 doi:10.20944/preprints201907.0275.v1

Remote Sensing and GIS Application for Land use/ Land cover Change Analysis: case study of Jarmet Wetland and its surrounding environments in western Ethiopia.

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ARTICLEINFO

Keywords:
Accuracy Assessment Analysis
Change Detection analysis
Environmental change
GIS and Remote Sensing
Jarmet and others wetland change
LULC change
population growth.

ABSTRACT

Wetlands are one of the crucial natural resources. They provide invaluable biodiversity resources, aid in water quality improvement, support ground water recharge, help in moderating climate change and support flood control. Environment is in the other hand, where we live and something, we are very familiar with our day to day life. Geographic Information Systems (GIS), Remote Sensing and Global Positioning System (GPS) were a useful tool for wetland and environmental change analysis and to improve on the classification accuracy. This study investigates population and environmental change of Jarmet wetland and its surrounding area change analysis over the period of 1972 to 2015. The purpose of this study was to show land use/ land cover change of Jarmet wetland and its surrounding environment over years as a response to population growth. For this purpose, multi-temporal satellite imageries (Landsat MSS 1972, TM1986, ETM+ 2000, 2005 and 2015 and SRTM 2000) were obtained and used for LULC change analysis, elevation analysis and change detection analysis. ERDAS Imagine 2015, ARC GIS 10.5.1, Global Mapper11, ENVI 5.0 and DNR Garmin softwares were used to process the image data and accuracy assessment analysis. The result of LULC showed that there is spatial reduction in wetland, forest, Shrubland and grassland in the period of 43 years (1972-2015) by -1,722.8 ha, -296.2 ha, -1,718.7 ha and -661.9 ha respectively, due to increase in the farmland and plantation area as a response to overpopulation, lack of environmental policy implementation and irresponsible for natural resource degradation. The accuracy assessment of LULC change are done for recent satellite image showed the overall accuracy of 84.06% with Kappa index than 75% of error. Finally, this study suggests that create strictly natural resource conservation law, stopping illegal expansion of farmland, educating society about the value of natural resource especially wetland and create a source of income for society rather than farming.

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75.19% this means this classification is accurately classified and handle greater

Introduction

Many definitions for wetlands have been proposed and utilized over the years (Ramsar Convention, 1971; Mac et al., 1998) and these definitions have been developed for various purposes, such as research studies, general habitat classifications, natural resource inventories and environmental regulations. But, no universal definition of wetland exists up to wetland protection law implemented. Before the beginning of wetland protection laws in 1960s, wetlands were broadly defined by scientists working in specialized fields (Lefor and Kennard, 1977). A botanist's definition would emphasize on plants; soil scientists would focus on soil properties, hydrologists' definition would emphasize of the water table and geographers and environmentalists' definition would emphasize the function and services of wetlands. Wetlands are useful natural resources and usually attract different types of wildlife and birds. They are also a fragile ecosystem that could irreversibly degrade with human impacts. The united states geological survey(USGS) (1992) defined wetland as a general term applied to land areas which are seasonally or permanently water logged, including lakes, rivers, estuaries and fresh water marshes, an area of low lying land submerged or inundated periodically by fresh or saline water.

According to UNPD (2009) the world's population are nearly one billion in 1800 and currently it has grown approximately to 7 billion. The recent estimation of population projection suggested that the world population will rise somewhere between 7.5 and 10.5 billion by 2050, depending on changes in national level fertility and mortality rates. When the population increases over years at the same time the wetland and the earth's ecosystems, that support people's livelihoods and wellbeing are rapidly degrading. Increases in human population size have dynamic, nonlinear impacts on the wetland and environment, with feed backs, thresholds and synergies amplifying risk and spending wetland and environmental change or degradations beyond the rate of population growth (Harte, 2007).

Thomas Malthus (1978) says in his statement ''the power of population is indefinitely greater than the capacity of the earth to produce subsistence for man''. This shows as if the number of populations grows the natural resources and environments are degraded. Because, if the population increases in number the populations carrying capacity on natural environment also increases. Although, population growth and human activity placing unprecedented and unsustainable demand on wetland and surrounding environments. Increasing demand for natural resources, the intensification of agriculture, the productions of hazardous waste, rapidly growing populations and globalizing economy and urbanization, all have contributed to wetland and environmental changes (DCDC, 2007).

The outcomes of the impacts of human on wetlands are manifested through land use/ land cover changes. Because, land use/ land cover changes are especially agricultural extensification converts and ultimately degrades natural habitats and wetland resources. Habitat degradation not only threatens biodiversity, wetland and environments; it also disrupts the soils natural regulatory functions, resulting in soil erosion, reduced water holding capacity and nutrient depletion, as well as wetland change and other forms of natural environment degradations. Although, wetland is an inherently dynamic system which can be created, modified, and destroyed by a range of natural processes, the direct and indirect consequences of human activity are the main causes of wetland and environmental change and loss worldwide (Williams,1991). Degradation on wetlands includes habitat loss and fragmentation, resource extraction, drainage and reclamation, pollution and so on. Land use /land cover (LULC) changes are the result of a complex interplay between socio-economic, institutional and environmental factors (Turner et al., 1994, 1995; Tegene, 2002; Lesschen et al., 2005; Lambin and Geist, 2006; Falcucci et al., 2007; Li et al., 2009).

The change of wetlands has created numerous problems including decrease and extinction of wild flora and fauna, loss of natural soil nutrients, water reservoirs and of their subsequent benefits. They have affected on various traditional occupations, socioeconomic conditions and cultural activities.

According to Finlayson and Moser (1991) wetlands occupy of about 6 percent of the land surfaces of the world, or approximately 890 million ha but an estimate of 50% of world's wetland may have been altered or lost in the last 50 years (Dugan, 1993). In tropical and sub-tropical areas conversions of wetlands to alternative land uses have accelerated wetland loss since the 1950s and agriculture is considered the principal cause for wetland loss or change (Moser et al., 1996). Africa is the best known for its savannas and hot desert, 1% of its surface area (345,000km^2) is covered by wetlands. In an

Ethiopian context, more than 85% of population live in rural areas and depend on agriculture for employment. The total land area of Ethiopia is 113,000,000 hectares or 1,130,000 km^2. Out of which 2 – 3.5 % is covered by high forests, whereas wetland constitutes only 1.15% (13,699km^2), 23.1% covered by Shrublands and 12.8% covered by savanna and grasslands. Ethiopian highlands produce in excess of 110 billion meter cubic of water, of which 74% flows into rivers draining into Sudan, Egypt, Kenya and Somalia (EPA, 2004; WBISPP, 2005). On the other hand, the recent data on forest resources of Ethiopia reported in FAO (2010) puts Ethiopia among countries with forest cover of 10-30%.

