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Study of Landuse and Landcover Changes for Monitoring the Uncontrolled Gold Mining Activity in Rophi Megada Forest. A Case Study in Bule Hora Wereda, Oromia Region, Ethiopia.

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***Abstract*— Changes of landuse and landcover around the world has been altering natural environment. Mainly, Human activities have degraded the environment for thousands of years. Significant increases in industry, urban development, agriculture, energy production, settlement, recreation, water catchment and storage have intensified these environmental changes over the last several centuries. This paper discusses about the use of a Landsat-TM for monitoring the gold mining activities caused by the action of independent illegal miners in search for gold at Rophi megada forest. The high demand for gold leads to increase in mining activities which results in land use changes. The land use and landcover study was conducted by mapping LANDSAT data of three different years (1986, 2000 and 2011), which spans over a time period of 25 years and it was precisely analysed using ERDAS and ArcGIS 10 software. The study revealed that the forest cover were 1739.81ha, 1454.94 ha and 1180.37 ha in 1986, 2000 and 2011. It was noticed that forest cover decreased in 2000 and 2011 due to increase in farming and illegal gold mining activities. Field observations show the current status and highlight the issues of environmental problems due to illegal gold mining and this study also suggests some remedial measures to protect the environment by government agencies.**

Keywords*— Illegal gold mining; Landsat imagery; Landuse and landcover changes.

I. INTRODUCTION

Landuse and landcover change studies have become key components for managing natural resources and monitoring environmental changes. It plays a major role in the study of global environmental change which indicates the influence of human activities on the physical environment. The growing population and the increase in socio-economic activities create a pressure on land use/land cover. This pressure results in unplanned and uncontrolled changes in landuse and landcover [1]. The landuse alterations are generally caused by mismanagement of industry, agricultural, urban, range and forest lands which lead to severe environmental problems. Landuse is a product of interactions between a society's cultural background, state, and its physical needs on the one hand, and the natural potential of land on the other [2]. In order to improve the economic condition of the area without further deteriorating the bio environment, every bit of the available land has to be used in the most rational way. This requires the present and the past landuse/land cover data of the area [3].

The land-cover changes occur naturally in a progressive and gradual manner, however sometimes it may be rapid and abrupt due to anthropogenic activities mainly when we consider mining. In the surroundings of surface mining area, land use/land cover changes are taking place rapidly, which causes serious environmental degradation to the landscape [4]. Land use/land cover in mining area is obviously affected by the development of mining industry which results in serious ecological degradation [5]. For example, coal extraction from the earth's surface through mining operation tends to make a prominent impact on the landscape, environment and biological community [6]**.** In the case of gold mining, environmental problems are related to the pollution of rivers and streams due to the use of mercury amalgamation for gold recovery, deforestation and erosion along mining area [7]**.**

Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate information about landuse and it plays an important role at local and regional as well as at macro level planning. Remote sensing technology has been widely used since the past few decades to monitor land use/land cover changes in time and space. During the last two decades, numerous studies have been published concerning accurate assessment of land cover classifications [8]. In many remote sensing change detection studies, land use and land cover change often are used interchangeably [9]. Temporal changes in land cover have become possible in less time, at lower cost and with better accuracy through remote sensing technology [10]. Remote sensing information being in digital form can be brought into a Geographical Information System (GIS) to provide a suitable platform for data analysis, update and retrieval [11]. GIS provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for change detection. Improvements in satellite remote sensing, global positioning system and geographic information system techniques in the past decade have greatly assisted the collection of land cover data and also in maintaining up-to-date landuse dynamics information for a sound planning and a cost-effective decision [12].

This study aims to evaluate the impact of gold mining activities on landuse and landcover changes in Rophi megada forest using multi temporal remote sensing data covering a period of 25 years from 1986, 2000 and 2011 supported by geographical information system, global positioning systems and ground truth data as other inputs. The main objective of present study is an aim to map and monitor the evolution of area degraded by land use change in time and space, in the back drop of gold mining activities.

