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MODELING AND PREDICTING OF FUTURE URBAN GROWTH USING GEOSPATIAL TECHNOLOGIES: THE CASE OF HOSSANA TOWN, SNNPR, ETHIOPIA

BY: MISGANU TUMISO

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, JIMMA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN GIS AND REMOTE SENSING.

Oct, 2019

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Declaration

I whom declared that, the thesis entitled “Modelling and Predicting Future Urban Growth using Geo-spatial Technologies: the case of Hossana Town, SNNPR, Ethiopia.” comprised my own work. All the materials and methods used for this work are as likely acknowledged.

Signature: ....

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Acronyms/Abbreviations

GIS	Geographic Information system
UN	United Nation
GPS	Global Positioning System
CBD	Central Business District
CSA	Central Statistical Agency
RS	Remote Sensing
TM	Thematic Mapper
ETM	Enhanced Thematic Mapper
QGIS	Quantum Geographic Information System
LULCC	Land Use and Land Cover Change
LR	Logistic Regression
GCP	Ground Control Point
CA	Cellular Automata
SNNPR	Southern Nation Nationality Peoples Region
HTAFED	Hosanna Town Administration Finance and Economy Development Office Report
IGBP	International Geo-sphere-Biosphere Program
IHDP	International Human Dimensions Program on Global Environmental Change
ASTER	Advanced Space borne Thermal Emission and Reflectance
GDEM	Global Digital Elevation Model
DEM	Digital Elevation Model

Abstract

This study examines the use of Geo-spatial techniques to model and predict urban growth of Hossana town between 2003 and 2018 so as to detect and analyze the change that has taken in the town between these periods. In order to achieve these the remotely sensed Google Earth Image of 2003, Ortho-photo of 2013 and 2018 have been obtained and pre-processed using EARDAS IMAGINE. Supervised image classification has been used to generate land use/land cover maps. Land use/land cover classification, accuracy assessment, and change and prediction map in ERDAS IMAGINE and IDRSI software. For the accuracy of the classified LULCC maps the confusion matrix was used to generate it in standard form. The overall accuracy and kappa coefficient results were 89.50% for 2003 and 92.46% for 2018 which had been above the minimum and acceptable threshold level. The result revealed that annual aggregate rate of changes of urban growth of Hosanna town has been occurred within 15 years from 2003-2013 and 2013-2018 were 135.35% and 121.36% respectively. Though the period of 2003 from 2018 there were dramatic change in built-up areas, whereas agricultural, open, and forest land has decreased in area. Accordingly, more land was occupied under built up. The results also shows that increase in built-up coverage of the town was due to population pressure, road infrastructure network development, and other physical and proximity factors on land. So the rate of change has been dynamic and it needs also infrastructure and other facilities development in the town. Generally, spatial analysis and modelling enables for sustainable managements of urban growth through proper planning, wise decision making, monitoring of urban expansion and development.

CHAPTER ONE

1. Introduction

1.1 Background of the Study

Urbanization is the process by which large number people become permanently concentrated in relatively small areas. It is induced by physical geography, living and property costs, demand for more living space, transportation, and lack of proper planning policies (Bhatta, 2010). Cities are nodal points for social and economic activities. They create job opportunities and other means of livelihood. In developed world, urban development rates are constant or decline due to regular settlement patterns and relatively stable population. In contrast, developing countries are still industrializing and urbanizing, so they are just beginning to face the additional challenge of making their development sustainable for the long-term (Kiamba, 2012).

Nowadays urban areas experience fast growth due to enormous population growth, rapid industrialization, economic development an specific economic policies adopted by governments and immigration of people from villages to cities. Accelerated urban growth is usually associated with and driven by the population concentration in an area. The extent of urbanization or its growth drives the change in land use/cover pattern (Kumar et al, 2008). According to United Nations (UN, 2014), urban centers of the world are growing fast in terms of geographical area and population and trends of global urbanization shows that 66% of the world's population is projected to be urban by 2050, with 90% of this expansion being anticipated in the developing countries. The concentration of the world population will be in Asia (52%) and Africa (21%) for most of the urban area by the year 2050 (UN, 2014). The urban areas of developing countries are experiencing a rapid state of change. This huge growth in urban population may force to cause uncontrolled urban growth resulting in sprawl. The rapid growth of cities strains their capacity to provide services such as energy, education, health care, transportation, sanitation, and physical security. Since governments have less revenue to spend on the basic upkeep of cities and the provision of services, cities become areas of massive sprawl and serious environmental problems.

Dimitrios and Giorgos (2012) concluded that urban land cover occupies only 2% or 3% of the earth. The alteration of surface materials also changes the amount of solar radiation reflected or absorbed resulting in micro-climate changes through temperature and humidity alterations. These changes contribute to the urban heat island phenomenon, which affects human health and comfort and increases energy demands for cooling. Furthermore, pollutants that are concentrated on urban surfaces degrade the biological, chemical, and physical characteristics of lakes, streams, and estuaries receiving urban runoff leading to aquatic and terrestrial habitat modifications.

Increasing numbers of researchers started to study urgent environmental tasks for the sustainable development of their urban regions, the planning challenges faced by the local authorities, and the application of remote sensing data and geographic information system (GIS) techniques for the analysis of urban growth to meet these challenges (Bhatta, 2010). It believes that information generated and classified urban area by using Geo-spatial techniques helps planners, decision makers to identify the trajectories of their cities, patterns, forms and structures.

In recent years, urbanization is a major trend in big cities all around the world. The main change of land use in these areas can be described as agricultural and forest land use converting into urban land. Unfortunately, the conventional survey and mapping techniques are expensive and time consuming for the estimation of urban expansion 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 modeling of urban growth using GIS and remote sensing techniques. For example, urban growth modeling can assist in adaptation and mitigation scenarios with respect to climate change because of the large amounts of air, soil and waste emissions that occur in urban areas. Furthermore, due to the increasing trend of urbanization along with potential environmental consequences, urban growth modeling appears to have a protagonist role in urban planning to assist in decisions related to sustainable urban development (Sivakumar, 2014).

Hosanna has one of the fast growing towns in the SNNPR. This is due to rapid population growth, economic activity, and spatial proximity with neighborhood towns, and high population migration from rural areas to the town this leads the town to expand horizontally both formally and informally. The expansion of the town has also indeed with homeless, crime, and etc. Although the focus of this research was on the physical expansion, the functional aspects have to be taken into account in interpreting the causal effects of the former as both interact spatially and temporally. For example, the activities at a location may influence the change in space at another location; the activities in a period may impact on the change in space at another later period. However, this study was conducted to identify, analyze, and predict urban growth of the Hossana town.

1.2 Statement of the Problem

Ethiopia is one of the least urbanized countries in the world, and only 18% of its population lives in urban areas (JMP, 2014). Urban population in Ethiopia is increasing rapidly. Estimated at only 17.3% in2012, Ethiopia's urban share is one of the lowest in the world, well below the sub Saharan Africa average of 37% (Abeje et al, 2014). But this is set to change dramatically. According to official figures from the Ethiopian CSA, the urban population is projected to nearly triple from 15.2 million in 2012 to 42.3 million in 2037, growing at 3.8% a year. Analysis for this report indicates that the rate of urbanization will be even faster, at about 5.4% a year. That would mean a tripling of the urban population even earlier by 2034, with 30% of the country's people in urban areas by 2028. This type of growth map pose a demographic challenges as cities and towns struggle to provide jobs, infrastructure and services, and housing. Infrastructure and services delivery are already undermined in many cities by growing urban extents and stretched municipal budgets, while formal labor markets are failing to keep up with demand for jobs. Ethiopian cities run the risk of becoming less attractive places for people and economic activity.
Moreover, constraints on rural-urban migration including the loss of land rights for those who leave rural areas reduce incentives to move to cities, which in the long run could slow agglomeration, reducing productivity and economic growth (Abeje et al, 2014).

Hosanna town are center for many neighborhoods and concentrated with a number of socio-economic activities such as trade, public services like hospital and health services, transport etc., and also population growth creates good opportunity for urban growth (Hosanna Town Finance and Economy Development (HTFED), 2018). Therefore, spatial pattern and physical extent and development activities such as houses, road construction, and other social facilities were changed from time to time. Moreover, the town administration was started to lead the town through proper plan by providing both structural and local development plan. However, planning process suffers largely at the stage of implementation. Due to the growing demands there were unsustainable changes of urban plans, conversion of reserved lands to other uses than the one proposed on master plan and failure to follow urban planning regulations. The results of uncontrolled urban growth are urban sprawl, formation of informal settlements which suffer from social, economic, and physical problems. Rapid growth of urban area from time to time changes farm land to urban activities affects the life of peri-agricultural community, decrease agricultural production, displacement of community from their farm land, separation of plots proceeding to worsening in their economy and altering their land use pattern and process in the area (Hosanna Town Municipality, 2018). So, decision makers and urban planners are increasingly becoming more concerned about urban expansion since trends and patterns of urbanization have huge effect on socio-economic development. Also policy makers must weigh the long term costs and benefits when decisions put in place now will influence urban systems for years to come. Coordination between land use and infrastructure investment is especially key because these systems have long lifespans and shape economic and social geography in a fundamental and path-dependent way of growth of the town (Hossana Town municipality, 2018).

There are numerous studies on urban growth in Ethiopia and especially in the study area. For instance, Impact of urban expansion on surrounding peasant land. In the Case of Boloso Sore Woreda, Areka Town, SNNPR, 2017. There were a gap on spatial analysis. Cellular automata model based urban sprawl mapping: a case of Mekelle city, 2017. There were a gap on the usage of independent variables like demographic and economic factors for urban growth. Other study has been done in Hosanna Town i.e. urban expansion and the livelihood of peri-urban agricultural society by using Geo-spatial techniques, 2018, unpublished. There was a gap in using urban modeling for data analysis. Besides to this, a gap exists between the research-focused results offered by prior researchers and applications of these data and methods by urban planners and decision makers in the urban area and also there were limited utilization of spatial and statistical models for data analysis. So, this study was conducted to fill gaps by using cellular automata model to examine state of change in land cover/land use and predict future urban growth of town by computing dependent and independent variables of social, economic, and environmental by using regression model in relation with spatial technologies.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study was to model and predict future urban growth of Hosanna town by using Geo-spatial techniques.

1.3.2 Specific Objectives

Specific Objectives of the study were:-

- To detect and classify urban land use/ land cover of Hossana from the images of 2003, 2013, and 2018 years.
- To determine trends and rates of the urban growth of the town by analysis of the imageries.
- To identify the drivers for Hossana town growth using quantitative approach.
- To predict and model the future urban growth for year 2028 by using CA model through examining the size, shape, and direction of built up areas.

1.4 Research Questions

- ✓ How can detect and classify urban land use land cover of the town?
- ✓ What are the trends and rates of the urban growth of the town in three periods?
- ✓ What are the drivers for urban growth and their relationships using quantitative approach
- ✓ How can predict and model the future urban growth for year 2028 using CA model through examining size, shape, and direction of built areas?

1.5 Significance of the Study

The urban growth and their growing spatial influence initiated a change from largely rural to predominantly urban places and patterns of living that has affected most cities over the last two centuries. Currently, not only do large numbers of people live in or immediately adjacent to towns and cities, but whole segments of the population are completely dominated by urban values, expectations and life styles. From its origins as a locus of non-agricultural employment, the city has become the major social, cultural and intellectual stimulus in modern urban society.

Hence, urban growth or spatial expansion studies are important tools for urban planners and decision makers to consider the impact of urban growth. Spatial and temporal variation of urban growth were studied to establish a relationship between urban growth and some its causative factors, like population, population density, density of built up. This study also was conducted to develop essential planning situation so as to manage urban area with economically productive, environmentally sound, and socially inclusive for inhabitants. The information generated from this study were believed to provide useful information for urban planners, decision makers, and GIS experts to exercise right judgment on the provision of urban planning and development by considering influential factors for urban growth. Moreover, the information provided by this study were used as a springboard for further studies related to urban growth especially by using Geo-spatial technologies.

1.6 Scope of the Study

The scope of this study were limited in terms of space, time and subject. Spatially this study were confounded within the boundary of the hosanna town and temporally this study was conducted in a multiple time series. Subject of the study was limited on modeling and predicting future urban growth using Geo-spatial technologies. The methods of data analysis was based on mixed sequential approaches i.e. both qualitative and quantitative system of data analysis.

1.7 Limitation of the Study

Limitation for this study were GPS error plus or minus 3m unable to control it; time shortage to review in detail related works done with other researchers before; absence of CA based works done in the study area; and financial shortage in a way to bought additional high resolutions satellites data. However, in contrast to physical data (space attributes), functional data (activities attributes) have proved a major barrier to modelling in this research .This is due to the lack of local data infrastructures.

1.8 Thesis Organization

The research comprises theory, methodology, analysis and results, and discussion and conclusion which correspond to the four major sections of the thesis.

Chapter 1 provides a general overview of the research. This includes its background, statement and justification, relevance, the questions that are addressed, its research objectives, significance, limitation and scope.

Chapter 2 provides the theoretical framework that are relevant to this research. The theoretical section is dominated by concept of urban growth; drivers of urban growth. Next, currently prevalent methods of modelling, such as CA, Shannon entropy, logistic regression model are evaluated based on the operational criteria, e.g. data availability, interpretability and GIS linkage.

This evaluation results in a conceptual model for the next two chapters. Theoretically discusses the relevant definitions of urban growth and explicitly develops a method for comparatively measuring temporal and spatial urban growth.

Chapter 3 deals with the materials and methods of data analysis and modelling requirements for the study area. This chapter aims to improve local knowledge of urban growth in order to produce the data framework for the modelling exercise, and also to develop methods for modelling spatial expansion of the town.

Chapter 4 the spatial and temporal patterns are quantitatively evaluated from the perspectives of land use structure change, trend and patterns of urban growth, annual growth rate, analysis of socio-economic drivers of the urban growth, predicting growth of the town, and discussions of the results.

Chapter 5, concluding the issues which have been series and important for decision makers based on modeling results and recommending some necessary ideas for coming activities.

CHAPTER TWO

2. Literature Review

2.1 Concepts and Definitions: Urbanization, Urban Growth and Urban Sprawl

Urbanization as an increasing share of a nation of population living in urban areas and those declining share living in rural areas. Most urbanization is the result of net rural to urban migration (Mefekir, 2017)

Urban growth, urban extension, and urban sprawl are sometimes used synomously, even though they differ conceptually. Urban growth is an increase in the urbanized land cover. Urban growth according to spontaneous or unplanned urban development is called urban sprawl. Urban sprawl usually has negative connotations, associated with the generation or intensification of complex urban problems, such as land, water, and air pollution, with their consequent negative impacts on human health (Kumar and Pandey, 2013).

Urban growth being attributed to natural population growth and the rural-urban migration is expected to increase at an unprecedented rate in the coming decades and this will definitely lead to more changes in the urban environment (Bauer et al, 2006). The rapid development of urban areas and the improvement in transportation networks have brought various land use problems in their wake, including urban diffusion and the phenomenon of urban sprawl. There is a strong need for accurate predictions of land-use change and future urbanization, as well as investigation of the appropriateness of present land use controls and the land use controls that will be required in the future (Kayoko, 2007).

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. Without urban growth there would be no appearance of urban sprawl. The rapid changes of land cover are often characterized by urban sprawl, farmland displacement, and deforestation, leading to the loss of arable land, habitat destruction, and the decline of natural greenery areas. Sprawl takes place at the urban fringes in the form of radial development or development along the highways with the elongated urban development (Nechyba et al, 2004).

Some of the causes of the sprawl include - population growth, economy and proximity to resources and basic amenities. Decentralization is a trend indicative of urban sprawl and present day industrial, commercial, and residential areas are no longer necessarily a part of the urban core. Rather, these types of development are often found in low-density areas that are separated from the major urban area by large tracts of homogeneous land. Hence, the needs for larger transportation networks and in turn a greater dependency on automobiles, which produce more air pollution. As new roads are put in place, precious farmland is often left unprotected from commercial or residential developers. Without regulations on urban growth, consequences of urban sprawl are likely to continue (Dhaoui, 2013).

The issues of using static measurements to quantify a dynamic phenomenon is essentially one of pattern. Many of the measurements that we have seen thus far seek to capture some qualities that are intrinsic in the patterns that sprawl generates. This is wholly appropriate in many instances, as sprawl is in many senses a pattern based phenomena. However, it does neglect many of the process that drive sprawl. To really understand how sprawl works to better inform policies to mitigate its negative effects. It is necessary to look at both pattern and process in an interactive/dynamic fashion. Again, modeling is one way in which this might be achieved. Also, CA models offer much promise in allowing both form and function to be represented and studied in a closely coupled and adaptive manner (Alberti, 2001).