Extensive loss of wetlands has occurred in many countries throughout the world (Mitsch and Gosse link, 1993). Ethiopia is one of the world countries known by loss of environments and wetlands. In many countries like Ethiopia, local economies depend on wetlands for fisheries, reed harvesting, grazing, drinking ground water, irrigation and recreation. A large number of Ethiopians depend on wetland resources for their survival **(**Wood and Dixon, 2002)**.** The causes of wetland degradation include the conversion of wetlands for intensive irrigation agriculture, the expansion of human settlement, industrial pollution, pesticides and fertilizers and water diversion for drainage and the construction of dams. Wetland conversion often results in water depletion, the displacement of populations, the destructions of traditional production systems, habitat degradation, salinization, increase of water borne disease and other adverse ecological impacts (WCED, 1987).

The aim of this research study was to identify, detect, analyze and visualize with the quantification of land cover/land use changes in the Jarmet wetland and its surrounding environments since 1972 to 2015 by using the GIS and remote sensing techniques of satellite image-based analysis.

The study area, Jarmet wetland is located in western part of Ethiopia and was claimed to have high diversity of wildlife, birds and surrounded by high forests. Currently, the area of the wetland has reduced and there is no wildlife life (except the most common ones such as hyena and common jackals). The surrounding high forest was replaced by agriculture and only remnant mature trees are scattered across the study area. Although the underlying factors can be anticipated, there is no recorded and quantified data to understand the original extent of the wetland and its current size. Second, there is no data that depict which land use type was converted to which. Third, the amount of the high forest surrounding the wetland is unknown. Fourth, there are also smaller wetlands which are part of Jarmet wetland and their status over years are also not known.

For the present study GIS and remote sensing technologies are used for analyzing population and environmental changes of Jarmet wetlands and its surrounding areas. GIS and remote sensing data are appropriate tools for analyzing and monitoring of wetland distribution, change area and spatio-temporal dynamic multiplicity. Remote sensing has many advantages for analysis of wetland and environmental changes and also provides information on surrounding land use and their changes over time. Landsat MSS, TM and ETM+ are a common data type for wetland classification and analysis of its spatial and temporal dynamic change.

2. Research methods

2.1. Study area

2.1.1. Location

The current study was carried out at Jarmet wetland and surrounding environments. Jarmet wetland is located in western part of Ethiopia and it lies between 9^{O}52' 43.00" N to 9^{O}42'1100 " N latitude and 36^{O}57'31.00 " E to 37^{O}05'50.00 " E longitude with an average elevation of 2,388 meter above sea level. This wetland is flooded during rainy season and gradually dries up. It is part of the Blue Nile watershed which encompasses the Ethiopian renaissance dam. The total land coverage of the study area is 8,113 hectares. Out of which Jarmet wetland covers an area of 291.0 hectares. Its watershed length (Jarmet-Imane watershed) is 0.083 Km^2 coverage (Fig.1).

 doi:10.20944/preprints201907.0275.v1

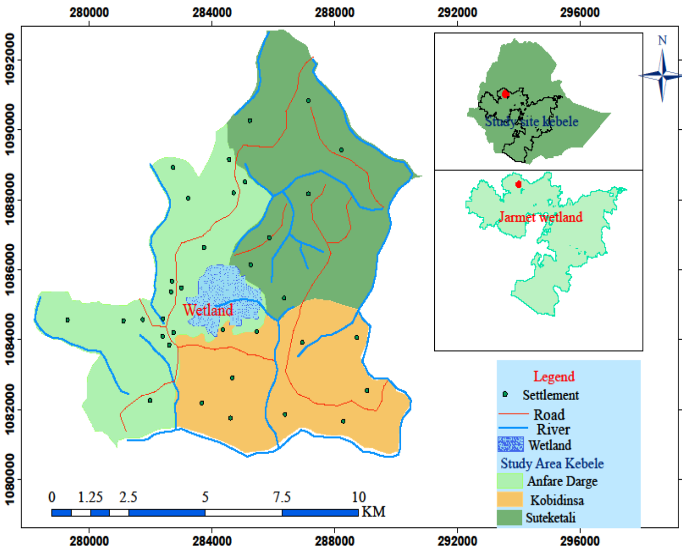

Fig. 1. Location map of the study area

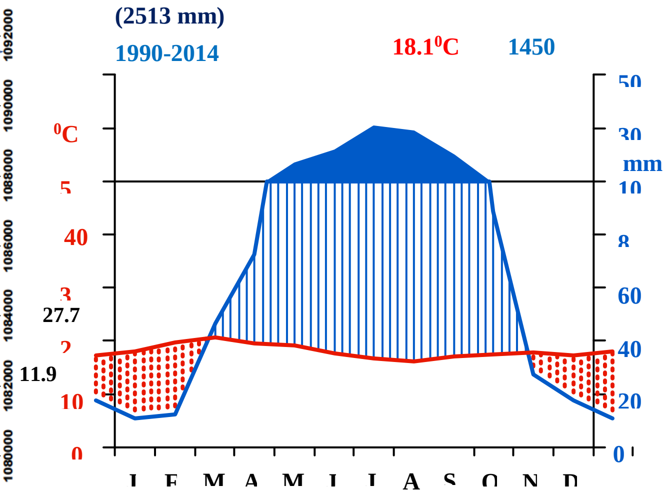

Fig.2 Average temperature and rainfall in both stations in 1990 to 2014

2.1.2. Climate

The climate of Ethiopia is mainly controlled by the seasonal migration of intertropical convergence zone (ITCZ) which follows the position of the sun relative to the earth and the associated atmospheric circulation, in conjunction with the complex topography of the country (NMSA,2001). The mean maximum mean monthly rainfall is recorded in both station average is 411.9 mm, 406.3 and 393.1mm, 334.6mm in July and August respectively. The analysis of monthly rainfall indicates that the rainfall pattern in the study area is predominantly bimodal (i.e., rainfall occurs over a continuous period of times, but dominated by two rain fall peaks). The first rain starts from March to April and the second from end of May to August. In general, the wet season starts from May and end in August sometimes continuous to September. The temperature of the area is related with altitude. The monthly mean maximum 27.7 °c in March and minimum temperature 11.9 °c in August of both stations shows as an average temperature of the station recorded. In Jarmet station the mean monthly highest temperature is recorded from February to April with its average 26.6°c and peak is 33.1 in February for this station.

2.1.3. Geology and hydrology

The main geological features of Western Ethiopia which includes the Nekemte map sheet NC37/9 is underlain by Precambrian, Paleozoic, Mesozoic, sedimentary rocks, quaternary schist and quaternary or recent unconsolidated sediments. The Precambrian rocks are divided into three N-S running zones; the western high-grade gneisses, the central low grades volcano sedimentary belt and eastern high-grade belts (Amenti, 1989). Jarmet wetland and its surrounding area geology are Paleozoic, Mesozoic sedimentary rock and quaternary rock covers (Fig.3).

