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Applications of Geoinformatics Technology in Land Use Land Cover Change Detection using Multi-Temporal Satellite Images: the Case of Mariamdehan tabia, Tigray Region, Northern Ethiopia

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Abstract
Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced Natural Resource Management and managing environmental changes. This study examines the use of Geoinformatics tools (GIS, GPS and Remote Sensing) to analyze land use land cover change over 31 years using Multi-temporal satellite images in the Maryamdehan tabia. Satellite image of the year 1984, 2005 and 2015 were collected from the USGS/glovis/ free satellite data provider website. Image classification was done using Arc Gis 10.2 environment and ground truthing was also taken using GPS tool for supervised image classification. Six main land use land cover classes were identified to see the changes among years. As a result, the total area of the tabia was 3646.49 hectare, from which in 1984, 40.691% covered by forest area, 26.15% by grass land, 10.81% by farm land, in 2005, 52.41% by settlement, 25.04% by forest area, 11.71% by farm land, and in 2015, 35.14% was covered by forest land, 30.04% by Settlement, 14.74% by Farm land. Regarding soil and water conservation practices Questioner was developed and 90% of the farmers revealed that in 2015 due to the introduction of different soil and water conservation structures soil erosion problem significantly decreased on their farm lands. The main driving forces of the land use land cover changes in this tabia were increasing population number, expansion of agricultural activity, settlement, and plantation practices.

Currently 35% of the tabia covers by forest area, so this plays its own role in minimizing soil erosion, soil stability and as option in minimizing climate change impacts through carbon sequestration process.
Keywords: Geoinformatics Tools, RS, GIS, Land use land cover change.

1. Introduction

Ethiopia is one of the most well endowed countries in Sub Saharan Africa in terms of natural resources including fauna and flora [1]. About 50 percent of Ethiopia is covered with mountain, because its altitude is above about 1500_m, with steep slopes. The country's highland areas comprise about 90% of its arable lands and are occupied by 90 percent of the human population and 60 percent of all livestock. The mountains of Ethiopia have natural diversity and resources and offer excellent opportunities for human development. Even though all over the highland parts of Ethiopia as they are very suitable places for living and agriculture, but know the natural resources are degraded because of the increasing of population density [2]. However, the country faces different problems in relation to natural resource management. From this, land cover change is one of the most serious environmental problems. According to Eric et al.[3] , summarizing a large number of case studies, and find that land-use change is driven by a combination of resource scarcity; changing opportunities created by markets; outside policy intervention; loss of adaptive capacity and increased vulnerability; and finally changes in social organization, in resource access, and in attitudes. In the Ethiopian, serious environmental problems are associated with the overwhelming proportion of the Ethiopian population lives in rural areas (85%) and about 90% lives in the Ethiopian highlands and directly depend on subsistence agriculture which is entirely dependent on natural resources [2]. Therefore, in the country, Land use and cover changes had been particularly dynamic in the 20th Century. This was due to increasing population, expansion of the agricultural sector and climatic change [4]. On the other hand, Amare [5] explain that rapid population growth and the low economic living standard in Ethiopia have brought in their awake numerous consequences to land cover and use changes; change in climate and hydrological status in the country. Besides, land tenure policy has been changed since 1975 that also contributed for the dynamic change of land use land cover [2]. Alemayehu and Arnalds [6] also studied on Land Use and Land Cover Dynamics in the Ethiopian Highlands between 1868 to 2008. The land use and land cover change from 1980s-2000s showed continued declines of shrub lands and forest cover, but improvements in vegetation cover in some areas.