2.2. Relevant Theories and Models

Theoretically, urban growth modeling should be considered as an interdisciplinary field as it involves numerous scientific and technical areas, e.g. geographical information science (GIS), remote sensing (RS), urban geography, complexity theory, land use/cover modeling etc. Understanding urban growth and applying this knowledge for planning are both closely linked with these areas. Hence, a systematic and "holistic" perspective should be adopted in the process of modeling (Jianquan, 2003).

2.2.1 Complexity Theory

Urban growth is in essence a complex subsystem; it involves multiple actors with differing patterns of behavior at various spatial and temporal scales. It centers on understanding the dynamic interactions between the socio-economic and built environments and major natural environmental impacts. Modeling spatial and temporal urban growth helps to identify the complexity hidden in its processes and provides urban development planning and land management with new theoretical concepts and methods (Cheng, 2003).

2.2.2 Land use change modeling

Jianquan (2003) argued that under the umbrella of sustainable development (e.g. the International Geo-sphere-Biosphere Program (IGBP), the International Human Dimensions Program on Global Environmental Change (IHDP) and NASA's Land Cover and Land Use Change Program), land use/cover change (LULCC) has attracted a great deal of attention. It spans the global, national, regional and local levels and is interdisciplinary in nature, with agricultural, ecological, landscape, forest and urban sub-themes. This research considers the complex interactions between land use/cover change and other systems, such as the impacts of change on ecological systems and vice versa. A systematic understanding of land use/cover change needs individual cases at different geographical levels and from a range of disciplines. Urban growth results from the transition from non-urban into urban land uses, both physically and functionally. In this land use/cover change, the human dimension is important. The outcome is a result of the interaction between natural and human systems. Land use/cover modeling aims at quantitatively specifying the mechanisms of the physical and functional transitions of the land system and interprets the causal effects hidden in its processes.

2.2.3 Hierarchy theory and the scale issue

Complexity frequently takes the form of hierarchy (Kronert et al., 2001). Hierarchy theory was developed by general systems theorists, notably Koestler and Simon, to deal with complex and multi-scaled systems (O'Neill, 1988). Hierarchy theory applies hierarchy to organize concepts and interpret various complexities. In essence, a hierarchy is an ordered ranking, which is a basic property of any system from the angle of general systems theory. A hierarchy is often called a multi-level system, i.e. A contains B and B contains C. A fundamental point is that a component in a larger system (higher level) is also a system. Higher levels set constraints or boundary conditions for lower levels. Larger scales operate much too rapidly to be of interest and can be ignored (O'Neill, 1988). The theory examines closely the issues of scale, levels of organization, levels of observation, and levels of explanation in a complex system characterized by hierarchical structures and interactions across levels. The key to understanding hierarchical structure is scale. Scale is a form of hierarchy. The importance of scale has been recognized in the sciences concerned with the spatial organization of human activities and physical processes on the Earth's surface for more than four decades (Marceau, 1999).

Spatial scale is linked with the terms “resolution” and “extent”. Resolution is the precision of measurement, usually defined by specifying the grain size, which determines the lowest or smallest visible level in a hierarchy or minimum sampling unit. In the case of raster or image data, resolution is the size of a rectangular pixel. Extent represents the boundary of the study area under consideration, and appears unambiguous. Extent and resolution define the upper and lower limits of resolution of a study. Pereira (2002) argued that the definitions of both resolution and extent become complementary rather than contradictory. Temporal scale is related to the terms “time step” and “duration”. The time step is the smallest temporal unit of analysis in a model, while duration refers to the length of time that the model is applied. Decision-making scale can be described in similar terms: “agent” and “domain”. Agent refers to the human actor or actors in the model who are making decisions. The individual human is the smallest single decision-making agent; other agents can include a household, neighborhood, county, state, province or nation. Domain, on the other hand, refers to the broadest social organization incorporated in the model. While the agent captures the concept of who makes decisions, the domain describes the specific institutional and geographical context in which the agent acts. Institutionally, agents may overlap spatially.

2.2.4. Multi-scale in urban growth

Scale issues are inherent in studies examining the physical and human forces driving land use and land cover changes (Currit, 2000). The multi-scale issue in urban growth has distinguishing spatial, temporal and decision-making dimensions.

As remotely sensed imagery is a primary data source for monitoring urban growth, its temporal dimension is impacted by the requirements of temporal pattern analysis and the availability of time series imagery.

Spatial patterns of urban growth first can be differentiated with varied spatial resolutions. This multi-resolution analysis principally explores the details of information extracted, which is utilized to test the sensitivity or stability of the models. Numerous experimental studies in various areas such as the agricultural, ecological and environmental sciences have reached consensus that resolution is an influential factor (Kok and Veldkamp, 2001). Data collected at a gross scale (coarser resolution) are considered less reliable in aiding the interpretation of events operating at fine scales (finer resolution) (Goodchild, 2000). However, multi-resolution analysis is implemented under a definite spatial extent as the latter largely affects the availability of data sources.

2.2.5 Techniques of Urban Growth Modeling

Urban growth is recognized as physical and functional changes due to the transition of non-urban landscape to urban forms (Thapa et al, 2010). The time space relationship plays an important role in order to understand the dynamic process of urban growth. The dynamic process consists of a complex nonlinear interaction between several components like: topography, drainage pattern and rivers, land use, transportation, culture, population, economy, and growth policies.

Urban modeling is the process of identifying appropriate theory, translating this theory into a mathematical or formal model, developing relevant computer programs and then confronting the model with data so that it might be calibrated, validated and verified prior to its use in prediction (Batty, 2009). Batty (2009) has suggested to group urban models into three main classes: (1) land-use-transportation model; (2) urban dynamics model; and (3) cellular automata, agent-based model and micro-simulation.

However, this classification also has several problems; for example, cellular automata and agent-based models are different. Further, it does not consider neural networks and fractal based modeling. For addressing the complex problems in city planning, it is not sufficient just to be concerned with the physical structure of the city; rather the interplay of intangible economic, social and environmental factors needs to be considered as well (Gilbert et al, 1996). Therefore linear and reductionist science is of limited value in urban modeling. This trend grew to produce the ideas of complexity science based models.

2.2.5.1 Cellular automata model

Cellular automata (CA) were introduced by Ulan and Neumann in 1940 and since 1980 numerous models have been developed for simulating urban growth. Cellular automata (CA), a technique developed recently, has been receiving more and more attention in urban and GIS modeling due to its simplicity, transparency, strong capacities for dynamic spatial simulation, and innovative bottom-up approach. When applied to real urban systems, CA models have to be modified by including multi-states of cell, relaxing the size of neighborhood with distance-decay effects, probabilistic rules, and link with complexity theory (Santé et al, 2010). Generally, the state of each cell depends on the value of the cell on its previous state as well as the values of its neighbors according to some transition rules. These rules affect the urban growth, indicating environmental and socioeconomic support or limitations. Therefore, the bottom up approach implemented in CA relies on the simulation of local actions that progressively create the global emergent structure (Batty, 2005).

Traditional form of CA consists of five main components: the lattice, time steps, cells, a neighborhood, and transition rules. CA is formally defined as follows (Batty, 2009):

$$St+1 = f\,(St, SN)$$

Where $St+1$ is the state of the cell at time $t+1$, SN is the set of states of neighborhood, f is a function representing a set of transition rules, and St is the state of the cell at time t. Time is divided into discrete time steps, and the transition rules examine the cells in the neighborhood to determine if and how the current cell will change state at the next time step.

Weakness of CA Model

CA methods also face challenges in urban simulations. Due to spatial heterogeneity, different parts of cities should be addressed by different transition rules. Therefore, global transition rules applied by CA may be inappropriate for modeling cellular space. Furthermore, spatial heterogeneity dictates that neighborhoods should be described by different shapes and sizes in order to capture better spatial interactions of urban structures. CA methods typically implement regularity in neighborhoods, limiting modeling capabilities. Finally, disadvantages of CA include the assumption of spatial and temporal in variance for transition rules and the inability of CA to deal with stochastic behavior. Another criticism is that CA only assumes the bottom up approach, and accounts for local specific cities that ultimately define the overall representation of the space generally. All constituents of urban systems, however, do not exhibit bottom up behavior like, urban planning decisions, national policies, macro-economy, and soon. These factors operate from top to bottom and serve to constrain the urban growth (Dimitrios and Giorgos, 2012).

Strength of CA Model

Turning to strength, the simulation of urban dynamics is an area of research where CA has been recently implemented. Here, CA represents a useful tool for understanding urban dynamics, improving theory, achieving realistic and operational urban models (Dimitrios and Giorgos, 2012). In the spatial modeling perspective, the strengths of CA lie in their capacity to perform dynamic spatial modeling over a discrete and continuous Euclidean space. Similarly, CA has the ability to exhibit explicit spatio-temporal dynamics.

Diappi et al. (2004) have identified four distinct advantages of CA: (1) spatial inherency definition on a raster of cells and on neighboring relationships are crucial; (2) simple and computationally efficient; (3) process-based modeling that deal with state changes; and (4) dynamic in nature and can represent a wide range of situations and processes. Finally, the flexibility of transitional rules embedded into CA architecture favors an effective control over the dynamic patterns that are generated.

2.2.5.2 Shannon's Entropy of Urban Growth Model

Shannon's entropy technique is widely used to study urban sprawl phenomena. As a good measure of spatial dispersion or concentration, Shannon's entropy model can be used to analyze and assess any geographical variable. This technique is able to reveal the configuration and orientation of spatial patterns and can analyze spatial variables within a GIS (Devkota et al., 2012). The level of urban sprawl is recognized by the entropy value. The relative entropy value starts from zero and extends to one. A zero value denotes the compact distribution of urban areas, whereas values near one indicate the dispersed distribution of urban areas. Thus, higher entropy values indicate higher sprawl occurrences.

2.2.5.3 Logistic regression model

Linear regression analysis examines the relationships between urban land uses and independent variables. When the dependent variable is dichotomous, logistic regression can be applied to predict the presence or absence of a characteristic based on a matrix of independent variables. For example, a dichotomous dependent variable can be urban change, where a value of 1 indicates change from non-urban to urban and 0 indicates no change. The independent variables can be continuous, categorical, or both. Linear and logistic regression models have been widely used in urban growth modeling, accommodating socio-economic and environmental independent Variables (Verburg et al., 2004). Like all linear regression models, the logistic regression is a predictive model. Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more metric (interval or ratio scale) independent variables. Unfortunately, linear and logistic regressions do not offer high modeling capabilities and they fail to capture non-linearity in the relationships between the dependent and independent variables or to address correlations between independent variables.

2.3 Urbanization Trends and Features: An Overview

Urbanization is an increase in the number of people living in towns and cities. Urbanization occurs mainly because people move from rural areas to urban areas and it results in growth in the size of the urban population and the extent of urban areas. These changes in population lead to other changes in land use, economic activity and culture. Historically, urbanization has been associated with significant economic and social transformations. For example, urban living is linked with higher levels of literacy and education, better health, lower fertility and a longer life expectancy, greater access to social services and enhanced opportunities for cultural and political participation (UNDESA, 2014). However, urbanization also has disadvantages caused by rapid and unplanned urban growth resulting in poor infrastructures such as inadequate housing, water and sanitation, transport and health care services.

2.3.1 Global Trends in urbanization

In 1960, the global urban population was 34% of the total; however, by 2014 the urban population accounted for 54% of the total and continues to grow. By 2050 the proportion living in urban areas is expected to reach 66% (UNDESA, 2014). Figure 2.1 below shows the change in the rural and urban populations of the world from 1950 through to projected figures up to the year 2050.

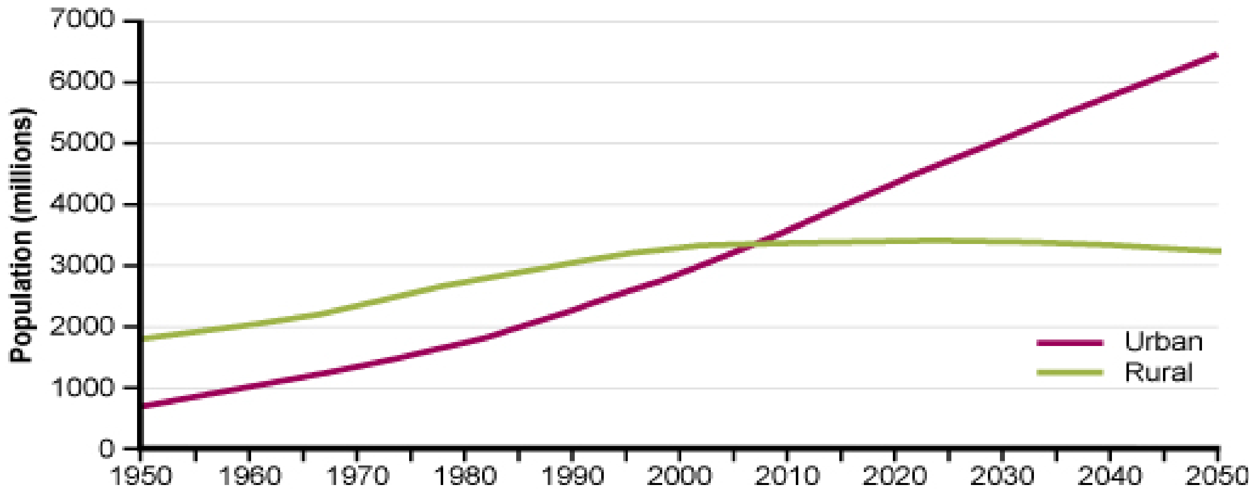

Figure 2.1. Urban and rural population of the world, 1950–2050. (UNDESA, 2014)

The two lines cross at about 2007 or 2008. This is when urban first exceeded rural population. The process of urbanization affects all sizes of settlements, so villages gradually grow to become small towns, smaller towns become larger towns, and large towns become cities. This trend has led to the growth of mega-cities. A mega-city is an urban area of greater than ten million people. Rapid expansion of city borders, driven by increases in population and infrastructure development, leads to the expansion of city borders that spread out and swallow up neighboring urban areas to form mega-cities. In 1970, there were only three mega-cities across the globe, but by the year 2000, the number had risen to 17 and by 2030, 24 more mega-cities will be added.

2.3.2 Urban Growth in the Developing Countries

Demographic and rural-urban migration in developing countries render human, water, or energy flows much harder to manage and control. The challenges to ensure that this urbanizing world facing tremendous mutations and the consequences of climate change remain sustainable. African cities are the fastest developing cities and are overwhelmed by the pace of urban development. Sub-Saharan cities will need to welcome 340 million more inhabitants over the next 20 years (www.thinktank-resources.com/en/themes/urban). In many cases, the capacity of the developing cities to solve issues facing them is strongly correlated to the level of capacity competence, and legitimacy granted to local authorities. Yet the general trend of decentralization ongoing in most developing countries has seldom came with sufficient levels of fiscal power that would enable local authorities to finance urban infrastructure investments, as these local governments are likely to rise their relative share in financing local investments, one funding model could be financing through property development and capturing land values (www.thinktank-resources.com/en/themes/urban).

2.3.3 Urbanization in Ethiopia

Ethiopia is one of the least urbanized countries in the world today, and only 18% of its population lives in urban areas (JMP, 2014). In common with many other developing countries, however, this pattern is changing. Ethiopia's urban growth rate is more than 4.0% per year, which places it among the highest in Africa and the world (MWUD, 2007). The rapid increase in urban populations has meant that peri-urban areas are growing much more quickly than formal urban centers. Peri-urban areas are those areas immediately around a town or city. They are areas in transition from countryside to city (rural to urban), often with undeveloped infrastructure, where health and sanitation services are under pressure and where the natural environment is at risk of degradation.

2.4 Drivers of Urban Growth

Historical studies indicated that urban expansion was the result of the joint effect of social, economic, and political factors (Verburg et al, 2004). Differences in the form of urban expansion have been attributed to six different types of effects: the effects of the natural environment; the effects of demographics; the effects of the economy; the effects of the transport system; the effects of consumer preferences for proximity; and the effects of governance. More specifically, aspects of the natural environment that may affect urban expansion include those of climate, slope, insurmountable barriers, and the existence of drillable water aquifers (Shalom et al., 2005).

2.4.1 Population Growth

Demographic effects may include rural-migration and natural population growth in the city, the level of urbanization in the country, and the rank of the city in the country's urban hierarchy. In industrialized countries the future growth of urban populations will be comparatively modest since their population growth rates are low and over 80% of their population already live in urban areas. In contrast, developing countries are in the middle of the transition process, when urban population growth rates are very high (Burchfield et al, 2006).

2.4.2 Economic Growth

Aspects of the economy that can affect urban expansion include the level of economic development, differences in household incomes, exposure to globalization, the level of foreign direct investment, the degree of employment decentralization, the level of development of real estate finance markets, the level and effectiveness of property taxation, and the presence of cycles of high inflation (Shalom et al, 2005). Expansion of economic base (such as higher per capita income, increase in number of working persons) creates demand for new housing or more housing space for individuals. This also encourages many developers for rapid construction of new houses. Rapid development of housing and other urban infrastructure often produces a variety of discontinuous uncorrelated developments. Rapid development is also blamed owing to its lack of time for proper planning and coordination among developers, governments and proponents.

2.4.3 Transportation

Aspects of the transport system that affect urban expansion may include the introduction of new transport technologies and most notably the private automobile, transportation costs vis-à-vis household incomes, the level of government investment in roads, the existence of city centers that were already developed before the advent of the automobile, and the existence of a viable public transport system (Shalom et al, 2005).

Transportation routes open the access of city to the countryside and responsible for linear branch development. The construction of expressways and highways cause both congestion in the city and rapid outgrowth. Roads are commonly considered in modeling and forecasting urban sprawl (Cheng and Masser, 2003), because they are a major catalyst of sprawl. Important to realize transportation facilities are essential to cities and its neighborhoods. Development of urban economy and thereby job opportunities are directly dependent on the transportation facilities. Therefore, transportation facilities can never be suppressed; rather initiatives to impede linear branch development by means of government policies and regulations should be practiced.

2.4.4 Physical Factors

Sometimes the sprawl is caused because of unsuitable physical terrain (such as rugged terrain, wetlands, mineral lands, or water bodies, etc.) for continuous development. This often creates leap-frog development sprawl (Barnes et al, 2001). Important to mention that in many instances these problems cannot be overcome and therefore should be overlooked

2.5 The Role of Geo-spatial Technologies in Urban Growth Prediction

Remote sensing and geographical information science (GIS) have proved an effective means for extracting and processing varied resolutions of spatial information for monitoring urban growth (Masser, 2001). However, they are still not adequate for process-oriented modeling as they lack social and economic attributes, in particular at detailed scale. In developing countries, socio-economic data acquisition and integration still have a long way to go. On this occasion, local knowledge (expert opinions, historical documents), albeit only qualitative or semi-quantitative, can be very valuable in assisting process understanding such as urban expansion , driving forces and the major actors involved. As a result of the rapid development of remote sensing (RS) and geographical information sciences (GIS) and techniques, increasingly large-scale studies of urban development have been facilitated (Ibid). Modern satellite imagery, together with traditional aerial photographs, provides rich multiple resolution and scales of data sources for monitoring urban development processes. By using GIS, it is technically possible to integrate large quantities of data for further spatial analysis related to urban development. However, it has become common knowledge that urban development is a complex dynamic process, which involves various physical, social and economic factors. The complexity arises from the unknown number of factors, multi-scale and cross-scale interactions among factors, and their unpredictable dynamics. Pattern and process are reciprocally related like "chicken and egg", and both they and their relationships are also scale-dependent. The identification of determinant factors on varied scales is the first step to understanding the dynamic process.

2.6 Empirical Evidences

Globally, land cover is often altered principally by direct human use such as agriculture and livestock raising, forest harvesting and management, urban and suburban construction and development. As submitted in several researches, hardly can we find any vegetation that has been affected or altered by man in the world (Oyinloye, 2010). In this regard, about 400,000 ha of vegetation cover are confirmed to be lost annually (Balogun et al, 2011). Due to anthropogenic activities, the earth surface is being significantly altered by man's presence and several activities on earth. I have reject this idea, because when we can see our country most of forest or vegetation cover were lost with human activities like deforestation for urban expansion and home consumption. According to Fazal (2000), land transformation has been asserted to be one of the most important fields of human induced environmental transformation. Environmental protection is facing critical challenges due to several factors like increasing population, depletion of natural resources, environmental pollution, unplanned land use, and several others.

Several researches have shown that unplanned changes of land use due to urbanization have become a major problem (Zhao et al, 2004). Most land use changes occur without a clear and logical planning and without giving attention to environmental impacts. Major flooding and air pollution in large cities as well as deforestation, urban growth, soil erosion, and desertification are all consequences of a mismanaged planning and inappropriate projects' execution without considering their environmental impacts.

There are some related studies were done in Ethiopia related with urban growth. For instance, according to Mefekir (2017), impact of urban expansion on surrounding peasant land. In the Case of Boloso Sore Woreda, Areka Town, SNNPR. There were a gap existed in the data analysis i.e only analyzed data in qualitative approaches so the results were not that much appropriate. Cellular automata model based urban sprawl mapping: a case of Mekelle city (Kidane, 2017). Also there were a gap in the variables usage to compute both dependent and independent factors that affect urban growth. The researchers was not used both demographic and economic factors that affect urban sprawl so I have used these two factors as a drivers for urban growth in Hossana town. Other study has been done in Hosanna Town i.e. urban expansion and the livelihood of peri-urban agricultural society by using Geo-spatial techniques (Akililu, 2018). So this researcher was not used any model to analyze data in a way to show results in logically accepted way. According to Tsegaye (2010), urbanization in Ethiopia: study on Growth, patterns, functions and alternative policy strategy. Urban expansion and neighbourhoods: the case of Bishoftu Town (Adem, 2010).

2.7 Conceptual Framework

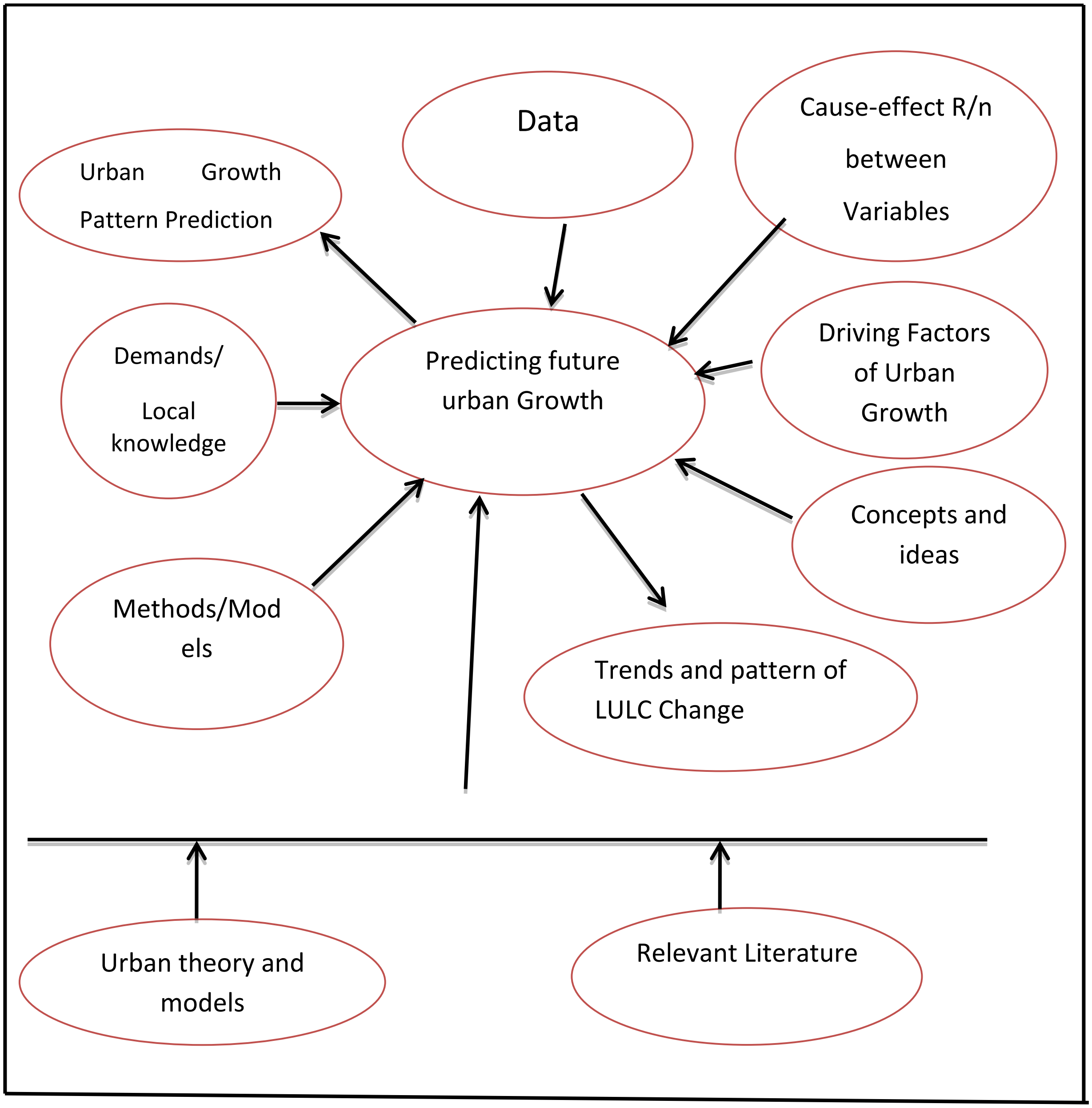

Fig. 2.2 Conceptual framework of the Research

Source: - Adapted from (Cheng, 2003) in 2019.

CHAPTER THREE

3. Description of the Study Area and Methodology

3.1. Description of the Study Area

3.1.1 Location of the Study Area

Hosanna is found in Hadiya Zone, SNNPR, is located at 232km south from the capital Addis Ababa, 168kms away from Hawassa, and 89kms away from Butajira. Administratively, the town belongs to Hadiya zone, SNNPR. It lies on an elevation ranging from 2130m to 2400meters above mean sea level, across the main high way leading from Addis Ababa via Butajira to Wolayitasodo and Wolkite to Hosanna. Physically, town has the total area of 41 square kilometers of land with alternatively changing horizontal and vertical landscape orientation. It includes several ups and downs, hills and plains which can commonly be said that the town is inclined dominantly from west to east. It is found 7°30' 30"N to 7°35' 30"N latitudes and 37°48' 30"E to 37°54' 30"E longitudes (HTFED, 2018).

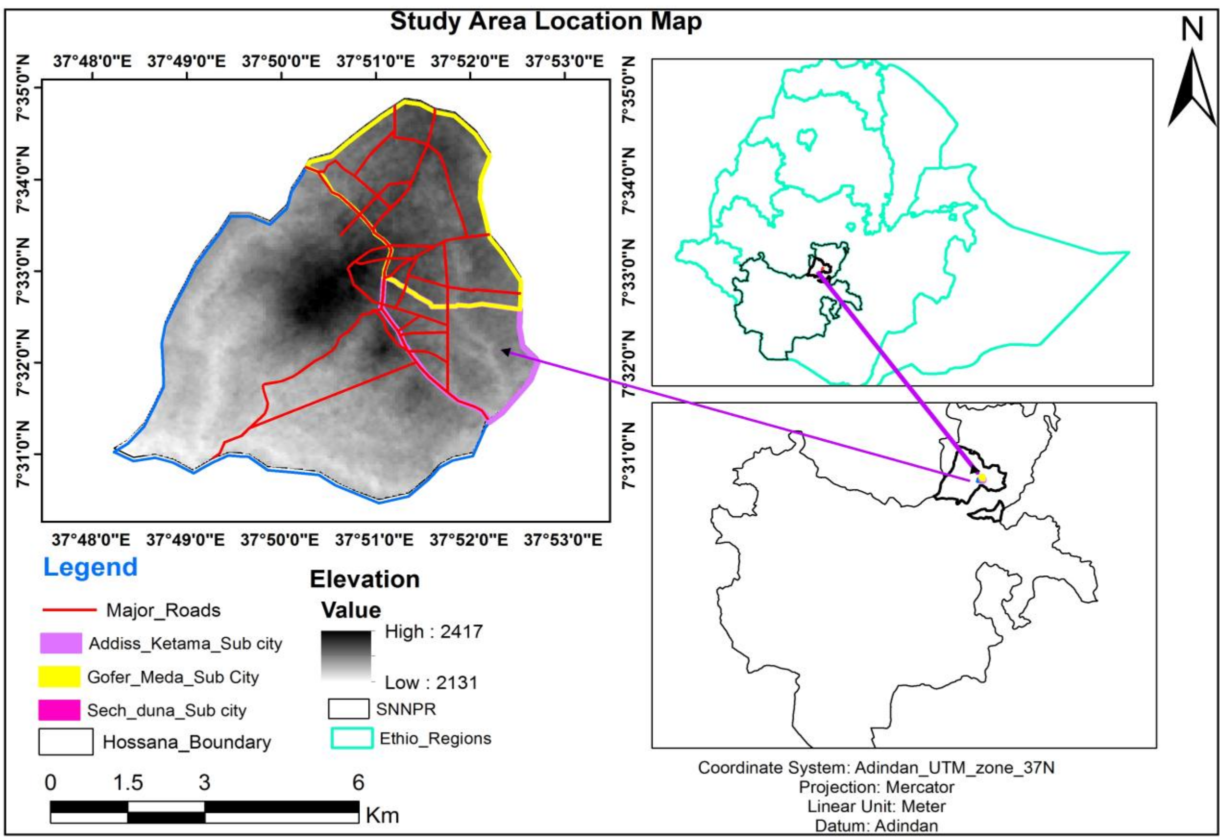

Fig. 3.1 Map of the Study Area *Source:-Ethio-GIS and CSA*

3.1.2 Climate Conditions of the Study Area

The whole study area is lying within a tropical climate as a humid region (Ethiopian Meteorological Agency, 2017).The climate of Hosanna town is characterized by four distinct seasonal weather patterns; that are the main wet season"kiremt" which extends from June to August, a minor rainy season (Autumn) "meker" extends from September to October, a little rainy season "belg" extends from March to May and more likely no rainy season "bega" extends from December to February. In general based on local climatic classification, Hosanna town is grouped under "woeina-dega" climatic zones (HTFED, 2017). The meteorology recorded of Hosanna station indicate that for rainy and dry seasons the minimum and maximum yearly average record of temperature ranges from 19.7°c to 21 °c (Fig 3.2). Similarly, the highest rain fall is recorded 2018 and the lowest in-2013.

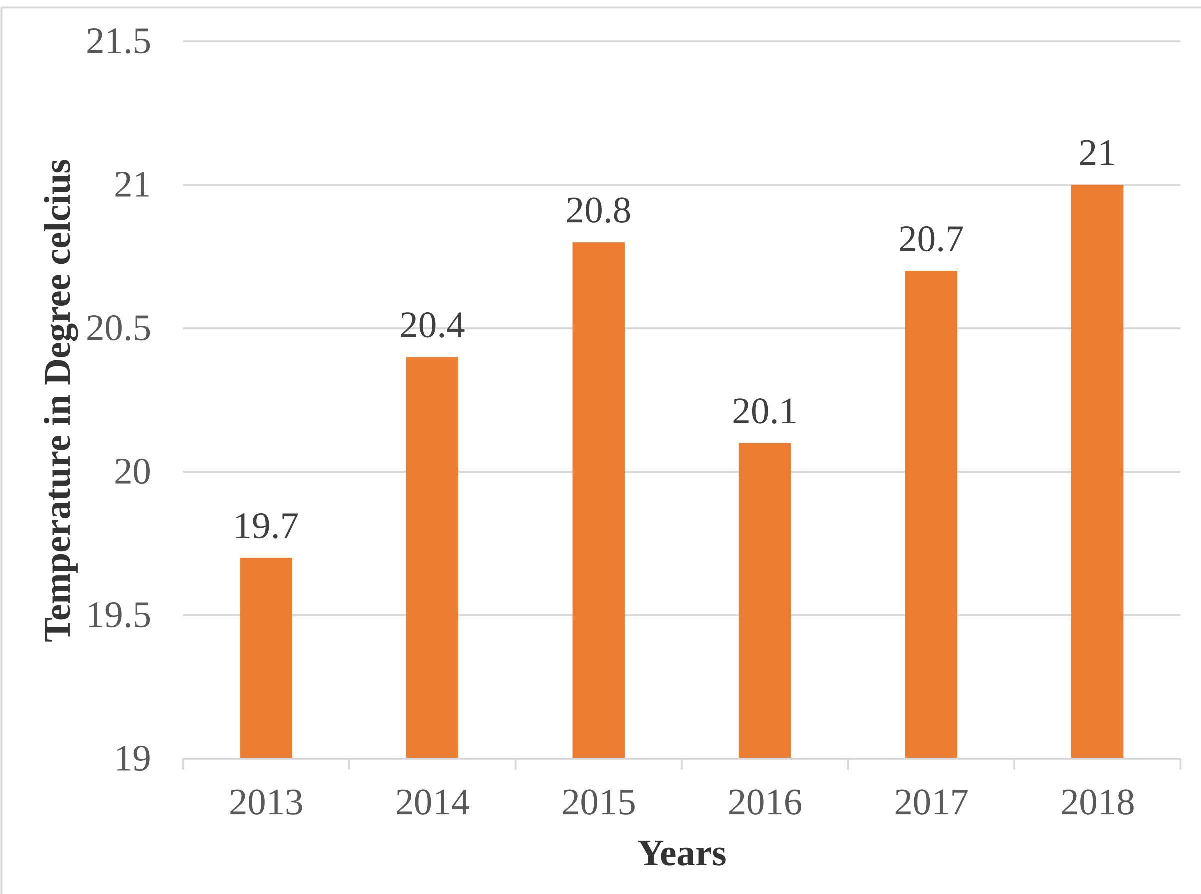

Figure 3.2. Annual (yearly) average temperature variations in hosanna town (HTFED, 2018)

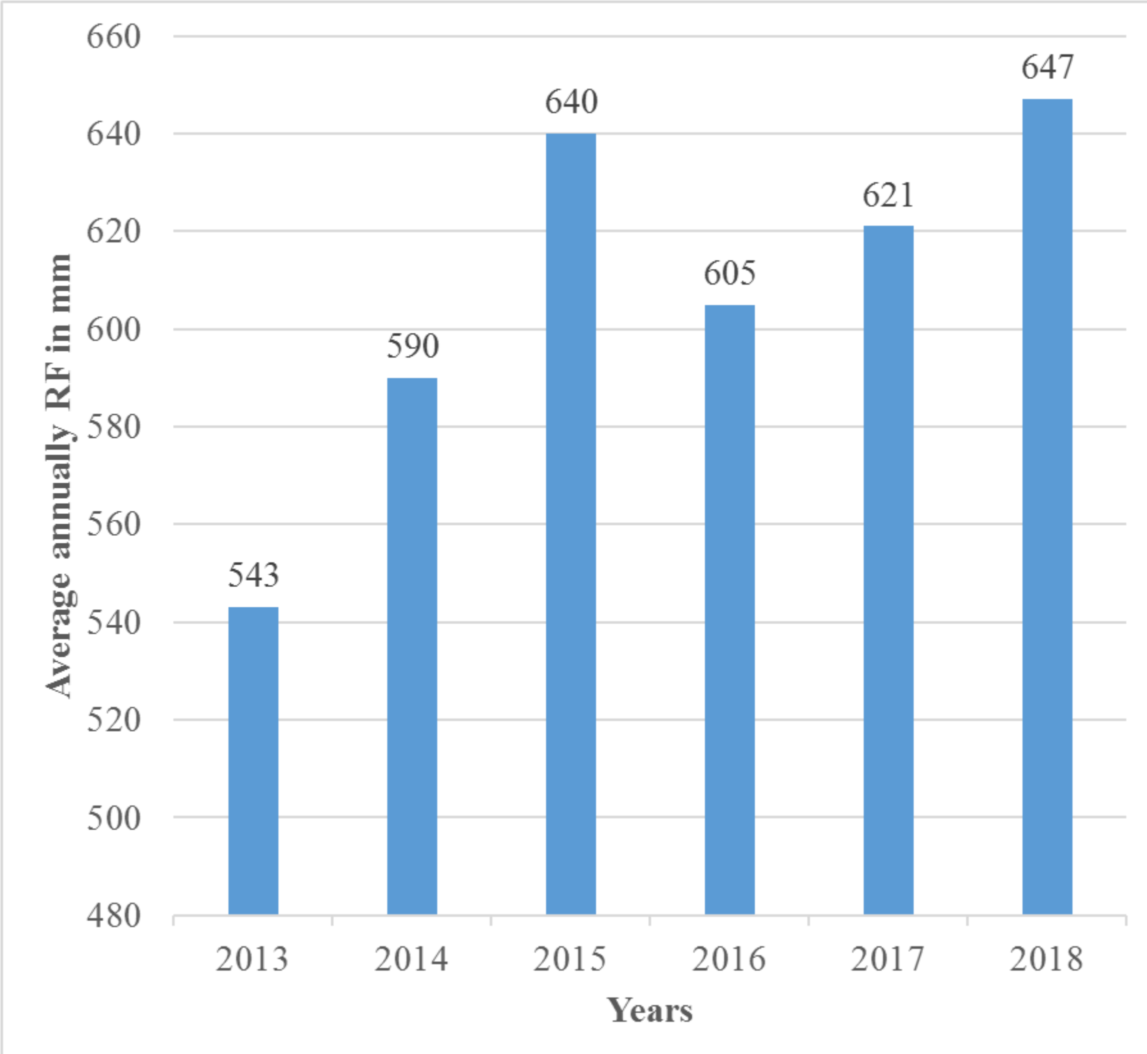

Figure 3.3 .Annual (yearly) average rainfall distribution of hosanna town (HTFED, 2018)

3.1.3 Demographic and Socio-Economic Characteristics of the Study Area

3.1.3.1 Population

Population is a key factor in carrying any plan in urban areas. According to CSA (1994), report the town had a total population of 31,701 of whom 15,593 were men and 16,108 were women. Based on the 2007 census conducted by the CSA, the town has a total population of 69,995, of whom 35,523 are men and 34,472 women. However, the latest report made by the city population center, total population of the town has been 89,300 in the year 2011. According to Projection of the central statistical Agency of Ethiopia (2015), total population of Hosanna was 133,800 of which 65,150 are male and 68,650 are females. Currently, the total population size of the town is expected to be 168,764 of which 80,132 are male and 88,632 are female, if the growth rate (2.9%). This is mainly triggered by the occurrence of high fertility. Large proportion of the town population belongs to below 15 years old (31.5%).

Practically from present existing situation the town has become the destination for many rural migrants and due to this the population number is increasing at rapid rate. The reason for this increased rural to urban migration in the town is due to remittance sent from South Africa (Daniel, 2018, unpublished). There are many migrants in South Africa from the surrounding rural parts of the Hosanna town and they send money back for investment and to meet other needs of the family. With the money sent back, the family left at homeland will move to the town looking for better education to their children, better life expectation and other interests.

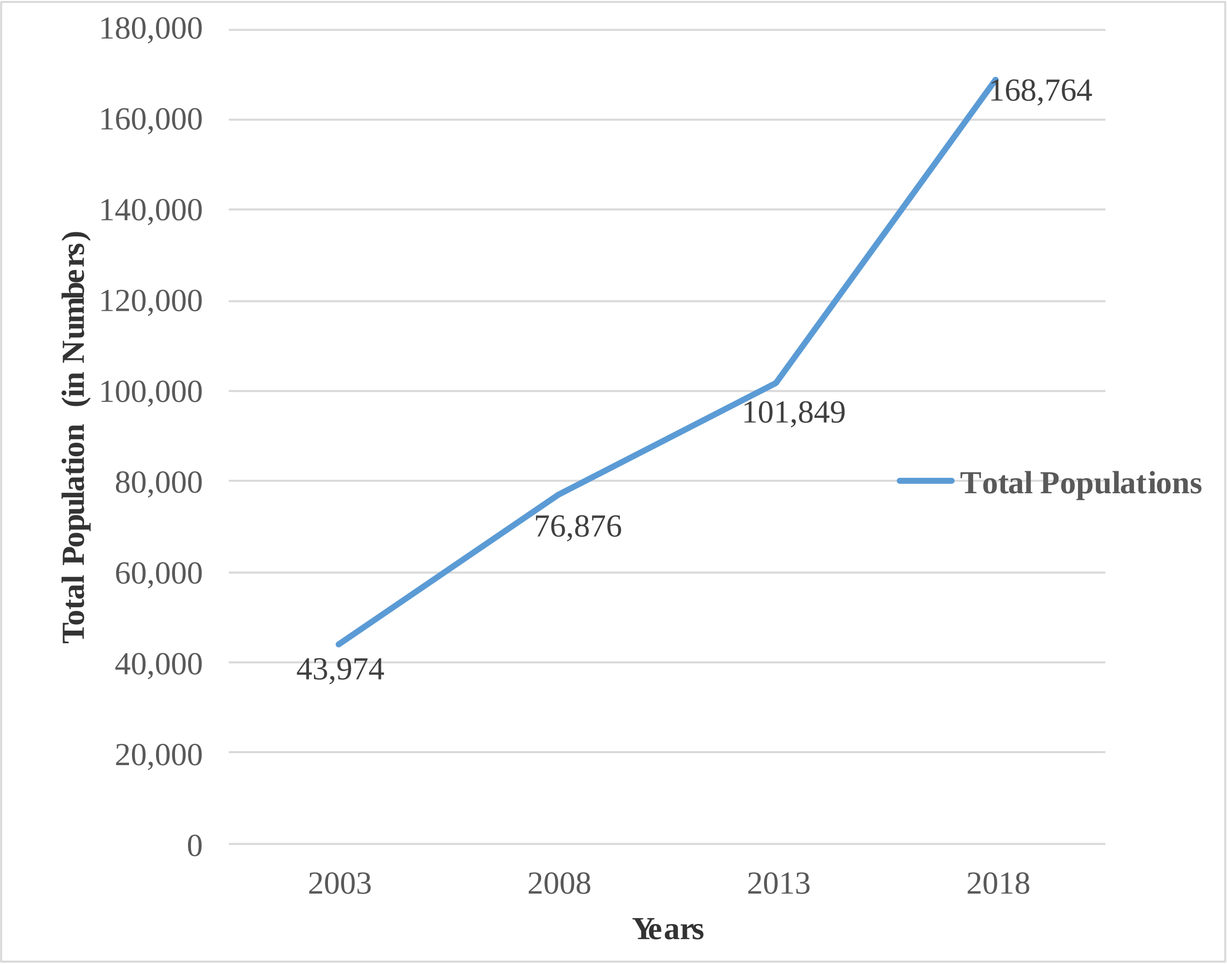

Figure 3.4. Population growth of hosanna town from 2003-2018 (CSA, 2007 &HTFED, 2018)

3.1.3.2 Economic activity

The main economic activities of the town are trade, public services, transport, urban agriculture and the like. Among these activities trade, hotel and restaurants are the main ones. The physical characteristic of housing units in the town has revealed that the majority of them are dilapidated around "Areda" and without the requisite services; however, there are newly emerging housing units at the center and periphery of the town. Its proximity to Addis Ababa, Butajira, Wolaita Sodo , Welkite towns and surrounding districts creates good opportunity for future development of the town. Hosanna has access to asphalt road that links the town with Addis Ababa, Buttajira,Wolita Sodo and Wolikete town and other surrounding woradas with gravel and asphalt road (HTFED, 2018).

3.1.3.3. Service and Infrastructure Development

Road is very important infrastructure and use as an indicator the level of development in a particular country. Road network is the geographical expression with line feature. Hosanna Town has the road network of 160 square km in 2003, 225 square Km in 2013, and 404 square Km length in 2018. (Hosanna Town Municipality, 2018 and Google Earth, 2003 and 2013).

The demand of clean water service in the town was 133,800 resident population. The prospects for expanding existing water supply was two projects currently under process with a capital amount of 4.5 million birr support from Wachamo University. But there were still a challenges in the provision of water infrastructure in the town indicating as follows: topography challenge, lack of coordination among infrastructure subsectors, problem in planned infrastructure provision, water abuse by using for construction works by users. They prioritized the challenges in the level of their importance: topographical, input shortage, limited community participation, technical capacity, land related rights issues for expansion works, governance related problems, budget. Other problems include: lack of coordination especially with municipality and road sector office (Hossana Town Administration Water Supply Office, 2018).

The number of the town people accessing the power infrastructure service was 10,500 as the secondary information provided as an indicator. In a town with more than 26,760 household's heads, only 10,500 people accessed. It was indicated that most of the households get access from other private households and some of the households do not have legal settlement and own house. Major challenges in the power infrastructure provision in the town as identified by sectors were budget deficiency, imbalance between staff and customer number, safety materials shortage for technicians (Hossana Town Hydroelectric Power Sub-station Office, 2018).

3.2 Methodology of the Study

3.2.1 Research Design

Research design of this study would be mixed sequential type approaches. This were due to application of both qualitative and quantitative methods for analysis of spatial and human perception/knowledge. Besides to this, study was used a holistic modeling approach i.e. combining CA, regression, and key experts ideas to identify the significant variables and policy that differentiate urban from rural and forest environments, the relative probability model which uses spatial interactions of neighborhood, distance, and key experts involvement to create a human input layer, set the growth scenarios, evaluate predictions and disseminate the information.

3.2.2 Data Sources and Database

The main data sources for this study were both primary and secondary data sources. Fieldwork/ observation, GCP, and interviews of key informants were also used to capture local knowledge. The remotely sensed images such as Google Earth image of 2003 and Ortho-Photo of 2013 and 2018 have been used in this study to derive the built-up area extents in town. Remotely sensed images were used for land use classification and to identify state of change pattern of urban growth. Land use/cover data would be combined from different times and extracted from high resolution satellite imagery. Other data have been used such as economic, demographic, biophysical, structural and local development plan, books, journals, documents, reports. Finally, for these study both raster and vector data sets/continuous or discrete were collected from different sources which stated below in table below.

Table. 3.1 Data Types and Sources

Data Types		Acquisition Year	Spatial resolution in meter	Sources
Satellite Images	Google Earth Image	2003	1m	Google Earth
	Ortho-Photos	2013 and 2018	1m	Ethiopian Geospatial Technology Agency
Biophysical	Elevation	-	-	Generated from ASTER DEM
	Slope	-	-	Generated from ASTER DEM
Socio-economic	Road network	2003, 2013, and 2018	-	Google Earth and Hossana Town Municipality
	Population data	2003, 2013 and 2018	-	HTFED
	Budget/Fund	2003, 2013 and 2018	-	HTFED
Others Data	Structural plan	2016	CAD format	Hosanna Town Municipality
	Administration Boundary	2003, 2013,and 2018	Vector format	CSA

3.2.3 Sampling Design

Sampling techniques is purposive or judgment sampling in a way to collect information from key informants about the drivers of urban growth different sector such as Hosanna town municipality, HTFED, Transportation, Agriculture and CSA, Hosanna Branch. To do this, key informants interview was given for 12 experts purposively.

A total of 20 ground control points (GCP), surveyed with Global Positioning System (GPS) receiver and used to make the satellite imagery geographically referenced of different years. A total of 200 points were selected randomly for training or GCP; from both developed (urban) and undeveloped (peri-urban) cells.

3.2.4 Materials/Instrument and Software's

The data collection tools of this study were GPS and interview. GCP data was surveyed with Global Positioning System (GPS) receiver to make the satellite imagery geographically referenced.

Non-spatial data were also collected from study area in attribute format. In addition photos of the land uses was captured by using digital cameras.

The following software's were used to analyze spatial and non-spatial data:-

- Microsoft Excel for descriptive statistics
- ERDAS Imagine for digital processing of remotely sensed data
- ArcGIS to produce final output map of prediction
- IDRSI for Multiple regression of dependent and independent spatial variables and cellular automata spatial data modeling; and
- Google Earth for on-screen sample point selection.

3.2.5 Methods of Data Analysis

Pre-Processing

Many pre-processing techniques were utilized to analyze, process, and extract information from remotely sensed data. Before starting to analyzing images to detect changes radiometric and geometric correction were made so as to take it as standard product, faithful representation of earth surface as possible, and to remove distortion occurred from atmosphere (e.g. particulate matter, moisture content, and turbulence. And also image enhancement was made to increase human vision. Images of different resolutions was used and pan sharpened/image fusion was made for re-sampling of spatial resolutions. A simple approach that can be used to fix this difficulty is the re-sampling of imageries that would have high resolutions to match imageries with low resolutions.

Post processing

Collected data such as primary and secondary data from diverse sources was further analyzed. After organizing data in Geo-database format it was analyzed through spatial analysis such as transition matrices, spatial statistics such as spatial heterogeneity and interaction, overlay analysis, Geo-statistical analysis i.e. Euclidean distance. Secondary data were analyzed by using simple descriptive statistics.