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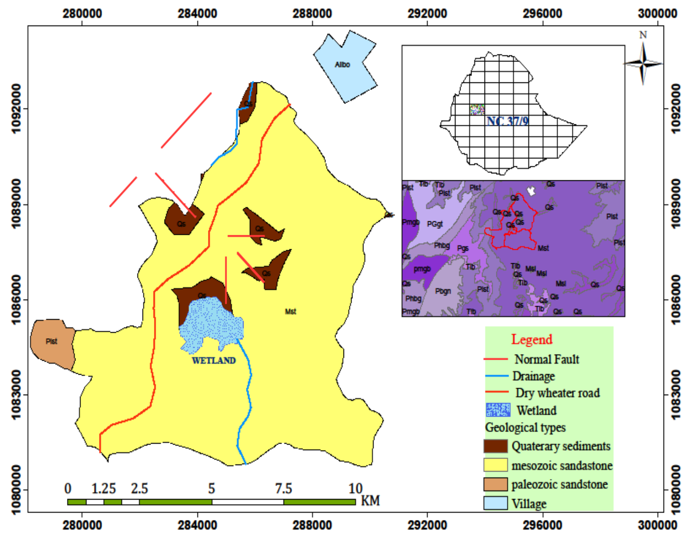

Fig.3. Geological Map of the study Area

2.1.4. Soils

The study area is dominantly covered by two major soil types (Fig. 4). These are Haplic and Eutric lithosols and Haplic Phaeozems. In addition, it's surrounding small areas of Eutric and Vertic cambisols are found in the study site (FAO, 2003). Those alluvial soils are found at Jarmet wetland on plain areas along rivers and streams courses.

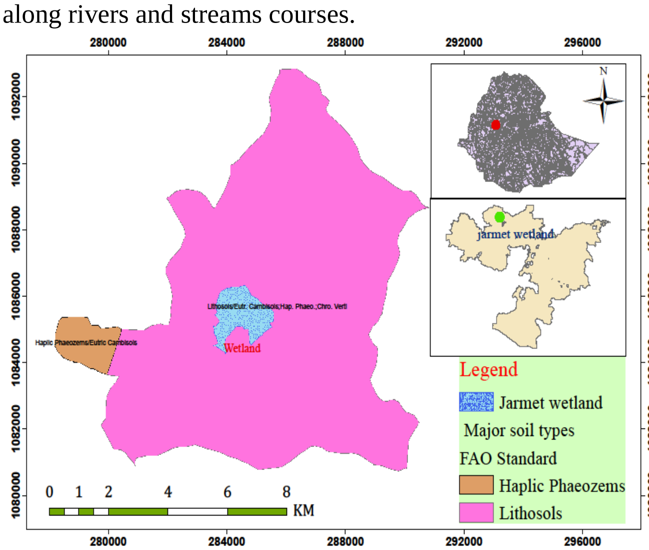

Fig.4. Major Soil types of the study area

2.1.5. Vegetation

Vegetation means the assemblages of plant species and all ground cover by plants and the main elements of biosphere. Previously, the study area was a pristine wetland surrounded by ***moist afro-montane forest***. There are still mature individual plants of *Olea europea subs. cuspidata*, *Cordia Africana*, *Podocarpus falcatus*, *Ficus sycomorus*, *Phoenix reclinata*, *Syzygium guineense*, *Croton macrostachyus* and *Ficus vasta* scattered across the study area.

2.1.6 Wildlife

Wildlife is a collective name for animals that have not been domesticated or tamed and are usually living in natural environment. The wetland and the surrounding forest of the study area were once a home to a variety of animals. Animals such as reedbuck, leopard and wolf were once common in the wetland but now absent. Although their number is very much smaller compared to the disturbance of the wetland and forest, there are still colobus monkey, aardvark, wild pig, bush buck, rabbit and python in the remnant pockets of forests.

2.1.7 Topography

Topography is important for wetland and its surrounding environment characterizations. The wetlands are topographically low lands and hence digital elevation model (DEM) data offers a fine opportunity to delineate low lands from up lands. Slope gradient (slope) and orientation (aspect) are primary attributes derived from digital elevation data. The elevation data of this study was derived from NASA shuttle radar topographic mission (SRTM), which was flown on board of the space shuttle mission in February, 2000.

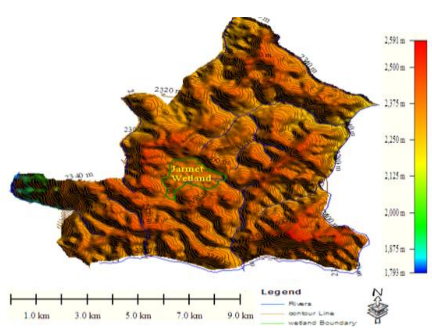

Fig. 5. Elevation map of the study area

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2.2. Remotely sensed data and maps used

This study attempts to investigate five multitemporal and multispectral Landsat images between 1972, 1986, 2000, 2005 and 2015 from USGS (Landsat GLCF) Path 170/Row 053 and path 182/ row 053 for analysis and detect changes happened in this study area. Remote sensing data are the basis of GIS which has the function of collecting, storing, managing, analyzing and describing all or part of the data which regards to spatial and geographical distribution, Global Positioning System (GPS), on the other hand can identify exactly the change of location, time and speed of any kind of object (Wang et al.,2008). The satellite based remote sensors are low cost, affordable GIS tools for effective analysis and detect the wetland and environmental change in surrounding areas as a response.

2.3 Methodology

The land use/land cover change of Jarmet wetland and its surrounding area was analyzed using GIS and remote sensing techniques. For the purpose of the current study both primary and secondary data sources were used. Primary data sources include semi-structured questionnaire, key informant interview, focus group discussion and satellite images. These were complemented by a number of qualitative and quantitative techniques. Secondary data sources include population data, geological map, soil map, meteorological data and topographic map. Several investigations were conducted in selected three study kebeles in the form of questionnaire survey, GPS survey and visual observation was also made to verify satellite image information. For this study many computers aided interpretation of images was conducted using environmental resources data analysis system (ERDAS) Imagine 2015, Department of natural resource (DNR) Garmin5.1 and environment for visualizing images (ENVI) 5.0 softwares were used for satellite image processing, land use/ land cover classification accuracy assessment and wetland and environmental change analysis. In addition, Global mapper 11, 3DEM and ARCGIS 10.5.1 were used for GIS based DEM processing, MS excel was also used for analysis

of meteorological data and population density.