The study of Land use/cover pattern is providing information for managing dynamics of land use and meeting the demands of increasing human population [7]. On the other hand, Information on land and land cover change in the form of maps and statistical data is very vital for special planning, management and utilization of

land for agriculture, forestry, pasture, urban-industrial, environmental studies,economic production etc [8]. Land use land cover change can be observed from processed aerial photographs and satellite images. Since remote sensed data from the earth orbit can be obtained repeatedly over the same area, they have been very useful to monitor and analyze LUCC in various regions of the earth and greatly contribute to planning and management of available resources, especially in the developing countries where other kinds of background data are often lacking**.** Although a number of studies have been conducted on land use and land cover changes, it is still crucial to generate site-specific information on land use/cover dynamics to ensure planning of sustainable and integrated management of the land resources.

Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

The land use/land cover pattern of a place/region is an outcome of natural and socio – economic factors and their utilization by human in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare.

Therefore, this paper attempts to map out the status and to detect land use land cover change of Maryamdehan tabia among 1984, 2005 and 2015 years through use of Geoinformatics tools such as Geographic Information System (GIS), Global Positioning System (GPS) and Remote Sensing data.

2. Materials and Methods

2.1. Study area description

This study was conducted at Tabia Maryamdehan, Enderta woreda/district, Tigray regional state, northern part of Ethiopia. Tabia is smaller administrative part of district, smaller than district. Tabia Maryamdehan was one of the tabia within Enderta district. Geographically it is found at 13.53^0 to 13.57^0 N latitudes and 39.44^0 to 39.47^0 E longitudes. The elevation varies from 1903 to 2273 meter and temperature varies between 18^0c and 19^0c with total area coverage of 3646.49 hectare.

