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A GIS AND REMOTE SENSING BASED ANALYSIS OF DETERMINANTS AND EXTENT OF URBAN SPRAWL IN THE CASE OF HOLOTA TOWN, SPECIAL ZONE OF OROMIA, CENTRAL ETHIOPIA

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This is to certify that the thesis prepared by Addisu Damtew, entitled: A Gis and remote sensing based analysis of determinants and extent of urban sprawl of Holota town, special zone of Oromia ,central Ethiopia submitted in partial fulfillment of the requirements for the Degree of Master of science in Gis and remote sensing department of geography and Environmental Studies complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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DECLARATION

I declare that this M.Sc thesis is my original work, has never been presented for a degree in this or any other university and that all sources of materials used for the thesis have been fully acknowledged.

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ACRONYMS

AMSL:	Above Mean Sea Level
AOI:	Area of Interest
°C:	Degree Celsius
CSA:	Central Statistical Agency
EMA:	Ethiopian Mapping Agency
ERDAS:	Earth Resource Development Application System
ETM:	Enhanced Thematic Mapper
FAO:	Food and Agricultural Organization
FCC:	False Color Composite
GCP:	Ground Control Point
GIS:	Geographic Information System
GLCF:	Global Land Cover Facility
GPS:	Global Positioning System
Ha:	Hectare
Km^2:	Square Kilometer
LULC:	Land Use Land Cover
LULCC:	Land use Land Cover Change
MLC:	Maximum Likelihood Classifier
RGB:	Red Green Blue
TM:	Thematic Mapper
UN:	United Nations
UNCED:	United Nations Conference on Environment and Development
USGS:	United States Geological Survey
UTM:	Universal Transverses Mercator

Abstract

Currently, urban sprawl is becoming a big problem in sub-Saharan African countries as cities are expanding without well planning. Therefore, the objective of this study is to assess spatio temporal Urban sprawl: in the Case of Holota town, Oromia Region, Ethiopia. GIS and remote sensing were used to analyze the phenomena of urban sprawl and its impacts. This thesis uses Geographic Information Systems (GIS) mapping and land cover change analysis, neighborhood statistics, community surveying, key-informant interviews with planners and developers, and planning documents to measure urban sprawl of the study area. Having employing the descriptive research methods, the researcher collected data based on both primary and secondary data. Research key informants' interviews, the researcher's participatory observation, GPS data, Satellite Image and documentary resources were tools to collect data. Data sources were both quantitative and qualitative data collection. The change detection method has been applied to investigate LULC Change. In order to achieve these, satellite data of Land sat TM for 1995, ETM for 2005 and 2017 have been obtained and processed using ERDAS IMAGINE 2010. The Maximum Likelihood Algorithm of Supervised Classification has been used to generate land use/land cover maps. For the accuracy of classified Land use/Land cover maps, a confusion matrix was used to derive overall accuracy and results were above the minimum and maximum threshold level. The satellite image results show that built up areas increased by (8.65%), (17.32%) and (32.32%) respectively in the first, the second and the entire study periods. While cultivated land, increases than all land use and land cover in the first, the second study period but grass land, and forest land, decreased in the first entire study

CHAPTER ONE

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Urbanization, which can be defined as a local increase of inhabitants density coupled with increased per capita energy consumption and extensive modifications of the local environment, represents an important type of land use and cover changes (Lulc) and is considered to be an inevitable tendency in today's world (Pickett et al., 2001). The world's urban population is estimated at 3 billion in 2003, and is expected to rise to 5 billion by 2030 by then; almost two thirds of the world's population will be living in towns and cities i.e. the rate of the urban population growth is more than that of the rural population. Urban growth is the expansion of city area with respect to the increase in number and size of the settlement. Urban expansion chiefly depends upon the human desires for their betterment, need of better livelihood, facilities and employment (Bruecknerand Helsley, 2011). More importantly, the speed and scale of this growth have usually been concentrated in developing countries which are characterized by larger metropolitan areas and great number of mega cities. Moreover, most of the urban population growth has been occurred in the developing countries (UN, 2009). Urbanization is one of the most important anthropogenic activities that create significant and extensive environmental implications at both local and global scales (Herold et al. 2003). Inevitably, population growth leads to a rapid expansion of urban growth, causing changes in land use land cover in many metropolitan areas. The rate of such change is obvious in developing countries with high population growth rates like Ethiopia.

This rapid growth of urban areas has caused complex problems such as environmental pollutions; endanger natural resources, reduced open spaces, unsatisfied infrastructures and unplanned or poorly planned land development (Parka *et al*., 2011). These uncontrollable urban changes around the Ethiopian towns can intensify a large number of social and physical problems, in addition to the agricultural lands changed. Due to the effects of continued growth and expansion of cities, rural communities residing in the outlying areas have been subjected to increasing eviction and adverse effects such as pollution, environmental, social and cultural disturbances. Urban growth is defined as modification of environment or the replacement of natural or agricultural land cover with urban land use (e.g., buildings, transportation, parking lots) (Slemp et al., 2012). The measures are being taken to manage the undesired effects, though not adequate. In this respect one of the typical manifestations of the undesired effects of urbanization is informal and/or illegal ownership of land and housing which are particularly intensified in the peripheral areas. Rapid urban development and increasing land use changes due to increasing population and economic growth is being witnessed of in Ethiopia and other developing countries. The measurement and monitoring of these land use changes are crucial to understand land use cover dynamics over different spatial and temporal time scales for effective land management. Holota is one of the fast growing urban centres in the Oromia regional state. Hence the expansion of the town is becoming irregular, uncontrolled and often resulting in creation of fragmented development. The town's growing industry, manufacturing sector, service and its proximity to Addis has led to increased investments and has resulted in high-speed economic and social development. Holota, being one of the towns in the developing countries has never been in a position to escape the forgoing undesired realities of rapid urbanization. Urban planning implementation principles and guidelines are fundamental to ensure healthy urban growth have never been put in place. In this study, the spatial analysis functions of GIS and remote sensing techniques to specify the urban expansion characteristics of the town have been used.

1.2. Statement of the problem

Ethiopia as many of the developing countries has a problem with the unplanned urban expansion and residential houses sprawl in many of its towns and cities. Therefore, there is a need for, mapping, analyzing and continuously monitoring of the phenomena of urban sprawl patterns because it is the responsibility of urban administrators, and planners to give the entire infrastructure and service facilities in a complex urban area. The conventional method of mapping urban sprawl is the use of ground survey and aerial photographs which is costly and slow process to get the necessary information such as the direction where urban growth occurs and the level of services needed on the new developmental sites.

Holota is characterized by low density and low-rise development. Like any third world town, leap frogging and sporadic developments are common in Holota. There has not been institutional and legal framework capable of managing informalities in trade and physical developments. City planners, urban managers and resource managers therefore need advanced approaches and a comprehensive knowledge of the cities under their jurisdiction to make the informed decisions necessary to guide sustainable development in rapidly changing urban environments (Pham et al., 2011).The importance of putting in place planning principles to be referred to in the planning process is not well recognized. This could give way to haphazard planning and subsequent ineffective implementation regarding settlement development two basic processes would be identified in Holota.The first step includes the development of rural settlements and/or informal and illegal land occupation, which usually starts, with the establishment of small rural/semi-rural housing units and settlements in the peripheral areas. The second step consists of informal land transfer from these original settlers to others. Informal land tenure rights especially that claimed by farmers have contributed to all the above processes to a great extent. The result of the land use and housing ownership survey shows that there are informal housing constructions and extension in all areas of the town especially at the peripheries. The population of the town has been raised and consequently the need for homes became serious. In addition to this the growth of the town is a continuous process so that it is important to measure its horizontal expansions in order to recommend possible solutions for future development. This paper will try to assess urban expansion and sprawl of Holota town using Remote Sensing and Geographical Information Systems and recommend possible solutions.

1.3. Objective of the study

1.3.1. General objective

❖ To assess the determinants and predict out the trends of urban sprawl for Holota town using remote sensing and GIS techniques between 1995, 2006 and2017.

1.3.2. Specific objective

- ❖ To identify the determinants of urban sprawl for Holota town.
- ❖ To map out the trends of urban sprawl for 1995, 2006 and 2017.
- ❖ To delineating urban land use classes of the town between 1995, 2006 and 2017
- ❖ To identify the extent and patterns of urban sprawl of the study areas

1.4 Research Questions (hypothesis)

The objectives of the study are achieved by way of seeking answers to the following basic questions;

1. What are the significant factors for urban expansion and sprawl in the town?
2. What are the determinants of urban sprawl for Holota town?
3. What are some of the urban land use that is changed since 1995?
4. What are the extent and the patterns of the study areas?

1.5 Significances of the study

One of the major impacts of urban sprawl is a shrinking amount of cultivated land through the development of infrastructures and various development projects. Therefore, residential Sprawl and land-use/land-cover change studies are important tools for urban or regional planners and decision makers to consider the impacts that can occur on sustainable urban development of the study area. The results of this study would provide information relevant to contribute in the environmental management plans and urban planning processes. Generally, the study after the completion of the research would have the following Significances: It would help the concerned bodies understand the sprawl/scatter development of residential houses and the rate of continuous land-use/ land-cover change in the study area. This may provide some idea to find appropriate solutions for scattering or none regulated urban housing sprawl and problems of unwise use of land resources.

1. Provide local engineers, urban planners and policy makers with the necessary information to depend on

2. Serve as an input for further studies.

1.6 The scope of the study

Currently, most of the towns of the country have little attention in terms of physical Expansion and dynamic population growth which create a burden on basic supply of public Services and infrastructural developments. Given the fact of current and future unmanageable urban growth problems, there is a need of decision making and planning to maintain at least some control of urban expansion. This is not possible without up-to-date Information about various aspects in the urban areas. Remote sensing and GIS techniques can help to get up-to-date information of the urban expansion and sprawl with frequent coverage and Low cost. Therefore, this research would investigate the rate of land use/ land-cover change that occur in the study area over those 22 years (1995 to 2017). Similarly, it was intended to investigate the level of urban sprawl in the study area between 1995 and 2017. The study also includes urban expansion suitability map to identify the most probably growth area of urban development in the future.

1.7. Limitation of the study

Shortage of time, limited network connection to down load images and lack of high resolution images because of lack of capital are some of the challenges that were facing the researcher in the course of the study.

1.8 Organization of the thesis

The thesis is organized in such a way that the first chapter is focused on the introductory parts of the thesis. The second chapter provides the review of literatures on the issue under discussion. In this chapter, urban land expansions of different countries trends as well as the situation in our country during different period and the application of remote sensing and GIS on urban land use change were reviewed. The third chapter describes the general overview of the study area.

Chapter four deals with urban expansion, image interpretation, analysis and present the main cause and implication of Lulc change on local population and environment. Finally, the fifth chapter presents the findings and recommendations.

CHAPTER TWO

2. REVIEW OF LITERATURE

2.1. CONCEPTS AND DEFINITIONS: URBAN EXPANSION, GROWTH AND URBAN SPRAWL

2.1.1 Urban expansion

JieyingXiaoa conducted analysis of urbanization trends in Shijiazhuang City, Hebei Province of China, by using Geographical Information Systems (GIS) and remote sensing and explores the temporal and spatial characteristics of urban expansion from 1934 to 2001, and land use/cover change from 1987 to 2001.

The built-up is generally considered as the parameter of quantifying urban Expansion (Epstein et al., 2002). It is quantified by considering the impervious or the built-up as the key feature of sprawl, which is delineated using top sheet or through the data acquired remotely. Therefore, integration of remote sensing and GIS have been recognized as powerful and effective methods in monitoring environmental change, especially in detecting the land use/ land cover change (LULC) (Weng, 2002; Güler et al., 2007; Gao et al., 2006).Previous attempts to study urban expansion at the expense of agricultural land in Ethiopia were not introduced to the dynamics of urban development, in order to try to predict future urban expansion. Also, no approach has been made to make a model or even calibrate an existing model to fit the Ethiopian context. Further, no approach has handled the problem using accurate data acquired from historical and recent satellite images using dynamic analysis techniques. Finally, no simulation attempt has been made to test the effectiveness of different planning actions that can help hindering future urban sprawl within the country context. The detection and analysis of land use changes in the urban environment is an important issue in planning. Remote sensing and geographic information systems are considered as the most efficient techniques for this type of studies. Thistechnique has been applied to investigate the urban sprawl and quantify urban growth.

2.1.2 Urban Growth

Post-classification comparison of satellite imagery is a commonly used method for urban change detection in studies of urban sprawl (e.g. Jat et al. 2008; Bhatta 2010; Hammann 2012). In this process satellite images taken at different times are classified independently into a common land cover schema. The resulting land cover classification maps are then compared on a pixel by pixel basis in order to identify land cover change. The classification performed may be either supervised or unsupervised. In a supervised classification the classes of the land cover schema are defined based on local knowledge and examples of image pixels comprising each class are identified. The spectral properties of these examples, known as training samples, are then used to classify all remaining pixels in the image into one of the classes. In an unsupervised classification knowledge of land cover in the study area is not necessary and only the number of land cover classes is defined. All image pixels are classified into one of these classes based on naturally occurring groupings in the spectral properties of the image pixels.

Ideal conditions for using remote sensing data to map land cover change include using images collected by the same sensor, under clear atmospheric conditions, at the same time of the year (Bhatta 2010). In addition to its conceptual simplicity, the post classification comparison method is favored because corrections are not required to account for sensor, atmospheric and illumination differences between images if these ideal conditions cannot be met, as the comparison is carried out between the resulting land cover classification maps and not the satellite imagery itself (Bhatta 2010).Figure 2 summarizes the steps that were taken in this study to apply the post classification comparison method in order to measure urban growth in Hamilton City. A supervised classification was performed, using the maximum likelihood classifier, due to considerable local knowledge and availability of ancillary data to assist in class definition. This was followed by an assessment of classification accuracy and post classification change detection.

2.1.3 Definition of urban sprawl

Urban planning evolved throughout the twentieth century, leading to a great variety of urban forms which often had little regard for their impact upon the environment. In both developed and developing societies, this disregard is most evident in the rise of urban sprawl as the primary form of urban development, one of which come under increased criticism in recent years because of its negative environmental, social and economic effects (Newman and Kenworthy, 1989).