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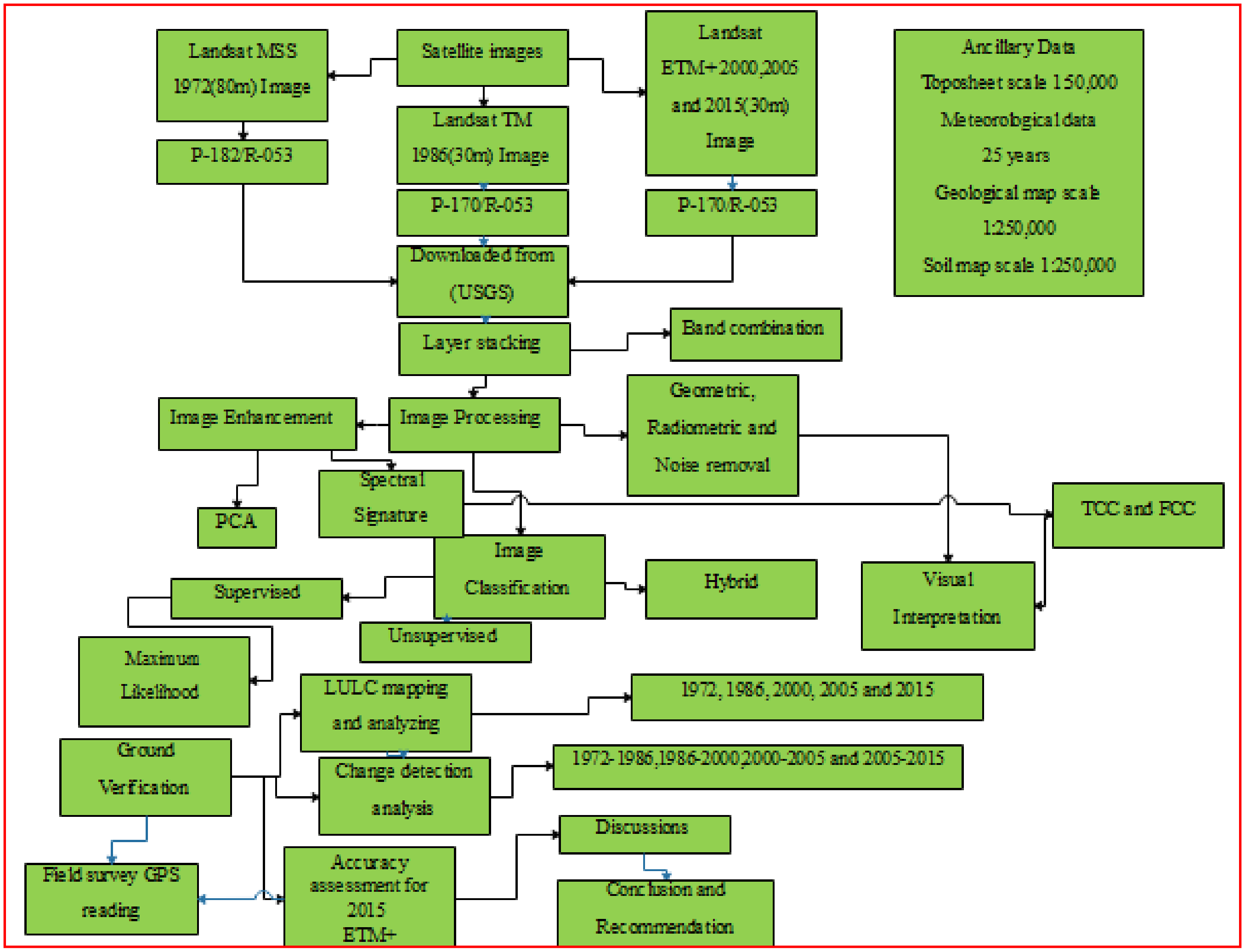

Fig. 6. The flowchart indicating image processing stages

2.4. Image processing

The first steps were subjected to principal component analysis (PCA) then apply clustering to the first principal component to classify and enhance the wetlands and environments of the surrounding areas. In the second step original remotely sensed satellite images were classified using unsupervised iterative self-organizing data analysis technique algorithm (ISODATA) algorithm and supervised classification method used. And these steps were compared and used to analyse wetlands and environmental changes to estimate their loss. All satellite images except those of year 1972 and 2005 were bought from the Ethiopian Mapping Agency. In order to compare the wetland and environment of Jarmet and its surrounding area change, many satellite images data of the area were used. These include Landsat Thematic Mapper (TM) of 1986, Enhanced Thematic Mapper Plus (ETM+) of 2000, 2005 and 2015 and Multispectral Scanner (MSS) of 1972. All of the images used for the study were re-projected from WGS84 coordinate system to universal transverse Mercator projection Adindand zone 37 Clarke1880 spheroid.

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Table 1. Satellite images used in LULC change detection

Size No.	Type	Format	Path/row	Spectral bands	Scene size	Date of acquired and source	Resolutions(m)
1.	Topo-graphic maps	Ana-logue	Sheet no.0937	______	_______	January1982 to october1983 EMA	1:50,000
2.L5	Landsat TM	Digital	170/053	1,2,3,4,5,7	185X185km	01-03-1986 USGS	30m
3.L7	Landsat ETM+	Digital	170/053	1,2,3,4,5,7	185X185km	01-04-2000 USGS	30m
4.L7	Landsat ETM+	Digital	170/053	1,2,3,4,5,7	185X185km	01-31-2005 GLCF	30m
5.L7	Landsat ETM+	Digital	170/053	1,2,3,4,5,7	185X185km	02-11-2015 GLCF	30m
6.L1-4	Landsat MSS	Digital	182/053	1,2,3,4	185X185km	12-09-1972 USGS	60m
7.	Geological maps	Ana-logue	Sheet no NC-37/9	----------	------------	August,2000 (GSE)	1:250,000

Table 2. LULC categories and their description

Number	Land use/land cover type	Descriptions
1.	Wetland	The area where the water table is near or above the land surface covered by marshes, swamps, bogs, rivers and streams.
2.	Forest	These areas are regions covered with big trees of different species, with little or no human activities.
3.	Farmland	These are areas used for growing agricultural crops and appeared cultivated during growing season.
4.	Shrubs	Areas covered with small shrubs, thickets and grasses with little or no trees are referred to as shrubs and its height is less than 5m.
5.	Plantation	All areas of eucalyptus plantation and temporary clear field stands a waiting replanting within in eucalyptus plantation.
6.	Grassland	Lands predominantly covered with grasses, fobs, and grass areas used for communal grazing.

2.5 Image Classification

The overall objective of the digital image classification procedures is to automatically classify all pixels in an image into land classes or themes (Lellisand et al., 2004). It is a powerful technique to drive thematic classes from multiband image data. It performed for extraction of distinct classes or themes, land use/ land cover categories from satellite imagery. For this study among the various classification methods, supervised and unsupervised classification procedures were used for satellite image classification. The most common used for unsupervised classification method are the iterative self-organizing data analysis technique (ISODATA). The ISODATA classifier refines clustering by splitting and merging of clusters. For this study, the1972 MSS and 2015 ETM+ Landsat image was subjected to unsupervised classification to produce land use/ cover class classification. For this classification 6 land cover classes were produced by merging unknown distribution of pixel values in the image data. These classifications were produced by using ERDAS IMAGINE 2015, before the field work. The true color composite (TCC) and false color composite (FCC) were used for assessing visualization of the land uses. For the present study, Landsat MSS 1972, TM 1986, and ETM+ of 2000, 2005 and 2015 were independently classified using the supervised classification method of maximum likelihood algorithm. This method is the most common method and widely used for supervised classification in remote sensing image data analysis (Richards, 1995). The maximum likelihood classification assumes that for all classes and the input data in each band follows the Gaussian (normal) distribution function. A pixel has a certain probability of belonging to a particular class. These probabilities are equally identifying and locates land cover types that are known a priori through combination of personnel experience interpretation of satellite images, map analysis and field works (Jensen, 2005).

