



Land Use and Land Cover Change Detection Analysis using Remote Sensing Techniques : The Case of Hawassa Town, Southern Ethiopia

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Land Use and Land Cover Change Detection Analysis using  
Remote Sensing Techniques: The Case of Hawassa Town,  
Southern Ethiopia.

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*A RESEARCH PROJECT SUBMITTED TO GEOGRAPHY AND ENVIRONMENTAL STUDIES  
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AND DIGITAL CARTOGRAPHY.*

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This is to certify that the a research project prepared by Ayele Abebe entitled Land use Land cover change detection analysis by Using remote sensing techniques: the case of Hawassa Town, Southern Ethiopia and submitted in partial fulfillment of the requirements for degree of Master of Arts ( Geography and Environmental Studies , Specialization : GIS , Remote Sensing and Digital Cartography) complies with the regulations of the University and meets the accepted standards with respected to Originality and quality.

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## **Declaration**

I hereby that the research project entitled Land use Land cover change detection analysis by Using remote sensing techniques: the case of Hawassa Town, Southern Ethiopia has been carried out by me under supervision of Dr. Desalegn Wana, Department of Geography and Environmental Studies, Addis Ababa University, Addis Ababa during the year of 2016/2017 as a part of Masters of Arts in Geography Environmental Studies, Specialized on GIS, RS and Digital Cartography. I further declare that this work has not been submitted to any other University or Institution for the any award of any degree or diploma.

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## ***Abstract***

*This project examines the use of GIS and RS in mapping land use land cover change in Hawassa town between 1995 and 2016 so as to detect and analyze the change that has taken in the town between these periods. In order to achieve these the Satellite of land sat TM for 1995, Landsat ETM for 2002, ASTER image for 2009 and Land sat 8 for 2016 have been obtained and preprocessing using EARDAS IMAGINE . The maximum likelihood algorithm of supervised Image classification has been used to generate land use land cover maps. Land use land classification, change map, accuracy assessment and confusion matrix by using Arc GIS. For the accuracy of the classified LULCC maps the confusion matrix was used to drive. The overall accuracy and kappa coefficient results were above the minimum and acceptable threshold level. Aggregate rate of changes of Land use and land cover of Hawassa town resulted that considerable change has occurred within twenty one (21) years from 1995 to 2016. Though the period of 1995 from 2016 there dramatic change in several LULC categories including that is , only bare land has decreased in (-40.6%), while the rest classes namely Settlement in +460.1%, wetland +66.6%, Agricultural land 14.4% and Vegetation coverage also increased by 6.4 % . Accordingly more land brought under Settlement and Vegetation. The project output stated that increase in settlement and vegetation coverage of the town resulted population pressure on land and there is awareness of society for reforestation programme the town.*

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## **Abbreviations**

ASTER	Advanced Space Borne Thermal Emission & Reflection Radiometer
CSA	Central Statistical Authority
DEM	Digital Elevation Model
DN	Digital Number
DSS	Decision Support System
EMA	Ethiopian Mapping Agency
ENVI	Environment for Visualization of Image
ERDAS	Earth Resource Data Analysis System
ERDAS	Earth Resources Data Analysis System
ETM +	Enhanced Thematic Mapper
GIS	Geographic Information System
GPS	Global Positioning System
Ha	Hectare
ITCZ	Inter Tropical Convergence Zone
Khat	Kappa Coefficient

LULC	Land Use Land Cover
LULCC	Land Use Ana Land Cover Change
MCDE	Multi Criteria Decision Evaluation
MSS	Multi Spectral Scanner
NASA	National Aeronautics and Space Administration.
NMA	National Meteorological Agency
RF	Rainfall
RGB	Red Green Blue
RS	Remote Sensing
SNNPRS	South Nations Nationalities People Regional State
SRTM	Shuttle Radar Topographic Ma
TM	Thematic Mapper
UN	United Nations
UNFPS	United Nation Fund for Population Studies
UNFAO	United Nation Food and Agriculture Organization
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
W.W.D.S.E	Water work design service enterprise
WGS	World Geodetic System

## **CHAPTER ONE**

### **1. INTRODUCTION**

#### **1.1. Background of the Study**

Land is a complex and dynamic factor which consists of, geology, topography, hydrology, soil and micro climate and community of plants and animals that are continually interacting under the influence of climate and people activities (Hudson 1995). The variation in land must be identified, characterized and the information communicated via the most inclusive and cost effective means if people are to understand different forms of land use. In Ethiopia ,farmers mainly use this basic resource in traditional ways without any logical organizations of different types of land according to their agricultural potential or their physical configurations ( Hudson 1995).This leads further performance of agricultural sectors in particular and the whole economy in general. However, continued agricultural growth remains a necessity not an options for most developing countries like Ethiopia and the growth must be achieved on a sustainable basis not jeopardizing the underplaying natural resource base or to impose costly externalities on others (Fitsum, 2003)

Land use / Land cover change plays a vital role in the study of global change. Land use / Land cover and human or natural modification have largely resulted in deforestation, biodiversity loss, global warming and increase of natural flooding. Thus environmental problems are often related to Land use/ Land cover change. The land use / land cover pattern of a region is an outcome of natural and socio economic factors and their utilization by man 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. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

Due to anthropogenic activities, the earth surface is being significantly altered in some manner and man's presence on the earth and his use of land has had a profound effect upon the natural environment. Thus, resulting into an observable pattern in the land use and land cover over time.

To understand how LULC affects and interacts with the earth systems (e.g. hydrosphere, biosphere, and atmosphere), accurate information is needed on what types of changes occur, where information is needed, what information is needed and when they occur, and rates of at which changes occur (Lambin, 1997, as cited Bewket, Teferi, Uhlenbrook, Wenninger et al, 2012).

Land use / Land cover change (LULCC) is urbanization induced. Rapid rate of urbanization has been shown to be a global problem present in most of the developing countries. For instance, the urban populations in these countries have grown by 40% between 1900 and 1975 Balogun, Adeyewa & et al (2012). Similar author also estimated that by the year 2025, 60% of the world's Population will live in cities (UNPF, 1999).

Hence, accurate and up-to-date land cover change information is necessary to comprehend and assess the environmental consequences of such changes (Lambin and Geist, 2007). There is a continuing demand for up-to-date LULC information for any kind of sustainable development programmer where LULC serves as one of the prime input criteria.

Viewing the earth from space is now decisive 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 prior benefit of LULUC study is that it is one of the most precise techniques to understand LULC mechanism. Timely and precise information about LULC change is extremely important for better management of decision making. There is a continuing demand for up-to-date LULC information for any kind of a sustainable development program where LULC serves as one of the major input criteria.

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity ( Wilkie and Finn, 1996).

## **1.2. Statement of the problem**

Land use changes arising from high rate of urbanization ( settlements), agriculture; pasturing and deforestation and road expansion are some of the contributing factors to land cover changes in **Hawassa town** . These changes in LULC reflect the population growth, land consumption rate and climate. Expansion of **Hawassa town** has resulted not only in depletion of natural resources, but deterioration of the environment. Agriculturally productive and non-productive land and forest land have been converted into residential and other land use classes. The land use and land cover pattern of a town is an outcome of natural and socio-economic factors and their utilization by man in time and space. The uncontrolled growth of urban development has adversely affected Hawassa towns's ecosystem which has influence to indirectly reflect on weather parameters and eventually leads to local climate modification (Balogun et al., 2009; Akinbode et al.,2007 ).

To do this research project initiated to understand and estimate the effect of LULCC of the town are no others researcher's work demonstrated about the case by using GIS and RS technologies urban LULC change detection analysis and change estimation of Hawassa town yet, in addition Researcher is familiar with the study area and there is high rate of urbanization in the Hawassa town. The evolution of land use and land cover change within the study area has scientific and developmental importance for the future. The researcher believes this project will provide base line information on issues of land use and land cover change and dynamics in relation to vegetation cover change in the study area. Basically, such information is vital for comparing the past and present condition and predicts the future trends of the LULC change and expanding such method of protecting the soil degradation and expanding such techniques to others town. Hawassa town is located in south nations and nationalities people's administrative city has

recorded incredible expansion and astonishing change in building, natural vegetation and many other anthropogenic activities.

The growing demand of space for human settlement and commercial purpose is diminishing the amount and size of Arable (agricultural) land. For instance, the dramatic constrictions of industrial park, commercial constructions, Hawassa university expansion, Hawassa international stadium are good examples. Moreover, the rapid rising of population has not yet only reduced the space for arable farming practiced in the border of the Hawassa *town* but also the biodiversity. This causes departing and marginalizing of the border peoples from their original home land and farm land which turns to conflict. Moreover, rapid expansion of new built up settlements in Eastern Hawassa, large arable and pasture land has converted in to excessive destruction. In long term, these land use and land cover dynamics are bound to compromise the economy of the small scale farmers. There are different reasons to do this research project. In the study area there were no others researcher's work demonstrated about the case by using geographical information system and remote sensing technologies urban land use and land cover change detection analysis and change estimation. As such, this is imperative to map the land cover and monitor temporal changes with a view to providing change estimates and patterns for larger part of the land and its resources in order to facilitate informed decision making on mitigation measure. This has therefore resulted in increased land cover change and a modification and alterations in the status of land use and land cover over time without any detailed and comprehensive attempt (as provided by a Remote Sensing data and GIS) to evaluate this status as it changes over time with a view to detecting the land cover change and also make attempt to predict same and the possible changes that may occur in this status so that planners can have a basic tool for planning. It is therefore, necessary for a study such as this to be carried out in *Hawassa town* to avoid the associated problems of a growing and expanding like many others town's in the world.

### **1.3 Objective of the Study**

The general objective of the this project is to attempt mapping out the land use and land cover change of Hawassa town over the period of 21 years (between 1995-2016) with view detecting the change that has taken place using Remote sensing and Geographic Information System techniques. The specific objectives of the project are:

- ❖ To produce land use and land cover Maps of study area.
- ❖ To quantify changes in land use and land cover for Hawassa town

### **1.4 Significance of the project**

The land use and land cover change within the study area has scientific and developmental importance for the future. The researcher believes this project will provide base line information on issues of land use and land cover change and dynamics in relation to vegetation cover change in the study area. Basically, such information is vital for comparing the past and present condition and predicts the future trends of the LU/LC change and expanding such method of protecting the soil degradation and expanding such techniques to Hawassa town in the South nation nationalities people region. Therefore, community of Hawassa town benefit primarily. Furthermore, policy makers, development planners, local land managers and concerned bodies benefit a lot from this project.

## CHAPTER TWO

### 2. LITERATURE REVIEW

#### 2.1. The concept and definition of land use land cover

Many books uses land use land cover change interchangeably, although they are different. Land use is defined to be any physical and biological or chemical change attributable to management, which may include conversion of grazing to cropping, change in fertilizer use, drainage improvement, installation and use of irrigation and plantation, building farm dams, pollution and land degradation, vegetation removal, change fire regimes, spread of weeds and exotic species, and conversion to non-agricultural uses (Quenitn et.al., 2006).

Land cover class refers the physical characteristics of the earth's , captured in the distribution of vegetation, water, desert, ice and other physical characteristics of land, including those created by solely by human activities such as settlement (Billah and Anisur, 2004). According to UNFAO land use is the “total of all arrangement, activities and inputs that people undertake in a certain land cover type.” However, the land use is obviously determined by environmental factors such as climate, soli characteristics, topography, vegetation and water body and etc. but also reflect land's importance fundamental factor of production.

According to Meyer, 1999 every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others. While land cover categories could be crop land, forest, wetland, pasture, roads, urban areas among others. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface and ground water as stated the same author, 1995).

Land cover data documents how much of the region is covered by forest, wet lands, impervious surfaces and crop lands, and other land and water types (wet lands or open water). Land use shows how people use land escape whether for development, conservation, or mixed uses. But

here there are classes which are both land use and land cover at the same time, so land use/ land cover is the most preferable term use Wogderes (2014, as cited in MaD CAT manual, 2011)..

Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and sub urban construction and development. There are also incidental impacts on land cover from other human activities such as forest and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by troposphere ozone resulting from automobile exhaust (Meyer, 1995).

## **2.2 Land use land covers change**

Land use and land cover change (LUCC) project and research are crucial to deal with the identification, qualitative description and parameterization of factors which drive changes in land use/ land cover, as well as the integration of their consequences and feedbacks. However, one of the major challenges in LUCC analysis is to link behavior of people to biophysical information in the appropriate spatial and temporal scales. But, it is argued that land use and land cover change trends can be easily accessed and linked to population data, if the unit of analysis is the national, regional, district or municipal level (Codjoe, 2007). Land use affects land cover and changes in land cover affect land use. A change in either however is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame, Meyer, and Turner, 1994).

Hence, in order to use land optimally, it is not only necessary to have the information on existing land use land cover but also the capability to monitor the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape.

Generally, land use and land cover changes have a wide range of impacts on environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and functions (Rimal, 2011). Therefore, the use of remote sensing data and analysis techniques provide accurate, timely and detailed information for detecting and monitoring changes in land cover and land use.

### **2.3 Geographic Information System (GIS) for LULC change**

The GIS technology is employed to assist decision-makers by indicating various alternatives in development and conservation planning and by modeling the potential outcomes of a series of scenarios. It should be noted that any task begins and ends with the real world. Data are collected about the real world. After the data are analyzed, information is compiled for decision-makers. Based on this information, actions are taken and plans implemented in the real world

Daniel et al, (2002) in their comparison of land use land cover change detection methods, made use of 5 methods with traditional post – classification cross tabulation, cross correlation analysis, neural networks, knowledge – based expert systems, and image segmentation and object – oriented classification. With the invention of Remote Sensing and GIS techniques land use/cover mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region ( Selcuket *et al.*, 2003). Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985) in association with GIS that provides suitable platform for data analysis, update and retrieval(Star *et al.*, 1997; Chilar, 2000). RS along with GIS tools used to gather, display, store, analyze and output data related to changes on environment, can provide researchers and planners with certain data sets in order to better understanding and management of a given area

The GIS technology is employed to assist decision-makers by indicating various alternatives in development and conservation planning and by modeling the potential outcomes of a series of scenarios. It should be noted that any task begins and ends with the real world. Data are collected about the real world. After the data are analyzed, information is compiled for decision-makers. Based on this information, actions are taken and plans implemented in the real world

## **2.4 Application of Remote Sensing for LULC change**

According to Maktav et al., (2005) showed that traditional data collection methods such as demographic data, census and sample maps were not satisfactory for the purpose of urban land use management. Accurate information of land use and land cover change is therefore highly essential to many groups. To achieve this information, remotely sensed data can be used since it provides land cover information. Remote sensing is referring to the science or art of acquiring information of an object or phenomena in the earth's surface without any physical contact with it. And this can be done through sensing and recording of either reflected or emitted energy and the information being processed, analyzed and applied to a given problem (Campbell, 2002). Remote Sensing is also defined as the science of acquiring information about an object through the analysis of data obtained by a device that is not in contact with the object. The instruments used for measuring electromagnetic radiation are called sensors. These sensors record the reflected radiation from the surface of the earth and will be used for many analyses; one of these is land use land cover change analysis ( Lelesand and Kiefer, 1994).

Remote sensing data as the sources for GIS have been one of the most important data sources for studies of land cover spatial and temporal changes. In fact, multi temporal remote sensing datasets, fortunately processed and elaborated, allow to map and identify landscape changes, giving an effective effort to sustainable landscape planning and management (Dewan and Yamaguchi, 2009).

The most useful characteristic of Remote Sensing in land use and land cover change detection is the multi spectral and temporal resolution of the data. That is, images are obtained in different portions of the electromagnetic spectrum and the same area is imaged with a specified periodic time interval. The advantage of using remote sensing in land use/land cover is that information from the same area could be easily obtained at different times, and this is important in change detection applications. Furthermore, remote sensing can provide the required data in short time with a reasonable accuracy (Billah and Anisur, 2004) and has an important contribution to make in documenting the actual change in land use/land cover on regional and global scales from the mid-1970s ( Ashenafi Burqa, 2008).

However, Herold et al (2005) reported that with the availability of high resolution imagery together with suitable techniques, urban remote sensing become a rapidly gaining interest in the remote sensing community.

Conventional ground methods of land use mapping are labor intensive, time consuming and are done relatively infrequently. These maps soon become outdated with the passage of time, particularly in a rapid changing environment. In fact according to Olorunfemi (1983), monitoring changes and time series analysis is quite difficult with traditional method of surveying. In recent years, satellite remote sensing techniques have been developed, which have proved to be of immense value for preparing accurate land use land cover maps and monitoring changes at regular intervals of time.

The generation of remotely sensed data/images by various types of sensor flown aboard different platforms at varying heights above the terrain and at different times of the day and the year does not lead to a simple classification system. It is often believed that no single classification could be used with all types of imagery and all scales. To date, the most successful attempt in developing a general purpose classification scheme compatible with remote sensing data has been by ( Anderson,et al, 2009) which is also referred to as USGS classification scheme.

In some instances, land use land cover change may result in environmental, social and economic impacts of greater damage than benefit to the area (Moshen A, 1999). Therefore data on land use change are of great importance to planners in monitoring the consequences of land use change on the area. Such data are of value to resources management and agencies that plan and assess land use patterns and in modeling and predicting future changes.

## **2.5 Image Classification approaches**

In order to examine and assess environmental and socioeconomic applications such as: LULC change detection and socioeconomic variables, image classification results with better accuracy are mandatory. Image classification refers to the extraction of differentiated classes or themes, usually land cover and land use categories, from raw remotely sensed digital satellite data (Weng, 2012). Image classification using remote sensing techniques has attracted the attention of research community as the results of classification are the backbone of environmental, social and

economic applications (Lu and Weng, 2007). Because image classification is generated using a remotely sensed data, there are many factors that cause difficulty to achieve a more accurate result. Some of the factors are: the characteristics of a study area, Availability of high resolution, remotely sensed data, Ancillary and ground reference data, Suitable classification algorithms, the analyst's experience, and Time constraint. These factors highly determine the type of classification to be used for image classification. Lillesand and Kiefer, (2000) described, in supervised classification the image analyst supervises the pixel categorization processes by specifying, to the computer algorithm, numerical descriptors of the various land cover types present in a scene. To do this, representative sample sites of known cover type, called training areas are used to create the parametric signatures of each class. According to Reichardt, (1999) supervised classification is the procedure most used for quantifying of remote sensing data. It rests up on using suitable algorithms to label the pixels in an image as representing particular ground cover types or classes.

Following image classification as part of the change detection process, accuracy needs to be assessed to evaluate the degree of acceptability of the classification process. A standard accuracy assessment procedure for baseline land cover products involves the use of the error matrix and the standard procedure for one-point-in-time land cover products can be extremely difficult to apply to multi-temporal change analysis products (U.S EPA, 1999). The methods are well established for small areas and single time periods. However, the assessment of accuracies for past time periods, and change databases can become problematic as it will be difficult to acquire an adequate database of historical reference materials. Accordingly, accuracy assessments are usually limited to the very recent image that serves as a reference using ground control points (GCPs) collected as part of the data required for the change analysis Wegderes (2014, as cited in Hussein Ali, 2009).

## **2.6 Change Detection Analysis approaches**

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times by using remote sensing techniques. Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population

of interest. Essentially, it also involves the ability to quantify temporal applications of remotely-sensed data obtained from Earth-orbiting satellites (Singh, 1989). Land use land cover change may result in environmental, social and economic impacts of greater damage than benefit to the area (Moshen A, 1999). Therefore data on land use change are of great importance to planners in monitoring the consequences of land use change on the area. Such data are of value to resources management and agencies that plan and assess land use patterns and in modeling and predicting future changes. Macleod and Congation, (1998) list four aspects of change detection which are important when monitoring natural resources:

- ❖ Detecting the changes that have occurred
- ❖ Identifying the nature of the change
- ❖ ensuring the area extent of the change
- ❖ Assessing the spatial pattern of the change

## **2.7 Causes, Consequences and trends of land use and land cover changes**

Understanding the mechanisms leading to land use/land cover changes in the past is crucial to understand the current changes and predict future ones. Therefore land use and land cover change project and research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use/land cover as well as the integration of their consequences and feed backs (Hussein Ali,( 2009). As a result, underlying causes also tend to be complex, formed by interactions of social, political, economic, demographic, technological, cultural, and biophysical variables. Nevertheless, underlying causes are usually exogenous (originate externally) to the local communities managing land and are thus uncontrollable by these communities. (<http://www.eoearth.org/view/article/150964/>). Accordingly major causes of land use/land cover change are natural variability, economic and technological factors, demographic factors, institutional factors, cultural factors and globalization. Natural variability, natural environmental changes interact with the human decision making processes that cause land use/land cover change while Economic and technological factors influence land use decision making by altering prices, taxes etc. on land use inputs and products.