A complex of driving forces such as social, economical, political, physical factors and their interactions cause urban sprawl. Different factors and methods were used to build models that can either help predict or explain better the effect of sprawl. However, the complexity of the term and the Ambiguous meaning it is given in different contexts makes it difficult to come to a consensus of distinct pattern. While some argue that urban sprawl is bad, harmful and a threat to ecology, others argue that it is something inevitable and maybe even should be encouraged. The study presented here does not attempt to resolve the difference of opinion, but the position is with those that are troubled by it. Therefore, throughout this paper the research would focus on urban sprawl as problematic and would stress on measures that should be taken to combat it. Until recently, the problem of urban sprawl was restricted to the developed world. But it also exists in developing countries although in different form. For developing countries sprawl is largely a result of necessity- people move to the city in search of better employment and opportunity (Menon, 2004). This leads to an increase in size well beyond the limits of the city. In contrast, sprawl in developed countries is results of higher incomes, which in turn result in people preferring (and affording) to live in the outskirts of the city, with open spaces at reasonable distances from cities. Even though the causes and patterns of sprawl are different depending on the context in which they occur, solutions proposed are similar with some modifications. Prior needs and economic viability should be taken into consideration for best results. Concentrating growth is what many planners recommend as a measure against sprawl for a sustainable city. The increase in population should lead households to be willing to live further from their work site and to pay more for a residential tract at the urban fringe. Hence, developers will outbid farmers for land on the urban fringe and hence will acquire more agricultural land. Brueckner and Fansler (1983) provide some evidence that existing levels of density are a result of these market forces. Consistent with what we argued above they predict that the size of an urban spatial area should be related positively to population and income and negatively to transportation costs and the price of land at the urban fringe. They find empirical support for their predictions; metropolitan areas with larger populations, higher incomes, lower transportation costs, and lower values of agricultural land occupy greater amounts of land.

There are many potential causes of urban sprawl and any two occurrences of the phenomenon may have different causes. Bhatta (2010) divides the potential causes into two groups:

- Factors which contribute to urban growth in general such as population growth, economic growth, industrialization and transportation facilities. Whether the urban growth resulting from these factors is considered to be urban sprawl depends on its pattern, process and consequences.
- Factors which may directly facilitate urban sprawl such as poor urban planning, land values, physical geography, development and property taxes, housing availability, and the personal preference of residents

The consequences of urban sprawl are as varied as its causes and may be both positive and negative. Bhatta (2010) summarises the positive effects of urban growth in general such as higher economic production, increased opportunities for the unemployed and improved public services such as transportation and water supply. Other studies identify the positive effects of urban sprawl specifically, including increased satisfaction in housing preferences, easy access to open space, the benefits of later infilling "leapfrogged" land, the generation of suburban local governments which are likely to who both live and work in the suburbs (Kaplan and Austin 2004; Frenkel and Ashkenazi 2008; Wassmer 2008). However the negative effects of urban sprawl are widely considered to outweigh any positive effects, leading to the term having a negative connotation. The negative effects, as summarized by Bhatta (2010), can be divided into three groups:

- Economic effects including loss of productive farmland and increased public service and infrastructure costs.
- Environmental effects including loss and fragmentation of habitats, reduced air and water quality, and increased land surface temperatures.
- Social and public health effects including reduced accessibility and workability, increased dependence on private motor vehicles, and race and income based segregation. Song and Knaap (2004) provide more detail as to the link between urban sprawl and reduced public health. They state that, according to critics of urban sprawl, contemporary suburban developments:

- Are homogeneous and lack a mix of land uses, being dominated by single family dwelling units on large lots.
- Contain too many winding streets and cul-de-sacs, creating blocks that are too big and thus lack connectivity. As a result contemporary suburban development is characterized by too much separation between land uses and increased travelling distances. This leadsto a reduction in accessibility, walking and biking, and an increase in the use of private motor vehicles (Song and Knaap 2004)

(Siedentrop *et.al*.2005) mentions five quite different types of definitions of sprawl:

1. Definitions of sprawl according to density attributes of a settlement system: these definitions consider low-density forms of settlement, decreasing density und functional decomposition of cities as sprawl. Representatives of these definitions are for example (Glaeser and Kahn, 2003, Fulton et al., 2001).

2. Definitions of sprawl that deal with de-concentration processes of urban functions combined with the spatial expansion of urban uses into rural areas, represented by e.g.(Glaeser et al. 2003; Pumain, 2003).

3. Definitions of sprawl characterized by structure and form attributes of a settlement system. Sprawl is understood as an urban form building process that transforms a former monocentric compact structure into a discontinuous, polycentric and disperses settlement structure (Galster et al. 2000, Torrens, Alberti 2000, et al.).

4. Definitions based on socially relevant effects of land use, e.g. traffic induced effects, loss of fertile soils, etc. (Ewing, 1997, Downs, 1999).

5. Definitions based on normative planning and order perceptions. Unplanned urban development that runs counter to the objectives of spatial development is identified as sprawl (Gassner 1978 et al.).

Urban sprawl is initially detected by gauging urban growth in many ways. Masek measures urban growth by using remote sensing and GIS to measure rates of urbanization (Masek et al 2000). Other studies have measured sprawl in terms of data layers within a GIS to detect patterns of urban sprawl (Clarke et al 1998). Wilson et al. (2003) not only measure change of an individual pixel, but also changes within a framework of a neighborhood of pixels. This technique is known as neighborhood statistics and is extremely useful in visualizing densities of new growth areas.

In modeling the complex nature of urbanization, it is often necessary to apply more than one technique to understand how to measure an increase in urban growth or urban sprawl. In South Carolina, Allen et al (2003) used an integrated approach to model urban sprawl in which aspects of three different techniques were employed to model urbanization. The first enlisted a logistic regression model to predict urban transition probabilities. Next, a relative probability model was used to test different growth scenarios. Later, they organized focus groups to help set growth scenarios. While quantification of urban growth often involves a direct measurement of new built-up or urban land, it is also important to include qualitative information. A study done in the Chicago metropolitan region by Zhang (2001) found that social-economic factors were most important in attracting residents to a new development, potentially leading to urban sprawl. The discernment of qualitative data does not come from any single computer program because of the complexities of urbanization. Clearly, there have been many ways to measure urban dynamics indicating that there are numerous avenues to reach a similar destination. Population growth can be a driving force behind urban sprawl.

"If population growth is substantial enough to produce the required consumer market, "big box" commercial development often takes place. Seeking larger lots for stores, ample parking, easy access for multiple communities, and heavy commuting traffic, big-box developments locate on the outskirts rather than in the existing town commercial centers (Lindstrom et al., 2003, 11)."

A study done by Sprawl City, a non-profit organization that researches urbanization issues shows that there is a correlation between the amount of population growth and the consumption of land in what the United States Bureau of the Census calls urbanized areas (Sprawl City, 2005). Urbanized areas are comprised of the contiguous developed land of the central city and its suburbs (Sprawl City, 2005). In order to understand urban sprawl it is important to contemplate many different urban growth dynamics including population growth, land conversion practices, and market forces.

2.1.4 The Distinction between Growth and Sprawl

As urban growth occurs, that growth is often confused with urban sprawl. However, there is a distinction between urban growth and urban sprawl. Cities often experience growth either physically, by population, or by a combination of both. Urban sprawl is much more complicated because it may or may not qualify as urban growth. How a city grows can create the appearance of sprawl. Such urban growth may appear as a low density leapfrog pattern, a linear or strip development pattern along highways, or a tightly condensed pattern of new development around pre-existing built-up landscapes (Nechyba et al 2004). Without urban growth there would be no appearance of urban sprawl. The patterns represented by sprawling landscapes are aligned with the definition of the word sprawl. If I lay out on the floor in an awkward way, I am sprawling out. This idea coupled with urban development gives a good visualization of what urban sprawl may look like. A formal entry reads this way: "Sprawl v. sit or spread out in a relaxed or awkward way - n. sprawling position" (Goldman, 1993, p. 279). This definition coupled with the phrase urban growth is one example of the difference between simple growth and urban sprawl. Urban growth may have more of a planned appearance while the pattern of sprawl often appears awkward, uncontrolled, and haphazard. Perhaps there is a new development very similar to an urban landscape in the middle of a seemingly rural area broken up by many other rural landscapes such as farmland or forested areas. Perhaps the timing of this development closely follows the completion of a new road network or major highway.

The debate over urban sprawl is relatively new, yet there are many definitions of urban sprawl. This is due in large part because there is no consensus on what sprawl is and what is simply urban growth. Despite vivid examples of what some may classify as sprawl over a given landscape, there is no clear definition of urban sprawl that is shared by all who study urban phenomena. There are definitions based on characteristics of urban sprawl, effects of urban sprawl, and factors leading to urban sprawl. Further, definitions of urban sprawl are also influenced by the people that create them. Many definitions of urban sprawl may include bias towards being pro or con urban development. It is important to note a few of the definitions from different time periods. Here I would present those definitions in a chronological manner in order to show a progression in the concept of urban sprawl. Ottensmann (1977, 389) defines urban sprawl as "the scattering of new developments on isolated tracts, separated from other areas by vacant land." Ewing (1997, 108) characterizes urban sprawl as "leapfrog land use patterns, strip commercial development along highways, and very low-density single-use developments." Zhang (2001, 221) states that "urban sprawl results from poorly planned, large scale new residential, commercial and industrial developments in areas previously not used for urban purposes." For the purposes of my research, I would use a combination of all of the previous three definitions in my conceptualization of urban sprawl. In operational zing sprawl, I would use many of the techniques found in the literature review section of this paper. I would begin operationalization by isolating only urban land within the GIS for 1995 and 2001.I will incorporate road data at this point. Then, I would use neighborhood statistics to measure the density and connectivity of new patches of urban growth. After quantifying how dense and connected patches of new growth are, I would classify those new growth areas as one of three types of sprawl: linear along highways, cluster, or leapfrog. I would also incorporate responses to interview questions from developers, land owners, and local planners and analysis of planning documentation to gauge opinions and perceptions of sprawl as well as planning practices.

2.2 Global trends in Urban Sprawl

As population increases, urban sprawl on a global scale is becoming more apparent than ever. Increases in population often lead to increases in development, which has a direct influence on agricultural land conversion. Masser (2000) states that urban growth is inevitable over the next two decades and that most of this growth will take place in less developed countries. In China, rapid land use change has occurred since economic reform (Gar-On Yeh et al 1998). A study done there measures urban sprawl in terms of land suitability and the favorability that land has for being converted to an urban use (Gar-On Yeh et al 1998). The authors were interested in developing a model that could be used for sustainability purposes in an attempt to control urban sprawl under rapid rural urbanization (Gar-On Yeh et al 1998).

"This is most severe in southern China and the coastal areas where the economy is developing very rapidly and the conflict between the environment and economic development is most severe (Gar-On Yeh et al., 1998, 169-170)."In Dongguan, a fast growing city in southern China, the conversion of agricultural land into urban land has removed the possibility for food production forever (Gar-On Yeh et al 1998).

Southern China is not the only place where patterns of urban sprawl are materializing due to sharp increases in population and the creation of new infrastructure. In other developing countries like India, where the population is over one billion, one sixth of the world's population, urban sprawl is taking its toll on natural resources (Sudhira et al 2004).The study area of Mangalore, India is a national leader in banking, private entrepreneurship, insurance and other financial institutions (Sudhira et al 2004). Mangalore, India has also seen an increase in the amount of industrialization in the form of Iron Ore Pelletization Units, Fertilizer, Refinery, and Petro-chemicals with the economy also fortified by agricultural processing and port related activities (Sudhira et al 2004). Over 25% of India's population lives in urban centers and it is projected that about 33% of the population will be living in urban centers in the next 15 years (Sudhira et al 2004).

This indicates the alarming rate of urbanization and the extent of sprawl that could take place. In order to understand this increasing rate of urban sprawl, an attempt is made to understand the sprawl dynamics and evolve appropriate management strategies that could aid in the region's sustainable development (Sudhira et al., 2004, 29).The approach to the Sudhira (2004) study is to use change at the landscape level within a Geographic Information System to calculate the fragmentation and patch density of newgrowth areas and classify those areas as sprawl. While many models seek to achieve this goal, they do not relate urban sprawl to anything more than urban growth. The inadequacy in some of these is that the models fail to interact with the causal factors driving the sprawl such as population growth, availability of land and proximity to city centres and highways (Sudhira et al., 2004, 30). Sudhira et al (2004) use GIS, remote sensing, and landscape metric techniques to quantify urban sprawl by measuring densities and spatial distributions of built-up land. Using landscape metrics that show densities of urban land and connectivity of that land, the authors are able to justifiably classify different types of urban sprawl: cluster, leapfrog, and linear (Sudhira et al 2004). More dense and compact areas of built-up land are classified as cluster, while medium density areas with low connectivity areas are indicative of leapfrog patterns. The linear pattern of sprawl is classified as high and medium density built-up areas of development located along the highways (Sudhira et al 2004). This technique for quantifying urban sprawl is extremely adequate based on the assumption that it is the pattern and spatial distribution of urbanization that is the key component to urban sprawl.

2.3 Measuring Urban Sprawl

Just as there are many ways to define urban sprawl, there are also many ways to measure the phenomenon. Frenkel and Ashkenazi (2008) divide measurement methods suggested in the literature into five major groups, and each group addresses different definitions of urban sprawl:

- Growth rates – measures include comparison of the growth rate of an urban area versus the population living in that area (Jat et al. (2008); Bagan and Yamagata 2012; Hammann 2012).
- Density – measures include determining the ratio between the amount of a certain urban activity (e.g. residential units) and the area in which it takes place (e.g. Galster et al. 2001; Song and Knaap 2004; Knaap et al. 2005; Lowry and Lowry 2014).
- Spatial geometry – measures involve determining the geometric configuration and composition of an urban area including the degree to which its configuration is irregular, scattered and fragmented, and composition homogeneous and segregated (e.g. Torrens and Alberti 2000; Galster et al. 2001; Song and Knaap 2004; Knaap et al. 2005; Lowry and Lowry 2014).
- Accessibility – measures include determining household travelling distances and/or times to public service facilities, employment areas and commercial areas (e.g. Song and Knaap 2004; Knaap et al. 2005; Sohn et al. 2012; Lowry and Lowry 2014).
- Aesthetics – measures include resident surveys and comparison of landscapes with defined archetypes of urban sprawl (e.g. Torrens and Alberti 2000). Beingsubjective by definition, it is difficult to measure and quantify the aesthetics of sprawl (Frenkel and Ashkenazi 2008).