II. MATERIAL AND METHODS

A. Study area

The study area covers a surface of approximately 30.67 sq.km in Rophi megada forest which is located between $38^0$17'30''E and $38^0$28'0''E longitude and $5^0$31'30''N and $5^0$34'30''N latitude in the southern side of Oromia region in Ethiopia (*Fig.1*). Landuse generally in the study area is very much controlled by rainfall and geology. The region experiences annual temperature ranging from 10^0C to 30^0C with mean annual temperature of 19^0C and it has an agro-climatic (bi-modal) condition with two major rainy seasons namely arfasa and ganna. Arfasa is the major crop season and it start from middle of March and ends by middle of May. Second rainy season is ganna in which only a few cereal crops are grown which begins from middle of September and ends by middle of November with the annual rainfall ranging from 400-2400mm [13].

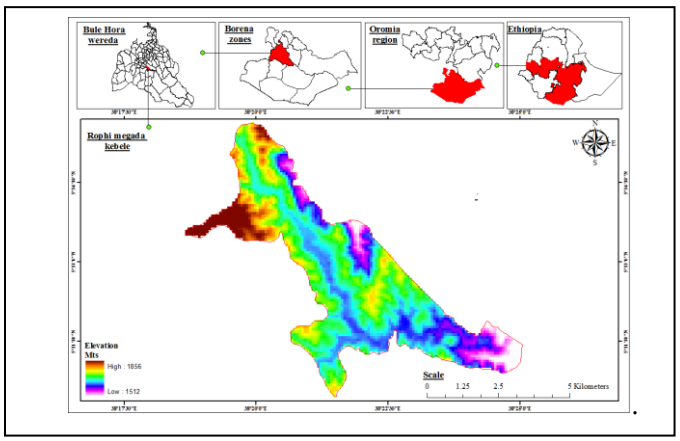

Fig: 1. Study area boundary map

B. Methods

To study landuse change dynamics at local level with a both quantitative and qualitative data (the mixed approach) were used as they are pertaining to the benefits, threats and management of the landuse. Methodologies adopted in this study are

- Creation of basemap like regional boundary, zones with wereda and kebele boundaries from ArcGIS 10 software.
- Landsat TM (Thematic Map) 1986, Landsat ETM (Enhanced Thematic Map) 2000 and Landsat 2011 with path and row of 168 & 56 was downloaded from USGS. All visible and infrared bands (except the thermal infrared) were included in the analysis. Remote sensing image processing was performed using ERDAS imagine 9.1software.
- Selection and extraction of a sub-scene covering of Rophi megada forest from the full scene of Landsat 2011 images of the area.
- Identification of ground control points (GCP's) and geo-correction of bands through resampling.
- Co-registration, creation of a sub-map of the area and resampling of the imageries to one resolution to make the pixels coincide.
- Cropping and mosaic of data corresponding to the study area.
- Fusion of Landsat data using RGB (Red, Green, Blue) to HIS (Hue, Intensity, Saturation) and HIS to RGB conversion technique.
- Generation of FCC (False Colour Composite) and identification of training sites on FCC.
- Classifying the imageries and the polygonising the base map of the study area.
- Overlaying the classified datasets and obtain changes in Land uses and Land covers of the study area.
- Collection of attribute information from field investigation to the chosen area sites using GPS.

III. RESULTS AND DISCUSSION

An analysis of the nature and rate of land use changes and its associated impact on landcover is essential for a proper understanding of the present environmental problems. Change detection is an important process in monitoring and managing natural resources because it provides quantitative analysis of the spatial distribution. The landuse and landcover categories delineated in the study area are forest, farm land, grass land, wet land and gold mining area. Table 1 shows the changes in landuse and land cover statistics in hectare (ha) that have taken place during the period between 1986, 2000 and 2011(*Fig.2,3 & 4*) and it is also represented graphically in bar diagram.

TABLE I.
Landuse and landcover change detection for the years 1986, 2000 and 2011

LULC Type	YEAR		
	1986 (ha)	*2000 (ha)*	*2011(ha)*
Forest	1739.81	1454.94	1133.05
Farmland	12.39	121.14	459.25
Wetland	*464.74*	*394.83*	*308.52*
Grass Land	872.04	1118.07	1180.37
Gold mining	0.00	0.00	7.79
Total	3088.98	3088.98	3088.98

The analysis of landuse and landcover changes that has been taken place under different land use categories from 1986, 2000 and 2011 due to the expansion of farm land and illegal gold mining activities are given below.