According to Lambin et al. (2003), land-use change is driven by a combination of the following fundamental high level causes. These are ; Resource scarcity leading to an increase in the pressure of production on resources, Changing opportunities created by markets, outside policy intervention ,Loss of adaptive capacity and increased vulnerability, and Changes in social organization, in resource access, and in attitudes. Some of the fundamental causes leading to land use and land cover change are mostly endogenous, such as resource scarcity, increased vulnerability and changes in social organization and exogenous factors such as changing market opportunities and policy intervention.

## **2.8 Socio Economic implications of Land use land cover changes**

The land use and land cover change may result in environmental, social and economic impact of greater damage than benefit to the area ( Moshen A,1999).Therefore, the data on the land use change are of greater importance for planners in monitoring the consequences of land use change on area. Such data are of value to resource management and assess land use patterns and in modeling and predicting future change. Change in economy and spatial distribution of population can occur through conversion from one land use to another, for instance, converting farming lands into residential, industrial, commercial or recreational use. The land owners play a key role in whatever will take place at the land and, therefore, their decisions identify the direction and quantity of changes (Ettema et al. 2007).Therefore, different types of land owners (e.g. farmers, developers, private individuals, government) decide in a different way according to their type and their parameters. The owners have to supply the financial investment of land change, thus, their awareness of the economic situation can control the speed of the changes. At each time step, the landowner can decide the following decisions:

- ❖ Leave the land at current circumstances;
- ❖ Develop the land by changing the land usage and exploit it;
- ❖ Develop the land by changing the land usage and sell it;
- ❖ Sell the land to another owner.

However, the options vary for some owners. For instance, a farmer is not able to develop his land into a residential area, if he does not have the required investment power and skills. Moreover, all actions may not be allowed given planning regulations .Ettema et. Al, (2007) differentiate

between three different types of owners with preferences: farmers (preferences: exploit, sell or buy), government (preferences: maintain, sell to farmer, sell to developer or develop and maintain) and developers (preferences: develop and sell, redevelop and exploit, sell). Eventually, the decision, which will be most likely made, totally depends on the expected value of each option to the owner. In case of commercial owners, utility will match with profitability: the action will be taken that delivers the highest profit. In case of governmental part, also social benefits might play a significant role, whereas in the farmers' case, personal and emotional reasons may influence their decision. The market price is a valuable index in deciding whether or not to sell a land with or without developing it (Ettema et al. 2007)

Assessing, forecasting, and evaluating future land change is a complex set of tasks and, hence, it has to be performed after a deep scientific knowledge of the extent individuals, characters, as well as consequences of land transformation have been gathered (Meyer and Turner 1994). A typical land use planning process requires the landscape planners to realize, classify, and investigate the current circumstances in order to project future probable development patterns, and propose plans based on available information (Brail and Klosterman 2001). According to Brail and Klosterman (2001), planners usually approach this task in two ways, a predominant or traditional approach and an analytical approach. The traditional approach foresees a future land use outcome and then prioritizes present-day policies required to achieve that outcome. The analytical approach simulates alternate current strategies and compares their consequences.

## **2.9 Basic Concept in Image Analysis**

Remotely sensed data includes a variety of data source that are defined from the range of Spectrum of electromagnetic radiations. Aerial photography is used to capture reflective signal from the visible and near infrared portion of the spectrum. Most digital scanners operate in similar portion of the spectrum. Thermal and radar sensor systems are sensitive to the Different portion of the energy spectrum. Remotely sensed data provides an operational GIS with timely and synoptic data. Image analysis techniques are commonly utilized to perform regional vegetation mapping and to update existing vegetation maps. According to Jensen (1995), the utility of a sensor system for the detection of surface phenomena must be assessed along four dimensions: spatial resolutions (area or size of features that can be identified), spectral

resolution (number and Width of electromagnetic bands for which data are collected), radiometric resolution (detector Sensitivity to various level of incoming energy) and temporal resolution (frequency of satellite overlaps).

Airborne and satellite digital sensor collect and store data values for discrete units of the Surface of the earth. A scene is composed of large matrix of these cells. Each cell is referred to as a picture element or pixel and may correspond to a square meter, hectare or square Kilometer, depending on the sensor. The spatial resolution of the sensor is usually expressed as the length of one side of the cell. Advanced Very High Resolution Radiometer (AVHRR) has spatial resolution of 1.1 km (Kidwell, 1988) ; Thematic Mapper (TM) 30 m; (Jensen, 1995). Digital Image Processing (DIP) refers to the manipulation and interpretation of digital images, by a Computer system, to prepare an image for display and interpretation and/or to extract useful information from the image. The possible forms of digital image manipulation are literally infinite ( Lillesand *et al.*, 1998). Digital Image Processing is largely concerned with four basic operations: image rectification and restoration, image transformation, image enhancement, And image classification ( Lillesand *et al.*, 1998).

## **2.10 Image classification**

According to (Diday, 1994.), Image Classification is an operation to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This normally involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image. Image classification is the process of creating thematic maps from satellite imagery. A thematic map is an informational representation of an image that shows the spatial distribution of a particular theme. The computerized interpretation of images from remote sensors is known as a quantitative analysis due to its ability to identify pixels based on the numerical properties. For quantitative analysis usually different procedures of classification are used. Classification is a method that assigns categories to different pixel groups according with the spectral character. There are two main spectrally oriented classification procedures for land cover mapping: unsupervised and supervised classifications. According to Diday, (1994) unsupervised classification is computer-automated and it enables user to specify some parameters that the

computer uses to uncover statistical patterns that are inherent in the data. These patterns are simply clusters of pixels with similar spectral characteristics. In some cases, it may be more important to identify group of pixels with similar spectral characteristics than it is to sort pixels into recognizable categories. .

According to Jensen (1996) and Landgrebe, (2003), each pixel in the data set is then compared numerically to each category in the interpretation key and labeled with the name of the category. There are different algorithms under this classification type in which minimum distance, variance and covariance of the classes are considered during classification. Of these algorithms the best is maximum likelihood classifier. It quantitatively evaluates both the Variance and covariance of the category spectral response patterns when classifying an Unknown pixel. It is hoped that at the more generalized first and second levels, accuracy in interpretation can be attained that will make the Land use and land cover data comparable in quality to those obtained in other ways. For Land use/land cover data needed for planning and management purposes, the accuracy of interpretation at the generalized first and second levels is satisfactory when the interpreter makes the correct interpretation 85 to 90 percent of the time. According to Richards, (1999) supervised classification is the procedure most used for quantifying of remote sensing data. It rests up on using suitable algorithms to label the pixels in an image as representing particular ground cover types or classes.

## **2.11 Accuracy assessment**

The accuracy is essentially a measure of how many ground truth pixels were classified correctly. When looking at the land cover map, it is important to remember that no map is a perfect representation of reality. There are always errors in maps and we need to keep in mind how accurate they are, and whether that level of accuracy is sufficient for the ways we want to use the map information (Awotwi, 2009). Based on the 30-meter resolution of the Land sat data used to create map, it is important to keep in mind that the map will be most accurate for viewing geographic patterns over larger areas. The result of an accuracy assessment provides us with an overall accuracy of the map based on an average of the accuracies for each class in the map. Producers Accuracy is the total number of correct pixels in a category divided by the total number of pixels of that category as derived from the reference data (column total). This

statistics indicates the probability of a reference pixel being correctly classified and is a measure of Omission error. (Jensen 2003). Users Accuracy is when the total number of correct pixels in a category divided by the total number of pixels that were actually classified in that category (row total), the result is a measure of Commission error. The user's accuracy or reliability is the probability that a pixel classified on the map actually represent that category on the ground (Jensen 2003). The overall accuracy is calculated by summing the number of pixels classified correctly dividing by the total number of pixels.

## **CHAPTER THREE**

### **3. DATA AND METHODOLOGY**

#### **3.1 Description of study area**

Hawassa town is located in the Southern Nations Nationalities and peoples Regions. Absolute location is between  $6^{\circ} 55'$  to  $7^{\circ} 6'$  Latitude North and  $38^{\circ} 25'$  to  $35^{\circ} 34'$  Longitudes east and Relative location is Lake Hawassa in the West, Oromia region in the North, Wondogenet woreda in the east and Shebedino woreda in the South. The elevation of the town is 1708 m above sea level and Hawassa situated 275 km south of Addis Ababa. The city administration has an area of 157.2sq. kms , divided in to 8 sub city 32 rural Kebeles . These eight sub cities are Hayek Dar, Menehariya , Tadore , Misrak , Bahile Adarash Addis ketema , Hawela-Tula and Mehal sub city . (Source 2008E.C socio economic profile)

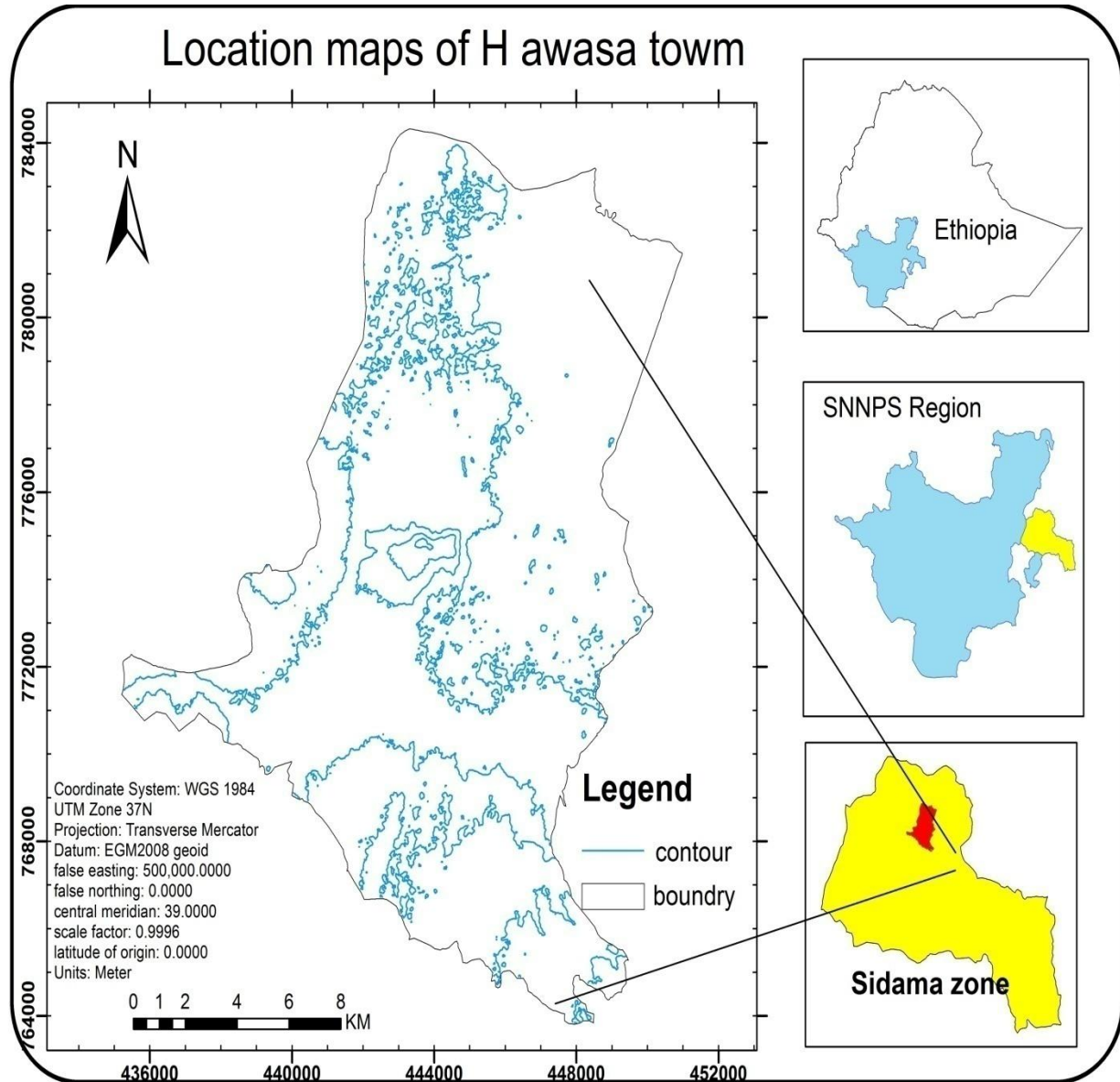


Fig 3.1 Location map of study area (Source: CSA, 2007)

### **3.1.2 Population**

Based on the 2007 census conducted by the central statistical agency of Ethiopia this town has total population of 157139 out of this 81020 are men and 76119 women are living in the city . (CSA, 2007). Based on the result of housing and population census of May, 2007, in 2016 the projected population of Hawassa city administration to be 371,826 people, out of this 191,352 are male and 180,474 are females. Based on CSA report total number of the population of the city administration 242,489 peoples live in urban area while the reaming 129, 337 peoples live in rural areas of the administration. The annual population growth rate 4.02% from this 4.8% growth rate in Urban and 2.8% growth rate in rural areas of the city. Much of the population growth in Hawassa has been the result of internal migration and expansion of Educational and other facilities, also widening of the city boundary has caused some the increased. Hawassa has a young population around 65% of the peoples are under 25 years of age and only about 5.5% of the population is over 50 years of age .(source 2008E.C socio economic profile city administration)

## **3.2 Climate**

### **3.2.1 Temperature**

The highest mean maximum temperature in the Hawassa town about 31.5°C from April to September and 31.5°C from October to March are recorded as the Afar depression in the north east Ethiopia. The other areas are north western low lands which experiences mean maximum temperature of 31.5°C in June and the western and south eastern low lands with mean maximum temperature of 31.5°C to 40°C April.

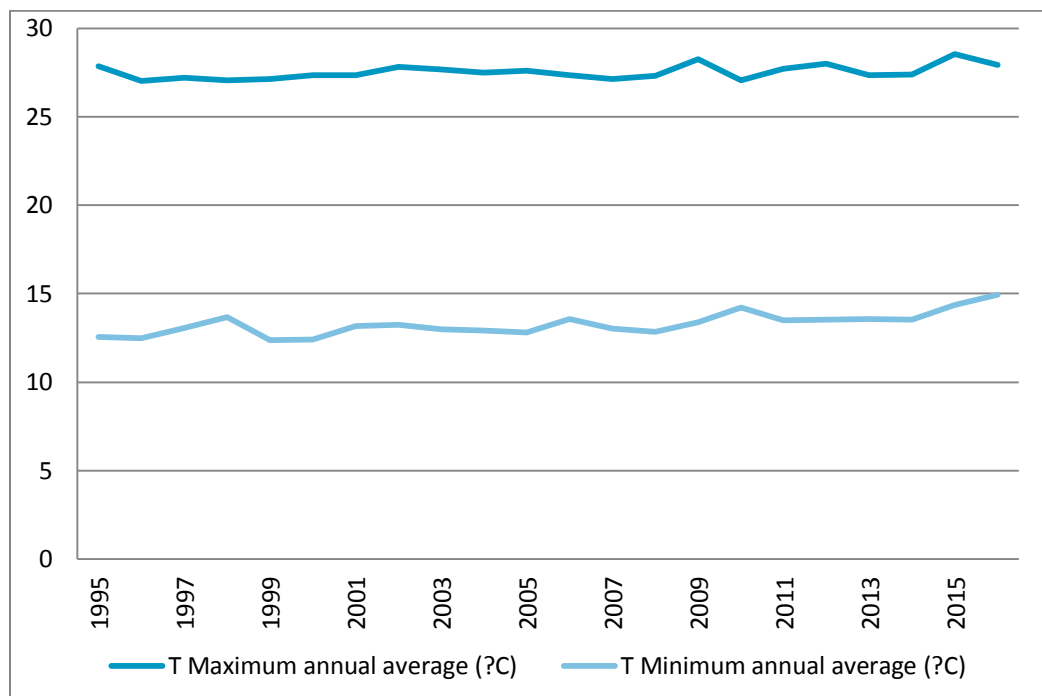


Fig 3.2 shows maximum and minimum average temperature of study area (Source: National Meteorological Agency)

### 3.2.2 Rainfall

Hawassa town however has even extended period of wet season ( March-October with mean monthly rainfall varying from 85 to 133mm). The moisture for precipitation in the area originates from southwest equatorial air stream, which moves northwards with inter-tropical convergence zone (ITCZ), (W.W.D.S.E 2001). June to September rainfall contributes 44% to the mean annual precipitation in the town. Maximum annual rainfall 1188.9 mm and annual minimum rain fall is 632.5 mm.

No.	Year	Annual rainfall (mm)
1	1995	1004.4
2	1996	1189.1
3	1997	1054.1
4	1998	1148.3
5	1999	808.9
6	2000	821.5
7	2001	1021.7
8	2002	919.3
9	2003	888.9
10	2004	897.7
11	2005	1002.6
12	2006	1188.9
13	2007	1152.7
14	2008	915
15	2009	703.7
16	2010	1032.3
17	2011	922.9
18	2012	632.5
19	2013	889.5
20	2014	1154.6
21	2015	671.8
22	2016	884.1

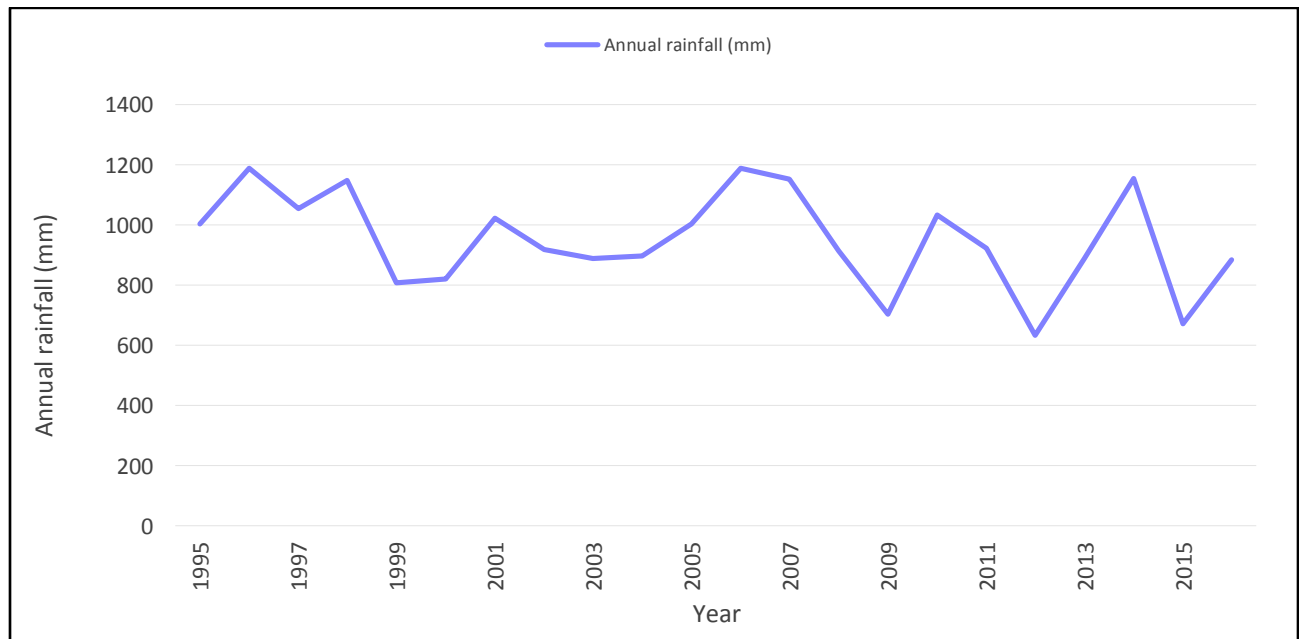


Fig. 3.3 Rainfall distribution of the Study Area (Source: National Meteorological Agency)

### **3.3 METHEDOLOGY**

#### **3.2.1 Data collection**

The researcher has used both primary and secondary sources Land sat satellite images of the study area was acquired for four years; 1995, 2002, 2009 and 2016. These images were obtained from United States Geological Survey (USGS). The images was acquired from the period January–February, as this is a clear sky season in the region, reducing atmospheric , radiometric and penology effects . The primary data source was included field data that was collected with the use of Global Positioning Systems (GPS), Satellite image and field observation. The secondary data source involves EMA contributed large scale maps1:50,000 , Ethiopian central statistics agencies population data of study area , Ethiopian meteorological agencies I get temperature and rainfall data, SNNPS city plan office and information’s from written document and shape file of the town from Hawassa city administration. The database was structured in a format for implementation using the application of Arc GIS10.3 , Erdas imagine 2014 , Envi 4.2, Microsoft words, MS Excel was used for writing reports in textual format and list of data. In order to accomplish this, free internet sources were used to acquire the satellite imageries in other words all land sat TM (1995-01-30),ETM (2002-02-26),ASTER (2009-11-12) and Land sat 8 (2016-12-09) were accessed free of charge from US Geological Survey (USGS) and center for Earth Resources Observation and Science through <http://earthexplorerusgs.gov/>.