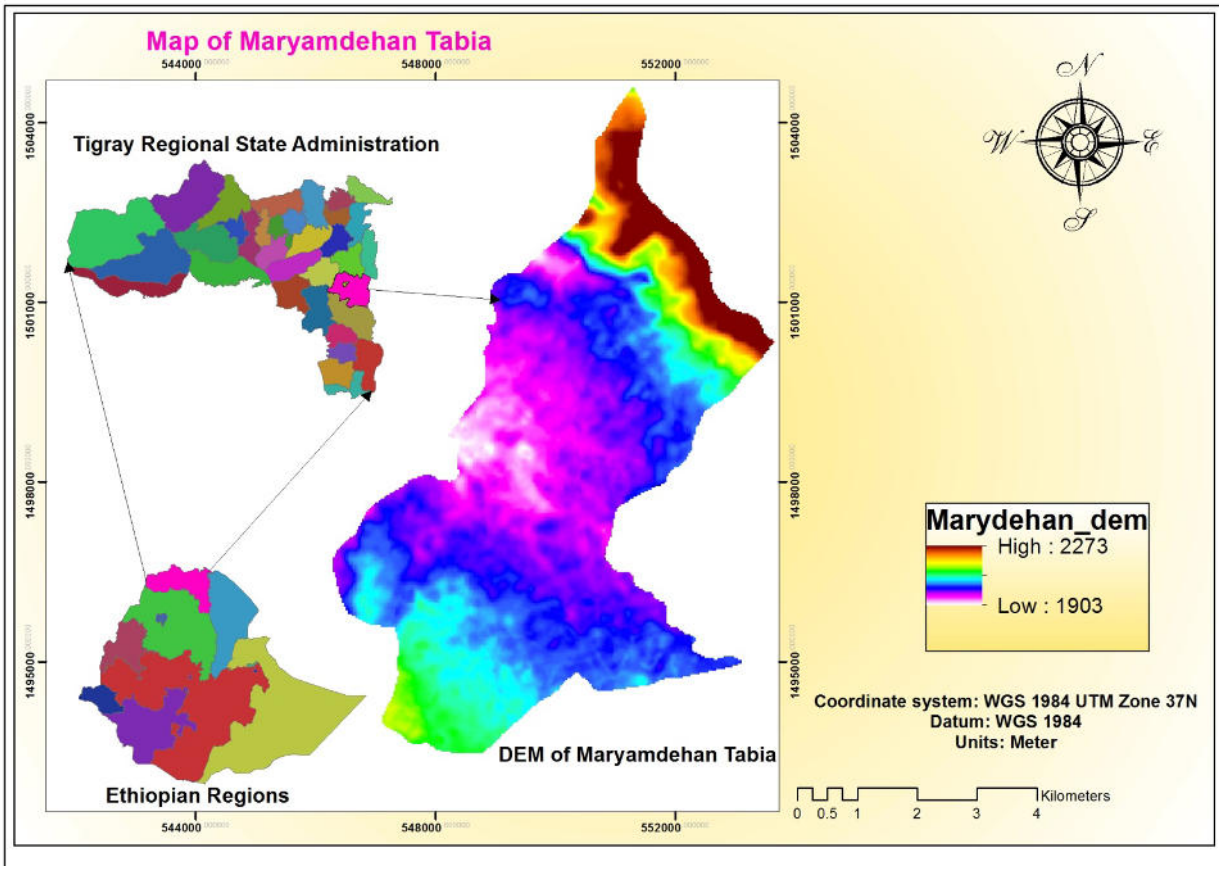


Figure: 1 Geographical Location of the study site.

2.2. Satellite data analysis procedure

The satellite data analysis follows the common procedures on land use land cover change detection analysis to reach at the final expected output. land sat satellite images of 1984, 2005 and 2015 with 30m resolution was downloaded from USGS/glovis website to prepared land use land cover, DEM 30 meter from ASTER image, slope derived from DEM and soil data was derived from FAO database after that layers stacking, satellite images subset ting, image supervised classification, vectorization, and tabular area calculation in Arc GIS environment and GCPs collected using GPS tool. By using Ground Control Points (GCP) supervised image classifications were performed to detect land use land cover changes among 1984, 2005 and 2015 years. General frame work of the study was as follows;

