ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES,
DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Monitoring Urban Expansion and Suitability Analysis for Residential Housing by Using Geographic Information System and Remote Sensing; the Case of Sululta Town; Oromia Regional State of Ethiopia

By
Negasa Jeba

A Thesis Submitted to the School of Graduate Studies of Addis Ababa University, in Partial Fulfillment of the Requirements for the Degree of Master of Arts in Geographic Information System, Remote Sensing and Digital Cartography

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By
Negasa Jeba

Advisor: Solomon Mulugeta (Dr.)

June, 2017
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Declaration

I, the researcher, declare that this project thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been well acknowledged.

Name: Negasa Jeba Signature: ________________ Date: ______________

Confirmation

This thesis have been submitted for examination with my approval as a university advisor

Name: Dr. Solomon Mulugeta Signature: ________________ Date: ______________

Approval

This is to certify that the research project thesis by ***Negasa Jeba***, entitled: "*Monitoring Urban Expansion and Suitability Analysis for Residential Housing by Using Geographic Information System and Remote Sensing: the Case of Sululta Town,"* that submitted in partial fulfillment of the requirements for the Degree of Master of Arts in GIS, RS and Digital Cartography complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abbreviations and Acronyms

AHP	Analytical hierarchy process
ASL	Above Sea Level
CSA	Central Statistical Authority
DEM	Digital Elevation Model
ETM	Enhanced Thematic Mapper
FGD	Focus Group Discussion
GCP	Ground Control Point
GIS	Geographic Information System
GPS	Global Positioning System
ICT	Information communication Technology
LULC	Land Use land Cover
MCDM	Multi Criteria Decision method
MSS	Multi Spectral Scanner
OUPI	Oromia Urban Planning Institute
R&D	Research and Development
RS	Remote Sensing
STFEDO	Sululta Town Finance and Economy Development Office
TIN	Triangular Irregular Network
TM	Thematic Mapper
UN	United Nations
UTM	Universal Transverse Mercator

Abstract

The title of this thesis is "Monitoring urban expansion and suitability analysis for residential housing by using Geographic Information System (GIS) and Remote Sensing (RS) the case of sululta town "which is to examine rate of expansion of land use- land cover (LULC) classes such as cultivation land, Vegetation, settlements, Grassland and Bare land in thirty years by fifteen years interval which is 1986, 2001, 2016 as well as to indicate a suitable residential housing for future planning purpose.

For change detection and residential housing suitability analysis integrated methodologies such as data collection, preprocessing, classification, post classification, accuracy assessment were used by application software such as ERDAS EGIME, ArcGIS, excel, etc. and GIS and Multi criteria decision making (MCDM) techniques and tools supported the processes. The primary data such as satellite Google image of TM 1986, 2001, and 2016 as well as GPS Google map, Field Observation, FGD, and the secondary data were widely used from different sources.

The result of change detection analysis revealed that the area has shown a remarkable land Cover/land use changes in general LULC classes such as settlements, cultivation land, vegetation, grassland and open area cover. When settlements increased cultivation land, and vegetation land were decreased rapidly in general. Others were Grass land classes which in 1986 where as in 2001 decline by 20.47% and in 2016 it rapidly increased by 30.30% in study area. Bare land were increased in each three study years which were constituted 0.58% in 1986, and 62.47ha 1.40% and 228.80ha 5.12% in 2001 and 2016 respectively.

Suitable residential areas were selected for future urban planning purpose by considering factors such as LULC, road Proximity, Geology, Slope value, river, soil types, and population density. By using these factors the results indicate that the very suitable sites has an area value which accounts 131.9ha (3 %) and followed by moderately suitable site which accounts 1551.8ha (34.7%) while marginally suitable area accounts 2731.2ha (61%) and not suitable lands of study area constitutes 55.6ha which is 1.3%.

The problem of sululta town rapid expansion of urban land is directly linked with the activity of man such as population pressure dynamics (natural increasing and migration), and the socio-economic factors such as expansion of investments activities.

In order to overcome the problem and effectively manage the town corrective measures had been Suggested which can be implemented both in the short term and long term time for intended bodies.

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CHAPTER ONE

1.1. Introduction

Residential housing is a basic need in human history. Progress in modern Remote Sensing and GIS techniques have opened up great opportunities, and significant success to achieve monitoring and managing fast urban expansion and spatial modeling like feasible site of housing construction. According to Karen C. Seto (2006), the size of the world's growing urban population gives urgency to the need for accurate estimates of the location, size, and growth of existing urban areas as well as forecasts of likely regions, magnitudes, and configurations of urban growth. Satellite remote sensing and spatial modeling offer tremendous opportunities to map historical patterns of urban growth, monitor urban areas, and forecast urban expansion.

Urban expansion is one of the important areas of man's interaction with his environment with great impact on the natural land cover. With increasing recognition of urbanization as an agent of land use/land cover change, necessary and reliable data are required to monitor, analyze and predict present and future trend of land use/land cover change resulting from the urbanization. However, available data in most developing countries are of low quality, unreliable and scattered in various ministries, agencies, institutions of higher learning and research agencies, thus creating a gap in the available data required for planning at national, state and local levels (Olawole et al:2011). While determining future growing-areas of cities, monitoring city-growth, in other words, determining land-use changes has an important role in urban development. Immigration, especially emerged from improvement of industry, is an important factor causing urban land use changes (2003: Selçuk Reis et al).

Recent advances in Geographic Information System (GIS) and Remote Sensing (RS) tools with varying analysis techniques have enabled researchers to model urban change effectively. By using of satellite image of RS and GIS in depths there are more and more understanding of the dynamism of urban areas through change detection and urban modeling. (NicoKotzeet al, 2014).

As Moeller (2004) and Feng (2009) referenced in NicoKotze et al, (2014), Remote sensing (RS) and Geographic Information Systems (GIS) techniques are geospatial tools being widely used to assess natural resources and monitor spatial changes. Land use/cover (LULC) change dynamics can be analyzed using time series remotely sensed data and linking it with socio-economic or biophysical data in GIS. The incorporation of RS and GIS enables unique analyses involving environmental changes and these include land cover mapping, detecting and monitoring over time, identifying land use attributes, and change hot spots. With the advancement of technology, reduction in data cost, availability of historic spatial-temporal data and high resolution satellite images, GIS and RS techniques are now useful research tools in spatial change and modeling.

According to NicoKotze et.al, (2014) suggested M1onitoring of urban expansion is, however, not easy because of the lack of information in the past. Remote sensing may provide us with an efficient tool to monitor land-cover changes in and around urban areas during for more than past thirty years especially in developed countries and for past ten years in developing countries. This is due to development of technologies in GIS and RS tools and techniques. By using such tools it is possible to produce past event information for current and future urban planning and management in which suitability analysis of spatial modeling and detecting change of urban dynamics is effectively executed.

In order to determine the most desirable direction for future development, the suitability for various land uses should be carefully studied with the aim of directing growth to the most appropriate sites. Establishing appropriate suitability factors is the construction of suitability analysis. Initially, suitability analysis was developed as a method for planners to connect spatially independent factors within the environment and, consequently to provide a more unitary view of their interactions. Suitability analysis techniques integrate three factors of an area: location, development activities, and environmental processes. These techniques can make planners, landscape architects and local decision-makers analyze factors interactions in various ways. Moreover, such suitability analysis enables officials and land managers to make decisions and establish policies in terms of the specific land uses (Malczewski, 1999).

The integration of RS and GIS has been widely applied and been recognized as a powerful and elective tool in detecting urban land use and land cover change. Satellite aerial remote sensing collects multi spectral, multi resolution and multi temporal data, and turns them into information valuable for understanding and monitoring urban land processes and for building urban land covers datasets (Tran, 2000).

In Ethiopia there is lack of manpower that uses RS and GIS tools in urban administration offices even though these tools crucial for monitoring and managing daily activities of the city and towns. This is due to lack of using modern technologies in many governmental offices as a whole and specifically poor skills and knowledge's of individuals. A few researchers start researching different urban problems by using RS and GIS tools in past years. This issues necessitate researcher to investigate the problem by using RS and GIS tools and the title of the research also crucial for policy makers and urban planners. Why? Because the main problem in urban land management are traditional working methods and lack of update data management techniques and tools. Therefore, in this project paper researcher would be used RS and GIS tools to indicate ways of monitor of urban expansion in time series of 1986, 2001 and 2016, and selected suitable site for residential housing for further modern ways planning in urban areas to do a right things at a right places in sululta town.

1.2. Statement of the Problem

At the moment, Ethiopia is among the countries of low level of urbanization and as result, most urban settlements are characterized by shortfalls in stock housing and water supply, urban encroachments in fringe area, inadequate sewerage, traffic congestion, pollution, poverty and social unrest making urban governance a difficult task to maintain healthy urban environment. High rate of urban population growth is a cause of concern among Ethiopia's urban and town planners for efficient urban planning. Therefore, there is an urgent need to adopt modern technology of remote sensing which includes both aerial as well as satellite based systems, allowing us to collect lot of physical data together with GIS helps us to analyze the data spatially, offering possibilities of generating various options (modeling), there by optimizing the whole planning process. Then after, by provide an important linkage in the overall planning process and making it more effective and meaningful (Praveen Kumar et al..., 2011).

Urban areas of today are more exactly described as sprawling regions that become interconnected in a dendritic fashion. The positive aspects of urbanization have often been overshadowed by deterioration in the physical environment and quality of life caused by the widening gap between supply and demand for basic services and infrastructure (T. Carlson,2002). Praveen Kumar et al...**, (**2011**)** described as Urbanization is inevitable, when pressure on land is high, agriculture incomes is low and population increases are excessive, as is the case of most developing countries of the world. The 21st century is the century of urban transition for human society in way urbanization is desirable for human development. However, uncontrolled urbanization has been responsible for several problems, our cities facing today, resulting in substandard living environment, acute problems of drinking water, noise and air pollution, disposal of waste, traffic congestion etc. To minimize these environmental degradations in and around cities, the technological development in related fields have to address to these problems caused by rapid urbanization, only then the fruits of development will percolate to the most deprived ones.

According to Praveen Kumar et al...**, (**2011**)** a numbers of significant studies were made for environmental quality management by using different GIS and RS techniques. Thus, various techniques have been applied for mapping urban land use/land cover. It helps in encroaching urban problems even of very small magnitude and dire. According to Patkar, (2003) different studies carry out recently by using remote sensing and GIS for Urban problem. Accordingly this is due to RS can provide an important source of data for urban land use/land cover mapping and environmental monitoring as well as Urban land cover/use mapping has received an increasing amount of attention from urban planners and scientists including geographers.

Merga (2012) study on evaluation of land use planning and implementation in Sululta town with concern to environmental issue by using GIS and RS. In his study he stated his research result that the effectiveness of the plan implementation were affected by factors like lack of policy and commitment of officials, shortage of implementation tools, skilled man power, and community awareness. Therefore, the ineffective land use planning and implementation resulted by the factors like unhealthy natural environment in the town via various development activities such as abattoirs, industries, housing, quarrying activities, etc; insufficient urban greenery, land and soil degradation, poor solid and liquid waste management, noise and poor air quality, poor sanitation infrastructures and poor environmental management has led to several social and health problems, environmental pollution, and poor urban image.

However even though he proposed Suitability map of industrial, Landfill Site (waste materials) and conservation areas, he didn't identified suitable site for residential housing, health center, schools, and etc. Moreover he didn’t research time series of land use land cover change of sululta town which is very important for decision making on urban development and future planning as well as for other further research purpose. Therefore, due to absence of other researches on the study area on the issue of spatial suitability of residential housing and time series change detection analysis of sululta town expansion, the researcher decided to study these issues.

Due to lack of proper Monitoring of urban expansion and its land use, several problems happen in the study area. This is associated with uncontrolled population growth and migration (i.e. migration from metropolis of Addis Ababa City to sululta and from different rural areas to sululta). People migrate to the capital in search of job from different corners of Ethiopia. Housing is a basic requirement for any social class. But the housing condition of the city is of Addis by far inadequate in quantity and quality terms to meet the needs of the residents. This condition paved a way for the proliferation of squatter settlements and illegal occupancy of land in the fringe areas. The existing housing shortage which is the main problem of the city is created as a result of rapid population growth and insufficient housing supply to satisfy the newly forming households. According to the UN estimate, by the year of 2050 Finfine's (Addis Ababa's) population will grow from 4 million to 12 million. Even massive housing programs like the on-going condominium housing project may not be able to keep with this type of the demand (UN HABITAT, 2007).

As far as the researcher familiar for problem of housing in Finfine (Addis Ababa) and mismanagement of peripheral urban land, low income households to be engaged in informal settlements and squatter settlements around the fringe of the city. Others who are not able to afford for the ever increasing housing rent in the center of the city are escaping to the fringe areas even beyond the boundary limit of the city administration. The concentration of such people including the new migrant population who temporarily stay in the fringe areas caused the expansion of both formal and informal settlements over the sululta town. Finfine (Addis Ababa) city is currently having a number of commuting population who reside outside of the city boundary but work in different institutions in the center of the city. This situation is favored by the presence of good transportation facility and due to shortest distance between the town of sululta and Finfine (Addis Ababa) city administration.

Finfine (Addis Ababa) as a regional capital for Oromyia Regional State and National city hosts different sectoral offices of the region where the majority of workers in different offices are forced to commute from the surrounding small towns of the special zone. Such a situation has facilitated the very strong interaction physically between the two administrations and has its implication for the growth of the city beyond its sphere of influence.

Most rural people in Ethiopia tend to move to urban areas either because they are attracted by the settings and situations in urban areas such as better standard of living, better chance for employment opportunities, sufficient provision of social services or because they are forced by the conditions in rural areas such as scarcity of agricultural land, stagnation of the agricultural sector and rural poverty. This phenomenon has been exacerbating because of the continuing ecological degradation, drought, famine and other natural catastrophes put much pressure on urban areas in socio-economic, legal, political and environmental terms. Obviously without socio-economic development along side with the rapid urbanization process, there would not be a balance between the increasing urban population and available economic opportunities and social services. Therefore, these fellow of people from metropolis to sululta and rural Ethiopia to sululta town need high attention to monitor and manage properly by having time series accurate data and planning suitable site for housing (due to it is basic need) in turn to implements governmental programs and strategies by using modern technologies that used recent time in urban management.

Thus, situation need sustainable planning, design and Urban risk management by using GIS and RS tools and techniques through the study of historical change detection of the town and this issues necessitates for further project work to overcomes problems of residential housing.

Therefore, there are different reason to do this project. In the study area there were no other researchers work demonstrated about the case by using GIS and RS tools. The next reason was about usefulness of GIS and RS technologies for urban monitoring and planning. Now a time there is need of construction of housing of Oromyia National regional state to give land for housing for dwellers and expansion of housing investment in the form of apartments and condominium in Oromia special zone like sululta town. These are due to relatively price of land is cheap and at the same time, there are open investment land in the town. Therefore, by using GIS and RS researching such issue at this time is crucial for decision making of town administration. And at the end, to generate different spatial data for further use and research and to show a right way for future researchers.

1.3. Objectives

1.3.1. General Objectives

To examine changes in the land use land cover patterns and land suitability of housing analysis by using GIS and RS in Sululta Town..

1.3.2. Specific Objectives

1. To analysis patters of dynamic land use change among 1986, 2001, and 2016 years of sululta town.
2. To indicate the expansion urban and its effect on existing land use types of sululta town
3. To distinguish factors of rapid expansion of urban land of the sululta town
4. To Identify suitable sites for housing of the sululta town.

1.4. Research Question

2. What are the difference patterns of dynamic change of LULC in time series of 1986, 2001 and 2016?
3. Is it possible to identify the magnitude of the direction of change in the land use types of sululta town?
4. What are the major factors of the dramatic urban expansion causes?
5. Where is the suitable site for residential housing ?

1.5. Scope of the Study Area

The spatial scope of this study was limited to Oromyia Regional State, Sululta Administrative Town. Whereas the sequential scope conducted RS and GIS based analyses of Land use /Land cover changes, related with the effect of LULC change over the past 30 years (1986-2016). This study also analysis suitable site for residential housing in the study area by using spatial modeling approach of GIS based multi criteria method.

1.6. Limitations of the Research

This project work was limited to sululta Administrative Town. Not all this , but also there was many limitation in which researcher face challenge during the researching period. Those were problem of dysfunction of internet, absence of aerial photographs of intended years and high quality of the satellite image of the intended years and months. Time shortage due to there were others class for two courses in 1st semester, financial weakness for ground control data collection and so on were others limitation.

1.7. Significance of the Study

Monitoring of urban expansion play a vital role in effective urban management in terms of providing social facilities such as water supply, storm water drainage, sewerage and solid waste collection, health and education services, road network and quality and so on.

In recent years, the significance of spatial data production technologies, especially the application of remotely sensed data, has increased and GIS have been widely used in developed countries. In the case of developing countries such like our countries Ethiopia, the way of using the modern 21st century technologies and solving social, political, economical and environmental problems is at infancy stage. But it is impossible to protect one country from affecting modern technological and digital world because of globalization. Therefore, living in smart digital world required having skills and knowledge's to do and working with those digital technologies to solve different problems easily and timely.

This study investigates the change detection of urban expansion process in terms of land use land cover, and identifying suitable residential housing using remotely sensed images of sululta town, located in Oromyia regional state. Moreover, it has been identified that in the study area pulling factories from rural to urban and metropolis to urban and suitable site for residential village.

Common land use categories; namely settlement, open space, cultivation land, grassland and vegetation were considered for classification. In settlement categories such as high-density built up area and low-density built up area are included. Due to this, policy makers and urban planners should use the result of the study for further monitoring the activities of the town and planning purpose.

1.8. Organization of the Project Thesis

This study organized into five chapters as follows. The first chapter is introducing the reader with the study. It will highlight the reasons that necessitated the research and the objectives that are intended to be achieved. The introductory chapter briefly reviewed the concept of using GIS and RS for monitoring urban expansion and identification of suitable residential housing and briefly outlines the statement of the problem. It also stated the objectives, scope and limitations of the study and Organization of this thesis all are included. The second chapter will look into some previously conducted studies literature on the issues. The third chapter also will focus on the background of the study area and methodology. It begins with the description of the study area highlights the geographic, economic and social realities of the area. It will then discuss source of the data, Sampling techniques, and methods of data analyses. The fourth chapter more concerned to analysis and interpretation of the data collected. The last and the fifth chapter covered the conclusion and recommendation.

CHAPTER TWO: LITRUTURE REVIEW

2. GENERAL OVERREVIEW

In recent years, cities all over the world have experienced rapid growth because of the rapid increase in world population and the irreversible flow of people from rural to urban areas. Specifically, in the larger towns and cities of the developing world the rate of population increase has been constant and nowadays, many of them are facing unplanned and uncontrolled settlements at the densely populated sites or fringes (UN, 1997).

Urbanization is one of the most evident human-induced global changes. Population growth is an important factor that contributes to change in any urban system. Although urbanization has been an issue of concern, its rate is of a more serious concern. Despite its economic importance, urban growth has a considerable impact on the surrounding environment. Addressing the various challenges posed by urbanization process requires spatio-temporal analysis of cities and regions. This is because cities are dynamic in which the processes that are shaping cities globally and locally. Researchers and city planners have assessed urbanization processes through the lens of RS and GIS. Recent advances in RS and GIS tools with varying analysis techniques have enabled researchers to model urban change effectively (Nico Kotzeet al, 2014).

2.1. Status of World Urbanization

Population growth and urban expansion have advanced at an unprecedented pace over the past few decades. Although cities occupy only a very small portion of the Earth's total land surface, almost half of the world population lives in urban areas (United Nations, 2007).Urban growth has had increasingly significant socioeconomic and environmental impacts at local, regional and global scales (Meysam, 2002).

The very first example of Remote Sensing in urban studies is represented by a camera carried on a balloon by Tournachon to study parts of Paris in 1858. Since 1948, when the full potential of aerial photography in urban analysis was examined, conventional black and white photography first, and color photography later, have been increasingly used in socio economic and demographic studies. Such studies were focused mainly on the use of photo interpreted data as auxiliary data sources for the census, or to predict socioeconomic variables such as poverty from housing density, structure type or vegetation cover. With the advent of the first generation satellite sensors (Land sat MSS) in the 1970s and the subsequent Land sat TM and SPOT, which were able to collect information in multiple spectral bands, including thermal infrared, virtually all research in urban areas focused on land use or land cover classification (Turkstra, 1996).

Consistent and efficient characterization of the urban environment provides the basis for urban planning and decision making, and facilitates the study of local and regional environmental processes in the broader context of global environmental change and the sustainability of cities and their hinterlands. Satellite systems can provide timely and accurate information on existing land use and land cover and have been increasingly used to characterize urban areas and to monitor urban changes in conjunction with socioeconomic and demographic changes. It is becoming more and more evident to both the physical and the social science research communities that remote sensing represents an essential tool in any environmental and socioeconomic analysis of urban areas (Meysam, 2002)

Planning is a widely accepted way to handle complex problems of resources allocation and decision making. It involves the use of collective intelligence and foresight to chart direction, order harmony and make progress in public activity relating to human environment and general welfare. In order to provide more effective and meaningful direction for better planning and development necessary support of the organization has become essential. Hence the need for a suitable information system is increasingly being felt in all planning and developmental activities, whether these are for urban or rural areas. Urban areas of today are more exactly described as sprawling regions that become interconnected in a dendritic fashion (As Mahesh Jhawaret al (2012) quoted Carlson and Arthur, 2000).

Mahesh Jhawar et al (2012) in their work said ,"the purpose of using GIS is that, maps provide an added dimension to data analysis which brings us one step closer to visualizing the complex patterns and relationships that characterize real-world planning and policy problems. Visualization of spatial patterns also supports change analysis, which is important in monitoring of social indicators. This in turn should result in improving need assessment. The RS and GIS applications in various stages of planning, implementation and monitoring of the urban area".

Recent advances in remote sensing—both in satellite hardware technology and image-processing algorithm development—provide opportunities for collection and dissemination of timely information on urban form and size that can be useful for policy and planning.

Urbanization or urban drift is the physical growth of urban areas as a result of rural migration and even suburban concentration into cities, particularly the very largest one. It is closely linked to modernization, industrialization, and the sociological process of rationalization. The rapid urbanization of the world's population over the twentieth century is described in the 2005 Revision of the UN World Urbanization Prospects report. The global proportion of urban population rose dramatically from 13% (220 million) in 1900, to 29% (732 million) in 1950, to 49% (3.2 billion) in 2005

2.2. Status of Africa Urbanization

In recent times, cities and towns in developing countries have been observed to be experiencing unprecedented growth in size and number. It is estimated globally that more than five billion people will live in urban areas by 2025 and eighty percent of these are expected to live in cities in developing countries (ITC, 2005). Urban expansion is one of the important areas of man's interaction with his environment with great impact on the natural land cover. The majority of cities in the developing countries in general and African cities in particular are typically known for their weak land use planning, poor enforcement of their existing plans and lack of horizontal and vertical coordination which affect the normal functioning of cities as engines of development. Rapid urban expansion in many cities of developing countries has been identified as a major cause of land use /land cover change (LULC) (Codjo, 2007, Oyinloye and Adesina, 2006).

Urban expansion monitoring and mapping thus becomes necessary to make efficient policy for development and controls of further growth of urban centers. Such monitoring requires reliable data at regular interval. Remotely sensed data, RS techniques and GIS tools have become the veritable tools in the acquisition, monitoring, evaluation and mapping of urban expansion. Land use/cover maps produced through the use of RS and GIS are the most reliable information in urban growth studies. The combined use of RS imagery and GIS techniques is a powerful tool for land cover data generation, and for storing, measuring, modeling and analyzing spatial data

(Geneletti and Gorte, 2003). Remote sensing data derived from satellite sensors such as Land sat can provide information about the areal extent, conditions, boundary and monitoring of urban changes. Recent studies make use of data from different sensors to measure changes in landmass and population size (Nico Kotzeet al, 2014).