Table 3.1 Description of the satellite images for project study.

year	1995	2002	2009	2016
Satellite sensor	TM	ETM	AST	OLI
Path/Row	168/55	168/55	168/55	168/55
Acquisition date	1995-01-30	2002-02-26	2009-11-12	2016 -12-09
Pixel spacing	30	30	15	30
Sun elevation	42.26311342	54.38650435	59.62989	51.88474475
Sun azimuth	122.07134938	116.12143695	144.764594	142.77357038
Sunzenith (90-sun elevation)	47.73688686	35.61349565	30.37011	38.11525525
Data types	L1TP	L1TP	L1T	TIRS
Image quality(bit)	9	9	9	9
Cloud cover	00	00	1	3.28
Revisit time/days/	16	16	16	16
Cost	Free	Free	Free	Free

### 3.3.3 Pre-processing

Raw satellite image is full of errors and will not be directly utilized for features identification and any applications. It needs some correction. Pre-processing is done before the main data analysis and extraction of information. Pre-processing involves two major processes: geometric correction and radiometric correction or haze correction. Remote sensing imageries are inherently subjected to geometric distortions. These distortions may be due to the perspective of the sensor optics, the motion of the scanning system, the motion of the platform (the platform altitude, attitude and velocity), the terrain relief, or the curvature and rotation of the earth (Lillesand and Kiefer, 2000). Pre-processing aims to correct distorted data in order to create more faithful representation of the original scene, this typically involves the initial processing of raw image data to correct for geometric distortions, to calibrate the data radio metrically, and to eliminate noise present in the data

### **3.3.4 Geometric correction**

Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface. Hence, the data sets were geo-referenced or geo-coded that is registered to a geographic coordinate system (UTM Zone 37). The geometric correction process is normally fulfilled as a two-step procedure. First, those distortions that are systematic or predictable are considered. Second, those distortions that are essentially random or unpredictable are considered. The former are well understood and easily corrected by applying formulas derived by modeling the sources of the distortions mathematically. For example, a highly systematic source of distortion involved in multispectral scanning from satellite altitudes is the eastward rotation of the earth beneath the satellite during imaging. This causes each optical sweep of the scanner to cover an area slightly to the west of the previous sweep. This is known as *skew distortion*. The process of *deskewing* the resulting imagery involves offsetting each successive scan line slightly to the west. The skewed-parallelogram appearance of satellite multispectral scanner data is a result of this correction (Remote Sensing and Image Interpretation). The later and unsystematic distortions are corrected by analyzing well-distributed ground control points (GCPs) occurring in an image. GCPs are features of known ground location that can be accurately located on the digital imagery.

### **3.3.5 Haze Reduction Atmospheric correction**

The objective of atmospheric correction is the elimination of atmospheric and terrain effects to retrieve physical parameters of the earth's surface, including surface reflectance, ground visibility and temperature. Such correction is especially important in cases where multi-temporal, multi-sensor or multi-condition images are to be compared and analyzed. The Atmospheric Correction (with ATCOR 3 IMAGINE extension) more of Chavez (1996). The Haze Removal workflow allows us to calculate water and cloud masks for the input scene, and remove haze from images before performing atmospheric correction, thematic classification, or creating a mosaic. Haze consists of atmospheric aerosols and molecules that scatter especially visible spectrum and absorb solar radiation, thus affecting the downward and upward solar radiance to be recorded by remote sensing sensors. Haze modifies the spectral signature of land classes and

reduces classification accuracy, so causing problems to users of remote sensing data. Hence, there is a need to reduce the haze effects to improve the usefulness of the data. A way to do this is by integrating spectral and statistical approaches ERDAS IMAGINE 2014 with an ATCOR 3 extension has dual function for haze reduction and Atmospheric correction respectively. The result shows that the haze reduction method is able to increase the accuracy of the data statistically and visually.

### **3.3.6 False Color Composite (FCC) Image Preparation**

Different color composite images were prepared, in order to select the best band combination, that enhance the raw satellite images for the identification of the different land cover classes in the study area. In this research project the false color composite image made using Land sat 8 bands 5-4-3(R-G-B), Land-sat TM bands 4-3-2 (R-G-B) and ETM+ 4-3-2 (R-G-B) and ASTER images band 3-2-1(RGB) were found to be best for the identification of major land cover classes in the study area.

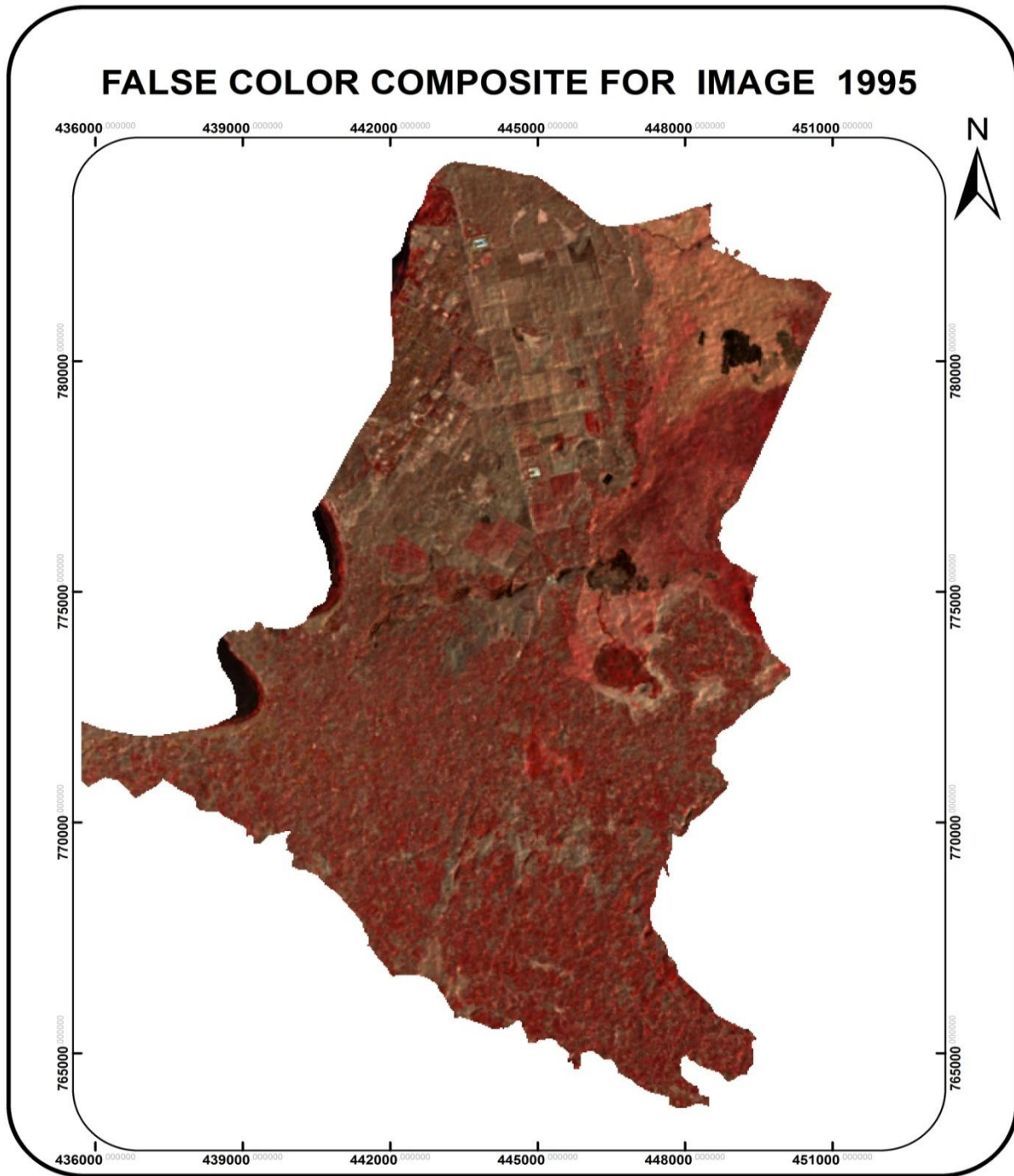


Fig 3.5 False Color Composite Of 1995 Image

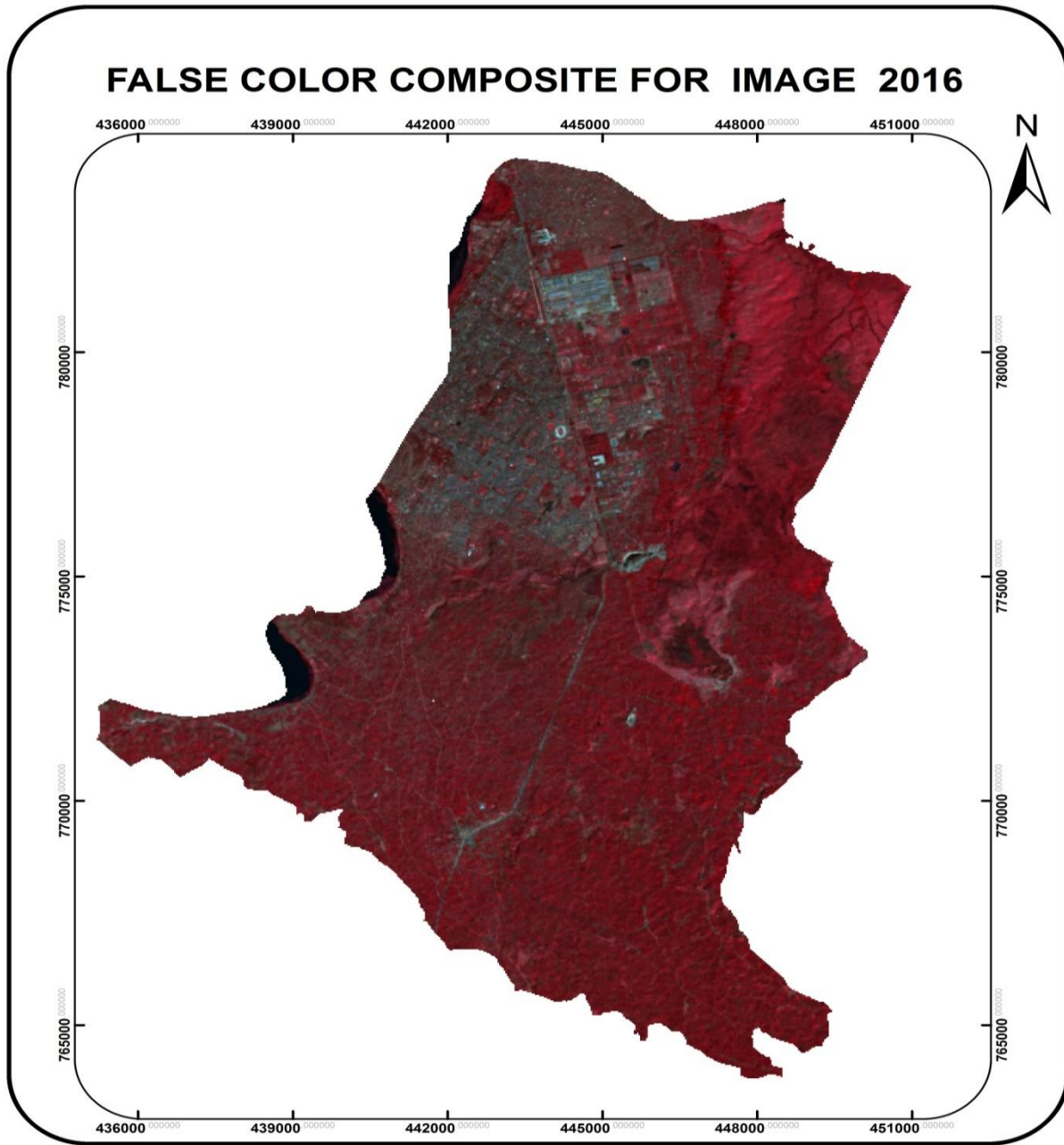


Fig 3.6 False Color Composite Of 2016 Image

### **3.4 Software and Platforms**

Preparation of thematic maps from the digital satellite data was instigated by using ERDAS IMAGINE 2014, ENVI 4.2 and ARC GIS ver. 10.2.1 Standard methods, which included use of image elements like tone, texture, shape, location, association, pattern, etc., of digital image

#### **3.5.1 Supervised classification**

Supervised classification can be used to cluster pixels in a datasets in to classes corresponding to user defined training classes or the process of using samples of known identity (i.e., pixels already assigned to informational classes) to classify pixels of unknown identity. This classification type requires that researcher select training areas for use as the bases for classification .Various comparison are then used to determine if specific pixel qualifies as a class members .Types of supervised classification includes Paralleloped ,Minimum distance, Mahalanobis distance, Maximum likelihood, spectral angle mapper etc .

#### **3.5.2 Maximum likelihood classification algorithms**

This classification assumes that the statistics from each class in each band is normally distributed and calculates the probability that a given pixel belongs to the specific classes. Moreover, it quantitatively evaluates both the variance and covariance of the category of spectral response patterns when classifying unknown pixels after computing the probability in each category the pixel would be assigned to the most likely class that is to the highest probability values. Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless you select a probability threshold, all pixels are classified. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood). If the highest probability is smaller than a threshold you specify, the pixel remains unclassified. (Anderson, et al, 2009) .

#### **3.5.3 Reclassification of Land use land covers classes**

In this project researcher have thirteen (13) LULC classes based on their reflectance and associated object characteristics from Google Earth however, to summarize the individual LULC classes into groups of similar classes researcher reclassified them in to five (5) land use land

cover classes .The reclassification tools is used to reclassify or change cell values to alternative values using the variety of methods. Replacing values based on new information the research project has described as follows:

1. Dense settlements, spares settlements, built-up area and industrial area are reclassified to Settlements.
2. Dry agriculture and grown up agriculture are reclassified to Agricultural land
3. Bedrock, Bare lands and roads reclassified to Bare land
4. Dense forest, Vegetation and sparse forest reclassified to Vegetation.
5. Wetland and water body reclassified to wetlands.

Hence, the final reclassification result produced in to five LULC classes of settlements, agricultural land , Vegetation , bare land and wetland indicated in ( fig 3.6) below.

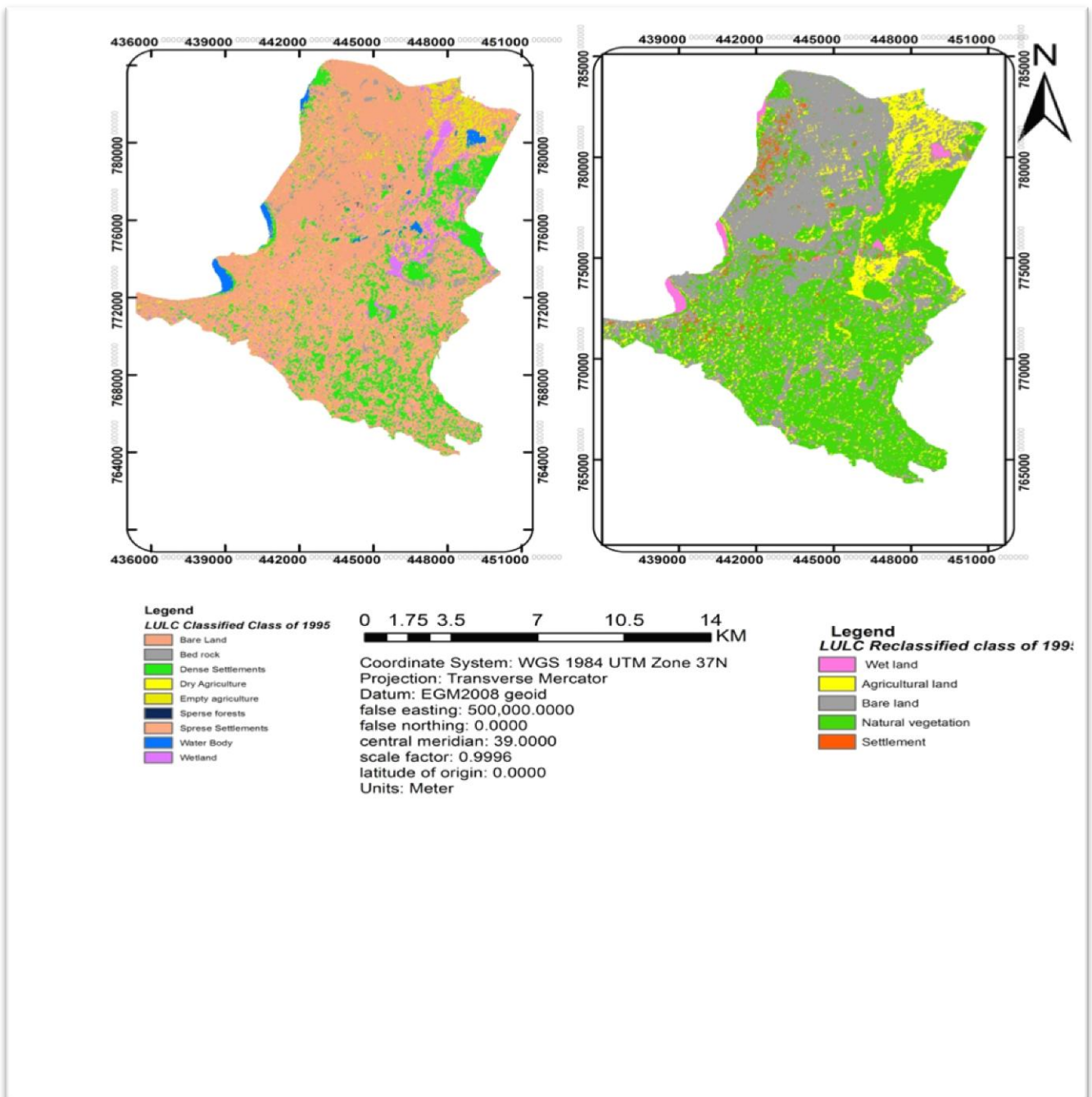


Fig3.7 Maximum likelihood supervised classifications and reclassification of 1995

