Jimma University

College of Social Sciences and Humanities Department of Geography and Environmental Studies

Monitoring of Urban Sprawl through GIS and RS

BY Eman Nuru

A Thesis Submitted to School of Graduate Studies of Jimma University, In Partial Fulfillment of the Requirement for Degree of Masters of Science in Geographic Information System and Remote Sensing

October, 2018

Jimma, Ethiopia

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This is to certify the Thesis Prepared By Eman Nuru entitled as “Monitoring of Urban Sprawl through GIS and RS: a Case Study of Jimma city South West Ethiopia Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geographic Information System and Remote Sensing Compiles with the Regulations of the University and Meets the Accepted Standards with its Originality and Quality.

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Acronyms

CSA	Central statistical agency
DEM	Digital Elevation Model
ERDAS	Earth Resource Data Analysis System
ETM	Enhanced Thematic Mapper
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Global Positioning System
JCFEB	Jimma City finance and economy bureau
LULC	Land Use Land Cover
MOA	Ministry of Agriculture
OLI	Observational land Imager
OUPI	Oromiya Urban Planning Institute
RS	Remote Sensing
UN	United Nation
USGS	United States Geological Survey
TIRS	Thermal Infra-red sensor
TM	Thematic Mapper

Abstract

Rapid urban expansion is becoming the Characteristics of cities in developing countries. Hence, it is normal to assess and monitor urban growth changes using remote sensing and other spatial tools to quantify urban sprawl that provide paramount information for city administration. Urban growth pattern of Jimma for the last two decades (1997 to 2017) was studied. Satellite images and geospatial tools were employed to quantify and analyze the spatiotemporal urban land use changes during the study periods, the acquired satellite images were classified and land-use Land cover maps were produced using maximum likelihood of supervised classification method. Post classification change detection analysis and selected spatial metric indices (shannon Entropy) calculation were made to detect, and monitor urban growth and quantify urban sprawl in the study area. Change detection analysis results indicated that, the built-up area constituted 25.16% for 1997, 43.97 % for 2007, and 48.02% for the year 2017. The analysis of urban sprawl shows the city is expanding evenly to the east, west, and north direction. High sprawl is observed to the south directions, therefore, the city planners need to plan ahead and implement plans properly to cope up with the rapid and unprecedented growth of the city in the years to come.

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Urban areas represent built environments that are physically distinguishable from the natural environment, and potentially identifiable through the use of remotely sensed sources such as satellite images and aerial photography. Nowadays, most of the world population lives in cities and metropolises. However, it is often the case that settlements grow irregularly under the pressure of masses coming to cities and these do not develop according to well-defined plans. This unplanned and uncontrolled spread out of built up area often considered as Urban sprawl (Verzosa and Gonzalez, 2010). This Urban sprawl has become a global or universal problem, and is being faced both developed and developing countries.

Africa is urbanizing fast. Its rate of urbanization soared from 15 % in 1940 to 40 % in 2010, and is projected to reach 60 percent in 2050 (UN Habitat, 2007). Africa's urban growth is in line with trends observed in most emerging and developed countries. However, a level of urbanization is still below 20% in poorest countries of the region including Ethiopia, Malawi, Burkina Faso, and Uganda. But, in the rapidly industrializing economy of South Africa, approximately 60% of the population now lives in urban areas (UN Habitat, 007).

Ethiopia is one of the most populous countries in Sub Saharan Africa and urban population growth is estimated at 6%, a much higher figure compared to other Sub Saharan African countries (CSA, 2007). The country is one of the least urbanized of the third world and its economy almost entirely depends on agriculture. Like most developing countries, Ethiopia experiences high rural to urban migration in search of better employment and different opportunity. Formal and informal settlements are stretching out horizontally from the central capital in all directions. Land is ineffectively used, and new developments are planned on virgin land usually leapfrogging from cores such development is considered as Urban sprawls (Haregewoin, 2005).

Nechyba et al., (2004) states the lists of problems linked to sprawl such as the loss of open space, urban decade, unsightly strip mall developments, the loss of a sense of community, patchwork housing developments in the midst of agricultural land, increasing reliance on the automobile, the separation of residential and work locations, and the spreading of urbanized developments across the landscape are some of the problem caused by urban sprawl. And

factors for those problem either population increase, socio-economic factors, technological development or development policies. According to Haregewoin, (2005) sprawl in Ethiopia is a result of population pressure both from natural births and migration

According to Abebaw (2015) Ethiopian cities have significantly expanded due to different development activities and migration of people from rural sites and various changes have been occurred in the city, but there are no regularly updated maps to indicate those changes. The same thing is true to Jimma city it is significantly expanded due to different development activities and migration of people from rural sites. Various changes have occurred in the city but there is no regularly updated map to indicate those changes. So Urban sprawl monitoring and modeling are the basic information they need for long term planning. For balanced development, municipal authorities need tools to monitor how the land is currently used, assess future demand, and take steps to assure adequacy of future supply. For a better planning of future urban development and infrastructure planning, municipal authorities need to know urban sprawl phenomenon and in what way it is likely to move in the years to come.

In general, it is interesting to study and observe the urban sprawl of Jimma city in recent years. Therefore, Jimma city is chosen for this study to generate urban spatial data using Remote Sensing and Geographical Information System technologies to help present and future generations. Thus, this research paper have an intention to identify the sprawling of the city in 1997, 2007 and 2017 using Geographic Information System and Remote Sensing technologies and generate urban sprawl map of Jimma city.

1.2 Statement of the Problem

Many developing countries including Ethiopia has been encountered a problem of urban sprawl. This urban sprawl has brought environmental, social and economic problem (Zewdu, 2011). Urban sprawl is unplanned urban expansion ; decreased aesthetic appeal of landscape, loss of farmland, reduced diversity of species, increased runoff of storm water and ecosystem fragmentation (Burchell et al.,1998). Accurate information on the extent of urban growth is important and a great interest for the municipalities of growing urban and suburban areas for diverse purposes such as urban planning, water and land resource management, marketing analysis, service allocation, etc. Urban authorities and municipal corporations are required to devote more time, attention and effort to manage the use of land in order to accommodating the expanding population. Urban sprawl monitoring the basic information they need for long term planning. For balanced development, municipal authorities need to know urban sprawl

phenomenon how the land is currently used, assess future demand, and take steps to assure adequacy of future supply. In general for a better planning of future urban development and infrastructure planning, municipal authorities have to know urban sprawl phenomenon and in what way it is likely to move in the years to come.

Jimma is one of Ethiopia cities in which condition of sprawling has been occurring for the past few years. No study has been made on monitoring of urban sprawl on Jimma city and the city has no updated maps to indicate those urban growth changes with an acceptable resolution that can at least give a picture about the physical changes and growth rate of the urban area of the city. Various studies have been done on urban sprawl and its socio economic impacts on different urban area. But, all studies focus on analyzing the socio economic impact. But this study comes up with monitoring of urban sprawl for the past 20 years and to show the spatial extent of the city. Therefore, this research seeks to monitor the situation of sprawl through remote sensing and GIS technique with focus on Jimma city.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study is monitoring of urban sprawl of Jimma city in the past 2 decades between 1997 and 2017 using satellite imageries.

1.3.2 Specific Objectives

Based on the general objective, this study has the following specific objectives.

1. To monitor urban sprawl of Jimma city for the years 1997 to 2017.

2. To identify the pattern and direction of urban sprawl.

3. To generate urban sprawl map of Jimma city.

1.4 Research Question

1. What are the patterns of urban sprawl of Jimma city?

2. What is the capability of GIS and RS in monitoring urban sprawl?

3. What type of sprawl characterize Jimma city

1.5 Significance of the Study

This study has significance for various stakeholders. For city administration, regional and/or urban planners by providing information which supports decision making process. Also the study helps to identify, monitor pattern of urban sprawl which is useful for natural resource planning and utilization, and provision of infrastructure facility based on produced result of the study. Finally, it serves as an input or base for further studies.

1.6 Scope of Study

The scope of the study is spatially limited to Jimma city, conceptually limited on monitoring of urban sprawl through remote sensing and GIS. Temporally, limited between the years 1997 and 2017 using Landsat satellite imageries to show the level and pattern of the sprawl in Jimma city administration.

1.7. Limitation of the study

The big challenge in doing this thesis came from availability of suitable spatial resolution satellite images: The spatial resolution of the Landsat images might have an impact in the generation of the land cover maps. However the researchers hand over the challenge by using various methods, techniques and tools.

1.8 Organization of the Thesis

This research paper have five chapter the first chapter is the introductory part which includes the background, statement of the problem, objectives, research questions, significance of the study, scope of the study, and organization of the Paper, and the second chapter is literature review which helps to have an insight about the problem by looking over hypothetical and conceptual frameworks of other scholars' writings. and the third chapter is research methodology; it is the heart of the research that shows the methods and materials used, the research design adapted , the data source and subsections like locational description, about population are included, and the forth chapter is data analysis and presentation and finally the fifth chapter draws conclusion and related recommendation.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Conceptualization and Definitions

This section tries to conceptualize or define some concepts about Urban sprawl, Urbanization, monitoring, Land cover, land use, GIS and RS.

2.1.1. Urban Sprawl

Different researchers define sprawl differently based on their perspective which made the term complex and ambiguous.

Sprawl is a pattern and pace of land development in which the rate of land consumed for urban purposes exceeds the rate of population growth which results in an inefficient use of land and its associated resources (Meles and Vanum, 2012).

Also Urban sprawl is characterized by the dispersion of urban occupation, which rapidly reaches rural areas and is qualified mainly by the low population density of the areas, which extend beyond the consolidated city center (Burchell, 2003).

According to Zhang, (2001) as cited in Almeida "urban sprawl results from poorly planned, large scale new residential, commercial and industrial developments in areas previously not used for urban purposes. In other hand Sprawl refers to some type of development with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats. In addition Urban sprawl is often considered as unplanned and uncontrolled spread out of built up areas (Verzosa and Gonzalez, 2010).

Urban sprawl is not to be considered as increase of urban lands in a given area rather it is an extent of urbanization mainly caused by population growth and large scale migration which is mainly unplanned and unchecked (Sudhira et al.,2004). It can also describe as scattered development outer of compact urban and village centers along highways and in rural countryside (Nanda, 2005). Also defined it as a cause of an externality, such as high dependence on the automobile, isolation of the poor in the inner city, the spatial mismatch between jobs and housing, or loss of environmental qualities. He also point out it as the consequence or effect of some independent variable such as fragmented local government

and poor planning (Glaster, 2001). The various definitions of sprawl indicate that Sprawl is conditions and patterns of development characteristic of an urban area or part of that urban area over a period of time (Galster et al., 2001). The given definitions suggest that there can be different levels and types of sprawl and that sprawl can be viewed as a process because of the inclusion of time (Galster et al., 2001). It is worth mentioning that opinions on sprawl held by researchers, policy makers, activists, and the public differ sharply; and the lack of agreement over how to define the sprawl certainly complicates the efforts to characterize and restrict this type of land development (Bhatta, 2010).

To Sum up, even if there is no accurate definition of urban sprawl; different writer define differently. A general consensus is that urban sprawl is uncontrolled, scattered suburban development that increases traffic problems, depletes local resources, and destroys open space (Peiser, 2001). The direct implication of sprawl is change in land-use and land-cover of the region and brings the increase in built-up and paved area (Sudhira et al., 2004).

2.1.2. Urbanization

The definition of urbanization and urban areas vary from place to place and country to country (Mason, 1989; Frey and Zimmer, 1998; Sudhira, 2008; Rui, 2013; Wray et al., 2013; UN, 2014). The word 'urban' has its root in a Latin word 'Urbanus' meaning city dwellers (Sudhira, 2008), and urbanization can be defined as the increasing proportion or percentage of peoples living in urban areas. It is precisely defined as "the increasing share of a nation's population living in urban areas (and thus a declining share living in rural areas)" (Satterthwaite et al., 2010 p. 2011). Urbanization is a process leading to the formation of towns, cities and agglomeration of people and their socio-economic activities in areas classified as urban based on different criteria. While the highest urban population is found in developed world, rapid urbanization and expansion have been the characteristics of cities and towns in developing world in the past 20 years taking a considerable area of their surroundings (UN-Habitat, 2016). In contrary to this, a vast majority of the population in the third world remain residing in rural areas. By now Asia and Africa are the least urbanized, sharing 48 and 40 per cent of their population urbanized, respectively. Angel et.al. (2011) indicate that under the current rate of growth world urban population will double in 43 years but urban expansion will double in 19 years. As the pace of urbanization becomes rapid, it gives little time for government and municipalities to plan and fulfill infrastructures and services needed by increasing number of people.