Understanding the urban patterns, dynamic processes, and their relationships is a primary objective in the urban research agenda with a wide consensus among scientists, resource managers, and planners, because future development and management of urban areas require detailed information about ongoing processes and patterns. These patterns can be systematically mapped, monitored and accurately assessed from satellite data along with conventional ground data. RS and GIS techniques may be used as efficient tools to detect, assess and map land use changes (NicoKotzeet al, (2014) cited Araya et al, (2010),

"Urban growth is an unstoppable process in development which can only be managed through proper planning. The planning process can only start by identifying the growth points within urban areas. Satellite remotely sensed data has proven essential in this identification and mapping process of such growth. Numerous works have shown that satellite remote sensing has the potential to provide accurate and timely geospatial information describing urban changes. Although LULC changes have in the past been monitored by traditional inventories and surveys, satellite RS can be more effective as it can provide greater amounts of information along with advantages of cost and time savings for extensive areas. Advances in satellite-based land surface mapping are contributing to the creation of considerably more detailed urban maps, offering planners better understanding of urban growth dynamics and sprawl. Recently, the implementations of these techniques to quantify, analyze, and model the urban growth dynamics has been successful (NicoKotzeet al, (2014).

2.3. Status of Ethiopia Urbanization

There were significant towns established in Ethiopian at ancient Empire (Abyssynia) like the oldest cities of Axum, Gondar, Asmara in the northern part. Archaeological and historical evidences witness the existence of towns since the Axumite period. The birth of a number of important earlier Abyssinian towns Axum, Gondar and Asmara was attributed to political and commercial situations in the northern Ethiopia during those days. Ethiopia has long history of urbanization despite lack of permanent city until the foundation and final consolidation of the rulers at Finfine (Addis Ababa) in 1887.

Ezana (2013) quoting Mesfin (1976) explains that the process of urban development in Ethiopian is known for its extremely slow and sporadic progress. This is in part a result of the fact that pre-twentieth century Ethiopian urbanization was intimately linked with political capitals. After the abandonment of Aksum as a capital, Ethiopian kings have for centuries practiced a tradition of roving capitals because of political, military, and environmental reasons. Menilik's decision to make *Finfine (Addis Ababa)* a permanent capital represented an end to this longstanding practice.

According Getahun (2000) quoted to R.J Horvath (1966) who studied the role of small towns around the capital, urbanization in Ethiopia has undergone fundamental metamorphosis during the twentieth century. A system of towns existed in the historic Ethiopia whose establishment and functions were quite different from the towns we observe today. Getahun described sixty years back a study conducted by Messing (1957) showed that the towns in the northern Ethiopia had their origin within the feudal social organization of the Amhara society where as the southern towns were trading centers.

The Italians promoted urbanism significantly by founding towns and expanding the economic base of the existing towns. For example sululta town founded in 1929 E.C by Italian military camp. Now a day elders evidenced and named sululta town by so called 'mishig' (means military camp) due to Italian military occupied there and make small village. After the departure of Italians towns were founded and grew at unprecedented rate. The towns in the southern Ethiopia served as important commercial, and political centers'. Most of them were therefore, the result of politico-military development of the Emperor.

However, regarding the impetus for urbanization in Ethiopia, Getahun (2000) asserted that there is a continuous debate among scholars of Ethiopia on whether urbanization in Ethiopia was the result of Menelik's conquest or the result of local social, economic and cultural dynamics which impacted the growth of towns. The debate focus on whether urban growth during the period was attributed to internal developments or external factors. Getahun in his paper entitled 'A History *of* Addis Ababa from Its Foundation in 1886 to 1910 (2000)' has revealed that even if these two debating cases existed, recent research has clearly supported the fact that pre-existing social, economic and cultural factors in the conquered regions made significant contribution to the evolution of Menelik's garrison in to towns. It was in this fashion that Finfine emerged from a small settlement grown to one of the biggest metropolis in Africa.

Horvath divided the evolution of towns in Ethiopia into three periods the classification which largely portrays the functional bases of the towns. The pre-Italian period (the period covers long time before the Italian Occupation of Ethiopia i.e., before 1936). The second period is the period of Italian Occupation of Ethiopia (1936-1941). The third period is the post-Italian occupation, which means from 1941 onwards.

During the first period i.e., before the 1936, the majority of the towns in the country were formed by the military occupation of the internal power, Menelik. After the foundation of Finfine (Addis Ababa) as a city, which took geographic advantage being centrally located in the heart of both the former Abyssinian and the newly incorporated southern Ethiopian territory, there emerged towns like Holota Gannat which are located closer to the seat of the Emperor. The Emperor has been using the nearby towns and rural areas as a source of resources to depend on.

Around 1915 the nuclei of four towns were established by the company building Addis Ababa – Djibouti railroad. Kaliti, Akaki, Galan, Dukam stations were established along the railroad and were located in the closer distance from Finfine (Addis Ababa). These towns existed till today though their growth is not as such highly appreciated (Horvath 1966). Towns like *Harar, Dire Dawa*, *Bonga and Jimma*were among the oldest towns in the 'southern' region even before the conquest of Menelik to Finfine (Addis Ababa)(Ezana, 2013).

Finfine (Addis Ababa) has the highest share of urban population of the country and of course, as a city it has significant share of the total population of Ethiopia (nearly 25 per cent of the urban population and 5.5 per cent of total population of Ethiopia is contributed by Finfine). On the other hand the growth and development of regional towns in the country was highly affected due to the reason that the past governments have been giving more attention to the development of the capital city than the other towns in the country. This situation has affected the development of other towns. But recently there is an attempt to boost the growth and development of regional towns which may influence the primacy of the capital and contribute to fair distribution of resources and population to all other towns and cities of the country (Ezana, 2013).

According to the CSA 2007 report, there are about 973 settlements designated as urban (with population size of 2000 and more) in Ethiopia and the number of towns and cities are tremendously increasing from time to time. However, there are only 12 towns whose population size is more than 100000. Finfine is the only city which has more than 1 million populations. Therefore, its primacy is unquestionable and now it is 10 times more than the second largest town, Dire Dawa, in population.

According to a report in 1996, since 1940 the proportion of urban population to the national has grown 5 times. While the rate was only 3 percent in 1940, it was almost tripled and reached 8.5 percent in 1967. In the year 1970 about 9.7 percent of the population was living in urban areas, while in 1984 and 1994 it reached 11.4 and 15.7 percent respectively. Today, about 17.6 percent of the total population is estimated to live in urban areas and this is expected to reach about 29 percent by the year 2020. These figures display the fact that t.he rate of urbanization in Ethiopia is well below the African average, which is about 30 percent in 1996.

The Special Zone of Oromia Surrounding Finfine(SZOSF) is situated surrounding the city boundary of Finfine. The developments that take place in the city boundary of Finfine are the major factors for the changes and transformations taking place in this metropolitan region. The linkage between the city and the other rural and semi-urban areas in the metro-region is strong. Therefore, pulling factors such as migration from metropolis city to Sululta town is the result of increasing demand of housing and open urban land market existence of informally and formally.

2.4. The Special Zone of Oromia Surrounding Finfine (SZOSF)

Though it is beyond the scope of this thesis project paper to discuss in detail the genesis of relationship between Ethiopia, Oromia, Finfine and the SZOSF, historical realities make it easy to create connections between them. A study of their geography can explain a number of other relations. Oromia is one of the 9 (nine) ethnically based regions of Ethiopia. It is indeed the largest centrally positioned region, stretching from western border in an arc to south-western corner of the country. Located in the heart of Oromia and Ethiopia, Finfine is the capital city of The Federal Democratic Republic of Ethiopia and the Oromia Regional State, too. Surrounding this city in all directions and sharing boundaries with it there are six districts rural woredas and eight towns' administration of Oromia region which is consisted in the "Special Zone" of Oromia surrounding Finfine.

The Special Zone of Oromia Surrounding Finfine (SZOSF), was established in 2007 by comprises of the six districts surrounding Finfinefrom the North Shawa Zone, West Shawa Zone, Southwest Shawa and Eastern Shawa zone of the Oromia region. This special zone has many small towns under it but the major ones are the 8 towns (Burayu, Dukam, Galan, Holota, LagaTafo- LagaDadhi, Sabata, Sandafa andSululta). Moreover, the zone leads and coordinates the operations of these towns and superintends their day to day activities in which establishment of the special zone is strategic in the sense that it unifies the so far disorganized efforts of dealing with Finfine (Wondwossen, 2010).

2.5. Rural – Urban and City - Town Linkage: Sululta and its Hinterlands

Demographic and economic expansion of town, through the processes such as migration and industrialization tend to be accompanied by spatial expansion, resulting in encroachments by town upon adjacent peri-urban or fringe areas. At the same time areas that were earlier distant from the city and rural in character will subsequently start falling within the towns' reach or 'band of influence'. Typically increased interaction with and access to the town economy in terms of capital, labor (public and private) goods and services will subsequently trigger the transformation of rural to peri-urban areas.

Coming to the specific situation of the nature and magnitude of linkage between the Sululta town and fringe area understudy, there are different manifestation of linkages so far established and in progress between the town of sululta and its fringe kebeles.

As per the study conducted by the Special zone administration in consultation with the OWWDSE during the land use planning study from 2008 -2011, the linkage between the main city and the surrounding areas takes both the form of rural-urban and urban-urban linkages.

The national population and housing census conducted in 1994 puts the population of Sululta town as 1271. Whereas, the national population and housing census conducted in 2007 shows that the total population in the town as 12,452. This is less than the figure provided by OUPI in 2007 which is 14,000. From these two national censuses, it is possible to calculate the observed population by computing the growth rate of the town exponentially. Hence, Sululta town population is forecasted for the planning year with the consideration of the two CSA base population data of 1994(1271) and 2007(12452). Thus, the growth rate from the two years population data were calculated and it could be 17%, from which the total population from 2012 to 2022 was projected (Merga Mekonnen, 2012). The following Fig.2.8. expresses the above reality.

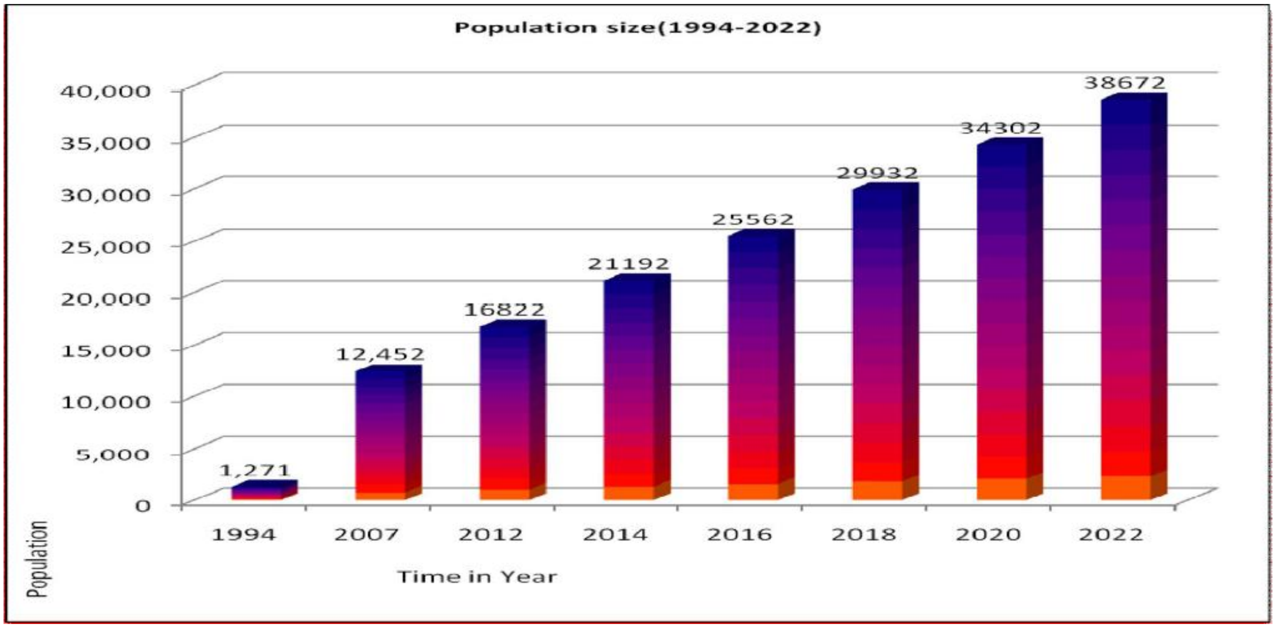


Figure 2.1. Population of the study area computed from CSA, 1994 and 2007
(Source: Merga Mekonnen, 2012)

Population Composition

The composition of age of a particular's society is a very critical component of Land use planning. migration from urban to urban and rural to urban should be facilitate and enable to predict what will be the future demand and development activity needed. The more the young generation, as an example, the higher the future land demand for different activities. Hence, aiming to plan for land use pattern of the study area. As the table below shows, the age structure is relatively distributed modestly to the different categories (See table 2.1).

Table 2.1 Population in age group

Age group	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>or= 60
Male	62	74	90	92	84	38	33	37	19	19	13	13	27
Female	73	64	92	92	75	53	38	29	29	20	32	22	53
Total	135	138	182	184	159	91	71	66	48	39	45	35	78

Source: CSA 1994

According to CSA 1994 the population size of the town is 1271 of which (47.1%) male and (52.9%) female. From the table above the number of population aged from 0-14 are children economically dependent population, those accounts about 455(35.8%) and those found in active work force age from 15-64 accounts about 773(60.9%). Whereas those that found above 65 ages constitute only 43(3.3%).

Concerning the ethnic composition of the town, Oromos are the original and dominant settlers that take the lion's share of more than 85%. Whereas, Amaharas were later settlers by different pulling factors in the town from other parts of the country and rarely found only sharing 11.6%. The rest population size in terms of ethnic composition in the town was shared by Sodo guraghie, Siltie, Agew and Afar. In 2014 or 2006 E.C the sululta town socio- economy profile indicated rapid population growth which is above merga's projection at 2020 reach 34,302. That means with six years lefting the number of population reached 37,988. Which means 3686 population come from others in the form of migration. Therefore, for the reason of urban expansion migration is a great factors.

Another concern of demographic study is religious composition which has a vital role in determining the different land use patterns, like social amenities, worship places, cemeteries, and other major land use and infrastructural amenities. In this regard about 85.9% of the religion in the town is Orthodox Christian followed by Protestant Christian accounting about 10.5% and the rest are shared by Muslim, Waqefata and others.

Population Dynamics

According to Merga (2012) Population dynamics refers to the numbers of births, deaths, immigrants, and emigrants over the specified time interval that determines the change in population size. As the country develops from primarily agricultural to industrial economy and urbanization is going on, large scale of migration from rural to urban takes place. The growth rate of urban areas is typically double the pace of overall population increase during this process. Sululta is the one where high rate of population growth is observed as a result of different pushing factors. Mainly better standard of living, job opportunity and poverty alleviation, despite the serious problems of overcrowding, sub-standard housing, crime and burden for the government to manage and fairly allocate the resource.

Based on the table 2.2 below out of the total population size of the town, about 38.5% are migrants from other areas. From this about 12 % were from urban areas while 26.5% were from countryside. Therefore, most of the migrant population of the town is from rural areas.

Table 2.2 Population migration

Sex	Number	Area of previous residence			
		Non-migrants	Migrants	urban	rural
Male	599	372	227	-	-
Female	672	410	262	-	-
Total	1271	782	489	152	337

Source: CSA, 1994

Economy of the Town

The major economic bases of the town are industrial development, private investment, urban agriculture, commercial activities, and micro and small enterprise development. While the town is less potential for industrial development, it is possibly yet at its infancy stage.

The existing limited manufacturing industries are largely concentrated in northern fringe and those that are under construction where concentrated in the center of the town. Most of the existing industries are Agro-processing industries, mainly dairy farm and tanneries that create job opportunity for significant number of peoples (sululta Town Mayor office, 2016).

The next economic base of the town is private investment. The main private investment areas in the town are trade, industry (such as manufacturing, Tourism, etc), social service and agro-processing. Thus, they may be considered as engine of economic growth due to the fact that private investment play indispensable role in reducing poverty by creating jobs and increasing purchasing power of the poor. It is also the main source of tax revenues, contributing to public funding for health, education, and other services (ibid).

Urban agriculture is also the economic base of the town and characterized by closeness to markets, high competition for land, limited space, use of urban resources such as organic solid wastes and water, low degree of farmer organization, mainly perishable products, high degree of specialization, to name a few.

Urban Agricultural is a widely practiced activity that is taken as a means of livelihood for many in the town. It is an important income supplement for urban families and it is an integral component of urban economic and ecological systems. It comprises a diversity of agricultural production systems in and around the town often specialized in perishable products, such as, milk, eggs and meat. The fodder of animals is also another agricultural product in the town that serves as economic source for many dwellers (ibid). Even though most of the time such like economic activities not much considered as urban economic activities, Sululta town households or dwellers way of their livelihood had been carried out agricultural types of economic activities such as poultry, milk farming or rearing, farming, fattening animals and etc.

Formal and Informal trade activities are another most important form of trade activities in town. The livelihood of significant number dwellers directly and indirectly depends on these activities that involve the transaction of highly diversified agricultural and industrial commodities raging from light consumer goods to higher order /capital goods. Thus, the sector plays an important role in employment creation and poverty alleviation by providing incomes to unskilled and semi-skilled workers who otherwise would be unemployed.

The small business sector is also seen as an important force to generate employment and more equitable income distribution, to activate competition, exploit niche markets, enhance productivity and technical change, and through all of these stimulate economic development. Tourism is again another significant economic potential of the town, particularly concerning Solon birds observed in waserbi and Entoto ridges and forests. There are also other bird’s species which lives around the wetland of the study area. Therefore, these areas can be conserved for the attraction of tourists for bird watching, protection of soil erosion, forest and water conservation, and for overall management of natural resources of the area.

Land Use/ Cover

According to Merga (2012) Land use/cover is an important aspect for modeling and understanding the earth as a system and is a key input for planning and management activities. It goes without saying that informed Structure planning promotes sustainable development and use of the natural resources. The land use/cover of the study area constitutes settlement, bush and shrub land, cultivated land, flower farm, open grass land, plantation forest and wood land. These are also shown on the map below for further evaluation of land use plan and implementation of the study area. The components of the land use/cover of the study area are also assessed in the Figure 2.7 below.

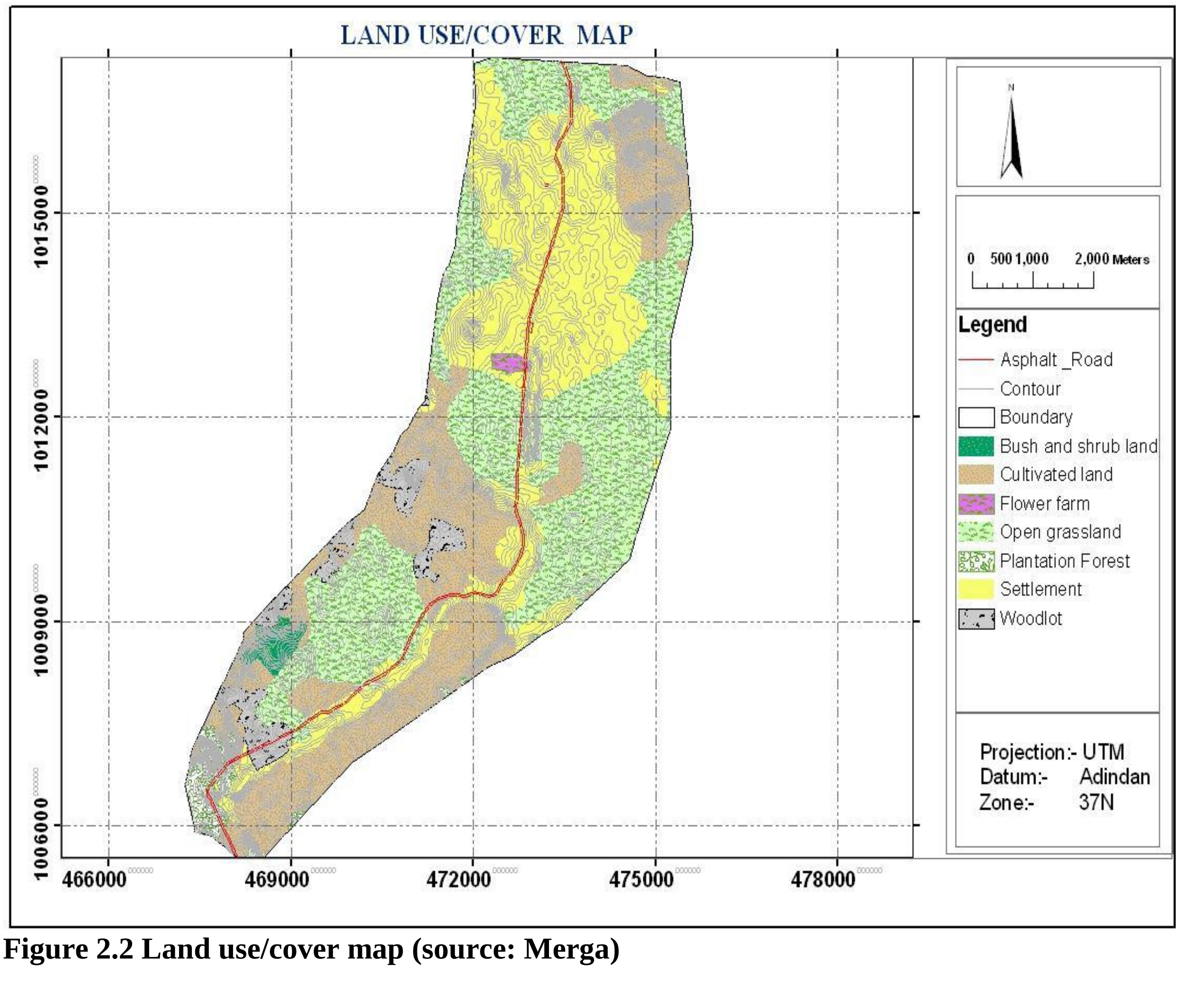


Figure 2.2 Land use/cover map (source: Merga)

Based on the figure 4.7 above the dominant land use/cover in the study area is open grass land which accounts about 36.57% of the total land use/cover. Settlement is the second larger land use/cover of the study area which accounts about 30.56% followed by cultivated land taking about 26.93% and wood land that constitute about 4.12%. The rest land uses/cover of the study area has been occupied by plantation forest and flower farm.

Structure Plan

The 2006 structure plan of Sululta town was prepared by the Oromia Urban Planning Institute (OUPI), for 10year planning period and for a population of 22,374. During this period the population of the town was 14,000 (OUPI, 2006). The dominant land use type during this planning period was the urban greenery. The next land use categories were the residence followed by transport and road network. This structure plan had brought a model for the town's development. The structure plan expansion areas followed the main road of Addis Ababa- Bahir Dar, in the direction of Addis Ababa town linearly.

In general, the existing structure plan of the study area is composed of different proposed land uses like administration, commerce, residence, manufacturing and storage, Transport and Road network, reserved area, urban greenery and social services. The plan covers an area of 4470.55 hectares within its delineated boundary and the plan is as shown below with little modification in converting from AutoCAD file to GIS file to easily analyze it (See table 2.3).

