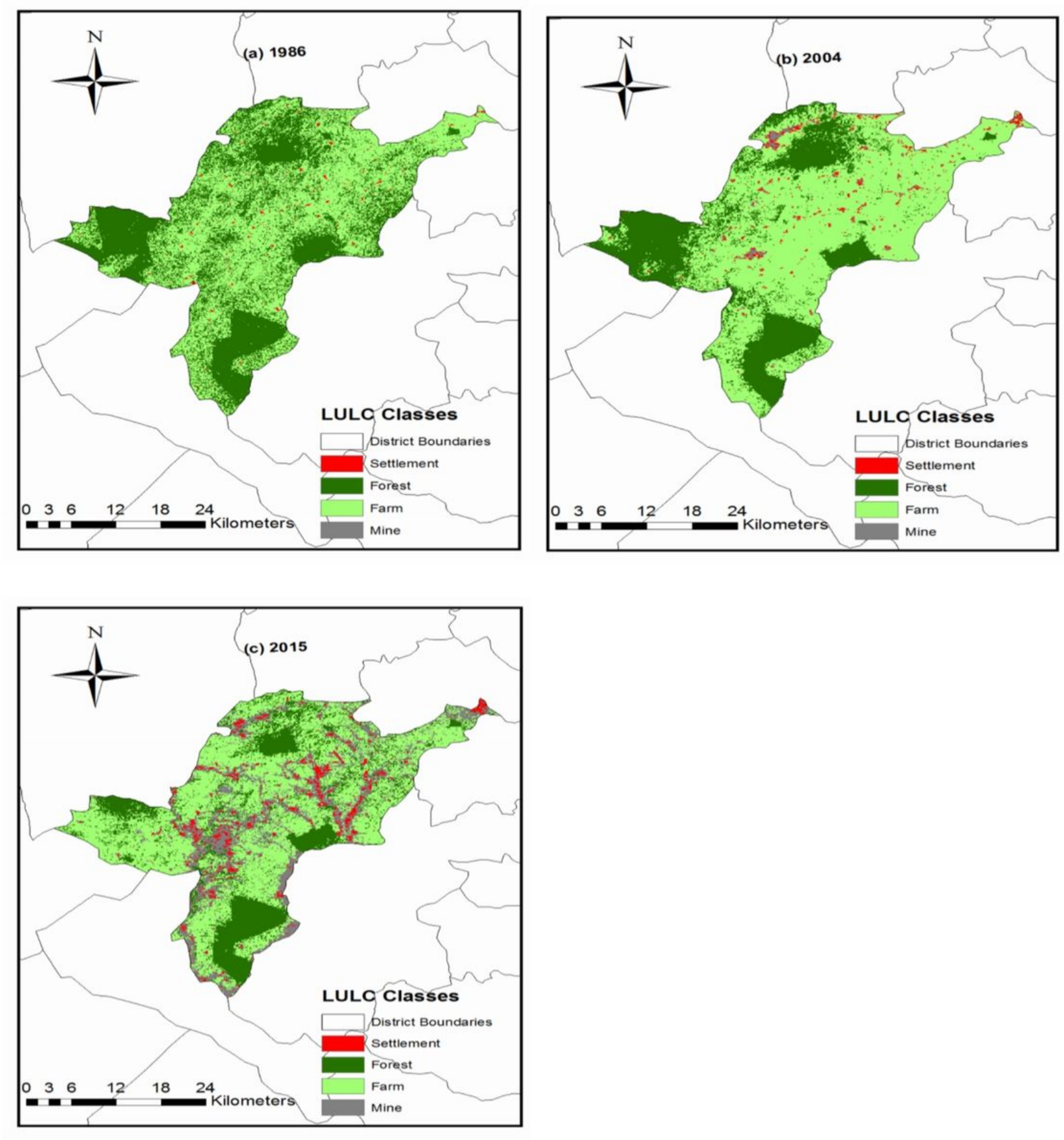