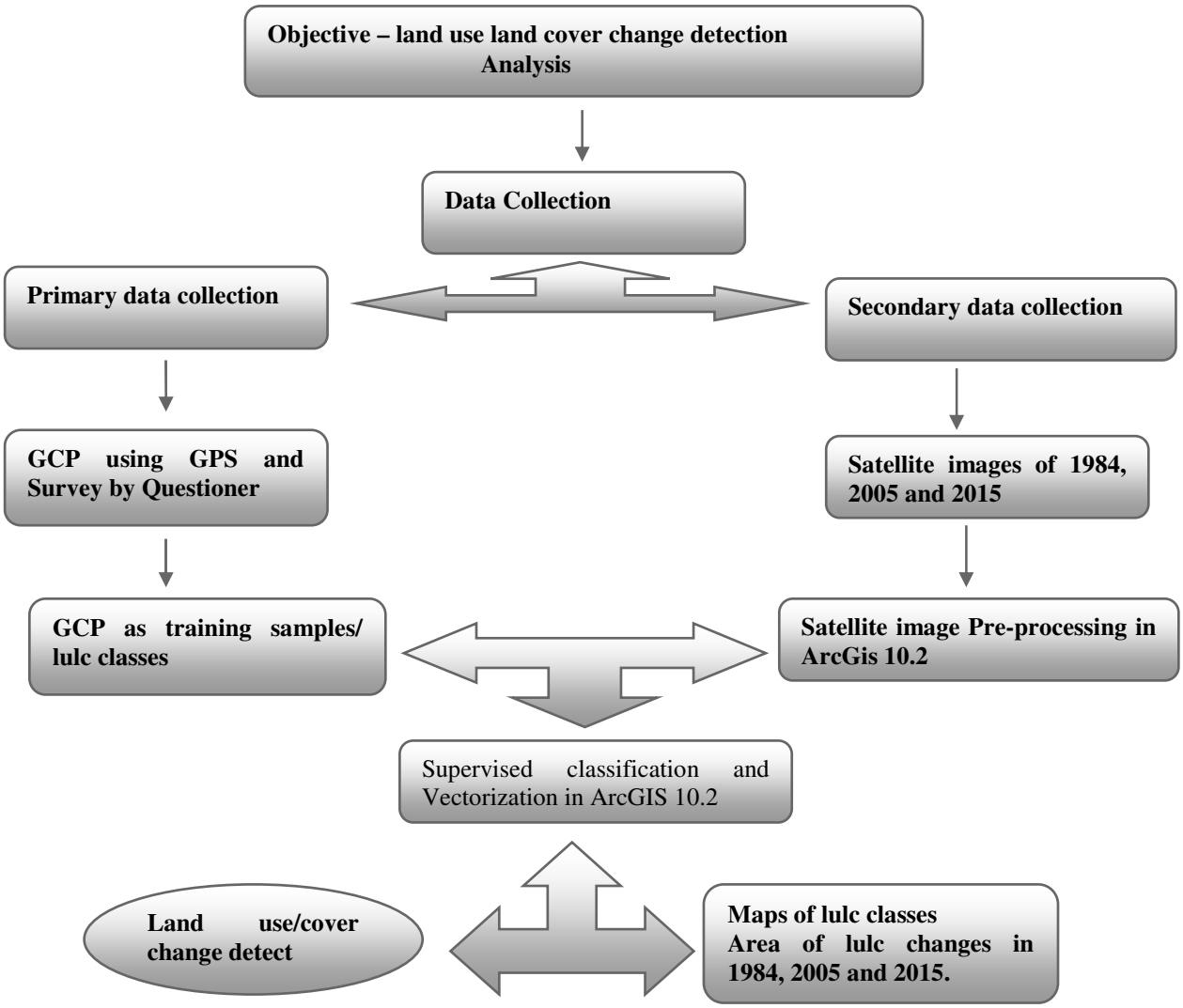
3. Objectives

3.1. General Objective

A. To detect land use land cover change using multi temporal satellite images in Maryamdehan tabia using Geo-informatics tools.

3.2. Specific Objective

1. To detect land use and land cover change among 1984, 2005 and 2015 years.



2. To see land use land cover change dynamics on the tabia.
3. To assess community based integrated soil and water conservation practices in the tabia.

4. Results and Discussion

In the Arc GIS environment all Satellite images of the tabia has been processed and classified at 1984, 2005 and 2015 years, and six main LULC classes: Bare land, forest land, settlement, farm land , water body and grass land were identified and their area calculated to see the changes within these periods. We get the changes from their attribute tables of all the classified images in the selected years and we understand/detect easily what land use

land cover changes to what class, by what amount using transitional metrics.

4.1. Land use land cover classification in the year: 1984

The land use land cover classes of 1984 were prepared from satellite image of land sat TM and involves six main land use land cover categories: Bare land, Forest land, Settlement, Farm land, Water body and Grass land. From the total area of the tabia, which is 3646.4 hectare, in the year 1984, 40.69% was covered by forest land, 26.15% by grass land and 10.81% by farm land; and the least coverage was 3.18% that is bare land. In this period water body have high coverage than bare land and water body have 9.03% of the area coverage which is better coverage as compare with 2005 and 2015 years. (Figure: 2)

4.2. Land use land cover classification in the year: 2005

The land use land cover classes of 2005 were prepared from satellite image of land sat TM and involves six main land use land cover categories: Bare land, Forest land, Settlement, Farm land, Water body and Grass land. From the total area of the tabia, which is 3646.4 hectare, in the year 2005, 52.41% was covered by settlement, 25.04% by forest land ,10.81% by farm land; and 11.17% covered by farm lands. The least coverage was 0.35 which is water body, reason for decrease of water resource in this year was expansion of agricultural activities and high demand of water for different uses by the community (Figure: 3)