Table 2.3 Structure plan, area coverage in hectares and percentage

No	Land use Type	Area in hectares	Area in percentage
1	Administration	6.67	0.15%
2	Commerce	189.86	4.25%
3	Urban greenery	2473.68	55.33%
4	Manufacturing and storage	121.18	2.71%
5	Reserved area	89.03	2%
6	Residence	750.72	16.79%
7	Social service	267.38	5.98%
8	Transport and road network	572.03	12.79%
9	Total	4470.55	100%

Source: OUPI, 2006

Based on the table 4.3 and figure 4.10 above the dominant land use in the study area is urban greenery which accounts 55.33% of the total land use. These land use composed of recreation area, neighborhood open space, urban agriculture, forest, buffer zones, road side greens, squares, and grazing land. Residence is the second larger land use in the area which accounts for about 16.79 % followed by transport and road network taking about 12.79% and social service constitute about 5.98%. The rest land uses have been occupied by commerce, manufacturing and storage, reserved area, and administration.

The four kebeles town's of the sululta are found very closer to the main city within an average distance of 23 kilo meters. In addition, these towns are situated along the already established road outlets and are well connected to the town as Figure 4.7 road displayed on the map. These towns are in turn connected well with the rural villages and the towns act as intermediate supply zones of industrial goods for the rural settlements. Proximity also facilitated such interaction. Medium sized shops in sululta town are receiving the imported or domestically produced goods and keep in their stock and retail the goods to the rural surrounding population. Consumable goods are the dominant ones.

The other most important linkage is between cities and rural settlements or between the major city and the town is the flow of factors of production, labor and capital. Labor is the major source that flows between rural and urban areas, particularly unskilled labor at large extent and pace flows from rural areas to the nearby urban areas. In Ethiopia it is still difficult to document the exact data on the labor movement from rural to urban areas and Urban to urban except that some researchers trace their source region. It is obvious that urban sector activities are expanding to such fringe areas where job opportunities in the construction sector can easily be secured.

The continuous horizontal growth and development of sululta for the last decades to the surrounding areas has claimed enormous amount of rural agricultural land and household from the vicinity. The further pressure it has put on the neighboring Sululta rural woreda has now come to the point where such expansion is thought destroying the rural district side due to different facets of developments that the town is not able to accommodate. One of such pressures is the lack of spaces for residential houses for the ever increasing size of population of the town. There are also space requirements for other developments coming out from the main city (for industries, land for new housing estates, and so many others).

In general, the major development pressures prevailing speeding up the transformation of landscape in the fringe areas of sululta town with special reference in which because of Population size is highly increasing in the fringe areas, Land conversion and land loss to urban activities is, competition over land for commercial activities (services like hotels, supermarkets, recreations, investments and others). There is also huge land market operating in the study areas where both the government and the informal markets are actively operating, real estate development and speculative activities, shift in occupation from the side of the former farmers, but dozens of them being still in confusion, resources are under threat, especially land and open spaces including the rura1 ecosystem. Due to this, effective and efficient ways of monitoring the rapid expansion of urban and proposing the suitable site of residential housing is the main goal of this study.

2.6. The Role of GIS and Remote Sensing in Urban Management and Planning.

The ability of GIS to store, manage and manipulate large amounts of spatial data provides urban managers with a powerful tool. GIS's ability to link tabular, non-spatial data to location information is likewise a powerful analytic capability. Many different facets of government use GIS technology. GIS also provides ways of viewing and analyzing data that was previously impossible or impractical. With the aid of a GIS, a local planning and community development office can track zoning and site design plans that help form and shape a city (Zeng, 1999).

RS and (GIS) is a novel technology widely used to survey the land use problem. The GIS adopts the numerical methods and spatial analysis tools to delineate the land use. The methods can yield the same results after repeatedly applying the same procedures. Moreover, they reduce the manpower and time consumption for the delineation of land use. In contrast with the manual methods, the GIS is the most economic and objective methods. They can be used separately or in combination for application in studies of urban sprawl. In the case of a combined application, an efficient, even though more complex approach is the integration of remote sensing data processing. The applications of Remote Sensing and GIS in urban studies at present is giving more weight on the acquisition of urban land use information and the comparison on the urban sprawl spanning most recent several decades, giving an image that remote sensing and GIS applications are located in the dynamic monitoring of urban growth only, therefore only in a few cases, we see GIS technology are applied in empirical analysis on the urban spatial structure (Barnes et al., 2001).Urban growth remains a major topic concerning GIS and remote sensing applications. Remote sensing and GIS have proved to be effective means for extracting and processing varied resolutions of spatial information for monitoring urban growth (Epstein, 2002). According to department of Geography and Environmental studies of AAU (20016) there are different uses (application) of GIS and RS such as for government plan a significant portion of state government has a geographical component application. Other one is for natural resource management; highways and transportation purpose. Businesses use RS and GIS for a very wide array of applications such as retail site selection & customer analysis; logistics: vehicle tracking & routing, natural resource exploration (petroleum, etc.), precision agriculture and civil engineering and construction professionals are widely used. Military and defense organizations also used it for the purpose of Battlefield management, Satellite imagery interpretation, and so on. Not only these, but also there are use of it on the issues of Scientific research application disciple such as (geography, geology, botany, Anthropology/sociology, economics, political science, Epidemiology and criminology), Urban Planning, Management & Policy such as (Zoning, subdivision planning, Land acquisition, Economic development, Code enforcement, Housing renovation programs, Emergency response and Crime analysis and Tax assessment, Environmental Sciences area such as (Monitoring environmental risk, Modeling storm-water runoff, Management of watersheds, floodplains, wetlands, forests, aquifers, Environmental Impact Analysis, Hazardous or toxic facility sitting, Groundwater modeling and contamination tracking), Political Science area on the issue of (Redistricting, Analysis of election results and Predictive modeling), Civil Engineering/Utility area (for Locating underground facilities, Designing alignment for freeways, transit and Coordination of infrastructure maintenance), for Suitability Analysis on the issue of (Demographic Analysis and Market Penetration/ Share Analysis Site Selection), Education Administration (Attendance Area Maintenance, Enrollment Projections, School Bus Routing),real estate area (Neighborhood land prices, Traffic Impact Analysis, Determination of Highest and Best Use) for Health Care purpose (Epidemiology, Needs Analysis, Service Inventory) and site selection criteria and etc.

According to the guidelines published by FAO (1993), land use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land use options. The purpose of land use planning is "to select and put into practice those land uses that will meet the needs of the people best while safeguarding resources for the future". Land suitability analysis expresses how well a land unit matches the requirements of the land utilization type, and is seen as an appropriate way to quantify land development constraints and opportunities and help planners cope with the land use plan design problem (Wu; 2000).

2.7 Site Selection Process

Site selection requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use. The selection of housing sites involves a complex array of critical factors drawing from physical, demographical, economic, and environmental disciplines. The current spatial decision making could benefit from more systematic methods for handling multi criteria problems while considering the physical suitability conditions. Traditional decision support techniques lack the ability to simultaneously take into account these aspects. The process of housing site selection begins with the recognition of an existing or projected need. This recognition triggers a series of actions that starts with the identification of geographic areas of interest. In the past, site selection was based almost purely on economical and technical criteria. Today, a higher degree of sophistication is expected. Selection criteria must also satisfy a number of physical, social and environmental requirements, which are enforced by legislations and government regulations (SIOR and NAIOP 1990).

2.7.1. Site Selection Tools

Until as recent as the last decade, most spatial planning activities worldwide have been done without the use of geographic information systems (GIS) and multi-criteria decision analysis (MCDA) technologies, and even today they are rarely combined, despite the fact that most planning organizations have sufficient computer and software resources (Purevtseren M. et al..., 2017).

Multi-criteria Decision Analysis for Spatial Planning. One of the biggest challenges local governments and community groups face today is to find new areas for development in a sustainable way, without degrading land values. GIS and MCDA together provide tools for handling such natural resource management issues (J. Malczewski, (2004)). In short, GIS-based MCDA takes data (input) and combines it into a weighted map (output).As GIS is capable of handling and combining different types of data (both non spatial and spatial as well as multi-temporal and multi scale) in a time-efficient and cost-effective way, there has been a steady increase in interest for using GIS together with MCDA techniques (National Research Council (2003). Furthermore, the previous conventional map overlay approaches have been considerably advanced thanks to the integration of MCDA techniques with GIS (Malczewski, 2004), and therefore local governments and community groups, among others, have started to implement the technology together with more sophisticated spatial analysis. As Malczewski (2004) suggested in his work; for successful implementation of spatial MCDA two things are of critical importance (i) "The GIS capabilities of data acquisition, storage, retrieval, manipulation, and analysis" (ii) "The MCDM capabilities for combining the geographical data and the decision maker's preferences into one-dimensional values of alternative decisions". With the advent of powerful personal computers, practical MCDA tools, and user-friendly GIS, a number of studies have been carried out showing the usefulness of these techniques.

For the last three decades, geographic information systems (GIS), and Multi criteria decision making (MCDM) techniques have been used in solving site selection problems.

2.7.2. Multi Criteria Decision Making (MCDM)

The techniques adopted in the various approaches of decision analysis are called multi criteria decision methods (MCDM). These methods incorporate explicit statements of Preferences of decision-makers. Such preferences are represented by various quantities, weighting scheme, constraints, goal, utilities, and other parameters. They analyze and support decision through formal analysis of alternative options, their attribute, evaluation criteria, goals or objectives, and constraints. MCDM used to solve various site selection problems (Badri al et..., 1999). The choice of the MCDA method is very important since it has a significant effect on the final outcome. MCDA characteristics and properties should be compatible with the specific nature of the decision problem. For example, some MCDA techniques efficiently handle a continuous set of alternatives and criteria belonging to the same domain (e.g. economic). Other MCDA methods can only consider a small set of discrete alternatives but are more efficient to handle heterogeneous criteria (Florent et al..., 2001).

Because of conceptual difficulties involved in formulating and solving spatial decision problems, researchers have developed multi-criteria-spatial decision support systems (MC-SDSS). Multi-criteria decision making (MCDM) and a wide range of related methodologies offer a variety of techniques and practices to uncover and integrate decision makers' preferences in order to solve "real-world" GIS-based planning and management problems.

Spatial multi-criteria decision problems typically involve a set of geographically-defined alternatives (events) from which a choice of one or more alternatives is made with respect to a given set of evaluation criteria. In Spatial MCDM analysis results depend not only on the geographical distribution of attributes, but also on the value judgments involved in the decision making process (Indian Agricultural Research Institute, 2011).

If there is a conflict between the various actors, they can negotiate the subjective parameters, like the weights associated with each criterion before adopting a common set of values. It is also possible to repeat the MCDA process and thus select, for each different group of stakeholders, a solution that is adapted to its specific needs. MCDA results can be mapped in order to display the spatial extent of the best areas or index of land suitability.

The negotiating parties can then discuss and compare the results by overlaying these maps, which are in fact geographical representations of their own set of preferences. For example Purevtseren M. et al..., (2017) Implications of a Spatial Multi-criteria Decision Analysis for Urban Development in Ulaanbaatar of Mongolia used the following factors.

Table 2.4. Suitability criteria for urban development

Land attribute	Suitability criteria of factor		
	Unsuitable	Moderate with limitations	Most suitable
Slope gradient (%)	>15	8–15	<8
Soil texture*	Sand, silt	Loamy sand, sandy clay loam, silt clay loam	Loam, clay loam, silt loam
Soil character	Moving sand, undeveloped soil, boggy, saline, rock	Water, wind eroded, content of stones, low humus, permafrost, and so forth	No evidence of erosion, low amounts of stone, sufficient humus content, and so forth
Distance from road** (m)	<100; >3000	1500–3000	100–1500
Aspect (degrees)	North 0–22.5; 337.5–360	West 22.5–112.5 East 247.5–337.5	South 112.5–247.5
Close to built-up area (m)	>3000	1500–3000	150–1500
Close to river (m)	<500; >3000	1500–3000	500–1500
Vegetation cover (NDVI index)	<0.2	0.2–0.3	0.3–0.8

*Department of Housing [27].

**City and village planning and construction norms and rules (no. 30-01-04) of Mongolia [28].

Sources: Purevtseren Myagmartseren et al..., (2017)

On the other hand Yao Mu conducted case study in Canada (2006) on the issue of "Developing a Suitability Index for Residential Land Use" and concluded that, based on weighting relevant factors often considered in land suitability studies include natural environment factors (e.g. slope, soil type, geologic hazards present, land cover, etc.), built environment factors (e.g. existing land use, planned land use, accessibility to roads, availability of utilities, etc.), economic factors (e.g. land value, tax rate, etc.), and social factors (e.g. population present, jobs present, historical features present, etc). are the important factors for suitability analysis of housing site selection.

Yao Mu(2006) Quoted many researchers such as(Collins et al., 2001; Shen, 1999; Hu, 1995; McDonald and Brown, 1984) for residential land urban use, a lot of factors related to the local economic, social and physical environment which have been generally used in a lot of cases, such as schools network, water supply system, economic features, environmental degradation, employment, landform, environment factor, sewer network, road network hospital network, water availability, wild life, vegetation, drainage, wildlife interest, microclimate, heavy structure, lawns, access to major roads, access to city water and access to sewer lines.

The weighted linear combination (WLC) is one of the methods to present parametric approach that involves standardization of the suitability maps, assigning the weights of relative importance to the suitability's maps, and then combining the weights and standardized suitability maps to obtain an overall suitability score (Malczewski, 2004). Two critical elements of WLC are the weights assigned to attribute maps and the procedure for deriving commensurate attribute maps. Weight is the basic concept for parametric approach. The decision maker can directly assign the weights of "relative importance" to each attribute map layer. A total score is then obtained for each alternative through multiplying the importance weight assigned for each attribute by the scaled value given to the alternative on that attribute, and summing the products over all attributes (Malczewski, 2004). When the overall scores are calculated for all of land units, the units with the highest overall score is chosen as highly suitable lands. The parametric approaches classify and evaluate the influencing factors based on their importance for land suitability. The level of suitability is determined as the sum of the influencing factors scores. The physical evaluation consists of a model that assigns a score to every land unit based on its value on each factor. The suitability *S* at the K_{th} pixel was computed as follows:

$$S = \sum_{i=1}^{n} W_i C_{ij}$$

Where: *S* is the composite suitability for one land unit;

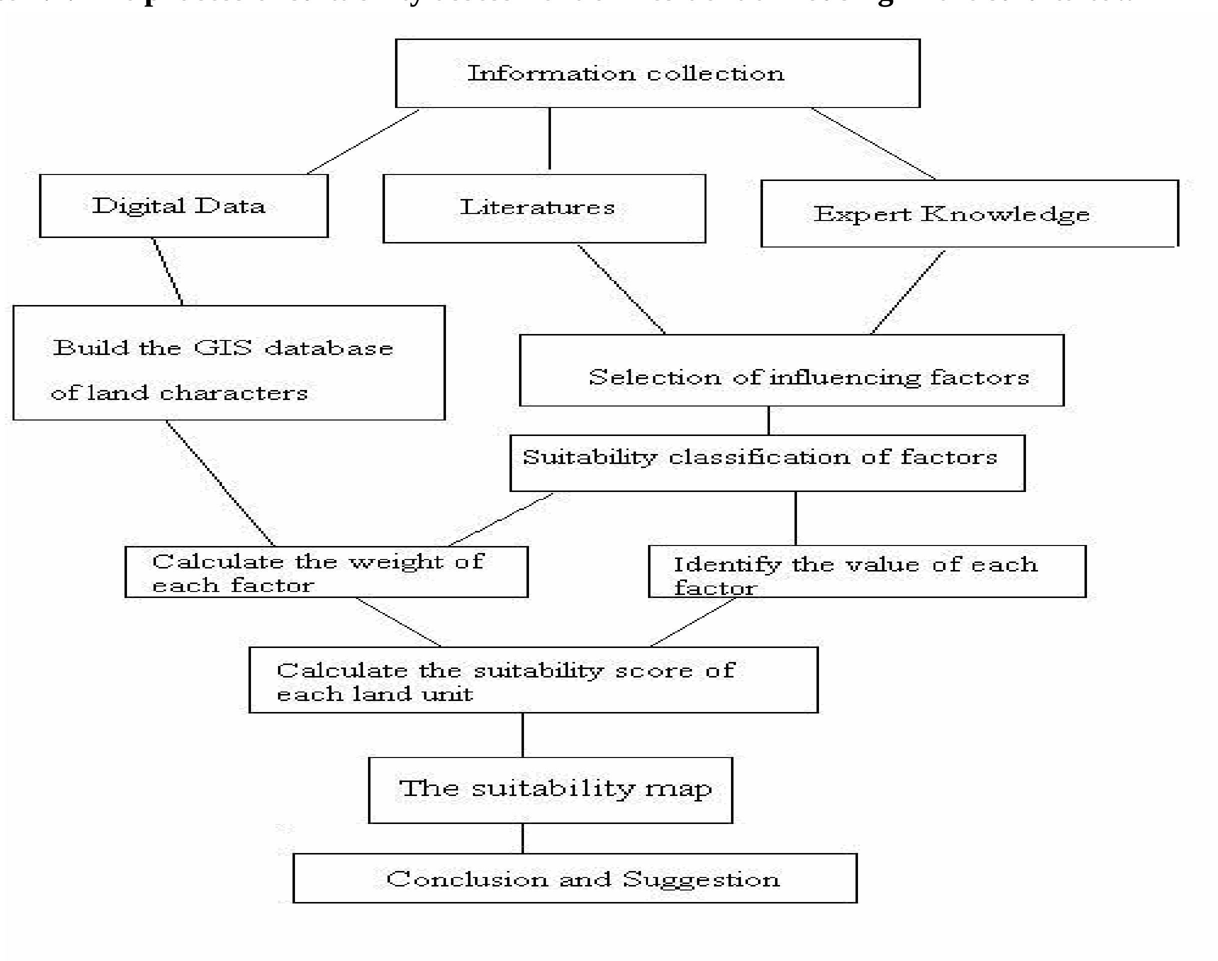
W_i is the weight of the *th*−i factor;

C_{ij} is the suitability class value for *i- th* factor in the j criterion's score of experts rank;

n is the quantity of the influencing factors.

The entire procedure of mathematical calculation is based upon the popular decision-making tool Analytic Hierarchy Process (AHP) as proposed by Thomas Saaty in the early 1980s. AHP is one technique used in parametric methods, and has been incorporated into the GIS-based land use suitability procedures. AHP can be used as a consensus building tool in situations involving a committee or group decision-making (Saaty, 1980). AHP uses a hierarchy of factors where each general factor is subdivided or composed of several contributing sub-factors. The method can be operational zed using any GIS system having overlay capabilities and implemented in both raster and vector GIS environments. The overlay mapping allows the evaluation criterion map layers to be combined in order to determine the composite map layer. This technique is also more appropriate for implementation in the vector-based GIS.

Pilate 2.1. The process of suitability assessment of Residential housing in the sululta town.



Source: Researcher

Table. 2.5.The full set of criteria for residential land suitability assessment in the sululta Town

Criteria		Description
Physical Environmental	Slope	Slope is one of the basic parameter for land suitability assessment. The slope map is derived from DEM.
	Drainage class	Potential periodic flooding, where land areas are subject to periodic flooding.
	Land use type	Current land use is the crucial indicators for the residential. The specialty-crop lands can not be changed to construction use.
Social Environment	Schools network	The school includes the day care center, elementary school and high school.
	Commodity network	This includes the convenience store, superstore, bank, shopping centre, restaurant, etc..
	Hospital network	The proximity to the hospital is the factor that influenced people's choice.
	Waste management	The management of domestic waste solid. It determined by the number of refuse depot and proximity to refuse collect point.
	Sewer network	The basic requirement for the residential area.
	Main roads network	This part includes the local road network and the intercity transportation network.
Living Environment	Water area	The proximity to the water area is an indispensable parameter
	Riverway network	This parameter is selected based on the suggestions from the experts.
	Population density	High population density will reduce the public's interest.
	Open space	The greenbelt and open space will improve the quality of life.
	Bus routes	The proximity to bus routes.
	Environmental pollution	The current environmental pollution situation includes the water pollution, air pollution, noise that will effect the living environment.
	Water quality	This includes the quality of groundwater and drink water that affect the quality of living environment.
	Proximity to industrial area	The proximity to industrial area will affect the living environment quality.

Source: Merga

Most of the physical environmental factors describe the attributes of the soil. Sharp slope is not suitable for residential lands. Since the study area includes river way network, the flooding drainage class is another physical environment that influences selecting residential land. Current land use type is a key feature in the residential land suitability assessment. For other kinds of land use, considering the physical features of soil, most suitable factors should be current residential lands and some kind of economic crop land. On the other hand, water area and unused land are lest suitable for residential land use. The residential lands are subjected to building a comfortable community for future use. Social environment and living environment are necessary for considering the suitable land for future residential use.

The classification of the suitability

The FAO classification model for suitability is widely used in the studies of land suitability by different researchers in many countries. The following table is depicted the FAO's classification

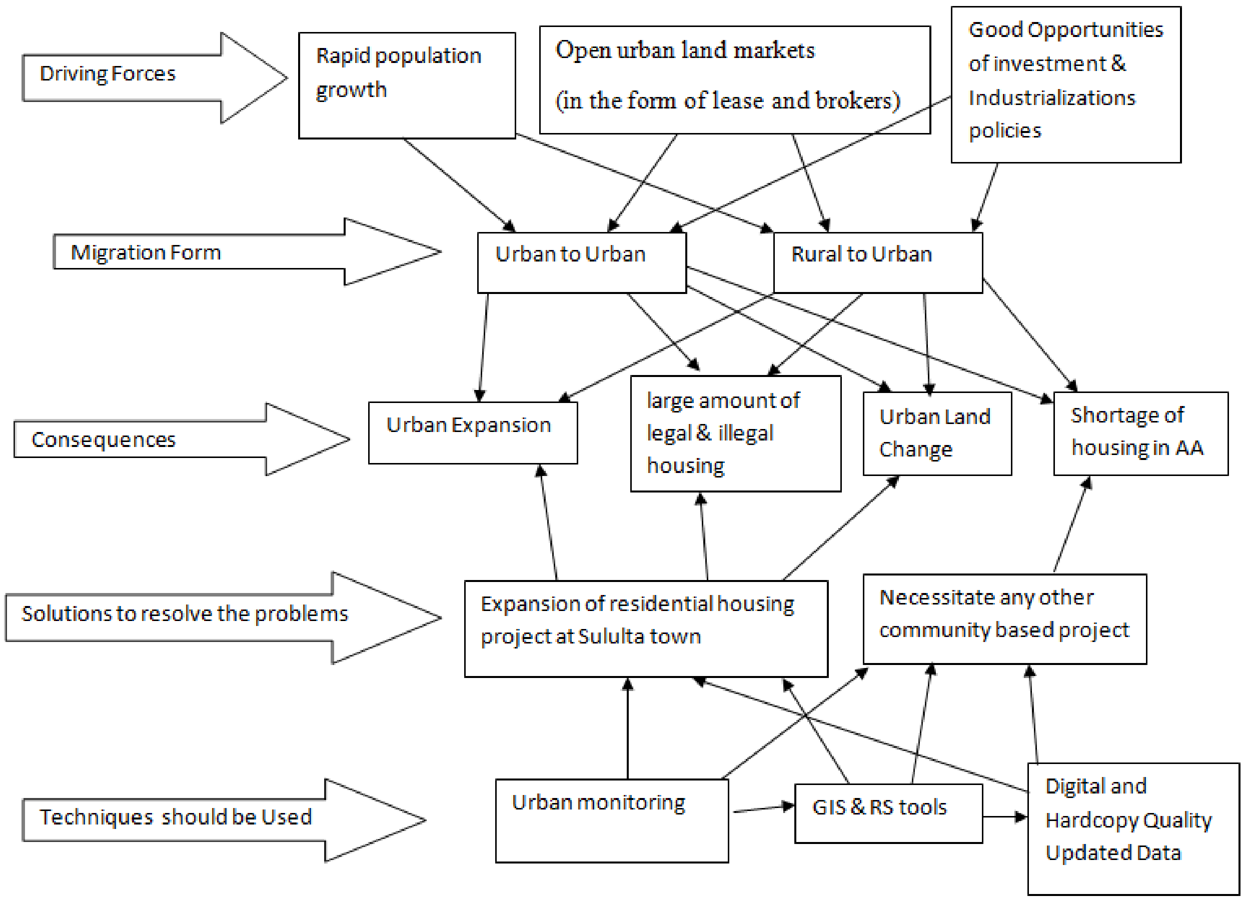
Table: 2.6 The description of land Suitability Classes

Land suitability Orders	Land suitability Classes	Definitions of Classes
Suitable	Highly Suitable (S1)	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce benefits.
	Moderately Suitable (S2)	Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.
	Marginally Suitable (S3)	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits or increase required inputs, that this expenditure will be only marginally justified.
Not Suitable	Currently Not Suitable (N1)	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner.
	Permanently Not Suitable (N2)	Land with limitations to sustained use that cannot be overcome.