2.4 Methodological approaches to Sprawl

As the previous discussion shows, urban sprawl is difficult to measure because it is difficult to define. Further, definitions and ideas about urban sprawl abound and are largely shaped by contributions of many different disciplines and their ideas about urbanization. A starting point for much of the research on urban sprawl is measurement and understanding urban growth processes. Assuming that all urban sprawl comes from urban growth, there is an obvious connection between the two.

Much of the quantitative research on urban sprawl begins with measurements of urban growth over a given time period. Gar-OnYeh et al. (2001) measure the urban form of an area to examine a change in shape, size, and configuration of the built-up environment. They use Shannon's entropy, which measures the degree of spatial concentration or dispersion of a geographic variable, coupled with a GIS and remote sensing technology to calculate sprawl. This type of research keys in on aspects of sprawl such as density, connectivity, and location of new urbanization. There is also an inherent variable of time that must be incorporated into these studies to account for rates of growth, which is a key component of sprawl. Allen et al. (2003) calibrated their model of urban growth with data from 1973, 1975, 1981, 1985, 1989, and 1994 in order to predict growth scenarios up to the year 2030. The researchers used a logistic regression technique to generate probabilities that parcels of land would be converted to urban land use based on land suitability (Allen et al 2003). By using remote sensing and GIS to examine different urbanization scenarios for different years, Allen et al. (2003) predicted the degree of urbanization over the next 20 to 30 years.These approaches although useful do not consider the underlying social processes that generate urban sprawl. Zhang (2001) examined local and regional factors related to urban sprawl such as federal policy on mortgage interest taxation and public spending, community location, transportation accessibility, and community features of a neighborhood.

2.5 Causes of urban sprawl

According to Siedentop (2005) there are two rivaling explanation patterns for causes of urban sprawl: firstly sprawl is explained by the demand for urban land. Driving forces are land consumption of households, companies, and public uses. Factors such as income, wealth and car use provide the framework and location choices are made based on a comparison of utility effects and costs. Secondly sprawl is explained by specific regulation patterns. The massive public subsidies for low density, suburban forms of living and the publicly financed construction of street networks and local infrastructure reinforce urban sprawl. According to this view, urban planning is the main cause of sprawl. Conceptually, the arguments based on the demand for urban land relate to the

“monocentric modell” of the Alonso-Muth-Mills type. In this model, the externally given central business district (CBD) is the center of the city and the location where all relevant interaction takes place. Households – and in some versions also businesses – choose their location in the surrounding area on the basis of microeconomic constrained optimization. They allocate their income optimally between land, consumer goods, and cost of transportation to the CBD. Sprawl-like phenomena can arise from three factors: declining transport costs, increasing income, and increases in total population. The first two factors yield the same effects. Since households demand more land and can afford longer commutes, density declines near the CBD, but increases at the outer parts of the city. The size of the city increases as agricultural land at the urban fringe is converted to urban uses. As far as the footprint of the city is concerned, an increase in population has the same effect. Density increases in all parts of the city as a reaction to population growth. In percentage terms, this increase in density is much larger at the outskirts than near the CBD. While in the monocentric model we are constrained by assumption to only one centre, in polycentric versions of the model, these driving forces lead to the creation of new

Sub centres, and can explain the rise of edge cites. Since the causes are two fundamental economic trends – increasing incomes and declining transport costs – the question arises, whether their logical consequences should be called urban sprawl. Particularly, when taking into account the negative connotations of the term. Mieszkowski and Mills (1993) see these factors as driving forces in a “natural evolution” theory of what causes suburbanization. Gordon and Richardson (1996) speak about “natural economic factors”. Closely related are some social segregation processes that are often related to sprawl. In the monocentric model, households with higher income will locate at higher distance from the CBD than low- income households, since they allocate more money to transportation to the CBD in their optimal allocation than. This effect is supported further by the lower land prices at the urban fringe. This process is in line with Tie bout’s argument that people sort themselves into different local jurisdictions based on their preferences for local amenities. The income effect in the monocentric model relaxes the constraint for Tie bout-type self selection and can itself be viewed as contributing to the pull factor of the argument. The segregation process is possibly strengthened by some cumulative feedback loops – sometimes called “flight from 10the bright” – that push certain social groups from central locations.

2.6 Characteristics of urban sprawl

Many of the aspects which characterize sprawl have been already mentioned indirectly. Burchell et al. (1998) characterize sprawl in two ways: on the one hand residential low-density scattered development and on the other hand non-residential scattered commercial and industrial development. Scattered development is a form that is commonly associatedwith urban sprawl. He further describes 10 points that characterize urban sprawl – these following characteristics are based on a review of research findings:

- Low residential density
- Unlimited outward extension of new development
- Spatial segregation of different types of land uses through zoning regulations
- Leapfrog (discontinuous) development
- No centralized ownership of land or planning of development
- All transportation dominated by privately owned motor vehicles
- Fragmentation of governance authority over land uses between many local governments
- Great variances in the fiscal capacity of local governments because the revenue rising capabilities of each are strongly tied to the property values and economic activities occurring within their own borders
- Widespread commercial strip development along major roadways
- Major reliance upon the filtering or "trickle-down" process to provide housing forlow-income households.

This categorization brings a lot of points into the discussion – the problem is that within this list, the limits between causes, characteristics and consequences of sprawl are ambiguous and a clear distinction between these categories is not entirely possible. The 10 points stated can be subdivided in spatial patterns, main causes and main consequences of sprawl. One of the most elaborated characterizations of urban sprawl is given by Galster et al. (2001). Galster contends that sprawl is characterized by 8 dimensions. We will find these dimensions again, when we talk about measuring sprawl, because he orientates along these dimensions when quantifying the degree of sprawl. Within this section we present these 8 dimensions and their meaning:

- ✓ Density: is a widely used indicator of sprawl whereby different types of density can be described.
- ✓ Continuity: is the degree to which the unused land has been built densely in an unbroken fashion. Sprawl can be continuous or discontinuous in other places.
- ✓ Concentration: describes the degree to which development is located disproportionately rather than spread evenly.
- ✓ Clustering: sprawl is frequently clustered what means that it only occupies a small portion of the respective land area.
- ✓ Centrality: the loss of centrality is one of the most serious concerns about sprawl.
- ✓ Nuclearity: describes the extent to which an urban area is characterized by a mononuclear pattern of development.
- ✓ Mixed uses: sprawl is seen as a process that separates the different kinds of land uses (separation of homes, workplaces, conveniences, income segregation along residential communities).
- ✓ · Proximity: proximity is the degree to which land uses are close to each other (housing, work, shopping, etc.). The lack of proximity contributes to many of the externalities attributed to urban sprawl.

2.7. Urbanization and urban Growth

Urbanization or urban drift is the physical growth of urban areas as a result of global change. Urbanization is also defined by the United Nations as movement of people from rural to urban with population growth equating to urban migration. Urbanization is the outcome of social, economic and political developments that lead to urban concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and governance.

The rapid urbanization of the world's population over the twentieth century is described in the 2005 Revision of the UN World Urbanization Prospects report. Based on this, global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005. According to the UN State of the World Population 2007 report, sometime in the middle of 2007, the majority of people worldwide will be living in towns or cities, for the first time in history; this is referred to as the arrival of the "Urban Millennium" or the 'tipping point'. In regard to future trends, it is estimated 93% of urban growth will occur in developing nations, with 80% of urban growth occurring in Asia and Africa. Urbanization rates vary between countries. The United States and United Kingdom have a far higher urbanization level than China, India, Swaziland or Niger, but a far slower annual urbanization rate, since much less of the population is living in a rural area.

2.7.1. Trends of urbanization in Africa

Urbanization is increasing in both developed and developing countries. However, rapid urbanization, particularly the growth of large cities, and the associated problems of unemployment, poverty, inadequate health, poor sanitation, urban slums and environmental degradation pose a formidable challenge in many developing countries. Although urbanization is the driving force for modernization, economic growth and development, there is increasing concern about the effects of expanding cities, principally on human health, livelihoods and the environment. The implications of rapid urbanization and demographic trends for employment, food security, water supply, shelter and sanitation, especially the disposal of wastes (solid and liquid) that the cities produce are staggering (UNCED, 1992). The question that arises is whether the current trend in urban growth is sustainable considering the accompanying urban challenges such as unemployment, slum development, poverty and environmental degradation, especially in the developing countries. Natural population increase (high births than death) and migration are significant factors in the growth of cities in the developing countries. The natural increase is fuelled by improved medical care, better sanitation and improved food supplies, which reduce death rates and cause populations to grow. In many developing countries, it is rural poverty that drives people from the rural areas into the city in search of employment, food, shelter and education. In Africa, most people move into the urban areas because they are „pushed" out by factors such as poverty, environmental degradation, religious strife, political persecution, food insecurity and lack of basic infrastructure and services in the rural areas or because they are „pulled" into the urban areas by the advantages and opportunities of the city including education, electricity, water etc. Even though in many African countries the urban areas offer few jobs for the youth, they are often attracted there by the amenities of urban life (Tarver, 1996).

2.7.2. Trends of urbanization in Ethiopia

Ethiopia was under-urbanized, even by African standards. In the late 1980s, only about 11 percent of the population lived in urban areas of at least 2,000 residents. There were hundreds of communities with 2,000 to 5,000 people, but these were primarily extensions of rural villages without urban or administrative functions. Thus, the level of urbanization would be even lower if one used strict urban structural criteria. Ethiopia's relative lack of urbanization is the result of the country's history of agricultural self-sufficiency, which has reinforced rural peasant life. The slow pace of urban development continued until the 1935 Italian invasion.

Urban growth was fairly rapid during and after the Italian occupation of 1936-41. Urbanization accelerated during the 1960s, when the average annual growth rate was about 6.3 percent. Urban growth was especially evident in the northern half of Ethiopia, where most of the major towns are located. Addis Ababa was home to about 35 percent of the country's urban population in 1987. Another 7 percent resided in Asmera, the second largest city. Major industrial, commercial, governmental, educational, health, and cultural institutions were located in these two cities, which together were home to about 2 million people, or one out of twenty-five Ethiopians. Nevertheless, many small towns had emerged as well. In 1970 there were 171 towns with population of 2,000 to 20,000; this total had grown to 229 by 1980. The period 1967-75 saw rapid growth of relatively new urban centers. The population of six towns--Akaki, Arba Minch, Awasa, Bahir Dar, Jijiga, and Shashemene--more than tripled, and that of eight others more than doubled. Hawasa, Arba Minch, Metu, and Goba were newly designated capitals of administrative regions and important agricultural centers. Hawasa, capital of Sidamo, had a lakeshore site and convenient location on the Addis Ababa-Nairobi highway. Bahir Dar was a newly planned city on Lake Tana and the site of several industries and a polytechnic institute. Akaki and Aseb were growing into important industrial towns, while Jijiga and Shashemene had become communications and service centers.

Urban centers that experienced moderate growth tended to be more established towns, such as Addis Ababa, Dire Dawa, and DebreZeyit. A few old provincial capitals, such as Gonder, also experienced moderate growth, but others, such as Harer, Dese, Debre Markos, and Jimma, had slow growth rates because of competition from larger cities. By the 1990s, Harer was being overshadowed by Dire Dawa, Dese by Kembolcha, and Debre Markos by Bahir Dar. Overall, the rate of urban growth declined from 1975 to 1987. With the exception of Aseb, Arba Minch, and Hawasa, urban centers grew an average of about 40 percent over that twelve-year period. This slow growth is explained by several factors. Rural-to-urban migration had been largely responsible for the rapid expansion during the 1967-75 periods, whereas natural population growth may have been mostly responsible for urban expansion during the 1975-84 periods. The 1975 land reform program provided incentives and opportunities for peasants and other potential migrants to stay in rural areas. Restrictions on travel, lack of employment, housing shortages, and social unrest in some towns during the 1975-80 period also contributed to a decline in rural-to-urban migration. Although the male and female populations were about equal, men outnumbered women in rural areas. More women migrated to the urban centres for a variety of reasons, including increased job opportunities. As a result of intensified warfare in the period 1988-91, all urban centres received a large influx of population, resulting in severe overcrowding, shortages of housing and water, overtaxed social services, and unemployment. In addition to beggars and maimed persons, the new arrivals comprised large numbers of young people. These included not only primary and secondary school students but also an alarming number of orphans and street children, estimated at well over 100,000. Although all large towns shared in this influx, Addis Ababa, as the national capital, was most affected. This situation underscored the huge social problems that the Mengistu regime had neglected for far too long (Asefa, 1993). According to a report in 1996, since 1940 the proportion of urban population to the national has grown 5 times. While the rate was only 3 per cent in 1940, it was almost tripled and reached 8.5 per cent in 1967. In the year 1970 about 9.7 per cent of the population was living in urban areas, while in 1984 and 1994 it reached 11.4 and 15.7 per cent respectively. Today, about 17.6 per cent of the total population is estimated to live in urban areas and this is expected to reach about 29 per cent by the year 2020. These figures display the fact that the rate of urbanization in Ethiopia is well below the African average, which is about 30 per cent in 1996 cited in (Seid, 2007).

2.7.4. Impacts of urban Expansion

As the World Bank transport and urban Development Department indicated, even though, the available evidences are spotty, controversial and not necessarily applicable to developing country cities, suggest that the growth and expansion of cities are associated with both positive and adverse outcomes that affect the welfare and wellbeing of the citizens. The available literature concerning urban expansion is rife with blame for its inappropriate and unnecessarily costly for developing world cities. Most blame is directed at expensive leapfrogging green filed development. It is claimed that such development reduces both access and view of open space. It encroaches on sensitive environments and on scarce farmlands. It requires long journeys to work; it leads to higher levels of car use and therefore, to higher levels of air pollution, energy use, and the production of greenhouse gases; it increases dependence on vehicles; it makes public transport less attractive and less efficient. It also requires longer and more costly extensions of public infrastructure networks and it imposes additional costs on residents of new expansion sites. It also diverts construction away from the central parts of the cities that needs to be redeveloped. As a result of urban expansion social interaction between people reduces and urban lifestyle becomes less exciting resulting in alienation, social fragmentation, and both economic and social segregation and unplanned changed of farming land into urban land (Durlauf et al,1995).