4.3. Land use land cover classification in the year: 2015

The land use land cover classes of the year 2015 were prepared from satellite image of land sat TM and involves six main land use land cover categories: in this year the tabia dominantly covered by forest land (35.14%), by Settlement (30.04%) and 14.74 by farm lands and the least coverage was 0.64% which is water body (Figure: 4)

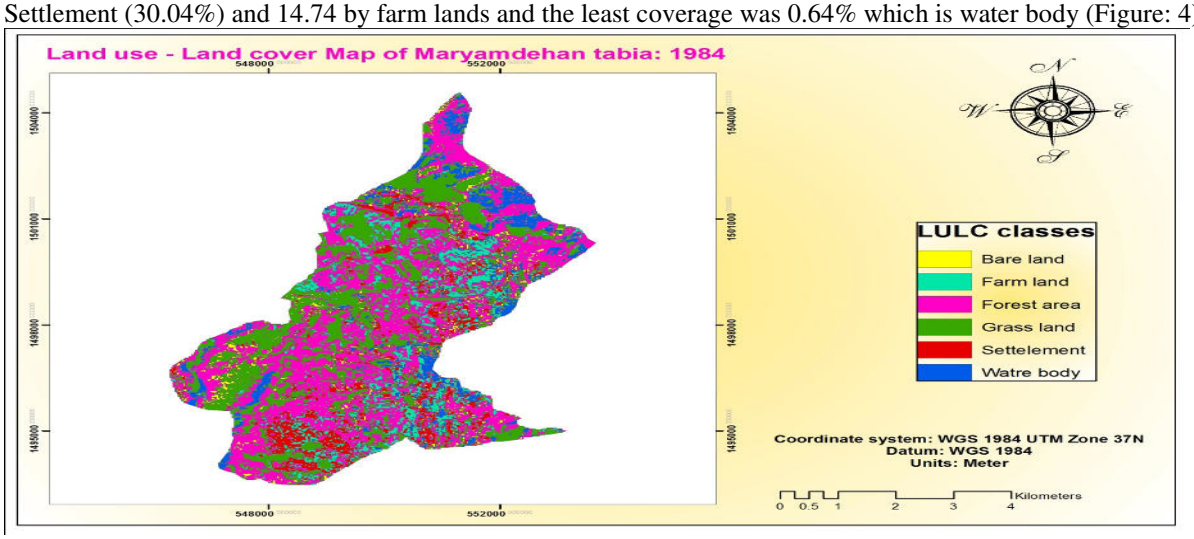


Figure: 2 Land use land cover classes of Maryamdehan Tabia in the year 1984

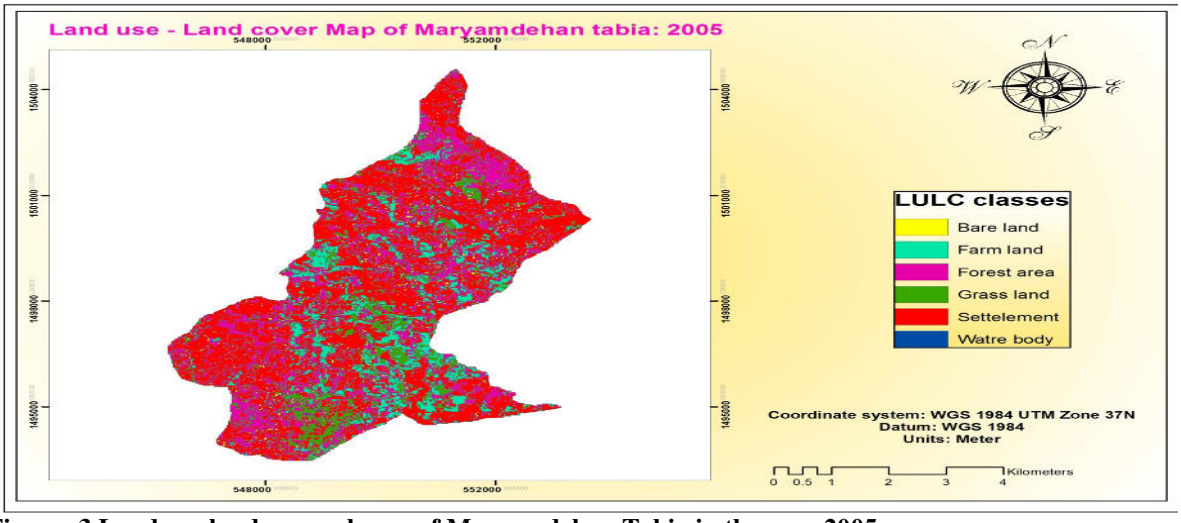


Figure: 3 Land use land cover classes of Maryamdehan Tabia in the year 2005

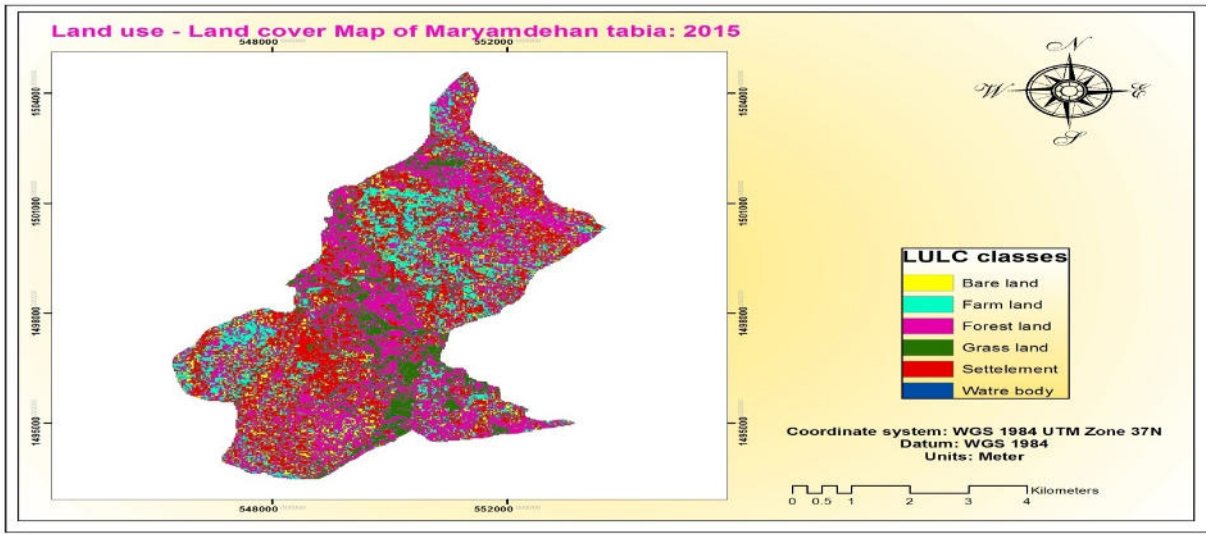


Figure: 4 Land use land cover classes of Maryamdehan Tabia in the year 2015

Table: 1. land use land cover category description for classification purpose in the tabia

No	LULC category	Description of land use land cover classes
1	Bare land	Free lands, or covered by bare soil and exposed rocks.
2	Farm land	Agricultural lands, lands used for farming activities
3	Forest area	Areas covered by trees forming closed or nearly closed canopies; Forest; Plantation forest
4	Grass land	Land covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests
5	Settlement	Land being used for settlement both in rural and urban lands
6	Water Body	Lands with water sources, lakes, ponds and streams

Table: 2. the static land use land cover distribution for each study year as derived from the maps are presented in the table above.