Source: FAO,1993

Conceptual Framework

Plate 2.2: Conceptual Framework of the study Area



CHAPTER THREE: STUDY AREA DESCRIPTION AND RESAERCH MEDHOLOGY

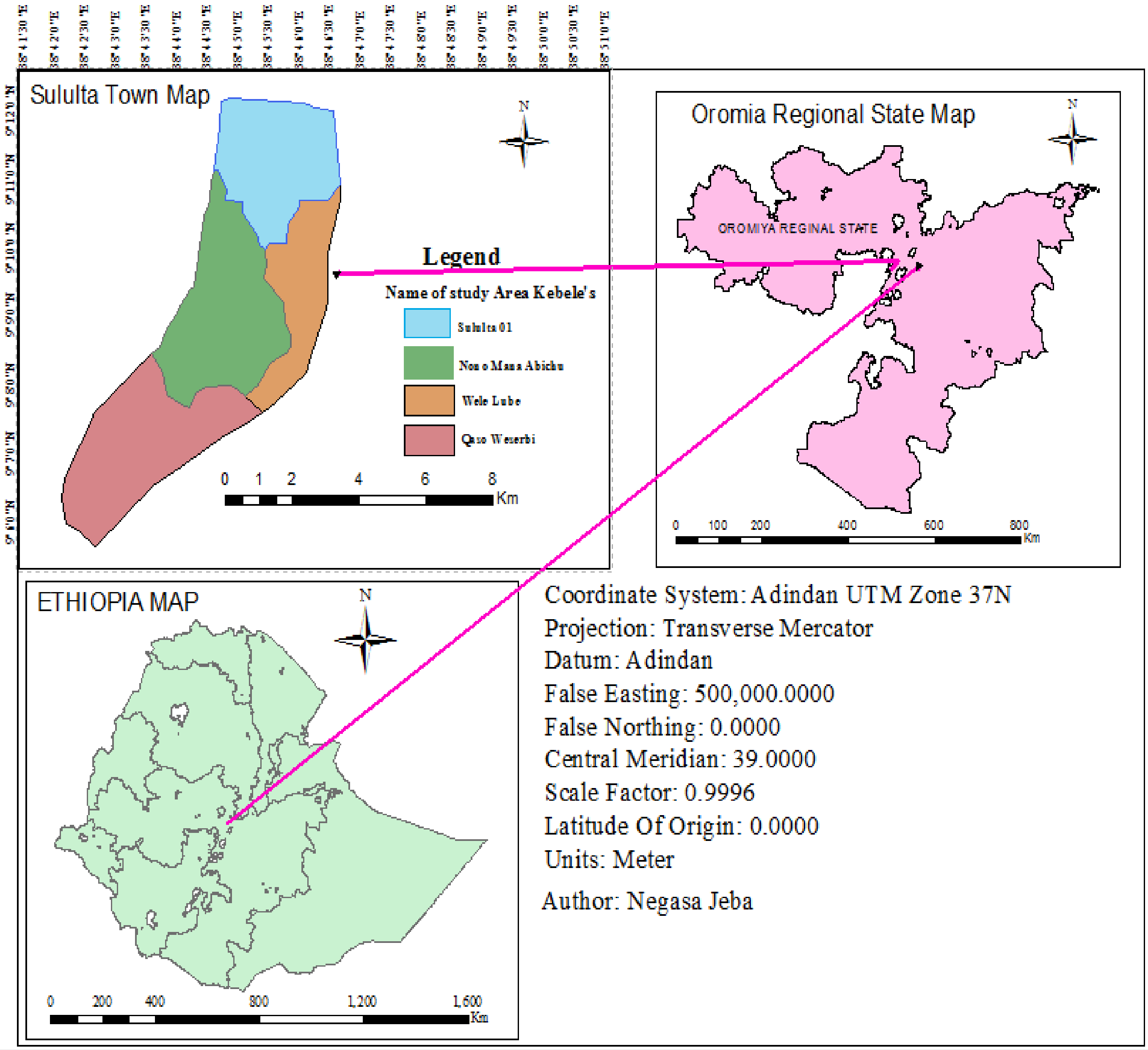
3.1. Description of Study Area

3.1.1. Location and Area

Sululta town is found in the central part of Ethiopia, Oromia Special Zone surrounding Finfinne and reached via the main high way of Addis Ababa-Bahir Dar. Astronomically, the study area extends from 9^o 30'00''N to 9^o 12'15''N latitude and 38^o 42'0''E to 38^o46'45''E longitude. In relative terms, Sululta town is located at a distance of 23km along Addis Ababa- Bahir Dar road and in south direction by Finfine(Addis Ababa) and in the left three direction by Sululta rural woreda. Its location at this spot favors the town with many opportunities to share development with Finfine city.

Information about the exact time and condition of coining and naming of “Sululta town” has been difficult and needs further investigation. However, there are two major oral traditions for the name Sululta. The first one, there are those who argue that the name belongs from one of the Tulama Oromo clan conquering the area for agricultural and strategic purpose. Whereas the others argue that the name of Sululta is related with its scenery. As early Oromos appreciate nature, it was believed that this area was named as “Sulula” by early Oromo settlers in expressing their appreciation for the greenness and plainness of the area. This expression was largely supported by poems of early elders of the area. For many the name Sululta came from Afan Oromo word “Sulula”, meaning a plate land that sounding by mountain peaks that has associated with attractive landscape. Before 2006 E.C sululta town had one kobeles that was called 01. After that due to rapid urbanization of the town rural kebeles such as 'Nono mana Abichu', 'wale lube' and 'kaso Wasarbie' were included in the administrative boundary of the town (OUPI, 2008). The social interaction from the nearby Addis Ababa and rural areas of the town is very high due to accommodating large numbers of people by residential housing from metropolis in which many people those work in Finfine live in the town. There are different driving forces for rapid expansion of the town. Those are migration from rural to urban and city to urban for different reason. It discussed as follows: town Administration at the moment (STAO, 2016) (See figure 3.1.below for detail information).

Fig. 3. Study Area Map



Source: Developed by researcher

3.1.2 Topography

3.1.2.1 Elevation Range

The topography of the area varies from chains of mountains around Entoto ridge in the south to plain lands in the East, North-west, and north. The average elevation in the town is 2600m above mean sea level. The altitude of the study area generally dropdown south-north direction from 2800m to 2500m above mean sea level. The peak altitude of the area is 2800m at Entoto ridges and the lowest is 2500m to the north fringe of the study area. The minute elevation difference with in the whole area contributes a lot for water logging as most of the area is possibly classified as black cotton soil area. See the map below for detail information.

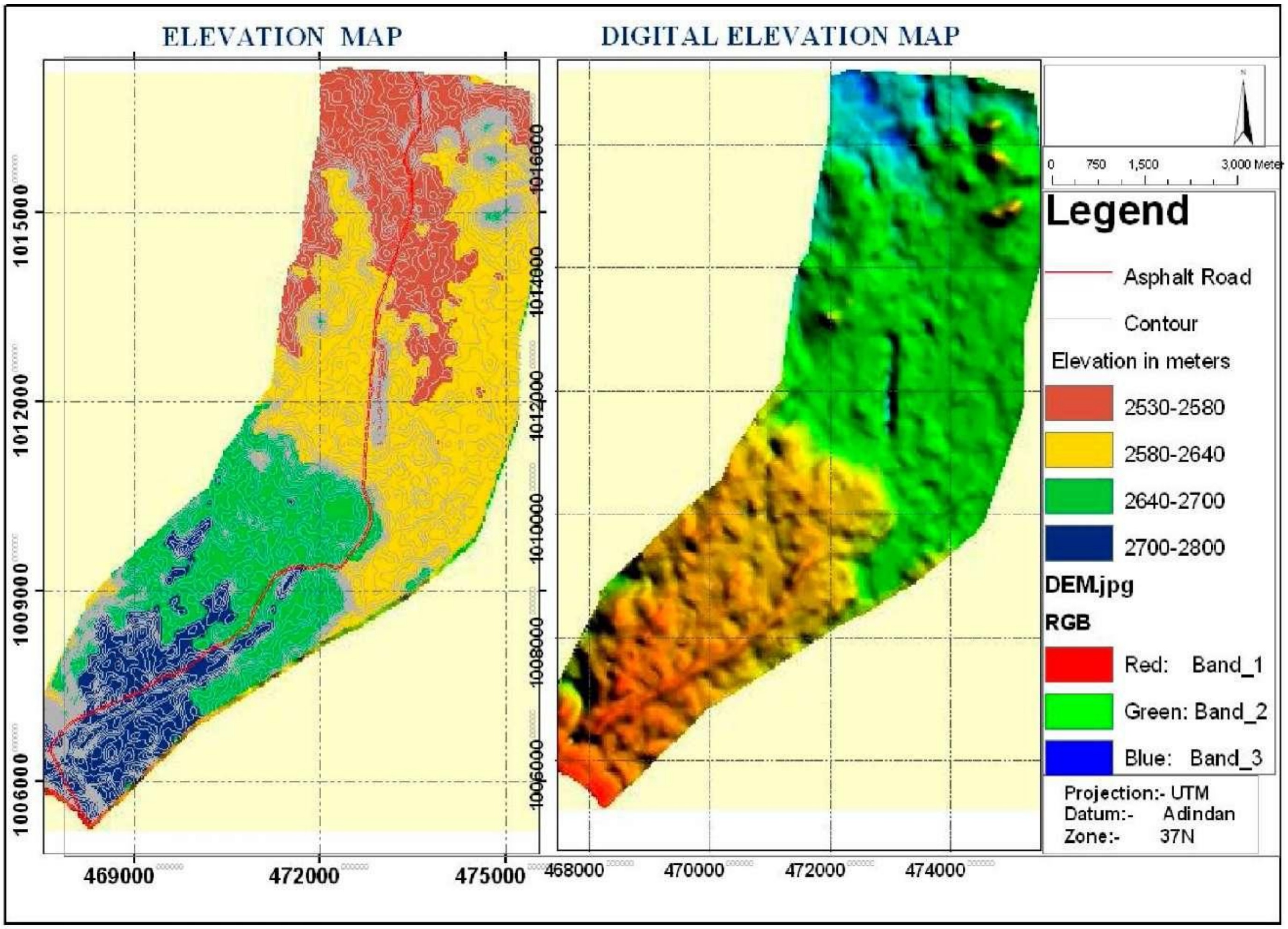


Figure 3.1 Elevation and Digital elevation model map (source: Developed by researcher)

Based on the above figure 3.1, the elevation range between 2580m to 2640m is the dominant class in the study area which accounts for about 39.6%. The range of altitude that found in the category of 2640m to 2700m is the second larger class followed by ranges of 2530m to 2580m and 2700m to 2800m which accounts about 21.28% and 14.85% respectively. Generally, the dominant elevation range in the study areas is the range of 2580m-2640m where the existing settlement of the town lies.

3.1.2.2. Slope

In the study area the slope is also another topographical aspect that influences the land use planning and management. The steepest slope in the area is situated in the elevation range of 2640m to 2800m almost around the southern ridge of Entoto and north-eastern fringes. By implication high run off and lateral erosion is high in these areas compared to the gentle slope locations. The gentle slope lies mostly in the central part of the study area within 2580m to 2700m altitude where the existing built up area lies. The flat area of the Town is found in the altitude of less than 2580m in the east and north-west of the study area. This area is one of the likely water logging area during the rainy season and potential grazing land in dry season.

3.1.3 Geology and Soil

3.1.3.1 Geology

The geological setting of the study area is generally classified in to two major groups; namely, Tertiary Volcanic (Plateau Basalts) and Quaternary units (Rift Volcanic and Sediments). The classification is based on age of eruptions, special distribution, and mode of occurrence .Tertiary Plateau Basalts are part of the Trap-Series volcanic products consisting huge accumulation of basaltic rocks with minor silica intercalations, whereas the Quaternary Rift Volcanic and sediments comprise variety of rock units (both acidic and basic) associated to the formation of the Main Rift System during the Quaternary Period. However, each of them has subdivisions; whereby Tertiary Volcanic (Plateau Basalts) consists of Aiba Basalt, Alaji Basalt and Chancho Basalt on the other hand Quaternary units (Rift Volcanic and Sediments) comprises Adama Group and Entoto Silicics **(**Merga, 2012).

3.1.3.2 Soil

Soils are the world's natural resource and a soil map is a spatial representation of these resources. Therefore, soil map is fundamental and should be the starting point when planning every type of land use. In the study area there are four major types of soil which are stated below. Cambisols are soils with initial stage of soil formation or weakly developed soils relating to their parent material. Beginning transformation of soil material is evident from weak, mostly brownish discoloration and/or structure formation below the surface horizon. The cambisol in the study area is found distributive in limited places. The soil texture is loamy to clay and identified on undulating to rolling plateaus in the study area with stony phase and limited in depth. Leptosols are soils with an incomplete solum and/or without clearly expressed morphological features. They are particularly common in hilly to mountainous area of the southern fringe of the study area and it covers a small proportion of the area. Luvisols are soils whose dominant characteristic is a marked textural differentiation within the soil profile, with the surface horizon being depleted of clay and with accumulation of clay in a subsurface. Normally, it is not present as individual particles but is clustered to aggregates that consist wholly of clay or of a mixture of clay and other mineral and/or organic soil material. Luvisols have typically a brown to dark brown surface horizon over a reddish brown to strong brown. As you can observe from the map the large proportion of the study area is occupied by this type of soil particularly the central part of the Town where the existing built up area is lied. Vertisols are soils having, after the upper 20 cm have been mixed, 30 percent or clay in all horizons to a depth of at least 50 cm. In the study area vertisols are found almost to the southeastern direction associated with Luvisol and Leptosol **(**Merga; 2012)

3.1.4. Climate

Climate influences the physical and cultural environments, the types of vegetation and crops to be grown, the land use patterns and ultimately the economy. Therefore, in the land use planning and implementation evaluation, climatic variables should be considered as an analytic land qualities/ or land characteristics. Globally the climatic condition of the project area is part of the tropical humid climatic region, which is locally classified as dega agro-climatic zone. The area receives a minimum rainfall of 780mm and maximum of 1390mm in the year 1996-1999 E.C, on the average the area receive the annual rainfall of 1085mm (from Sululta satellite station). On the other hand, the maximum temperature is 16^{o}c and the minimum is 11^{o}c. Thus, the area experienced the average temperature of between 13 ^{o}c - 14^{o}c. This is distinguished by cool sub-humid and high rain fall. It also characterized by its alternating wet and dry season, that determined largely by the annual movements. The one which is across the country of equatorial low pressure zones were caused by the convergence of the dry north-easterly winds and with moist winds of the south- easterly or south westerly origin. In the study area, from October to February when the Northeasterly winds persist long period, the dry weather are experienced. Between February and the ends of April the weather become more unsettled and a convergence of moist southeasterly air stream causes light rains-commonly referred to the

"Belge Rains". The dominant rain fall is occurring between June to September when moist winds from the Atlantic and Indian oceans converge over the Ethiopian high lands. Thus, rainfall intensity is high during this period and runoff and erosion would be very high, unless different soil and water conservation structure are implemented. It is obvious that temperature decreases as one move from lower altitude to higher altitude. In the study area, as Entoto is found at higher elevation (above 2700m above sea level (asl) and the center of the town is located relatively at lower altitude (about 2580m msl) so the maximum temperature records are lower for Entoto area and higher for the area near to the center of Sululta town (Sululta Municipality office; 2016).

3.1.5 Drainage System

A drainage system describes the way of streams that feed other larger streams and rivers branch off in different directions. Thus, major drainage pattern in the study area can be described as streams and rivers, in which the Streams tend to from about 3 major rivers in the area. These are Dima, Orgogo and Billo rivers, as most areas of the town is flat and the rivers transient through it are narrow in width and shallow in depth, they get over flooded. In addition, they also filled with wastes discharged in to it by different units. These in turn aggravated the river pollution and unpleasant odor that prohibited the dwellers to get the benefits that the resource gives. There are also seasonal wetlands that are situated mostly in the East and northwest of the Abyssinia water factory in the town. The wetland contributes a lot of environmental benefits like run off reduction, ground water recharge, waste water purification, and home for a variety of birds' life. However, these benefits are not considered by the town administration and local dweller thus the current condition of the resource do not seem to be under consideration. In general, the streams, rivers and wetlands have economical, social and environmental benefits for societies. By creating artificial lakes, streams and fountains for recreation, storage of water for fishing, and for planting, 40 particularly in the study town it is largely used for domestic purposes like drinking, cooking and washing in addition with construction purposes**(**Sululta Municipality office; 2016).

3.2. Data Sources, Materials and Methods of the Study

3.2.1. Data Sources

Because of the nature of the problem to be investigated, diverse sources of data are used for this study. Reliable data is necessary to realize the designed objectives and hence the study is based on both the primary and secondary data.

A) Primary Data

In the first place, primary source of data important for the investigation of both the land use/cover changes in time series due to urban expansion and suitability analysis taking place in Sululta town, which includes the four kebeles . For this purpose satellite image of 1986, 2001 and 2016 used. Latest Google Earth imageries are used due to the study area has small area and possible to digitizing and TM Landsat of the study area hadn't high resolution image . Elders are interviewed as a form of Focus Group Discussion (FGD), field observations using to generate primary information regarding the ground truth. Because Elders know Land use classification for the general urban development trends due to they know the trend more than everyone specially land cover types that accommodate before transform to the present.

B) Secondary Data

Secondary data sources have abundantly been used for the study. Books, journals and articles, internet resources are widely been utilized. Literature and policy review and archival analysis will be also conducted in the form of desk research. Secondary data was collected from the official documents of the sululta Town administration and Oromyia housing and urban planning offices on information pertaining to land-use plans, development plans and general profile of the Town proper and the surrounding fringe settlements. Qualitative and quantitative data sources are triangulated in order to confirm information gap of one by the other.

3.2.2. Sampling Techniques and Sample Size

In the context of this study, the sululta town is located incorporating four kebeles. From four kebeles and 12 zonal kebeles' villages whose boundary is clearly known for detail investigation of the issue under discussion.

One of the criteria used is the degree of land use conversion and other transformations taking place due to expansion of settlement and other urban activities. Particular emphasis is given to rapidly urbanizing villages or sub-towns in the town administration, which are located adjacent the town boundary of sululta with the anticipation that such villages are highly affected by the urban development activities in which it identified by field observation.

Based on the observation four existing kebeles namely, Sululta 01, kaso wasarbie, Nono mana Abichu, and wale Lube are considered for the current study as case study areas and Very high and rapid development is observed in first three kebeles respectively and Wale Lube is considered fringe areas of the town until this research conducted. The kebeles (or villages) considered are located in different directions of sululta town is important to compare the degree of city expansion to these areas.

My target population among which interviews were interviewed are elders in the urban fringe and families who have resided in the former rural areas before the encroachment of the town and are now classified as part of the town's of the sululta administrative area.

Concerning the land use/cover change, it is very difficult to get well registered and organized types and amounts of land cover/use changes and transformation in the study area. But the researcher approached such problem using GIS and RS integrated techniques and tools to know amount of area transformed from one land class types to others due to urban expansion. Therefore, the investigator contacted purposefully 18 elders of the four kebeles (6 elders form one Focal Group) and cross-check analysis of land use transformation and satellite image interpretation implemented.

3.2.3. Methods of Analysis of Urban Change Data

As it is described in the above section this research benefited from combination of data from different sources. Likewise, different data analysis methods and tools are employed in this study. Therefore, as the nature of investigation involves both quantitative and qualitative data, methodologically combination of techniques is chosen both for the collection and analysis of data.

Analysis of spatial data was accomplished through integrated use of ERDAS IMAGE and ArcGIS software packages along with, excel and Microsoft office tools used. For analysis of qualitative data gathered through interview in the form of focus group discussion (FGD) themes were drawn from the responses and analysis was done accordingly.

In order to catch important information that might be squandered either during field survey and document analysis and/or in order to validate the information that will be one-sided(biased), triangulation method is used between both the quantitative and qualitative source of information.

A) Details of the Task

In order to produce virtuous maps that show land cover change explicitly as well as select suitable site for residential housing and analysis the result, the following activities are executed.
For detecting urban change such like activities were sequentially executed. The first activities was acquiring data of study area and applying different correction techniques on the images. After correction of data executed classifying the images using supervised classification and manual digitization techniques and conducted Post classification method to obtain a reliable classified image .After that Compare and contrast the of final output had been conducted and identified class transformation change detection analysis and distinguished suitable site of housing.

The Classification process

First of all, high resolution image downloaded from Google Earth and geo referenced the image. Next clip the image with the study area boundary and conducted manual digitization techniques for classifying the image. This techniques is reliable because the features are clearly identifiable. The image is classified and to make some correction before accuracy assessment, a post classification editing techniques applied to resolve some minor geometric errors. The vector classified image converted to raster format and in ERDAS Imagine 2014 software were generated and these points converted to Google Earth format(.kml), displayed on Google Earth and their representation taken and performed the accuracy assessment.

3.2.4. Methods of Suitability Analysis of Housing Site

3.2.4.1. Site Selection Criteria's

The development of urban Residential land use is influenced by numerous factors. These include physical, socio-economic and environmental quality and amenities. The first step that was taken in this analysis was to collect all of the data that would be needed to meet all of the criteria. Criteria were selected to evaluate potential housing sites and to support decisions concerning the location of additional housing areas. The criteria must be identified and include factors and constraints. The criteria were selected on the light of literature and planning guidelines (structural master plan) of sululta Town and in the other countries' research experiences. These factors include: land use, soil types, Geological structure, population density, slope, road and river.

3.2.4.2. Site Selection Process

Site selection requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use. The selection of housing sites involves a complex array of critical factors drawing from physical, demographical, economic, and environmental disciplines. The current spatial decision making could benefit from more systematic methods for handling multi criteria problems while considering the physical suitability conditions. Traditional decision support techniques lack the ability to simultaneously take into account these aspects. The process of housing site selection begins with the recognition of an existing or projected need. This recognition triggers a series of actions that starts with the identification of geographic areas of interest. In the past, site selection was based almost purely on economical and technical criteria. Today, a higher degree of sophistication is expected. Selection criteria must also satisfy a number of physical, social and environmental requirements, which are enforced by legislations and government regulations (SIOR and NAIOP, 1990).