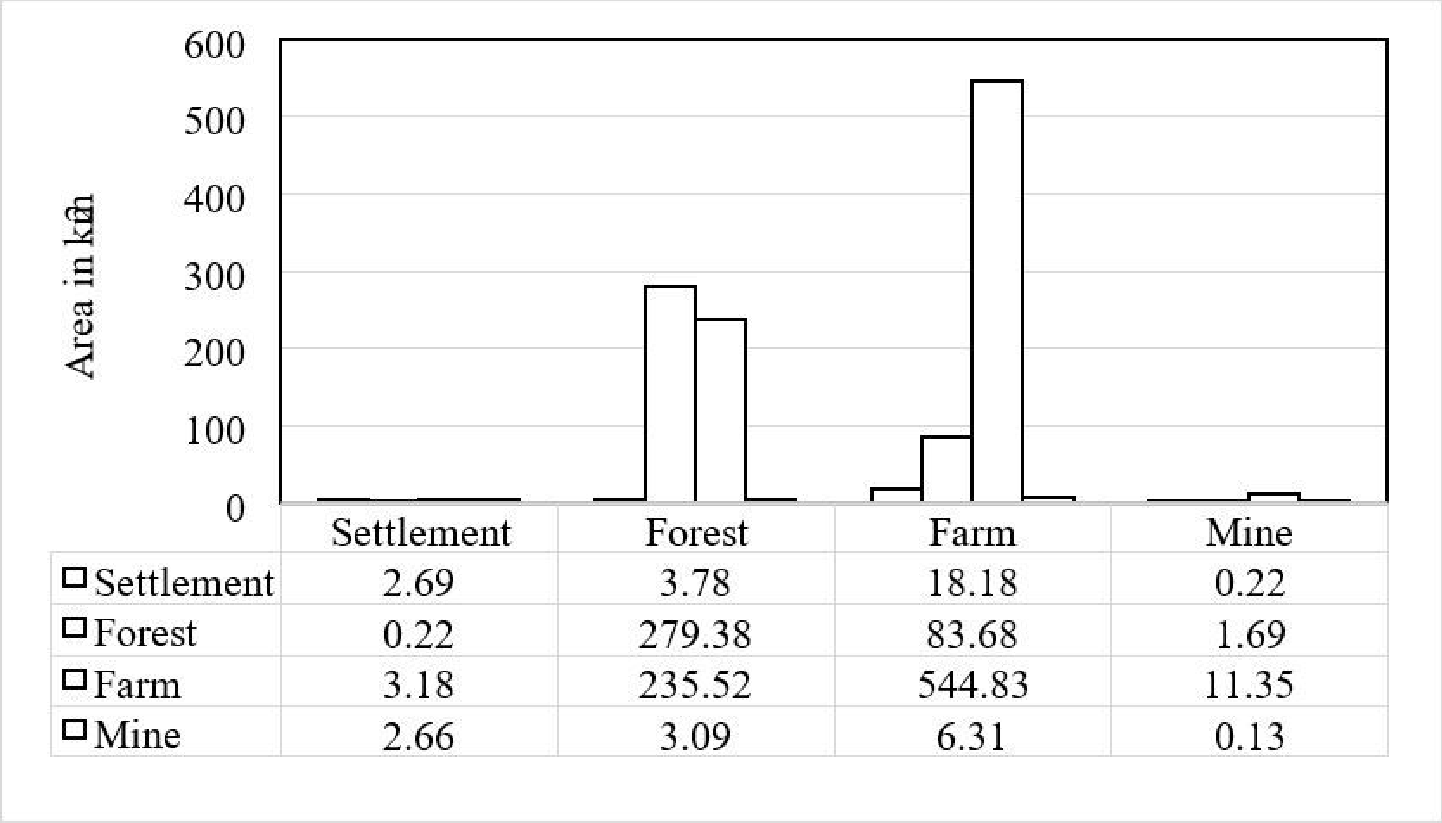