The specific algorithms or methods to be employed depend on the purposes of the study. ERDAS imagine, ArcGIS, and IDRSI software packages were utilized for remote sensing images processing, classified land-use map generation, spatial analysis, and map preparation. Supervised classification methods could be used to cluster pixels in a data-sets in to classes corresponding to user defined training classes or the process of using samples of known identity i.e pixels already assigned to informational classes to classify pixels of unknown identity. It assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Training point data were taken so as to relate and check accuracy through confusion matrix i.e. what the objects in the ground and how it is classified as land use type in the classification algorithm. Overall accuracy was calculated in ERDAS IMAGINE through referencing of GCP with classified imageries. The rate and change of land use were calculated by using the following formulas:-

$S=Ub-Ua$..Equation (1)

In this formula: Ua and Ub represents the area of a land use type at the start and the end of the study; S: absolute variation in the area of certain LU in the study period. Land use dynamic degree can be quantitatively described as the rate of change of a type land use within a certain time and certain area. The formula is:

$K=Ub-Ua/Ua\times 100\%$..Equation (2)

Whereas; K: Change rate of land use type

Ub and Ua: are the areas of a LU type at the beginning and end of the study.

Transition matrix analysis of the area between different Lu types could be processed in a way to understood dynamic nature of LU process (Peng, et. al, 2007).

Variables that can drive urban growth were selected through preparing interview questions for key informants and from reviewing of literatures. To the beginning of interview, there were a question related priority issues for urban growth and based on this the weight has been given for those factors only or analyzing the frequency of each of them. To do this, simple descriptive statistics was adopted to analyze collected data. In addition to that, regression model were utilized to compute dependent and independent variables and their relationships was validated by examining coefficient of variation and R square results for those spatial variables. Dependent variables was built up and independent variables were population growth i.e. population density and number, economic growth, proximity variables, physical factors. The results of model for those numerical variables validation were checked by examining the R square and P: value. If R square were near to 1 have been strong relationships between variables and p: value must be ≤ 0.01. Multiple logistic regression were used to analysis spatial socio-economic factors that affect LULCC in the area through providing spatial data in rst format in IDRSI software. After converting in rst format there were trying to generate the results of both dependent and independent factors. If the results of the model have indicated with r^2 have near to 1 means they have strong relationships between variables and it approaches to zero means they have weak relations. Both cellular automata and regression models have been used to analyze spatial data, quantify spatial or spatio-temporal indicators such as proximity, accessibility, density, intensity, explain complex spatial cause-effect relationships between variables selected from interviewing key experts, literature review, and predict future state of change of the objects. Prediction has been made based on the results of Markov transition probability from 2018-2028. Data must be pre-processed to do prediction such as raster images were converted into ASCII format, then ASCII converted into rst format in IDRSI and made band composite, reclassify, create transition areas file in Markov transition. Finally, prediction results were obtained from CA model in IDRSI. The selected methods for data analysis should have been based on an evaluation of the techniques, compatibility with GIS, their capacity to perform dynamic spatial modeling over a discrete and continuous Euclidean space, and computationally efficient in calibration, accuracy assessment of the results..

Finally, spatial modeling and prediction were made to estimate widest impacts of existing trends of population, land use change, economic development, and environmental change. Modeling and prediction results were shown in graph, tabular forms, figures, and maps making them easy to communicate with decision makers.

3.2.6 Validity and Accuracy or Reliability of Data

This study was conducted to add knowledge on the existing knowledge or give any contribution on what is being known. To do this, both conceptual and theoretical literature s related with the identified problem of the study were used and follow appropriate ways from data collection to actual implementation so as to provide expected outcomes of the study. Investigating urban models for urban growth and prediction through appropriate methods of data analysis helps so as to accomplish overall activities of the study. Simultaneously, this study were answering the question to what extent the established objectives have been relevant to the client needs/demands. Qualitatively, the classifications derived in this study was appear accurate; both spatially and thematically, owing to the level of expert-driven, post-classification editing of the results was made. Yet, there is a need for a quantitative expression of just how good the classifications really are. This is typically accomplished comparing a sample of pixels' classification with some form of reference data or ground control points.

3.2.7 Ethical Consideration

Permission to undertake the interview was obtained from the town administrative authorities. Official letters from Jimma University were written to the town. Informed consent/key experts were also obtained after explaining the purpose of the study. Participation of all key experts in the interviews was voluntary to identify driving factors of urban growth in the town. Measures are going to be taken to assure the respect, dignity and freedom of each expert in the interviews. Appropriate measures were taken to assure confidentiality of the information both during and after data collection. A data collection facility was conducted without disrupting the normal day-to-day activities of the facilities in as much as possible.

3.2.8 Methodological Flowchart

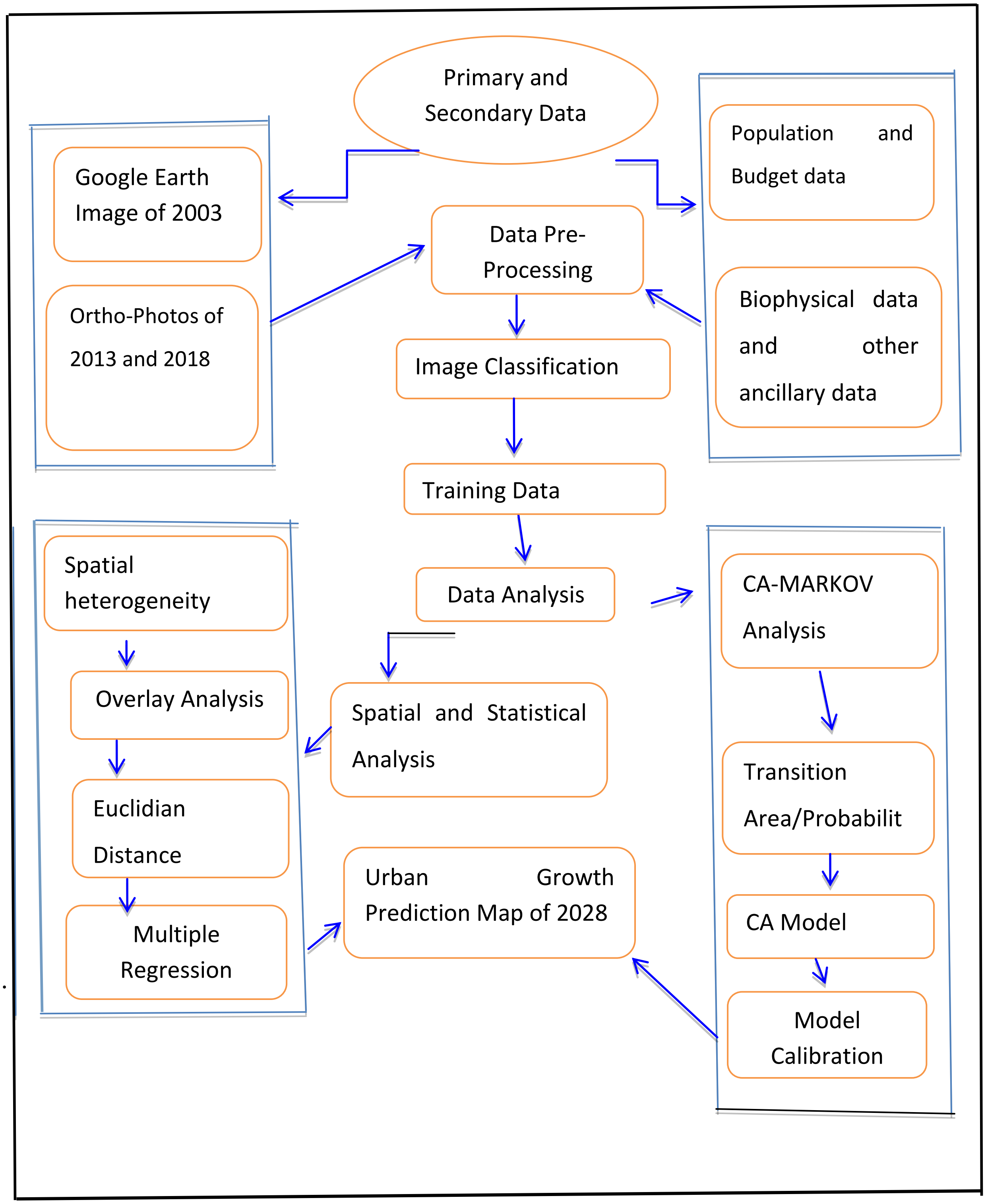

Fig 3.5 Methodological flowchart Source: Own Construct, 2019

CHAPTER FOUR

4. Results and Discussions

4.1 Detecting Urban Land Use/Land Cover Change

4.1.1. LULC Classification Map of 2003

The advantages of using Google Earth (GE) are that it provides the latest satellite imagery having spatial resolution less than 1m. Another advantages of GE that it provides images taken at different time periods which will be very useful for urban planners to perform land use detection studies. Moreover, as the spatial resolution is more detail, it is possible to visual see the buildings, roads, water bodies (Malarvizhi and Kumar, 2015). In recent decades, the use of satellite and aerial photos data has replaced the traditional survey methods in preparing urban land use maps due to achievement in remote sensing and GIS. As we know that in urban areas there were more specific LU classes and function. Indeed, without high resolution satellite we didn't identify LU type. So, high resolution images to classify specific state of object to analyze the change during 2003_2018 and predict urban growth of year 2028.

In this paper, the characteristics of LU structure spatio-temporal change analysis are based on coverage of the town extent. Meanwhile, muti-data fusion is the feature of this study as well including RS data, LU data and its data format conversion. In data processing, conversions among different formats are used, including the conversion between vector to ASCII format in ArcGIS and ASCII format and raster data in IDRSI. Idrsi software is essential to process remote sensing data so as to generate useful information about the change from one land use type to another from time to time. Figure 4.1 shows the thematic map of LULC derived from GE imagery. The statistics of individual land cover types are listed in table 4.1 below.

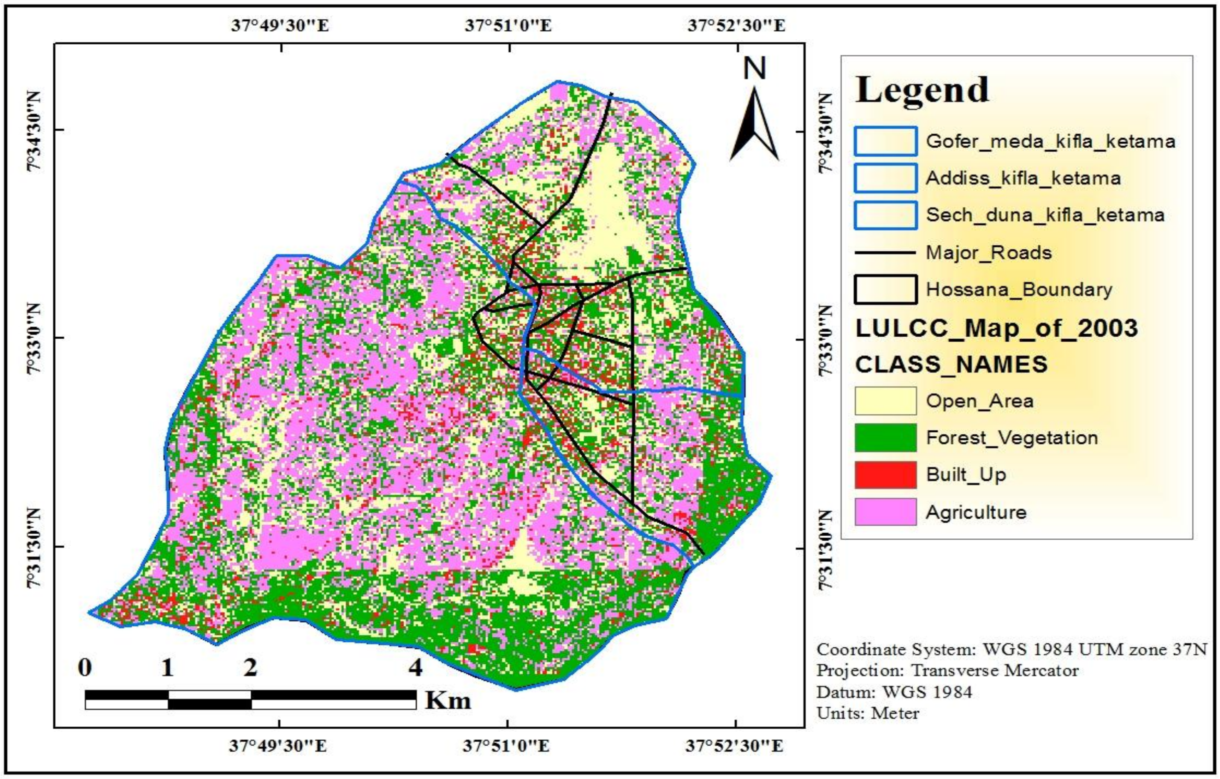

Fig. 4.1 LULCC Map of 2013

4.1.2 LULC Map of Year 2013

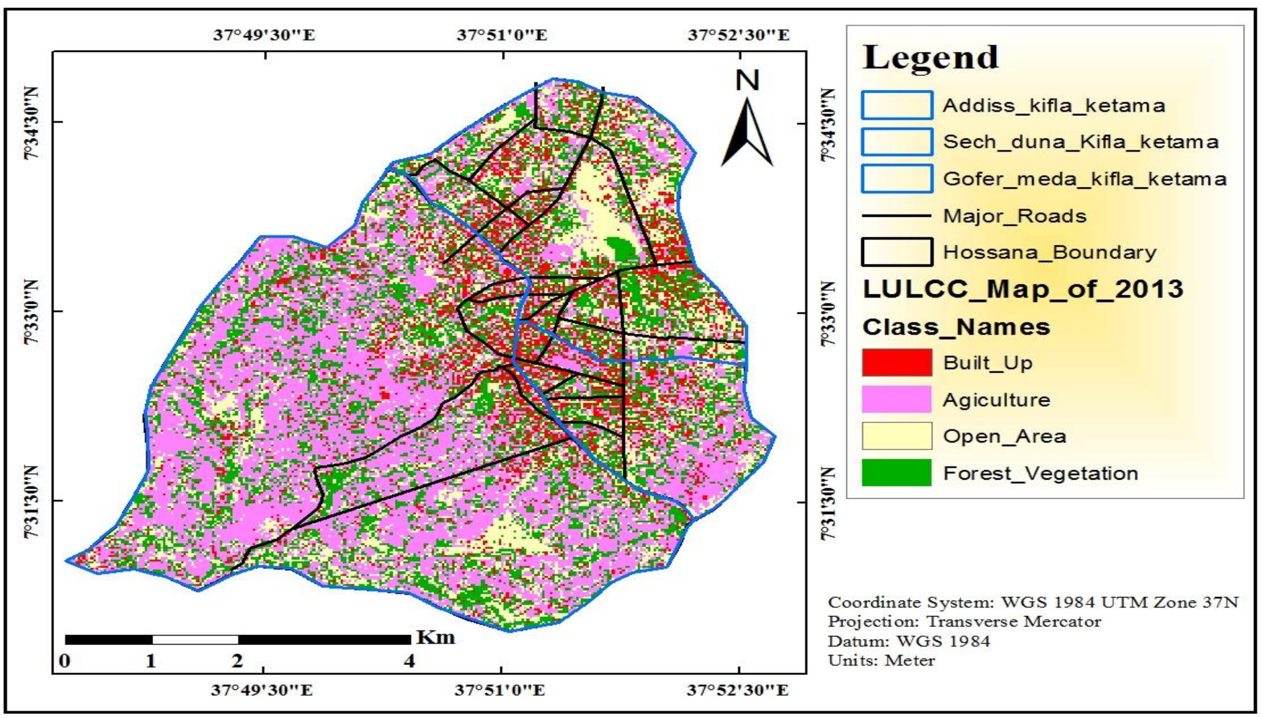

Fig. 4.2 LULCC map of 2013

4.1.3 LULC Map of Year 2018

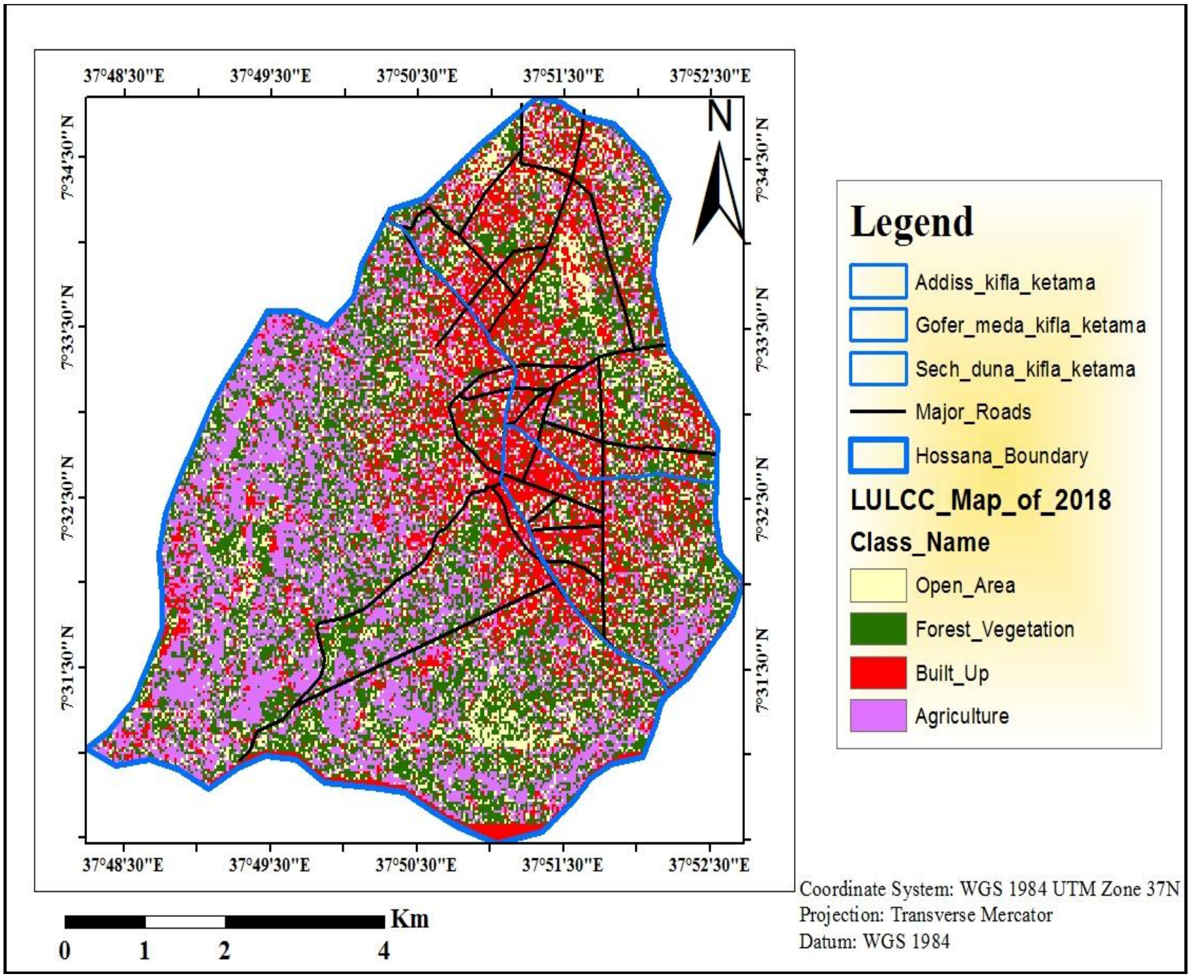

Fig. 4.3 LULCC map of 2018

4.2 Accuracy Assessment of the LULC Classification

The accuracy is essentially a measure of how many ground truth objects were classified correctly. There are always errors in maps and we need to keep in mind how accurate they are, and whether that level of accuracy is sufficient for the ways we want to use the map information (Awotwi, 2009). The result of an accuracy assessment provides us with an overall accuracy of the map based on an average of the accuracies for each class in the map .Once the classified image is integrated into a GIS, accuracy assessment should be processed as it limits the classification results of a remotely sensed imagery data. To do so, the accuracy of a classified map has to be LULCC analysis by using remote sensing techniques and compared with a referenced data using an error matrix. The accuracy assessment in this study was made using the original images and Google Earth image used for the 2003, 2013, and 2018.

Table 4.1 Classification Accuracy Assessment Report Of Year 2003

Error Matrix

Reference Data

Classified Data	built-up	Agriculture	Open Area	Forest Vegetation	Row Total
Built-up	**43**	3	1	3	50
Agriculture	3	**44**	3	0	50
Open _Area	0	3	**46**	1	50
Forest Vegetation	4	0	0	**46**	50
Column Total	50	50	50	50	200

Accuracy Totals

Class Name	Reference Totals	Classified Totals	Number Correct	Procedures Accuracy	Users Accuracy
Built up	50	50	43	86.00%	86.00%
Agriculture	50	50	44	88.00%	88.00%
Open Area	50	50	46	92.00%	92.00%
Forest/Vegetation	50	50	46	92.00%	92.00%
Totals	200	200	179	-	-

Overall Classification Accuracy = 89.50%

Kappa (K^) Statistics

Overall Kappa Statistics = 0.8600

Conditional Kappa for each Category.

Class Name	Kappa
Built-up	0.8133
Agriculture	0.8400
Open Area	0.8933
Forest Vegetation	0.8933

Table 4.2 Classification Accuracy Assessment Report of Year 2018

Error Matrix

Reference Data

Classified data	Built up	Agriculture	Open Area	Forest/vegetation	Row Totals
Built up	**46**	5	0	0	50
Agriculture	4	**46**	0	0	51
Open Area	0	0	**45**	3	48
Forest/Vegetation	0	0	5	**47**	50
Column Total	50	51	50	50	**200**

Accuracy Totals

Class Name	Reference Totals	Classified Totals	Number Correct	Procedures Accuracy	Users Accuracy
Built up	50	51	46	92.00%	90.20%
Agriculture	51	50	46	90.20%	92.00%
Open Area	49	48	45	93.75%	93.75%
Forest/Vegetation	50	50	47	94.00%	94.00%
Totals	200	200	185	-	-

Overall Classification Accuracy = 92.46%

Kappa (K^) Statistics

Overall Kappa Statistics = 0.8995

Conditional Kappa for each Category.

Class Name	Kappa
Built Up	0.8691
Agriculture	0.8924
Open Area	0.9176
Forest Vegetation	0.9199

The overall accuracy of the images of 2003 and 2018 were observed to be 89.50% and 92.46% respectively, and the corresponding Kappa coefficients were 0.86 and 0.89. The minimum level of interpretation accuracy in the identification of LULC categories from RS data should be at least 85% (Anderson et. al, 1976).

4.3. Trends and Rates of Urban Land use/ Land Lover Change in Hossana Town

The rapid LULCC by the growing population have reduced natural vegetation cover in most countries of the world (Nicholson, 1987). LULC changes arising from urbanization, housing development, agriculture, and deforestation are some of the contributing factors to conversion of land cover to urban growth. These changes reflect on the population growth, land consumption rate, and local climate.

Table 4.3 Major Urban land-use classes and Areal Coverage during 2003-2018

No	Major LULC Type	Areal Coverage					
		2003		2013		2018	
		Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)
1	Built-up	237.3	6.8	594.5	14.7	1316	32.5
2	Agriculture	1389	34	1579.5	39	884	22
3	Open Area	1040	25.7	835.5	20.6	686	17
4	Forest/Vegetation	1344.6	33.3	1038	25.7	1161.5	28.5
Total		4047	100	4047	100	4047	100

Accordingly Table 4.3, Agriculture is the most dominant urban land-use class occupying more than 31% of the total area and shares the largest portion 39% in 2003, 28.6% in 2013, and 26% in 2018. On the other hand, Forest/Vegetation is the second largest portion in the area during 2003 (33.5%), 2013 (16%) and 2018 (24.5%). Thirdly, built-up area shares the portion of amount 15% in 2003, 20% in 2013 and 27% in 2018. Although the rate of change has been greater for built-up area than others agriculture area were decreased during these time extremely from 39% in 2003 to 26% in 2018. If the trends continuous, agricultural areas has totally diminished. As shown in the table 4.3 above the coverage of agricultural, open, and forest land were decreased with the increment of built-up expansion. It needs plan to manage the spatial function of the town land uses classes so as to sustained for coming generation without land use conflict or make spatial integrity both in between class and out of the class. Besides, the change detection of time series analysis of urban land-use shows that the dynamic change of spatial structure in period. The dynamic change of spatial structure is an important indicator that can reflect the dynamic change of urban spatial expansion. Accurate and Up to date forest and agricultural land use information is an essential data required by planners and policy makers for carrying out various activities in urban planning and management. For example, the land use data is useful for urban planners and researchers in preparation of master plan, planning of smart cities and satellite towns, provision of basic amen-ties and urban infrastructure facilities, analyzes the changes that have occurred in the land use over the past years, prediction of future land use, urban growth analysis, etc.

4.3.1 Rates of Land Use Change

LU change rate refers to the type of LU changes in the size ranges, reflected in the different types of LU change on the total, reflecting the general situation of land use change and land use change structure. Currently, the land use dynamic degree can be used as a single land use dynamic degree (Yu, 2008). Rate of land use change was calculated by using equation 1 and 2.

Table.4.4 Rate of LULC Change

No	LU Type	Area in Ha			Absolute variation (S) in the area (Ha)		Change Rate of land use (K) in (%)	
		2003	2013	2018	2003-2013	2013-2018	2003-2013	2013-2018
1	Built-up	237.3	594.5	1316	321.2	721.5	135.35%	121.36%
2	Agriculture	1389	1579.5	884	190.5	-695.5	13.71%	-44%
3	Open Area	1040	835.5	686	-204.5	-149.5	-19.66%	-17.89%
4	Forest/Vegetation	1344.6	1038	1038	-306.6	123.5	-22.80%	11.89%

The rate of built up changed from 2003-2013 and 2013-2018 years revealed in table 4.4 were 135.35% and 121.36% respectively. This shows that the town grown at the rapid rate of change in the town. The factor that affect or play a crucial role to this change had been physical suitability, spatial proximity, informal settlement, and other socio-economic issues. However, agriculture has been decreased from 2003-2013 and 2013-2018 I.e -695.5% and -44% respectively. Open land were also diminished in rate from 2003-2013 and 2013-2018 such as -19.66% and -17.89% respectively. Again forest land of the town was changed during 2003-2013 and 2013-2018 such as -22.80% and 11.89% respectively. The rate of change that occurred in these three land use types i.e. agriculture, open land and forest land were due to the increment of the demands to investment, private, governmental, and non-governmental residential, commercial, industrial, and social uses in the town

4.3. The Drivers for Urban Growth in Hosanna Town

Table 4.5. General Information of Key Informants

No	Educational Level	No of Experts	Percentage (%)
1	<8 grade	-	-
2	<10 grade	-	-
3	<12 grade	-	-
4	Diploma	-	-
5	Degree	9	75
6	2nd Degree	3	25
7	PhD	-	-
Total		12	100

Source:-Field Survey, 2019

As indicated above in table, educational levels of key informants interviewed were the following proportion such as 75% 1st degree and 25% of 2nd degree was reveled respectively.

4.3.2. Key Informants Interview Data Analysis

Key informants of different sector are interviewed to identify the drivers/ factors for urban growth. As researcher got oral information from different informants of different sectors of the town. Due to this the following factors were majors for urban growth in the town as shown in table such as population growth, fund growth, infrastructure development, physical characteristics (slope), and proximity variables such as linear growth/distance from major roads listed below in Table 4.3.

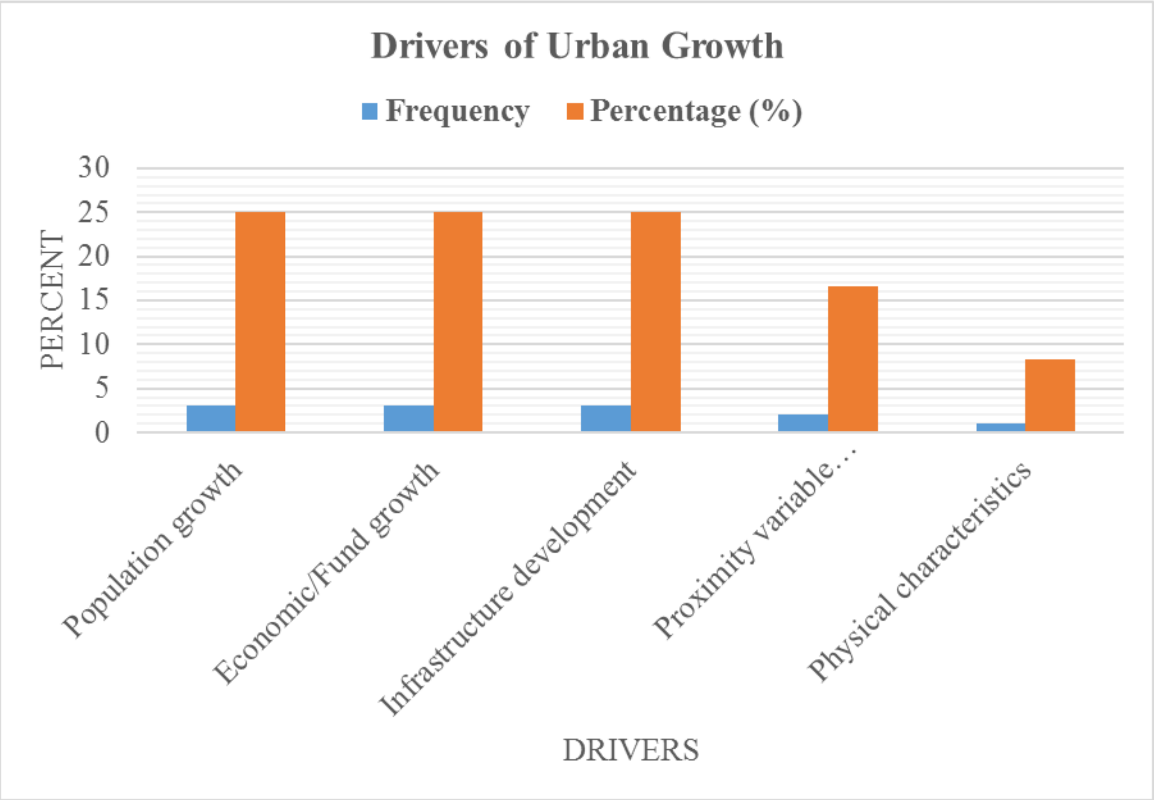

Fig 4.5 Drivers for urban growth

Table presents the causes that affects the town to grow during 2003-2018 was population growth, fund growth, infrastructure development, proximity factors, and physical characteristics of the town. The major factors for urban growth of the town is population growth, fund growth from World Bank, and infrastructure development out of total interviewee 9 (75%) are said it has the dominant than others. The interviewer also suggests that these three factors are go hand in hand because of the cause effect relationships. Infrastructure accessibility in urban area attracts peoples from any other places in a way to live in the town.

Proximity variable is the second major factor to grow of the town according to the interviewee experts. From the total interviewee 2 (16.7%) are said that distance from major roads is the second dominant drivers for urban growth.

Physical characteristics of the town are third factors lead the town to grow, the proportion of 8.3%. So, the researcher was suggests that suitability of topography is essential for different urban infrastructure development and waste disposal treatment.

4.3.1 Socioeconomic Factors for Urban Growth

Generally, there are several factors responsible for LULC change including urban growth patterns among these are social and economic factors (Yalew et al., 2016). A combination of these factors contributes to urban growth and determines the extent and spatial pattern of change. One of the major factors for urban growth is population with rapid growth of population in number, density, and also migration effects in the town as put great pressure on the demands for urban land spaces. There was no attempt in previous studies to determine the dominant pattern(s) of urban growth in the study area or relate urban growth with economic and human development indices for sustainable urban planning. It is for these reasons that this study was conceived.

Table.4.6 Population and Budget/Fund data during 2003-2018.

No	Year	Population			Budget/Fund	Road infrastructure Development
		Male	Female	Total	Total Fund (Birr)	Total Length in Km
1	2003	21,936	22,038	43,974	3,504,314	160
2	2013	51,689	50,160	101,849	65,697,035	225
3	2018	80,132	88,632	168,764	215,042,315	404

Source: - HTFED and Municipality Office, 2019

As indicated above in table 4.4, it indicates that population of the town grow during 2003-2018 in more or less in double rate. This shows that there were highest number of demands for different services of urban area such as house, infrastructure, social services, and others. Due to these the town has growing to grow at rapid rate of change. Therefore it needs precise decision of planning, managing, and sustaining for coming generation. Beside to this, fund from government and world bank for town development were also increased during these period. Again road network of the town has boost so as to accesses the community and connect the town with neighborhoods.

Regression Analysis of Dependent and independent Variables

Regression analysis allows you to model, examine, and explore spatial relationships and can help explain the factors behind observed spatial patterns. Regression analysis is also used for prediction. Regression analysis can help you better understand phenomena to make better decisions, predict values for phenomena at other locations or times, and test hypotheses. Modeling a phenomenon can yield a better understanding that can affect policy or provide input for deciding which actions are most appropriate (Scott, 2009).

P-values are generated by a statistical test that is performed by most regression methods to compute a probability for the coefficients associated with each independent variable. The null hypothesis for this statistical test states that a coefficient is not significantly different from zero (in other words, for all intents and purposes, the coefficient is zero and the associated explanatory variable is not helping your model). Small p-values reflect small probabilities and suggest that the coefficient is, indeed, important to your model with a value that is significantly different from zero (the coefficient is not zero). For example, you would say that a coefficient with a p-value of 0.01 is statistically significant at the 99 percent confidence level; the associated variable is an effective predictor. Variables with coefficients near zero do not help predict or model the dependent variable; they are almost always removed from the regression equation unless there are strong theoretical reasons to keep them. R2/R-Squared values, which range from 0 to 100 percent, are a measure of model performance. Multiple R-squared and Adjusted R-Squared are both statistics derived from the regression equation to quantify model performance. If your model fits the observed dependent variable values perfectly, R-Squared is 1.0 and you (no doubt) have made an error (Scott, 2009).

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.991596
R Square	0.983262
Adjusted R Square	0.966524
Standard Error	49.6945
Observations	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	145071.1	145071.1	58.74410987	0.082594594
Residual	1	2469.543	2469.543		
Total	2	147540.7			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	500.2047	67.59902	7.399586	0.085516418	-358.722251	1359.132	-359	1359.1317
Population in Density	20.69685	2.700363	7.664471	0.082594594	-13.61451063	55.00821	-13.6	55.008211

As indicated above in model report, the relationships between built-up expansion and population causes effect relationships are strong i.e. R^2 equal to 0.966524 and p-value also near to significance.

4.3.2 Physical Factors for Urban Growth

Physical factors such as slope, elevation, and distance from major roads were considered as factors for urban growth. Slope and elevation are usually restrictive factors to urban expansion especially for those areas with low development level (Braimoh and Onishi, 2007) Transportation accessibility usually guide urban expansion (Wu and Yeh, 1997). Slope of the town has found between 0-21 degree and elevation between 2130-2400 asl. Distance from major roads exerts impacts on the town growth via locational effects at a small scale. As indicated below in figure that the area near to major roads were more advantages/accessible socio-economic resources with low transportation cost than the one that far away distant. Spatial interactions of the people were higher around here. As depicted in figure above LULC change were less in southern parts of the town i.e. elevation between 2130-2236. In this area the classification results shows that urban reserve area. So, slope affects expansion around this area but there were also high expansion were occurred from the center to northern part of the town due to landscape comfort ability.

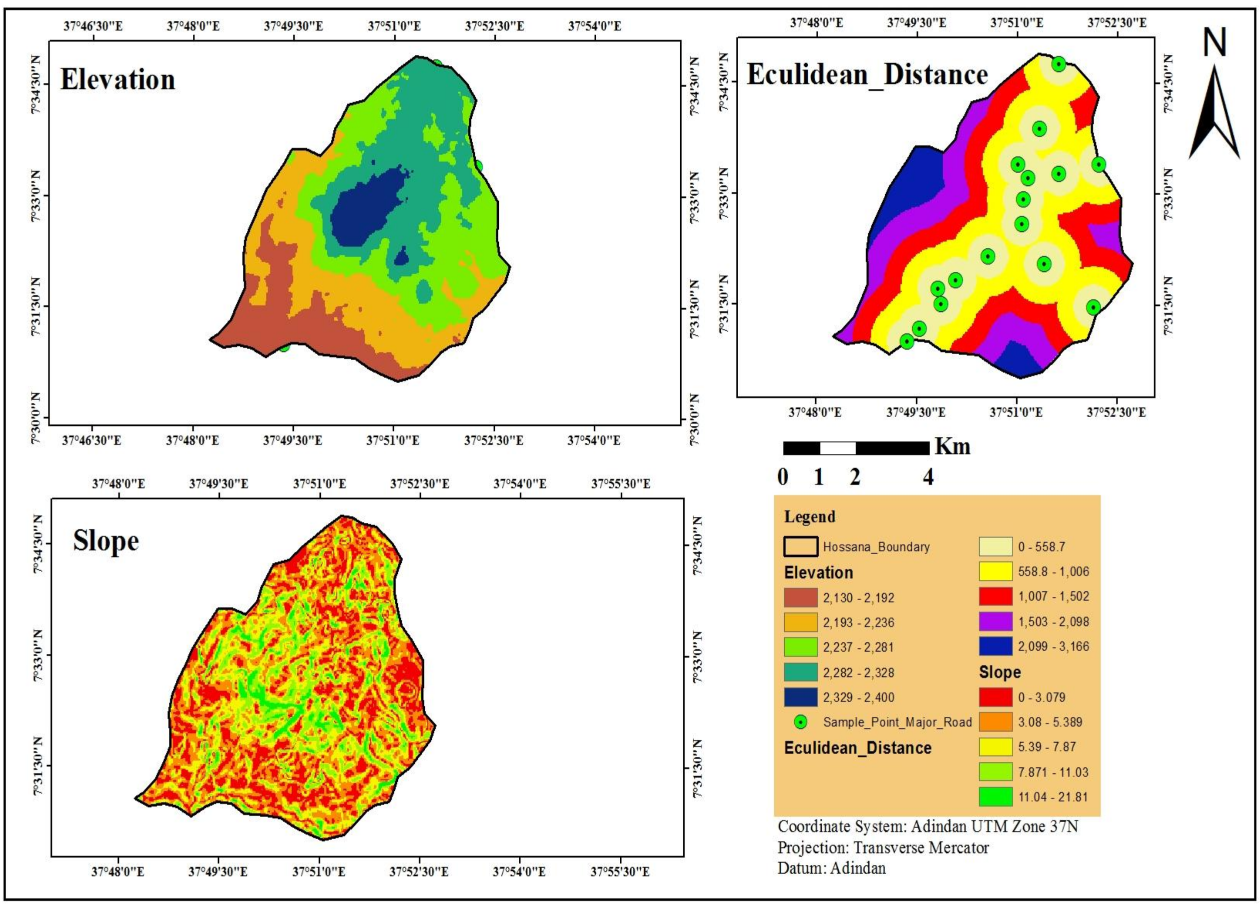

Fig 4.6. Physical Factors for urban growth

Multiple Regression Model Validation

Multiple Regression Results:

Regression Equation:

Built-up = 1316 - 1.0816*Euclidean Distance 0.1847*Elevation+ 1.0493*Slope

Regression Statistics:

Apparent R = 0.869725 Apparent R square = 0.756422

Adjusted R = 0.869725 Adjusted R square = 0.756421

F (3, 662032) = 685304.062500

ANOVA Regression Table

Source	Apparent degrees of freedom	sum of squares	mean square
Regression	3	2125620202.97	708540096.00
Residual	662032	684478920.35	1033.91
Total	662035	2810099123.31	

Individual Regression Coefficients

	Coefficient	t-test (662032)
Intercept	310.334031	340.434052
Eculidean_distance	-1.081604	-290.918457
Elevation	-0.184726	-63.382668
Slope	1.049331	409.234924

Three physical factors such as elevation, slope and distance from major road shows that there is negative effects on urban growth, revealing that urban growth has been dependent on natural conditions. As indicated in the model Apparent R square = 0.756422 and adjusted R square = 0.756421 and it shows that nearly strong relationships between dependent and independent variables. High altitude and steep areas are less likely to be developed because of higher costs are needed to construct built-up areas in these areas compared to flat areas. This observation is validated by the absolute values of their coefficients in the multiple regression model over time, given that the values indicating the natural conditions of the areas, i.e., elevation and slope, did not vary.

The accessibility factors, i.e., distance from major roads, were negatively linked to urban expansion, suggesting that a road benefited urban development with easier transportation access. The regression coefficients of these factors did not follow similar pattern because the values of these accessibility variable of one object may vary over time, as new road infrastructure has been constructed in the town as indicated above in the model result. Proximity factors i.e distance from major roads had played highest impacts on the change of built up area during 2003-2018 in the town, which leads the town to grown horizontally rather than vertically i.e the pattern of the town growth were linear type. The result of multiple regression model of dependent and independent shows that if the areas near to major roads were higher probability/relationships in a way to change into built up as indicated above in the model results. The town has grown more by following the major road networks.

4.4 Modeling and Predicting of Urban LULC Change

Recently, modelling LULC with CA Markov model with integration of GIS and RS has become a central component in urban geographical studies. It describes the change of LULC over time. It can be used to predict different scenarios of land use change. CA is a collection of cells arranged in a grid, such that each cell changes state as a function of time according to a defined set of rules that includes the states of neighboring cells *(http://geographycasestudysite.wordpress.com).*

4.4.1 Transition Probability Matrix

Transition speed from one state to another state is named transition probability, and it is calculated through annual average transition rate of a certain LULC type (Yu, 2008). As table shows that the transition probability of four LULC types area in (Ha) such as Built-up, agriculture, open area, and forest/vegetation coverage. It gives also the probability that a LULC class have been changed into another class, given the present state of the class using equation (1 and 2), i.e., the transition probability of a certain LULC type in 2003 converted into the same LULC type in 2013 and 2013 converted into 2018 was calculated.

Table 4.7 Transition probability matrix

Class Name	Built up	Agriculture	Open Area	Forest/vegetation
Built up	**0.9914**	0.0058	0.0028	0.0000
Agriculture	0.0036	**0.3978**	0.5986	0.0000
Open Area	0.0531	0.0531	**0.2772**	0.3241
Forest/Vegetation	0.3606	0.0000	0.0402	**0.5992**

Table 4. 8 Urban LULC Comparison between 2018 and 2028

LULC_Type	Area (ha) In 2018	Area (%)	Area (ha) In 2028	Area %	Absolute Variation (S)	Rate of Change (K) in %
					2018-2028	2018-2028
Built-up	1316	32.5	2236	55	920	70%
Agriculture	884	22	150	4	-734	-83%
Open Area	686	17	598	15	-88	-12.8%
Forest/Vegetation	1161.5	28.5	1063	26	-98.5	-8.49%
Total	4047	100	4047	100	--	----

As shown in table 4.8, that the rate of change from land use to land use were occurred significantly in the town. That means, built up growth will be projected to change from 2018-2028 in 70% , but those other three land use types will be estimated to be decreased during 2018-2028 i.e. agriculture (-83%), open land (-12.8%), and forest land (-8.49%). If the factors that affects the present state of change in the land use classes will be continuous, the town will be changed highly to built-up expansion. Whenever, only built-up area expansion is not fitted the function/structure of urban area networks. So, it needs other necessary classes which helps to build good urban land use networks i.e. agricultural, open, and forest lands. To balance the rate of change that happen in the near future the town administration, urban planners, GIS and RS experts, and other decision makers plans to works seriously. Unless and otherwise, the town will suffer the following problems such as over crowdedness, homelessness, crimes, lack of green and recreational space and aesthetic values in the town. Moreover, the town administration plans to adjust pre-condition to manages the land properly, provide proper master and structural plans, greening/planting trees, taken serious measurements on informal settlers and protected reserved land.

4.5 Predicted Urban Growth Map of 2028

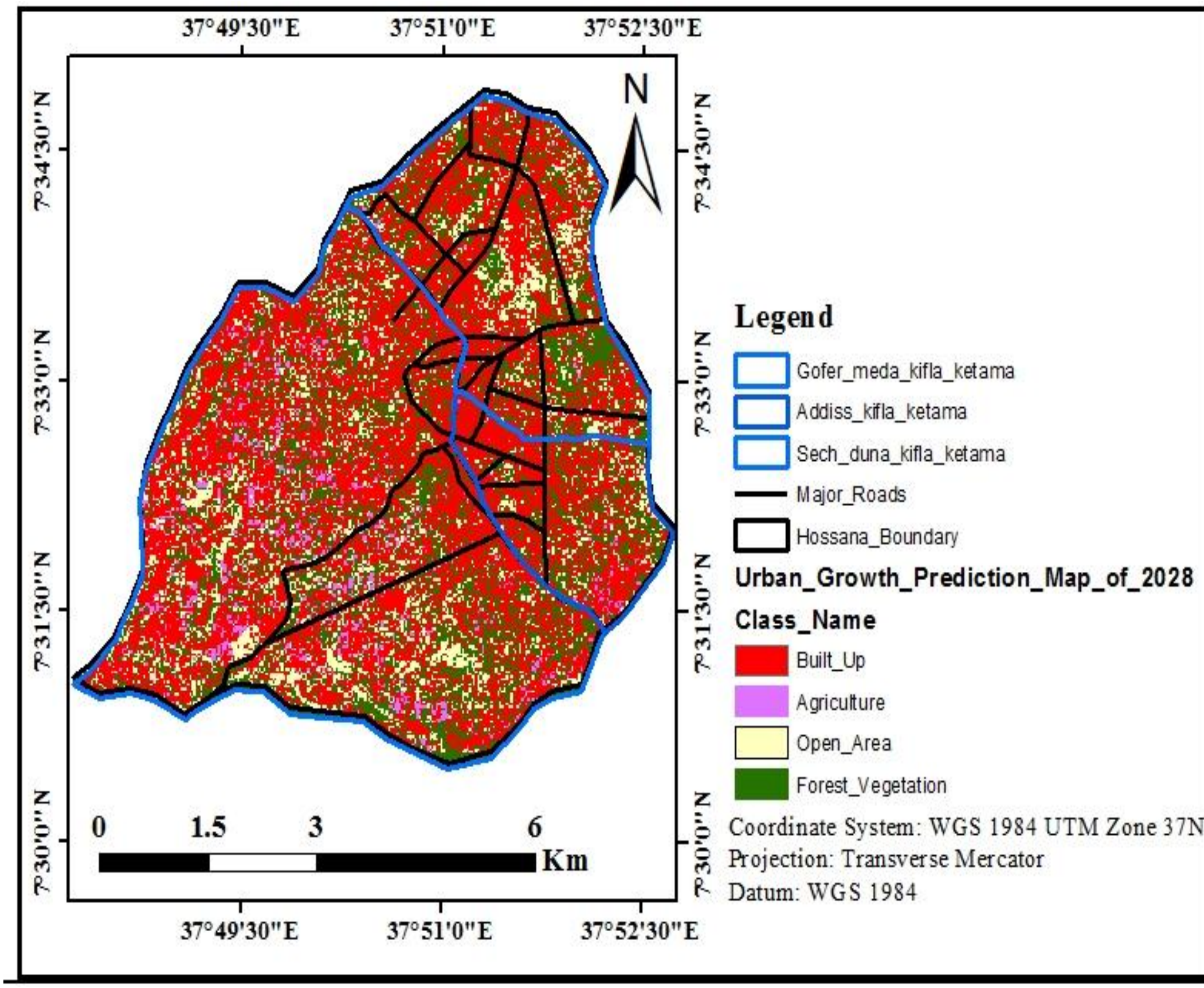

Fig 4.8 predicted urban growth map of 2028

As indicated above in table the result of prediction has the following assumption or estimation of 55% of built-up, 26% of forest/vegetation, 15% of open area, and 4% of agriculture. Therefore, agricultural coverage of the town from the beginning were higher portion of coverage but it has been declining and going to extremely decreasing. Moreover, built up area will be increasing in rapid rate of change affect the natural and man-made features such as weather condition of the town were changed, loss of biodiversity, increasing unemployment due to population growth, lack of good service facilities, and recreational sites. The main reasons for the increment of built-up land could be gradual population growth, linear settlement condition and development and physical suitability of the town. The transition probability matrix of year 2018 to 2028 the size of pixels were decreased to agricultural and open area than others.

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Summary

GIS in urban growth modelling has three objectives: to provide an integrated spatial and temporal database, to develop spatial indicators, and to facilitate spatial analyses. In this research, a wide range of data sources is utilized, including remotely sensed imagery, biophysical data, plan schemes, socio-economic data and historical documents. The primary data sources come from timely, cheap and multi-resolution imagery (Google Earth images and aerial Photographs of three periods).

Although supervised classification of images improves the accuracy of land cover mapping, temporal data consistency in a series of changes requires human interpretation, especially when images and aerial photographs are employed together for change detection. When interpreting past urban land uses from imagery, detailed historical documents such as the historical records of urban planning and urban construction provide the valuable references to temporal events. In most cases, interviews with local planners and other decision makers are also needed for further confirmation of drivers for urban growth.

Spatial analysis in this study includes both explanatory and exploratory data analysis. The basic objective in spatial analysis, particularly in large-scale modelling, is to quantify spatial or spatio temporal indicators such as proximity, accessibility, density, change detection, and spatial interaction. These indicators can be measured from various perspectives, representing different understandings of physical and socio-economic processes. Spatial exploratory data analysis aims to explore the spatial distribution of any indicator that can suggest a significant pattern for further modelling. Cellular automata (CA) can supply powerful and convenient spatial modelling functions, especially when they are integrated within a GIS environment. GIS offers CA a large volume of spatial and other socio-economic data. CA provide GIS with a strong process modelling function. The integration of both has proved successful in simulating and predicting of the spatial and temporal processes of urban growth.

5.2 Conclusion

Based on the overall of the works this study, it is possible to conclude the following points.

Geospatial technologies are very important in vector data collection and analysis of three feature classes such as point, line, and polygon. Remotely sensed images are vital in land use/land cover change detection as it provides spatial and temporal information of the land use land cover condition of the Hosanna town.

Urban Growth have wide range of consequences at spatial and temporal scales. Because of these effects and influences it has become one of the major problems for environmental change as well as natural resource management. Identifying the complex interaction between changes and its drivers over space and time is important to predict future developments, set decision making mechanisms and construct alternative scenarios

Urban growth is very dynamic in nature and has to be monitored at regular intervals for sustainable development thus it has become a central component in current strategies for managing environment and natural resources.

The results of this study revealed the existence of significant land use and land cover changes in the last 15 years due to growing population, economy, and other factors especially the expansion of built up area coverage at the expense of agricultural and open areas and green space i.e. 237.3 ha in 2003, 594.5ha in 2013, 1316ha in 2018, and it will be 2236 ha in 2028. So the areal coverage of change has dynamic and it needs also infrastructure and other facilities. Generally, spatial analysis and modelling enables for sustainable managements of urban growth through proper planning, wise decision making, monitoring of urban expansion and development.

5.3 Recommendation

Land use land cover change (LULC) mapping and detection of changes shown here may provide the real figure of classes due to high resolution of the imagery and ground control points (GCPs) serves as a base to understand the patterns and magnitude of built-up area. Therefore such LU/LC detection using high resolution satellite images was more essential.

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

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

Since most important factor of the urban growth in the study area was an increase in population, continuing the efforts of introducing family planning to make the people aware of consequences of population pressure on land resources should be carried out intensively

Spatial technology for change detection analysis is very important in a way to examines state of change in space and time. It is very important to deliver frequently. This job demands professional experts who are accountable to this specific career. However, important it is human power dedicated to this wing of development is very limited in skill and in number if it is based on Hossana town spatial data management. Therefore, it requires a due regard to handle appropriately.

Ethiopian Government has given due attention for urban planning and developing in integration with forest development and conservation considering its significance to the national economy, food security and sustainable development.

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Appendices

Appendix 1

Land use change rate formula and calculation

$$S: Ub - Ua$$

$$K: \frac{Ub - Ua}{Ub} \times 100\%$$

Where; S: absolute variation in the area of certain LU in the study period

K: Change rate of land use type

Ub and Ua: are the area of a land use type at the beginning and end of the study

LU type	2003-2013 period		2013-2018 period	
Built Up	Ub-Ua	S	Ub-Ua	S
	594.5-237.3ha	321.2ha	1316-594.5ha	721.5ha
Agriculture	1579.5-1389ha	190.ha	884-1579.5ha	-695.5ha
Open area	835.5-1040ha	-204.5ha	686-835.5ha	-149.5ha
Forest/vegetation	1038-1344.6ha	-306.6ha	1161.5-1038ha	123.5ha

Land use change rate

LU type	2003-2013		2013-2018	
	$\frac{Ub-Ua \times 100\%}{Ua}$	K	$\frac{Ub-Ua}{Ua} \times 100\%$	K
Built Up	$\frac{321.2}{273.3} \times 100\%$	135.35%	$\frac{721.5}{594.5} \times 100\%$	121.36%
Agriculture	$\frac{190.5}{1389} \times 100\%$	13.71%	$\frac{-695.5}{1579.5} \times 100\%$	-44%
Open Area	$\frac{-204.5}{1040} \times 100\%$	-19.66%	$\frac{-149.5}{835.5} \times 100\%$	-17.89%
Forest/vegetation	$\frac{-306.6}{1344.6} \times 100\%$	-22.80%	$\frac{123.5}{1038} \times 100\%$	11.89%

Appendix 2

Expert Interview

Dear respondents I am graduate student of Jimma University undertaking research entitled on Modeling and Predicting Future Urban Growth by using Geo-spatial technologies: The case of Hossana Town, SNNPR, and Ethiopia. Therefore, the intention of this interview is to identify the factors that leads the town to grow and decide which factor is most influential than others. I would like to thank you for your participation and devotion of time in a way to give information. While, personal information is not interested to know rather than information you provide us. Please state as much as possible information for the following questions and provide your possible responses on the space allowed for each questions.

General Information Questions

1. Education background

< Grade 8 ☐ < Grade 10 ☐ <Grade 12 ☐ Certificate levels ☐

College diploma Degree ☐ 2nd Degree ☐ Degree ☐

2. Field of study-------------------------------------Specialization------------------------------

3. Current position---

Detailed Questions

1. What are the driving factors for urban growth from time to time in Hossana Town?

---And which factor is most influential one for urban growth in the town?

----

2. What are the impacts of these factors?

Positive

Negative

Interviewee	Interviewer
Name--	Name -----------------------------------
Signature-------------------------------------	Signature-------------------------------
Date--	Date-----------------------------------

Appendix 3

Sample GCP of Year 2003

FID	X	Y	LULC	FID	X	Y	LULC
1	374333	836275	FV	26	372584	832166	AG
2	373994	836223	FV	27	372043	833835	AG
3	374136	836110	FV	28	371549	833733	AG
4	373811	835808	FV	29	369825	834215	OP
5	373319	836924	FV	30	370224	834676	OP
6	372573	836344	FV	31	370052	833062	OP
7	374262	837021	FV	32	374036	833076	AG
8	373339	837792	FV	33	373877	833322	AG
9	373243	831744	FV	34	374383	833285	AG
10	372669	831478	AG	35	374335	833590	AG
11	371883	831459	FV	36	374669	833665	AG
12	371581	831602	FV	37	373869	834218	OP
13	370953	831678	FV	38	373779	834129	OP
14	370301	831483	FV	39	373321	834267	AG

15	369949	831408	OP	40	373973	834883	OP
16	370167	831659	AG	41	374185	835117	AG
17	370497	831882	AG	42	374469	835123	AG
18	370784	832144	AG	43	375075	835282	AG
19	370701	832578	AG	44	375303	834451	AG
20	371193	832488	OP	45	373079	834046	AG
21	371748	832705	AG	46	372634	833981	AG
22	372530	832985	AG	47	372752	834200	AG
23	372886	832392	AG	48	373106	834277	AG
24	372459	831742	AG	49	373259	834369	AG
25	373510	834438	AG	50	373440	834444	AG
51	373580	834479	BU	76	373476	834902	BU
52	373414	834578	BU	77	373150	834633	BU
53	373997	834498	FV	78	373440	834853	BU
54	373870	834551	BU	79	373280	834756	BU
55	374128	834570	BU	80	372208	833302	AG
56	374410	834435	OP	81	373721	833189	BU
57	374985	834595	BU	82	373207	832883	FG
58	371881	834278	AG	83	373316	833306	OP
59	371869	833898	AG	84	373269	833738	BU
60	371596	834272	AG	85	373515	833956	BU
61	371170	834459	AG	86	373796	833785	BU
62	371172	834740	AG	87	373539	833734	BU
63	371648	834669	AG	88	375234	832469	AG
64	370667	835351	OP	89	375408	832288	OP
65	371235	835705	OP	90	373682	835192	BU
66	371460	835476	OP	91	373559	835294	BU
67	372011	835323	FV	92	375076	837516	AG
68	372250	835305	AG	93	374602	837965	AG
69	372016	834930	AG	94	375236	836843	FV
70	372405	834870	AG	95	372391	835624	AG

71	372263	834150	BU	96	373290	835212	BU
72	372564	834100	BU	97	373111	835168	BU
73	372853	834821	BU	98	372447	837092	FV
74	373216	834971	BU	99	372040	836894	OP
75	373577	834073	BU	100	373783	837405	BU
101	373524	837534	AG	127	373341	836268	BU
102	373240	837453	AG	128	373019	836759	OP
103	373870	837970	AG	129	373783	836201	BU
104	374103	837750	AG	130	373045	836342	BU
105	374751	835338	FV	131	373036	835970	BU
106	374764	835237	FV	132	373100	835789	OP
107	374937	835190	BU	133	372735	835755	AG
108	374989	835408	BU	134	372866	835528	BU
109	375284	835310	BU	135	372905	835242	BU
110	375155	835293	BU	136	372570	835352	AG
111	375350	835050	BU	137	372481	835160	AG
112	373260	836068	BU	138	372550	834723	BU
113	373128	836114	BU	139	372584	834553	FV
114	373183	835712	OP	140	371984	834477	FV
115	373389	835482	OP	141	374458	834102	BU
116	373481	835381	OP	142	374327	835905	OP
117	373678	835417	BU	143	374296	836667	OP
118	373615	835279	BU	144	370210	832910	OP
119	373739	835281	BU	145	373301	831979	OP
120	373911	835206	BU	146	371713	832540	OP
121	373973	835175	FV	147	373286	831360	OP
122	374036	835415	BU	148	371037	833038	OP
123	374317	835493	BU	149	369997	831934	OP
124	374564	834862	OP	150	369085	832506	OP
125	374873	836513	AG	151	371193	830933	OP
126	374016	836800	BU	152	373681	833675	FV

153	374117	834151	BU	177	371406	833464	FV
154	374763	833242	BU	178	369531	834099	FV
155	373430	833695	BU	179	371576	836264	FV
156	375798	833289	BU	180	372081	836664	FV
157	373965	834641	FV	181	374334	832927	OP
158	372837	834614	FV	182	374148	833863	OP
159	373562	834246	FV	183	373005	833883	OP
160	373431	835994	FV	184	372703	833240	OP
161	371872	833740	FV	185	373656	832688	OP
162	372443	833796	FV	186	369858	833478	OP
163	373074	832660	FV	187	369953	832343	OP
164	371181	832605	FV	188	371495	835903	OP
165	371189	833998	FV	189	372676	836024	OP
166	372377	831592	FV	190	372009	834570	OP
167	371520	831639	FV	191	373171	835992	OP
168	371413	832564	FV	192	371400	833993	OP
169	373175	832008	FV	193	371721	831803	OP
170	374611	832433	FV	194	372350	832298	OP
171	374750	831604	FV	195	374716	834995	OP
172	372647	831111	FV	196	372525	836519	OP
173	372694	830655	FV	197	373237	837649	OP
174	371873	832707	FV	198	374691	837751	OP
175	369321	833247	FV	199	374011	836557	OP
176	369486	833898	FV				

Sample GCP of Year 2018

FID	X	Y	LULC	FID	X	Y	LULC
0	369335	831785	AG	26	374965	832929	AG
1	370125	831653	AG	27	373155	832929	AG
2	370780	831752	AG	28	374746	835785	AG
3	370816	832020	AG	29	373183	835930	AG

4	369712	832198	AG	30	372627	835491	AG
5	369768	832417	AG	31	373976	835544	AG
6	370370	832466	AG	32	374127	834893	AG
7	370138	831425	AG	33	374431	835020	AG
8	370515	831272	AG	34	374968	834898	AG
9	372007	831484	AG	35	370881	835807	AG
10	371934	832122	AG	36	370460	835390	AG
11	372248	831484	AG	37	371359	835909	AG
12	371977	832592	AG	38	370422	835772	AG
13	369222	832268	AG	39	370897	835569	AG
14	371190	832959	AG	40	371264	835585	AG
15	370482	833144	AG	41	371796	836371	AG
16	373347	832025	AG	42	372146	836409	AG
17	371795	833065	AG	43	372031	836120	AG
18	372580	830797	AG	44	373760	837731	AG
19	373141	830686	AG	45	374276	837448	AG
20	371728	832560	AG	46	374276	837813	AG
21	375511	832306	AG	47	373446	837374	AG
22	375305	832067	AG	48	372263	836781	AG
23	374342	831041	AG	49	374544	837876	AG
24	373707	830670	AG	50	373436	835887	BU
25	374015	832257	AG	51	373987	835712	BU
54	373208	835733	BU	79	374687	833063	BU
55	373647	837373	BU	80	374929	832793	BU
56	372980	835313	BU	81	374643	832114	BU
57	372742	835134	BU	82	375139	831336	BU
58	373000	835003	BU	83	373790	831511	BU
59	373504	835146	BU	84	371714	833593	BU
60	373901	835202	BU	85	371710	834202	BU
61	374191	835249	BU	86	369566	834131	BU
62	374500	835622	BU	87	370352	834329	BU

63	374893	835360	BU	88	373554	834346	BU
64	375139	834309	BU	89	373079	831311	FV
65	374032	834110	BU	90	373378	831152	FV
66	373770	834035	BU	91	373627	831203	FV
67	373798	833900	BU	92	373643	831327	FV
68	373282	833809	BU	93	373899	831184	FV
69	373214	833920	BU	94	374124	831364	BU
70	373262	834372	BU	95	374183	831647	BU
71	372639	833884	BU	96	373053	831668	BU
72	372282	834579	BU	97	372965	831520	BU
73	372361	832047	BU	98	372741	831364	BU
74	373353	832388	BU	99	372418	831255	BU
75	373679	832642	BU	100	373161	831962	BU
76	373425	832721	BU	101	374452	831668	BU
77	373996	832741	BU	102	373500	830742	BU
78	374397	832598	BU	103	370232	831160	BU

109	370017	832768	OP	133	374903	833504	OP
110	369975	833059	OP	134	374689	833982	OP
111	369993	833323	OP	135	375315	833709	OP
112	370290	833323	OP	136	375157	834162	OP
113	370412	833651	OP	137	375400	833599	OP
114	371676	833720	OP	138	374035	833286	OP
115	370771	833008	OP	139	370479	831624	FV
116	371737	833122	OP	140	371521	831645	FV
117	371726	833421	OP	141	372122	831960	FV
118	374088	836590	OP	142	371318	832270	FV
119	374255	836204	OP	143	371379	832113	FV
120	374368	835974	OP	144	370299	832169	FV
121	374337	835802	OP	145	369958	831370	FV
122	371179	833718	OP	146	369778	831457	FV
123	373768	835963	OP	147	372011	830907	FV

124	373765	835418	OP	148	372373	830970	FV
125	375104	835950	OP	149	372363	831494	FV
126	374882	835897	OP	150	372485	831748	FV
127	373166	837494	OP	151	372082	831939	FV
128	372570	836263	OP	152	368828	831444	FV
129	373642	836097	OP	153	369156	832576	FV
130	372670	836067	OP	154	369272	832116	FV
131	374050	833701	OP	155	375315	832441	FV
132	374359	834063	OP	156	375109	832560	FV
157	375344	832846	FP	178	373094	836624	FV
158	376112	833068	FV	179	373308	836501	FV
159	375866	833108	FV	180	373038	837231	FV
160	376170	832743	FV	181	373788	835758	FV
161	375990	832563	FV	182	374483	837537	FV
162	375553	833140	FV	183	373848	837398	FV
163	374892	833432	FV	184	373975	837195	BU
164	375285	835647	FV	185	372993	833743	OP
165	375551	835170	FV	186	373579	833591	OP
166	375063	834738	FV	187	373698	833803	OP
167	369947	834286	FV	188	372918	833578	OP
168	369681	834727	FV	189	373132	834045	OP
169	370340	835405	FV	190	372890	834047	OP
170	370732	835667	FV	191	372594	834071	OP
171	370363	835147	FV	192	373103	834156	OP
172	371649	835211	FV	193	373203	831461	OP
173	371098	834623	FV	194	373286	831282	OP
174	371935	835199	FV	195	373078	831150	OP
175	372189	835469	FV	196	373459	831163	OP
176	371971	836239	FV	198	373395	831476	OP
177	371780	836608	F	199	373997	831582	OP