3.2.4.3. Site Selection Tools

For the last three decades, geographic information systems (GIS), and Multi criteria decision making (MCDM) techniques have been used in solving site selection problems. A brief description of the strength and weakness of each tool with regard to sitting problems is provided below.

A) Multi Criteria Decision Making (MCDM)

The techniques adopted in the various approaches of decision analysis are called multicriteria decision methods (MCDM). These methods incorporate explicit statements of Preferences of decision-makers. Such preferences are represented by various quantities, weighting scheme, constraints, goal, utilities, and other parameters. They analyze and support decision through formal analysis of alternative options, their attribute, evaluation criteria, goals or objectives, and constraints. MCDM used to solve various site selection problems (Badri 1999, Korpela and Tuominen 1996). However, they assume homogeneity within the study area, which is unrealistic for site selection problems (Malczewski 1999).

The choice of the MCDA method is very important since it has a significant effect on the final outcome. MCDA characteristics and properties should be compatible with the specific nature of the decision problem (Laaribi et al. 1996, Salminen et al. 1998). For example ,some MCDA techniques efficiently handle a continuous set of alternatives and criteria belonging to the same domain (e.g. economic). Other MCDA methods can only consider a small set of discrete alternatives but are more efficient to handle heterogeneous criteria(Florent et al. 2001).

If there is a conflict between the various Authors, they can negotiate the subjective parameters, like the weights associated with each criterion before adopting a common set of values. It is also possible to repeat the MCDA process and thus select, for each different group of stakeholders, a solution that is adapted to its specific needs. MCDA results can be mapped in order to display the spatial extent of the best areas or index of land suitability.

The negotiating parties can then discuss and compare the results by overlaying these maps, which are in fact geographical representations of their own set of preferences.

Details of the task

Data requirement and description: means definition of site selection criteria. Determination of evaluation factors: means preparing criterion maps Reclassifying Land use map: reclassifying each factors, Data preparation model: formulation of geographical spatial modeling. Weighting for multi criteria analysis :to minimize adverse effect.

- *Analytical Hierarchy process*: is a theory of measurement through pair wise comparisons and relies on the judgments of experts to derive priority scales(Saty T.L., 2008). According to satty(2008),to make comparisons, we need a scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared.
- *Personal judgment*: There are no clear standards which specify the relative weight of factors in the Ethiopia context when selecting sites for residence. Therefore, form different literature review and personal experience the relative weight of factors were assigned.

Weighted Overlay Analysis

The factors (LULC, Road, river, Geology, soil, slope and population density) were reclassified according to their suitability rank. A consistence weight for each factor were generated using AHP technique and used in the weight overlay analysis to obtain suitable areas.

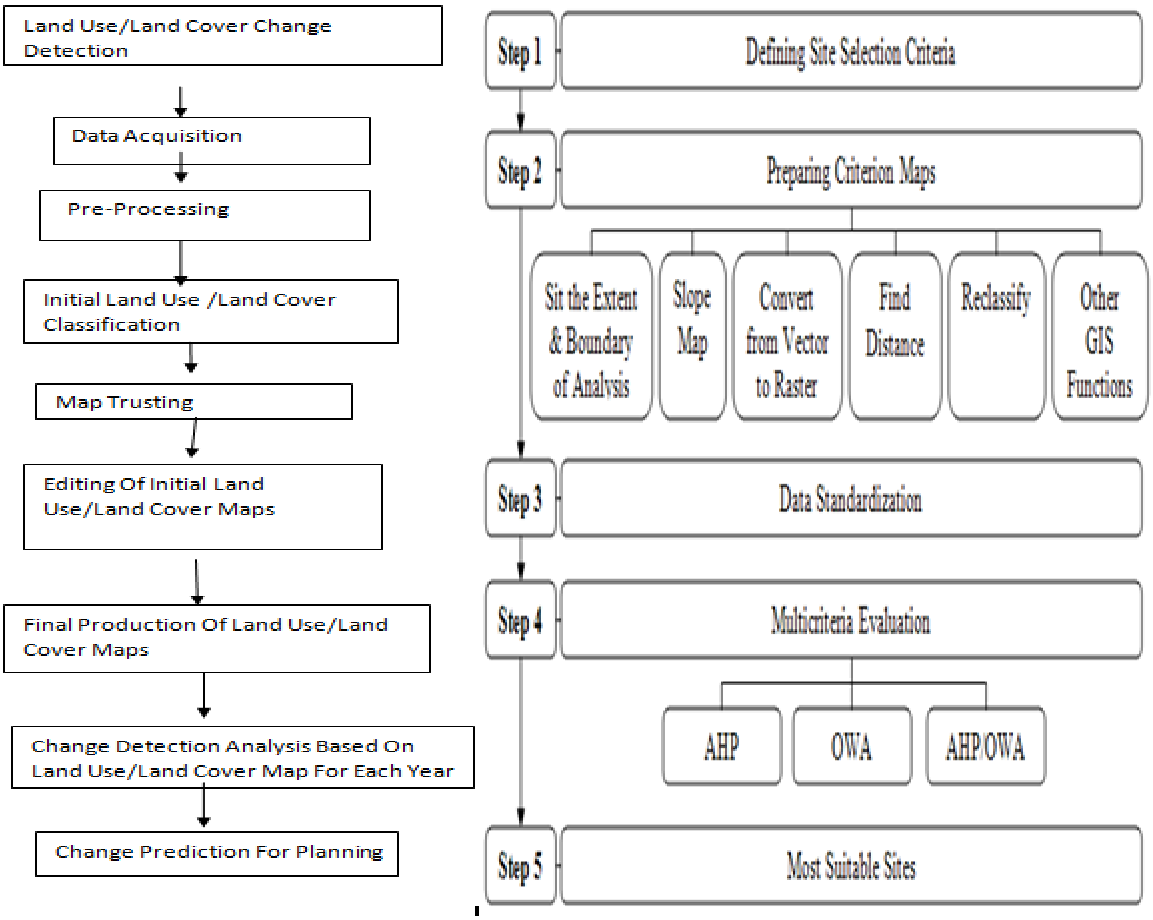


Fig 3.2. Cartographic Model
Source: National research council (2003)

3.2.5 Image Acquiring and Classification

3.2.5.1. Acquiring Image

The raw images were obtained from Global Land Cover Facility -GLCF (http://www.landcover.gov) and Earth Explorer (http://earthexplorer.usgs.gov) for free. However, the images used for LULC analysis was downloaded from Google Earth because of to get reliable data that has high resolution. Prior to the usage of the images, geo-referencing techniques had been applied to get an image overlay to study area.

3.2.5.2. Types of Software used

- ✓ ArcGIS software
- ✓ ERDAS IMAGE 2014 software
- ✓ Micro soft word

3.2.5.3. Supervised Classification

A person supervises the classifier by first identifying small sample areas of the desired land cover classes. The classifier then compares each sample to the training classes and allocates the sample to the most similar class. Supervised classification can be used to cluster pixels in a data set into classes corresponding to user-defined training classes. This classification type requires that researcher select training areas for use as the basis for classification. Various comparison methods are then used to determine if a specific pixels qualifies as a class member.

In order to identify the class features of the images, due to the visibility of the image and the study area is small, manual digitization techniques has been applied.

3.2.5.4. Post Classification

A) Accuracy Assessment

In thematic mapping from remotely sensed data, the term accuracy is used typically to express the degree of 'correctness' of a map or classification. A thematic map derived with a classification may be considered accurate if it provides an unbiased representation of the land cover of the region it portray (Foody, 2002: pp 186). Therefore, it is used to assess and/or measure how many ground truth geo-spatial classes were classified correctly. There are different steps conducting the accuracy assessment of post – classification comparison change detection. The basic steps include: Determine the total number of samples to be collected for each category; Design an appropriate sampling scheme (traditional or geo statistical); Obtain ground reference information at sample locations; Produce error matrix; and Evaluate the error matrices.

B) Confusion Error Matrix/ Classification Error Matrix

Literatures indicate that there are many methods of accuracy assessment in the remote sensing data classification accuracy assessment. The most widely promoted and used, should be derived from a confusion or error matrix (Foody, 2002). Furthermore, the confusion matrix is currently at the core of the accuracy assessment literature. As a simple cross-tabulation of the mapped class label against that observed in the ground or reference data for a sample of cases at specified locations, it provides an obvious foundation for accuracy assessment (Foody, 2002).

Confusion error matrixes used to compare the relationship between known reference data (ground truth) and the corresponding results of the classification. There are different measures of classification accuracy assessment of confusion matrix. According to Foody, one of the most popular is the percentage of cases correctly allocated. This is an easily interpretable guide to the overall accuracy of the classification. If attention focuses on the accuracy of individual classes, then the percentage of cases correctly allocated may be derived from the confusion matrix by relating the number of cases correctly allocated to the class to the total number of cases of that class. The most widely used methods of measuring include; overall accuracy, user accuracy and producer accuracy.

Overall Accuracy: The overall accuracy is calculated by summing the number of pixels classified correctly and dividing by the total number of pixels. The ground truth image or ground truth training area defines the true class of the pixels. The pixels classified correctly are found along the diagonal of the confusion matrix table which lists the number of pixels that were classified into the correct ground truth class. The total number of pixels is the sum of all the pixels in all the ground truth classes.

Producer accuracy: The producer accuracy is a measure indicating the probability that the classifier has labeled an image pixel into sample area given that the ground truth of sample area

User accuracy: User accuracy is a measure indicating the probability that a pixel is Class of sample given that the classifier has labeled the pixel into sample class.

Kappa Coefficient/Statistic: Scholarly articles as cited in Foody (2002) indicates that, a major problem for some users in the above three measures of confusion error matrix, is that some cases may have been allocated to the correct class purely by chance. To accommodate for the effects of chance agreement, Cohen's kappa coefficient has often been used. According to Foody the kappa coefficient has many attractive features as an index of classification accuracy. Particularly, it makes some compensation for chance agreement and a variance term may be calculated for it enabling the statistical testing of the significance of the difference between two coefficients. In addition, it is a way to measure the actual agreement and a chance agreement between the reference data and the classified data.

The Kappa coefficient represents the proportion of agreement obtained after removing the proportion of agreement that could be expected to occur by chance (Foody, 2002). This would be expressed in terms of the percentage of strong, moderate and poor agreement i.e. a value >0.80 (80%) -- strong agreement; a value b/n 0.40 and 0.80 (40 to 80%) represents moderate agreement; and a value < 0.40 (40%) represents poor agreement.

The kappa coefficient (κ) is calculated by multiplying the total number of pixels in all the ground truth classes (*N*) by the sum of the confusion matrix diagonals (x_{kk}), subtracting the sum of the ground truth pixels in a class times the sum of the classified pixels in that class summed over all classes ($x_{k\Sigma}x_{\Sigma k}$), and dividing by the total number of pixels squared minus the sum of the ground truth pixels in that class times the sum of the classified pixels in that class summed over all classes.

$$\kappa = \frac{N\sum_k x_{kk} - \sum_k x_{k\Sigma}x_{\Sigma k}}{N^2 - \sum_k x_{k\Sigma}x_{\Sigma k}}$$

Or, $K = \left\{\frac{N * \text{observed accuracy} - \text{Chance Agreement}}{N2 - \text{Chance agreement}}\right\}$

3.3. Operational Definition

GIS: Geo spatial information technologies that has five components (hardware, software, computer, Data and people) used for managing, manipulation, storing and processing of data.

RS: sensing and interpreting different types of information without body contact.

Urban monitoring: managing urban lands by daily activities and follow up.

Suitability Analysis: is the process to determine whether the land resource is suitable for some specific uses and to determine the suitability level. In other word Land suitability analysis is the process of determining the fitness of a given tract of land for a defined use.

Residential housing: Shelter: means types of building, peoples used for living in. it is one of the types basic need for human being.

Urban Expansion: Is the way of urban growth patterns and processes. In other hand Urban is areas of high concentration of human activities at a particular location in which more than 2000 (to called urban in Ethiopian standard) dwellers live together and expansion is the process of enlargement of urban areas in different direction and magnitudes.

Independent variable: GIS and RS techniques and tools

Dependent variable: Urban Expansion, and suitability analysis for residential housing.

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter introduces the thirty years sululta town land use land cover change situation urban expansion and the same time discusses the feasibility of the residential land suitability assessment process in the study area. The first section of the chapter introduces detailed information about the expansion of urban area as well as transformation of land use while the second section describes the feasibility of the residential land suitability for further decision making for the town administrative Organs.

4.1. Analyses and Results of Change Detection from 1986-2016 of Sululta Town

Based on Collected data and Google earth image, polygons were drawn using Arc Map for each class of the 1986, 2001 and 2016.Polygons which represent the same class merge together as one class and totally five different classes were created namely cultivation, vegetation, settlement, bare land and Grassland. By applying Interactive supervised classification, three classified images were analyzed and change detection map produced. Then after images of 1986, 2001 and 2016 were acquired and processed amount of land cover were identified for each classification types in which each intended year was depicted in the Table 4.1 and fig 4.1.of the following.

Table 4.1. Land Use Land Cover Change

Land Use Land Cover Class	1986		2001		2016	
	Hectare	%	Hectare	%	Hectare	%
Settlement	193.33	4.32	210.28	4.70	1858.15	41.56
Vegetation	784.43	17.54	687.47	15.38	407.12	9.11
Bare Land	26.01	0.58	62.47	1.40	228.80	5.12
Cultivation	2474.16	55.34	2596.46	58.08	622.36	13.93
Grass Land	993.76	22.23	915.01	20.47	1354.17	30.30
Total area (ha)	4470.5		4470.5		4470.5	

Sululta Town has 4470.5 hectare (ha) area of coverage when it established in the form of urban reform in 1999 E.C as municipality town administration. This 4470.5 ha area coverage is formed after others surrounding rural kebeles are delineated with the town.

From table 4.1. In 1986 the highest area coverage of study area was cultivation land (2474.16 which is 55.34%) and the 2nd and 3rd large area coverage is grassland and vegetation which is 993.76ha (22.23%) and 784.43ha (17.54%) respectively. On the other hand settlement covered 193.33ha which is 4.32% and bare land covered only 26.01ha which is 0.58%. In 2001 the large area coverage were also cultivation which is 2596.46ha (58.08%) while grass land and vegetation covered 915.01ha(20.47%) and 687.47ha(15.38%) respectively. settlement and open land covered were 210.28ha(4.70%) and 62.47ha(1.40%) respectively. In 2016 settlement coverage was become leading coverage by amount of 1858.15ha (41.56%) and the second area coverage was grassland which is 1354.17ha (30.30%). In this year cultivation land become decrease and decrease which is 622.36ha(13.93%) and the same time vegetation also by decreasing become to 407.12ha (9.11%) while bare land become to increase and increase throughout time series of the study and in 2016 covered 228.80ha (5.12%).

In general, settlement and bare land have increased and while land under vegetation has decreased progressively. Cultivation land increased between 1986-2001 while grassland decreased in between these years. On the other hand, Cultivation land decreased in between 2001 -20016 rapidly while grass land increased in between these years.

4.1.1. Coverage of Area Expansion (1986 - 2016)

As the result of images of 1986, 2001, and 2016 analysis indicated, different land cover land use formed in between 1986- 2016 years. These results were shows a change of LCLU in thirty years of the study area. Rates of changes and expansion of LCLU classes depicted in table 4.2 in below.

Table 4.2. Coverage of area expansion 1986 - 2016

Land use land cover change (ha)				Land use land cover rate of change (ha)		
Land use land cover class	1986 to 2001	2001 to 2016	1986 to 2016	15 years 1986 to 2001	15 years 2001 to 2016	30 years 1986 to 2016
Settlement	+16.95	+1647.87	+1664.82	+1.13	+109.86	+55.49
Vegetation	-96.96	-280.35	-377.31	-6.46	-18.69	-12.58
Bare Land	+36.46	+166.33	+202.79	+2.43	+11.09	+6.76
Cultivation	+122.3	-1974.1	-1851.8	+8.15	+131.6	-61.73
Grass Land	-78.75	+439.16	+360.41	-5.25	+29.28	+12.01

Settlement increased by 16.95 ha and indicates rise growth rate of 1.13ha in between 1986-2001 while in between 2001 - 2016 increased rapidly by 1647.87ha and indicates also increased growth rate of 109.86ha. As whole settlement indicates the highest coverage of urban expansion in the study area. For example between 1986-2016 the overall increased land LULC of settlement was 1664.82ha and 55.49ha growth rate.

Vegetation decreased by 96.96 ha and indicates decline growth rate of 6.46ha in between 1986-2001 while in between 2001 - 2016 also decreased rapidly by 280.35ha and indicates also decreased growth rate of 18.69ha. In general vegetation indicates the highest rate of degradation due to expansion of urban land and agriculture. The deteriorated area coverage of vegetation were in between 1986-2016 was 377.31ha and 12.58ha decline growth rate.

Bare land increased by 36.46ha and indicates rise growth rate of 2.43ha in between 1986-2001 while in between 2001 - 2016 increased rapidly by 166.33ha and indicates also increased growth rate of 11.09ha. As whole Bare land indicates urban expansion in the study area. For example between 1986-2016 the overall increased LULC of Bare land was 202.79ha and 6.76ha growth rate.

Cultivation land increased by 122.3ha and indicates rise growth rate of 8.15ha in between 1986-2001 while in between 2001 - 2016 indicates decreased land use cultivation by 1974.1ha and indicates increased growth rate of 131.6ha. In general cultivation land indicates the highest rate of degradation due to expansion of urban land and settlement. The deteriorated area coverage of cultivation were in between 1986-2016 was decreased by 1851.8ha and 61.73ha decline growth rate.

Grass land decreased by 78.75ha and indicates negative growth rate of 5.25ha in between 1986-2001 while in between 2001 - 2016 indicates increased land cover ofgrass land by 439.16ha and indicates increased growth rate of 29.28ha. In general Grass land indicates the high rate of increasing in area coverage in between 1986-2016 by 360.41ha and 12.01ha increased growth rate.

In general as the change detection analysis results revealed, this observed consistent expansion was attributed to the conversion of vegetation and cultivation land into settlement and open land lands at different stages. On the other, grass land indicate fluctuated change in different time of study. For example in between 1986 and 2001grassland decreased while in between 2001-2016 and in 1986-2016 increased. This was due to conversion of land form from vegetation and cultivation land to grassland and may be shifting cultivation system has been implemented in the study area.

4.1.2. Land use land Cover Change Matrix

Change detection analysis can also be done simultaneously for all existed class's. Means that there are two method of Change detection analysis. The first one is in which each class was individually analyzed and only identified the number of changed or unchanged class. However, this method exhibits both the number of changed classes and to whose class those classes were assigned. The second one is the pivoted matrix table indicates the total number of pixels/classes which changed to other classes or remains unchanged and also quantify to whose classes those changed pixels/classes were assigned. Although the number of changed pixels/classes are slightly higher in method one, generally both methods give approximately similar results. However, the method 2 capability of indicating where the changed pixels/classes are assigned makes it effective as compared to method one for the analysis of this project.

In order to perform the analysis, three classified images are required. First the three classified study area images were added into Arc Map. Then, combination of the images was performed using combine tool and finally the following output Data was produced.

A) Change Matrix of 1986 and 2001

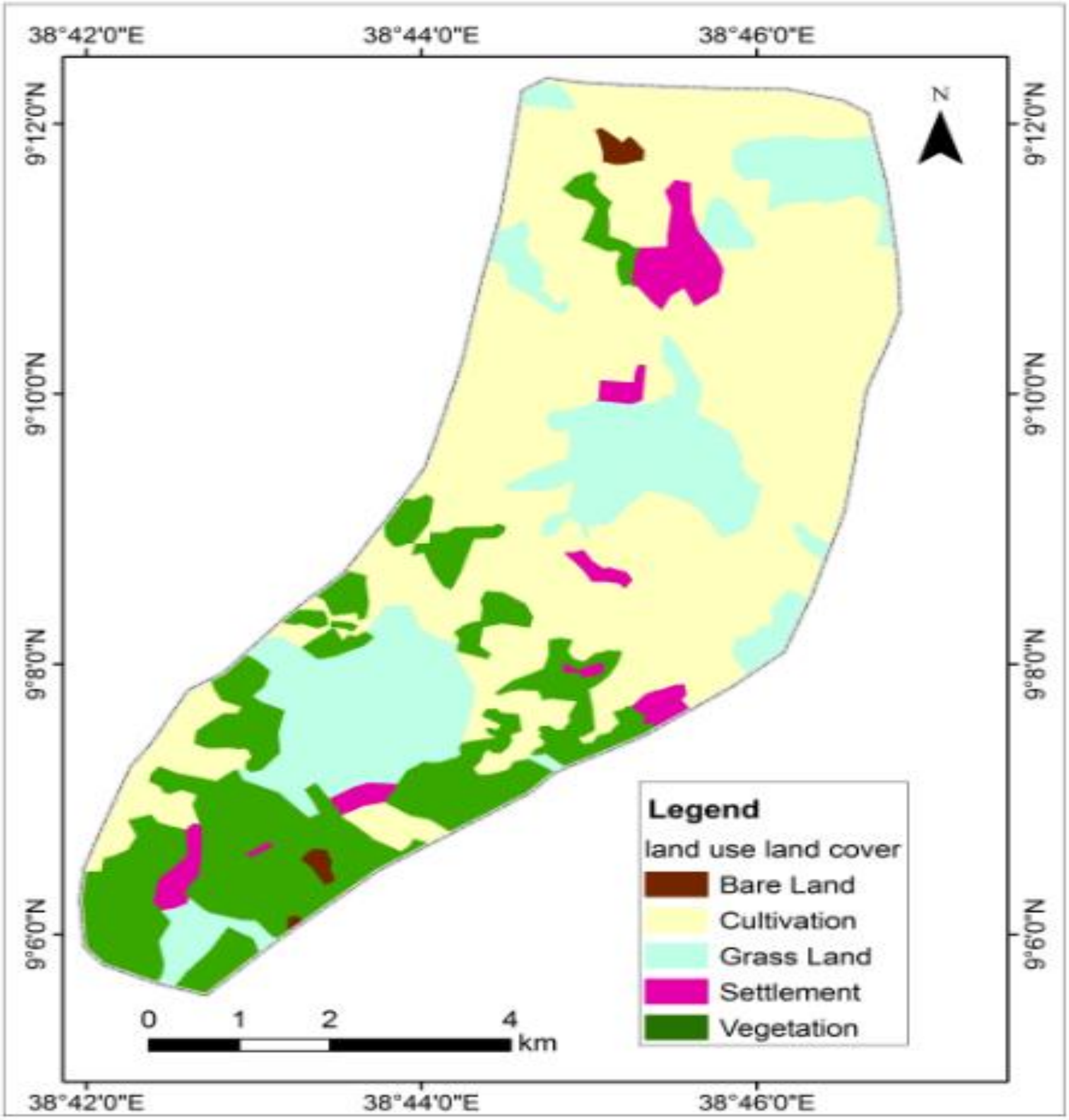
Table 4.3. change matrix of 1986 from/to 2001

1986 to 2001	Cultivation	Settlement	Bare Land	Grass Land	Vegetation	Total Sum in Ha
Cultivation	2087.43	54.25	2.44	264.19	65.85	2474.16
Settlement	40.63	122.31	6.59	14.07	8.54	192.14
Bare Land	10.49	0.00	7.26	5.36	2.90	26.01
Grass Land	370.29	14.07	8.26	562.19	38.96	993.76
Vegetation	87.63	19.65	37.92	69.21	570.02	784.43
Total Sum in Ha	2596.47	210.28	62.47	915.02	686.27	4470.50

As it depicted in table 4.3 in between 1986 and 2001 cultivatation land that converted to others classes are listed. In such cultivation land that changed to settlements, Bare land, Grassland and Vegetation were 54.25ha , 2.44ha, 264.19ha and 65.85ha respectively. In the same time Bare land 2.44 ha, Grassland 14.07ha and vegetation count 8.85 ha cosidernded in settlement classification. On the other hand bareland converted in to grassland 5.36 ha and vegetation 2.90 ha . This is due to Urban greeny economy program and watershade management and soil conservation developmental program of federal and regional state implimented in GTP one and two. Grassland converted in to bareland, settlement and cultivation were 5.36ha, 14.07ha, and 264.19ha respectively. Vegetation land cover class converted in to Grassland, Bareland, settlement and cultivation 38.96ha, 2.90ha, 8.54 ha and 65.85ha respectively.