Monitoring:-The monitoring of urban development is mainly to find out the type, the amount and location of land conversion for future planning (Shekhar, 2015).

2.1.3. Land Cover and Land Use

Land cover and land use are the two interrelated ways of observing earth's surface (Duhamel, 2011). The former represents the biophysical state of the earth's surface and immediate subsurface, while the later indicates the manner human population manipulate the biophysical attributes of the land and the purpose for which land is used (Meyer, 1995; Turner et al., 1995; Lambin., 2003; Pellikka, 2008; Duhamel, 2011)

2.1.4 Application of GIS and Remote Sensing in Urban Sprawl

Geographic Information System Geographic Information System is a computerized system that facilitates the phases of data entry, data analysis and data presentation especially in cases when we are dealing with geo referenced data. It is a system which provides a computerized mechanism for integrating various geo information data sets and analyzing them in order to generate information relevant to planning needs in a context. GIS is also a computer based tool for mapping and analyzing things that exist and events that happen on earth. Application of GIS is very wide it ranges from public to private sectors. However the application is limited by the imagination of the users (Patra, 2008). For the application of GIS, data is very important without data GIS not produce anything. Data for GIS were obtained from different sources like aerial photographs, satellite imageries, digital data, conventional maps, field data (surveys/GPS) etc. These data obtained from various sources were classified into two types; spatial data which describes location and attribute data which specifies the characteristics about the spatial data. Spatial data tells us, "Where the object is" Attribute data tells us "What the object is" or "How much the object is" In other words, it tells the characteristics at that location.

Remote Sensing Remote Sensing means obtaining information about an object, area or phenomenon without coming in direct contact with and /or acquiring information about earth's land and water surfaces by using reflected or emitted electromagnetic energy (Yeh and Xia, 2001).

There are two ways for interpretation of remotely sensed data. . Visual interpretation in which data is interpreted without computer (visually) and digital Interpretation: it facilitates quantitative analysis of digital data with the help of computers to extract information about

the earth surface. Digital interpretation is popularly known as ‘Image Processing’. Image processing deals with image correction, image enhancement and information extraction.

The application of remote sensing is unlimited and used in different area it is the best cost effective mechanism of data acquisition for a wide range of applications ever since the launch of landsat-1 in 1972 (Lo and Yeung, 2005). In remote sensing each sensor is designed for a specific purpose (Melesse et al., 2007). Urban growth and the physical expansion of cities can be detected, mapped and analyzed using remotely sensed data obtained from mostly Landsat multispectral scanner (MSS) thematic mapper (TM) and enhanced thematic mapper plus (ETM+), (Ward et al., 2000). Urban areas are complex geographic dimensions with a mixed combination of buildings, roads, gardens, soils, water etc. Such surface cover types, exhibit a unique radiative and thermal moisture properties hence unique spectral signature (Melesse et al., 2007) and the advancement in satellite has helped its application in urban land-use/cover change detection using high spatial resolution sensors.

The advantage that GIS and RS offer to sprawl research is the capability to visually assess and quantify defined sprawl patterns. Therefore remote sensing and GIS offer the best way to manage urbanization (Yang, 2005)

2.2. Trend of urban sprawl in developed and developing counties

2.2.1 Urban Sprawl in Developed Countries

Urban Sprawl is a major problem in the course of the urban development of the Western countries in the 20th century, most of the urban sprawl is considered to be the expansion of low-density accompanied by a series of environmental and socio-economic issues. Across states and cities of Europe and North America there is a growing awareness of, and concern about urban sprawl, which has different background from the cities of China. The cities of China have been developing rapidly after reform and opening-up since 1980, urban sprawl has emerged in some regions. Land development has been out of control and the construction land has kept expanding blindly, especially in the marginal areas of some metropolises. Some experts pointed out: the phenomenon of urban sprawl in the past decades is extremely severe, and the tendency of scattered development and sprawling growth has been formed, which seriously impede the modernization process in China if it could not be controlled. In China, some human geography and sociology scholars regarded urban sprawl as a by-product of suburbanization; some physical geography scholars described the process of urban expansion using remote sensing and tried to forecast the trend of urban expansion, but no good

explanation of urban sprawl raised up; some planning scholars characterized qualitatively urban expansion and pointed out the problems of urban sprawl during the process of urban expansion, and they gave some planning measures to solve these problems ,but the inner mechanism of urban sprawl was still no clear expression. There are just few studies on how to measure urban sprawl. In short, the research on urban sprawl in China is still in a preliminary stage, the basic characteristics of urban sprawl in China have no explicit expression, and the reveal of its internal mechanisms has been maintained in the level of empiricism. How to measure urban sprawl has been a hot spot of research. Some research organizations have put forward their indicators for measuring urban sprawl. Besides, many scholars focus on using indicators to measure urban sprawl by establishing multi-dimensional indicators by GIS analysis or descriptive statistical analysis (Tsai, 2005). Remote sensing and GIS can be separately or in combination for application in studies of urban sprawl. There are some researches on how to use remote sensing and GIS to monitor and measure urban sprawl (Jingnan Huang et al., 2007), But according to (Feng, 2009) in his research, an attempt has been made to find a good way to monitor and measure urban sprawl. And used the multi-temporal Landsat TM images to carry out the image classification. The built-up areas of four different years were extracted from the classified images so that the dynamic changes and the characteristics of urban sprawl could be recognized, and then the built up area was regarded as one of indicators. Together with other different indicators, he constructed the indicator system to measure urban sprawl. The calculation of indicators was carried out based on GIS, the final results of analysis were visualized as maps. On the basis of the calculation results of comprehensive indicators, and identified the different level of sprawl in Jiangning.

2.2.2 Urban Sprawl in Developing Countries

Urban sprawl is fast engulfing many developing countries where real estate developers are pushing a “world class lifestyle”. In many developing countries, urban sprawl comprises two main, contrasting types of development in the same city: one is characterized by large peri-urban areas with informal and illegal patterns of land use. This is combined with a lack of infrastructure, public facilities and basic services, and often is accompanied by little or no public transport and by inadequate access roads. The other is a form of “suburban sprawl” in which residential zones for high- and middle-income groups and highly-valued commercial and retail complexes are well-connected by individual rather than public transport. Urban sprawl adds to the urban divide, pushing social segregation along economic lines that result in spatial difference in wealth and quality of life across various parts of cities and metropolitan areas run down inner cities and more suburbs. Suburbanization in developing

countries happens mainly because people – rich and poor – flee poor governance, lack of planning and poor access to amenities. “In a nutshell: sprawl is a symptom of a divided city,” the report says. Urban sprawl involving the poor occurs because authorities pay little attention to slums, land, services and transport. Authorities lack the ability to predict urban growth and, as a result, fail to provide land for the urbanizing poor. In addition, the urban poor are denied a land right which is one of the main factors driving people to the periphery of city, associated with urban sprawl in developing countries. Other features typically associated with sprawl include overdependence on personal motorized transport coupled with a lack of alternatives, limited housing options and urban spaces that discourage pedestrian traffic. Most South African cities are an example of this. They are expanding primarily through development of new housing areas which, being located beyond the existing urban periphery, are relatively unplanned. As a result, the urban periphery consists of pockets of housing developments that are isolated and separated from each other by trunk roads or open spaces (UNHabitat, 2011).

2.2.2.1. Urban sprawl in Ethiopia

According to (Haregewayin, 2005) like most developing countries, in Ethiopia serious rural to urban migration is a common , Tribal wars and conflicts are common phenomena driving people from their villages. Slums are emerging in different parts of cities, additional population increase in bigger cities is accommodated by crowding of existing houses rather than new construction developments, and existing houses are often extended or divided illegally so that they would be rented for migrants. The need for housing is not integrated with the need to prevent horizontal expansion and hence saving land. Formal and informal settlements are stretching out horizontally from the central capital in all directions. Land is ineffectively used, new developments are planned on virgin land usually leapfrogging from cores. Generally, sprawl and land misuse in Ethiopia is a result of population pressure (both from natural births and migration), poor land policies, lease system and planning and regional imbalance.

So there is a need to open land for cities to expand Engel, (2014). Even though this approach is a contrary to the idea of compacted city development. Since this growth management or containment paradigm is inappropriate in rapidly urbanizing countries like Ethiopia, cities should expand in planned manner to overcome the lather fare development or sprawl (Engel, 2014) To do so we need some basic idea:-

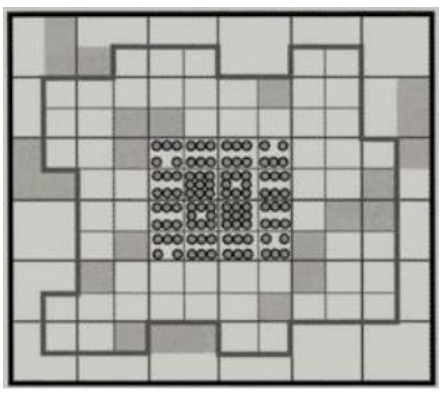
- ✓ to estimate the amount of land required for development :- how much land the cities need to accommodate the urban growth
- ✓ create generous city boundary and expansion
- ✓ setting aside land for arterial grid, the arterial grids cold be at 1 km interval
- ✓ securing a hierarchy of open spaces :- that is insuring the public space or protecting open space

2.3 Pattern of Urban Sprawl

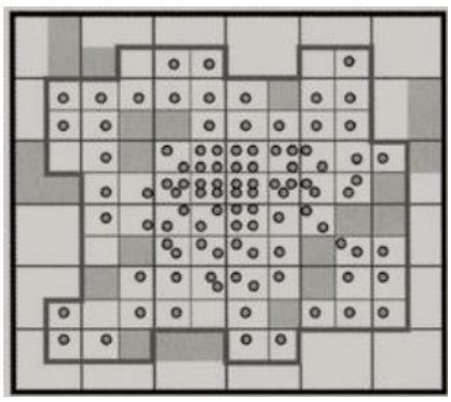
Urban sprawl is also described in various ways taking the processes, forms and patterns of urban development's into consideration. The most illustrative explanation was given by Galster et al. (2001) based on development patterns which is cited by various experts since then (Besussi et al., 2010; Yu, 2013; Reis et.al, 2015). The authors characterized urban sprawl based on forms, density and land-use patterns. According to Galster et al. (2001) forms refer to the physical growth or expansion of urban areas and represented by five types of patterns (Fig 2.1) compact development, scattered development, linear strip development, polynucleotide development, and leapfrog development. Compact development is physical growth around existing developments without interruption, mostly the preferred form of urban development (Batty, 2004; Tsai, 2005; Besussi et al., 2010). Scattered development is a dispersed form of urban growth whereas leapfrog is a form of urban sprawl that appears as discontinues development leaving open spaces in between (Caicedo, 2015). On the other hand, linear strip development is expansion of cities following the development of main roads, on the lines of accessibility (Batty, 2004; Yu, 2013), this is the most common form of urban sprawl in Ethiopia. The last form of development pattern is polynucleotide which is a type of growth around many smaller centers with a considerable distance in between them.