2. 7.5. Monitoring urban Expansion

Monitoring urban growth is one of the questions social scientists, urban planners and decision-makers deal with most frequently. The direct impacts of urban expansion on physical, ecological and social resources have made research on urban sprawl of increased interest. Traditional census sources are extremely useful in that they capture changes in thesocioeconomic and demographic structure of cities, but they lack spatial details and are not frequently updated. Remote sensing, on the other hand, makes available a vast amount of data with continuous temporal and spatial coverage and can therefore provide a successful means for monitoring urban growth and changes. Using remote sensing for change detection studies naturally requires that the different temporal images are atmospheric and zenith-angle corrected and carefully co-registered, in order to avoid errors in the estimation of land cover changes. Despite the extensive literature of change studies available, most of these studies are based on more traditional land cover classifications and only a few report developments of integrated datasets that can be used in planning and urban monitoring efforts. Many cities in developing countries are experiencing rapid increase in population and consequential urban Expansion. Remote sensing may provide fundamental observations of urban growth that are not available from other sources.

2.8 GIS and Remote sensing application in urban studies

Population growth and urban expansion have advanced at an unprecedented pace over the past few decades. Although cities occupy only a very small portion of the earth's total land surface, almost half of the world population lives in urban areas (United Nations, 2001). Remote sensing provides spatially consistent data sets that cover large areas with both high spatial detail and high temporal frequency. Dating back to 1960, remote sensing can also provide consistent historical time series data. The importance of remote sensing was emphasized as a "unique view" of the spatial and temporal dynamics of the processes in urban growth and land use change (Herold et al., 2003). Satellite remote sensing techniques have, therefore, been widely used in detecting and monitoring land cover change at various scales with useful results. Recently, remote sensing has been used in combination with Geographical Information Systems and Global Positioning Systems to assess land cover change more effectively than by remote sensing data only (Weng, 2002). It has already proved useful in mapping urban areas, and as data source for the analysis and modeling of urban growth and land use/land cover change. The increasing demands in urban planning and management sectors call for co-ordinate application of remote sensing and Geographic Information Systems for sustainable development of urban areas. Thus, there is an urgent need to adopt Remote Sensing and Geographic Information System approaches in urban studies and development processes. If this is done, it will certainly help in evolving efficient and economical models for the development and the allocation of industries, education, housing, water supply, service facility, and disposal systems that is related to urban studies. (GIS) and remote sensing application in land and natural resources management is widely used globally. Land use and land cover changes as one of the main force of global environmental changes, and for sustainable development. Current technologies such as geographical information systems (GIS) and remote sensing provide a cost effective and accurate alternative to understand the dynamics of landscape. Digital image base detection of LULC based on multi-temporal and multi- spectral remotely sensed data have depicted a great potential to understanding landscape dynamics to detect, identify map and monitor differences in LULC pattern over time. Unfortunately, the conventional surveying and mapping techniques are expensive and time consuming for the estimation of urban sprawl and such information is not available for most of the urban centers especially in developing countries. As a result, increased research interest is being directed to the mapping and monitoring of urban sprawl/growth using GIS and remote sensing techniques (Epstein et al., 2002). Remote sensing is cost effective and technologically sound, so is increasingly used for the analysis of urban sprawl (Sudhira et al., 2004; Yang and Liu, 2005; Haack and Rafter, 2006). For nearly three decades, extensive research efforts have been made for urban change detection using remotely sensed images.

The complexity of urban systems makes it difficult to adequately address their changes using a model based on a single approach (Allen et al., 2003, 1). Therefore, it is ideal to use a tool such as a GIS as part of research on urban sprawl because of its capacity to handle many different types of spatial data. In South Carolina, a GIS-based integrated approach to modeling and prediction of urban growth in terms of land use change was employed to meet the challenge of studying urban sprawl (Allen et al 2003). The researchers used satellite imagery incorporated into a GIS to map predictions of urban growth in the study area. The predictions were based on variables such as road density, forest, slope of the land, and population density. Each variable was entered into the system as a data layer and multiplied by a coefficient to determine how likely it was that a given parcel of land would be converted to urban land use (Allen et al 2003). In East and West St. Paul, Winnipeg, Manitoba, Canada, most urban sprawl was occurring on prime agricultural land (Hathout 2002). In that study, a GIS was used to predict future growth patterns and the impacts that such growth would have onagricultural land (Hathout 2002). Hathout (2002) used the data base analysis capabilities found in a GIS to analyze aerial photographs of the study area from 1960 and 1989 to determine impacts on agricultural land. For that study, land use derived from the aerial photographs in the GIS was placed in one of three main categories: urban, agricultural, and other (Hathout 2002).

A study conducted on the Washington-Baltimore CMSA used a cellular automata model combined with historical maps in a GIS to determine where future development may occur (Clarke et al 1998). The cellular automata model assumes an action within a given space, viewed in this case through a GIS grid, a set of initial conditions, and a set of behavior rules (Clarke et al 1998). GIS grid data layers were incorporated into IDRISI, GIS software, and iterations were performed to show different growth scenarios given different behavior rules

(Clarke et al 1998). The same study was also able to use the GIS to produce maps of different growth scenarios, which allowed visualization of the results. A GIS will not only allow for powerful visualization of urban sprawl within the study area by providing maps, but it will also allow for an in depth analysis of the data by providing the capability to examine all of the data in one system therefore facilitating the measurement of urban sprawl.

A GIS is also an extremely powerful tool for creating new data from existing data and is often referred to as a decision support system (Burrough et al 1998). In China, A GIS was used as a decision support system to test different development scenarios and land consumption parameters for use by planners and local government officials (Gar-On Yeh et al 1998). Using the neighborhood function in the GIS, Gar-On Yeh et al. (1998) were able to test development scenarios that would reduce the fragmentation of new growth, a component of urban sprawl (Gar-On Yeh et al 1998). In another study by the same authors, it was concluded that Landsat TM images coupled with an entropy integrated GIS was successful in measuring and monitoring urban sprawl patterns when the area is large and land use changes quickly (Gar-On Yeh et al 2001). Gar-On Yeh et al. (1998) employed a Shannon's entropy technique with the integration of remote sensing and GIS. Shannon's entropy is another landscape metric calculation technique whereby the authors measured urban sprawl patterns statistically based on the spatial variation and temporal changes of growth areas (Gar-On Yeh et al 1998). A numeric value was given to the new growth areas to quantitatively describe how dense and connected growth areas were (Gar-On Yeh et al 1998). The methods used to quantify urban sprawl throughout the literature are dependent on the intended purpose and the individual aim of each piece of research. The objective of the research conducted on the Washington-Baltimore CMSA was to relate observed changes in land cover to economic and demographic drivers of that change (Masek et al., 2000, 3474). They used historic and present-day satellite imagery to measure land use change, but it was unclear how the researchers were going to link those changes to economic and demographic data. The purpose of the study was to quantify and map urban growth thereby determining the geographic extent, pattern, and class of such growth over time. The researchers categorized satellite-derived imagery into three classes: developed, non-developed, and water. Then, a window technique was used within a GIS to analyze each pixel according to its neighboring pixels. The value of each pixel was added up and attributed to the center cell of the window each time it passed over the study area. This is an extremely effect method to measure urban growth patterns over time and therefore classify that growth as urban sprawl. "The model can be used to describe the urbanization processes in a way that offers insight into changing and emerging landscape patterns, without applying subjective labels (Wilson et al., 2003, 284)." As Wilson et al. (2003, 275) show, urban sprawl has been cited for its negative impacts on the environment, but with no clear definition of urban sprawl, it is difficult to measure.

2.14 Conceptual definition of urban sprawl

The term “sprawl” was first used in 1937 by Earle Draper of the Tennessee Valley Authority in the context of a national conference of planners (cit. in Wassmer 2002). Sprawl was referred to as an unaesthetic and uneconomic settlement form. According to Wassmer (2002) the term “urban sprawl” was first used in the opening paragraph of an article by the sociologist William Whyte in Fortune magazine in 1958. Planners have since then used the term to categorize an urban development, generating undesired social effects. Urban Economists also adopted the term and added to the debate terms like scatter, leapfrogging and ribbon development (explained later). The Real Estate Research Corporation inaugurated in 1974 the controversial debate on positive and negative effects of sprawl (Real Estate Research Corporation, 1974). In the 1990s the phenomenon of sprawl was adopted by other sciences as well as the general public in the US. At this time the Anti-sprawl-movement arose and first measures of urban sprawl were conducted. Small (2000) argues that the public and policymakers often use the term as a medical analogy. Urban sprawl is seen as a disease, detected by its undesirable symptoms. Many cures are offered for this disease, although we seem to be lacking a solid understanding of the underlying causes and mechanisms. Al Gore (cit. in Wassmer 2002) argues that sprawl has become the concept of the “enemy”, without understanding exactly what it really is. As the concept of sprawl was “invented” in the US, it was anchored in the US context and discussion for a long time.

CHAPTER THREE

3 Description of the study area and methodology

3.1 Description of the study area

3.1.1 Geographical Location

Holota town is located in central part of Ethiopia finfinne special zone .At present; the town has 8 administrative sub divisions or kebeles. Holota is the major town in the former welmerawereda. The total area of the town is 76.5square kilometer. It is located 28km from addis to the west. The study area lies within9^0 3' N 38^0 30'E longitude. The elevation of the study area lies 2391m (7844ft) above mean sea level (Holota town socio economic office2018)

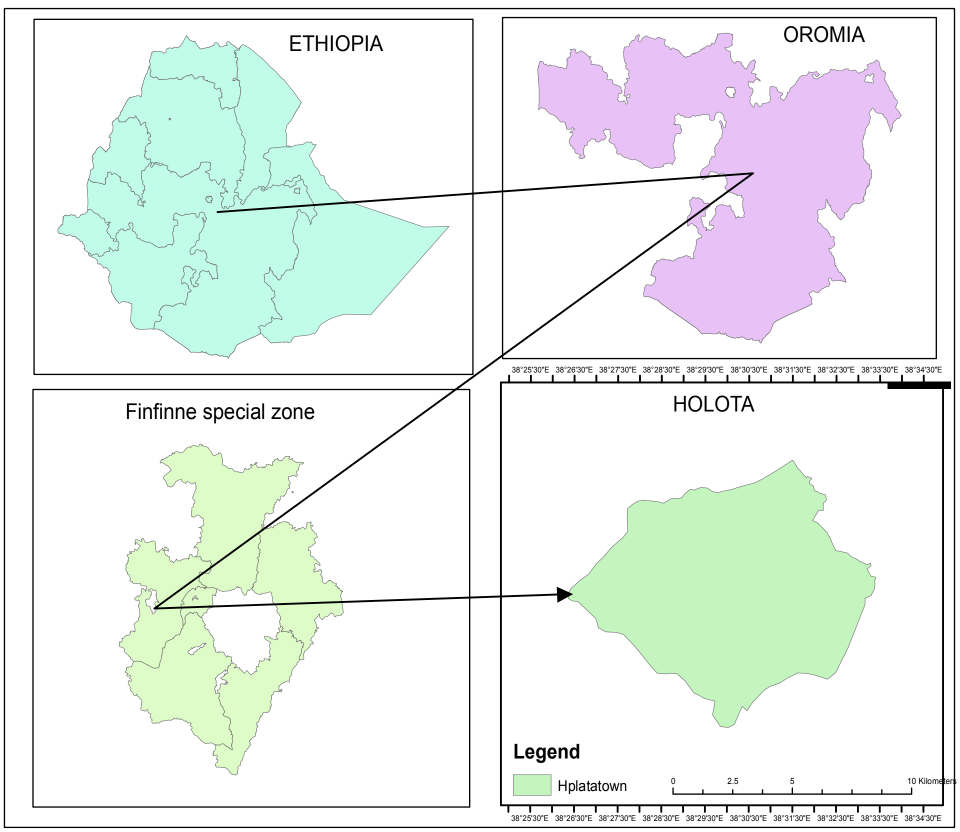


Figure 3.1 Map of the study area (sources Ethiopian geospatial agency and researcher)

3.1.2 Climate and Topography

Agro ecologically, the study area are classified as sub-tropical or it account 100%. The area receives higher rain fall at some part of the year. Te rain fall pattern is bimodal highly erratic and

UN predictable in nature and its distribution most of the time extends from June to August. It contains 43% of humidity and the wind direction of the study area is 8km/hr at the east direction. (Holota town Environmental protection and rural land Administration office 2010).

The rain fall data from the year 1995-2017 show that 75% of the total rain fall occurs b/n June to September. Based on the data from Holota town metrological station 23% of the total amount of rain fall in the month of April, May, October and November. And 2% occurs in January.

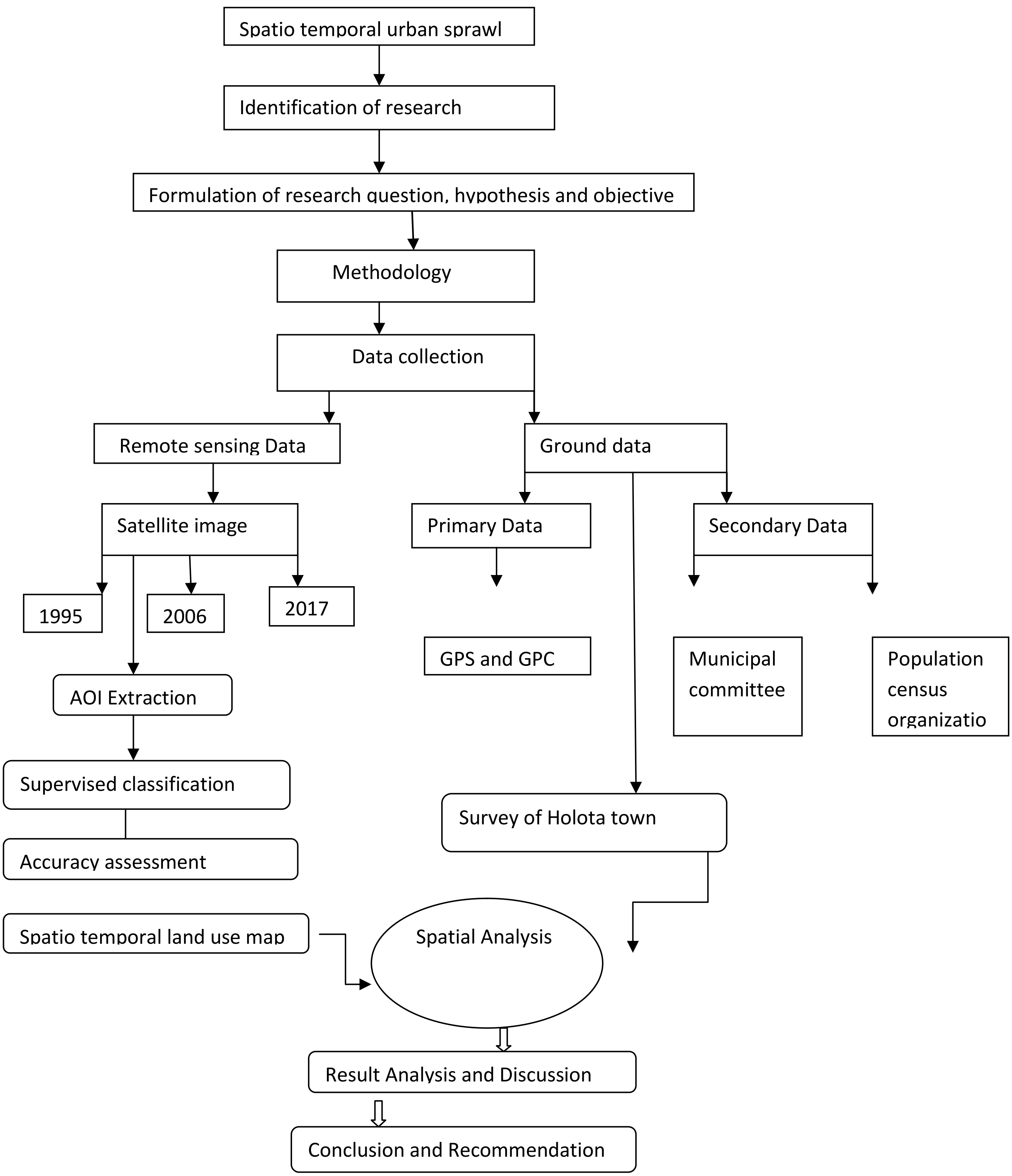
The highest and lowest rain falls of the study area 1100mm and 1040 mm respectively. The annual maximum and minimum temperature of the study area were 21^0C and 6^0C respectively. (Holota town Agricultural and rural development office 2010).