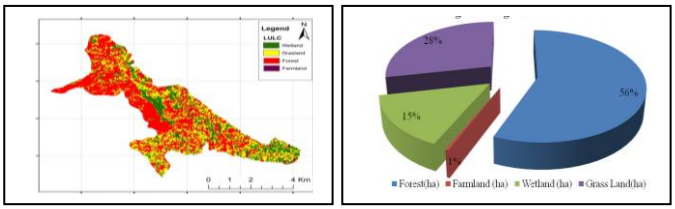

Fig: 2. LULC map and bar diagram for Rophi megada forest in 1986

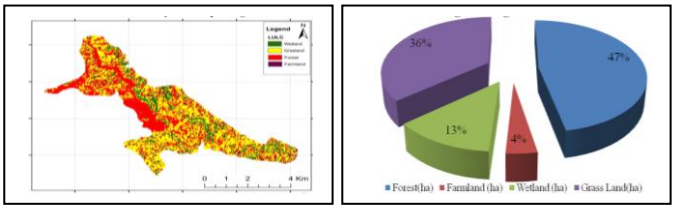

Fig: 3. LULC map and bar diagram for Rophi megada forest in 2000

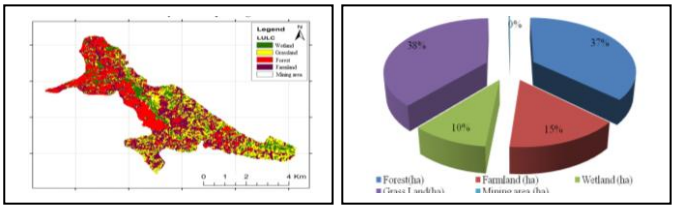

Fig: 4. LULC map and bar diagram for Rophi megada forest in 2011

A. *Forest*

The forest covers an area of 1739.81 ha in 1986, 1454.94 ha in 2000 and 1133.05 ha in 2011. Forest cover shows a decrease of 606.76 ha in area from 1986 to 2011 during a period of 25 years. Most of the mining activities are taking place in the forest area. The decrease in the forest area can also be attributed to removal of trees for the development of infrastructure, housing and excess dependences on forest for livelihood, fuel and fodder for the increasing human and cattle population.

B. *Farm land*

Farm land or cultivated land in the study area is under the dominant crops like maize, teff, barley, wheat, soybean and beans. Farm land coverage was 12.39 ha in 1986, 121.14 ha in 2000 and 459.25 ha in 2011. An increase in landcover under cultivation of 446.86 ha was observed during 1986 to 2011 and can be attributed to deforestation.

C. *Wetland*

Wetlands are crucial sources of biological diversity. The dominant plant species of the wetlands (hydrophytes), which are under threat, were identified by landuse analysis. The result shows 464.74 ha in 1986, 394.83 ha in 2000 and 308.52 ha in 2011 under wetland. A loss of 156.22 ha in wet land has been observed during 1986 to 2011 for a span of 25 years. It is due to development of farmland, infrastructure, and human settlements for mining industry.

D. *Grassland*

The area under grassland category covers 872.04 ha in 1986, 1118.07 ha in 2000 and 1180.37 ha in 2011. The grassland shows a gradual increase of 308.33 ha from 1986 to 2011. The increase might be due to the loss of forest land which has changed into grassland after deforestation.

E. *Illegal gold mining*

During the period from 1986 to 2000, there is no gold mining activity and from 2011 it started slowly in the forest area in about 7.79 ha. During field investigation in 2015, uncontrolled gold mining activities have largely developed and so many areas under forest cover were destroyed and changed into gold mining area as shown in *Fig. 5*


Fig: 5. Field observation photos in gold mining area.

IV. CONCLUSION

The detailed mapping of landuse and landcover is a major step to understand and monitor landuse changes in the study area in a bid to mitigate adverse effects. The results shows that Landsat image can be used to produce detailed maps of degraded areas associated with activities like illegal mining and farming and in the present research the increasing intensity of areas under mining surrounding the Rophi megada forest. The landuse and landcover changes between 1986, 2000 and 2011 shows that the increase of farm land, grass land and gold mining are due to increase of degradation of forest land. During field investigations in 2015, large area of forest land has changed in to illegal gold mining area without any proper management. Gold mining is a good source of income for countries like Ethiopia and will improve the economy of the country. But till now no proper investigation has been carried out in the study area. So government should take holistic decisions and consider scientific approaches for developing and sustaining of gold mining industry and proper management of natural resources.

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