Figure:-2.1 Pattern of Urban Sprawl

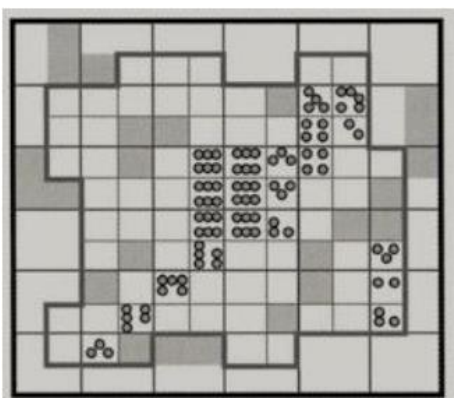
Compact Development



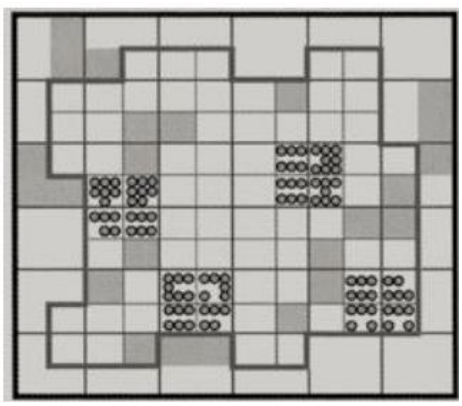
Scattered Development



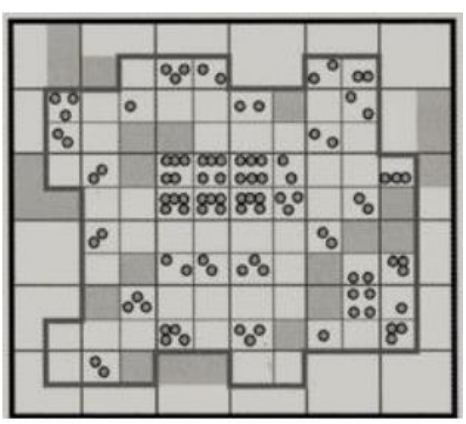
Linear Strip Development



Polynucleated Development



Leapfrogging Development



2.4 Impact of Urban Sprawl

2.4.1 Land-use and Land Consumption

There is a major controversy whether land-use and consumption decisions are the primary engines of urban sprawl or whether it is continuing population boom that provides most of the expansion (Haregewayin, 2005). Some argue that sprawl is first and foremost a land-use phenomenon since even an area of static population can experience sprawl as its built environment is modified in a scarce, low-density, auto-friendly way pushing city limits further and further out (Haregewoin, 2005). A careful analysis of U.S. Census Bureau data found that these two sprawl factors share equally the fault for some, if not all, of the sprawl in some regions of the country. Cities grow, with or without planning, and develop landscape characteristics ill function. Fulfilling the resource requirements of a growing population ultimately requires some form of land-use change in order to provide for food, living space, recreation, infrastructure development and service provision. Historical constraints on city size limitation were cost of transport to export goods/ import agricultural products, the degree of economy of scale relative to market demand and the cost of carrying on day-to-day activities within the city itself (commuting to work, delivery of water, disposal of waste and sewage). These were all relaxed with time. Some possible forces driving land-use and land-cover changes are population, technology (mainly automobile), political economy and political structure. Land consumption - the amount of land used per person - is the inverse of population density, the higher the population the lower the amount of land used per person urban land use generally expands at the expense of agriculture as demand for housing grows. These brings about differences between land consumption in the center and fringe of the urbanized area and create changes in land consumption rates through time (Haregewayin, 2005).

2.5 Urban Land Use Land Cover Change Detection

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Essentially, it involves the ability to quantify temporal effects using multi-temporal data sets (Singh, 1989). Various researchers (Belaid 2003; Jensen et al. 2005; Berkavoa 2007) have attempted to group change detection methods into different broad categories based on the data transformation procedures and the analysis of techniques applied. However, numerous techniques are applied on images of different dates in order to detect the changes occurred through the years. Hence, the techniques are

generally divided into two categories: pre-classification and post-classification change detection methods. Pre-classification techniques are applied on rectified and normalized corrected images of single band, or could be on many bands of the image (e.g., image algebra, transformations, etc.) and detect the possible position of change without providing any information for the type of land cover change (Yuan, et al., 1998). The pre-classification and change detection methods can be performed in various software platforms. Whereas, post-classification techniques, are based on the comparison of classified images and provide detailed information about the nature of change for every pixel or object (Im et al., 2005). According to Abuelgasim et al., (1999), the pre-classification are known as categorical while post-classification are continuous of changes detection.

2.6 Measures of Urban Sprawl

Understanding the rate of urban growth and urban spatial pattern, from remote sensing data, is a common approach in current urban studies. Maps of urban growth from a classified images derived primary from remotely sensed data can assist planners to visualize the pattern of change in urban areas. Currently, there are a number of applications of analytical methods and models available for urban studies. Utilization of geospatial tools: remote sensing (RS), geographic information system (GIS), ISRISI, and other related software programs for monitoring, measuring, analyzing and modeling is common.

Quantifying the urban growth from remote sensing data is not a difficult task; however, as it is noted by (Bhatta, 2010) quantification of sprawl, as a pattern or process, is a real challenging issue. (Wilson et al., 2003) has also said that without a universal definition, quantifying and modeling of urban sprawl is extremely difficult. Even so, many authors have attempts to measure sprawl for e.g. (Leta et al. 2001; Yeh and Li 2001; Sun et al. 2007). There are various ways to quantify urban sprawl. Urban sprawl is monitored and measured by taking different factors into consideration. Most of researchers use urban density decline in terms of households, housing units, population and employment, accessibility to streets, distance from central business districts (CBD), fragmentation of built up areas and land-use mix to measure urban sprawl (Ewing et al., 2002; Angel et.al., 2011; Ewing and Hamidi, 2014). The most sited method in measuring urban sprawl was provided by Galster et al. (2001) that indicate about 8 dimensions of the development patterns of land-use which are taken as the best indicators to measure urban sprawl. The authors presented land-use dimensions with graphical descriptions based on the concentrations or cluster of housing

units or workers per square mile. Mostly the lower concentration or cluster of developed units under these eight dimensions is considered as a measure and an indication for urban sprawl. All the dimensions are being used by various scholars. (Handy, 2003; Tsai, 2005; Yongqing, 2010; Angel et al., 2011; Li, 2012). Galster et al., (2001) developed them and described all the dimensions as follows:

1, Density: is and indicator to show the number of residential or non-residential units per square mile of developable land.

2, Continuity: indicates the degree to which development has taken place in unbroken fashion in urban areas**.**

3, Concentration: shows how development is located disproportionately in few square miles of the total urban area rather than even distribution.

4, Clustering: is the degree to which development has tightly bunched to minimize the amount of land occupied by residential and non-residential units.

5, Centrality: an indicator used to show how developments are close or far to the central business district (CBD) of the urban area.

6, Nuclearity: the extent to which urban area is characterized by polynuclear development patterns.

7, Proximity: is the degree to which different land-uses are close to each other in the urban landscape.

8, Mixed Use: shows the degree how two different land-use types exist within the same area. It measures whether an urban area is characterized by mixed use or single use.

Also Hasse and Lathrop (2003) considered five indicators as follows:

Density of new urbanization, loss of prime farmland, loss of natural wetlands, loss of core forest habitat and an increase of impervious surface.

Others also use Shannon Entropy index to measure urban sprawl at zonal level as a measure of dividedness and spatial dispersion (Cabral et al., 2013).

2.7 Shannon Entropy

One of the most commonly used approaches, in most urban sprawl studies, is to integrate Shannon's Entropy with GIS tools. This is relatively efficient approach to analyze urban sprawl.

The entropy value varies from 0 to 1. If the distribution of the built up is maximally concentrated in one region the value of entropy is 0. The value is 1; if the built up is unevenly dispersed distribution across space. The dispersion of built-up areas from a city center or road network leads to an increase in the entropy value. This gives a clear idea to recognize whether the urban expansion is more dispersed or compact. The Shannon entropy (En) is computed by:

Equation 2.1: Shannon Entropy $$H_n = \frac{\sum_{1}^{n} p_1 \log(1 / p_1)}{\log n}$$

Where, $p_i = x_i \Big/ \sum_{i}^{n} x_i$ and xi is the density of land development, which equals the amount of built-up land divided by the total amount of land in the i^{th} of n total zones.

Since entropy can be used to measure the distribution of a geographical phenomenon, the difference in entropy between two different periods of time can also be used to indicate the change in the degree of dispersal of land development or urban sprawl (Yeh and Li 2001).

$\Delta En = En\ (t+1) - En\ (t)$

Equation 2.2: Difference of Entropy

Where, ΔEn is the difference of the relative entropy values between two time periods, En (t+1) is the relative entropy value at time period t+1, En (t) is the relative entropy value at time period t.

CHAPTER THREE

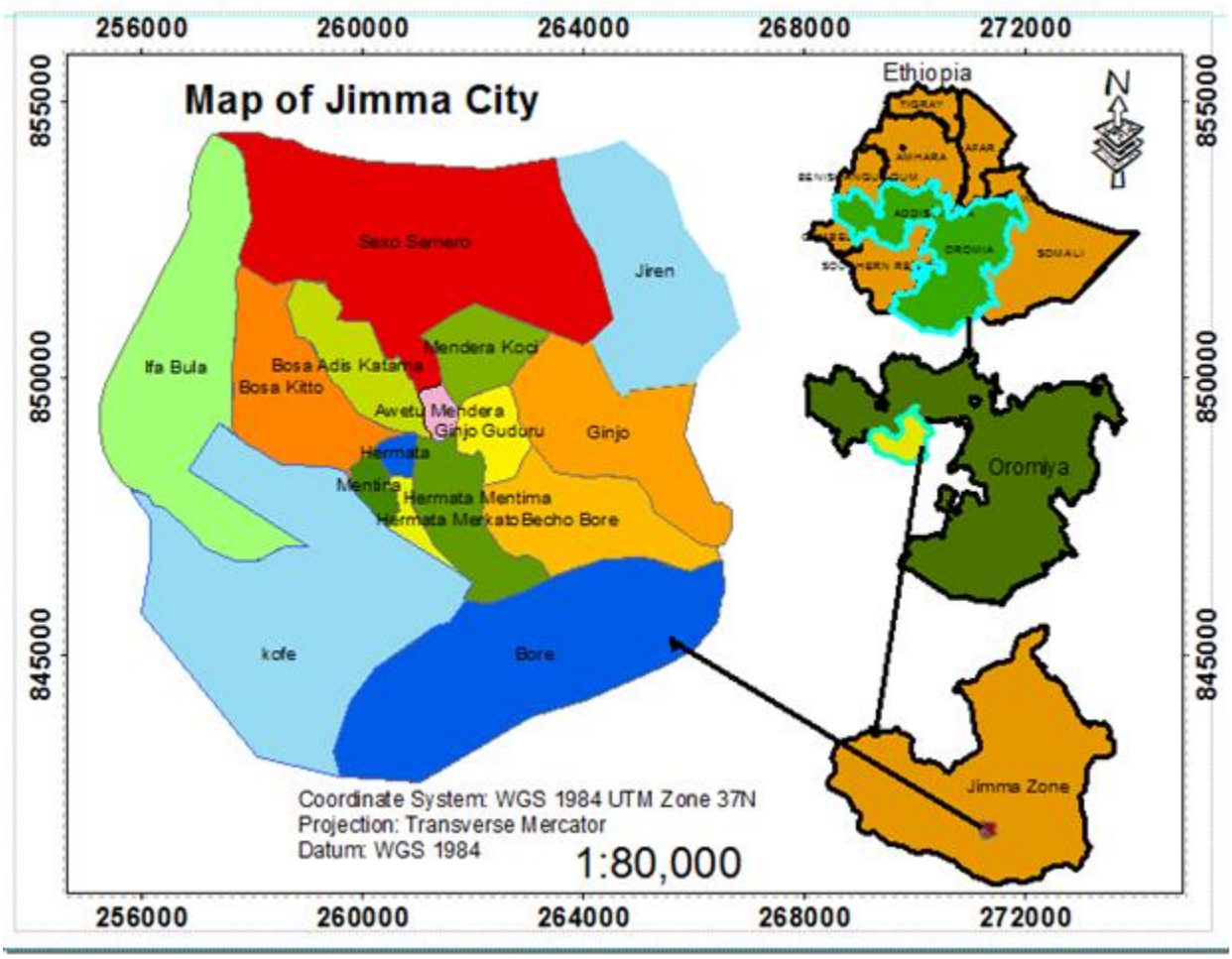
3. Description of the Study Area and Methodology

3.1 Description of the Study Area

3.1.1 Location

Jimma city is the capital of Jimma zone, it is found in oromia national regional state. Geographically situated between 7^{o} 40´N and 36^{o} 50´ E with a total coverage area of 102 km^2 (Figure: 3.1) and located at a distance of about 352 km of the south west of Addis Ababa.