3.1.3 Demographic and socio-economic profile of the study area

The current total population of the study area is 63139 of which 30938 are male and 32201female. Total the population density of the study area is about 38 persons per square kilometer (Holota town, 2017).Religious activities practiced in the study area include Christianity with different denominations like Protestant, Orthodox, Adventist, and Catholic. Islam, Waqefata and indigenous beliefs are also being practiced in the District (Holota town socio-economic profile, 2018).

3.2 Research Design

The method of research for this study was survey research design. The reason for this researcher chooses this design was that it enabled to describe the intended study of spatio temporal urban sprawl in Holota town. In order to address the stated objectives the researcher was use both qualitative and quantitative types. This is because the proposed study needs the collection of statistical (numerical) data for the quantitative approach. Qualitative method applied to describe the existing conditions of sprawl of the town and by using qualitative data, options that are hold and processes that are going on regarding to the urban expansion to periphery of Holota town.


Spatio temporal urban sprawl
Identification of research
Formulation of research question, hypothesis and objective
Methodology
Data collection
Remote sensing Data
Ground data
Satellite image
Primary Data
Secondary Data
1995
2006
2017
GPS and GPC
Municipal committee
Population census organizatio
AOI Extraction
Supervised classification
Survey of Holota town
Accuracy assessment
Spatio temporal land use map
Spatial Analysis
Result Analysis and Discussion
Conclusion and Recommendation

Firure 3.2: Methodological flowchart of the study

3.3 Data sets and sources

Reliable data is necessary to realize the designed objectives and hence the study is based on both Primary and secondary data.

3.3.1 Primary Data Sources

Important sources of primary data for this study were key informant interview, field observations and Ground Control Points (GCP). Those generated during geophysical survey and the number of Ground Control Points measure by GPS (Global Position System) from field.

A) Key informant interview

The researcher prepared an interview guides for displaced farmers, experts of the municipality, kebele administration and elders of the community. Because experts and office head who are directly working on the issue believed to have rich data than the others. In addition, it helps to get required information from community elders could describe changes resulted over time than other existing young people. Hence, purposive sampling was used to select participants for key informant interviews. Finally, 10 people participated in the key informants interviews. More specifically, three from Municipality of the town, two from Office of Land Management of Holota town, three from Community elders, two from kebele Administration.

B) Field observation

Ground truth data‟s on the field were collected by direct observation on the selected area for this study. The researcher observed and collected the necessary visual information with the help of hand held GPS and camera from the existence of urban expansion. Observation used by the researcher in order to get more information to accurate the information gets from the other tools. Observation checklist was used by researcher to conduct field survey systematically.

3.3.2. Secondary Data Sources

The secondary sources of data were also collected from books, journals, official reports, websites, legal documents, satellite images, previous study documents, meteorological data, population data, aerial photograph and topographic map 1:50,000 of Holota town from the former Ethiopian Mapping Agency(EMA)or currently Ethiopian geospatial agency data's were widely used. The primary and secondary data are the two major categories of information sources would be used in this study. These among others include results of the spatiotemporal and the history of the town focus group discussions, in-depth interviews, GPS, satellite image and files, archives and documents on the other. Similarly, all available published and unpublished sources on urban expansion and sprawl in general and on Holota town in particular will be used carefully and patiently.

A) Satellite Imageries

In order to assess the urban sprawl in the study area, Landsat imagery of (1995, 2006 and 2017) cloud free image for Holota town, path 169 and row 54 were acquired from website. These data's were used to produce the historical land use/ land cover maps of the study area urban sprawl and expansion changes. The images were downloaded from the United States Geological Survey (USGS) Earth explorer website and spatially referenced in the Universal Transverse Mercator

UTM) projection with datum World Geodetic System (WGS) 1984 UTM zone 37N. The images were extracted to Tiff formats for processing and the detail of image properties are summarized in (table 3.1) below.

Table 3.1. The characteristics of landsat satellite data used in this study

Acquisition date	**Sensor**	**Path/Row**	**Spatial resolution**	**Number of band**	**format**	**Source**
25 Jan,1995	Landsat 7 ETM+	169/54	30	7	GeoTiff	USGS
20 Feb,2006	Landsat 7 ETM+	169/54	30	8	GeoTiff	USGS
22 March,2017	Landsat 8 OLI	169/54	15	11	GeoTiff	USGS

Satellite bands were composed in different ways in order to identify surface features in the study area. True color composite usually known by RGB 321 combination where band 3 reflects red color, band 2 reflects green and band 1 reflects blue color. Another composite called "false color composite" which uses an RGB combination of 432. In this band combination band 4 represents the NIR infrared, band 3 belongs to red and band 2 to green.

3.4. Sampling method

To interview and ask some important questionnaire it would be conducted using purposive sampling was used to select participants for key informant interviews. Finally, 10 people participated in the key informants interviews. More specifically, three from Municipality of the town, two from Office of Land Management of Holota town, three from Community elders, two from kebele Administration. In the Gis and RS technique the supervised maximum likelihood classification method would be used to classify the Landsat images from 1995, 2006 and 2017 into four LULC classes. Such as built up area, Agricultural land, grass land and forest land.

- Built-up

Urban or Built-up land is comprised of areas of intensive use with much of the land covered by structures. Included in this category are all manmade features such as houses, roads, transportation, power, and communications facilities,

- Cultivated land or Agricultural land

Agricultural Land for the purpose of this study defined broadly as land used primarily for production of food. On high spatial resolution imagery, agricultural activity can be seen with distinctive geometric field and road patterns on the landscape. However, on Landsat images, the agricultural land is classified based on pixel reflectance properties

- Grass land

From Landsat imagery alone, it generally is not possible to make a distinction between Cropland and Pasture with a high degree of accuracy. However, grass land and pasture had different pixel reflectance property on Landsat imagery used for this work. High resolution image was referred for the spatial location of grass and pasture. Therefore, grass and pasture in this work includes open field with grass and land used for grazing purpose.

➢ Forest land

In this study the vegetation includes planting of trees around compounds, eucalyptus wood lots and road side tree planting

3.5 Methods of data collections

Multiple data gathering instruments would be employed to collect data in the study areas

3.5.1 Data Generation from Digital Elevation Model (DEM)

The physiographic characteristics of a given area can determine the amount, pattern and direction of land-use/ land-cover change on a given urban environment. Spatial data used in GIS analysis come from a wide variety of sources, in a number of different formats, resolutions, scales, and projections. One of the data source for GIS is Digital Elevation. Digital elevation models are essential for a number of topographic and hydrological analysis including slope computation, stream generation and watershed delineation etc. This study will attempt to combine various forms of Digital elevation data to study urban spatial pattern and growth. The most important physiographic data that were extracted from DEM include slope, aspect, drainage, and hill shade.

Are the following:

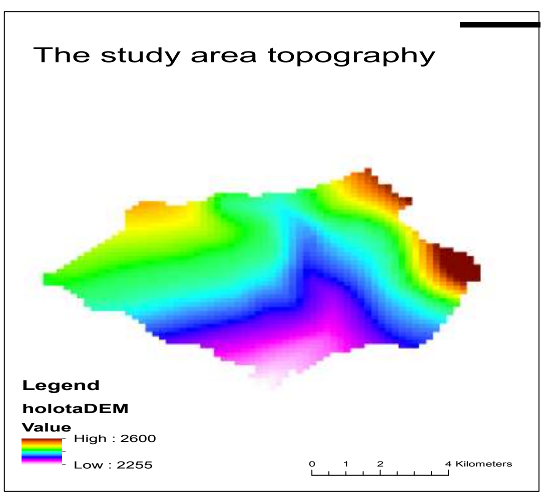


Figure3.3 the slope of the study area

3.5.2 Training Data Collection

To get a land-cover/land-use map at reasonable accuracy, training areas have been chosen with the help of different sources such as landsat image 30m and15m resolution, Google Earth and topographic map.30m resolution Landsat image was used. Google Earth provides an access of high resolution image on the internet. The study area has a high resolution Google Earth image, dated 2010. Clearly recognized objects on Google earth image were digitized and taken as AOI (Area of Interest) and used to classify Landsat images.GPS points and digital camera were used to locate some sample ground cover situation at the time of filed visit. Some land-use/land-covers in urban area, like woodlots, and built-up area stay for long time without change to other land-use/land-covers. Therefore, some ground photographs and sample GPS points were used to minimize the processes of land-use/land-cover classification and as the same time used to validate the accuracy of land-use/land-cover results.

It Provide excellent result in both Landsat images. However, the land use and land cover classes signatures are further analyzed using the scatter plot and histogram techniques to separabality of the bands used in the LULC classes. Show flow chart of the proposed method, in which two years data is selected for experiment such as Landsat 7ETM+, 1995 and Landsat 2006, 2017. Firstly the study area would crop and creates signatures for LULC classes. Scatter plot and histogram would perform to evaluate the training samples of LULC. Secondly supervised would employed to classify the two images and Boolean techniques were performed to extract the urban area from both images and calculate the statistics of LULC classes. Some post-calcification techniques would used to purified all the LULC classified image and remove the noise, the filter which would used in this paper are the majority filter 3 × 3 neighborhood relationship. Finally, raster calculator would used to calculate the statistic of LULC in both in term of percentage and hectare. The entire processes are performed in the ESRI software Arc GIS 10.1

3.5.3 Materials and Software's

Table 3.2. Materials and Software's were used in the study area are the following.

Materials and Software's	Function
ERDAS Imagine 2013	To image pre-processing, layer stacking single bands, supervised classification of land classes and accuracy assessment of the classification.
ArcGIS 10.3	To create study area shape file, identify path and row of the study area, data analysis, management, geo-referencing, the study area delineation and clipping and make layout for final mapping.
Micro-soft excel	To perform different statistical calculations.
Micro-soft word	To write the research paper.
GPS	To collect ground control points (GCPs) used to conduct ground accuracy assessment.
Digital camera	To capture urban expansion images in the study area.

3.6 Method of Data analysis and Presentations

Data analysis is application of logic understanding and interprets the data that have been collected. Data would be collected and processed by coding, editing and tabulating using tables, graphs (charts), percentages and rank orders would be employed by summarizing the data so as to identify and evaluate the idea participants, group, offices or other unit of analysis in the study to make sound generalization and conclusion by statistical techniques of paired sample. The magnitudes of the urban expansion would discussed using spatiotemporal detection of 1995, 2006 and 2017 by the collected data that would analyzed using different GIS and RS techniques Histogram, LULC classification the urban land into four different Agricultural land, forest cover, Built up area and Grazing land. Then analyzing1995, 2006 and 2017 land classification by using table, pie chart, percentage, graph and etc. Landsat ETM+ would also georeferenced and finally clipped with the existing shape file of the study area. Different land use categories would digitized from the satellite imageries followed by building the topology to minimize errors during digitizing and to ensure that the entire polygons are closed. In the process of screen digitizing some features in the imageries did not properly identified. To solve this problem the researcher would use the image interpretation techniques of patterns, tones, textures, shapes, and site associations to derive information about LULC. Population growth of the study area would also analyze fairly fro 1995, 2006 and 2017 by table and percentage to now the spatiotemporal changes of the study areas which might be attracted by different factors. The primary data obtained from interview to government office experts and elder person community members selected in the pre-urban evicted farmers was analyzed qualitatively.

3.7 Methods of presentation

The result of study would be presented in report form Reformation, suggestion and conclusion drawn from analysis of study. Since, it would depend on GIS and RS techniques visualization is the most important method of presenting the outcome of the study beside other methods. The results are ultimately, processed and assessed carefully by the use of thematic map, tables, graphs, charts and other statistical techniques and eventually presented in the analysis of the research out. There are two methods of image classification. Supervised image classification involves selecting pixels that represents land cover classes that are recognized by the analyst. This requires, however, prior knowledge of the area by the analyst. Unsupervised image classification is more computers automated. It enables the analyst to specify some parameters that the computer uses to reveal statistical patterns that are inherent in the data

3.8. Ethical considerations

All research studies present a number of ethical and moral dilemmas which must be identified and addressed prior to carrying out any research study in order to protect all participants from potential harm. Also the privacy and confidentiality of study’s subjects was maintained, all findings are portrayed in a confidential manner so that no personal or identifiable information is record or print in the study. Thus, the name of participants was not record during the data collection process. Therefore, before data collection, an introductory letter of permission to carry out the research from Jimma University, college of social science and humanities Department of

Geography and Environmental Studies would be presented to the concern bodies. and explained the general objective of the study. Then, the researcher gathers the required data for the study after getting permission from the concerned organizations.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter deals with presentation, interpretation and discussion of results. In recent years, a lot of thrust in this field has been to understand and analyze urban sprawl pattern. The common approach is to consider the behavior of built-up area and population density over the spatial and temporal changes taking place and in most cases the pattern of such sprawl is identified by visual interpretation. However, in order to achieve sprawl pattern identification visually, the area under study has to be observed at different spatial and temporal scales. This is made possible by the availability of dated and recent satellite imageries at relatively good resolutions that enable visual analysis and interpretation. In this chapter, satellite images at different temporal scales were used to facilitate a time series analysis of the spatial and morphological transformation of the city of Holota town between 1995, 2006 and 2017.