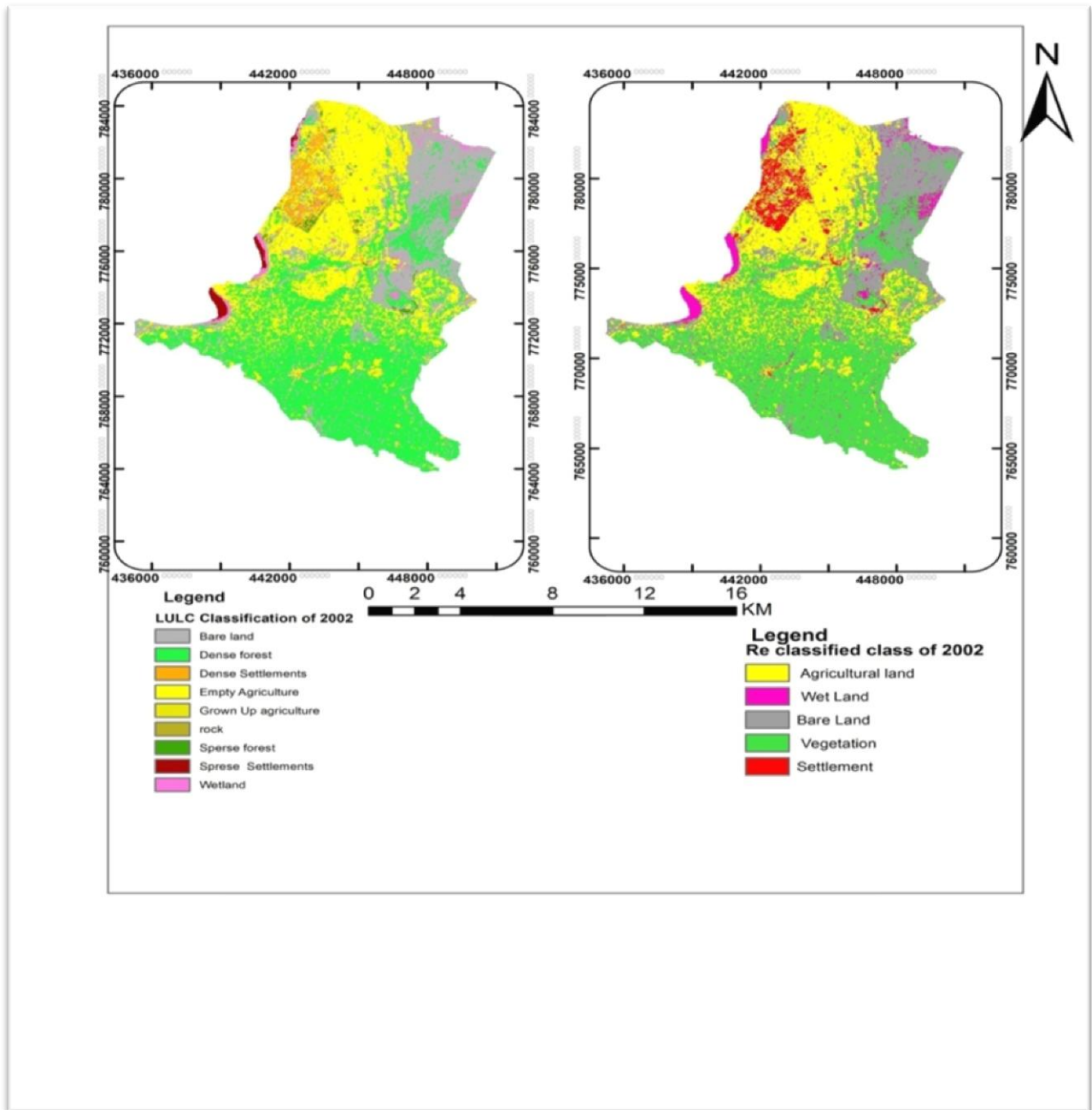


Fig3.8 Maximum likelihood supervised classifications and reclassification of 2002

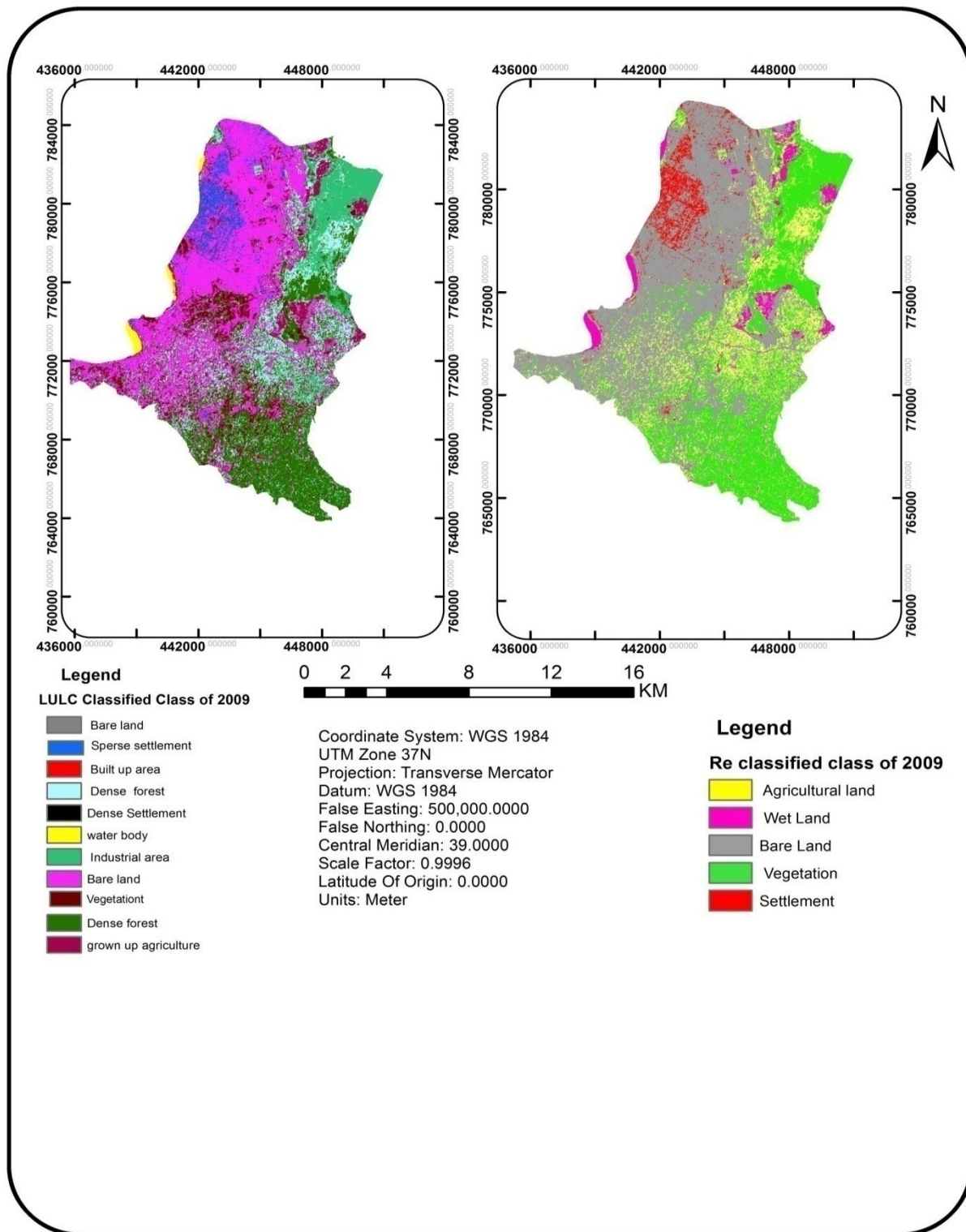


Fig3..9 Maximum likelihood supervised classifications and reclassification of 2009

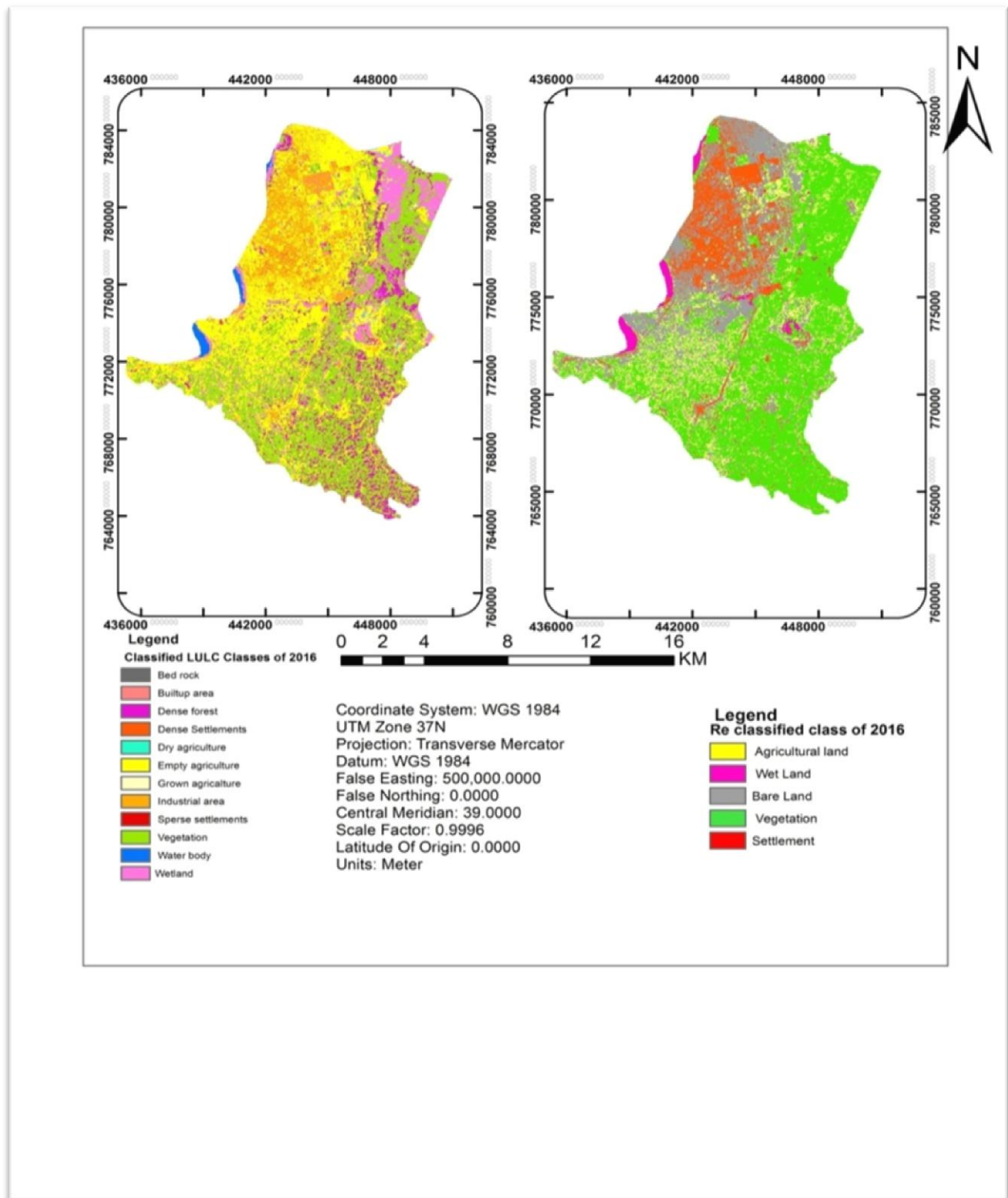


Fig3.10 Maximum likelihood supervised classifications and reclassification of 2016

### 3.6 Development of classification scheme

Based on the prior knowledge of the study area and additional information from different materials in the study area five different types of land uses and land cover classes have been identified for Hawassa town. According to researcher identified five classes such as Settlement, Vegetation, Agricultural land, bare land and wetland. The descriptions of these land use and land cover classes are given below.

Table 3.2 Descriptions of land use land cover types identified in study area

s. no	LU/LC Classes	CODE	Description of land use classes
1	Settlement	S	Urban areas and permanent residential areas of varied pattern for example ,cities, towns, villages, strip developments along highways, transportation, power, and communications facilities
2	Vegetation	V	Refer to all plants and trees collectively, typically those in a specific region.
3	Agricultural land	AL	The land area that is either arable under perm ant crops or land used primarily for production of food and fiber
4	Bare land	BL	Land of limited ability to support life and in which less than one-third of the area has Vegetation or other cover. In general, it is an area of thin soil, sand, or rocks or The area with no dominant vegetation cover on at least 90% of areas covered lichens or mosses
5	Wetland	WL	Those areas where the water table is at, near, or above the land surface for a significant part of most years .e.g. marshes, mudflats, and swamps

Sources: (Anderson, 1972)

### 3.7 Accuracy assessment of the classifications

User's Accuracy is when the total number of correct pixels in a category divided by the total number of pixels that were actually classified in that category (row total), the result is a measure of Commission error. The user's accuracy or reliability is the probability that a pixel classified on the map actually represent that category on the ground (Jensen 2003). The overall accuracy is calculated by summing the number of pixels classified correctly dividing by the total number of pixels. The enough number of samples that represent the thematic classes and ensure good distribution across the map is important to test the attribute accuracy. Rule of thumb is 50 samples per map class or can be derived using the formula devised by Grenier *et al.* (2008) For this research project minimum sample size used 50 and maximum sample size is 65 .

### 3.8 Kappa coefficient

Kappa is used to measure the agreement or accuracy between the remote sensing derived Classification map and the reference data as indicated by the major diagonals and the chance Agreement, which is indicated by the row and column, totals (Jensen 2003). The Kappa coefficient represents the proportion of agreement obtained after removing the proportion of agreement that could be expected to occur by chance (Foody, 1992). This implies that the Kappa value of 0.8454 represents a probable 84.54% better accuracy than if the classification resulted from a random, unsupervised, assignment instead of the employed maximum likelihood classification. A value >0.80 (80%) -- strong agreement, a value b/n 0.40 and 0.80 (40 to 80%) represents moderate agreement, and a value < 0.40 (40%) represents poor agreement (Anderson, 2003)

The Kappa factor is given by the formula (Anderson, 2003)

$$K = \frac{N \sum X_{ii} - \sum X_{class} * \sum X_{ref}}{N^2 - \sum X_{class} * \sum X_{ref}}$$

**Where,** N= is the total number of observation

$\sum X_{class}$  = are the observations for classified data

$\sum X_{ref}$  = are the observations for reference data

$\sum X_{ii}$  = the observation along the diagonals

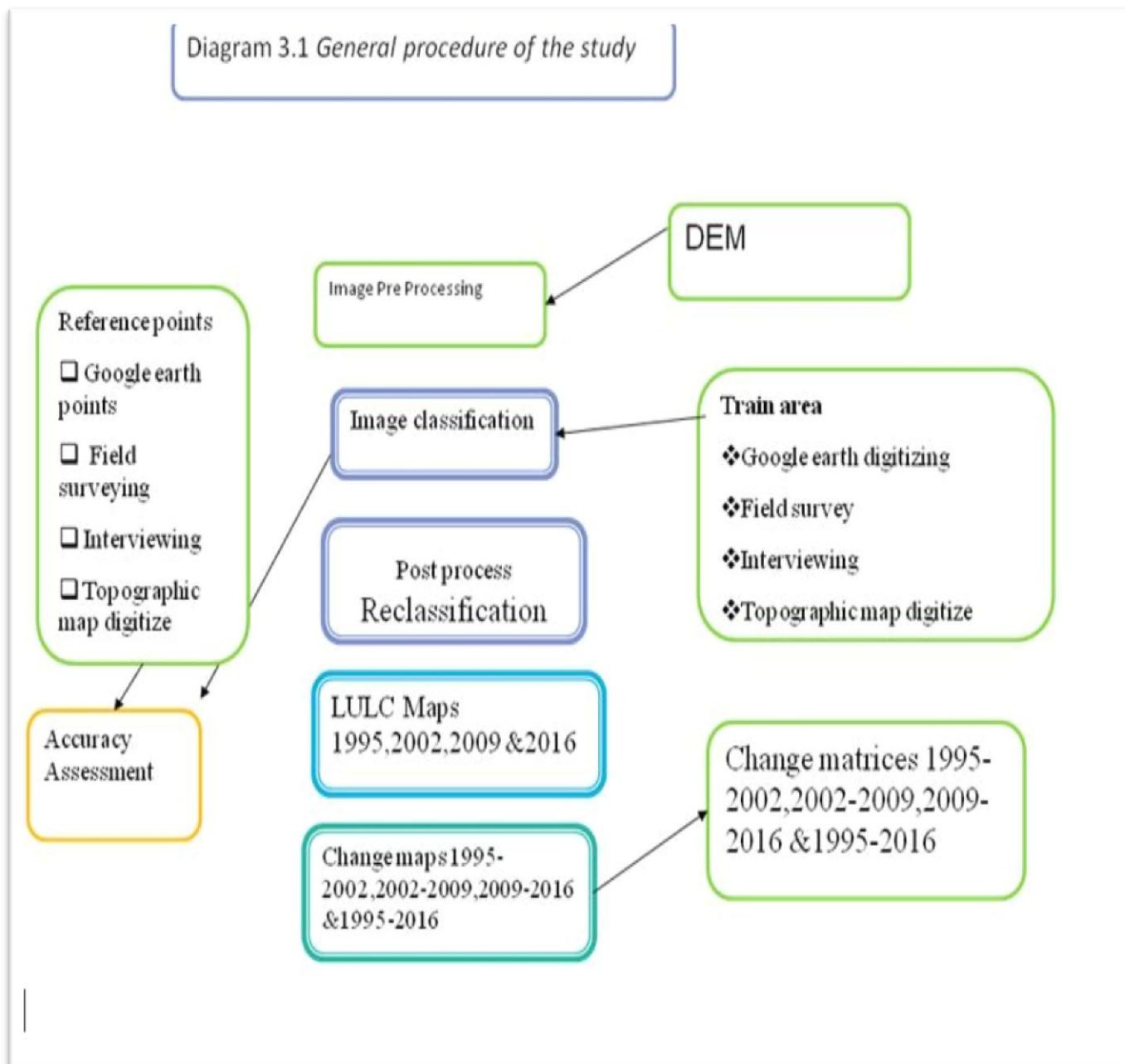


Fig3.11 General procedures of the study

## **CHAPTER FOUR**

### **4. RESULTS AND DISCUSSIONS**

#### **4.1 Land Use/Land Cover change**

As indicated in the classification scheme Settlement, Vegetation, Agricultural land , Bare land and wetland, are the major LULC classes for the study periods .The classified images were acquired, when crop harvesting had already started (dry season), in order to assure similar penology . Regarding vegetation, there were relatively undisturbed areas that had been serving as a home for some wild animals with varying levels of density, ground cover and disturbance. Some of these forests have been sources of wood for house construction, household energy and farm implements.

##### **4.1.1 Landsat Thematic Mapper (TM) data 1995**

The wave length range for the TM sensor ranges from the visible in to the thermal infrared portion of the electromagnetic spectrum and it has a spatial resolution of 30 meter (Hussein Ali, 2009). After six bands of the TM (excluding thermal band) were considered for layer stacking, TM band 4, 3 and 2 were combined to make conventional false color composite image.