Land use land Cover classes	1984 Area (Ha.)	Area (%)	2005 Area (Ha.)	Area (%)	2015 Area (Ha)	Area (%)	Rate of change b/n 1984 - 2005	Rate of change b/n 1984 - 2015
Bare land	115.975	**3.18**	63.900	1.75	329.588	9.039	- 52.075	+ 213.613
Farm land	394.247	**10.81**	427.336	**11.71**	537.825	**14.74**	+33.089	+143.578
Forest area	1483.816	**40.69**	913.147	**25.04**	1281.682	**35.14**	-570.669	-202.134
Grass land	953.599	**26.15**	318.567	8.73	378.196	10.37	-635.032	+59.629
Settlement	359.441	9.85	1911.293	**52.41**	1095.699	**30.04**	+1551.852	-815.594
Water Body	339.412	9.30	12.778	**0.35**	23.547	**0.64**	-326.634	10.769
Total	3646.4	99.98	3646.4	99.99	3646.4	99.96	---	----

Table: 3. Land use land cover Change detection on years 1984, 2005 and 2015.

No	LULC category	Change detection (1984 - 2005) Area(Ha)	Area (%)	Change detection (2005 - 2015) Area(Ha)	Area (%)	Change detection (1984 - 2015) Area(Ha)	Area (%)
1	Bare land	-52.075	-44.901	265.688	+184.188	+213.613	+334.2926
2	Farm land	+33.089	+8.392	110.489	+36.418	+143.578	+33.59839
3	Forest area	-570.669	-38.459	368.535	-13.622	-202.134	-22.136
4	Grass land	-635.032	-66.593	59.629	-60.340	-575.403	-180.622
5	Settlement	+1551.852	+431.740	-815.594	+204.834	+736.258	+38.52146
6	Water Body	-326.634	-96.235	10.769	-93.062	-315.865	-2471.94

4.4 Land use land covers change detection between 1984 and 2005

As a result in this period farm land and settlement area have increment trends in the Maryamdehan *tabia*. Whereas there is decreasing trends on the land use land cover classes of bare land, forest land, water body and grass land and, this because in this period there is expansion of agricultural activities and increasing population numbers so

this leads for increasing water resource demand for different household activities and most of the farmer's daily life depends on agriculture.

4.5. Land use land covers change detection between 2005 and 2015

As mentioned in the above table, there is land use land cover changing trend in the years of 2005 and 2015; commonly the changing might be positive or negative trends. As a result in this period bare land, farm land and settlements have positive trends, whereas forest area, grass land and water body have negative trend in the study site. This may be the reason as mentioned above and some other driving forces which is implemented by the community.

Over the entire changing trend in the tabia from (1984 - 2015) have high positive trend in bare land, farm land and settlement area, whereas there is a negative trend in forest area, grass land as well as water body. Here some of the water body changes into bare lands and forest lands change in to farming lands.

5. Conclusion

As a result of this study there was a change in land use land cover class from the year 1984 to 2015 in *tabia* Maryamdehan, Enderta district of Tigray Regional State. The land use land cover change detection clearly shows that farm/agricultural lands and settlement land increased throughout the periods of 1984 to 2015, the main reason might be due to increasing trend of population growth and expansion of agricultural activities. Grass land and water body coverage dynamically decreases in the periods, but the bare land has high coverage in 2015, because some of the water body and grass lands change into bare lands.

Currently there is scarcity of water resource in the tabia with high demand, so constructing water harvesting structures, introducing water use efficient technologies and awareness creation on natural resource utilization for farmers plays its own role in improving their livelihoods. And also there is high coverage of forests, these also have their advantage in minimizing climate change impacts and it needs additional research work on carbon sequestration and carbon trading aspects. Some of the farmers said that there is decreasing rate of soil erosion on their farm land, but they need to apply improved soil and water conservation technologies for improving their soil resource as well as to improve their agricultural production to eradicate drought.

Generally, Geo-informatics tools play a great role in performing land use land cover change detection of a place using multi – temporal satellite images for sustainable natural resource utilization and planning, and it is best tool on spatial decision making issues for policy makers.

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