4.2 The significant factors for urban sprawl in Holota

4.2.1 Land-use/Land-cover change detection

Change Detection Analysis comprises a broad range of techniques. The most common land -use/ land-cover use change detection approaches are grouped in to two (Singh 1989). These are:

a. Post classification comparative analysis of independent produced classifications from different dates (map-to-map comparison).

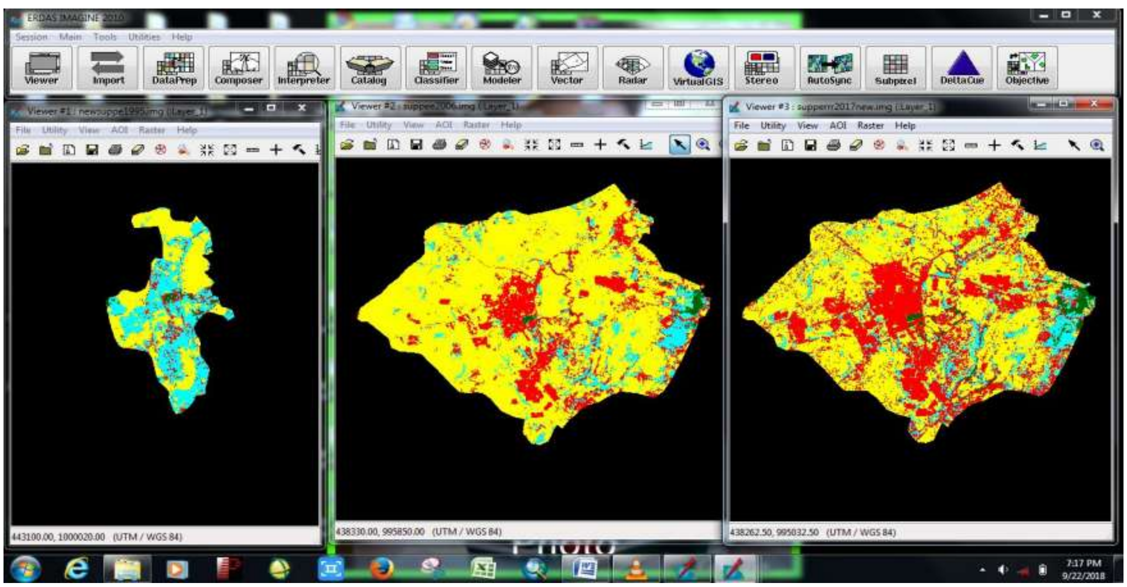
b. Image-to -image comparison. In the post-classification approach, images belonging to different dates are classified and labeled individually. In this thesis, Post-classification method is used. Post-classification comparison determines the difference between independently classified land-use land cover classes from each of the dates under study years. After post classification, the absolute change and relative change were calculated using ERDAS IMAGINE 2010 Software. Absolute change is calculated by subtracting the area of land-use/landcover of the first from the area of later land-use/land cover image (Area at Time 2- Area at Time 1). This method was used to get an aggregate of area change of each class.

Relative change is also another approach to measure land-use/land-cover in terms of percentage (% area at Time 2 - % area at Time 1). The relative change method allows comparison between areas related to land cover indicators.

A. Absolute Area Change

The first process of land-use land cover change detection on the study area was to perform supervised image classification techniques on each image of 1995, 2006 and 2017. After performing an image classification, scattered individual pixels were filtered and cleaned up for better visual display. Then the subtractive change detection based on their area extent was performed on the classified images. The image was classified by ERDAS IMAGINE 2010 as follows:

Figure 4.1 ERDAS software classification of the study areas.



Source: Analysis of satellite imageries.

There are many factors for urban sprawl in Holota town.One of the requirements for understanding urban sprawl is successful land-use/land-cover change detection. The amount of land-use/land-cover change over the study years and the land-use/land-cover category loss and gain were investigated by mapping the land use/land-cover of the study area for 1995, 2006and 2017 with Land sat image archives.

4.2.2 Land Grabbing by the name of investment.

Land grabbing today is marked by variation across different agro-ecological contexts and property rights regimes. It is affecting contexts as diverse as sub-urban corridors, highly productive floodplains, forested uplands, and remote rural outposts. It is unfolding in diverse land rights regimes, including private, public, and community land, and regardless of whether existing rights and arrangements are recognized by state law or not. And actual reallocation processes are taking place under diverse political-legal conditions, with some illegal and others 'perfectly legal'. Some of the most prominent cases involve physical harassment, intimidation and violence; but others do not. Finally, it is worth noting that a good deal of these recent land investments have remained dormant, and thus are more related to land value speculation than to productive ventures. (World Bank 2010)

Different classes of peasants show the diverse social and class relation that determine their livelihoods and resistance against the force that influence them. Populists bundle together the broad categories of laborers and different peasants as 'people of the land' (Baglioni & Gibbon, 2013:9). However, the term peasantry is no longer applicable due to the socio-economic differentiation of the agrarian population (Hobsbawm, 1973:3). Similarly, there is no single class of peasant rather it involves differentiated classes (Bernstein, 2006:453). In contrast, Chayanov's theory of peasant economy neglects the differentiated class of peasants by seeing peasants as unchanging element. Peasant struggles are different based on their demand and the forces they resist for or against. Peasants may struggle against expulsions/re-location program that expels them somewhere to continue what they were previously doing. But, the worst scenarios is when people get expelled without compensation, especially people with informal land right and have no place to go and no jobs to do that determines their level of resistance (Borras &Franco, 2013:9)Scale of resistance depends up on the effect of land deals on the livelihoods of communities. So, land grabbing threatens subsistence crisis that determines the political reactions of people; what James Scott's framed it as 'often it is not about how much was taken, but how much was left' (Borras &Franco, 2013:10). Peasants do not need to completely remove domination rather they claim to secure their subsistence needs (Scott, 1986:26-28)

In simple terms, land at the urban fringe is demanded by farmers and by developers. By developers we mean anyone wanting to acquire land in order to build housing or commercial or industrial facilities. There are Factors which contribute to urban growth in general such as population growth, economic growth, industrialization and transportation facilities. Whether the urban growth resulting from these factors is considered to be urban sprawl depends on its pattern, process and consequences. Bhatta (2010)

The more productive is land in agricultural use, the greater its value to farmers, and thus the higher the price developers will have to pay to acquire the land. To the extent that demands for development increases, it is expected that developers will bid away more land from agricultural uses. There are three main economic forces affecting the demand for land and thus the development of land on or beyond the fringe of urban areas: population growth, rising income, and falling commuting costs (Mieszkowski and Mills, 1993; Brueckner, 2001b, 2000).

The historical physical urban sprawl was analyzed using the Landsat image of 1995, 2006 and 2017 in case of our study area. The rate of urban land cover change has been calculated from the Landsat images. Data extracted from the supervised land sat image of 1995, 2006 and 2017 By comparing dwelling units from these three supervised images sources, the level of housing scatter (sprawl) has been identified. The investments are the most important significant factor for urban sprawl in the town. There are 91 investments companies which are registered legally in the town according the municipalities of the town. This also increase the total population of the town as the positive factors which also leads to urban sprawl and expansion

Table 4.1(a) the distribution of different industries and company in Holota town.

No	Name of the company	Type of work	Area/ hectare	Location	Beginning year
1	MMB PLC	Spongy factory	0.513	B/H	2006-2007
2	Blue Spring water	Packed water factory	0.5	Sadamo .	2002-2006
3	Lucy roof tales	(roofing tales) factory	1	sadamo	2005-2007
4	Oromia Wonder	Flower company	20.6	Sadamo	
5	Bang Yong Yang	Blankets factory	0.45	B/H	2005-2008

6	Jardan	Plastics factory	0.45	B/H	1999-2001
7	Oromia paper	Paper &soft factory	0.4	Sad	2005-2008
8	Alamiyee agr.investiment	Fruits production	23.7	B/H	1997-2006
9	Ethio- dream	Flower &fruit factory	58.3	T/ Harbuu	
10	Agri-floria	Flower company	51.9	G/kuyu	
11	Kaarmiliyoos	Flower company	26	G/kuyu	
12	Euro flora	Flower company	20	G/Kyu	
13	Ethio Agri. Seft	Flower company		T/H	
14	Joe Flawor	Fruit company		B/S	
15	Holeta Flawor	Flower company		B/S	
16	Garment Eng.	Water tube		B/H	
17	Holeta marble & granite manufacturing	Ceramics		B/H	
18	Gypsum factory	gesso		B/H	
19	MML Bending In.	spongy		B/H	
20	Haneri manufacturing	Leather		B/H	
21	Yonaas Bonger	Flower company		B/H	
22	Tsahayi Tujo plc	Rearing animal		B/H	
23	Sibihat enaa Lijochu PLC	Dairy			
24	Yomiyyuu keenyaa Ind.PLC	Sandstone production			
26	Holeta Engineering	biloket			
27	HWSEN flower	Flower company			

The federal government companies are also one of the factors for urban sprawl of the town they cover very large areas and considered as a bottle necked for the development of the town according to land management office manager ato fikiru Itefa.These federal Government Company holds large area coverage along the main road to finfinne and Ambo. According to Siedentop (2005) there are two rivaling explanation patterns for causes of urban sprawl: firstly sprawl is explained by the demand for urban land. Driving forces are land consumption of households, companies, and public uses.

Table 4.2 (b) the federal government companies in Holota

No	Name of organization	service	Establishment year
1	Agricultural institute	Research on animals & crops	1958
2	Military academy	Military training	1934
3	Mulgeta Buli collage	technical Training	1968
4	Holeta nucleus herd, administration & Genetic improvement team case.	Genetic improvement	
5	Ethiopian telecommunication	service	
6	Electric energy	service	
7	National agri. Biotechnology Research Laboratory.	Bio technology research	2002
8	Renascence Dame Holeta Sub station	Electric energy station	20005

Sources; *socio- economic study and structural plan of Holota town (june- 2010 E.C)*

4.2.3 Urban population Growth (Demographic factors)

Knowledge of past and current population trends and projecting population growth into the future helps to determine the level of municipal services that will be needed for future growth of the town. The population census data from Central Statistics Agency of Ethiopia were used to predict total population growth between 2006 and 2017. The most recent census data (2007) show that holota town grew by 32230 people, and had a growth rate of 5.3% annually. (Holota town socio economic office2018).Clearly, there have been many ways to measure urban dynamics indicating that there are numerous avenues to reach a similar destination. Population growth can be a driving force behind urban sprawl.

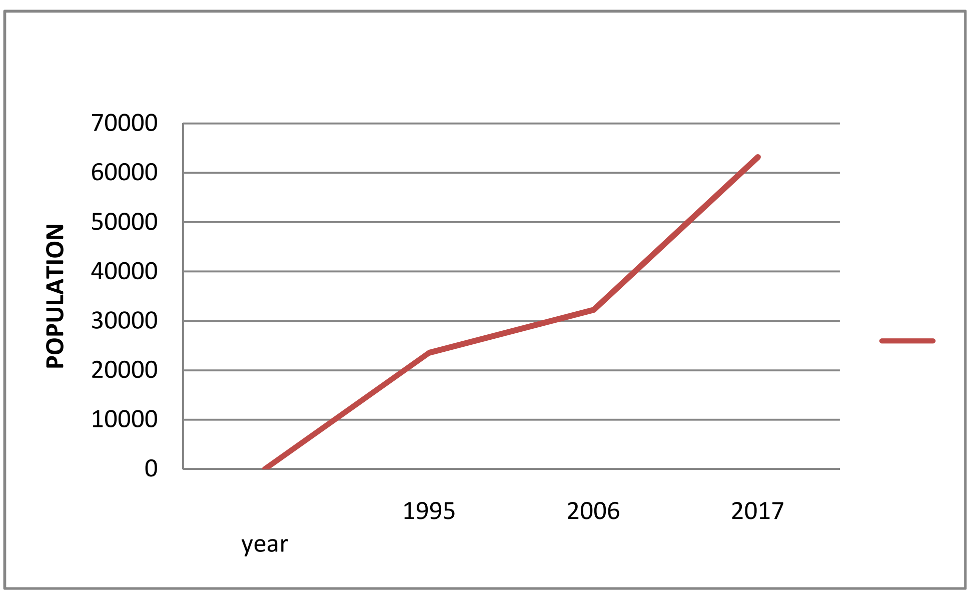
"If population growth is substantial enough to produce the required consumer market, "big box" commercial development often takes place. Seeking larger lots for stores, ample parking, easy access for multiple communities, and heavy commuting traffic, big-box developments locate on the outskirts rather than in the existing town commercial centers (Lindstrom et al., 2003, 11)."

Table 4.3 the predicted present's population growth of Holota town from kebeles (Holota town municipality)

year	population
1995	23541
2006	32230
2017	63139

Sources; *socio- economic study and structural plan of Holota town (june- 2010 E.C)*

Graph4.1 Population distribution by Kebele



Sources; *socio- economic study and structural plan of Holota town (june- 2010 E.C)*

Table 4.4 the population of Holota town by kebele (2017)

No	kebeles	Area/hectare	Households			Total population			remark
			M	F	T	M	F	T	
1	Gooroo Qeerransa	722	2075	1287	3362	8,615	8967	17,582	Town
	1.1 Agri-institute	370							
	1.2military accadamy	182.8							
	1.3 Holota nucleus herd & genetic improvement.	154							
	1.4 Agri collages	16.4							
2	Burka Harbu	410	3187	2523	5710	8,748	9105	17,853	"
3	Birbirsa Sibaa	538	764	667	1431	4415	4570	8985	"
4	Galgal Kuyyu	1249	308	345	653	4939	5122	10061	Villages
5	Burqaa Walmaraa	739	574	434	1008	1556	1619	3,175	"
6	Saadamo	864	153	138	291	983	1022	2005	"
7	Medda Guddina	270	181	99	280	835	931	1766	"
8	Tulu Harbu	758	128	71	199	847	865	1712	"
	Total	5550	7367	5567	12934	30,938	32201	63,139	

Sources; *socio- economic study and structural plan of Holota town (june- 2010 E.C)*

The holota town is divided into three town administration kebeles and five village kebeles. Most of the urban sprawl took places towards the out fringe village kebeles. As a result most the agricultural lands were invaded by both legal and illegal land invaders' especially Saadamoo, Burqa/Walmaraa, Tulu/Harbuu, Galgala/Kuyyuu.