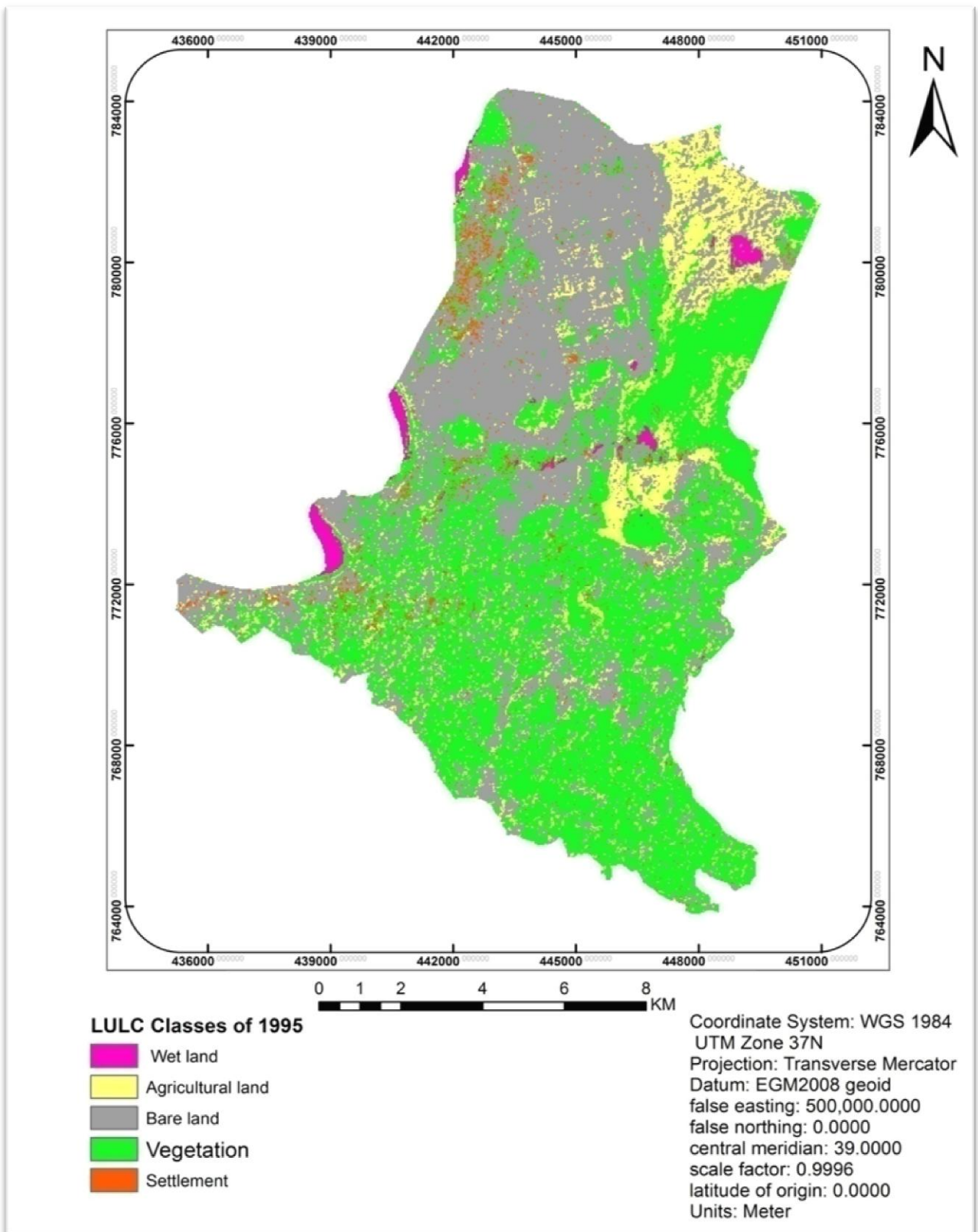


Fig. 4.1 LULC Map of Hawassa town in 1995

*Table 4.1 LULC Class Distributions of Hawassa town in 1995*

No.	LULC type	1995	
		Area (ha)	Area (%)
1	Settlement	349.0	2.2
2	Bare Land	6122.4	38.9
3	Agricultural Land	1973.3	12.6
4	Vegetation	7065.7	44.9
5	Wet land	211.1	1.3
Total		15721.6	100.0

According to Table 4.1 the classification result of the Land sat TM 1995 image revealed that Vegetated land constituted the largest proportion of land in the town with a value of 7065.7 ha (44.9%), Bare land which accounts for 6122.4 ha (38.9%), followed by Agricultural land 1973.3 ha (12.6%) and Settlement and Wet land constituted 2.2%, 1.3% respectively.

#### **4.1.2 Land sat ETM<sup>+</sup> of image 2002**

The Landsat Enhanced Thematic Mapper (ETM<sup>+</sup>) was introduced with Landsat 7. ETM<sup>+</sup> data cover the visible, near-infrared, shortwave, and thermal infrared spectral bands of the electromagnetic spectrum. The Landsat Project is a joint initiative of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA). Landsat's Global Survey Mission is to establish and execute a data acquisition strategy that ensures repetitive acquisition of observations over the Earth's land mass, coastal boundaries, and coral reefs. Enhanced Thematic Mapper (ETM<sup>+</sup>) which improved version of TM sensor. (ETM<sup>+</sup>) Thermal band has an improved spatial resolution 60m compare to the TM's 120 m spatial resolution. In addition the ETM<sup>+</sup> also contain 15m panchromatic band. After six bands of the (ETM<sup>+</sup>) (excluding thermal band) were considered for layer stacking, (ETM<sup>+</sup>) band 4, 3 and 2 were combined to make conventional false color composite images.

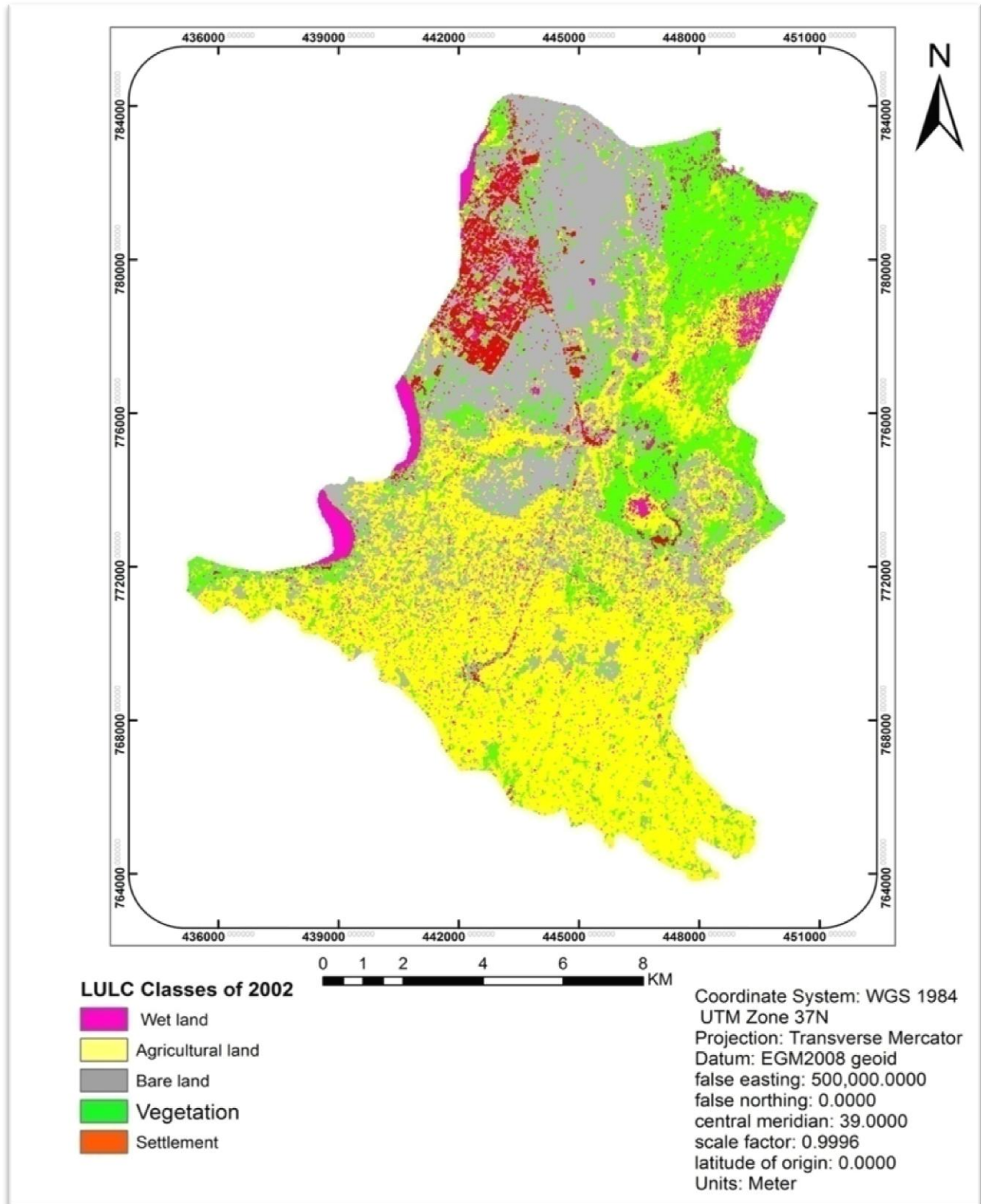


Fig. 4.2 LULC Map of Hawassa town in 2002

*Table 4.2 LULC Class Distributions of Hawassa town 2002*

No.	LULC type	2002	
		Area (ha)	Area in percent
1	Settlement	691.6	4.4
2	Bare Land	4670.5	29.7
3	Agricultural Land	6459.7	41.1
4	Vegetation	3249.5	20.7
5	Wet land	600.4	3.8
Total		15721.6	100.0

As shown above Table 4.2 for the land sat ETM<sup>+</sup> 2002 image of the town, the proportion of land allocated for agriculture increased to 6459.7 ha (41.1%). Furthermore, bare land and vegetation coverage decreases to 4670.5 ha (29.7%) and 3249.5 ha (20.7%) respectively. However, the proportions of wetland and settlement have increased to 600.4 ha (3.8%) and 691.6 ha (4.4 %) respectively.

### **4.1.3 ASTER IMAGE OF 2009**

The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) is an advanced multispectral imager that was launched on board NASA's Terra spacecraft in December, 1999. ASTER covers a wide spectral region with 14 bands from the visible to the thermal infrared with high spatial, spectral and radiometric resolution. An additional backward-looking near-infrared band provides stereo coverage. The spatial resolution varies with wavelength: 15 m in the visible and near-infrared (VNIR), 30 m in the short wave infrared (SWIR), and 90 m in the thermal infrared (TIR). Each ASTER scene covers an area of 60 x 60

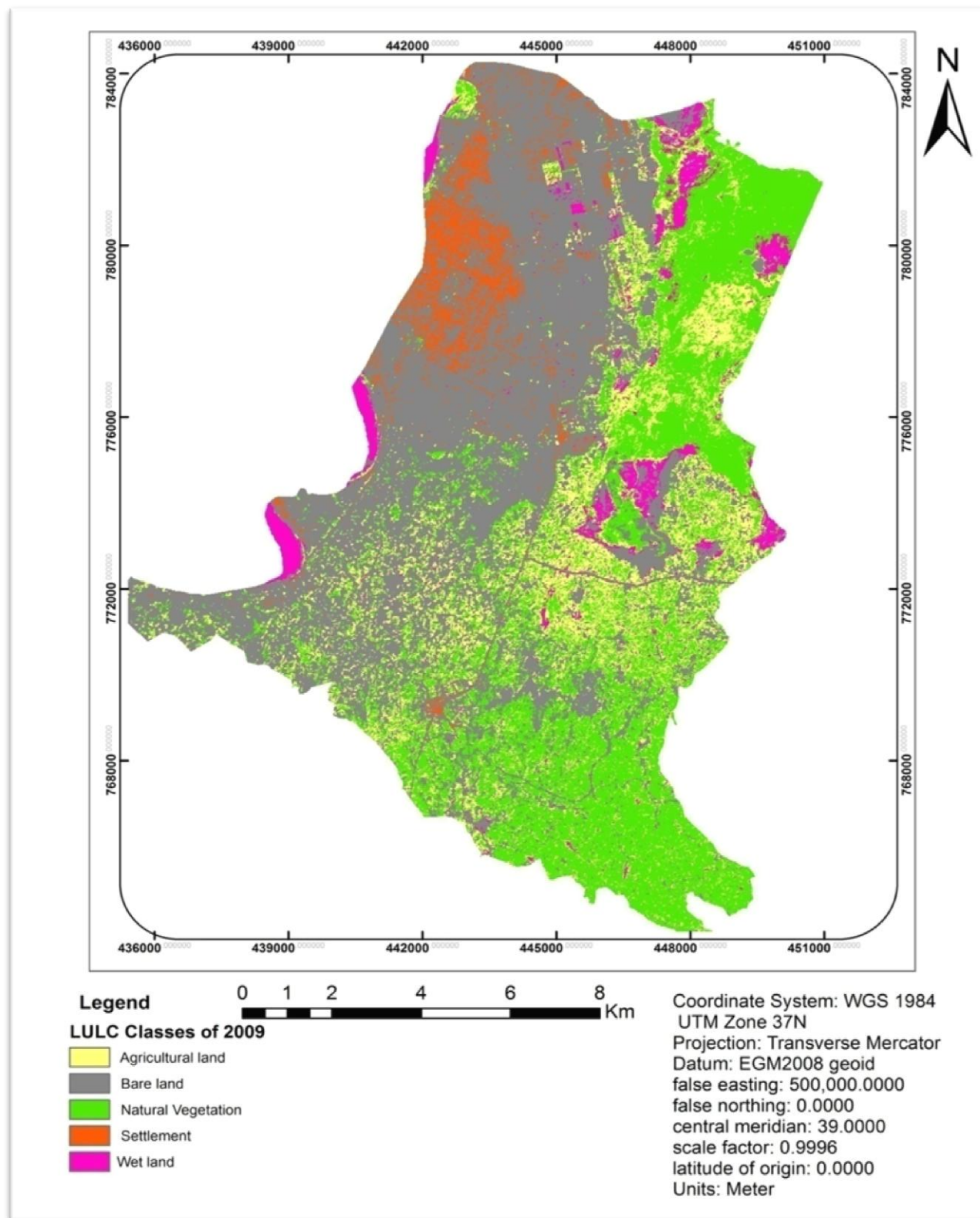


Fig. 4.3 LULC Map of Hawassa town in 2009

*Table 4.3 LULC Class Distributions of Hawassa town 2009*

No.	LULC Type	2009	
		Area (ha)	Area (%)
1	Settlement	742.2	4.72
2	Bare Land	7193.1	45.7
3	Agricultural Land	2222.5	14.1
4	Vegetation	4894.7	31.1
5	Wet land	667.6	4.2
Total		15720.0	100.0

As shown in above Table 4.3 for the ASTER 2009 image of the town, the proportion of land allocated for bare land increased to 7193.1 ha (45.7%). Furthermore, Vegetation Coverage and the size of settlements' increased to 4894.7 ha (31.1%) and 742.2ha (4.72%) respectively. However, the proportions of agricultural land and wet land decreased to 2222.5 (14.1%) and 667.6 ha (4.2%) respectively.

#### **4.1.4 Landsat 8 Data for 2016 Images**

NASA successfully launched the Landsat Data Continuity Mission on February 11, 2013. The satellite was renamed Landsat 8 and operation has been transferred to the USGS. Data collected since April 11, 2013 by the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) on board Landsat 8 are available for download. Of its 11 bands, only those in the very shortest wavelengths (bands 1–4 and 8) sense visible light –all the others are in parts of the spectrum that we can't see. The true-color view from Landsat is less than half of what it sees. As a result, the images need to be contrast enhanced (stretched). Following this recommendation histogram equalization has run to enhance the image and a good result was found. After seven bands of the Landsat 8 (excluding thermal band) were considered for layer stacking, Landsat 8 band 5, 4 and 3 were combined to make conventional false color composite images with a spatial resolution of 30 meters (<http://www.eoearth.org/view/article/150964/>)

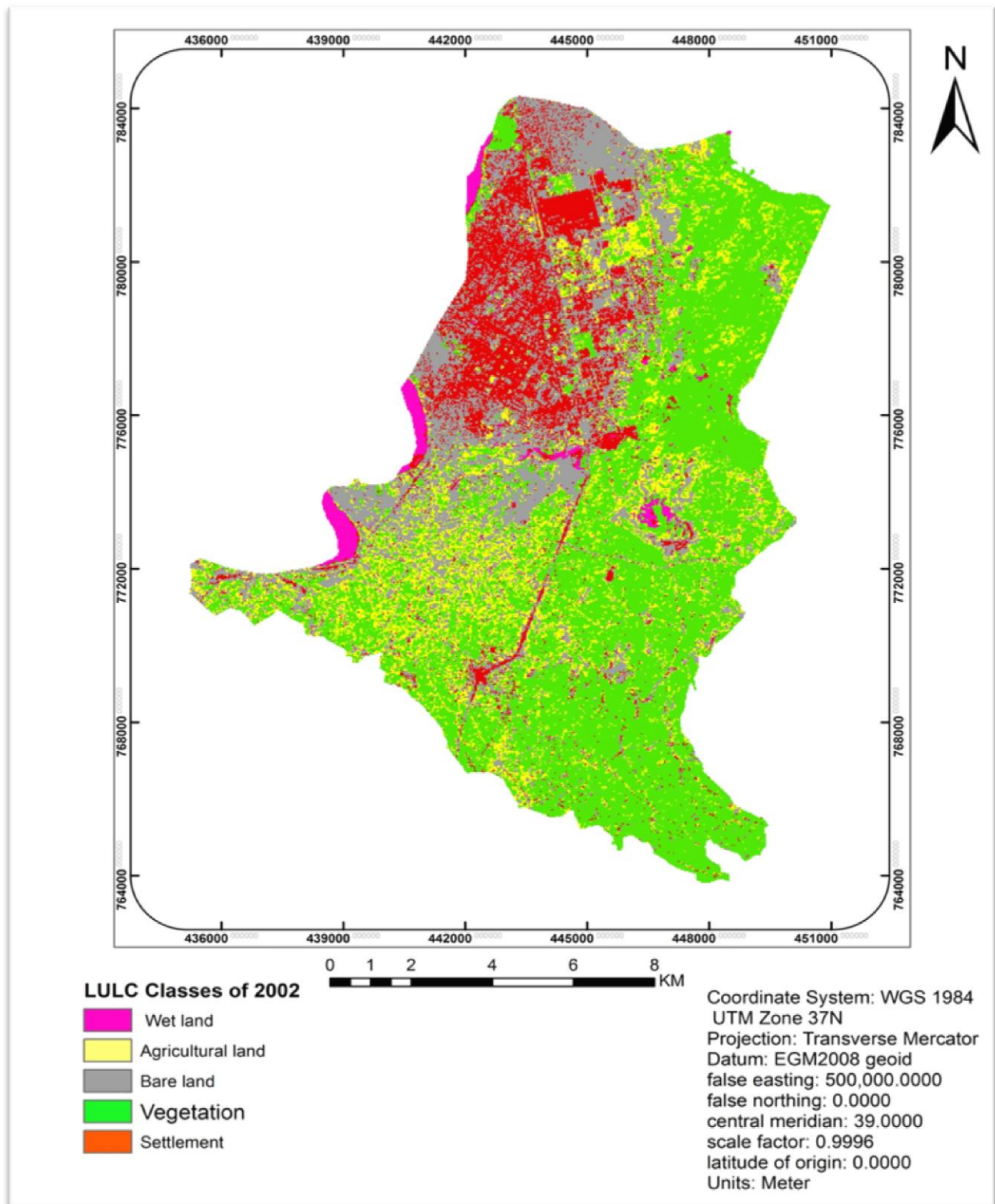


Fig. 4.4 LULC Map of Awassa town in 2016

*Table 4.4 LULC Class Distributions of Hawassa town in 2016*

No.	LULC Type	2016	
		Area (ha)	Area (%)
1	Settlement	1954.9	12.4
2	Bare Land	3638.1	23.1
3	Agricultural Land	2257.7	14.4
4	Vegetation	7519.2	47.8
5	Wet land	351.7	2.2
Total		15721.6	100.0

As it is indicated above table .4.4 land use and land cover map of land sat 8 images 2016 dramatic expansions of vegetation coverage and settlements which was accounts for about 7519.2 ha (47.8%) and 1954.9 ha (12.4%) of the total land area of the town respectively , followed by agricultural land which accounts about 2257.7ha ( 14.4% ) and dimensioning of bare land and wetland 3638.1 ha (23.1%) and 351.7 (2.2%) respectively.

## **4.2 Accuracy Assessment of the Classification**

The accuracy is essentially a measure of how many ground truth pixels were classified correctly.. There are always errors in maps and we need to keep in mind how accurate they are, and whether that level of accuracy is sufficient for the ways we want to use the map information (Awotwi, 2009). Based on the 30-meter resolution of the Land sat data used to create map, it is important to keep in mind that the map will be most accurate for viewing geographic patterns over larger areas. The result of an accuracy assessment provides us with an overall accuracy of the map based on an average of the accuracies for each class in the map .Once the classified image is integrated into a GIS , accuracy assessment should be processed as it limits the classification results of a remotely sensed imagery data. To do so, the accuracy of a classified map has to be

assessed and compared with a referenced data using an error matrix. The accuracy assessment in this project was made using the original images and elders who live in the study area for 1995, 2002 and 2009 and field observation and Google Earth image used for the 2016 study period.

### 4.3 Accuracy assessment of 1995 to 2016 images

Table 4.3.1 Accuracy assessment of LULC Map of 1995

Classified pixels	Ground truth								
	LULC Types	A	B	N	S	W	Grand Total	Users accuracy	
	Agricultural Land	39	4	4	2	2	51	76.5	
	Bare land	10	60	4	8	4	86	69.8	
	Vegetation	4	4	46	3	9	66	69.7	
	Settlement	2	4	3	37	0	46	80.4	
	Wetland	0	0	0	0	28	28	100	
	Grand Total	55	72	57	50	43	277		
	Producers accuracy	70.9	83.3	80.7	74	65.1			
Overall accuracy		<b>0.758</b>							

where AL= Agricultural Land

BL= Bare land

NS = New settlements

V= Vegetation

S= Settlements

W= Wetland

Over all accuracy=0.7581( 75.81) %

Kappa=0.70or 70%

Producer Accuracy			User Accuracy		
<b>AL</b>	=0.709	=70.9%	<b>AL</b>	=0.755	=75.5%
<b>BL</b>	=0.8333	=83.33%	<b>BL</b>	=0.698	=69.8%
<b>V</b>	=0.8070	=80.7%	<b>V</b>	=0.697	=70%
<b>S</b>	=0.740	=74.0%	<b>S</b>	=0.804	=80.4%
<b>W</b>	=0.651	=65.1%	<b>W</b>	=1.0	=100.0%

The Land sat TM Image of 1995 supervised classification Results shows user's accuracy in this study showed that the maximum class accuracy was 100%, which was wetland where correctly classified and the minimum was bare land class with an accuracy of 69.8 % as presented in table 4.3.1 above.

#### Kappa coefficient 1995 image

$$K = \frac{N \sum X_{ii} - \sum X_{class} * X_{ref}}{N^2 - \sum X_{class} * X_{ref}}$$

$$X_{ii}=210 \quad \frac{277(210) - 15843}{76729 - 15843} = \frac{58170 - 15843}{76729 - 15843}$$

$$N = 277 \quad 76729 - 15843 \quad 76729 - 15843$$

$$N^2 = 76729 \quad \frac{42327}{76729 - 15843} = \underline{0.70} = \underline{70\%}$$

$$N \sum X_{ii} = 58170 \quad 60886$$

$$X_{class} * x_{ref} = 15843$$

The Land sat TM Image of 1995 supervised classification with an overall accuracy of 75.8% was achieved with a Kappa coefficient (Khat) of 0.70. This value implies moderate agreement with good accuracy, and is often multiplied by 100 to give a percentage measure of classification accuracy. According to the above table (4.3 .1). Therefore, the Khat value of 0.70 represents a probable 70 % better accuracy.

Table 4.3.2 Accuracy Assessment of LULC Map of 2002

Classified pixels	Ground truth							
	LULC types	A	B	V	S	W	Grand Total	Users accuracy
	AL	37	4	3	3		47	78.7
	BL	5	44	5	7	5	66	73.3
	V	7	3	49		3	62	81.7
	S	1	7		49		57	79
	W		2		1	27	30	90
	Grand Total	50	60	57	60	35	262	
	Producers accuracy	74	73.4	86	81.6	77.1		
<b>Overall accuracy</b>								<b>0.786</b>

Where, AL= Agricultural Land

BL= Bare land

V= Vegetation

S= Settlements

W= Wetland

Over all accuracy=78.6 %

Kappa=0.73 or 73%

<i>Producer Accuracy</i>			<i>User Accuracy</i>		
<b>AL</b>	=0.74	=74.0%	<b>AL</b>	=0.7872	=78.7%
<b>BL</b>	=0.7333	=73.33%	<b>BL</b>	=0.7333	=73.3%
<b>V</b>	=0.8596	=85.96%	<b>V</b>	=0.7903	=79%
<b>S</b>	=0.8166	=81.66%	<b>S</b>	=0.8166	=81.6%
<b>W</b>	=0.7714	=77.14%	<b>W</b>	=0.90	=90.0%

The land sat ETM<sup>+</sup> Image of 2002 supervised classification results of user's accuracy in this study showed that in 2002 the maximum class accuracy was 90 %, which was wetland where correctly classified and the minimum was bare land class with an accuracy of 73.3 % as presented in table 4.3.2 above. In 2002, the class accuracies range from 73.3% to 90%.

#### **Kappa coefficient 2002 images**

$$K = \frac{N \sum X_{ii} - \sum X_{Class} * \sum X_{ref}}{N^2 - \sum X_{class} * \sum X_{ref}}$$

$$X_{ii}=206 \qquad \frac{262(206) - 14314}{68644 - 14314}$$

$$N = 262 \qquad 68644 - 14314$$

$$N^2 = 68644 \qquad \frac{39658}{68644 - 14314} = 0.73 = 73\%$$

$$N \sum X_{ii} = 53972 \qquad 54330$$

$$\sum X_{class} * \sum X_{ref} = 14314$$

The land sat ETM<sup>+</sup> Image of 2002 supervised classification with an overall accuracy of 79 % was achieved with a Kappa coefficient (K hat value) of 0.73. This value implies moderate agreement with good accuracy, and is often multiplied by 100 to give a percentage measure of classification accuracy. According to the above table (4.4.2). Therefore, the Khat value of 0.73 represents a probable 73 % better accuracy.

Table 4.3.3 Accuracy assessment of LULC Map of 2009

Classified pixels	Ground truth								
	LULC Types	A	B	V	S	W	Grand Total	Users accuracy	
	Agricultural Land	52	3	3			5	63	82.5
	Bare land	9	55	1	8		1	74	74.3
	Vegetation	3	2	54	3		4	66	81.8
	Settlement		5	2	49		1	57	86
	Wetland	2	1	59			29	32	90.6
	Grand Total	66	66		60		40	292	
	Producers accuracy	78.8	91.7	90	81.7		72.5		
<b>Overall accuracy</b>								<b>0.82</b>	

Where, AL= Agricultural Land

BL= Bare land

NS = New settlements

V= Vegetation

S= Settlements

W= Wetland

Over all Accuracy =0.8185(82%)

Kappa =0.782 or 78.2 %

<i>Producer Accuracy</i>			<i>User Accuracy</i>		
<b>AL</b>	=0.7878	=78.78%	<b>AL</b>	=0.8257	=82.57%
<b>BL</b>	=0.9167	=91.67%	<b>BL</b>	=0.7432	=74.32%
<b>V</b>	=0.90	=90%	<b>V</b>	=0.6969	=69.69%
<b>S</b>	=0.8168	=81.68%	<b>S</b>	=0.8043	=80.43%
<b>W</b>	=0.725	=72.5%	<b>W</b>	=1.0	=100.0%

The ASTER image of 2009 supervised classification results of user's accuracy in this study showed that in 2009 the maximum class accuracy was 100 %, which was wetland where correctly classified and the minimum was Vegetation class with an accuracy of 69.7 % as presented in table 4.3.3 above. In 2009, the class accuracies range from 69.9 % to 100%.

#### Kappa coefficient 2009 image

$$K = \frac{N \sum X_{ii} - \sum X_{Class} * X_{ref}}{N^2 - \sum X_{Class} * X_{ref}}$$

$$X_{ii} = 239 \quad \underline{292(239) - 17636}$$

$$N = 292 \quad 85264 - 17636$$

$$N^2 = 85264 \quad \underline{52152} = 0.77 = 77\%$$

$$N \sum X_{ii} = 53972 \quad 67628$$

$$X_{class} * x_{ref} = 17636$$

The ASTER image of 2009 supervised classification with an overall accuracy of 82 % was achieved with a Kappa coefficient (Khat value) of 0.782. This value implies strong agreement with good accuracy, and is often multiplied by 100 to give a percentage measure of classification

accuracy. According to the above table (4.3 .3). Therefore, the Khat value of 0.782 represents a probable 78.2 % better accuracy.

*Table 4.3.4 Accuracy assessment of LULC Map of 2016*

Classified pixels	Ground truth							
	LULC Types	A	B	V	S	W	Grand Total	Users accuracy
	Agricultural Land	38	3	7	2	2	52	70
	Bare land	3	35	3	11	1	53	66
	Vegetation	9	2	52	1	6	70	74.3
	Settlement		9	2	51		62	82.3
	Wetland		1	1		21	23	91.3
	Grand Total	50	50	65	65	30	260	
	Producers accuracy	76	70	83.9	82.3	70		
<b>Overall accuracy</b>		<b>0.76</b>						

where AL= Agricultural Land

BL= Bare land

NS = New settlements

V= Vegetation

S= Settlements

W= Wetland

Over all accuracy=0.7692(76.92%)

Kappa=0.71 or71%

Producer Accuracy			User Accuracy		
<b>AL</b>	=0.76	=76%	<b>AL</b>	=0.7007	=70.07%
<b>BL</b>	=0.70	=70%	<b>BL</b>	=0.66.03	=66.03%
<b>V</b>	=0.8387	=83.87%	<b>V</b>	=0.7428	=74.28%
<b>S</b>	=0.8225	=82.25%	<b>S</b>	=0.7846	=78.46%
<b>W</b>	=0.70	=70%	<b>W</b>	=0.913	=91.3%

The Land sat 8 images 2016 supervised classification results of user's accuracy in this study showed that in 2016 the maximum class accuracy was 91.3 %, which was wetland where correctly classified and the minimum was bare land class with an accuracy of 66.03 % as presented in table 4.3.4 above. In 2016 , the class accuracies range from 66.03 % to 91.3 %

#### Kappa coefficient 2016 image

$$K = \frac{N \sum X_{ii} - \sum X_{class} * \sum X_{ref}}{N^2 - \sum X_{class} * \sum X_{ref}}$$

$$\begin{aligned}
 X_{ii} &= 197 & \frac{260(197) - 14520}{67600 - 14520} &= \frac{51220 - 14520}{67600 - 14520} \\
 N &= 260 & & \\
 N^2 &= 67600 & \frac{36700}{67600} &= 0.69 = 69\% \\
 N \sum X_{ii} &= 51220 & & \\
 \sum X_{class} * \sum X_{ref} &= 14520 & &
 \end{aligned}$$

The Land sat 8 images 2016 supervised classification with an overall accuracy of 76 % was achieved with a Kappa coefficient (Khat value) of 0.69 . This value implies moderate agreement with good accuracy, and is often multiplied by 100 to give a percentage measure of classification accuracy. According to the above table (4.3.4). Therefore, the Khat value of 0.69 represents a probable 69 % better accuracy.

Generally the overall accuracy of above (table 4.3.1 to 4.3.4). It is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows an overall result of the tabular error matrix. The overall accuracy performed in the study period 1995 was 76 % (table 4.3.11), in 2002 was 79 % (table 4.3.2), in 2009 was 82 % (table 4.3.3). and during 2016 it was 76 % (table 4.3.4). As mentioned by Anderson *et al.* (1976) for a reliable land cover classification, Kappa is used to measure the agreement or accuracy between the remote sensing derived Classification map and the reference data as indicated by the major diagonals and the chance Agreement, which is indicated by the row and column, totals (Jensen 2003). The Kappa coefficient represents the proportion of agreement obtained after removing the proportion of agreement that could be expected to occur by chance (Food, 1992). This implies that the Kappa value of 0.8454 represents a probable 84.54% better accuracy than if the classification resulted from a random, unsupervised, assignment instead of the employed maximum likelihood classification. A value  $>0.80$  (80%) -- strong agreement, a value between 0.40 and 0.80 (40 to 80%) represents moderate agreement, and a value  $< 0.40$  (40%) represents poor agreement.

#### **4.4 Change detection analysis**

Remotely sensed images are vital in land use and land cover change detection as it provides spatial and temporal information of the land use land cover condition of the Town. In this research project 21 year time span, and four period change detection have been made first period 1995 to 2002, second period 2002 to 2009, third period 2009 to 2016 and the fourth period from 1995 to 2016 (from initial to final years changes) which is Moderately enough in showing long history of land use and land cover. These time periods were chosen based on the availability of satellite image and other data in the town. The LU/LC change detection was assessed using post classification cross-tabulation approach in ARC GIS software. Land use and land cover change detection method used in this study was post classification comparison and multi-date composite image change detection. This method is widely used and easy to understand. The advantage of this method includes the detailed from-to information that can be extracted. Change detection was done for 1995 -2002, 2002 – 2009, 2009 -2016 and the fourth

1995-2016 to get the from-to information of changes in land use land cover and specially to see the rate (trend ) of the settlement, agricultural land and vegetation coverage of study area .

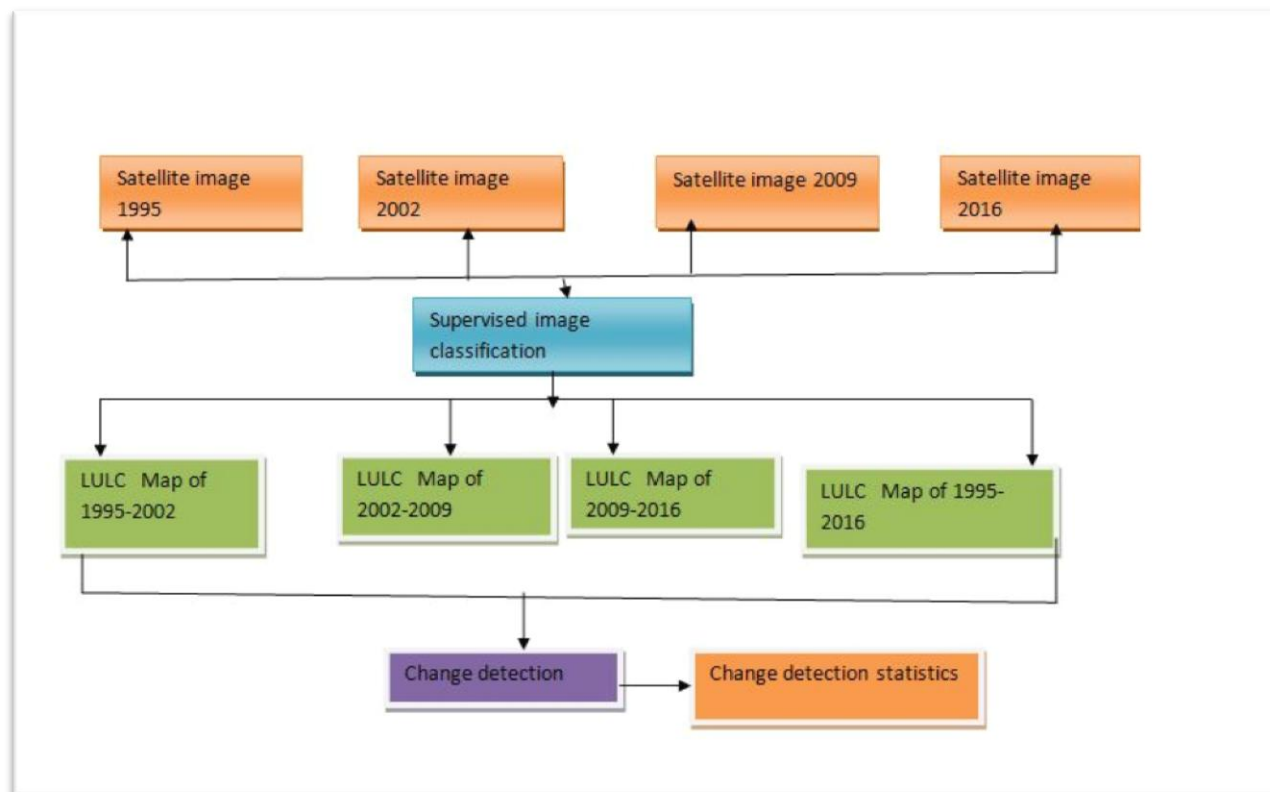
The classified images were compared in four periods i.e. 1995-2002, 2002-2009, 2009-2016 and 1995-2016. Change statistics will be computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The values was presented in terms of hector and percentage. Quantification of the rate of change has been applied to generate information about the land use/land cover change of the study area. The rate of change of each land use and land cover calculated using the following formula.

$$\text{Percent change} = \frac{X-Y}{Y} \times 100$$

Where, X= final area of land use land cover

Y= initial area of land use/land cover

$$\text{Annual rate of change} = \frac{\text{percent change observed}}{\text{Rate of Time intervals}}$$



*Fig. 4.5* General procedure of change detection analysis

Using the rate of change between the four periods, the rate of change per annum can also be computed by dividing it with the year difference between the two periods. The relationship between LULC distribution and changes in each category was extracted in Arc GIS by combining images. The assigned LULC classes during supervised classification on Arc GIS Map were reclassified by representing years 2009 & 2016 with the values as 1 = Bare land , 2 = Settlement , 3 = Vegetation , 4 = Agricultural land and 5 = Wetland and for years 1995&2002 with the values as 1 = Bare land, 2= Vegetation, 3= Settlement , 4 = Agricultural land ,5=Wetland on Arc GIS Map. Cross tabulation is a means to determine quantities of conversions from a particular land cover to another land cover category at a later date ( Alphan, 2008). The change matrices based on post classification comparison were obtained and are shown in table

To show four periods land use land cover change researcher used the following symbols for different classes

AL=Agricultural Land
BL=Bare land
V=Vegetation
S=Settlement
WL=Wetland

#### 4.4 .1 Land Use/Land Cover Changes: Rate and Magnitude of 1995-2002

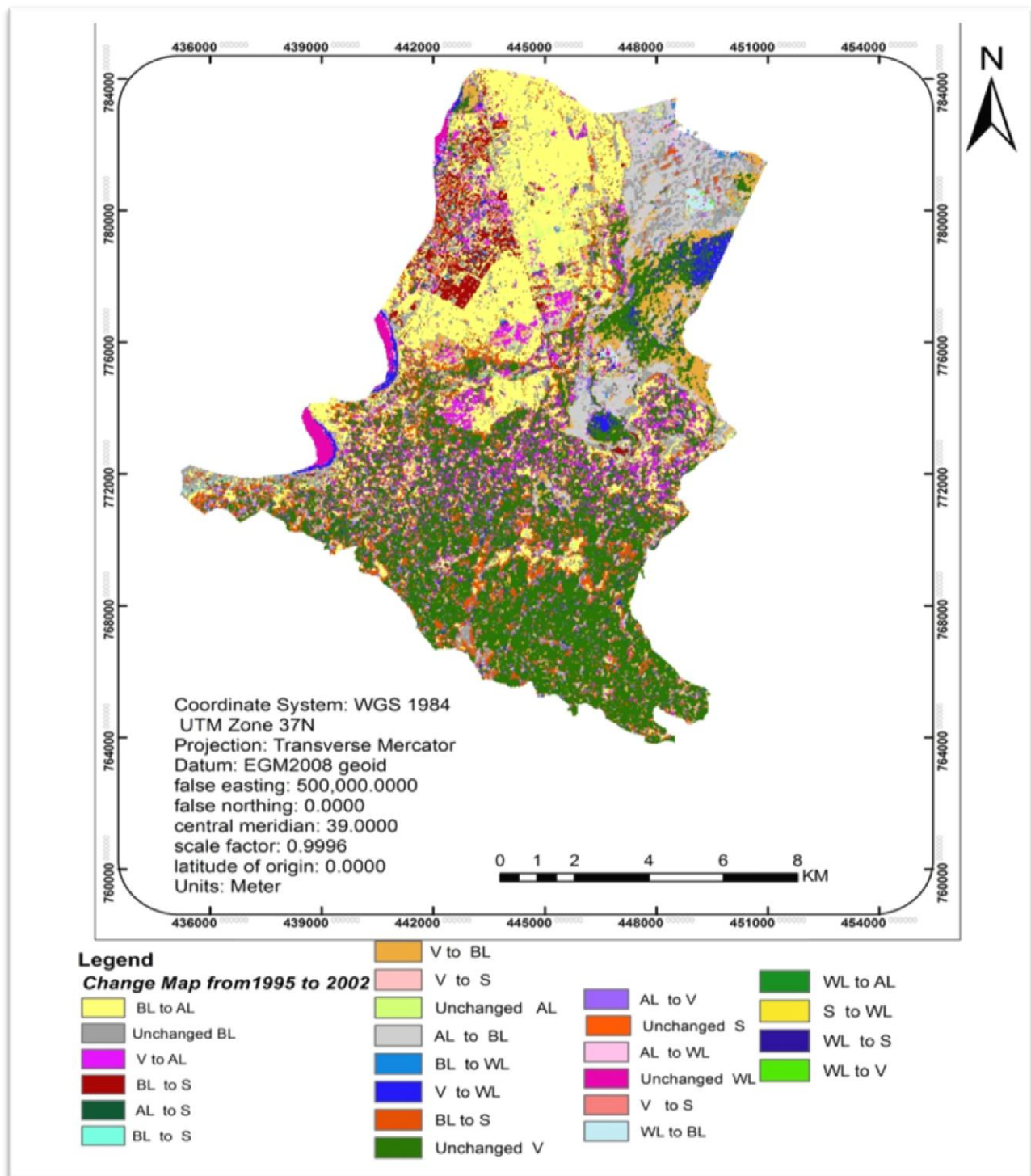


Fig 4.6 LULC change map from (1995\_2002)

Table 4. 4.1 LULC Conversion matrix for the year 1995 - 2002

LULU Types	1995	2002	LULCC 1995_2002 change	
	Area in( ha)	Area in (ha)	Area in (ha)	Area in( %)
Settlements	349	691.6	0.41	41
Bare land	6122.4	4670.5	-0.32	-31.9
Agricultural land	1973.3	6459.5	2.27	227.3
Vegetation	7065.7	3249.5	-1.17	-117.4
Wetland	211.1	600.4	0.73	73

According to above table 4.4.1 though the period of 2002 to 2009 there substantial change in several LULC categories including agricultural land (2.27 ha) ,wetland (0.73 ha) and settlements (0.41 ha) area increased. According to above table tendency towards more land brought under agriculture, wetland and settlement. These data expressly stated that increase in agricultural land and settlement resulted population pressure on land at the period from 1995 to 2002.

Table 4 4.5 Post-classification Matrix of Study Area between 1995 and 2002

year		2002										Total area(ha)	Total area%
1995	classes	AL		BL		S		V		WL			
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%		
	AL	229.95	1.5	3265.3	20.7	0	0	1020.69	6.4	7.92	0.05	4523.85	28.8
	BL	1082.61	6.9	1030.8	6.5	0	0	1030.86	6.5	57.24	0.4	3201.48	20.4
	S	78.06	0.5	47.3	11.1	68.67	0.4	9.02	1.07	0.45	0.003	203.5	2.2
	V	600	3.8	1699.92	10.8	0	0	4544.46	28.9	7.92	0.05	6852.3	43.6
	WL	99.27	0.6	127.08	0.8	22.41	0.14	394.02	2.5	137.61	0.87	780.39	5
Grand Total		2089.89	13.3	6170.4	39.2	91.08	0.57	7159.05	45.5	211.14	1.3	15721.56	100

According to the above Table 4.4.5 conversion matrix for the year 1995 - 2002, the change in the land use/ land cover in the study area was by increase attributed to expansion of vegetation coverage (43.6 %) and agricultural land (28.8%). This class has expanded at the expense of bare land (20.4%), and wetland. There was also significant change of bare land to agricultural land in this period. Generally there is a sharp decrease of wetland and bare land in this period which goes to vegetation, agricultural land and settlement.

#### 4.4.2 Land Use/Land Cover Changes: Rate and Magnitude of 2002-2009

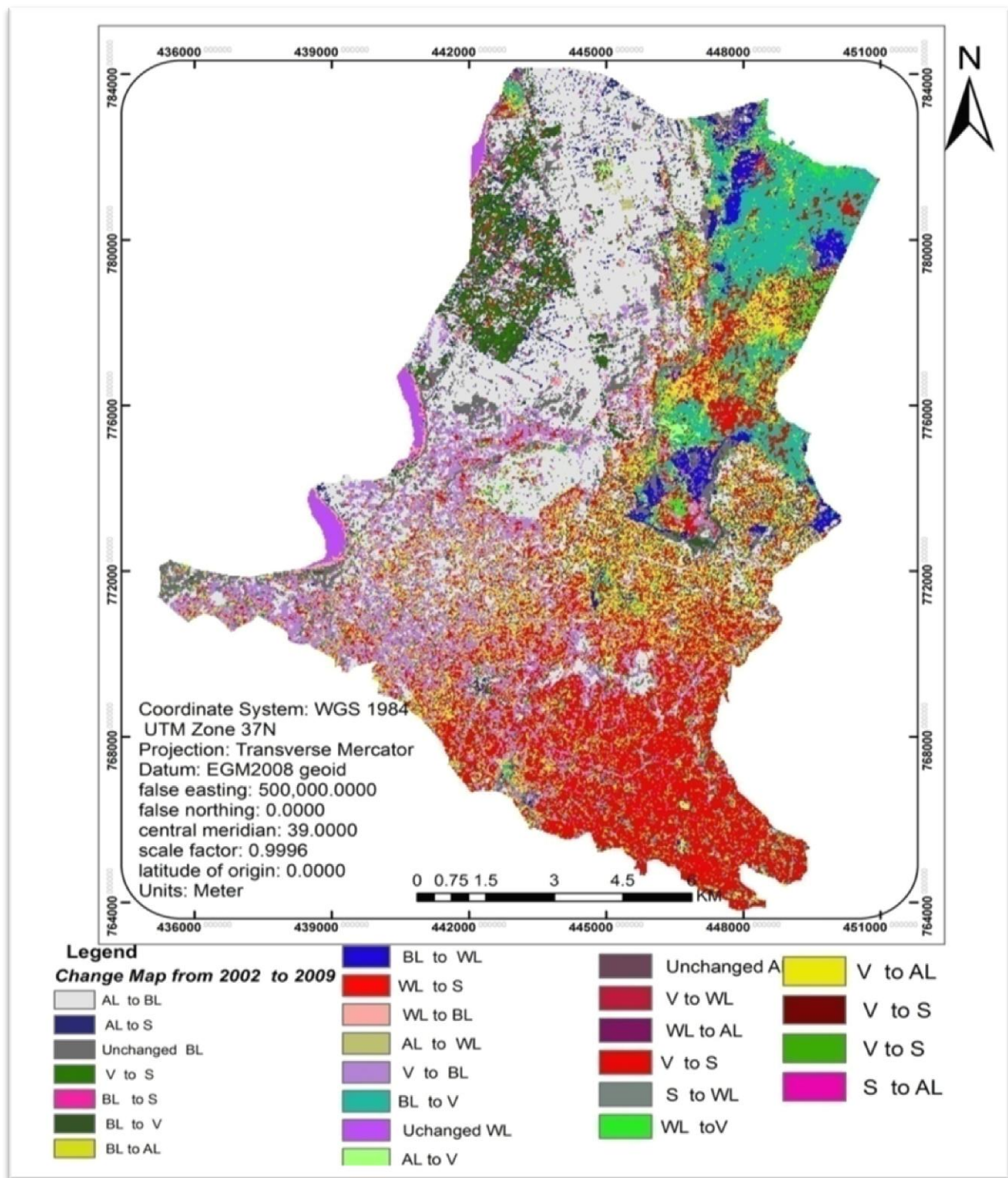


Fig 4.7 LULC change map of (2002-2009)

Table 4. 4.2 Land use/Land cover conversion matrix for the year 2002-2009

LULU Types	2002	2009	LULCC 2002_2009 change	
	Area in (ha)	Area in( ha)	Area in (ha)	Area in (%)
Settlements	591.6	642.2	0.08	8
Bare land	4640.5	7293.1	0.364	36.4
Agricultural land	6459.5	2222.5	-1.90	-190
Vegetation	3249.5	4894.7	0.336	33.6
Wetland	780.4	667.6	-0.169	-16.9

Though the period of 2002-2009 there substantial change in several LULC categories including bare land (0.346 ha) and vegetation (33.4 ha) and settlement (0.08 ha) area increased. According to above table tendency towards more land brought under bare land, vegetation and settlement. These data expressly stated that increase in bare land, Vegetation and settlement resulted population pressure on land and good government policies. And decreases of agricultural land and wetland. Table 4 Post-classification Matrix of Study Area between 2002 and 2009

Table 4.4.3 Post-classification Matrix of Study Area between 1995 and 2002

year		2009											
2002	classes	AL		BL		S		V		WL		Total area(ha)	Total area
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%		
	AL	398.61	2.5	467.82	2.9	9.54	0.06	1208.07	7.7	128.7	0.8	2212.74	14.1
	BL	3592.08	22.8	1029.69	6.5	0	0	2133.81	13.6	214.56	1.4	6970.14	44.3
	S	0.5		43.29	0.3	279.63	1.8	20.0		15.46	0.2	3391.73	21.7
	V	304.47	1.9	1669.68	10.6	256.7	1.6	3033.360	19.3	225.18	1.4	2456.01	15.6
	W L	61.56	0.4	355.86	2.3	2.43	0.01	80.1	0.5	173.43	1.1	673.38	4.3
	Grand Total	4636.35	29.5	3566.34	22.7	268.7	1.7	6455.34	41	777.33	4.9	15704.01	100

According to the above Table 4.4.6 conversion matrix for the year 2002 to 2009, the change in the land use/ land cover in the study area was by increase attributed to expansion of bare land (44.3%) and settlements (21.7%) and vegetation (15.6%). This class has expanded at the expense of agricultural land (14.1%), and wetland (4.3%). Generally there is a sharp decrease of agricultural land and wetland in this period which goes to, bare land, settlement and vegetation.

#### 4.4.3 Land Use/Land Cover Changes: Rate and Magnitude of 2009-2016

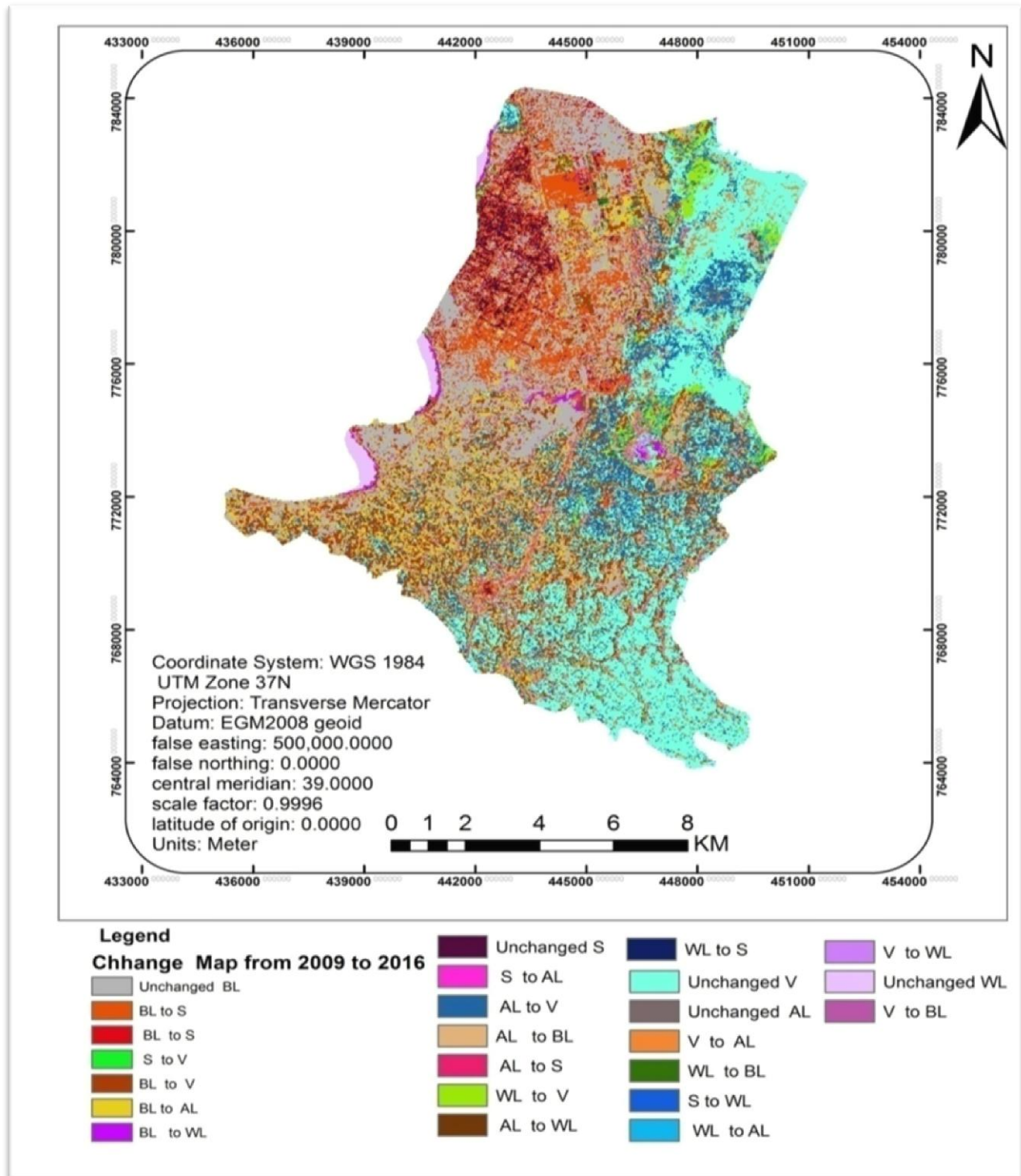


Fig4.8 LULC change map of (2009-2016)

*Table 4. 4.4 Land use/Land cover conversion matrix for the year 2009-2016*

<b>LULU Types</b>	<b>2009</b>	<b>2016</b>	<b>LULCC 2009_2016 change</b>	
	Area in ha	Area in ha	Area in ha	Area in %
<b>Settlements</b>	642.2	1954.9	0.671	67.1
<b>Bare land</b>	7293.1	3638.1	-1.00	-100
<b>Agricultural land</b>	2222.5	2257.7	0.0156	1.56
<b>Vegetation</b>	4894.7	7519.2	0.349	34.9
<b>Wetland</b>	667.6	351.7	-0.89	-89.8

Though the period 2009-2016 there substantial change in several LULC categories including settlements (0.671ha) and vegetation (0.349 ha) and agricultural land (0.0156 ha) area increased. According to above table tendency towards more land brought under settlements, vegetation and agricultural land. These data expressly stated that increase in settlements, Vegetation and agricultural land resulted population pressure on land and good government policies. And decreased of bare land and wetland.

Table 4.4.7 Post-classification Matrix of Study Area between 2009 and 2016

year		20016										Total area(ha )	Tota l area	
2009	classes	AL		BL		S		V		WL				
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%			
		AL	413.91	2.6	1140.21	7.2	15.84	0.1	683.01	4.3	122.76	0.78	2375.73	15.1
		BL	237.96	1.5	2762.28	17.5	0	0	325.71	2.07	76.95	0.5	3402.9	21.6
		S	69.57	0.4	1620.27	10.3	353.97	2.3	0	0	23.58	0.5	2067.39	13.4
		V	1470.51	9.3	1880.64	11.9	25.02	0.16	3827.88	24.3	295.11	1.9	7499.16	47.7
		WL	21.96	0.1	126.9	0.8	7.56	0.04	50.67	0.3	144.45	0.9	351.54	2.2
	Grand Total	2213.91	14.08	7530.3	47.9	402.39	2.5	4887.27	31.08	662.85	2213.91	15721.56	100	

According to the above Table 4.4.7 conversion matrix for the year 2009-2016, the change in the land use/ land cover in the study area was by increase attributed to expansion of vegetation coverage (47.7%) and settlements (13.4%) and agricultural land (15.1%). This class has expanded at the expense of bare land and wetland. Generally there is a sharp decrease of bare land and wetland in this period which goes to, vegetation, settlement and agricultural land

4.3.4 Land Use/Land Cover Changes: Rate and Magnitude of 1995-2016

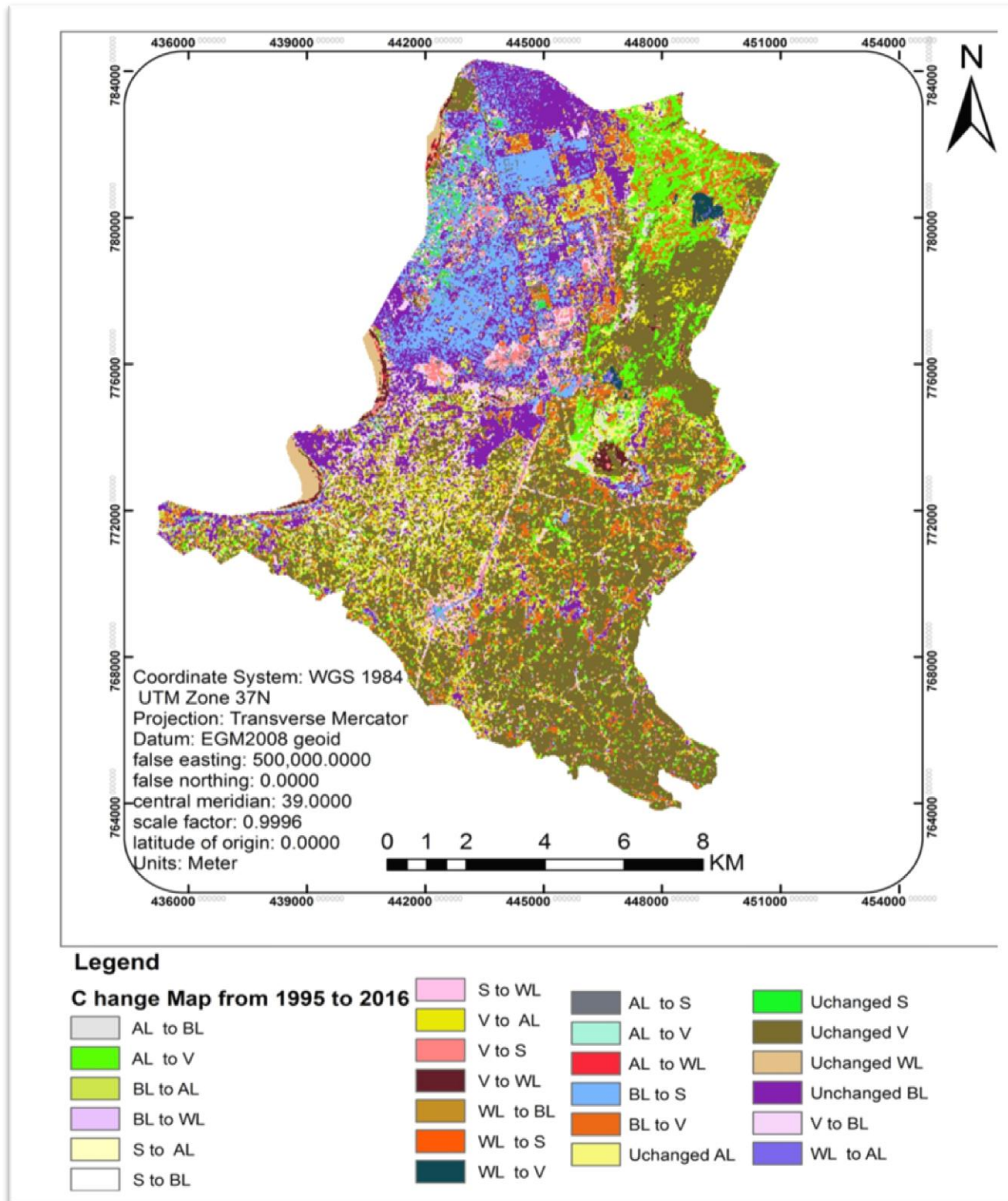


Fig 4.9 Land use/Land cover conversion matrix for the year 2009-2016

Table 4. 4.3 Land use/Land cover conversion matrix for the year 2009-2016

LULU Types	1995	2016	LULCC 1995_2016 change	
	Area in ha	Area in ha	Area in ha	Area in %
<b>Settlements</b>	349	1954.9	0.821	82.1
<b>Bare land</b>	6122.4	3638.1	-0.683	-68.3
<b>Agricultural land</b>	1973.3	2257.7	0.126	12.6
<b>Vegetation</b>	7065.7	7519.2	0.06	6
<b>Wetland</b>	211.1	351.7	0.399	39.9

Though the period of 1995 to 2016 there is dramatic expansion of several LULC categories including settlements (0.821 ha) or (82.1 %), vegetation (0.06 ha) or (6 %), agricultural land (0.126 ha.) or (12.6%) and wetland (0.399 ha) or (39.9%) area increased and bare land decreased to (-0.683ha) or -68.3% .According to above table tendency towards more land brought under settlement and Vegetation. These data expressly stated that increase in settlement resulted pop

Table 4 .4.8 Post-classification Matrix of Study Area between 1995and 2016

year		2016											
1995	classes	AL		BL		S		V		WL		Total area(ha)	Total area
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%		
	AL	444.33	2.8	888.48	5.6	47.43	0.3	866.16	5.5	11.25	0.07	2257.65	14.4
	BL	286.65	1.8	2450.7	15.5	101.16	0.6	797.94	5.07	1.62	0.01	3638.07	23.1
	S	1217.07	7.7	1350.18	8.5	4996.44	31.8	380.43	2.4	7.38	0.04	7951.5	50.6
	V	86.67	0.5	1381.14	8.8		0	0	0	54.81	0.04	1522.62	9.7
	WL	25.2	0.16	51.93	0.3	6.48	0.04	132.03	0.8	136.08	0.04	351.72	2.2
Grand Total		2059.92	13.1	6122.43	38.9	5151.51	32.7	2176.56	13.8	211.14	0.04	15721.56	100

#### 4.5 Gain and loses of land use/ land cover change (1995- 2016)

Generally there is a continuous land use/land cover change taking place for most parts of the Hawassa Town in the last 21 years. The land cover change from 1995 to 2016 has been discussed in four periods. Each period has seven years of gap i.e. the first period from 1995 to 2002, second period 2002 to 2009, third period from 2009 to 2016 and last period has 21 years gap from 1995-2016 . The cover dynamics. Discuss the rate of land cover change from 1995 to 2002, 2002 to 2009, 2009 to 2016 and aggregate land cover change from 1995to 2016 .Table 4.4.8 clearly shows the land cover change rate for the past 21 years.

Table 4.5.1 Rate of change in land use/ land covers classes

Land use/ Land cover Classes	PERIOD							
	1995	2002	2009	2016	Annual rate of change (%)(1995 -2002)	Annual rate of change (%)(2002- 2009)	Annual rate of Change (%)(2009- 2016)	Aggregated Rate of change (%) (1995- 2016)
	ha	ha	ha	h				
Settlement	349.0	691.6	742.2	1954.9	+14	+1.03	+26.78	460.1
Bare Land	6122.4	4670.5	7193.1	3638.1	-3.45	+7.7	-74.6	-40.6
Agricultura l Land	1973.3	6459.7	2222.5	2257.7	+32.5	-9.4	+0.71	+14.4
Vegetation	7065.7	3249.5	4894.7	7519.2	-7.7	+7.2	+53.5	+6.4
Wet land	211.1	600.4	667.6	351.7	+26..5	-2.2	-6.44	+66

Vegetation shows the highest annual rate of change for 1995 to 2002, by -7.6 % per annum decrease and the same scenario for bare land by -3.4% per annum while agricultural land , Settlement and Wetland shows +32.5% , +14% and +26.3 % per annum increment for the same time period. Possibly due to destruction of vegetation and bare land for Fuel wood, Expansion of agricultural land, Timber production, Construction purpose and urban expansion

The second time period between 2002 to 2009 the rate of change shows significant decrease both in increment and decrease, that is, the maximum decrease is in Agricultural land class with -9.4% per annum and maximum increment is Vegetation +7.2 % per annum for class of bare land followed by Settlement with +7.7 % and +1.04% per annum respectively. Agricultural land possibly decreased due to Expansions of settlement (Agricultural land changed in settlement), Secured Industrial areas ,Farmers transform (sells ) their lands for urban settler, Land grabbing.

The third time period is between 2009 to 2016 the rate of change also a shows significant decrease and increase both in increment and decrease, that is, the maximum decrease is in Bare land class with -74.6 % per annum and maximum increment is Vegetation +53.5 % per annum for class followed by Settlement with +26.78 % and bare land +0.4% per annum . possibly Bare land decreases due to areas left for Industrial park construction , Institutional constructions, Residence constructed and Settlement increased and vegetation increased due to government policy encourage vegetation .

When we see the general scenario with reference to the aggregate rate of change indicates that only bare land has decreased in (-40.6%), while the rest classes namely Settlement in +460.1%, wetland +66.6%, Agricultural land 14.4% and Vegetation coverage also increased by 6.4 %. Possibly Expansion settlement result: seasonal climate modification, decrease the amount of rainfall , increase temperature and decrease agricultural product and public awareness for the use vegetation by planting urban forestry for Soil and Water conservation, shading and Ventlet their compounds

#### **4.6 Summary of land use land cover change from 1995 to 2016**

Table 4.6.1 Summary of land use land cover change in percentage from 1995to 2016

Years	Settlement	Bare Land	Agricultural Land	Vegetation	Wet land	Total
1995	2.2	38.9	12.6	44.9	1.3	100%
2002	3.8	29.5	41.1	20.7	5.0	100%
2009	4.1	46.4	14.1	31.1	4.2	100%
2016	12.4	23.1	14.4	47.8	2.2	100%

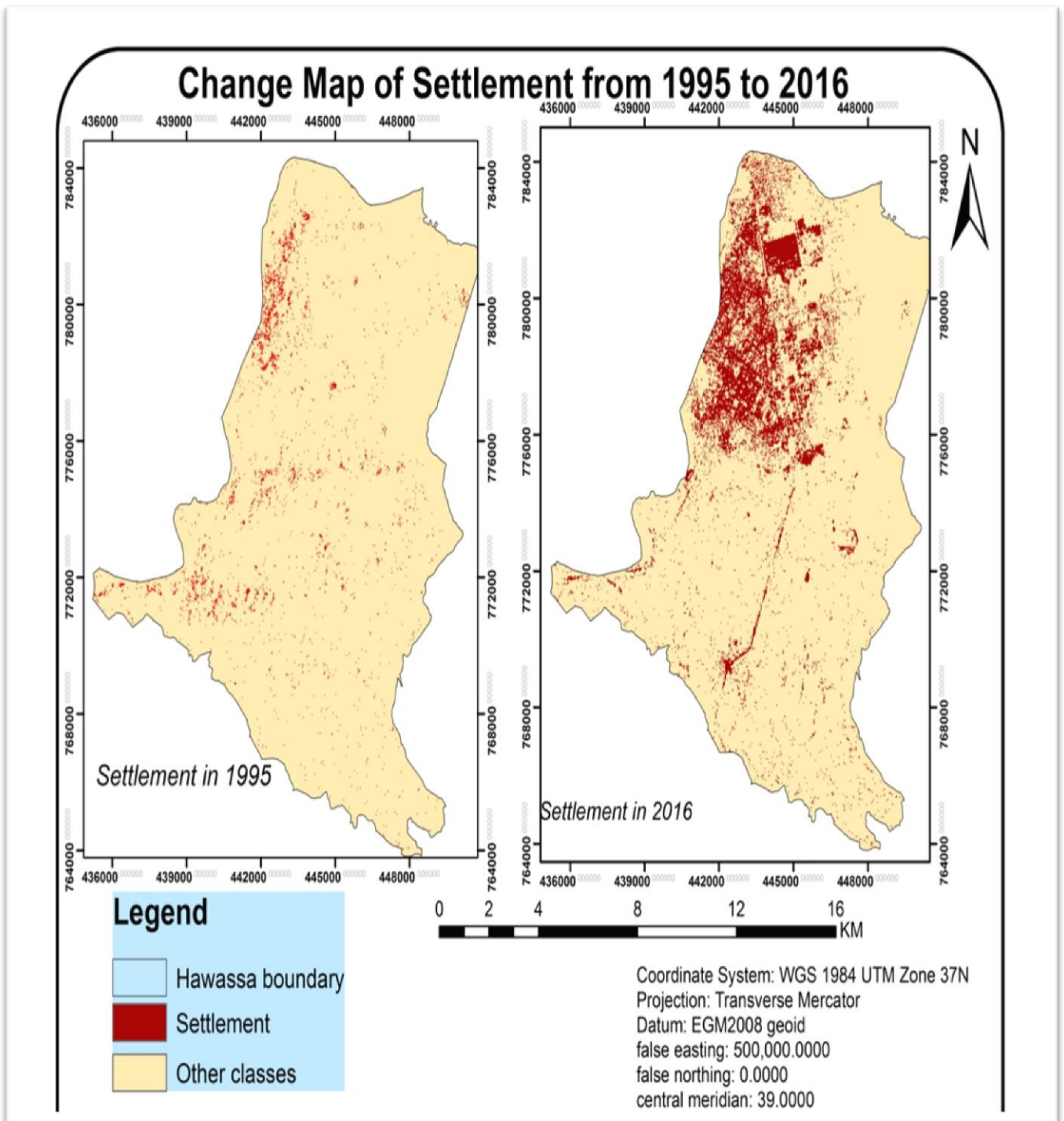


Fig 4.10 Settlement changes of Hawassa town from 1995 to 2016

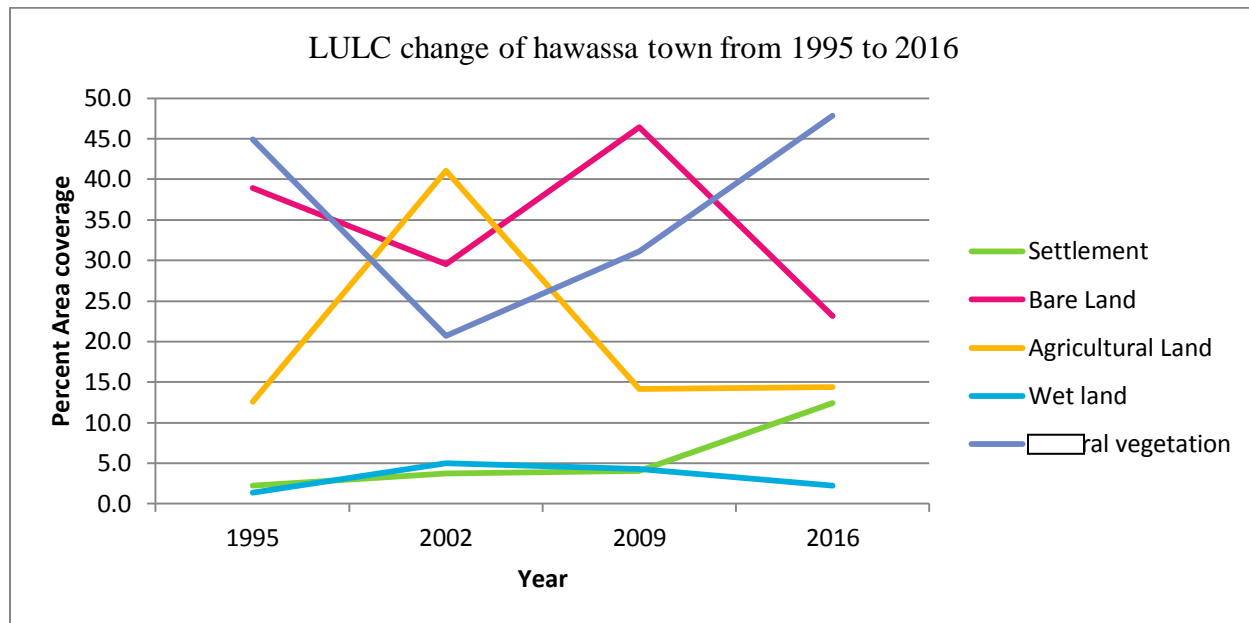


Fig 4. 11 LULC Changes of Hawassa town from 1995 to 2016

Though the period of 1995 from 2016 there is dramatic change in several LULC categories including settlements (1605.9 ha.) or (10.2%), vegetation (453.5 ha) or (2.9%) , agricultural land(284.4 ha.) or (1.8%) and wetland (140.6 ha) or (0.9) area increased and bare land decreased(-15.8%) . According to above table tendency towards more land brought under settlement and Vegetation. These data expressly stated that increase in settlement and vegetation coverage of the town resulted population pressure on land and there is policies encourage afforestation the town . These growing demand of space for human settlement and commercial purpose is diminishing the amount and size of Arable (agricultural) land. Expansion of construction of industrial park, commercial constructions, Hawassa university expansion, and Hawassa international stadium are good increment of Settlements.

## **CHAPTER FIVE**

### **5. CONCLUSION AND RECOMMENDATION**

#### **5.1 CONCLUSIONS**

Based on the overall of the project works, it is possible to conclude the following points. Remotely sensed images are vital in land use/land cover change detection as it provides spatial and temporal information of the land use land cover condition of the Hawassa town.

Land use and land cover change detection method used in this project was post classification Comparison which is very important in knowing the from- to change LULC changes have wide range of consequences at spatial and temporal scales. Because of these effects and influences it has become one of the major problems for environmental change as well as natural resource management. Identifying the complex interaction between changes and its drivers over space and time is important to predict future developments, set decision making mechanisms and construct alternative scenarios

Land use/land cover is very dynamic in nature and has to be monitored at regular intervals for sustainable development thus it has become a central component in current strategies for managing natural resources.

The results of this project revealed the existence of significant land use and land cover changes in the last 21 years. Especially the expansion of settlements and vegetation coverage at the expense of bare land.

Land use and land cover change of Hawassa town resulted that considerable change has occurred within twenty one (21) years from 1995 to 2016. Though the period of 1995 from 2016 there dramatic change in several LULC categories including settlements (1605.9 ha.) or (10.2%), Vegetation 453.5 ha or (2.9%), agricultural land 284.4 ha. or (1.8%) and wetland (140.6 ha) or (0.9) area increased and bare land decreased(-15.8%) . Accordingly more land brought under Settlement and Vegetation. The project output stated that increase in settlement and vegetation coverage of the town resulted population pressure on land and there is good government policies for encourage reforestation programme the town.

The second ranked change is to be transition from bare land area to vegetation .This increased in due to increased awareness of public and good governmental policies to reforestation programmed of the country though an effort has be made success in the increasing of vegetation cover of the town.

Aggregate the rate of change of Hawassa town from initial year to final (1995 to 2016 ) that is , only bare land has decreased in (-40.6%), while the rest classes namely Settlement in +460.1%, wetland +66.6%, Agricultural land 14.4% and Vegetation coverage also increased by 6.4 %.

Expansion Settlement and public awareness for the Plant vegetation.

Generally, geographic information system and remote sensing analysis enables for sustainable managements of LULC change planning, wise decision making, monitoring of urban expansion and development.

## **5.2 Recommendations**

Land use land cover change ( LULC ) mapping and detection of changes shown here may not provide the real figure of classes due to low resolution of the imagery but it serves as a base to understand the patterns and magnitude of LULCCs in the area. Therefore such LU/LC detections using high resolution satellite images would be more dependable.

Rapid settlement increase has played a major role affecting LULC change and there should be strategic planning to monitor abrupt urban expansions of the town from concerned governmental and none governmental bodies (offices).

Population increase has played a major role on LULC change and there should be strong family planning awareness creation campaigns with adequate health services from Concerned governmental and none governmental bodies (offices). To minimize the problems of landless youths, it will be imperative to create and strengthen off-farm income generating activities due to limited capacity of land to accommodate additional population.

Promoting the development of none agricultural economy to the town peoples and conserving the forest by strong follow up and by creating reserved area for forest only.

Since most important factor of the land use / land cover change in the study area was an increase in population, continuing the efforts of introducing family planning to make the people aware of consequences of population pressure on land resources should be carried out intensively. Geographical information system and remote sensing technology for change detection analysis is very important for the development of one country. It is very important to deliver frequently. This job demands professional experts who are accountable to this specific career. However, important it is human power dedicated to this wing of development is very limited in skill and in number if it is based on Hawassa Town GIS data management. Therefore, it requires a due regard to handle appropriately.

Ethiopian Government has given due attention for forest development and conservation considering its significance to the national economy , food security and sustainable development. Hence it is advisable conserving and develop forest resource properly t.

## REFERENCES

- A, M. ( 1999). *Enviromental Land Use Change Detection and Assessment Using with Multi temporal satellite IMAGERY*. Zanjan University.
- ABEBE, Z. (2011). *A Urban sprawl mapping and land use change analysis using remote sensing and geographic information system (Case study of Debre Birhan town)*. .
- Abera, L. (2007). *Assessing the Impacts of Land Use and Land Cover Change on Ground Water Recharge Using Remote Sensing and Geographic Information System. Case of Awassa Catchment, Southern Ethiopia*. .
- Anderson, e. (1976). *A Land Use and Land Cover Classification System for Use with Remote sensor Data Geological survey Professional Paper*. Washington D.C: U.S Government.
- Anderson, J. (1971). Land use classification schemes used in selected recent geographic applications of remote sensing: *Photogramm.* 37, 379\_387.
- Anderson, J. R. (1972). A land-use classification system for use with remote-sensor data. 671.
- Chavez, P. S. (1996). *Image-based atmospheric corrections—revisited and improved. Photogrammetric Engineering and Remote Sensing*.
- Codjoe, S. (2007). Integrating Remote Sensing, GIS, Census, and. A Litreture Update.African Development . *Vol.XXXII* (2), 197-212.
- Congalton, R. G. (1983). *Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques. Photogrammetric Engineering and Remote Sensing*.
- Congalton, R. G. (1983). *Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques. Photogrammetric Engineering and Remote Sensing*, .
- Congation, M. (1998). *A Quantitative Comparison of Change Detection Algorisms for Monitoring Eelrass from Remote Sensed Data Phoigrametic Engineering & Remote Sensing*. .

- Daniel, e. a. (2002). A comparison of Land use and Land cover change detection Methods. *ASPRS-ACSM Annual Conference and Congress* , XXII, 2.
- ESRI. (2006). *Drivers of landuse change , Final report Matching Opporitunities to Motivations project.* . Department of Sustainability and Environment, Australia.
- Ettema D, D. J. (2007). *multi-agent modelling of urban systems. In modelling land-use change.* Netherland.: PUMA.
- Foody, G. M. (12 March 2001). *Status of land cover classification accuracy assessment*accepted . (1. J. 2001, Ed.) UK: Department of Geography, University of Southampton.
- G, A. B. (1998). Radar interferometry for environmental change detection In Remote Sensing Change Detection,. (M. A. R. S. Lunetta and C. D. Elvidge (Chelsea, Ed.) *Environmental Monitoring Methods and Applications* .
- Gazed, B. M. (2004, June 7-9). . *Land Cover Mapping of Khulna City Applying Remote. Geospatial Information Research* .
- Inc, E. (1992). ERDAS Production Service Map State for Georgia DNR in the Monitor. .
- J.F, O. (1983). *Monitoring Urban Land- Use in Developed Countries An aeral phoographic approach.*
- Jensen, J. R. (1996). *Introductory Digital Image Processing, ( Second edition ed.)*.
- Koomen E, S. J. (2007). *Modeling land-use change: progress and.* . New York.
- Lillesand, T. a. (1994). . *Remote sensing and image intepretation : John Wiley and Sons,inc.* Ne York.
- Merer, W. (1995). *Past and Present Land-use and Land cover in the U.S.A. Consequences.* . U.S.A.
- Meyer, W. *Changes in Landuse And Landcover: A Global Perspective.* Cambrige Univesity pres.

Riebsame, W. . (1994). *Modelling Land use and Cover as Part of Global Enviromental Change. Climate change .*

Shoshany, e. a. (1994). Monitoring Temporal Vegetation Cover Change in Mediteranean and Arid Ecosystem using Remote Sensing Teching. *Journal of Arid Environment* , 9-21.

Singh, A. (1989). *Digital Change Detection Techinques Using Remotely Sensed Data. International Journal of Remote Sensing* , 1,.

Survey, U. G. (1999, 10 11). *USGS on the World Wide*. Retrieved 1999, from The Land sat Satellite System Link, Retrieve, from : [http://landsat7.usgs.gov/landsat\\_sat.html](http://landsat7.usgs.gov/landsat_sat.html).

U.SEPA. (1999). *A Summary of Models for Assessing the Effects of. Ohiot.* : U.S , Office of Research and Developmen: Enviromental Protection Agency.

Wilkie, D. a. (1996). *Remote Sensing Imagery for Natural Resources*. New York: Colombia University Press.