Figure 3.1: Location Map of the Study Area



Source:-Extracted from Ethio GIS

3.1.2 Topography

Jimma town lies on gentle slope with an elevation varying from 1,700masl to 2,020masl. Topography of the town can generally be divided in two main zones:

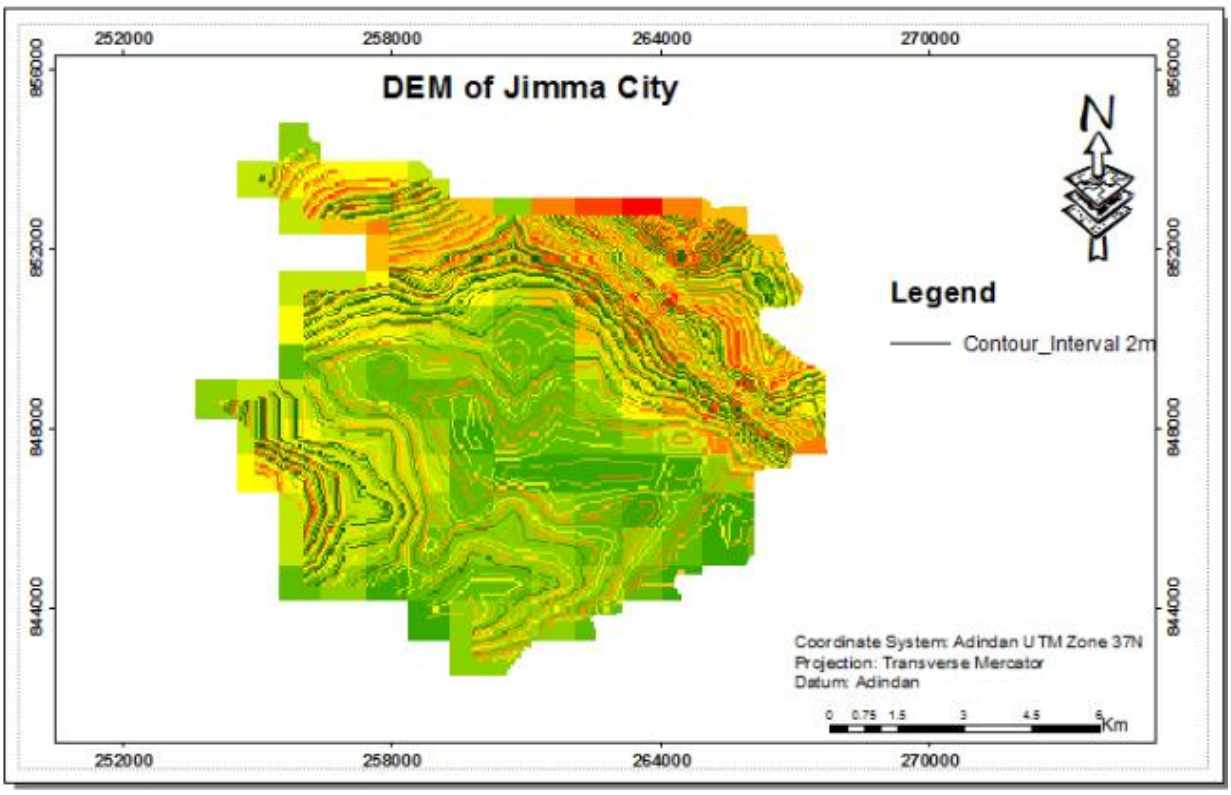
• Escarpment and

• Alluvial plain zones

Escarpment zone: represents topographically elevated areas and surrounds the city in the northwest, north and east.

Alluvial Plain zone: contains fairly broad valleys and represents lower grounds and elongated low-hills. It starts from the foot of the escarpment zone and trends to the south- south east. This zone covers most of the settlement area of the town and diminishes into flat further south of the town, (Oromia Urban Planning Institute, 2008).

Figure 3.2: Topography Map of the Study Area



Source:-Computed from Ethio GIS DEM Data

3.1.3 Demography and Socioeconomic Profile of the Study Area

3.1.3.1 Population

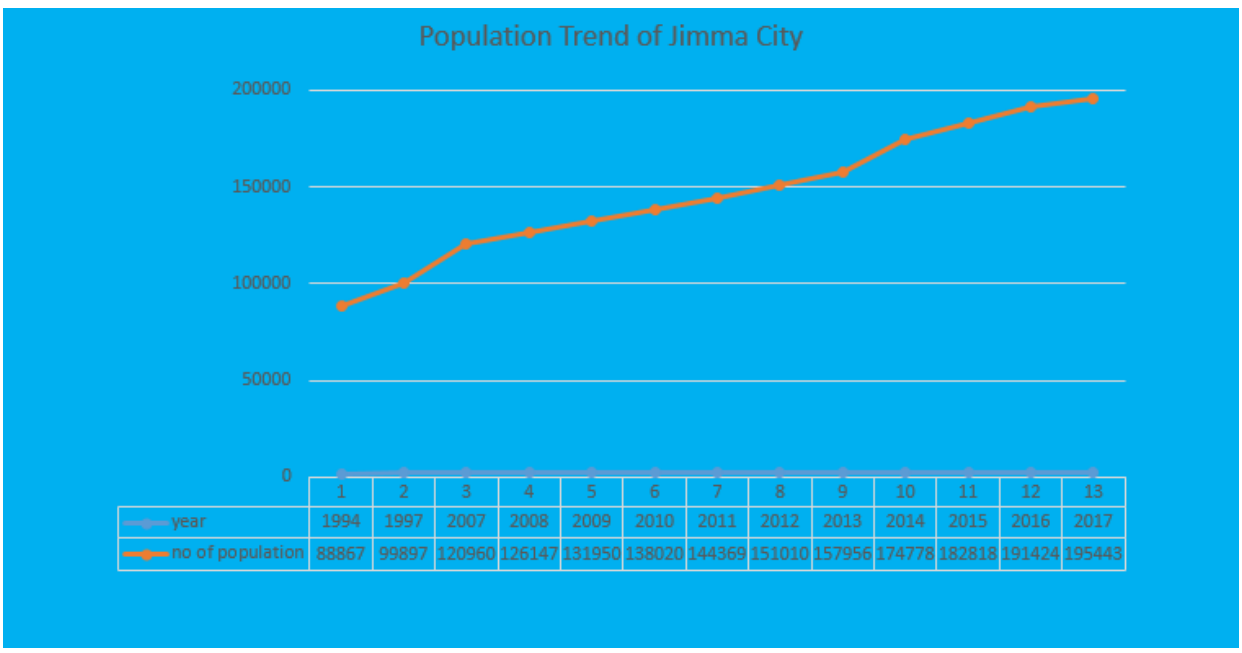
According to the 2007 population and housing census of Ethiopia the total population of Jimma city is 120, 600 (CSA, 2007). Based on this 50.2 percent of population is males and the remaining which is 49.8 percent is females. Currently the total population who reside in the city is approximately 195,443 with annual population growth rate of 4.6 Percent.

Table3.1: Population of Jimma City

No	Year	Total population	Remark
1	1997	99,897	
2	2007	120, 600	
3	2017	195,443	

Source: - CSA, (2007)

Figure 3.3 Population Trend of Jimma city



Source: - Computed From CSA, (2007)

3.1. 3.2 Land Use & Land Cover

Ecologically the Jimma city lies in wet land ecosystem. It is bounded by wet ever green forest ecosystem. Because of the climatic suitability the green coverage of the city is very significant and estimated to be about 26 % including farm lands and vacant areas. Green areas in Jimma give recreational services, Moreover they contribute in reducing air pollution, controlling flood and protection of land and soil from degradation as per the structural plan of Jimma (Oromia Urban Planning Institute, November 2008.). Jimma has green areas in its various parts as well the peri urban areas. In the city, green areas are found along streets, in urban parks, in public and private yards According to the Structural plan recommendations, the most important green areas in the city include private green yards and small public green

areas, semipublic institutions, land between buildings, street trees, green areas along Aweytu River, stream channels, flood plain green areas, private horticulture, trees and wood lands, and peri- urban thick forest, (Oromia Urban Planning Institute, November 2008.)

3.1. 3.3 Economic Activities

The main economic activities in the city are commerce (trading & cater in services) and small scale manufacturing enterprise. The industries in the city are small- scale and cottage industries like grain mills, wood & Metal. Workshops, coffee hullers, hollow block manufacturing, bakeries and pastries. Now a day the city also becomes service delivery center (JCFEB, 1997).

The consumption and exchange of agricultural product as well as goods and services between its surrounding urban centers has contributed significant role to become the city being the center of trade and commerce. Furthermore the city has strong economic and social bond with the big city's which are found in the south western part of the country.

3.1. 3.4 Infrastructures

Physical Infrastructures; Regarding Physical infrastructure the city enjoy with almost all infrastructure such as asphalt and cobblestone road, 24 hours electric power supply, Transportation service both inter and intra transport service are available

Social infrastructure, Regarding these different government and private higher educational institutions (University, university- colleges, and Colleges), referral specialized hospitals, high standard hotels and other facilities are available in the city and make the city to be service center (Development partner, 2008).

3.2 Methodology of the study

3.2.1 Research Design

The study use both quantitative and qualitative research approach. Quantitative approach employed for description of phenomena, and for exploration of how urban sprawl changes over time with in the study area. Under this method a longitudinal study be employed to compare different years' time series imageries within the same parameter. The qualitative approach be used to analyze the data from focus group discussion (FGD) and observation.

3.2.2 Data Sources and Data Types

The data source were both primary and secondary. Data from the primary sources include. A digital camera to get photo of the area, GPS to get ground truth point for ascertain different land use classes. Field observation to prove situation. A discussion with elders and experts working in the municipality about the past and present status of LULC of the city was conducted.

Secondary data those of multi-spectral sensor satellite data for three study periods (1997, 2007 and 2017). obtained from USGS which is free of cost; land sat TM of the year 1997, land sat ETM+ of the year 2007 and Landsat 8 for the year 2017 be used (table:3.3).Geospatial tools be employed to quantify and analyze the spatiotemporal urban land use changes during the study periods was collected from different offices like oromiya urban planning institute (OUPI) to get aerial photo and 20 m digital elevation model (DEM) of the city, from Municipality shape file of the study area and structural plan of the city and demography data from Central Statistics Agency (CSA) and from Jimma finance and economy bureau (JCFEB) is collected. In addition data from published and unpublished sources such as; books, journals, articles, internet sources, research paper and reports were used.

Table 3.2: Satellite Image Description

Landsat Series	Sensor	Spatial Resolution	Number of Bands
Landsat 5	TM	30 m	7
Landsat 7	ETM+	30 m	8
Landsat 8	OLI-TIRS	30 m	11

3. 3. Population and Sample Size

3. 3.1 Sample Size and Sampling Techniques

To address the objective of the study and to get answers for questions related to urban sprawl non-probability sampling techniques is employed. The study has purposively selected 9 experts from Municipality of the city based on their experience and discussion is made.

3.4 Software and Instruments

For this study ArcGIS 10.3, and ERDAS IMAGIN 2010 software for image processing and Garmin 60 GPS instrument to collect the ground truths points for field verification purpose, digital camera to capture photography of the study area is used.

Table 3.3 Software and Their Purposes

No.	Software	Purpose
1	**ArcGIS10.3**	For clipping, georeferencing, preparation of map layout, for extraction of polygon from raster, extraction of slop and elevation maps from DEM data.
2	**ERDAS2010**	For layer stacking, subseting, clipping, performing the classification of the different LULC categories, post classification, Computing area, assessing the accuracy of classification
3	**Garmin 60 GPS**	To collect the ground truth control point
4	**Digital Camera**	Digital camera to capture photography of the study area

3.5 Techniques and Methods of Data Analysis

In this part digital images preprocessing techniques were applied for those data acquired from website (USGS), since it is not complete enough for direct usage. Accordingly, the acquired images were pre-processed before a classification of the images into different urban LULC classes for analysis of urban sprawl of the study area. This image pre-processing technique like layer stacking means combining layer together to make ready for classification. Image enhancement to increase tonal vibration with in an image for better visualization, image restoration; correction and calibration of image in order to achieve faith full representation of the surface and image classification (Supervised classification) techniques were employed to extract the study area data that were recognized by the researcher).

Landsat image of 2007, Landsat of 1997 and 2017 were classified by using supervised method of maximum likelihood algorithm techniques to classify urban LULC of 1997, 2007 and 2017 in order to see the possible LULC changes over time and for identification of pixels that have specific spectral characteristics and to determine the different land use/cover classes

represented by these groups. Five training areas for the supervised classification were taken for the following five LULC class categories. The first one is an area of land with different construction like buildings for different purpose such as commercial, office, residential, industrial, recreational uses built up land. Vegetation is an area of land covered by forest, shrub, grass land and trees. Farm land is a land use for the cultivation of different farms like teff , wheat and etc. Bare land an exposed soil, area of excavation and fallow land. Lastly water area covered stream, river, reservoir, pond and wet and.

After completion of image classification urban LULC classification result was evaluated by employing accuracy assessment technique using the ground truth points collected by GPS instrument aerial photo. In order to overcome errors of commission and omission occurred during data processing error matrix or confusion matrix methods were employed by using ERDAS IMAGINE 2010. After producing urban LULC map for 1997, 2007 and 2017 years, the reclassification process is employed by spatial analyst tool in ArcGIS 10.3 for the purpose of change detection.

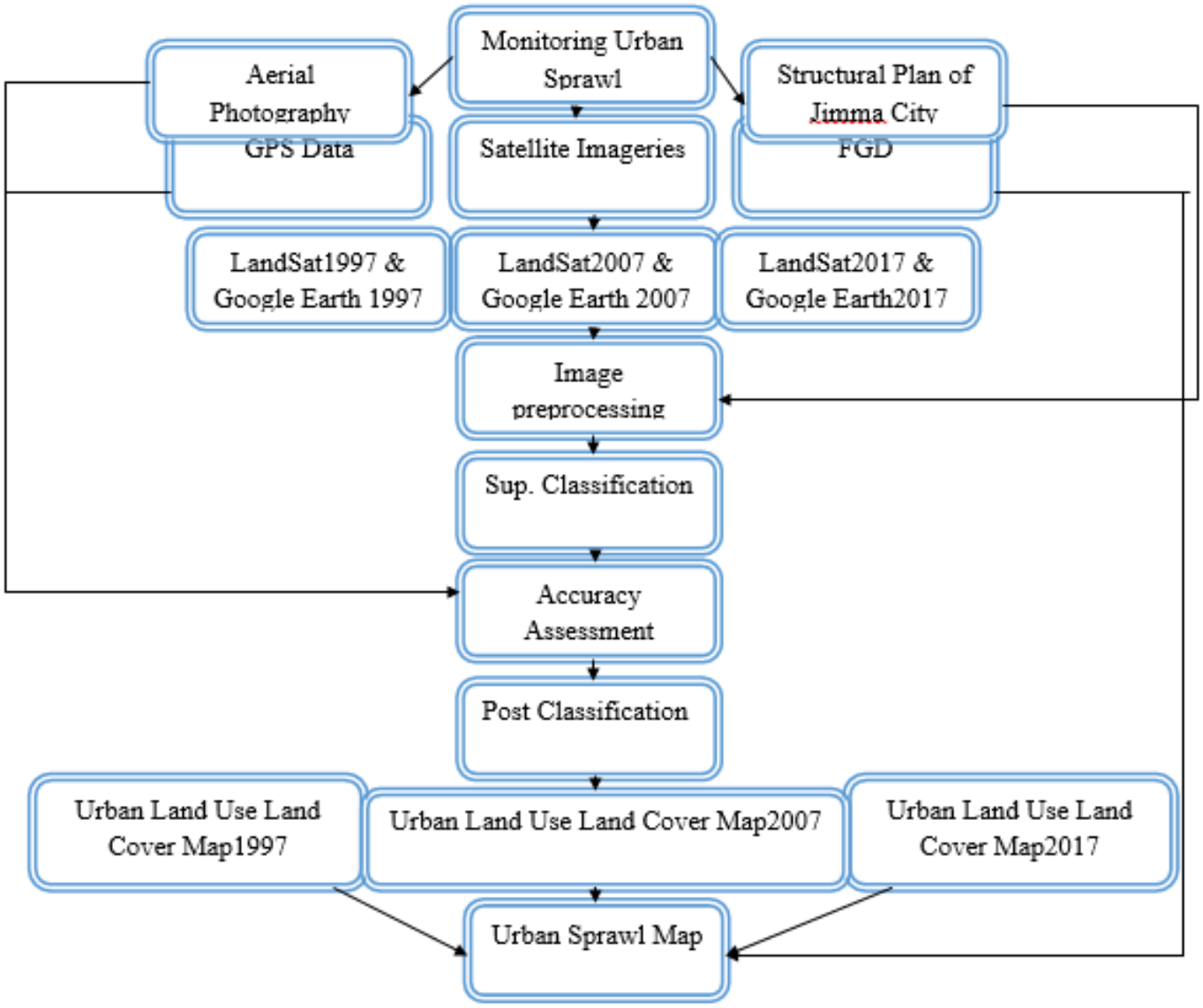
The next step were reclassifying to builup and non-built up to measure the concentration and desperation of sprawl using Shannon's Entropy. Finally, urban sprawl map of jimma city was produced. Based on the data obtained from field survey; Digital camera and field observation and discussion made with expertise analyses were made through tables, graphs, and figures.

Table 3.4 Land use land cover Description

Land use land cover	**Description**	Remark
Built-up	Residential, commercial, industrial, transportation (road) and other urban features	
Vegetation	Forest, mixed forestlands, shrubs and grass land (green area)	
Farmland	Crop field	
Bare land	Exposed soil, area of active excavation and bare land	
Water body	River, stream, pond, water land and reservoir	

Source: - Anderson, James R. (1971).

Figure: - 3.4 Methodological Flow Chart



Source:-Researcher

3.6 Validity and Reliability of Data

In order to assure the validity of the research, the researcher try to review quite adequate conceptual and empirical literatures related to the problem under investigation. This enables the researcher incorporates major themes in data generating instruments so as to investigate the problem in all-embracing way. In the same way, the researcher consult methodological aspects on past research outputs and scholarly articles undertaken in order to select accurate data generation tools and techniques.

3.7 Ethical Consideration

Ethical consideration is arises during the design and data collection phases of a study. Acknowledgement of data generated by others and appropriate citations of scholarly research outputs, books, websites, and any other related documents is one of conducting ethical research. By recognizing this, the researcher has cited and acknowledged all the information taken from scholarly literatures. The researcher has also considered herself as one member of a society and respected the norms, value and also confidentiality.

CHAPTER FOUR

4. Result and Discussion

4.1 Land Use Land Cover Analysis from 1997-2017

To monitor the change in different year Landsat TM of 1997, Landsat 7 ETM+ of 2007 and Landsat 8, 2017 satellite image data are used to classify the land use/land cover of the study area .And the image was classified by arcGIS10.3maximum likelihood algorithm techniques in supervised image classification method. The area was classified into five major different categories of land use types. The categories are urban built up, vegetation, farmland, bare land and water as written in figure 3.5 above. These all land use or land cover were classified with high level of accuracy. But some points classified as interrupted by agriculture from bare land area and forest cover.

4.1.1 Land Use Land Cover Analysis of 1997

In 1997, the urban area of Jimma city was 42. A Square kilometers with a population of 99,897 and the total length of the city boundary was 25.609 km. Figure 4.1 shows Land Use of the town in 1997.

Figure 4.1. Land Use Land Cover Map of the Study Area in 1997

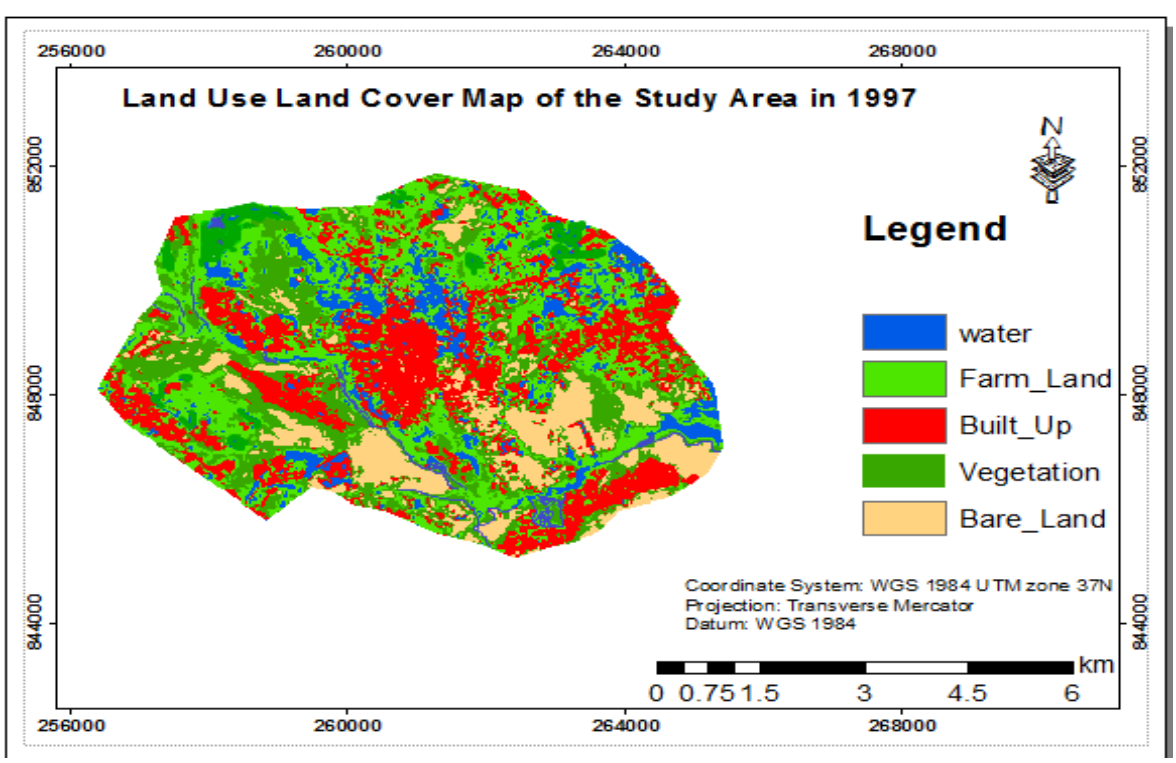


Table 4.1 proves that which LULC classes is the highest and least by hectare and percent. Based on this Farmland constitutes 28.29 % the highest and 11.53% of Water body is the least. Built up, Vegetation and Bare Land accounts 25.16%, 22.24% and 12.78 % respectively.

Table 4.1 Percentage of Land Use Land Cover of Jimma City 1997

Lu/Lc type	Hectare	%
Built up land	1062.99	25.16
Vegetation	939.78	22.24
Farmland	1175.29	28.29
Water	485.08	11.53
Bare Land	540.09	12.78
Total	4203.23	100

Source: Structural Plan Report1997

4.1.2 Land Use Land Cover Analysis of 2007

In 2007 Physical status of the city area and the boundary was remaining the same with 1997 which is 42 Square kilometers and 25.609 kilometers respectively in 2007. For the period of 1997 – 2007 population of the town rise to 120,960.

Figure 4.2. Land Use Land Cover Map of the Study Area in 2007

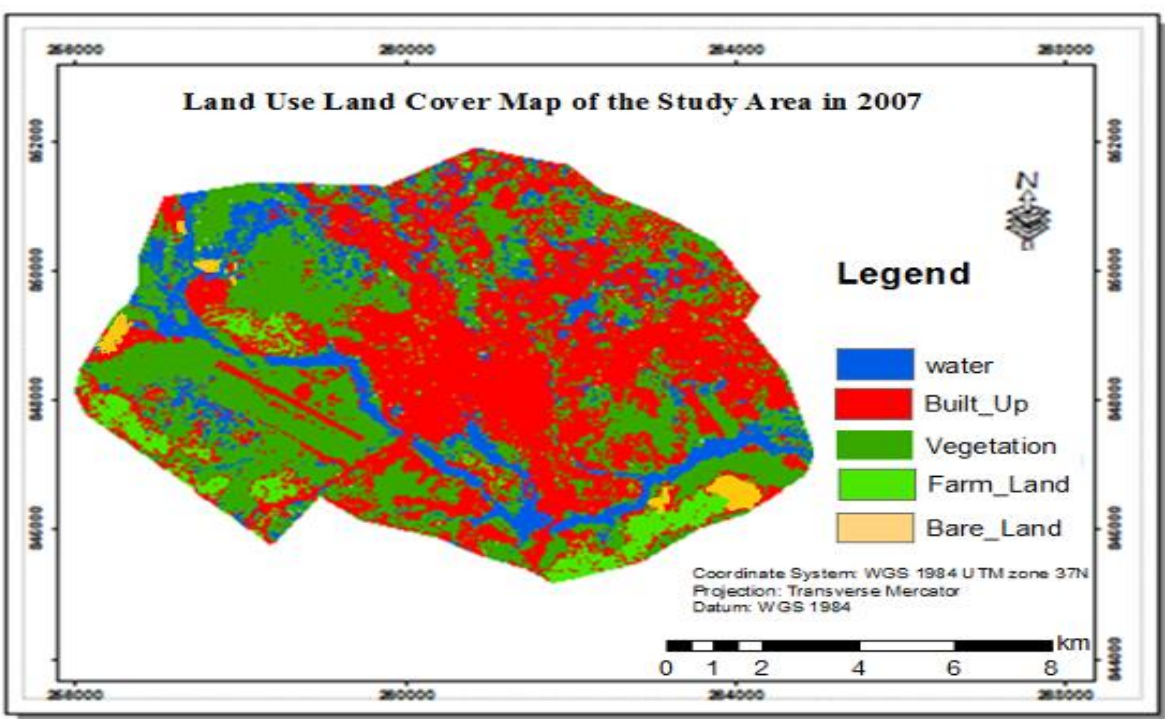


Table 4.2 proves that which LULC classes is the highest and least by hectare and percent. Based on this Built up land constitutes 43.97% the highest and 0.25% of bare land the least. Vegetation, Water and Farmland land accounts 37.68%, 12.26% and 5.84% respectively.

Table 4.2 Percentage of Land Use Land Cover of Jimma City 2007

Lu/Lc type	Hectare	%
Built up land	1835.28	43.97
Vegetation	1572.48	37.68
Water	541.47	12.26
Farmland	243.81	5.84
Bare Land	10.53	0.25
Total	4203.57	100

4.1.3 Land Use Land Cover Analysis of 2017

As it indicated in figure 4.3 below Built up land still take the first place compared to other land use classes. Vegetation and Farmland also decrease in area coverage even if the area of the city is increased from 42sq.km to 102sq. km. Besides number of population is increase from120, 960 to195, 443 in Jimma city.

Figure 4. 3. Land Use Land Cover Map of the Study Area In2017

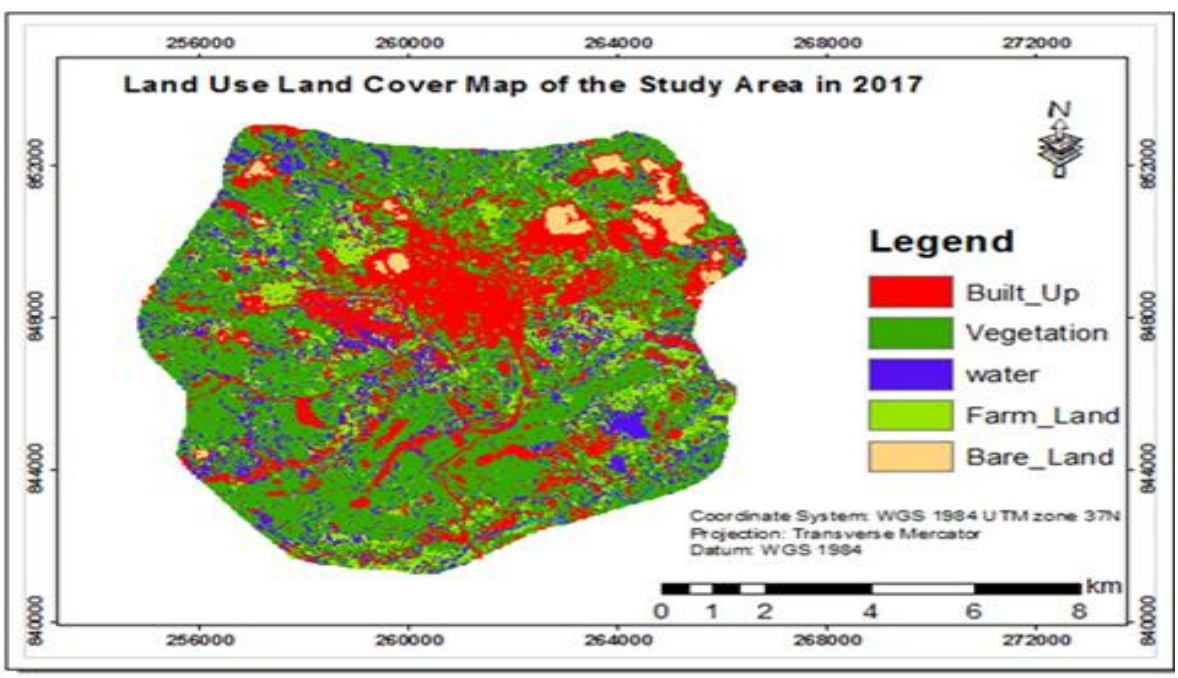


Table 4.3 Percentage of Land Use Land Cover of Jimma City 2017

Lu/Lc type	Hectare	%
Built up land	4911.22	48.20
Vegetation	3267.81	31.98
Farmland	841.99	8.24
Water	601.34	5.88
Bare Land	595.64	5.70
Total	10218	100

Table 4.3 proves that which LULC classes is the highest and least by hectare and percent. Based on this Built up land constitutes 48.20% the highest and 5.7% of bare land the least. Vegetation, Farmland and Water land accounts 31.98%, 8.24% and 5.88% respectively.

4.2 Trend and Pattern of Urban Sprawl

4.2.1 Spatial Trend of Urban Sprawl

In the first decade 1997-2007 highest increment expansion of the built up area was observed accompanied by high population growth. Following this most part of farm land and open area become highly decreased. As a result of this the city particularly the built up area increased year after a year. For the second decade 2007-2017 the built up land keeping high rate of expansion accompanied by increment of the city boundary from 42sq.km to 102sq.km. But the others LULC classes had lost their former coverage.

Table 4. 4 LULC Distributions of the Study Area from 1997–2017

Land-use	**1997**		**2007**		**2017**	
	Area /ha/	%	Area /ha/	%	Area /ha/	%
Built up Area	1062.99	25.16	1835.28	43.97	4911.22	48.20
Vegetation	939.78	22.24	1572.48	37.68	3267.81	31.98
Farmland	1175.29	28.29	541.47	12.26	841.99	8.24
Water	485.08	11.53	243.81	5.84	601.34	5.88
Bare Land	540.09	12.78	10.53	0.25	595.64	5.70
Total	4203.23	100	4203.57	100	10218	100

The above table indicates that the total area of built-up increased intensively from 25.16% in 1997 to 48.2 % in 2017 while a farm land area decreased from time to time from 28.29% in 1997 to 12.26% in the year 2007 and 8.24% in 2017. The trend of other categories varies increasing and decreasing at various times. Thus, farmland and bare land LULC categories experienced considerable loss in both of the two study period between 1997- 2007 and 2007-2017. Built up LULC category with the highest rate of expansion from 1062.99 he (25.16%) in 1997 to 1835.28he (43.97%) in 2007 and 4911.22 he (48.2%). Vegetation land shows relatively change of increase from 939.78ha (22.24%) in1997 to1572.48ha (37.68%) 2007 and 3267.81 ha (31.98 %) in 2017 however the percentage still takes the second rank this is because of expansion of the city.as compared to other LULC it is relatively same within the study year. This is presented graphically so that the trend of all categories can be seen more clearly as shown in the Figure 4. 6.

Figure 4.4. Trend of Land Use Change from 1997-2017

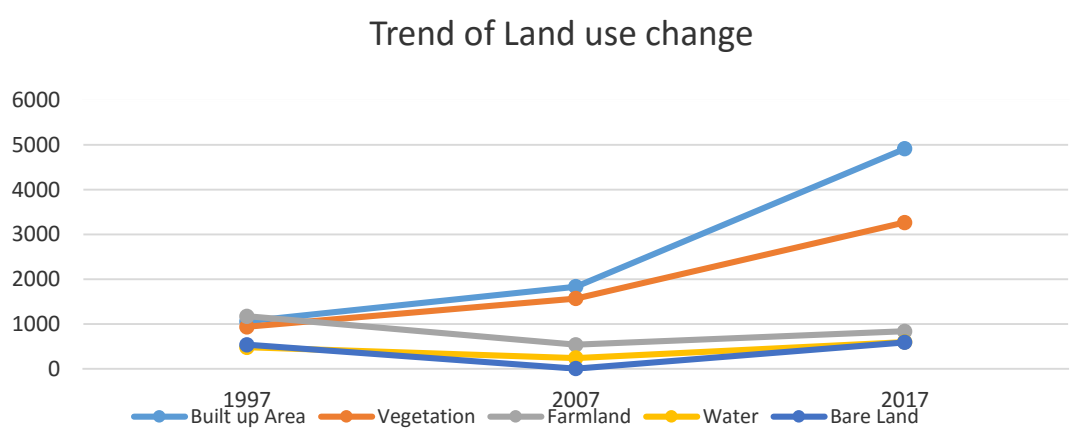
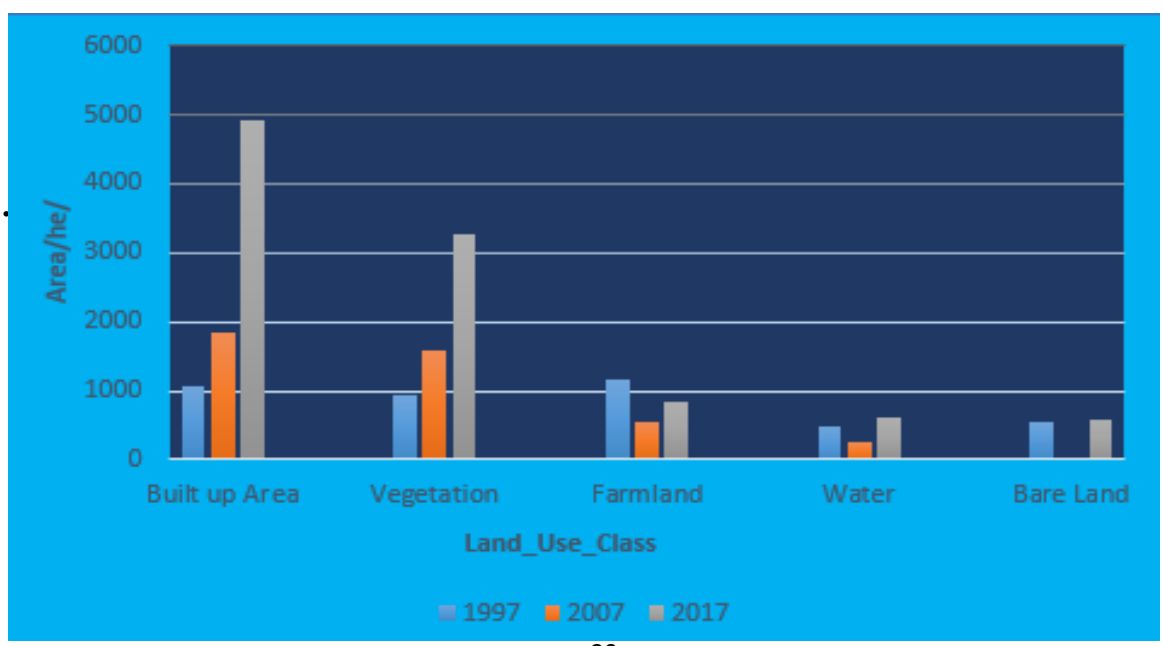


Figure 4.5 Area of Each Land-Use Types from 1997–2017



4.2.2. LULC Change Detection Analysis

One of the most common applications of change detection is determining urban land use change and assessing urban sprawl. This would assist urban planners and decision makers to implement sound solution for a sustainable urban growth and environmental management.

Numerous techniques are applied on images of different dates in order to detect the changes occurred through the years. One of the techniques used to detect LULC is post-classification change detection methods. The classification of images of the study area over the study periods was essential in the detection of changes of different LULC categories.

It is also possible to compute the amount of gain (positive) and/or lose (negative) of each category and see the change in percent in each year.

As shown in table 4.4 farm land constituted the largest LULC category in 1997 the bare LULC class contained the least cover in all years. But farm land LULC class showed a regular pattern of decrease over the study periods. It decreased from 28.29 % in 1997 to 12.26 % in 2007, decreased from 12.26 % in 2007 to 8.24% in 2017. After farm land LULC class, the bare land take the second LULC category which showed a regular pattern of decrease between the study periods. It decreases from 12.78% in 1997 to 0.25% in 2007. In all the study periods the built up LULC showed regular pattern of increase from 25.16% in 1997 to 43.97% in 2007 and from 43.97 in 2007 to 48.2% in 2017.

Farmland and bare LULC categories experienced considerable loss in both of the two study period between 1997- 2007and 2007-2017table 4. 5. Built up LULC category with the highest rate of expansion from 1062.99 ha. (25.16%) in 1997 to 1835 ha.(43.97%) in 2007 and vegetation LULC shows change of increase from 939.78 ha.(22.24%) to 1572.48 ha.(37.68%) and bare land from 540.09 ha.(12.78%) in 1997to 10.53 ha.(0.25%) in 2007 loss of the previous extent of land.

In the second period of the study (2007-2017) the city boundary was increase more than half at the same time vegetation cover increase from 1572.48 ha to 3267.81ha also built up area and bare land increased from 1835.28ha (43.97%) to 4911.22ha (48.2%) and 10.25ha (0.255) to 595.64ha (5.7%) but the other land use categories lost early extent almost by half and above.

Table 4.5 Gain and Loss of LULC Class of Jimma City from 1997–2017

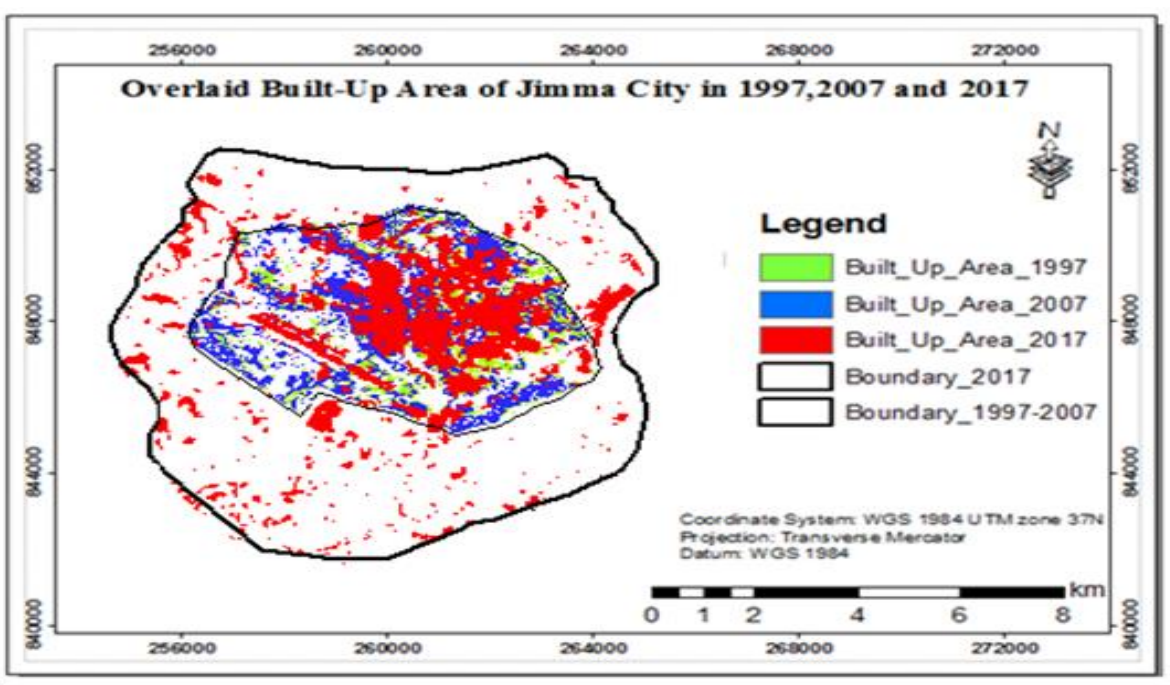
	1997-2007		2007-2017		1997-2017	
Built up Area	772.29	18.81	3075.94	4.23	3848.23	23.04
Vegetation	632.7	15.44	1695.33	-5.7	2328.03	9.74
Farmland	-633.82	-16.03	300.52	-4.02	-333.3	-20.05
Water	-241.27	-5.69	357.53	0.04	116.26	-5.65
Bare Land	-529.56	-12.53	585.11	5.45	55.55	-7.08

In general at the second study period (2007-2017) the built up land keeping high rate of expansion. The others LULC classes had lost their former coverage but vegetation is increasing next to built up area this is due to the expansion of the city from 42sq km to 102sq km. As a result of this the town particularly the built up area expanded year after a year.

4.2.3. Urban sprawl Pattern and Direction

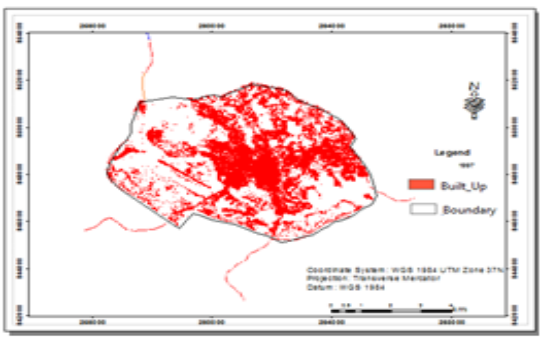
Urban sprawl is also described in various ways taking the processes, forms and patterns of urban developments into consideration. The most illustrative explanation was given by Galster et al. (2001) based on development patterns which is cited by various experts since then (Besussi et al., 2010; Yu, 2013; Reis et.al, 2015). The authors characterized urban sprawl based on forms, density and land-use patterns. According to Galster et al. (2001) forms refer to the physical growth or expansion of urban areas.

Figure 4. 6 Overlaid Built-Up Area of Jimma City from 1997–2017.

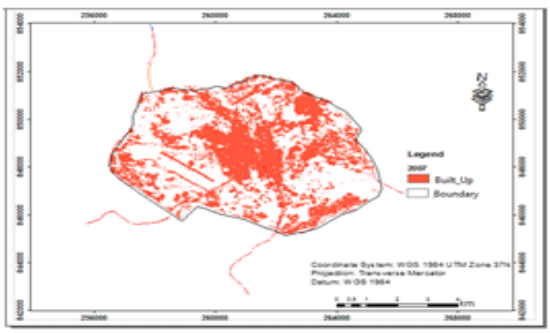


So based on the findings; in the first decade (1997-2007) Jimma city doesn't show any physical growth were as in the second decade the city has shown tremendous change from 42 sq. km to 102 sq. km however in both decade the urban built up area was keeping increasingly from 25.16% to 43.97 % from 1997-2007 and 43.97%-48.2%. Regarding the pattern of the development figure 4.8 illustrate that it has the same development pattern in the year 1997 and 2007 which is categorized under compact development pattern where as in 2017 the development of the city is characterized under scattered development pattern.

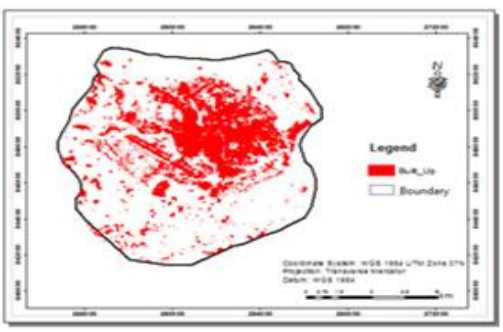
Figure 4.7 Development Pattern Describe Sprawl



Development pattern of Jimma City 1997



Development Pattern of Jimma City 2007



Development pattern of Jimma City 2017

Figure 4. 8. Typical urban sprawl in Jimma city Bore Kebele

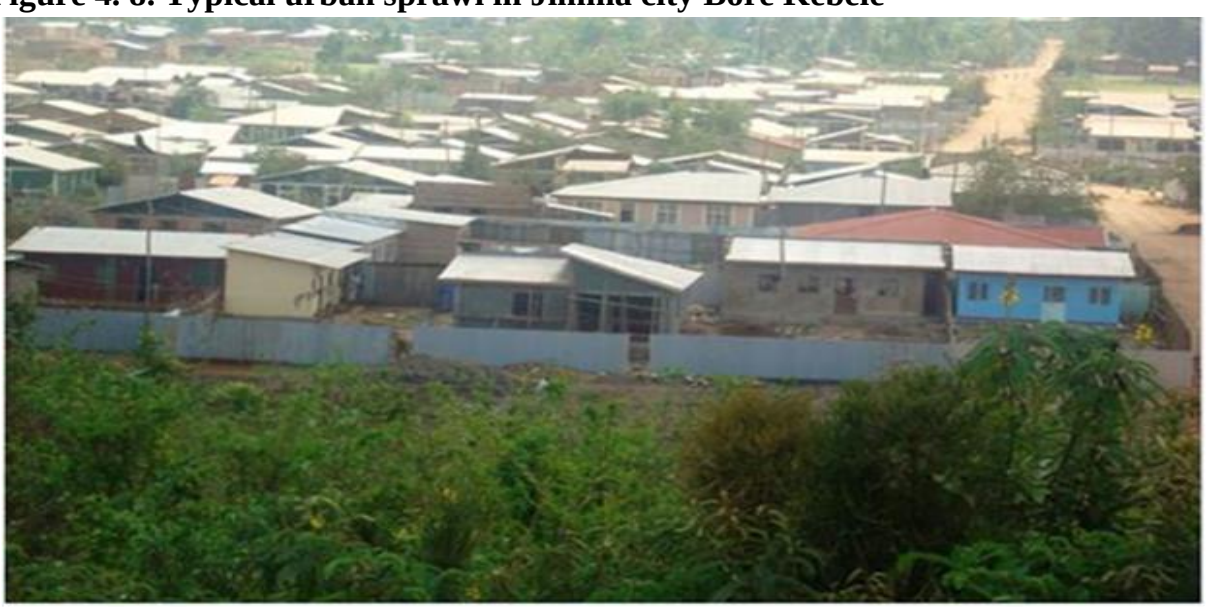


Figure 4.9. New Urban Development in Bore Kebele

Source: - Field Survey

4.2.4 Urban Sprawl Measurement

Utilization of geospatial tools: remote sensing (RS), geographic information system (GIS) and other related software programs for monitoring, measuring, analyzing and modeling is common. Once having a data of study area analyzing using geospatial tool is common and possible to give visual interpretation of the physical patterns and forms of urban growth. However, it is important to quantify the degree of sprawling. As it is noted by Bhatta (2010), quantification of sprawl, as a pattern or process, is a real challenging issue. Wilson et al. (2003) has also said that without a universal definition, quantifying and modeling of urban sprawl is extremely difficult. One of the most commonly used approaches, in most urban sprawl studies, is to integrate Shannon's Entropy with GIS tools. This is relatively efficient approach to analyze urban sprawl.

Thus the focus of this topic is to use some measurement techniques for measure pattern of urban sprawling in the City. by visual interpretation of the maps (Figure 4.8) it has been said that there is some form of sprawling to the city of Jimma however, it is not possible to conclude that all form of growth are sprawling (Roca et al. 2004), the measurement result would help and prove the healthiness or unhealthiness of the growth.

In this study, the degree of urban sprawl over the three periods: 1997, 2007and 2017 was determined by computing the area of all the built ups from the land cover maps. The

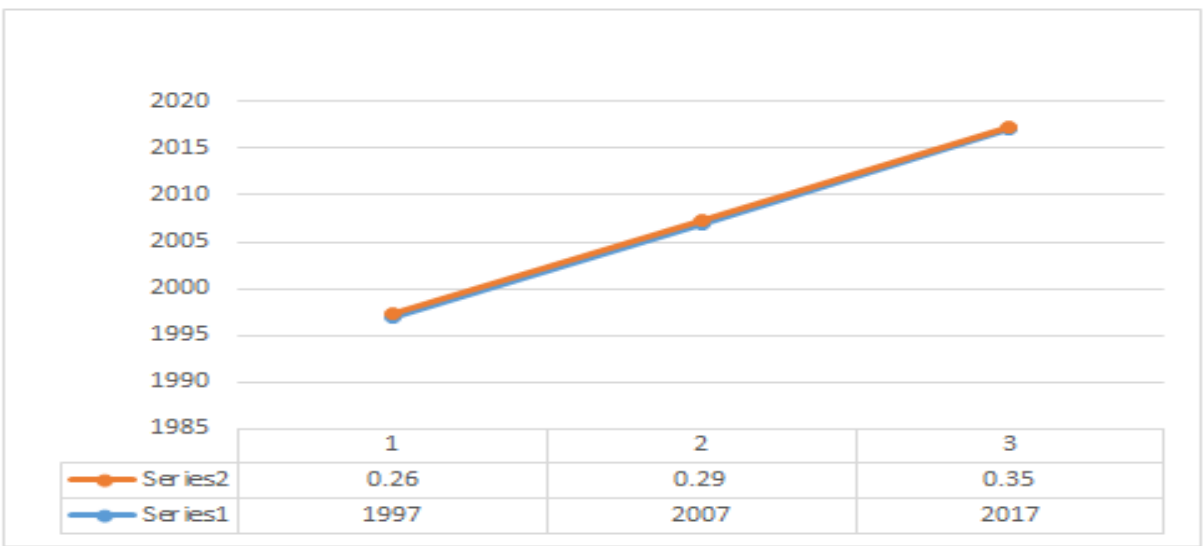
Shannon's entropy along with GIS tools was applied to measure the sprawl during the study period. Shannon's entropy measures the degree of spatial concentration and dispersion on the surface of area of study (Yeh and Li 2001; Sudhira et al. 2004). In order to make the measurement of the study periods of sprawl, the three land use maps for the years 1997, 2007 and 2017 and Shannon entropy approach was employed. The entropy value were 0.26, 0.29 and 0.35 for 1997, 2007 and 2017 respectively. And the entropy value varies from 0 to 1. If the distribution of the built up is maximally concentrated in one region the value of entropy is 0. The value is 1; if the built up is unevenly dispersed distribution across space. The dispersion of built-up areas from a city center or road network leads to an increase in the entropy value. This gives a clear idea to recognize whether the urban expansion is more dispersed or compact.

The measurement of the difference on entropy between (t) and (t+1) was also computed, and it indicate the temporal change in the degree of dispersal of land development or urban sprawl. The change in the entropy values is given in Table 4.6.

Table 4.6 Shannon's Entropy Values of the Three Years and Difference among the Periods

En(Entropy During the 3 Study Periods)			**Δ En (Difference of Entropy)**		
1997	2007	2017	1997-2007	2007-2017	1997-2017
0.26	0.29	0.35	0.03	0.06	0.09

Figure 4. 9 Graph of the Entropy Value of Jimma (1997, 2007 And 2017)

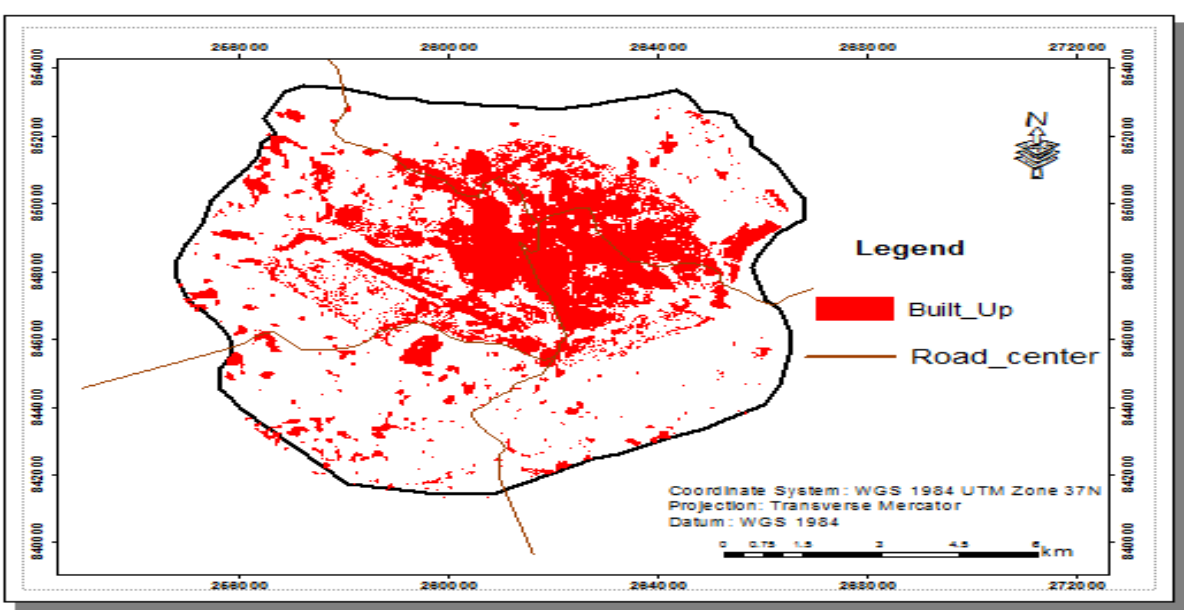


4.3. Mapping urban sprawl of Jimma city

Mapping urban sprawl area is one of the best way which give a visual impression of urban sprawling rate and direction. Mapping urban built up is the best parameter for the purpose of quantifying urban sprawl condition (Barnes et al., 2001; Epstein et al., 2002) urban built up maps of the study area were produced at different periods to illustrate the urban built up growth and its direction.

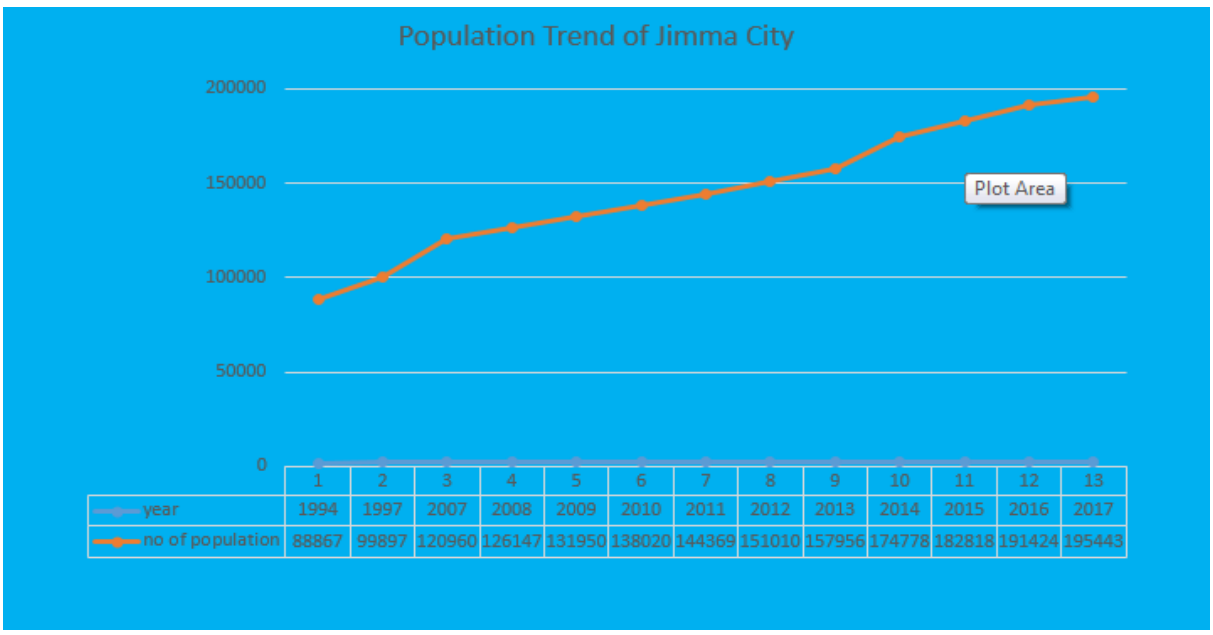
In figure 4.6 three of the different images of the study area were overlaid to compare the extent of expansion in the built up between them. As it is visually analyzed the built up was expanded for the last 20 years of the study period almost in all directions consuming land from the other LULCs. The built up area in the year 1997 was only 1062.99he of the total land. This was grown to 1835.28 he in 2007 it was increased by 18.81%. Big increment was recorded in 2017 with a total land cover of 4911.22 ha which means grown by 23.04 % from 1997 and 4.23 % from 2007. According to the figure 4. 9 during 1997 to 2007 physical growth is not observed even though built up area of the city is increased. At the same time the city population has increased from 99,897 to 120,960 .But from 2007-2017 city expansion is observed towards all direction North, North-East, North West, East and west. In south direction a significant change is observed. The city area also rises from 42 sq.km to 102 sq. km, showing a remarkable expansion. Accordingly the total population of the city also increased to 195,443 in 2017. Also According to the discussion made with expertises who are working in land management agency argue that most of the land use change is observed in the second decade. And the cause for the land use change is improper implementation of the structural plan which is produced in the year 2008.

Figure 4.10 Urban Sprawl Map of Jimma City



According to (Haregewayin, 2005) like most developing countries, in Ethiopia serious rural to urban migration is a common Formal and informal settlements are stretching out horizontally from the central capital in all directions. Land is ineffectively used, new developments are planned on virgin land usually leapfrogging from cores this kind of development considered as urban sprawl and in Ethiopia sprawl is a result of population pressure (both from natural births and migration), poor land policies, lease system and planning and regional imbalance. Also in Jimma city population no is increasing from year to year one of the cause for sprawl is population number increase.

Figure 4.11 Population Trend of Jimma City



Source:-Computed from CSA, 2007

In addition availability or proximity to existing infrastructure, the Development potential, Distance from existing development and topography of the area is major factor for sprawl of a city. So from urban sprawl map produced in this study and using other ancillary data it is possible to visualize the future potential sprawl zone (area) of the city.

Table 4.7 Reaction about Urban Sprawl

no	Basic Concept of urban sprawl	No of expertise under discussion	Percent
1	yes	6	66.7
2	no	3	33.3
total		9	100

Source: Computed based on the information obtained from discussion

According to the discussion made with expertises who are working in land management agency and municipality 66.7% of the respondent have similar concept about urban sprawl and the other 33.3% have no idea about sprawl. Most of the workers under discussion argue that the cause for sprawl of the city was improper implementation of the structural plan and the other argues the lease policy is expanding the sprawl of cities because one can acquire land only through tender. Middle income and low income group didn't have a chance to be house holder so they choose the illegal way of occupying land and this increase sprawl in the city.

No	Factor for urban Sprawl	No of expertise under discussion	Percent
1	Improper implementation of the structural plan	8	88.8
2	The land lease policy no721/	1	11.2
Total		9	100

Source: Computed based on the information obtained from discussion

No	When LULC major change occurred	No of expertise under discussion	Percent
1	**1997-2007**	**0**	**-**
2	**2007-2017**	**9**	**100**

Source: Computed based on the information obtained from discussion

Most of the respondents are working in land management and municipal bureau. All of the answers given by experts are similar with each other. They believe that there is a change in different land use land cover class, expansion of built up area were high for different purpose and decrease in farm land. The major cause for this change is population growth, and the change is occurred during 2007-2017.

No	Possible solution for reduce urban sprawl	No of expertise under discussion	Percent
1	Handover the included 4 kebeles	1	11.0
2	Increasing the no of expertise in each of kebele	4	44.5
3	Releasing serviced land at least two times in a year	4	44.5
Total		9	100

Source: Computed based on the data obtained from field survey

CHAPTER FIVE

5. Conclusions and Recommendations

5.1: Conclusions

The main objective of the study was to monitoring of urban sprawl of Jimma city. In order to meet the objective, three years- 1997, 2007 and 2017 were selected. Then, satellite images were acquired and processed to generate maps that can serve as an input. Once the map is produced and classified in five LULC class built up, vegetation farm, land bare land and water body the area covered by each category was calculated for each study years. Built-up was calculated in hectare and the results were found 1062.99 in 1997, 1835.28 in 2007, and 4911.22 in 2017. In other words, the percentage of built-up area comprised about 25.16%, 43.97%, 48.2% and 47.46% for the years 1997, 2007 and 2017 out of the total study area, respectively. The major contributors for the growth of urban area are farm land and bare land areas which decreased 28.29% and 8.24% from 1997–2017, respectively. This is a major important indication that Jimma is growing on the expense of farmland the trend shows the built up is increasing from year to year and in the contrary the other land uses were decreasing. Regarding the development pattern the development were in all direction whereas the concentration differ from time to time this value is computed using Shannon's entropy with the integration of GIS and the value of the entropy was 026,0.29 and 0.35 for the year 1997,2007 and 2017 respectively. In other hand the city administration had not play its role to overcome the sprawling phenomenon occurring in the city thus there is no way to stop sprawl in the city

In general in the last two decades, Jimma have experienced a rapid growth which resulted in loss of valuable farm land and uncoordinated outward sprawling. And resulting burden on the city administration to provide the necessary infrastructure.

5.2: Recommendations

Based on the findings and the results built up expansion in the town was a usually occurrence it is necessary to think the future impact of urban sprawling so the following points are recommended.

1. The city is expanding horizontally and this expansion is becoming natural phenomenon thus it is better to leave a space for expansion.

2. Studies indicate that the structural plans formulated so far to guide the development activities of the city suffered from lack of proper implementation. Therefore, it is time to plan ahead and cope up with the pace of urban growth with proper implementation.
3. In order to mitigate loss of farmland and the impact of urban sprawl on urban area, city planners must look inside and accommodate infill development and ensure proportionate horizontal expansion of the city.
4. Those of Urban planners and environmentalist need to consider the use of geospatial tools for planning and decision making purposes. Because, they are the means to obtain land use information at a wide coverage, provide a quantitative and spatially explicit picture of the extent and dynamics of LUCC.

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