2.6 Classification Accuracy Assessment

Accuracy assessment is a general term for comparing the classification to geographical data that are assumed to be true, in order to determine the accuracy of classification process. The accuracy assessment is essentially a measure of how many ground truth pixels were classified correctly. According to Edwards et al., (1998) accuracy assessment is a crucial step in classification in order to check for errors propagated by the way data acquired, analyzed and converted from one form to the other. In this study accuracy assessment was done for recent satellite image of Landsat ETM+2015 for which the ground truth data is likely corresponding. Error matrix is one of the most common methods of expressing classification accuracy (Congalton, 1991). An error matrix is square array of numbers set out in rows and columns which express the number of sample units (i.e. pixels, cluster of pixels, or polygons) assigned to a particular category relative to the actual category as verified on grounds.

The k ("KHAT') statistic is a measure of the difference between the actual agreement between reference data and an automated classifier and the chance agreement between the reference data and a random classifier (Jensen, 1996). Conceptually, Ḱ can be defined as

$$\acute{K} = \frac{\text{observed accuracy - chance agreement}}{\text{1 - Chance agreement}}$$

In reality, k usually ranges between 0 and 1.
The KHAT statistic is computed as

$$\acute{K} = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^{r} (x_{i+} \cdot x_{+i})} \quad \text{......equation (1).}$$

Table 3. Error Matrix resulting from classifying training Set pixels for Landsat ETM+2015

Classified data	Reference data						Row total	OE%	UA%
	Shrub-land	Grass-land	Forest	Plantation	Wetland	Farmland			
Shrub land	1	0	0	1	0	0	2	87.5%	50%
Grassland	1	15	1	1	0	3	21	25%	71.43%
Forest	3	1	22	1	0	0	27	24.1%	81.48%
Plantation	0	0	0	16	0	0	16	0%	100%
Wetland	0	0	2	0	15	1	18	11.8%	83.33%
Farmland	3	4	4	5	2	105	123	3.7%	85.37%
Column total	8	20	29	24	17	109	207		
Commission. E%	50%	28.6%	18.5%	0%	16.7%	14.6%			
Producer. A%	12.50%	75%	75.86%	66.67%	88.24%	96.33%			

The current study revealed an overall accuracy of 84.06% with kappa index of agreement of 0.7519. This was reasonably a good overall accuracy and accepted for subsequent analysis and change detection. Sabins (1997) says that accuracy levels of more than 80% are considered adequate enough for reliable classification of land cover types.

3. Results and discussion

3.1 Areal extent of wetlands and its associated land use in the study area

From visual and digital interpretations of the satellite imagery, different land use/land cover categories were distinguished for this study. For the purposes of measurement of areal extent of Jarmet wetland and its surrounding environment; the satellite images were interpreted and analyzed and classified into six different classes. The areal extent of these land use features are given below (Table-4).

Table 4. Areal extent of wetland and other land use/ land cover classes in ha and its percentage

S. N	LULC Classes	1972 Ha	%	1986 Ha	%	2000 Ha	%	2005 Ha	%	2015 Ha	%	1972-2015 Ha	%
1.	Shrub-land	+1,956.2	24.1	-693.4	8.5	+1,518.4	18.7	-263.3	3.2	-237.5	2.9	-1,718.7	-19.53
2.	Farm-land	+523.1	6.4	+1,422.2	17.5	+2,495.5	30.8	+4,102.2	50.6	+4,510.8	55.6	+3,987.7	45.31
3.	Plan-tation	+179.2	2.2	+315.0	3.9	+348.4	4.3	+354.0	4.4	+591.3	7.3	+412.1	4.68
4.	Forest	+1,587.6	19.6	+2,279.7	28.1	-1,932.3	23.8	-1,496.6	18.4	-1,291.4	15.9	-296.2	-3.36
5.	Grass-land	+1,638.5	20.2	+2,411.6	29.7	-382.9	4.7	+1,390.4	17.1	-976.5	12.1	-662	-7.52
6.	Wet-land	+2,228.7	27.5	-991.4	12.3	+1,435.8	17.7	-506.8	6.3	-505.8	6.2	-1,722.9	-19.58
7.	Total	8,113.3	100	8,113.3	100	8,113.3	100	8,113.3	100	8,113.3	100	8,113.3	100

Note: The positive sign (+) means gain and the negative sign (-) indicates loss in areal extent

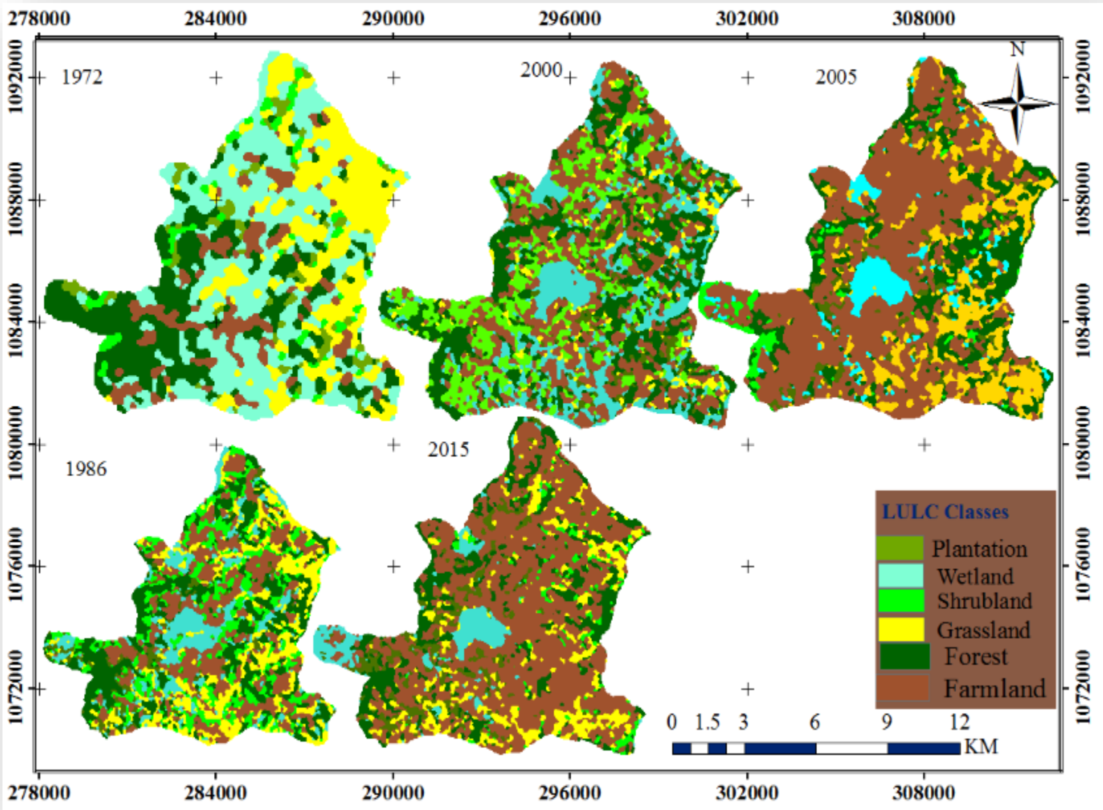

Fig. 7. Land cover and use maps of the Study area in 1972 to 2015

The total area of each land use category and percentage of each class of the study area between 1972 and 2015 were calculated and presented in Table 4. Forestland, Shrubland, farmland and wetland were the major land use types of the study area. The area of these four categories accounted for 3.36%, 19.53%, 45.31% and 19.58% of total area, respectively. From 1972 to 2015, the wetland and its surrounding environment's land use pattern changed dramatically. One of the most marked changes were the rapid decrease in wetland and forested land, from 27.5 percent in 1972 to 19.58 percent in 2015 and from 19.6 percent in 1972 to 3.36 percent in 2015 respectively. This was matched by a dramatic increase in farmland and plantation. Farmland occupied 6.4 percent of the study area in 1972 and increased to 45.31 percent in 2015. Similarly, plantation cover increased from 2.2 percent in 1972 to 4.68 percent in 2015. Other land use/ land cover like grassland showed both increment and decrement over the study period.

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3.2 Land Use/Land Cover Change Detection from 1972-2015

Change detection plays a pivotal role at local and regional scale for land use/land cover change analysis of classified satellite image. Changes in land use/land cover can be categorized in to two types: -those are modification and conversion. Modification is a change of condition within the same cover type. While, conversion is a change from one cover to another. A common method for classified satellite image change detection is to compare one satellite image to the other. For change detection of land use/land cover change analysis for this study Landsat imageries are used starts from 1972 to 2015. The statistics of land use/land cover were computed and summarized to detect the nature of major changes of Jarmet wetland and its surrounding environment within 43 years.

Table 5. LULC change statistics of Jarmet wetland and its surrounding environmental area between1972-2015

Land use/ land cover classes	Land use/land cover change in hectare and percent								Total area Δ in (ha) 1972-2015	Area (%)
	1972-1986		1986-2000		2000-2005		2005-2015			
	Area (ha)	(%) change	Area (ha)	(%) change	Area (ha)	(%) change	Area (ha)	(%) change		
Farm-land	+899.1	17.98	+1,073.28	22.58	+1,606.8	30.66	+408.408	31.62	+3,987.588	45.31
Grass-land	+773.101	15.46	-2,028.711	- 42.68	+1,007.49	19.23	-413.828	-32.0	-661.948	-7.52
Wet-land	-1,237.398	- 24.74	+444.478	9.35	-929.0	-17.72	-0.949	-0.07	-1,722.869	-19.58
Shrub-land	-1,262.83	- 25.25	+825.0	17.36	-1,255.1	-23.95	-25.802	-1.99	-1,718.732	-19.53
Planta-tion	+135.801	2.715	+33.389	0.70	+5.611	0.107	+237.332	18.37	+412.133	4.68
Forest	+692.09	13.84	-347.4	-7.31	-435.71	-8.31	-205.165	-15.88	-296.185	-3.36

According to the results obtained, grassland, Shrubland, wetland and forest are revealed negative sign of total area change which implies decline in the area. On the other hand, farmland and plantation have shown positive sign of total area change which implies increase in area coverage. The statistical table of change detection shows us the various proportions of losses and gains amongst the various land uses.

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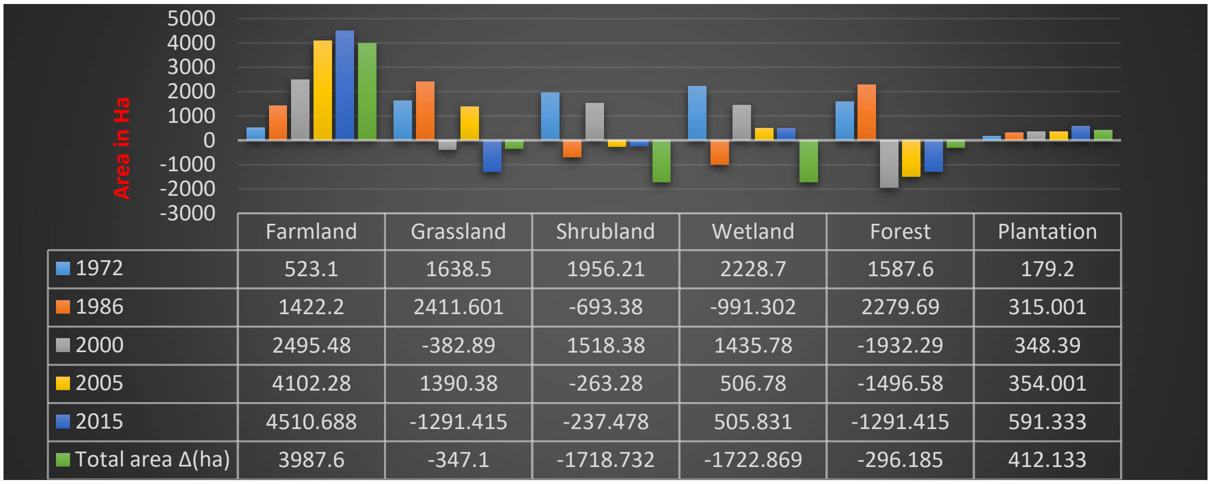

Fig.8. Land use/land cover change between 1972-2015

3.3 Trend and Rates of Land Use/Land Cover Change (Dynamics)

The absolute percentage and annual rates of land use/land cover change within the study area for the period of 1972-1986, 1986-2000, 2000-2005 and 2005-2015 and 1972-2015 was analyzed in Table 6. The percentage change is calculated using the equation

Land use/land cover trend (%) change= observed change X 100……………………………..........equation (2).
Sum of change

Annual rate of change= OC/(X2-X1) Where;

OC=is observed change X1= starting year and X2=is the ending year

Table 6. Trend and rate of change analysis of LULC in the study area

Land use/ land cover classes	Annual rate of change in ha				
	1972 to 1986	1986 to 2000	2000 to 2005	2005 to 2015	1972 to 2015
Farmland	64.22	76.66	321.36	40.84	92.73
Wetland	-88.38	31.75	-185.8	- 0.095	-15.39
Grassland	55.22	-144.9	201.41	-41.38	-40.07
Shrubland	-90.20	58.93	-251.02	-2.58	-39.97
Plantation	9.70	2.38	1.12	23.73	9.58
Forest	49.43	-24.82	-87.14	-20.51	-6.88