As it is seen from the Fig. 4.1 of the following map, most of the study area in between 1986 and 2001 was covered by cultivation and vegetation classes respectively. Grassland account the 3rd rank of area coverage while settlement ranked at 4th and bare land accounted a few area coverage. On the other hand, sululta 01, and Nono Mana Abichu kebeles were largely covered by cultivation (1st one), Grassland (2nd), settlements (3rd) and a few amount of Bare land existed while Kaso wasarbie and Wale Lube large part of area coverage were covered by vegetation (1st), Grassland (2nd), cultivation (3rd), small amount of settlement (4th) and a few amount of Bare land coverage.

Fig.4.1. Change Detection map of 1986 -2001



Sources: Developed by researcher

Table 4.4. change matrix of 2001 from/to 2016

2001 to 2016	Cultivation	Settlement	Bare Land	Grass Land	Vegetation	Total sum in Ha
Cultivation	486.50	1049.35	100.22	885.61	74.79	2596.47
Settlement	7.22	188.32	3.46	7.70	3.57	210.28
Bare Land	4.91	41.08	1.56	0.25	14.66	62.47
Grass Land	74.68	316.70	30.25	452.34	41.04	915.01
Vegetation	49.05	262.60	93.30	8.27	273.05	686.27
Total Sum in Ha	622.36	1858.05	228.80	1354.17	407.12	4470.50

As it depicted in table 4.5 in between 2001 and 2016 cultivatation land that converted to others classes are listed. In such cultivation land that changed to settlements, Bare land, Grassland and Vegetation were 1049.35ha, 100.22ha, 88.61ha and 74.79ha respectively. In the same time and Grassland 0.25 ha , and vegetation count 14.66 ha cosidernded in settlement classification. On the other hand bareland converted in to grassland 13.51 ha and vegetation 1.45 ha . This is due to Urban greeny economy program and watershade management and soil conservation developmental program of federal and regional state implimented in GTP one and two. Grassland converted in to vegetation cover was bareland, settlement and cultivation were 0.25ha, 7.70ha, and 885.61ha respectively. Vegetation land cover class converted in to Grassland, Bareland, settlement and cultivation 24.12 ha, 1.45ha, 6.81ha and 72.78ha respectively.

B) Change Detection Map 1986 - 2001

As it is seen from the map most of the study area in between 2001 and 2016 was covered by cultivation and grassland classes respectively. Vegetation account the 3rd rank of area coverage while settlement ranked at 4th and bare land accounted a least and last area coverage.

On the other hand, cultivation land cover class covered in four kebeles of study area. However it largely covered in sululta 01, Nono Mana Abichu and Wale lube kebeles and it accounts more than half percent of the study area. Grassland the second large coverage class was covered largely in sululta 01, Nono Mana Abichu and Kaso Wasarbie kebeles and a few amount in Wale Lube. Kaso wasarbie kebele was largely covered by vegetation and Wale Lube and Nono Mana Abichu were medium covered. Settlement class was hold 4th area coverage and sparsely distributed edge side of Addis to Bahir Dar asphalt in all kebeles but a medium dense in sululkta

01 and KasoWasarbie. A least one was coverage of Bare land in which it covered in Wale Lube and kasoWasarbie kebeles. These issues are depicted in the following Fig. 4.2

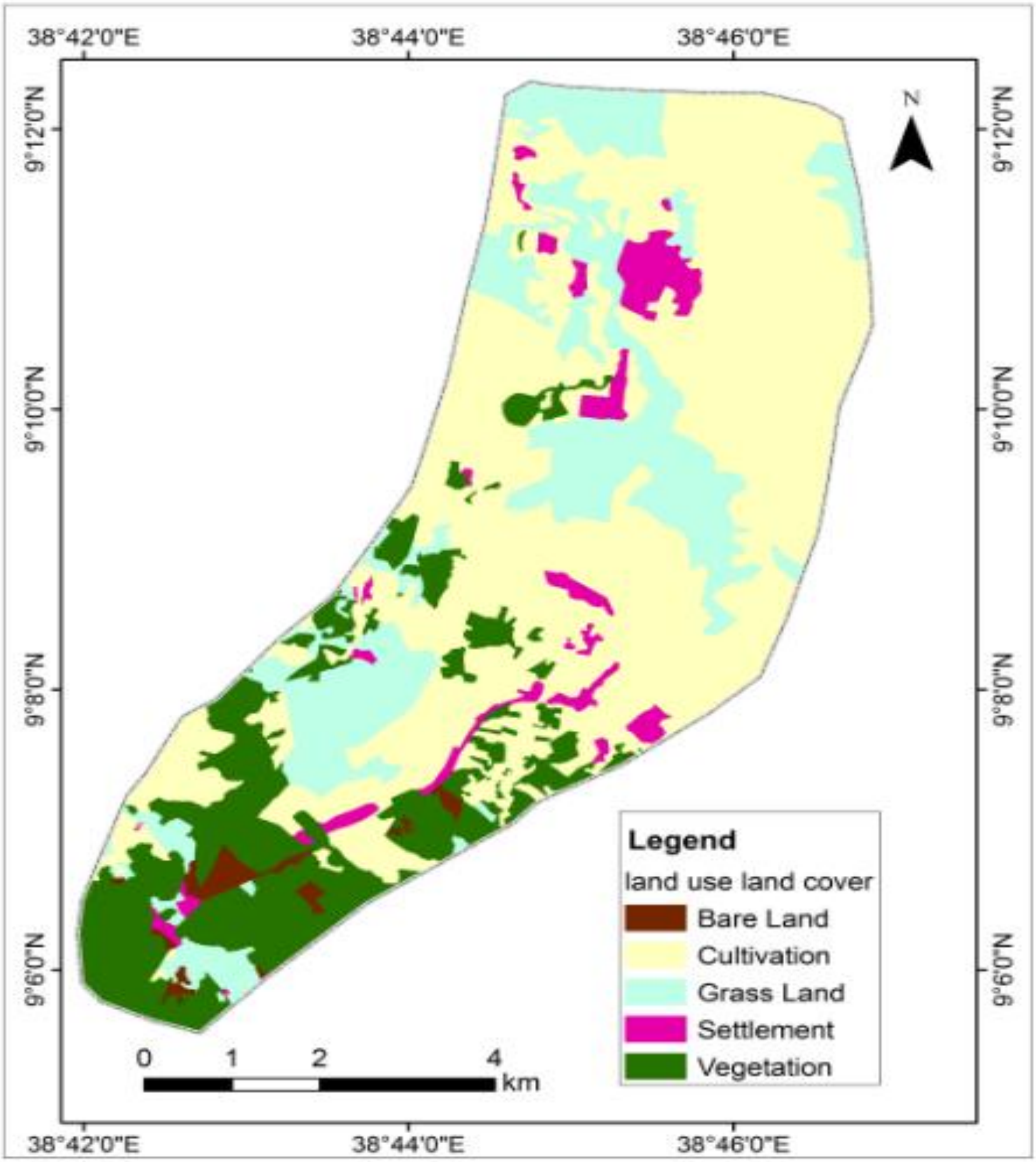


Figure 4.2 Change Detection Map 1986 - 2001

C) Change Matrix of 1986 and 2016 **Source: Own computed**

Table 4.5. change matrix of 1986 from/to 2016

1986 to 2016	Cultivation	Settlement	Bare Land	Grass Land	Vegetation	Total Sum in Ha
Cultivation	497.55	1013.40	107.15	783.28	72.78	2474.16
Settlement	1.14	179.51	2.34	2.34	6.81	192.14
Bare Land	0.00	8.74	2.31	13.51	1.45	26.01
Grass Land	62.29	358.68	12.39	536.28	24.12	993.76
Vegetation	61.38	297.73	104.60	18.75	301.97	784.43
Total Sum in Ha	622.36	1858.05	228.80	1354.17	407.13	4470.50

As it depicted in table 4.5 in between 1986 and 2016 cultivatation land that converted to others classes are listed. In such cultivation land that changed to settlements, Bare land, Grassland and Vegetation were 1013.40ha, 107.15ha, 783.28ha and 72.78ha respectively. In the same time Bare land and Grassland 2.34 ha , and vegetation count 72.78 ha cosiderndded in settlement classification. On the other hand bareland converted in to grassland 13.51 ha and vegetation 1.45 ha . This is due to Urban greeny economy program and watershade management and soil conservation developmental program of federal and regional state implimented in GTP one and two. Grassland converted in to bareland, settlement and cultivation were 13.51ha, 2.34ha, and 783.28 ha respectively. Vegetation land cover class converted in to Grassland, Bareland, settlement and cultivation 24.12 ha, 1.45ha, 6.81ha and 72.78ha respectively.

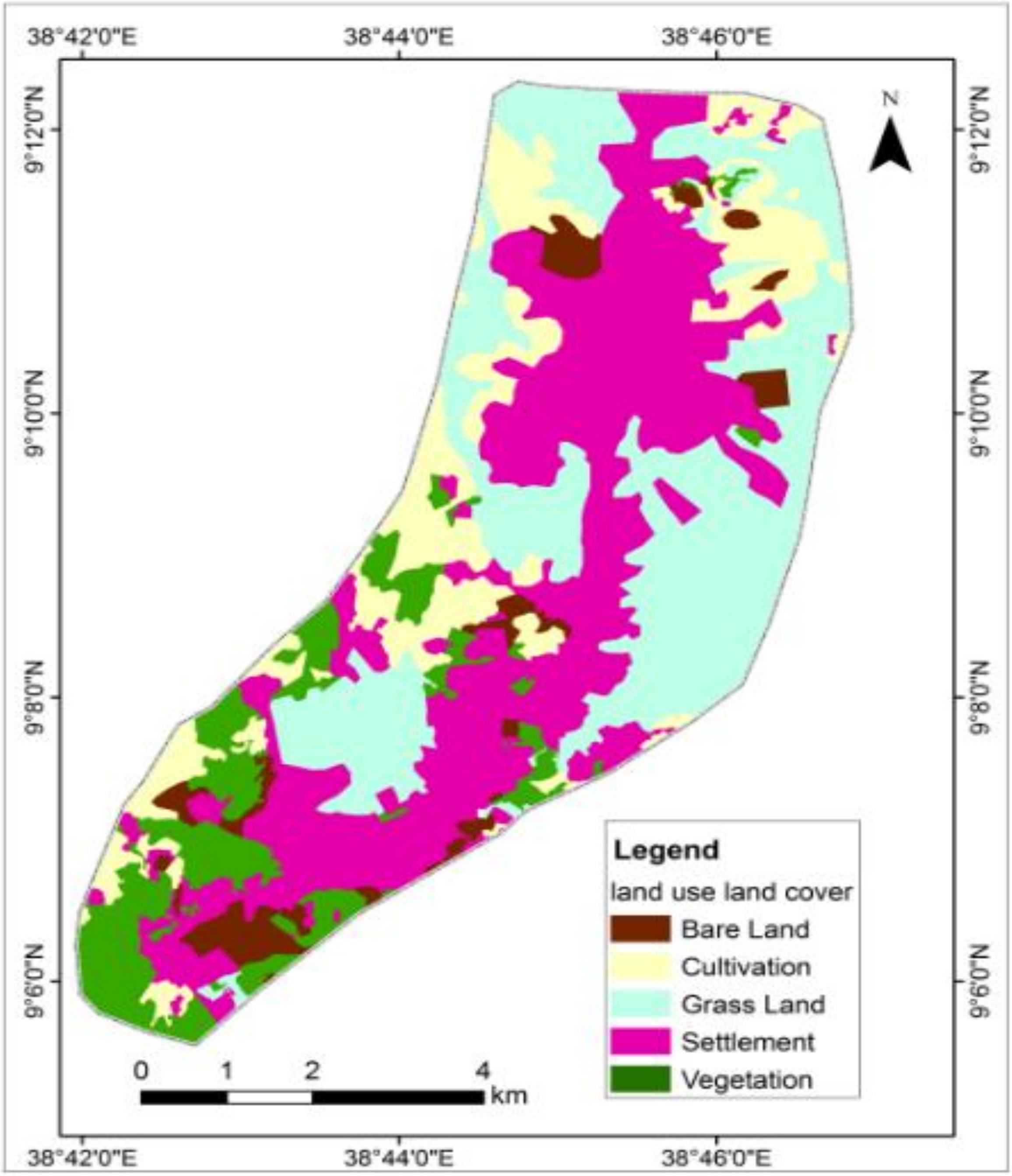


Fig. 4.3.Change Detection Map of Image 1986 - 2016 Source: Own Computed

In change Detection map that depicted in fig.4.3 settlement become dominated land cover class in all kebeles. In the same time cultivation and vegetation become detotriated and detotriated, then after they replaced by settlement and others classes. The other one is incresing Bare land class in all kebeles. This is due to an ineffective use of land use implimantation.

4.1.3 Classification Accuracy Assessment

Based on data collected from field and Google Earth map, which were not used for classification purpose, error matrix (confusion matrix) was produced. This matrix compares the relation between known reference data (ground truth) and the corresponding results of the classification.

Table 4.6 Confusion matrix of 1986

Ground truth	Data Referenced Data						
Class Name	**Settlement**	**Vegetation**	**Bare Land**	**Crop Land**	**Grass Land**	**Total**	**User Accuracy %**
Settlement	41	1	3	1	1	47	91.11
Vegetation	1	47	1	1	3	53	95.92
Bare Land	0	0	41	2	2	45	85.42
Crop Land	2	0	2	49	2	55	89.09
Grass Land	1	1	1	2	45	50	84.91
Total	45	49	48	55	53	250	
Producers Accuracy %	87.23	88.68	91.11	89.09	90		

Overall Accuracy **(%)**=89.2
Kappa Statistics = 0.8649

As shown in table 4.6, the confusion matrix of 1986 indicates that the overall accuracy assessment is very strong i.e. 89.2%, which is greater than requirement for strongly acceptable classification, i.e. 84% (Anderson, 1997,).The users and producer's accuracy assessment also calculated for each land classes and indicated acceptable agreement. The kappa hat value of 0.8649 indicates a better accuracy that the classification that was resulted from random sample classes classification. Since the kappa hat value fell above 80%, it represent strong agreement.

Table 4.7 Confusion matrix of 2001

Ground truth Data	**Referenced Data**						
Class Name	**Settlement**	**Vegetation**	**Bare Land**	**Crop Land**	**Grass Land**	**Total**	**User Accuracy%**
Settlement	47	1	0	3	1	52	92.16
Vegetation	3	43	0		1	47	95.56
Bare Land	0	0	53	4	1	58	98.15
Crop Land	1	1	1	37	3	43	82.22
Grass Land	0	0	0	1	49	50	89.09
Total	51	45	54	45	55	250	
Producers Accuracy (%)	90.38	91.49	91.38	92.5	92.45		

Overall Accuracy **(%)**= 91.6
Kappa Statistics = 0.8948

As it shown from table 4.7 the overall accuracy assessment of 2001 classification was very strong i.e. 89.6%, which is greater than requirement for strongly acceptable classification, i.e. 84% (Anderson, 1997,).The users and producer's accuracy assessment also calculated for each land classes and indicates strongly acceptable agreement. The kappa hat value of 0.8948 indicates a better accuracy classification that was resulted from random sampling.

Table 4.8 Confusion matrix of 2016

Ground truth	Data Referenced Data						
Class Name	Settlement	Vegetation	Bare Land	Crop Land	Grass Land	Total	User Accuracy %
Settlement	46	0	1	0	1	48	91.49
Vegetation	1	45	1	1	1	49	97.83
Bare Land	1	0	40	2	2	45	86.96
Crop Land	0	0	0	51	3	54	86.44
Grass Land	2	1	1	5	45	54	86.54
Total	50	46	43	59	52	250	
Producers Accuracy %	95.56	91.84	88.89	89.47	83.33		

Overall Accuracy **(%)**=89.6

Kappa Statistics = 0.8697

As it shown from table 4.8 above the overall accuracy assessment is very strongi.e.89.6%, which is greater than requirement for strongly acceptable classification, i.e. 84% (Anderson, 1997,).The users and producer’s accuracy assessment also calculated for each land classified types and indicates a better user’s accuracy and producer's accuracy.

The kappa hat value of 0.8697 indicates a better accuracy that the classification that was resulted from random sampling was assigned appropriately.

4.1.4. Factors of Rapid Expansion of Urban Land

To identify factors of urban expansion different data sources were analyzed. The result indicated that two major factors contributed for rapid expansion of sululta town. Those factors are Population Dynamics (rapid population growth and migration) and investment expansion. As researchers analyzed secondary and primary sources of data these two mentioned issues are the main factors for rapid expansion of study area.

4.1.4.1. Population Dynamics

Population dynamics refers to the numbers of births, deaths, immigrants, and emigrants over the specified time interval that determines the change in population size. As the country develops from primarily agricultural to industrial economy and urbanization is going on, large scale of migration from rural to urban takes place. The growth rate of urban areas is typically double the pace of overall population increase during this process. Sululta is the one where high rate of population growth is observed as a result of different pushing factors. Mainly better standard of living, job opportunity and poverty alleviation, despite the serious problems of overcrowding, sub-standard housing, crime and burden for the government to manage and fairly allocate the resource (Merga, 2012).

The national population and housing census conducted in 1994 puts the population of Sululta town as 1271. Whereas, the national population and housing census conducted in 2007 shows that the total population in the town as 12,452. This is less than the figure provided by OUPI in 2007 which is 14,000. From these two national censuses, it is possible to calculate the observed population by computing the growth rate of the town exponentially. Hence, Sululta town population is forecasted for the planning year with the consideration of the two Central statics Agency (CSA) base population data of 1994(1271) and 2007(12452). Thus, the growth rate from the two years population data were calculated and it could be 17%, from which the total population from 2012 to 2022 was projected by the researcher (See table 4.9 below).

Table 4.9 Population in age group

Age group	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>or=60
Male	62	74	90	92	84	38	33	37	19	19	13	13	27
Female	73	64	92	92	75	53	38	29	29	20	32	22	53
Total	135	138	182	184	159	91	71	66	48	39	45	35	78

According to CSA 1994 the population size of the town is 1271 of which (47.1%) male and (52. 9%) female. From the table above the number of population aged from 0-14 are children economically dependent population, those accounts about 455(35.8%) and those found in active work force age from 15-64 accounts about 773(60.9%). Whereas those that found above 65 ages constitute only 43(3.3%).

Table 4.10.Total summary population in 2006

Age categories	Names of sululta Town kebeles and their population														
	Sululta 01			N/M/Abbichu			Q/Wasarbie			W/Lube			Total		
	male	female	sum	male	female	sum	male	female	sum	male	female	sum	male	female	sum
0-14	1910	2089	3999	1454	1315	2769	1757	1836	3593	1025	1033	2058	6146	6273	12419
15-29	2072	2875	4947	1276	1907	3183	1841	1955	3796	814	854	1668	6003	7591	13594
30-64	1918	1535	3453	1110	1167	2277	1745	1596	3341	823	838	1661	5596	5136	10732
65+	165	148	313	152	158	310	197	175	372	135	113	248	649	594	1243
Total sum	6065	6647	12712	3992	4547	8539	5540	5562	11102	2797	2838	5635	18394	19594	37988

Sources: Sululta Town Administration Office: 2006 E.C

As it seen from table 4.8 in 2006 E.C the sululta town socio- economy profile indicated rapid population growth which is above merga's projection at 2020 reach 34,302. That means with six years lefting the size of population reached 37,988. Which means 3686 population come from others in the form of migration. In 2016 the population size increased and reached 55,841 which is male 27,039 (48.43%) and female 28,802 (51.58%) constitutes. All these are due to natural increase and migration. More over migration play vital role for the reason of urban expansion as a great factors.

Different scholars used a common formula to compute rate of population growth. Then researcher used it to compute rate of population growth as follows.

$$r = (\ln\{p2/p1\}/t) * 100$$

Whereas *r*_ rate of population growth

ln - natural logarithm

P2 final population size

p1 initial population size

t time difference between initial and final population size

Therefore, when the rate of growth of 1994-2007, 200-2016 and 1994-2016 computed the result should be look like the following.

$$r = (\ln\{p2/p1\}/t) * 100$$

Given pop. of 1994= 1271

pop. of 2007= 12,452

pop. of 2016 = 55,841

r = (in between 1994 &2007)={ ln(12452)/1271}13*100 = 17.55%

r = (in between 2007 &2016)={ ln(55841)/12452}9*100 = 16.67%

r = (in between 1994 &2016)={ ln(55841)/1271}22*100 = 17.19%

As it shown from above figure the growth rate of population of sululta town in between 1994 & 2007 in thriteen yaers it was 17.55% while in between 2007 & 2016 maens in 9 years it was 16.67% as well as in between 1994 & 2016 twenty two years it was 17.19%. Most probably one of the year of population sezi had error due to it seems approixemetly costant growth rate. I think most of the time CSA population data under estimated the population of many area.

Migration.

Migration from rural to study area and different types of urban to study are happened. For example in 1994 and 2007 population census indicated migration play vital role for rapid expansion of sululta town. Based on the table 4.7 below in the census of 1994 out of the total population number of the town, about 38.5% are migrants from other areas. From this about 12 % were from urban areas while 26.5% were from countryside. Therefore, most of the migrant population of the town is from rural areas.

Table 4.11 Population migration

Sex	Number	Area of previous residence			
		Non-migrants	Migrants	urban	rural
Male	599	372	227	-	-
Female	672	410	262	-	-
Total	1271	782	489	152	337

Source: CSA, 1994

Table 4.12. Ethnics composition of Number of Population

S/N	Ethnics	Sululta 01		N/M/Abbichu		Q/Wasarbie		W/Lubee		Ida'amaa	
		No of Popⁿ	%	No of Popⁿ	%	No of Popⁿ	%	No of Popⁿ	%	No of Popⁿ	%
1	Oromoo	8237	64.8	7154	83.8	6927	62.4	5417	96.1	27,735	73
2	Amara	3870	30.4	899	10.5	2957	26.6	170	3	7896	20.8
3	Tigre	151	1.2	91	1.1	86	0.8	20	0.4	348	0.9
4	Gurage	246	1.9	358	4.2	313	2.8	16	0.3	933	2.5
5	Silte	57	0.5	5	0.06	28	0.3	-	-	90	0.2
6	Gamo	115	0.9	30	0.4	773	6.9	12	0.2	930	2.5
7	others	36	0.3	2	0.02	18	0.2	-	-	56	0.1
Total sum		12,712	100	8,539	100	11,102	100	5,635		37,988	100

As merga (2012) described in his research concerning to the ethnic composition of the town, Oromos are the original and dominant settlersthat take the lion's share of more than 85%. Whereas, Amaharas were later settlers by different pulling factors in the town from other parts of the country and rarely found only sharing 11.6%.The rest population size in terms of ethnic composition in the town was shared by Sodo guraghie, Siltie, Agew and Afar. However, field surveyed in 2006 E.C conducted by sululta Town Administration shows high migration from Amhara ethics and others ethnics take place. see table 4.12 above Oromo ethics the former and indigenous settler of sululta town which is constitutes 85% before three years minimized to 73% and Amhara ethnics groups increased from 11.6 to 20.8% and the same way Gamo and Gurage accounts 5%. These means there were high rate of migration took place and facilitate expansion of study highly.