Table 4.5 the kebels of the Holota town.

No	Name of the kebele	types
1	Goro/Qeeransaa	Twon
2	Burqa/Haarbuu	Twon
3	Birbirsa/Siibaa	Twon
4	Meda/Guddinaa	village
5	Galgala/Kuyyuu	village
6	Saadamoo	village
7	Burqa/Walmaraa	village
8	Tulu/Harbuu	village

Sources; *socio- economic study and structural plan of Holota town (june- 2010 E.C)*

The three kebeles categorized under the town are the down towns which established in 1894 during the regime of emperor minilik II.The town gets its first master plan in 1974.The town also added five village kebeles from the surrounding wereda. These are; Galgala/Kuyyuu, Meda/Guddinaa, Tulu/Harbuu, Burqa/Walmaraa and Saadamoo.The agricultural institute and military accademy are both located in gooroo Qeeransaa kebele admnistrative

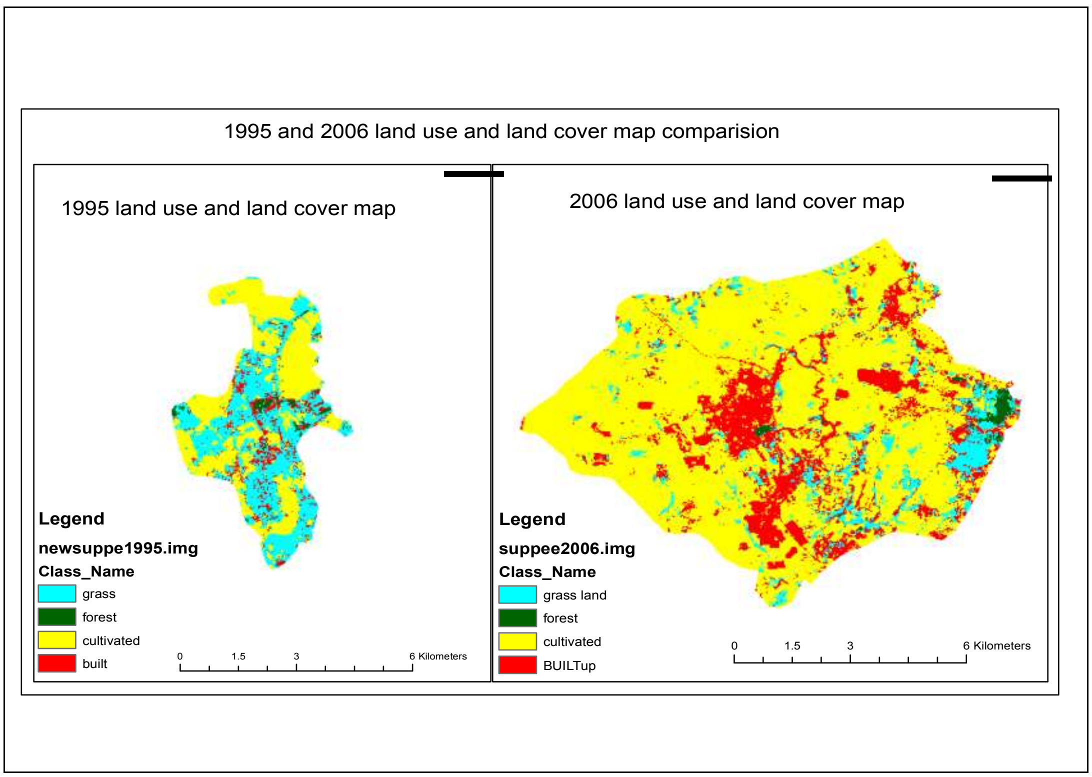
Table 4.7(a) the Percentage matrix of 1995-2006

	2006				
1995	Built-up	cultivated land	Forest land	Grass land	Total class
Built up	12.50	6.24	15.95	15.42	50.11
cultivated land	20.65	59.88	0	35.88	116.41
Forest	4.53	0.78	75.53	2.61	83.45
Grass land	62.31	33.07	8.51	46.07	149.96
Total class	99.99	99.97	99.99	99.98	

Source: Analysis of satellite imageries.

The first process of land-use land cover change detection on the study area was to perform supervised image classification techniques on each image of 1995, 2006 and 2017.Afterperforming an image classification. The classification matrix of the 1995- 2006 shows the land use and land cover changes that are changed since 1995.This classification matrix is done by ERDAS imagine 2010.According to this classification land use and land cover changes were: both cultivated land and Built-up were increasing 30.95% and 13.32% respectively.

The built-up area in 1995 occupied the least area with 4% of the total class. Cultivated land occupied more than 42.13 % of the total area in each of the study year. This may be due to the conversion of grass land, forest land and bare soil to agricultural land. But the most probable reason might be the time of the year in which the area was imaged which could be a major contributing factor of the high percentage of the observed classification. Mean while the grass land is decreasing from1995 to 2006 because many grass lands changed to cultivated land built – up areas. Both forest land and grass land decreased from 1995 to 2006as there is increase in built up and cultivated land. The visualization of the two respective years shows more information about the study areas. Image by image comparison (map-to-map comparison) is also one of the methods of analyzing the supervised image to know the spatio temporal land use and land cover of the study areas.



Source: Author's Analysis, August, 2018

Figure4.2 Map to map comparison of 1995-2006

Table 4.7(b) the Percentage matrix of 2006-2017

			2017		
2006	Built-up	Cultivated land	Forest land	Grass land	**Total class**
Built-up	37.54	5.45	33.61	12.19	88.79
Cultivated land	58.52	89.07	4.12	56.22	207.93
Forest land	0.06	0.04	31.26	0.35	31.71
Grass land	3.86	5.42	30.98	31.23	71.49
Total class	99.98	99.98	99.97	99.99	

Source: Analysis of satellite imageries.

Table 4.8 land use and land cover change by class in the study period.

Land use and land cover change by Percentage (%) and areas in (hectare)						
LULC Classes	Years interval changes					
	1995		2006		2017	
	(%)	Areas(hect)	(%)	Areas(hect)	(%)	Areas(hect)
Built-up	8.65	157.5	17.32	1326.33	32.32	2465.39
Cultivated land	46.47	845.28	73.08	5593.32	52.78	4026.10
Forest land	2.36	43.02	0.83	64.26	2.41	184.45
Grass land	42.50	773.01	0.66	669.6	12.46	950.69

Source: Analysis of satellite imageries.

$$\text{Urban Area (hectare)} = \frac{\text{No of urban pixel} \times 30m \times 30m \text{ or } 15m \times 15m \text{ (2017 image)}}{10,000}$$

The first process of land-use land cover change detection on the study area was to perform supervised image classification techniques on each image of 1995, 2006 and 2017. After performing image classification. The classification matrix of the 2006- 2017 shows the land use and land cover changes that are changed since 2006.This classification matrix is done by ERDAS imagine 2010.According to this classification land use and land cover changes were: both cultivated land and Built-up were increasing and respectively from 1995 to 2006.While the built-up increasing by 15% in 2017, and the cultivated is decreasing by20.3% in this interval.

Built –up increased by an alarming rate in both interval period of study from 2006 to 2017 but cultivated land decreases because of the population demography of the study areas and huge investment interests in the town from time to time. This may be due to the location of the town accessibility to finfinne.But the most probable reason might be the time of the year in which the area was imaged which could be a major contributing factor of the high percentage of the observed classification. Mean while the grass land is increasing alittlebit from 2006 to 2017 because many grass lands and cultivated lands were given to investors but it is not yet used for nothing. It is simply fenced without any uses. The visualization of the two respective years shows more information about the study areas. Image by image comparison (map-to-map comparison) is also one of the methods of analyzing the supervised image to know the spatio temporal land use and land cover of the study areas.(Singh 1989).

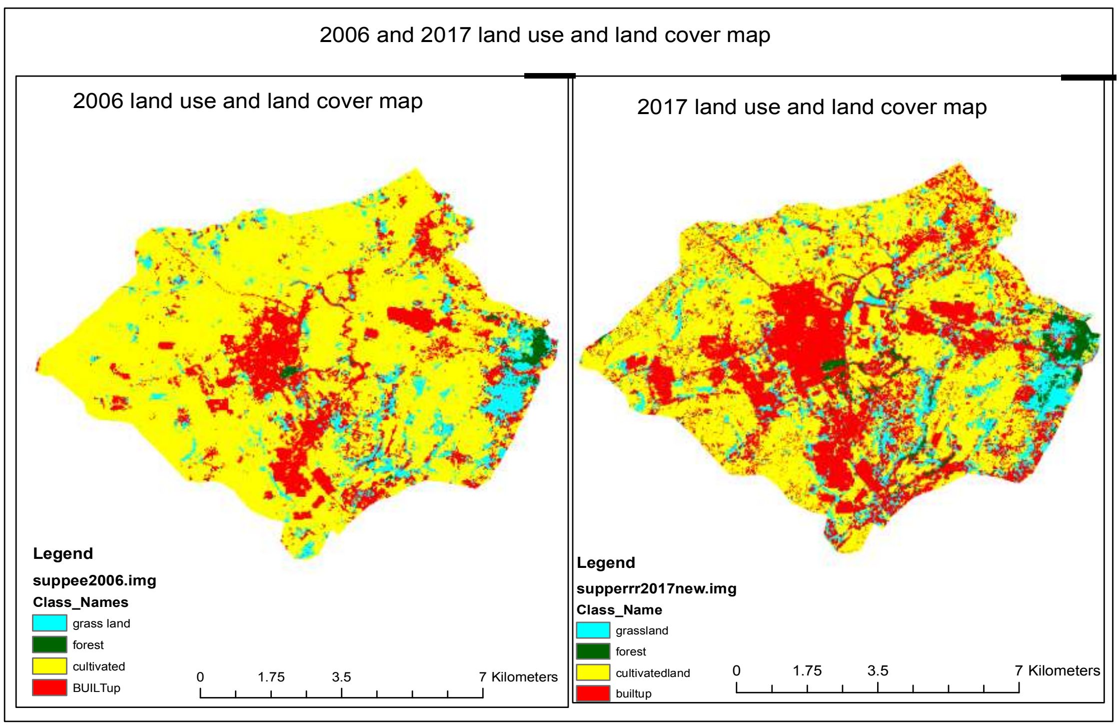


Figure4.3 maps of 2006 and 2017 land use / land cover comparisons.

Source: Author’s Analysis, August, 2018.

4.3. Accuracy Assessment

In order to determine classification accuracy, it is necessary to determine if the output map meets, exceeds, or does not meet certain predetermined classification accuracy criteria. One of the most common and typical method used to assess classification accuracy is the use of an error matrix (sometimes called a confusion matrix or contingency table (Lillesand and Kiefer, 1994)). Currently, accuracy assessment is considered as an integral part of any image classification. This is because image classification using different classification algorithms may classify pixels or group of pixels to wrong classes. The most obvious types of error that occurs in image classifications are errors of omission or commission. After classification process is completed, accuracy assessment for each land-cover/land-use has been done to make sure the classification is accurate enough for use. To assess classification accuracy the classified map derived from remotely sensed data and the existing sources of reference information such interpretations from landsat image, topographic map, and ground truth data were used as a means of time and cost-efficient error checking. To do this a set of randomly selected pixels whose true values well known were used and ERDAS Accuracy Assessment tool was used to conduct an accuracy assessment. ERDAS IMAGINE uses a square window to select the reference pixels. Among the three different types of distribution parameters namely random (no rules will be used), stratified (the number of points will be stratified based on the extent and area of each thematic class), and equalized random (each class will have an equal number of random points regardless of its extent), simple random was used to evaluate the accuracy assessment of the land cover/land-cover classes. The study assessed accuracy of the classification results with 40 randomly sampled reference points for each classified image. The error matrix for each classification was created and then overall accuracy and Kappa coefficient were calculated and evaluated (Table 4.5).

Table 4. 5: Overall accuracy and Kappa (K^) statistics for the classifications

Accuracy statistics	1995	2006	2017
Overall classification accuracy (%)	95%	97.50%	100%
Overall Kappa (K) statistics	0.92	0.96	1.000

Source: Analysis of satellite imageries.

4.4 Change statistics errors

For the change matrix between 1995 and 2006, built-up contributes 12.48% and agricultural land 85.54% of the total area change converted to built-up land (Table 4.7.) The vegetation (tree canopy along roads) cover converted to built-up. These changes may seem to be classification errors. But in some cases there is a probability that vegetation area may be converted to roads. Roads are mostly included to built-up area when classified from low resolution image. But when tree canopies along the roads grow, it is common to see mixed pixels on low spatial resolution satellite image. Therefore, pixels near the roads may be generalized as vegetation or as built-up during post classification processing such as majority filters and boundary clean Due to the heterogeneous nature of urban area; spectral based land-use/land-cover changes have always some drawbacks. One of the problems occurs is the existence of mixed pixels on different objects which become spectrally similar one another. For example, from land-use/land cover conversion statistics, there were errors indicating the conversion of built-up area to land-use/land-cover. However, the conversion of built-up area to other land cover classes is unlikely to happen especially within 5 years (2000 and 2005). One solution that has been done to correct this problem was to compare the result with high resolution Ikonos image.

4.5 Extent and patterns of the holota town Interpretation

The maps of urban or built-up land cover show that new urban growth has occurred within the study area. Without urban growth, there would be nothing to classify as urban sprawl. The percentage of natural to urban ground-cover change over the 22 year time period increased by almost 28.32%, a great deal of change that provides a strong chance that a substantial amount of urbanization in Holota town over the period of time between 1995and 2017 could be classified as urban sprawl. By including road data, I was able to visualize clearly where patterns of linear sprawl were taking place. Leapfrog patterns of sprawl appeared to be somewhat disconnected from other areas of existing or new urban growth areas. Cluster patterns of sprawl appeared to be part of existing built-up land. Cluster patterns also appeared to grow out of what was once a leapfrog pattern of development in some areas. However, the patterns of sprawl represented in my research are not exclusive of neighborhood statistic calculations that give measurements of the density of new growth areas and display the connectivity and fragmentation of those new growth areas.The maps that I produced with the neighborhood statistics are important in showing where urban land density increased and decreased. There is a clear increase in the density of urban land to the northeast, east and western direction of the study areas.