The above table indicated that LULC trend and rate of changes of the study area during the period of the study. It reveals a drastic decrease in the coverage of forest, wetland, grassland and Shrubland which contributed to concomitant increase mainly in farmland and plantation area. The forest cover's annual increase of the study area from 1972-1986, about 49.4 ha was increased by 13.8% rate per annum and from 1986-2000 about -24.8 ha was converted by 7.3% rate of change per annum. After 2000 years the forest coverage shows continuous decrease by -87.1 ha (-8.3%) and -20.5 ha (-15.9%) during the period of 2000-2005 and -6.88 ha during the period of 2005-2015 rate of change per annum respectively. This revealed that the forest decrease is as a result of population growth, unwise use of resource and the forest resources change to other land units. From 1986 to 2000, the Shrubland cover of the study areas has experienced the expansion of its spatial cover due to its encroachment into the wetlands and at the expense of the grass land covers. In addition, afforestation and reforestation of plantings conducted in the area have played great role in the expansion of Shrubland. Furthermore, the number of livestock from time to time and conversion of grasslands and rangelands to agriculture created livestock pressure on existing grasslands and rangelands.

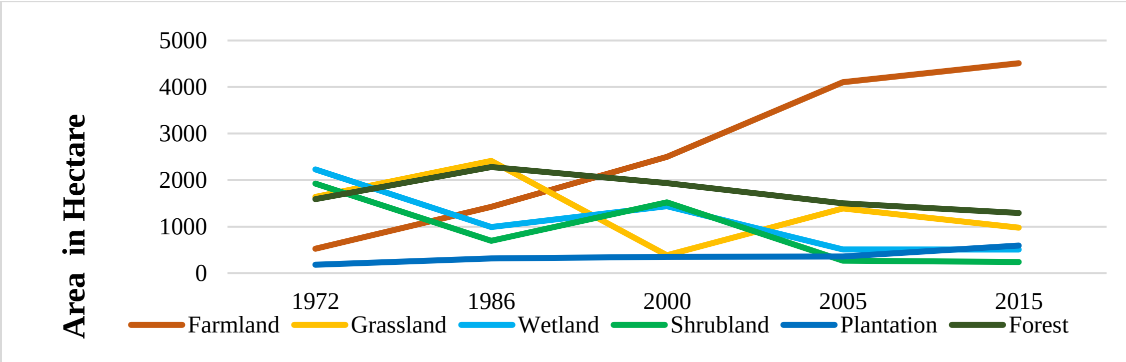

Fig.9. Land use/land cover trend of the study area in 1972-2015

3.4 Nature of Land use/Landover Change from 1972 to 2015

The nature of Land use/land cover change refers to the identification of 'what land use/land cover is changing and from what to what?' A post-classification comparison changes detection technique revealed different trends in land use/land cover changes over the period from 1972- 2015.This information will reveal both the desirable and undesirable changes and classes that are "relatively" stable overtime. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay. The nature of changes has been examined in terms of areas of land use/land cover remained unchanged, gained from other classes and lost to other classes. The statistics on nature of changes for the study area during the periods 1972-2015 are presented as below (Table 7).

Table 7. Change Detection Matrices of 1972 to 2015

		Initial State 1972													
	LULC types	SHL		GL		FR		PL		WL		FL		RT	CT
		Area		Area		Area		Area		Area		Area			
		Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%		
Final State 2015	SHL	28	1.4	78	4.8	33	2.1	1	0.6	88	4	8	1.5	236	244
	GL	208	10.7	312	19.2	101	6.3	8	5	321	14.4	21	3.9	971	988
	FR	143	7.3	125	7.7	567	35.5	16	0.1	298	13.4	105	19.5	1,253	1,302
	PL	358	18.4	35	2.1	116	7.3	19	11.9	47	2.1	24	4.5	599	600
	WL	52	2.7	19	1.2	165	10.3	0	0	261	11.7	7	1.3	504	511
	FL	1,153	59.2	1,052	64.6	575	36.3	16	0.1	1,186	53.3	371	69	4,454	4,493
	CCT	1,946	100	1,629	100	1,596	100	160	17.7	2,225	100	538	100	8,017	8,111
	CC	1,918	98.6	1,317	80.8	1,029	64.5	141	88.1	1,964	88.3	168	31.2		
	ID	-1,701	-87.4	-641	-39.3	-294	-18.4	439	2.7	-1,713	-77	3,954	734.9		

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***Note**: Land cover categories: SHL: Shrubland, GL: Grassland, FR: Forest, PL: Plantation, WL: Wetland and FL: Farmland = unchanged area of land cover over the years, RT: Row total, CC: Class Change CT: Class total ID: Image difference CCT: Column Class total*

Between the years 1972 and 2015, the major land use/land cover changes were dominated by changes from wetland, Shrubland and grassland to farmland (Table 7). Quantitatively, 1,186 ha, 1,153 ha and 1,052 ha of wetland, Shrubland and grassland respectively were converted to farmland. These changes were attributed to population growth which forced the farmers to till and expand their lands in greater extent than before to cope up with the conditions and to sustain their life. In terms of land cover remained unchanged over the period of 43 years; 28 ha, 312 ha, 567 ha, 19 ha, 261 ha and 371 ha were recorded for Shrubland, grassland, forest, plantation, wetland and farmland respectively. Overall, 1,558 ha (19.43%) of the total study area remained unchanged over the period of 43 years (1972-2015). The change detection matrix also indicates that there was gain in farmland and plantation area coverage by 1.67 km^2 (167 ha) and 1.41 km^2 (141 ha) respectively; whereas grassland, Shrubland, wetland and forest showed decrease (loss) by -641 ha, -1,701 ha, -1,713 ha and -294 ha in the same order.

3.5 The Impact of LULC change on Climate Change

Of course, climate change is a global issue which is partly triggered as a result of LULC change. Therefore, I have concisely included the impact of wetland land use/land cover change on its surrounding wetland ecosystem specifically and global climate change generally as discussed under the "The Impact of LULC change on Climate."

LULCC plays a major role in climate change at global, regional and local scales. At global scale, LULCC indirectly contribute to the concentration of greenhouse gases in the atmosphere, and thereby driving to global warming. Similarly, the degradation of wetland covers of the study area as well leads to the concentration of carbon dioxide in the atmosphere and disturbance of terrestrial ecosystems of the wetland and its surrounding environment. Deforestation is the major driver of wetland change in the study area which is followed by the expansion of agriculture that triggers the release of soil carbon in response to soil disturbance by tillage. The wetlandland cover changes alter the reflection of sunlight from land surfaces of the study area. As confirmed by the discussion made with the local people, LULCC put great stress on Jarmet wetland ecosystems, reduced its water resource, the number and diversity of birds.

4. Conclusion

This research work demonstrates the ability of GIS and Remote Sensing in capturing spatio-temporal data for Jarmet wetland and its surrounding environmental change analysis as a response to human population on land use/land cover change. The analysis of wetland and its surrounding environmental change over years are by using a time-series analysis technique of comparing remotely sensed images from Landsat missions. The link between human development, illegal land taking, weak environmental conservation policy, unwise use of wetland and other land cover recession can be measured through image classification, given that data is available and affordable for researches. In addition, land Use/ Land Cover dynamics is a result of complex interactions between several biophysical and socio-economic conditions. The effects of human activities are immediate and often radical, while the natural effects take a relatively longer period of time. The difference in increase by households and land cover change indicates the pressure on wetland, Shrubland, grassland and forest cover and related biodiversity. Generally, as the wetland, grassland, Shrubland and forests future, that the outlook is not so good. Therefore, appropriate policies and education about sustainable land management practices and wise use of those resources and adopting necessary conservation measures are the best method for those natural resource save from degradation.

List of Abbreviations

LULC: Land Use/Land Cover
Ha: Hectare
LULCC= Land Use/Land Cover Change

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Format for Biographies

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Acknowledgments

Special thanks to the Almighty God for his guidance and grace that allowed me to stay until this time and my work come to be successful. I thank my advisor Dr. Asmamaw Legas for his unreserved advice, encouragement, direction and support to complete this research. I also appreciate the support of: Prof. Sileshi Nemomissa, Mr. Dessalegn Gurmessa, Mrs. Elizabeth Kumsa, and Naol sileshi, Iyasu Kumsa, Webanchi Fikadu and Mekdes Taye. I am thankful to Ethiopian Mapping Agency, Ethiopian Geological Survey, National Meteorological Service Agency, Central Statistical Agency and Alibo Bureau of Agriculture for their support in providing data required for this study.

References

[1] Amenti Abraham, (1989). Tectonic history of the Pan-African low-grade belt of western Ethiopia. Ethiopian Institute of Geological Surveys. Note No. 305, 14p, Addis Ababa, Ethiopia.

[2] Congalton, R. (1991). A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data, Remote Sensing of Environment37: *p* 35-46.

[3] Dugan P. (1993). Wetlands in Danger. Oxford University Press, New York, NY, USA.

[4] Edwards, T.C. G.G. Moisen & D.R. Cutler, (1998). Assessing map accuracy in a remotely sensed, ecoregion-scale cover map, Remote Sensing of Environment, 63:73-83.

[5] Falcucci, A., Maiorano, L., Boitani, L., 2007. Changes in land-use/land-cover patterns inItaly and their implications for biodiversity conservation. Landsc. Ecol. 22, 617–631.

[6] EPA (Environmental Protection Authority), (2004). Proceeding of the national workshop on the Ramsar Convention and Ethiopia, Addis Ababa, unpublished, 130 pp.

[7] FAO, (2003). Livestock's long shadow; 00153 Rome, Italy.

[8] FAO (2010) Global Forest Resources Assessment 2010 - Country Report Ethiopia. Food and Agriculture Organization (FAO), Rome, Italy (www. fao.org/forestry/ fra/fra2010/en/, accessed date September 15, 2010).

[9] Finlayson M. and M. Moser (eds.). (1991). Wetlands. International Waterfowl and Wetlands Research Bureau. Facts on File Ltd. Oxford, UK 224pp.

[10] Harte, J. (2007). 'Human population as a dynamic factor in environmental degradation', Population and Environment, Vol. 28, Nos. 4–5, pp.223–236.

[11] J. R. Jensen, "Introductory Digital Image Processing, A Remote Sensing Perspective third edition," Prentice Hall, Upper Saddle River, NJ, USA. (2005).

[12] Lambin, E.F., Geist, H., 2006. Land-Use and Land-cover Change: Local Processes and Global Impacts. Springer-Verlag Berlin Heidelberg, Printed in Germany, pp. 236
(ISBN: 1619-2435).

[13] Lefor, M.W., and Kennard, W.C. (1977). Inland wetland definitions: Storrs, Conn., University of Connecticut., Institute of Resources, Report 28, 63 p.

[14] Lesschen, J.P., Verburg, P.H., Staal, S.J., 2005. Land-Use and Land-Cover Change (LUCC)Project. IV. International Human Dimensions Programme on Global Environmental Change (IHDP) V. International Geosphere Biosphere Programme (IGBP). International Livestock Research Institute, Kenya.

[16] Lellisand, M.T., Kiefer, R.W. and Chipman, J.W. (2004). Remote Sensing and Image Interpretation. (Singapore: John Wiley & Sons, Pvt. Ltd).

[17] Macleod R.D. and Congalton R.G. (1998). A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. Photogrammetric Engineering and Remote Sensing 64: 207–216.

[18] Malthus, T.R. (1798). An Essay on the Principle of Population, 1st ed., Pickering Press, 1986, London.

[19] Mitsch WJ & Gosselink JG., (1993). The value of wetlands: importance of scale and landscape setting. Ecological Economics35, 25-33.

[20] NMSA (National Meteorological Services Agency), (2001). Initial national communication of Ethiopia to the UNFCCC. Addis Ababa.

[21] Ramsar. (1971). The Convention on Wetlands: An Active Player in the Fight against Poverty.[22] Richards J.A. (1995). Remote Sensing Digital Image Analysis: An Introduction. Guide to GIS and Image Processing, 2:57-82.

[23] Sabins, F.F. (1997). Remote Sensing: Principals and Interpretation, 494 pp. (New York: W.H. Freeman and Company).

[24] Tegene, B., 2002. Land-cover/land-use changes in the Derekolli catchment of the SouthWelo zone of Amhara region, Ethiopia. East. Afr. Social. Sci. Res. Rev. 18, 1–20.
[25] United Nations Population Division, (2009). World Population Prospects, 2008 Revision. UN press, New York City, NY.
[26] Turner II, B.L., Meyer, W.B., Skole, D.L., 1994. Global land-use/land-cover change: towards an integrated study. Ambio 23, 91–95.
[27] United States Geological Survey (USGS), (1992). Multi-resolution land characteristics – state wide digital data for Mississipi.http://landcover.usgs.gov/nationallandcover.html.
[28] Wang TL, Zhou LF, Yang PQ. (2008). Study of Panjin wetlands along Bohai Coast: (I) the information System of wetlands based on 3S technique. Journal of Ocean University of China (English Edition), 7(4): 411-415.
[29] WBISPP. (2005). A national strategy plans for the biomass sector. Addis Ababa, Ethiopia.
[30] WCED (World Commission of Environment and Development), (1987). Our Common Future. WCED. Oxford University Press. New York, U.S.A. 398pp.
[31] Williams M. (1991). Wetlands: A Threatened Landscape. Oxford, UK.
[32] Wood A., P., & Dixon A., B. (2002). Sustainable wetland management in Illubabor Zone. Huddesfield, UK: Huddesfield University.