Figure 3

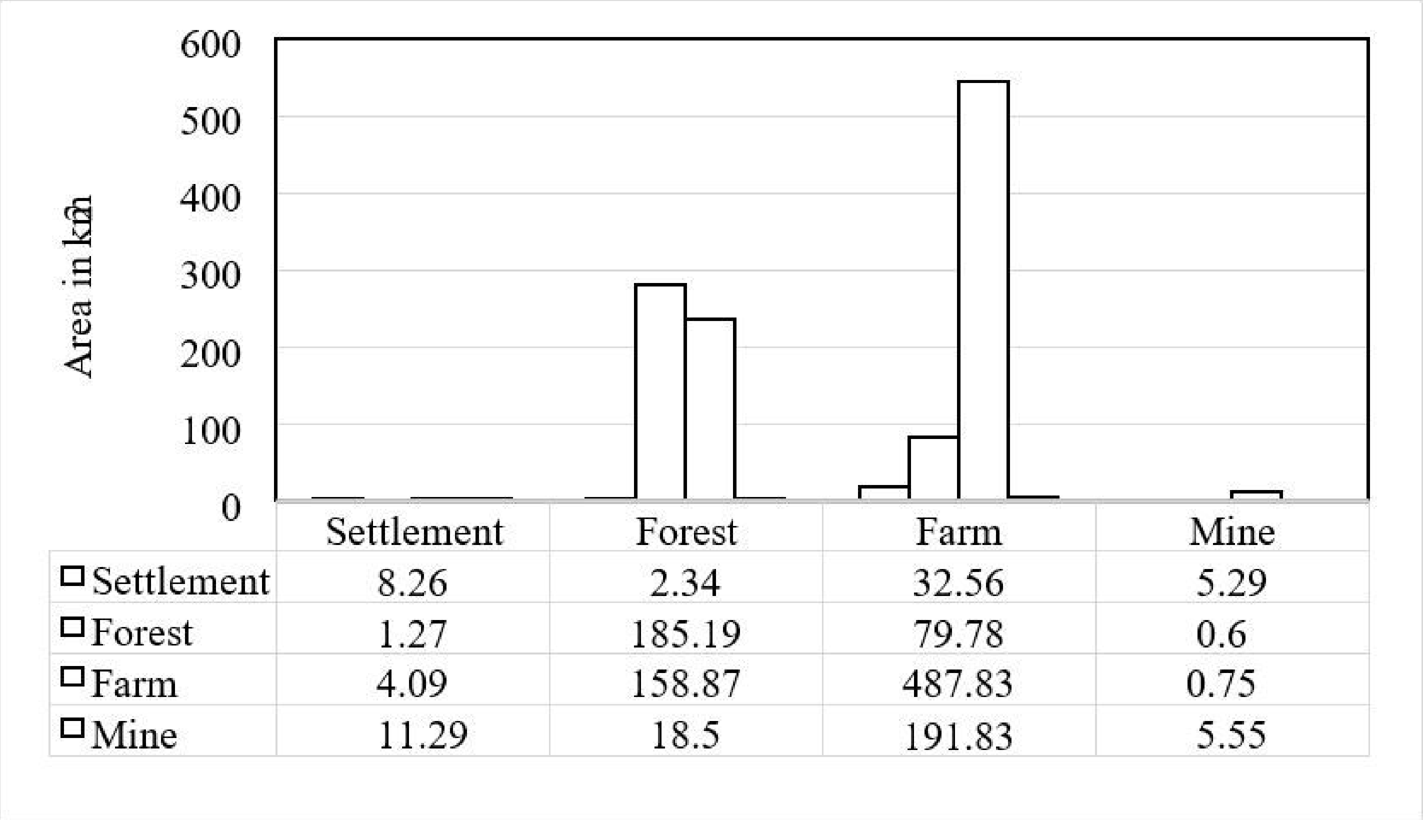
LULC classified maps of Amansie West District (a) 1986, (b) 2004, (c) 2015



	Settlement	Forest	Farm	Mine
□ Settlement	2.69	3.78	18.18	0.22
□ Forest	0.22	279.38	83.68	1.69
□ Farm	3.18	235.52	544.83	11.35
□ Mine	2.66	3.09	6.31	0.13

Figure 4

LULC changes in Amansie West district (1986-2004)



	Settlement	Forest	Farm	Mine
☐ Settlement	8.26	2.34	32.56	5.29
☐ Forest	1.27	185.19	79.78	0.6
☐ Farm	4.09	158.87	487.83	0.75
☐ Mine	11.29	18.5	191.83	5.55

Figure 5

LULC changes in Amansie West (2004-2015)