I also based my initial classifications on the recognition that a parcel or patch of land changed in 1995 from a given land use to urban or built-up. I detected many possible patterns of urban sprawl outside of the city limits based on land use change from non-urban to urban. The farther from the town the particular land cover, the more visible these patterns became. This seems to be because there is so much urban or built-up land in the actual Holota town that it was difficult to detect any land use change there. It comes without surprise that most of the patterns within the city would be characteristic of urban growth. However, as the town grows, it often takes the shape of what some would classify as a cluster pattern of urban sprawl. Because the study area as a whole did see a dramatic 28.32% increase in urbanized land cover from 1995 to 2017, it was not difficult to detect any of the possible patterns of sprawl that I was interested in; linear or strip along highways, cluster or expansion, and leapfrog or relocation. This is because the first step in discovering sprawl patterns in my research was to determine the level of urbanization over the given time period. However, increases in urban land density are apparent throughout the study area (Figure 4.1) & (Figure 4.2) above.

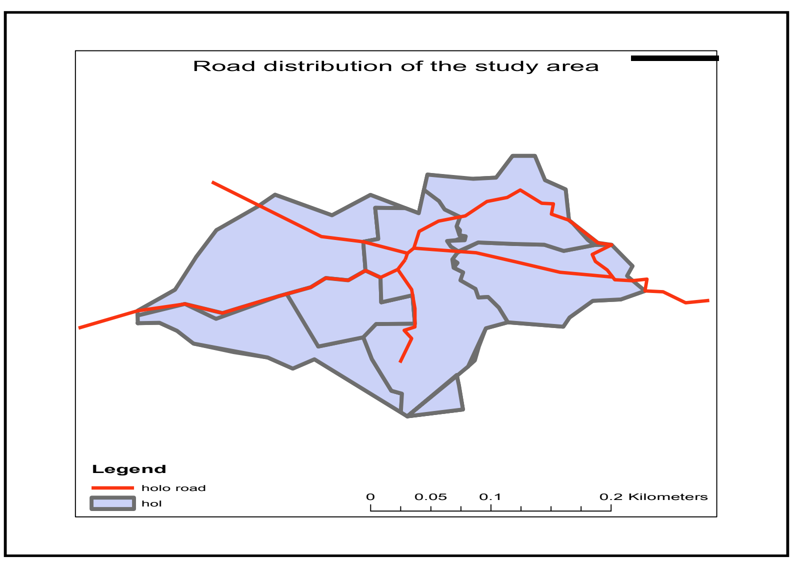
4.6 Trends of holota town urban sprawl and Expansion

The settlement of Holota town was influenced by the main railroad from Finfinne to wollega, industrialization and the feeder roads that connected the rural areas with the town. The first is industrialization which increases the total population. The town was expanded since 1991in alarming rate .the town was also residential home for the workers of industries surrounding the town .As result, population increases from year to year.

4.7 Neighborhood Statistics Interpretation

Neighborhood statistics were performed on the land use data in order to understand and visualize how disconnected and dense patches of new growth were. It was clear with the density maps of urban land in 1995 and urban land in 2006 where the greatest level of increased urban density took place. In addition to the density of urban land in 1995, 2006, and new urban growth, this technique allowed me to examine how disconnected areas of growth were. The highest density of new urban growth occurred to the west direction to the Galgala kuyyu kebele and saadamo kebele of the study areas. The lowest density occurred in Birbisa siba and madda guddina kebeles experienced moderate new urban growth density and the results that I was most concerned with were growth densities and patterns in the counties that surround the town. Neighborhood statistics not only allowed me to view the density and connectivity of new urban growth but it also allowed me to quantify density of new urban growth within a specified window of one kilometer by one kilometer. Putting categories of low, medium, and high density on new growth, as the well as the ability to display how connected patch densities are, was crucial in clarifying the quantification of urban sprawl for the purposes of my research. I found that there was a mix of low, medium, and high density development throughout the study area.

Figure 4.4Road distribution of the study area



Source: Author's Analysis, August, 2018

4.8 Neighborhood Statistics

Using neighborhood statistic calculations in my research was important in understanding the density and connectivity of new development. This is often the basis for classifying new development as sprawl rather than simple growth. In order to justifiably label a patch of new growth as sprawl, I felt that it was vital to be able to put a number on how dense that growth was. In the case of density, I wanted to be able to say that something was cluster because numerically, it was very dense and compact. Neighborhood statistics also strengthened my results because the data allowed me to visualize how connected new patches of growth were to other areas of development. In classifying something as leapfrog or relocation urban sprawl, I was interested in numerically reporting how dense new development was in relation to other growth areas. I also used these same data in conjunction with road data to determine where linear or strip patterns of urban sprawl were taking place.

4.10 Qualitative Results

I conducted personal interviews with the town municipality and planners and examined land use surveyors, and land management office expert to reach qualitative conclusions for my research. Collectively, the qualitative data helped explain some of the results of the quantitative portion of my research. The hypothesis for the second research question is supported by the data I collected during personal interviews with developers and land owners as well as land management office expert. It is clear that some of the new urban growth within the study area is directly related to jurisdictional planning documentation, zoning practices and ordinances, and the appeal of land to developers for profitability reasons.

4.11 Interviews with Municipality and Planners

My interviews with planners and surveyors were extremely helpful because I was able to see both sides of the development story in the Holota town area over the past 10 to 22 years. With an increase population and development, the task of the region planning departments of land management office was to implement their comprehensive plan to accommodate new growth. Holota town is one the oromia region town incorporated under finfinne special zone because of their assessebilty to the capital city. There is high interest of investment from the internal and external investors according to ato Fikiru Itefa the land management office director. (holota town land management 2017)

Although the comprehensive plans point the way about where new growth should occur, it is the developer who must find the balance between what the market wants and project feasibility. The goal for a developer is to generate the most profit from a new project, but the land management office and other regulations are often viewed as barriers between a developer and maximization of profits. The developers I spoke with approached the interviews with the admission that their only goal was to make money and that growth had to go somewhere. The balance was found between planners who were willing to accommodate inevitable growth and developers who were willing to abide by standards set forth in comprehensive plans and other governmental regulations. Sudhira et al, (2004) suggested that while many models seek to measure urban sprawl, they do not relate to anything more than urban growth. It is therefore vital to understand what is involved in the process of urban sprawl, which entails cooperation between planning departments and developers (surveyors) who have the capability to avoid haphazard development patterns. "The inadequacy of some of these models is that the models fail to interact with the causal factors behind the sprawl such as population growth, availability of land, and proximity to city centres and highways (Sudhira et al. 2004, 30)."in Holota town, I was able interact with aspects of planning decisions, population dynamics, land conversion practices, and market forces in order to measure urban sprawl there.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

This study is generally aimed at analyzing the spatio-temporal pattern of urban sprawl in Holota town, using GIS and remote sensing technique. The study adopted the concept of determinants of urban sprawl, as the spatial expansion of town and cities with respect to increase in the size of built-up areas and the extent and patterns of urban sprawl. The face at which third world or Developing countries urban areas are growing reveals distinctive spatial and temporal Variation of land use/ land covers in locally urbanized environment. Therefore, in achieving the aim of the study both physical and social surveys were used for both physical and social Measurement of urban sprawl. The study used low resolution imageries of Holota town urban areas for years of 1995, 2006 and 2017 images based on the data available and scope of the study period. Field survey and social survey were used in capturing the socio-economic functional changes as well as the impact of the changes, the residence of traditional core historical existence settlement of Holota town, new settlements and sub-settlement all around the Holota town, the formation of newly developed layout base of time variation were also used as sample interview. Others include planning and management information which was obtained from interviews with various stake holders, Holota town Urban Planning Development Authority, as well as the planning authorities of oromia State urban planning institute. The findings of this study revealed that, Holota town urban area since before 1995 was a typical Rural and urban settlement. Every day, Holota is experiencing rapid influx of people which resulted to increase in urban land use, spatial expansion from 18.18 Sqkm in 1995 to 76.5sqkm in 2017, while the population increase within this period of only 20,000 persons, to 30,730in 2017according to Holota town social affairs Biro. Holota experience more growth both in population and built-up area since before 1995, all as a result of the establishment of Socio economic development that took place since then. Such as the establishment flower investments, military academy, Habesha cement factory and different business sectors were evolved. However, these growth continues rapidly most especially from 1995 to 2017.The areal extent of Holota is increasing in geometrical rate, while built-up area are increasing in arithmetical rate. Also in relation to population growth, the population is also increase in an arithmetically, while the built-up areas increase geometrically. The sprawl pattern commonly occurred in the study area is the, linear, leapfrog or scattered development and low density single used development urban sprawl. The spatial dimension of Holota urban area increase the travelling distance, as proximity to place of work is determining the people choice of place of residence, as some travelled over 10km to their place of work. The result of urban area overlay analysis revealed that the major sprawl pattern occur along the major roads to their place of work. These three major roads that cross from all the direction became the major Growth poles. The road from finfinne to wellega, the road from Holota to mugger which leads to elongated development for Holota town urban sprawl. Traditional settlement, determine the growth pattern. Subsequently, within that same period range, idealization of Holota Wall road to small village road took place as well as expansion and renovation of flower investment companies same period. Holota linear, leapfrog and Low density single use development structural growth process already engulfed so many settlement within and around the town from that 1995 to 2017. Which only included 3 administrative kebeles in 1995 is now 8 administrative kebeles in 2017.Within the period under study, holota town experienced substantial growth in socio economic functions, the growth almost touches all the sectors of the economy, include education, commerce, recreation, transportation, health, infrastructural development, etc .As the third world urban centers growth cannot disassociated with environmental and socioeconomic problems, the problem of Holota urban area are more visible in organic traditional settlement, as most of the people residing in the sprawl areas outskirt the old Holota wall are mainly high and medium income civil servants.Including waste disposal system, bad roads with their street, pollutants at water logs in the center of town, as well as poor drainage systems etc.

5.2 Conclusion

The examination of the findings of the research along with other general observations supports the advancement of the two general conclusions. The first conclusion is that the sprawl analysis as conceived in the early and initial stages of the research is workable and viable. Second that its application in the mapping and analysis of sprawl in Holota has demonstrated that urban planners and managers alike can utilize it as a cost effective, convenient and accurate means of monitoring urban growth, analyzing varying resultant patterns, examine factors responsible and explaining the socio-economic effect of urban and development. This then offers tremendous opportunities for effective monitoring and management of development control which currently is lacking in the study area and most other urban areas in Ethiopia.

5.3 Recommendation

Because of its versatility, it is recommended that urban planners and managers interfaceRemote Sensing and Geographic Information System GIS in the mapping of growth, sprawl pattern, the rate of the sprawl and the socio-economic effect of sprawl activities. As shown from the study, not only will there be value from the precision of the tool, but the saving of in the analysis allows proactive response to urban management issues. To draw value from the methodology, the basic constraints to its adoption need to be removed. In most planning offices, the equipment and personnel base to utilize the method is lacking. The constraint of lack of capacity can be removed through training and education. Secondly, there is an urgent need for government as represented by its agencies to improve mapping at suitable spatial scales and also improve the generation and archiving of other data types. This will facilitate effective research and formulation of robust urban management and development control strategies.

a) Recommendation for Holota town municipality

It is recommended that the Oromia State Urban Planning and Development Authority lead the adoption of the tool in Holota by creating an urban growth analysis and monitoring unit within the existing structures of the office. This unit will engage departments and units within the board and other office in carrying out the periodic analysis of urban growth and the dissemination of the information gathered to public and private organizations that have use for it. Examples of organizations with need for such information include utility providers, property developers, telecommunication providers, security agencies, fire department, the Health Ministry, and the Education Ministry. From the outcomes of the research, the tool will be beneficial to Holota in the following ways.

(b) Planning of infrastructure and Urban Services Delivery

The ability of the cost of providing urban services and infrastructure can be very useful in the process of infrastructure planning, budgeting and priotization of interventions based on the objective identification of the areas of greatest need within the city. The rapid assessment of the dynamics of urbanization will also assist the development of proactive measures for providing infrastructure and services rather than the usual reactive approach of waiting until there is a gap to be filled which has been shown to be extremely inefficient.

(c)Planning and Growth Management

In Holota town, planning and development control is greatly hampered by the dearth of data especially up to date maps seen as cardinal requirements that determine the effectiveness and success of activities. The tool will provide fast and convenient access to updated mapped data and will also facilitate regular updates that will enable concerned authorities keep up with the pace of urban growth and development. This will have a positive impact on planning and growth management efforts.

(d) Stakeholder Mobilization for Development through Advocacy

Urban planning and management decision –making process in Holota is very diffuse. It is spread widely among various government agencies, field practitioners and policy makers and a model where all stakeholders will work under a common jurisdiction. For all these actors to be carried along, an efficient system that is capable of collecting accurate and reliable data and at the same time communicating it to those involved in decision making through an efficient medium is required. The rapid mapping, update and visualization capabilities of the tool will help achieve the noble objective of engendering participatory planning and improve the quality of decisions in governing the city. The constraints and limitations to the adoption of the tool are three:

1. Lack of technical know-how,

2. Lack of equipment and

3. Lack of managerial support. To address these issues, the following are suggested:

(a)Skill and Education

Staff requires training and education to enable them attain the minimum level of expertise and Competence needed for the effective deployment of the GIS and remote sensing in Holota Suitable candidates for this type of training are highly motivated middle staff with Degree level education in Urban and Regional Planning, Cartography and Land Surveying.

(b) Equipment (Computer Hardware and Software)

The necessary hardware and software need to be acquired. Two properly calibrated computer workstations, one handle GPS unit, ArcGIS 10.5 software, Google Earth Software, other conventional software needed for proper functioning of the workstations and a reliable internet link are required as the initial investment.

(c) Managerial support and Goodwill

The management of Holota town needs to be adequately sensitized on the inherent benefits of the adoption of sprawl study in the town. This is because its goodwill and support is a Pre-requisite to the successful and sustainable utilization of the tool within the framework of the day to day operations of the authority.

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APPENDEXIES

The industry in Holota town