Investment

National policy of investment focused on Export promotion and import substitution method to carry out any development. To implement national policies investor choice special zone of Oromyia Surrounding Finfine. Sululta Town is on of special zone of Oromia that has different investment potential. Now a time there are more than 270 investors that products different types of goods and services. Investment activities connected with land, market and population density. Therefore, those investors, invested in sululta town took large area of land and accelerated expansion of the town. See table 4.10.

Table 4.13: Status of Investment

S/n	Types of projects	Land occupied (m^2)	Registered capital	No f projects	Job opportunity created	No of projects and their status			
						In Operation	On construction	On process	Bare land
1	Factories	1,436,250	2,132,662,188	43	2,274	9	8	16	10
2	Agro-industries	232,812	191,537,800	22	496	15	3	3	1
3	services	1,417,663	1,251,671,353	167	2793	55	11	72	29
4	Agricultures	610,000	128,190,000	3	377	3	-	-	-
	Total sum	3,696,725	3,704,061,341	235	5,940	82	22	91	40

Sources: Sululta Town Administration profile of 2006 E.C

As is seen from table 4.10 the area coverage that covered by investments were 3,696,725m^2 which is 369.6725hacteres. That means it accounts 8.3% of total area coverage of the study area. Therefore, one of the factors that accelerate sululta town urban expansion were investment accommodation. This took place due to two reason. One open land market and proximity of sululta town to Finfine (Addis Ababa). Urban land lease make opportunity for wealthier and crisis for local community. How? Government took land from farmers with low amount of compensation and sold it with high amount of price to investor. This is due to for the seek of increasing town revenues and for the need of development accessibility. Proximity of sululta town also made gravitation force to attract investors for different production. Investors attracted by sululta due to the investment potential of sululta and to minimize transport cost and other related cost due to sululta is nearest to the capital city of Ethiopia and Oromyia regional state.

Ideas of Elders about factors of rapid Urban Expansion

Elders of three groups from four sululta town formed and asked about rapid expansion of urban change. The concluded that the first reason was urban land market. The regulation of urban land didn't support farmers due to low compensation that government has been paid for owners. Then to escape governmental officials, urban land owners sold their land to every person relatively by low amount but greater than compensation. On the other hand, for the purpose of investments and land tillers for governmental office workers, governmental officials large amount of land from farmers especially kaso wasarbie, sululta 01 and nono mana Abichu.

The land cover change around yaya and atillet villages in kaso wasarbie were covered by vegetation, but now by building area. Eastern and western side of Nono Mana Abichu, wale lube and sululta 01 were covered by forests. For different purpose our societies deforested it. Now those forests converted to agricultural land, settlements, factories, grassland and etc.

Photo 4:1. Wasarbie kebele in past forest now settlment

Sources: Elders

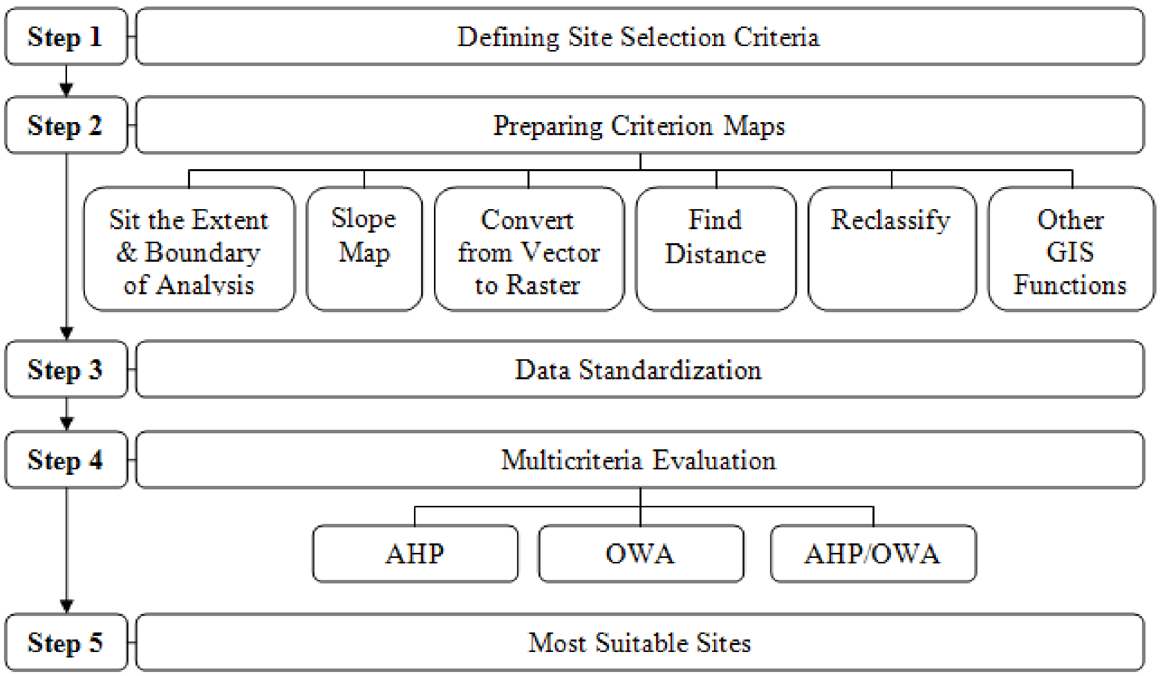
Photo 4: 2 Nono Mana Abichu kebele

As elders evidenced photo 4.2 shown that in past cultivation and vegetation land but now converted to built up area. The same way photo 4.1 indicates that in kaso wasarbie in past vegetation cover was converted to built up area.

4.2. Analyses and Results of Land Suitability of the Residential Housing

The use of GIS has helped planners to achieve desired and more accurate results and as such reducing the complex nature in the planning process allowing different stakeholders to reach a general conclusion. GIS-based Multi Criteria Analysis (GIS-MCA) can be defined as a process that integrates and transforms geographic data (map criteria) and value judgments (decision maker's preferences) to obtain overall assessment of the decision alternatives. (Khalid E., 2013).The Procedural steps of the proposed GIS-based MCA approach entails five steps as explained below and depicted in pilate4. 1.

Pilate 4.1 Steps of GIS-based MCDM



4.2.1. Identification and Justification of input Data

Accordingly to identify suitable residential housing for sululta town, a number of factors influencing the issues were identified. Those factors were slope, Geology, soil, River, Road, land cover land use and population density. This input data's were justified as follow.

A. Slope factor

One of the critical factors influencing suitable residential housing site selection is slope of the terrain. Since house construction on steep slope required extensive cut and fill and not feasible for human life gentle or flat terrain is feasible one. Due to this slope data of study area prepared as input data. Fig.4.8. depicted maps of slope in the following.

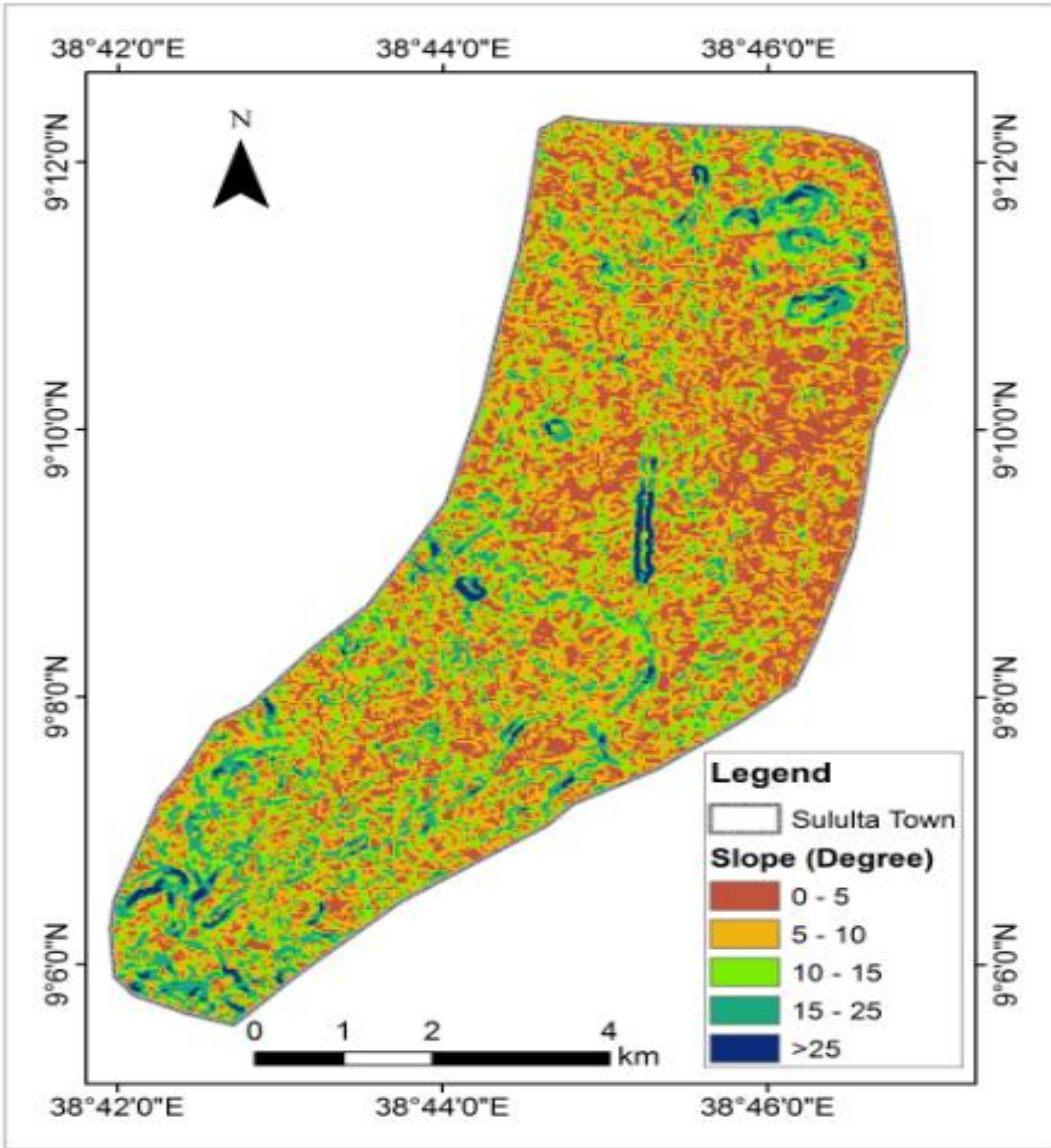


Fig. 4.4.Slope types of the study area (source: Developed by researcher)

Based on the above figure 4.8 the larger area of the town has a slope range between 0 to 15 % which accounts for about 41.06% of the study area. This range is very important for most developments mainly housing, commerce, administration, Industry and others.

The second larger area is found within the slope range of 15 to 25 % which accounts for about 37.22% and is moderate suitable for developments. The small part of the study area is found within the range of greater than 25% constituting 4.86% that may also not capable for most developments as high runoff and land slide may be expected in this area. Therefore, these unsuitable slope classes for development may be suitable for conservation purposes.

B. Soil factor

Suitable housing site constructed on soil that are either expansive (commonly called black cotton), unconsolidated or susceptible to erosion are costly unlike consolidated soil.

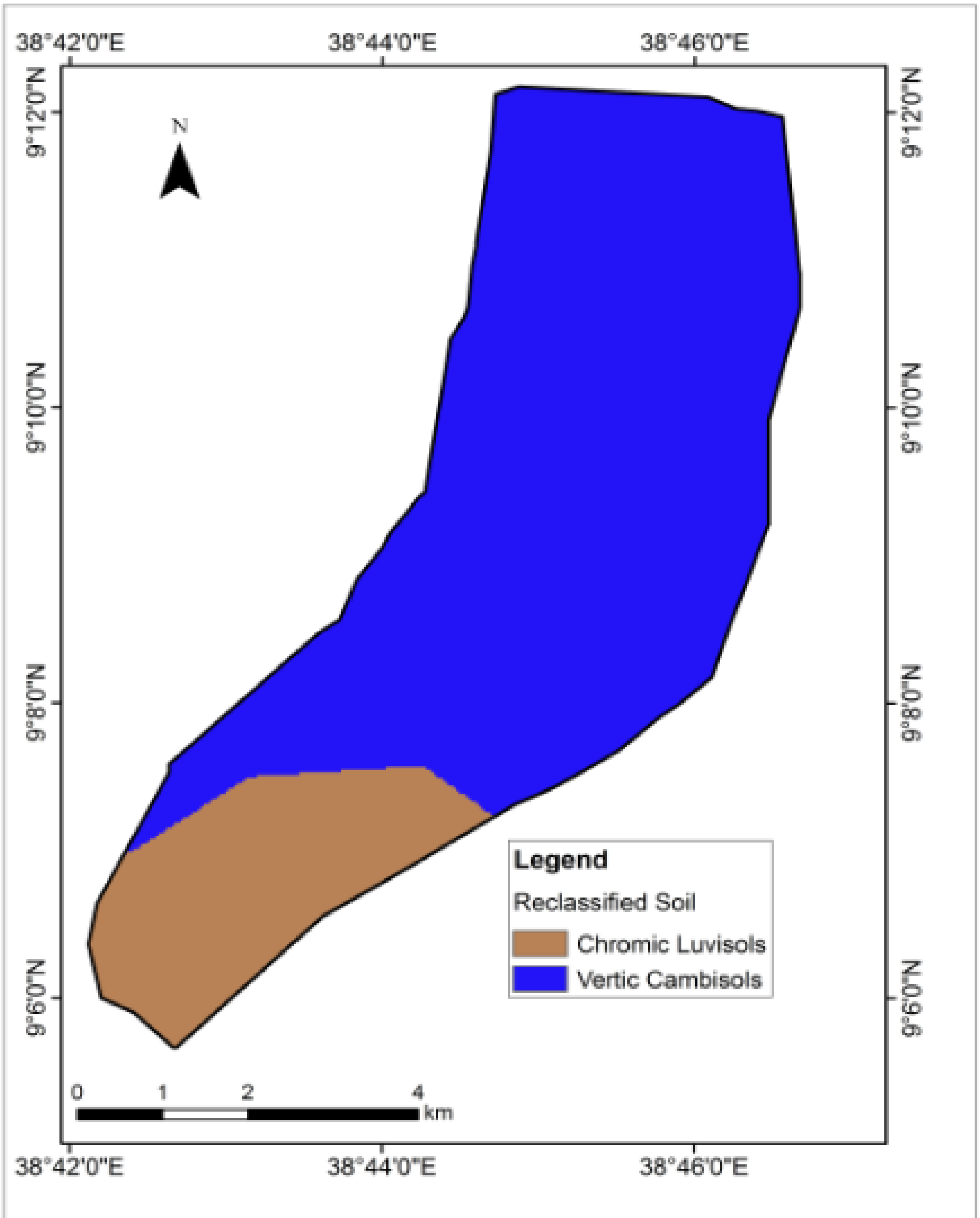


Fig. 4.5. Soil types of the study area (source: Developed by researcher)

Based on the above figure the dominant soil type in the study area is Luvisol which covers about 84%. The rest of the area is covered by Vertisol, Leptosol, and Cambisol constituting about 6%, 5.2% and 4.8% respectively.

C) Geology

Apart from soil type, Poor drainage also could have a negative impact on housing site. Conversely, construction of housing on well-drained soil are less expensive. Rocky terrain should be avoided as they increase construction cost due to heavy excavation of rock.

It should be depicted in Fig. 4.10. of the following.

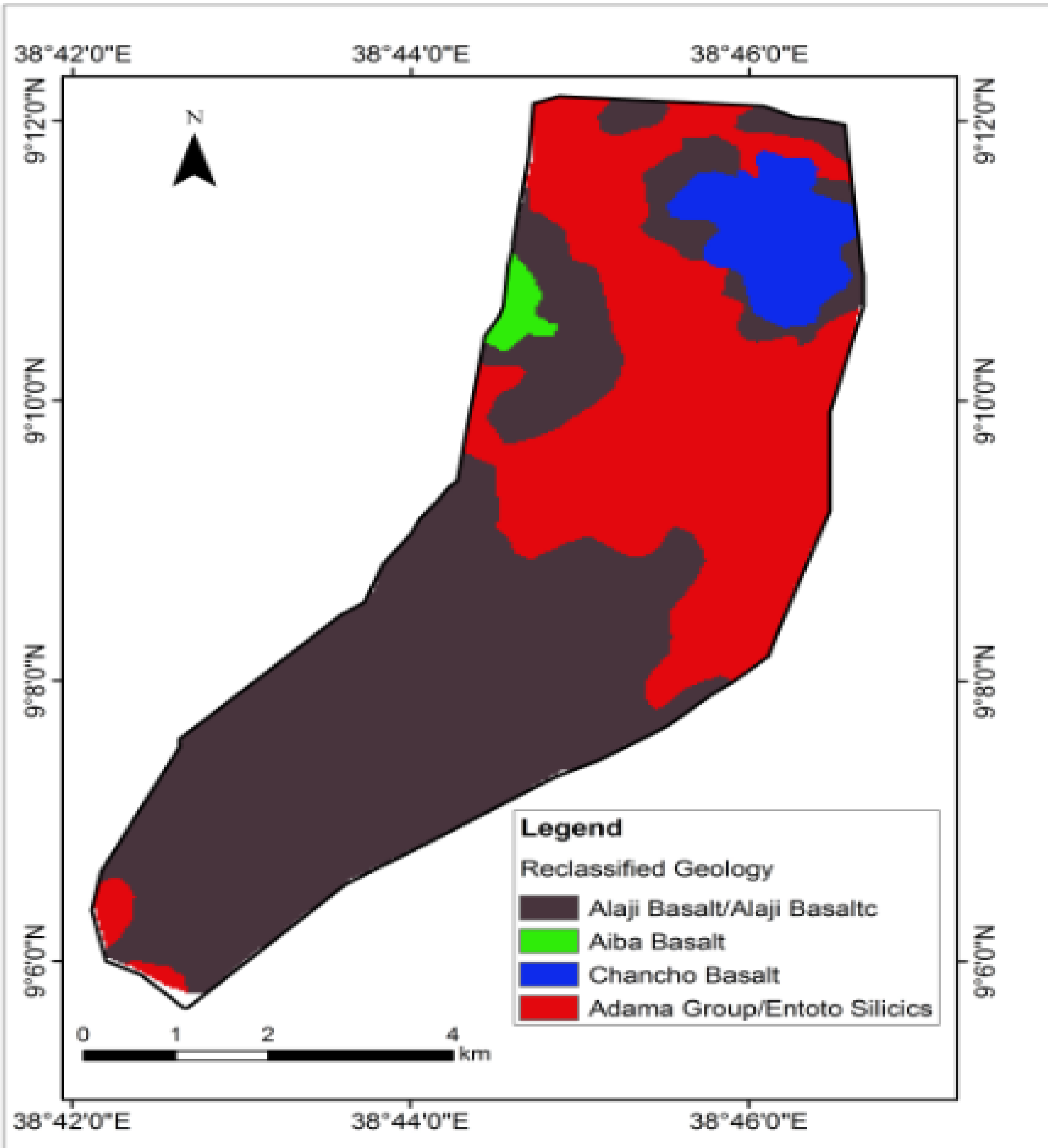


Figure4.6 Geological map (source: Modified from Hailu Warku, 2012)

Based on the above figure 4.10 the dominant geological component in the study area is Alaji_Basalt which accounts about 56.5%. Aiba_ basalt is the second dominant component which covers about 33.7% of the study area. The rest of the area is covered by Chancho_basalt, Adama_group and Entoto_silicics.

D. River factor

It is undesirable if the housing site have to nearest to several rivers. This is due to the risk minimization for the case of flooding of river damage on that could be occur on the site.

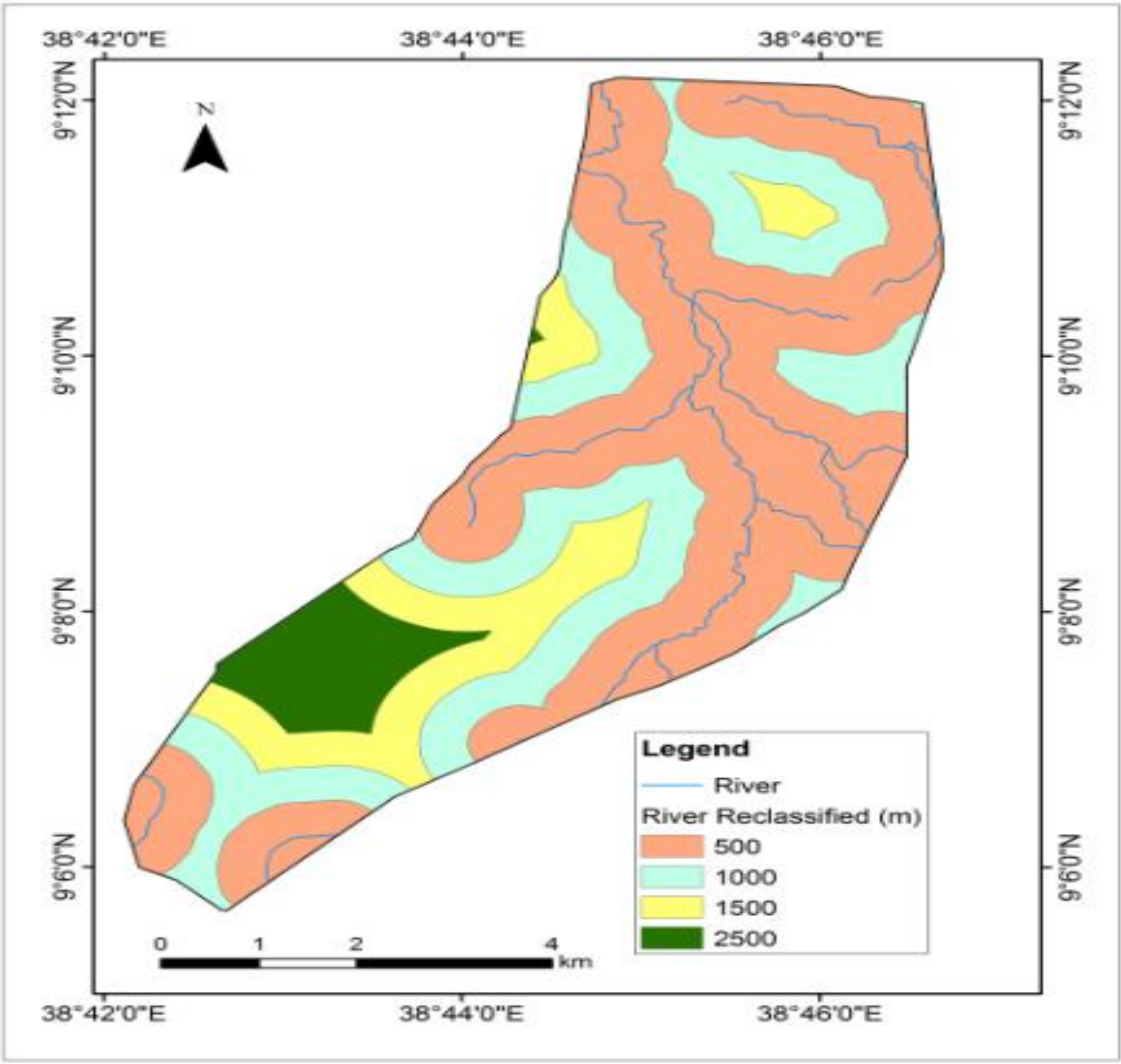


Fig.4.7.Drainage river structure of the study area
Source: Developed by researcher)

As it shown from Fig.4.7 above at 500m residential housing is not suitable due to it is near to river while at 1km or 1000m it is moderately suitable. On the other hand at 1.5km housing project is suitable and at 2.5km it is highly suitable due to it is far from risk area.

According to the geological well data and study done by Merga (2012) groundwater is known to be found in the range of 10 to 15 l/sec and the potential aquifer is found after 280m depth with in Scoriacous basalt .Spring is a concentrated discharge of groundwater appearing at the ground surface as a current of flowing water. With this understanding the springs of the study area are generally classified under depression springs. These springs are found commonly in recharge zone area near Entoto ridge. Most of them are emerging at the foot of associated slope. In the study town, low discharge springs and seasonal springs are common along the eastern and northeastern ridges of the catchment and it only yields about 0.5l/sec as Merga (2012) cited Todd, 1980 and OUPI, 2006).

E. Land use

Different land use have different values based on construction, operation and environmental structural plan of the Town. Fig.4.12 below depicted that sululta town land use map.

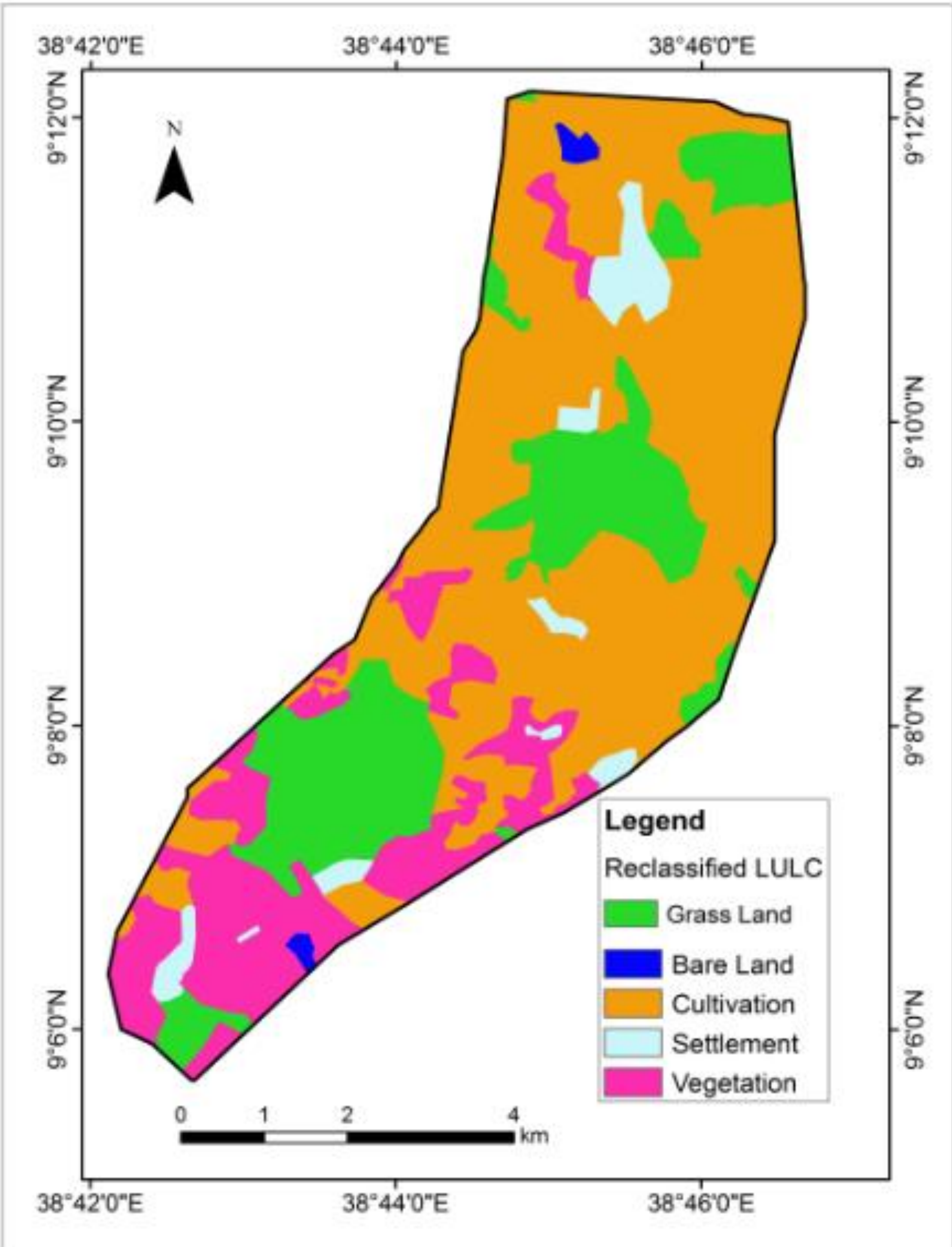


Fig.4.8 LULC map sululta tow

E. Road

Road accessibility is one of the important parameters for urban development as it provides linkage between the settlements. The distance to existing urban areas is important because the significantly impact moving costs, so the roads are an important factor in housing development because their presence indicates human activity. Fig 4.14.depicted road map as follow.

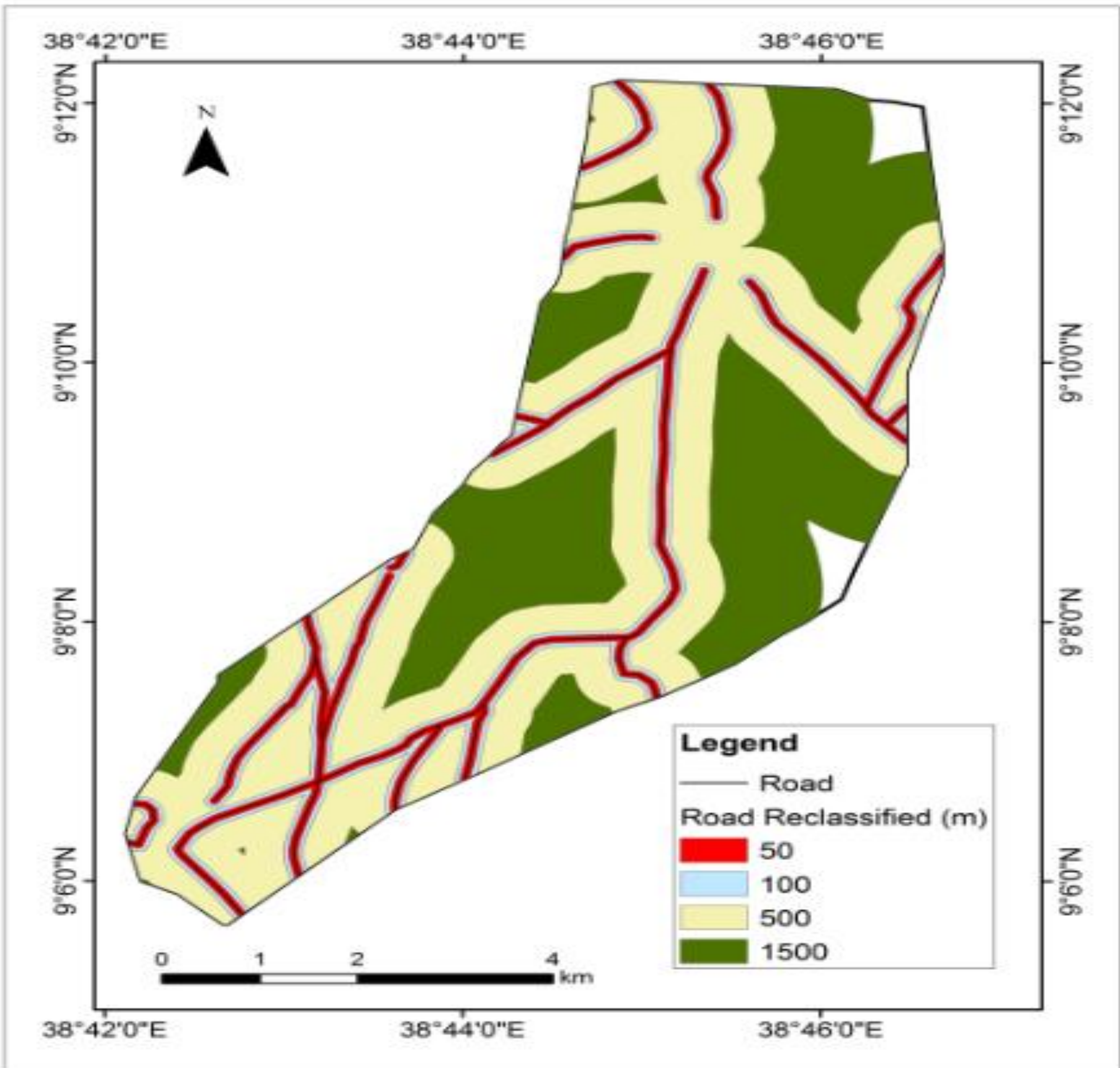


Fig 4.9 Road Suitability map of study area

AS it depicted in fig. 4.9 the rank of suitability of road is described. For example at 50m housing is highly suitable due to it is near to road while at 100m it indicates moderately suitable whereas at half kilo meter it is marginally suitable and at 1.5km it is not suitable due to far from transportation.

G. Population Density

As the main reason for the construction of these houses is the unpredicted population growth considerations of low- population density localities especially where housing expansions being carried out is more suitable than the densely populated areas. The population densities for every kebeles were calculated in order to reclassify the sites on the basis of their population as shown in Fig 4.10. So sites with low densities are more appropriate to the suitability values of the lands.

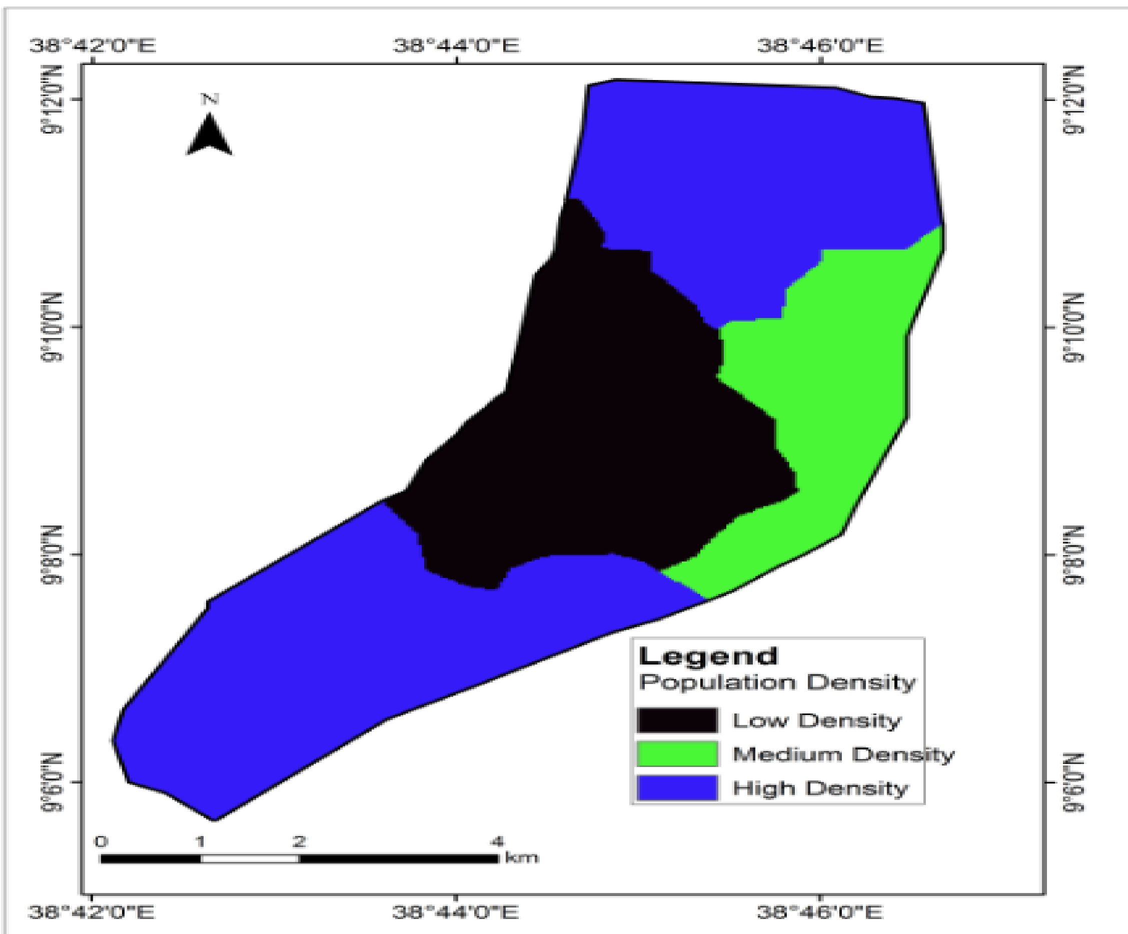


Fig.4.10. population Distribution map

AS it depicted in Fig.4.15 kaso wasarbie and sululta 01 are highly dense population distribution while wale lube is medium and sparse population distribution and Nono Mana Abichu populated with high density and sparsely.

4.2.2. Techniques for Weighting

The most frequently raised problem in MCDM is how to establish weights for a set of activities according to importance. Location decisions such as the ranking of alternative communities are representative multi-criteria decisions that require prioritizing multiple criteria. Saaty (1980) has shown that this weighting of activities in MCDM can be dealt with using a theory of measurement in a hierarchical structure. The analytic hierarchy process (AHP) is a comprehensive, logical and structural framework, which allows improving the understanding of complex decisions by decomposing the problem in a hierarchical structure. The incorporation of all relevant decision criteria, and their pair wise comparison allows the decision maker to determine the trade-offs among objectives. Such multi criteria decision problems are typical for housing sites selection.

PAIR WISE COMPARISONS METHOD

The Pair wise comparisons method was developed by Saaty (1980) in the context of the Analytical Hierarchy Process (AHP). This method involves pair wise comparisons to create a ratio matrix. As input, it takes the pair wise comparisons of the parameters and produces their relative weights as output.

Table 4.14 AHP Weighting Definition

INTENSITY OF IMPORTANCE	*DEFINITION*
1	***EQUAL IMPORTANCE***
2	***EQUAL TO MODERATE IMPORTANCE***
3	***MODERATE IMPORTANCE***
4	***MODERATE TO STRONG IMPORTANCE***
5	***STRONG IMPORTANCE***
6	***STRONG TO VERY STRONG IMPORTANCE***
7	***VERY STRONG IMPORTANCE***
8	***VERY TO EXTREMELY VERY STRONG IMPORTANCE***
9	***EXTREMELY IMPORTANCE***

Table 4.15. AHP Matrix

	Slope	Geology	Soil	River	Road	LULC	Pop_Density
Slope	1	2	3	4	4	5	5
Geology	0.5	1	2	0.5	2	3	3
Soil	0.33	0.5	1	2	2	2	3
River	0.25	2	0.5	1	2	2	3
Road	0.25	0.5	0.5	2	1	2	3
LULC	0.2	0.33	0.5	0.5	0.5	1	2
Pop_Density	0.2	0.33	0.33	0.33	0.33	0.5	1

N.B. LULC: Land Use Land Cover, Pop_Density: Population Density

Criteria Weighting Using Pair Wise Comparison Matrix

This requires determination of factor weights in the following three steps:

1) Filling the eigenvector value of the reciprocal matrix by comparing the priority importance of every two factors with respect to the problem. Either the upper or the lower triangle filling is sufficient
2) Adding every values of the column.
3) Dividing values corresponding to every factor by the column total to determine the relative weight of the factors.

Computation of consistency ratios (CR) was done after calculating consistency index (CI) and obtaining random index (RI), corresponding to the number of parameters considered, from table. On the basis of the above techniques the criteria weights for the seven parameters are determined using the ArcGIS software after they get prioritized and the consistency ratio found to be acceptable.

Table 4.16. AHP Weight

Parameters	Eigenvalues	Eigenvector of largest eigenvalue	Weights		Consistency Ratio
				%	
Slope	7.3827	0.7732	0.3503	35.03	0.0483
Geology	-0.2236	0.3594	0.1628	16.28	
Soil	-0.2236	0.3203	0.1451	14.51	
River	0.0632	0.3196	0.1448	14.48	
Road	0.0632	0.1981	0.0897	8.97	
LULC	-0.031	0.1393	0.0631	6.31	
Pop_Density	-0.031	0.0977	0.0442	4.42	

WEIGHTED OVERLAY ANALYSIS

The GIS overlay process can be used to combine the factors and constraints in the form of a Weighting Overlay process. The result is then summed up producing a suitability map as shown by the formula;

Suitability Map = Σ [factor map (cn) * weight (wn) * constraint (b0/1)]

Where,

cn = standardized raster cell,

wn = weight derived from AHP pair wise, comparison, and

b0/1 = Boolean map with values 0 or 1

Using ERDAS IMAGE software all factors has been given specific weights and the weighted overlay analysis has been conducted and produce housing suitability map.

Table 4.17.Suitability Result

No	Parameter	Area (ha)
1	Highly Suitable	131.9
2	Moderately Suitable	1551.8
3	Marginally Suitable	2731.2
4	Not Suitable	55.6

The areas of the proposed sites were calculated in GIS environment as it is shown in the table 4.7. The very suitable sites has an area value which accounts 131.9ha and followed by moderately suitable site which accounts 1551.8ha while marginally suitable area accounts 2731.2ha. The very suitable site constitutes 3 % of the total area of study and moderately suitable site constitutes 34.7% of its total study are while marginally suitable site constitutes the highest area coverage i.e. 61% of its total. On the other hand not suitable lands of study area constitutes 55.6ha which is 1.3%. Fig.4. 16 also indicates suitability Map for housing and table 4.7 depicted suitable area in each kebeles of study area in the following.

Suitability Map of study area

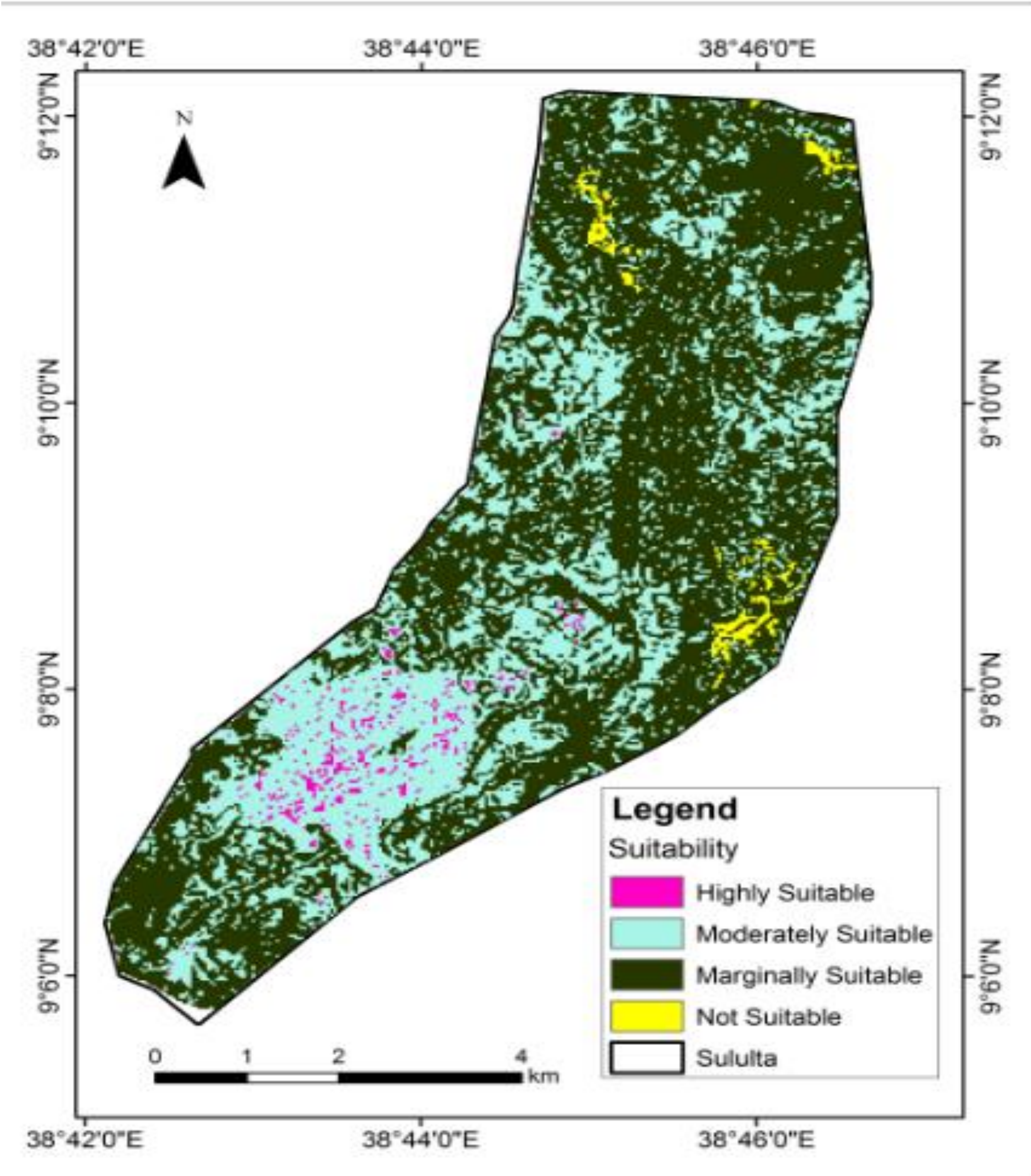


Fig.4.11 Suitability map of sululta Town

CHAPTER FIVE: CONCLUSION AND RECOMENDATION

5.1. CONCLUSION

The study area assessed urban expansion by integrating GIS and Remote Sensing techniques indicated surprising change in the years of study. Remote sensing in providing information with regarded to urban expansion and GIS for suitability analysis for housing are best methods for the study area.

Using image of 1986, 2001 and 20016 there are rapid urban expansion of the study area which means sululta town. In general as the change detection analysis results revealed, this observed consistent expansion was attributed to the conversion of vegetation and cultivation land into settlement and open land lands at different stages. On the other, grass land indicate fluctuated change in different time of study. For example in between 1986 and 2001grassland decreased while in between 2001-2016 and in 1986-2016 increased. This was due to conversion of land form from vegetation and cultivation land to grassland and may be shifting cultivation system has been implemented in the study area.

The very suitable sites has an area value which amounts 131.9ha and followed by moderately suitable site which amounts 1551.8ha while marginally suitable area accounts 2731.2ha. The very suitable site constitutes 3 % of the total area of study and moderately suitable site constitutes 34.7% of its total study are while marginally suitable site constitutes the highest area coverage i.e. 61% of its total. On the other hand, not suitable lands of study area constitutes 55.6ha which is 1.3%. suitable area in each kebeles of study area were also assessed. