Effect of Land Use/Cover Changes on Ecological Landscapes of the Four Lakes of Central Rift Valley Ethiopia

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Abstract
The objective of this study was to analyze land use land cover (LULC) changes in the landscape of Central Rift Valley over a period of 30 years (1985–2015). Satellite images of Landsat5 TM (1985), (1995) and Landsat8 OLI (2015) were used. All images were classified using supervised classification technique with ERDAS-13. Change analysis was carried out using post classification comparison in GIS-10.3.1. Twelve LULCCs were successfully captured and the classification result revealed that intensive cultivated land (44.52%), mixed cultivation (18.31%), and woodlands (11.13%), open water (7.99%), large scale farming (7.50%) was dominant LULC types in 1985. In 2015, mixed cultivation (35.90%), large scale farming (14.87%), intensive cultivation (13.99%), open woodland (8.37%) and irrigated land (6.94 %) were the major LULC types followed by others. The change result shows that a rapid increase in irrigable land, large scale farming, and mixed cultivation 8.37%, 14.87%, and 35.90 % occurred between the 1985 and 2015 study period, respectively. Similarly, open water/lake decreased by 2.31%, during the 1985 and 2015 study periods. More specifically, Lake Abijata showed a progressive decline by 25.6%. Analysis of the 30-year change revealed that about 80.79% of the land showed major changes in LULC. Based on the DPSIR framework of analysis, an integrated land use and development planning and policy reform are suggested to encourage the ongoing and planned ecosystem restoration, degraded land rehabilitation, and biodiversity conservation intervention in the Ethiopia Central Rift Valley areas. However, further detailed investigation may be need prior to any recommendation to address the drivers and consequences of land use and land cover changes in the area.
Keywords: CRV, ERDAS, GIS; Image; Landsat TM /Oli, Lake, LULC, RS

1. INTRODUCTION

1.1. Background and Justification

Land is the major natural resource on which economic, social, infrastructure and other human activities are undertaken. Changes in land use have occurred at all times in the past, present, and are likely to continue in the future (Lambin *et al.*, 2003). Land cover and land use change (LUCC) is a phenomenon starting from ancient time. However, the last three centuries witnessed rapid and extensive LUCC as part of global environmental changes (Lambin *et al.,* 2003; Gutman *et al.*, 2004; WRI 2005). Dramatic changes on the natural landscape and the Earth Summit in Rio de Janeiro in 1992, brought concern to scientists as well as policy makers. As a result, many studies have concentrated on environmental issues which have influenced the natural systems greatly (Benjaminsen, 2001; Glicken, 2000; Burgi *et al*, 2002; Buchecker *et al*, 2003). This makes the integration of man's activities into landscape studies most relevant (Wu and Hobbs, 2002). Land use land cover change is one of those major challenges that affect the natural landscape. It is one of the main driving forces of global environmental change, and central to the sustainable development debate (Lambin *et al*, 2000).

The causes and consequences of land use change on the physical and social environment have an impact on water quality, land and air resources, ecosystem function and climate (Veldkamp and Verburg, 2004; Lambin *et al*, 2000); biodiversity (Liu and Ashton,1998), soil degradation (Trimble and Crosson,2000) and the ability of natural systems to support life (Vitousek *et al.,*1997). Quantifying changes in the landscape is very important for an understanding of the spatial and structural variability in land use and their associated ecological effects (Turner, 2005). The method and scope used for such land use change study depends on the ecological process under study (Wiens, 1989; Allen and Hoekstra, 1992). Often times, an interdisciplinary approach, integrating the social and natural sciences have been argued (Lambin *et al*, 1999; Briassoulis, 1999).

In its wider sense, the term land use denotes the human employment of the land, which includes settlements, cultivation, grazing, recreational areas, or industrial zones. Whereas, land cover represents the biophysical cover of the land (Duadze, 2004). In line with this, LUCC is a term used for human modification or alteration of Earth's terrestrial surface from one to the other; for example, from forest to cultivation or grazing to degrade land (Lambin *et al.*, 2003).

Ethiopia has a long history of conservation. The first recorded indigenous conservation-oriented activity took place during the reign of Emperor Zerea Yacob (1434-1468). The country has a very diverse set of ecosystems ranging from humid forest and extensive wetlands to the desert (Melaku, 2011). It is becoming more and more recognized that wetlands are an important component of the terrestrial landscape, performing significant ecosystem services (Costanza *et al.*, 1989) as climate regulation, pollutant reduction, flood storage, drought control, water supply, and biodiversity conservation (Haslam, 2003; Mitsch and Gosselink, 2000). However, wetlands degradation is becoming more and more serious due to biological invasion, climate variability, and human disturbance, and the landscape of wetlands changing greatly, thereby accelerating the degradation and threatening ecological balance and environmental quality in wetlands regions (Dimitriou *et al.*, 2008; Day, 2003).

As wetlands are an important natural resource for land reclamation, the study of wetlands landscape change has become important to sustainable agriculture and environmental management efforts in recent years. The techniques of remote sensing have been widely utilized in natural science to characterize the process of land use and cover changes (Hill *et al.*, 1999, Rees *et al.*, 2003). Because land use change is closely related to socioeconomic development and environmental change, the relationship between landscape change and its driving forces was studied widely (Krausmann *et al.*, 2003; Serra *et al.*, 2008), and some researchers have also explored the impact of land use change on regional environmental quality (Jia *et al.*, 2004), biomass and biodiversity (Reidsma *et al.*, 2006) hydrological condition (LeBlanc *et al.*, 2008) and soil quality (Geissen *et al.*, 2009).

The Central Rift Valley (CRV) is one of the most environmentally vulnerable areas of Ethiopia. Most of the lowland in the CRV is arid or semiarid, and droughts occur frequently. The Central Rift Valley (CRV) situated in the administrative regions of Oromiya and the Southern Nations Nationalities and Peoples Region (SNNPR) is a closed area with an area of approximately 10,320 km2. The area encompasses 26 woredas (administrative districts) (Meshesha *et al.*, 2012). The area consists of a chain of lakes, streams and wetlands with unique hydrological and ecological characteristics (Ayenew, 2004; Legesse and Ayenew, 2006, Estifanos, 2008). Owing to the fragility of the environment and competing claims for land and water resources, the area has been experiencing serious environmental deterioration and socioeconomic challenges, a growing threat to the local community's existence. Over the last few decades, the rate and severity of the environmental degradation escalated as a consequence of non-judicious resource use, unregulated population and climate change related stresses (Temesgen *et al.*, 2013; Fetahi, 2015; Legesse *et al.*, 2004; Herco *et al*, 2007).

Powerful natural processes and phenomena such as bad climatic conditions (typically heavy rainfall), and natural terrain have been identified as causes of LUCC, but anthropogenic activities are being increasingly recognized as major factors (Green *et al.*, 1994). Human activities, such as overgrazing, large and small scale mining, deforestation, cultivation on steep slopes, rapid population growth, and clearing of vegetation, are playing increasingly important roles in changing environments, causing unprecedented land degradation and depletion of natural resources (Benneh *et al.*, 1990; Mundia and Aniya, 2006). The most important negative consequences of such changes are directly or indirectly related to biodiversity decrease (Duadze, 2004), nutrient depletion, water body decrease (Dalal and Mayer, 1986; Shan *et al.*, 2007), acceleration of soil erosion (Solomon *et al.*, 2000), and food insecurity (Wilson, 1988; Kebrom, 1999; Braimoh, 2003).

Previous researches have highlighted the depth of the intertwined problems, the severity and possible consequences of the environmental degradation in the CRV (Hengsdijk and Jansen, 2006b; Mikias, 2015; Nejibe, 2008; Legesse *et al*, 2005; Fetahi, 2015; Seyoum *et al*, 2015). However, compared to the magnitude of the environmental problems and the urgency to respond, these research outputs alone may not be adequate to design and suggest appropriate ameliorative options. Thus, it is necessary to augment the pervious data with recent findings so that informed decision can be made based on reliable scientific evidence.

LULC change analyses have been indicated as one of the high priority concerns for research and for the development of strategies for sustainable management (Vitousek, 1994). In this context, it is important to produce information related to landscape changes and their effects on the value of ecosystem services provided by wetlands in this zone.

To this end, this study aimed to analyse the land use and land cover changes in CRV at three different temporal scales viz. 1985, 1995 and 2015. With a close look to the empirical and statistical relation of the LULC changes, mainly focusing on water bodies and wetlands, it is anticipated that updated data will be generated to supplement the already recorded information that ultimately guide restoration and or conservation intervention in the CRV.

1.2. Objective of the Study

The general objective of this study is to characterize GIS-supported land use land cover changes over time and its effects on the ecosystem resources mainly around the wetland (lakes) ecosystems in the Central Rift Valley of Ethiopia and addresses the following specific activities: (i) Conduct GIS supported LULC change analysis over three periods (1985; 1995, 2015) and characterize LULC classes, (ii) Detect changes in the area of LULC classes over time based on the image analysis, (iii) Analyze and Prepare LULC change map and accompanying data for LULC classes, (iv) Identify the drivers and impacts of LULC changes using DIPSIR model and (v) Recommend possible ameliorative response/intervention strategy and policy options to address the drivers and impacts of the LULCC.

2. METHODS AND MATERIALS

2.1. Study Area Description and Delineation

2.1.1. Location

The Ethiopian Rift extends from north to south getting wider in the north and narrower at the south where it cross Ethio-Kenya boundaries which is divided into three subsystems: Chew Bahir (Lake Stephanie), the CRV and the Afar triangle. The CRV section where this research was conducted is about 200 km south of Addis Ababa, Ethiopia's capital city. The CRV is located between 38º15'E and 39º25'E and 7º10'N and 8º30'N, The study area covers an area of approximately 10,320 km^2. The scenic beauty of the area ranges from around 1,430 m a.s.l. in the lowest parts of the valley to more than 4,000 m on the eastern side. Area below 2000 m.a.s.l. accounts for about 40% while areas between 2000 - 3000 m.a.s.l. covers 21% of the land and 19.8% of the land lies with an elevation of less than 3,000 m.a.s.l. the remaining land lies within the elevation between 3,000 to 4,000 m.a.s.l. The study area is based on hydrological boundaries, but includes some adjacent high land. The east and west highlands are boundaries of the CRV with altitude of more than 3000 m above sea-level. The climate varies significantly with altitude and is generally characterized by warm, wet summers (with most of the rainfall occurring from July to September) and dry, cold, and windy winters. The temperature is relatively constant throughout the year, whereas the distribution of the rainfall across the year is highly erratic.

In the CRV two soils are predominant. In the central portion "*tropepts*" are found. These soils are characterized by moderately dark A horizon with modest addition of organic matter. The B horizon has brown or reddish colours, the C horizon are slightly pale. These soils are generally found in (Tropical) regions with moderate or high rainfall. In the eastern and western portion "*udalfs*" are found. These are also typical for a humid climate, often formed under a hard wood forest cover. They consist of brown soils formed in an udic (USDA, 1975) moisture regime and in mesic or warmer temperature regime (Herco *et al*, 2007). The estimated extent of each of the major soil units within the Rift Valley and the proportion of the total area occupied by these units are presented in table below (FAO/UNESCO. 1977). The most important groupings in terms of total area covered are: Vertisols (19.2%), cambisols (17.9%), Fluvisols (16.2%), regosols (15.8%), Lithosols (9.5%), andosols (7.1%) and acrisols (6.1%).

Table 2. Estimated extent of FAO soil units within the Ethiopian Rift Valley and the proportion of the whole area covered by each unit adopted from FAO/UNESCO (1977).

FAO soil unit	Total area (km^2)	% of whole area
Ferric acrisols	3367	6.1
Chromic cambisols	3671	6.7
Eutric cambisols	6166	11.2
Eutric fluvisols	8529	15.2
Calcaric fluvisols	391	0.7
Histosols	200	0.4
Eutric gleysols	262	0.5
Eutric nitosols	436	0.8
Vitric andosols	3888	7.1
Pellic vertisols	6229	11.3
Chromic vertisols	4330	7.9
Eutric regosols	8669	15.8
Lithosols	5210	9.5
Luvic xerosols	1780	3.2
Haplic xerosols	940	1.7
Orthic solonchaks	647	1.2
Orthic solonetz	253	0.4
Total	**54968**	

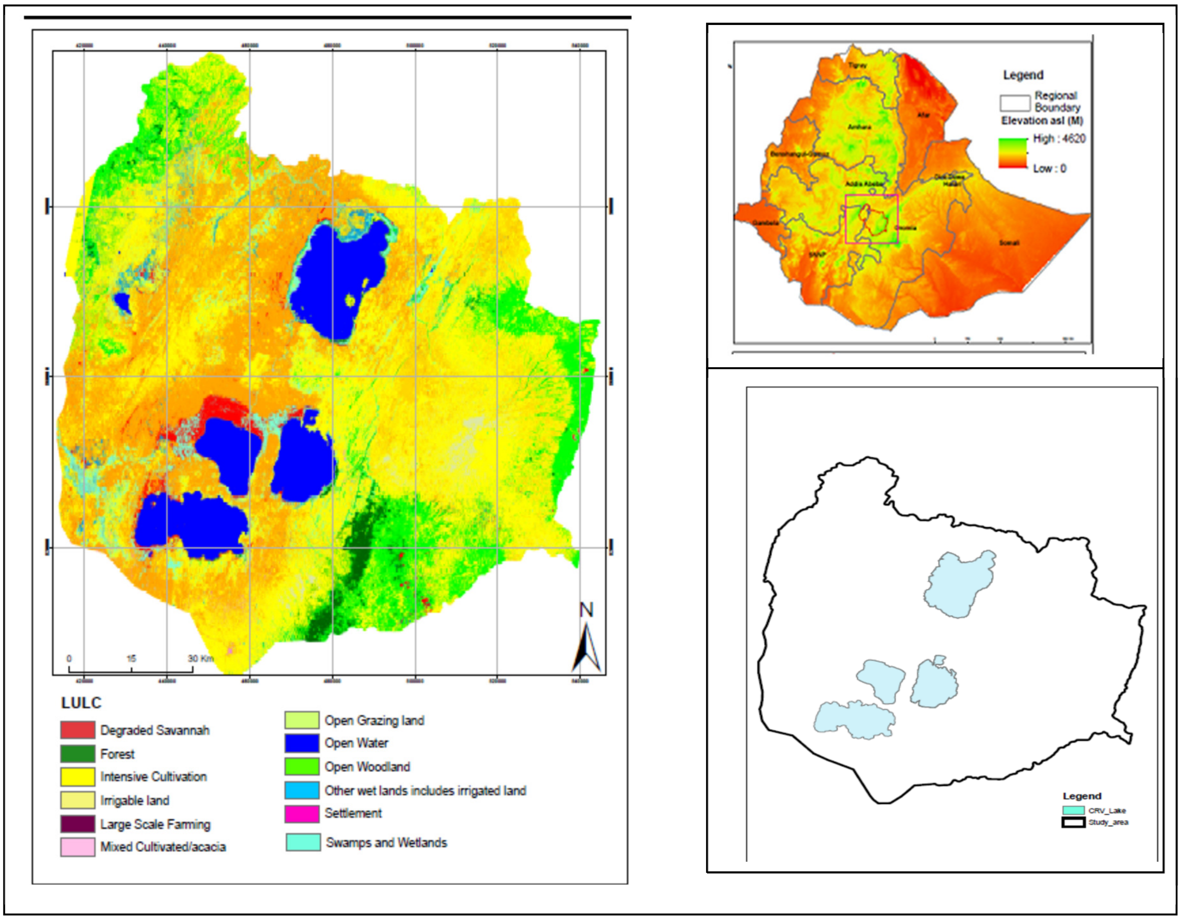


Figure 1. Map of the study area

2.1.2. Population

In 2007, there were around 1.9 million people living in the Central Rift Valley Basin, out of which 1.6 million were settled in rural areas. The CRV encompasses various administrative areas (woredas), of which the important once which situated in SNNPR and Oromia regions are listed in the table below.

Table 3. Some densely Populated Woredas in the CRV of Ethiopia (CSA, 2007)

Region	Woreda	Area (ha)	population
SNNPR	Sodo	83017	134,683
	Meskan	36615	155,782
	Mareko	50422	64,512
	dugda Bora	151423	144,910
	ATJK	125049	9,034
	Tiyo	63336	86,463
OROMIYA	Degeluna Tijo	97233	140,466
	Ziwaydugad	126729	120,862
	Munessa	152061	166,539
	Arsi Negele	134000	260,129
Total			**1,008, 231**

2.1.3. Vegetation

Mostly covered by woodlands and savannahs, the area is also under considerable agricultural use. Afromontane forests and woodlands cover 10.9% of the area, mainly in the highlands, while 76.8% of the land has been cleared for cultivation (Herco *et al*, 2007). In addition to different wild animal and bird species, there were different types of trees like *A. tortilis*, *A. senegal, A. seyal, B. aegptiaca, Ficus sycomorus,* and *Maytenus senegalensis* are dominant tree species in the study area (EWNHS, 2010).

2.1.4. Climate

The climate of the area is characterized by warm, wet summers with most of the rainfall occurring from July to September and dry, cold and windy winters. Rainfall and temperature in the CRV varies markedly with altitude. Over a period few decades, the area witnessed an increase of daily maximum temperature by about 1.5°C with a resultant effect of higher evapotranspiration (Herco *et al,* 2007). The further increase in temperatures is predicted that may significantly impact on the availability of water resources and on the water stress that is already experienced in rain-fed agriculture and ecosystems.

2.1.5. Agricultural production

Agricultural production and related activities constitute the main pillar sustaining the economy in the Central Rift Valley responsible for the life of the poor communities at large. However, because of the variability of rainfall and poor irrigation system, the agricultural production is much smaller principally affecting the poor farmers (Herco *et al*, 2007). Similarly, despite the large tracks of land being under agricultural management in the valley areas, only around 1.3% is being irrigated (Herco *et al*, 2007). For irrigated agriculture dry years result in higher water consumption which have negative effect on the relatively limited surface water resources.

2.1.6. Livestock

Animal husbandry is an important livelihood strategy in the conventional mixed farming systems in the CRV. Animals serve as traction power, but also as savings objects for periods with insufficient food. The number of animals also provides the owner socio-cultural status. Not only animals from mixed farming systems graze the area, but also nomadic pastoralists periodically graze their herds in the CRV, although their number seems to decrease as a result of more conflicts with arable farmers. The presence of animals in the CRV is highly dependent on the availability of food seasonally.

2.1.7. Lakes and Wetlands

The Rift Valley Lakes Basin is one of the eleven major river basins in Ethiopia with a total area of about 52,000 km^2 (MoWR, 2010). The basin is characterized by a chain of lakes varying in size as well as in hydrological and hydrogeological settings. It constitutes nine lakes, Lake Ziway, Lake Langano, Lake Abiyata, Lake Shalla, Lake Hawassa, Lake Abaya, Lake Chamo, lake Abbe and Lake Beseka (Alemayehu *et al.*, 2006).

The Central Rift Valley encompasses a chain of spatially and temporally strongly interlinked lakes (Ziway, Langano, Shalla and Abyata) that are feed by streams and the Meki and Ketar Rivers in the upstream portions of the catchments. These rivers drain into Lake Ziway travelling long distances. From Lake Ziway water is discharged into the Bulbula River, which flows to Lake Abjata. The Lake Ziway and its influent rivers are used for irrigation and is host to a wide array of economic, domestic and recreational activities, including the flower industry, soda abstraction and fish farming (Ayenew, 2007). These lakes support a wide variety of aquatic and wildlife and are habitat to different kinds of autochthonous edible fish. Human - induced and natural factors affect water quality in the area (Tefera, 2002; Ayenew, 2008).

2.2. Data Sources and Analysis

2.2.1. Data source

GPS coordinates of target LULC types were collected, and information regarding each site was noted. A 30 m Digital Elevation Model (DEM), based on Aster imagery was also employed. In addition, ancillary data were also utilized during analysis, including topographic maps. All data were projected to the Universal Transverse Mercator (UTM) projection system zone 37N and datum of World Geodetic System 84 (WGS84), ensuring consistency between datasets during analysis.

2.2. 2. Data Analysis

Image pre-processing and classification: The standard image processing techniques of extraction, layer stacking, geometric correction/ georeferencing and change detection were performed on the three Landsat TM/oli images (Table 2) obtained on different dates. Satellite image re-processing was done to establish a more direct affiliation between the acquired data and biophysical phenomena. Data were pre-processed in ERDAS imagine for geo-referencing, mosaicking and sub setting of the image on the basis of Area of Interest (AOI).

All satellite data were studied by assigning per-pixel signatures and differentiating the study area into twelve classes. For each of the predetermined land cover/use type, training samples were selected by delimiting polygons around representative sites. Spectral signatures for the respective land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. For the enhancement of classification accuracy and therefore the quality of the land cover/land use maps produced, visual interpretation was very important. Thus, visual analysis, reference data, as well as local knowledge, considerably improved the results obtained using the supervised algorithm.

Table 4. Satellite data specifications/Sensor, Acquisition years and Resolution of the study area image.

Sensor	Year of acquisition	Bands/color	Spatial Resolution (m)	Source
Land sat 5 TM imagery	1985	Multi-spectral	30*30	USGS glovis
Land sat 5 TM imagery	1995	Multi-spectral	30*30	USGS glovis
Land sat 8 **oli**	2015	Multi-spectral	30*30	USGS glovis

Methodological Flowchart for Land use/cover mapping

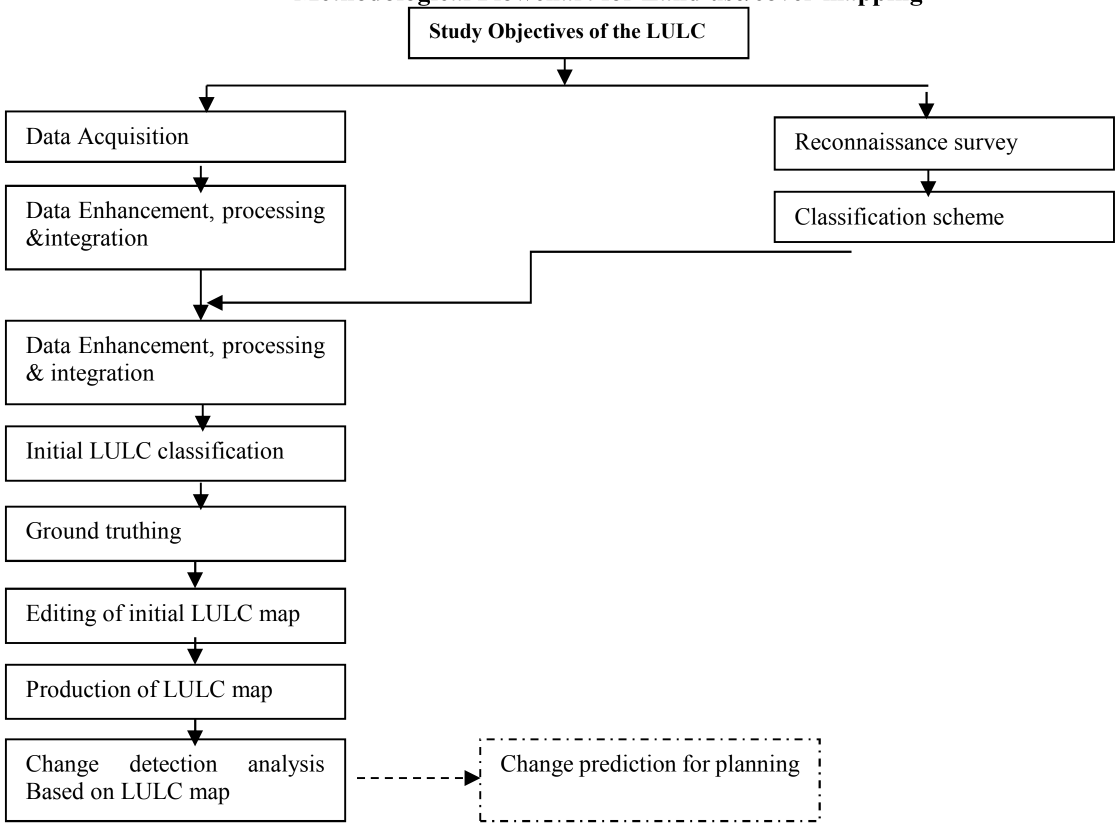


Figure 2. Methodological Flowchart for Land use/cover mapping

Land use/land cover change analysis:

Change analysis was conducted using post-classification image comparison technique (Singh, 1989). Images of different reference years were first independently classified. The classified images were compared in two periods, i.e., 1985–1995 and 1995–2015. Change statistics were computed by comparing image values of one data set with the corresponding value of the second data set in each period. This results in a summary table of the overall changes per class. The values were presented in terms of hectares and percentages. The percentage LULC changes were calculated using the following equation:

$$\textbf{Percentage LULC change} = \left[\frac{\textbf{Area final year} - \textbf{Area initial year}}{\textbf{Area initial year}} \times 100 \right]$$

Where Area is extent of each LULC type. Positive values suggest an increase whereas negative values imply a decrease in extent. LULC comparison between 1985 and 2015 was generated and the values were presented in terms of hectares.

Description of land use/land covers classes

Table 4. Classes delineated on the basis of supervised classification

LULC Types	General Description
Degraded savannas	Areas of land that already gets bad either due to erosion or misuses especially over grazing and crop cultivation.
Open grazing land	All areas covered with natural grass and small shrubs dominated by grass.
Open Water/Lakes Intensive Cultivation	Permanent lakes and other intermittent ponds. Areas of land prepared for growing agricultural crops. This category includes areas currently under crop, and land under preparation
Natural forests	Areas dominated by natural high forests, which are coniferous or deciduous.
Open woodlands	Forests found below 1900 m a.s.l. Mainly dominated by Acacia spp
Large Scale Farming	Area of land designated for large-scale farming.
Irrigable land	Area designated for irrigation farming
Mixed Cultivated/ Acacia	Area of land dominated by Acacia wood land used for mixed cultivation
Other wetlands + irrigated Land	Areas of land with temporary and or permanent water irrigation farming
Swamps and Wetlands	Area of land with temporary or permanent fragmented water bodies
Settlement	Area of land dedicated for doweling such as towns, villages etc.

3. RESULT AND DISCUSSION

3.1. LULC Change Maps of The CRV

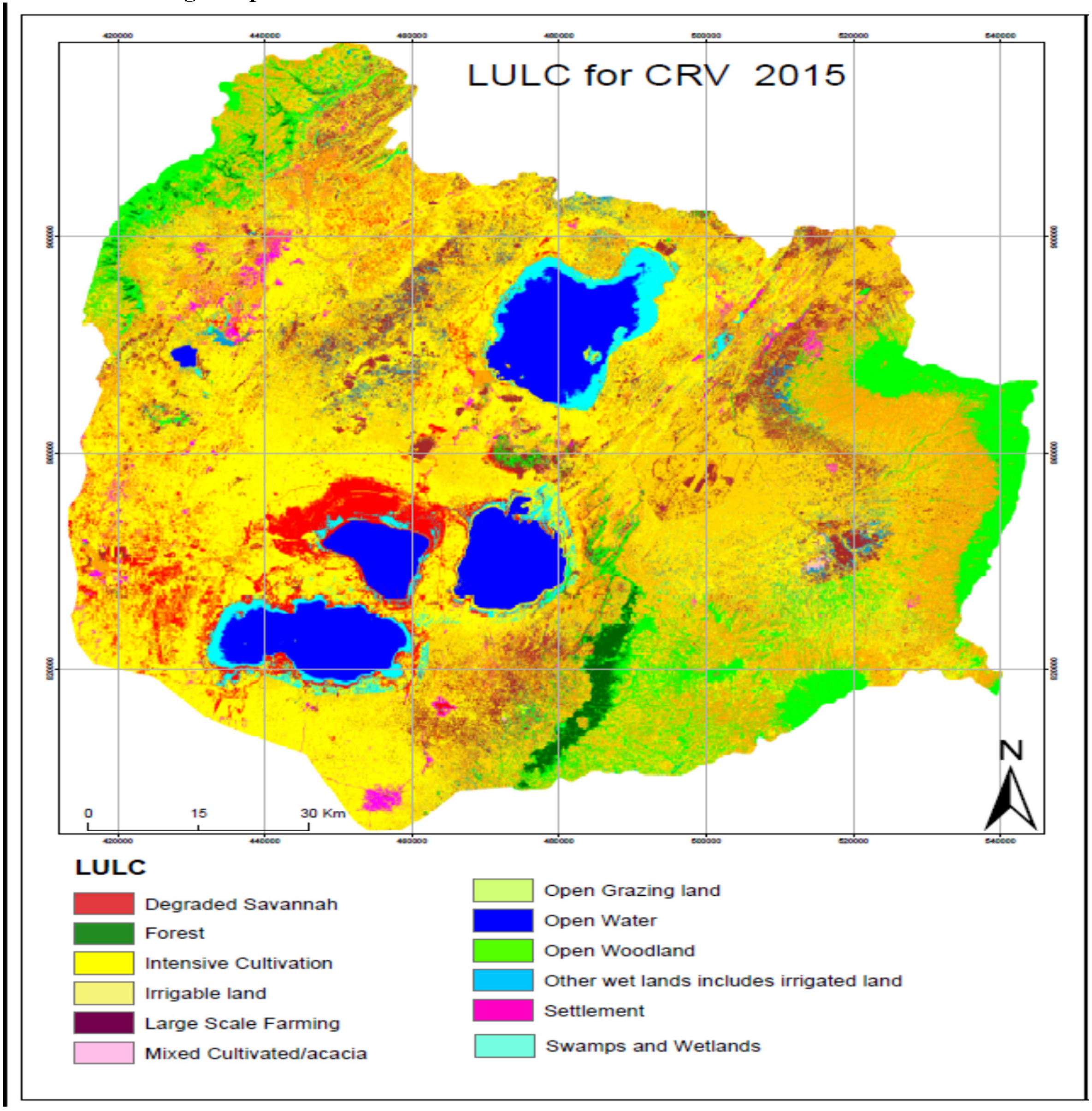


Figure 3. LULC Change of CRV for 2015

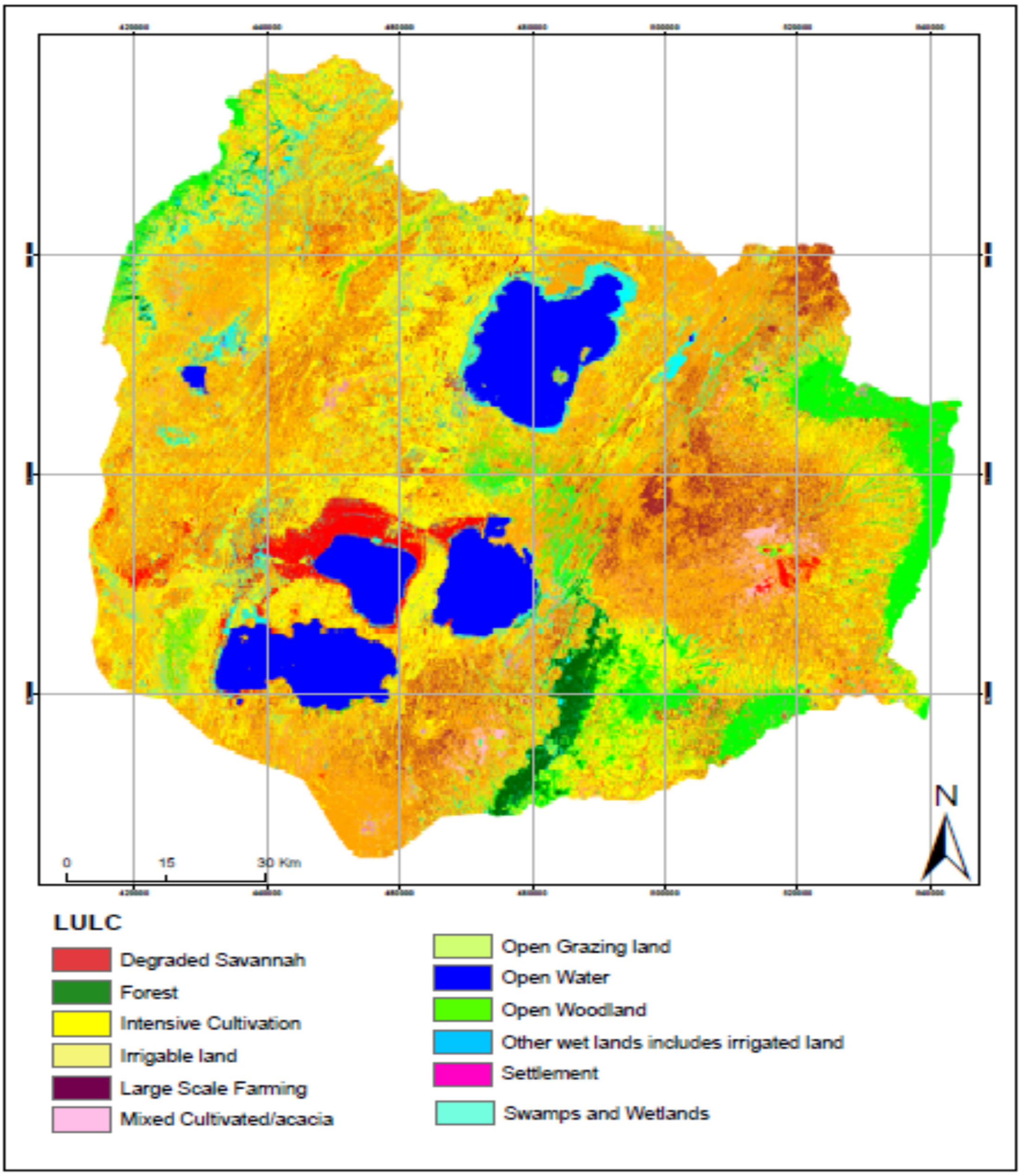


Figure 4. LULC Change of CRV for 1995

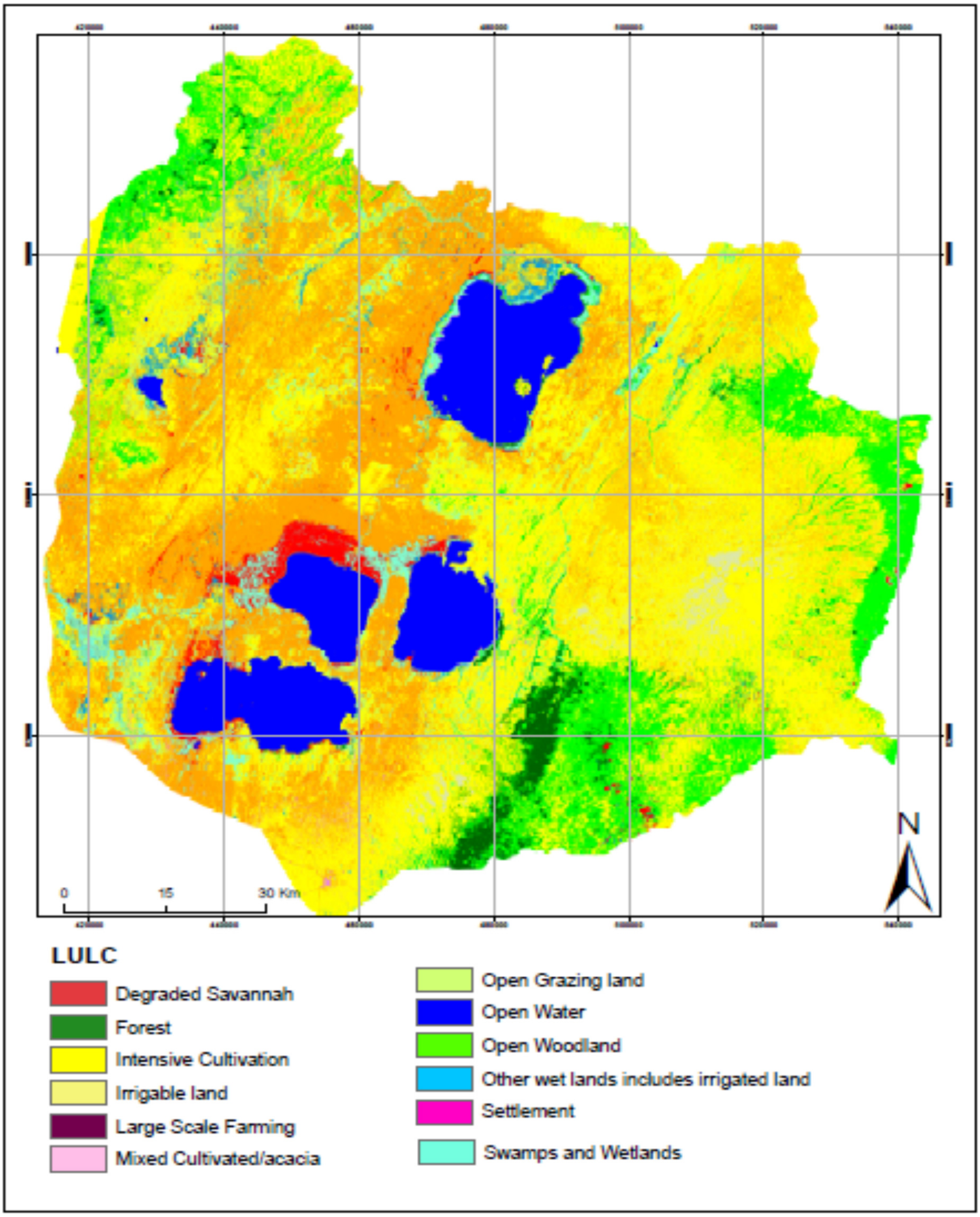


Figure 5. LULC Change of CRV for 1985

Table 5. Summaries of area of classified land use/land covers in the CRV area for the different reference years.

LULC types	Area Hectare per years						Change		
	1985	%	1995	%	2015	%	1985 to 1995	1995 to 2015	1985 to 2015
Degraded Savannah	20686.11	2.00	49381.85	4.78	29621.6	2.87	-28695.74	19760.25	-8935.49
Forest	22212.83	2.15	18010.11	1.75	8168.6	0.79	4202.72	9841.51	14044.23
Intensive Cultivation	459483	44.52	240673	23.32	144366.1	13.99	218810	96306.9	315116.9
Irrigable land	2467.62	0.24	67901.84	6.58	71662.7	6.94	-65434.22	-3760.86	-69195.08
Large Scale Farming	77396	7.50	101646.4	9.85	153486.1	14.87	-24250.4	-51839.7	-76090.1
Mixed Cultivated/acacia	188987	18.31	347434.1	33.67	370501.7	35.90	-158447.1	-23067.6	-181514.7
Open Grazing land	5836.41	0.57	8202.38	0.79	368.2125	0.04	-2365.97	7834.1675	5468.1975
Open Water	82468.82	7.99	79627.85	7.72	58629.65	5.68	2840.97	20998.2	23839.17
Open Woodland	114901	11.13	72076.03	6.98	86430.8	8.37	42824.97	-14354.77	28470.2
Other wet & irrigated land	35658.64	3.46	7842.78	0.76	79034.74	7.66	27815.86	-71191.96	-43376.1
Swamps and Wetlands	17547.26	1.70	24830.65	2.41	8535.78	0.83	-7283.39	16294.87	9011.48
Settlement	4384.26	0.42	14402.5	1.40	21223.5	2.06	-10018.24	-6821	-16839.24
Total	1032029	100	1032029.5	100	1032029.48	100			

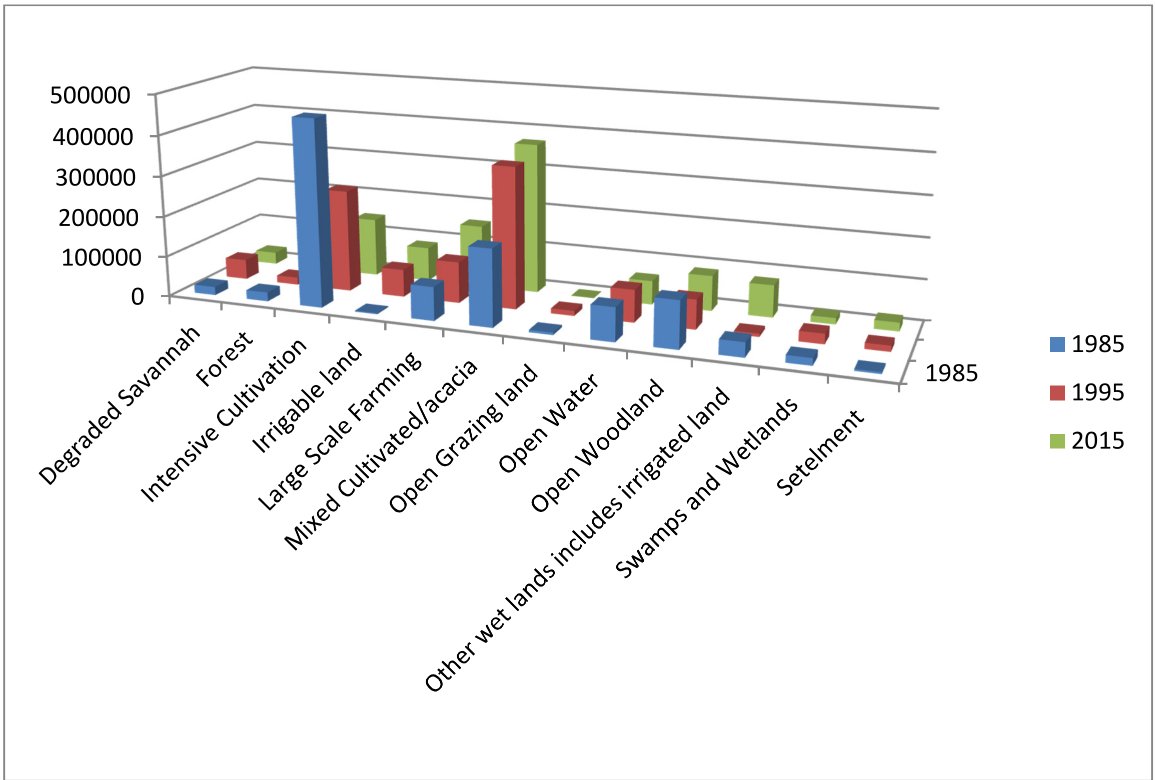


Figure 6. LULC changes in CRV for the three periods (1985, 1995, 2015) Hectares /years

3.2. States of Land Use/Land Cover

A total of twelve LULC types were extracted in the study landscape with different reference years, viz. 1985, 1995, 2015, (Figure 3, 4 and 5). In 1985, intensive cultivation was the dominant LULC type, making up 44.52% of the study landscape followed by mixed cultivated (18.31%) and open woodlands (11.13%), large scale farm (7.50) and open water (7.99%) (Table 5). In 1995, mixed cultivated land and intensive cultivated land in combination were also accounted for the largest part (56.99%) and large scale farming (9.85%), open water/lakes (7.72%), open woodland (6.98%) and irrigated land (6.58%) accounted the highest change of the study landscape, respectively. In 2015, the overall situation was changed. Area for mixed cultivated/acacia (35.90%), large scale farming (14.87%) was increased while area of open woodland and open water/lake shirked to 8.37% and 5.68%, respectively. Others occupied the smallest portion of the area.

3.3. Land Use/Land Cover Changes

The change results revealed a considerable reduction of woodlands, natural forests and open water over the periods (1985, 1995 and 2015). On the contrary, mixed cultivated land/acacia, irrigable land and large scale farming and settlement are increased. The continuing LULC changes in the CRV landscape have different implications. As shown in the result, expansions of cultivated land were due to the reduction in the woodlands, forests, and grasslands.

The overall increment and reduction of land use/land cover in the year between 1985 and 2015 is described in Figure 6 and 7. Intensive cultivation was reduced while mixed cultivation in the expense of reduction in acacia woodland increased. Similarly, irrigated land, other wetlands & irrigated land and large scale farming increased whereas open water/lakes decreased from its 1985' size.

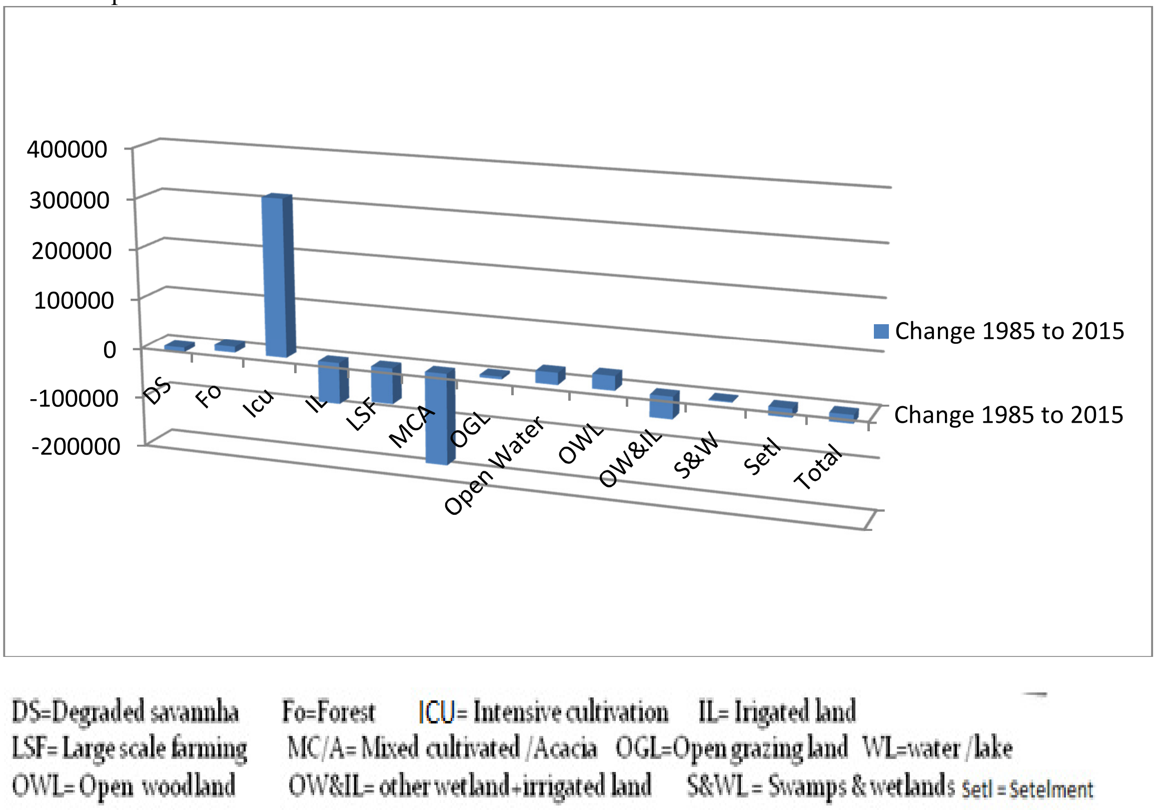
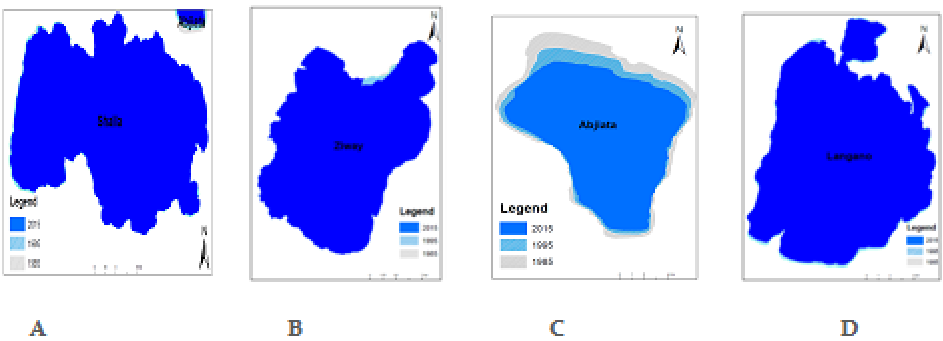


Figure 7. Magnitude of Land Use/ Land Cover changes during 1985 to 2015.

3.4. Change in Surface Area of the CRV Lakes

Water showed reduction during the whole study period. Specifically, Lake Abijata, Shalla, Langano and Ziway showed a reduction of surface area by 25.6%, 1.48%, 0.84 % and 0.63% (Table-6) from its 1985's size, respectively. Such kind of drastic change in surface area of lakes may have long lasting negativeconsequences. The reduction in surface area of the four lakes (Ziway, Abijata, Shalla and Langano) intertwined negative impact on ecosystems, biodiversity and livelihood of the community.



F*igure 8. Map of the 4 lakes in the CRV and change in surface area over the three-study period (1985, 1995, 2015). (A= Lake Shalla, B= L.Ziway, C = L.Abiyata, D=L.langano)*

3.4.1. Lake Ziway and Langano

The reduction in area of these lakes will have impact on fisheries and lake-related ecosystems and causing the shrinkage of outflows these lake which is associated with environmental degradation, particularly the loss of aquatic bird life, water users along the Bulbula River from Ziway lake (domestic water users, livestock and irrigated farms), Furthermore, the salinity level causing increased pollution that ultimately leads to making both lakes a life-threatening lake and with unwanted consequence for the local population's domestic water supply and livestock watering, recreation and Ecotourism development and on the development activities including investment of different types and the recent floriculture sector.

Table 6. Change in Lake Area (Ha) of the four lakes in the CRV for the period 1985, 1995 and 2015

	Area(Ha)			
Year	Abjiata	Ziway	Langano	Shalla
2015	13261.49	42478.66	22836.56	304.9699
1995	15387.01	42540.34	23183.73	306.9147
1985	17824.7	42746.9	23030.64	309.4953
Change (2015-1985)	-4563.21	-268.24	-194.08	-4.52539
%	**-25.6**	**-0.63**	**-0.84**	**-1.48**

3.4.2. Abiyata-Shala Lakes' National Park (ASLNP)

The Park was established as one of IBAs (Important Bird and Biodiversity Areas) in danger sites aimed to protect and conserve large number of water birds that use Lake Abijata as feeding and Lake Shala as nesting and breeding grounds. Lake Shala is an important site for breeding colony of great white pelicans and wintering ground and maintenance station for large number of birds including from Southern African, Sub-Saharan and Palaearctic species. ASLNP was submitted to the Ramsar Convention on wetlands as an international important candidate wetland site. However, the water level and surface area of the lake and the status of the park are deteriorating. The possible causes may include human encroachment, grazing by cattle, uncontrolled water abstraction and other anthropogenic activities (Tefera, 2002, Legese *et al.*, 2005, Reaugh, 2011).

Since the 1980s, the water level of Lake Abijata has significantly dropped. According to Ayenew (2002), uncontrolled water abstraction from Lake Ziway and the irrigation scheme on the River Bulbula significantly affects the water level of Lake Abijata. The fishery in Lake Abijata has totally collapsed and birds such as Lesser Flamingo (*Phoeniconaias minor Geoffroy*) and Great White Pelican (*Pelecanus onocrotalus roseus*) have been migrating to nearby lakes. If it continues like this, the lake will be facing imminent threat of collapse and the existence of the Park would be unlikely. Hence, the minimum water flow on river Bulbula should be maintained through an integrated water resource management practices on a basin-wide scale to maintain the life in the Lake Abijata.

3.5. DPSIR Conceptual Analysis

3.5.1. The DPSIR Frame Work

Understanding the complexity of land-use and land-cover (LULC) changes and their driving forces and impacts on human and environmental security is important for the planning of natural resource management and associated decision-making.

The DPSIR framework is a chain of causal links from 'driving forces' through 'pressures" to 'states' and 'impacts', leading eventually to 'responses'. Describing the causal chain from driving forces to impacts and responses is a complex task that tends to be broken down into sub-tasks. The DPSIR framework is useful in describing relationships between the origins and consequences of environmental problems (Bradley and Yee, 2015). Accordingly, in the framework, the "driving force" includes the increase in population, high demand for Natural resource (fuel wood, charcoal, timber etc), inadequate resource management strategy and policy gaps. The "pressure" includes unregulated harvest of the natural resource such as forest resources (for construction, fuel or energy), the extensive water abstraction for irrigation, conversion of woodlands to agricultural land, encroachments, etc. The "state "depicts the condition of the critical ecosystems and their integrity, function, quality and diversity (Bradley and Yee, 2015).

The"impact" refers to the influence of the change caused as the result of the pressure exerted on the state. The "response" refers to the effort made or to be made in order to abet the challenges, which may include institutional and policy reforms. Hence, the DPSIR framework can be used to demonstrate the complex interaction among the components of the framework, which ultimately helps direct institution to design a reasonable response to curb the impacts. In this document, the DPSIR model was used to analyze environmental problems related to land use issues in the CRV's local context.

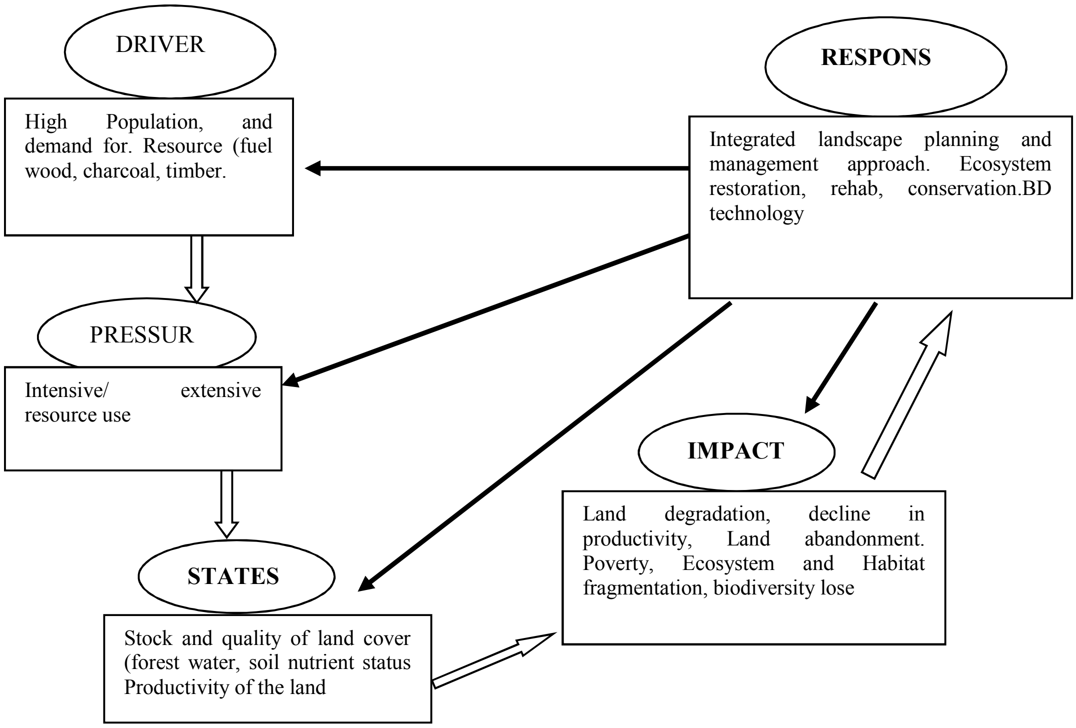


Figure 9. DPSIR framework for analysis of land use land cover changes in CRV of Ethiopia

3.5.2. DPSIR Analysis For Aquatic Environment

This DPSIR analysis is employed in the assessment of the CRV lakes and specifically, Lake Abijata. Based on the analyses framework, the linkages between problems and their immediate causes, sector activities/intermediate causes, and the root causes i.e., human activities leading to the creation of the problem were identified. Accordingly, the following five clusters were identified as prime concern to discourse the aquatic environment deterioration and possible remedial action in the CRV.

Freshwater shortage: as a result of modification of stream flow, pollution of existing supplies, changes in the water table, the lakes in CRV are facing critical threat. Catchment areas of these lakes are highly degraded and siltation of Lakes has been increasing.

Pollution Microbiological: Eutrophication, chemical, suspended solids, solid wastes, etc are the second serious concern to the survival of the aquatic biodiversity in these lakes. Apparently, the chemical industries in the shore of Lake Abiyata and the floriculture farms around Lake Ziway are key concern.

Habitat and community modification: Loss of ecosystems, modification of ecosystems or ecotones, including community structure and/or species composition is another key factor that may have progressing impact on the water resources. As a result of LULC changes that has been taking place in the area; much has been modified with resultant effect on the water resources.

Unsustainable exploitation of fisheries and other living resources: Over-exploitation, excessive by-catch and discards, destructive fishing practices, have been witnessed in the Lake Ziway with a negative impact on the viability of stock and the biological and genetic diversity. It is likely that some species of fishes may have already been exterminated.

Global change: Changes in hydrological cycle, sea level change, increased radiation Elnino-Lanina effect etc, will have an impact on local ecosystems' structure, function and resilience. The capacity to respond to these unpredictable climate changes may be further deteriorated as a result of unabated degradation and poor management of the natural resource in the area.

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

The CRV is one of those regions in Sub-Saharan Africa where poverty and degradation of natural resources firmly intertwined. Severe poverty forces people to deplete natural resources in their struggle for survival particularly for the predominant subsistence rain-fed farmers. The degraded natural resources together with the unfavourable, highly variable climatic conditions aggravated poverty. Generally, rapid population growth, agricultural expansion, environmental fluctuations, degradation of natural resource and loss of biodiversity are the most visible socio-economic and environmental problem in the CRV area.

Over the last 30 years period (1985 to 2015), major LULC changes were recorded in the CRV. Twelve

LULCCs were successfully captured and the classification result revealed that about 80.79% of the land showed there is a change in LULC. The intensive agricultural land was expanded in the expense of woodland and forest area degradation. The water resources have been shrinking in size and depth significantly. More specifically, L.Abijata showed a progressive decline by 25.6% resulting in severs degradation of the fragile ecosystems that has sustained the unique biodiversity (fauna and flora) for long. Consequently, the Abijata-Shalla National Park is at the verge of collapse, the second episode of lake collapse in the nation next to Lake Harommaya.

4.2. Recommendation

Based on the DPSIR framework of analysis, an integrated land use and development planning and policy reform were suggested to encourage the ongoing and planned ecosystem restoration, degraded land rehabilitation, and biodiversity conservation intervention in the CRV of Ethiopia. These include the following options: An effective water management plan and practice should be employed at the landscape level breaking down major river basin into sub-watersheds and prioritizing the sub-watershed for conservation and management based on degradation level so as to conserve and minimize the human induced impacts faced by it, Well-planned tree planting should be promoted to complement the area closures intervention in the degraded watersheds. The local community, the Government and collaborating non-governmental organizations should be engaged in the process with a clear role and contribution, Restoration, target investments and policy incentives must look to the most valuable parts of the landscape with the greatest restoration potential, To protect and restore the forest an incentive –based approach should be deployed to encourage the local people for guarding the new plantations, Government should take appropriate steps to restore the degraded lands specially degraded soil, water and forest lands and their further degradation must be prevented, Integrated land use and development planning should be done for the watershed prior to any developmental project being conducted in the area and must be preceded by a proper Environmental Impact Assessment (EIA), Considering their impact on water resources focus should be more on improving the environmental and economic performance of current systems than the further development of these systems, Restoration of critical watershed in the landscape mosaic of CRV need to be prioritized. Protecting and conserving critically endangered ecosystems, habitats and species in the CRV with due attention given to the migratory species this may include extensive restoration activities in the upper catchments of the CRV landscape that contributes to the sustainable flow of water to down streams, In addition, more research is needed to investigate the possibilities to improve the performance of rain-fed agriculture and other livelihood strategies as income alternatives to the predominant poor population and a more detailed study should be conducted to assess and anticipate the impacts of climate changes on the CRV in more detail.

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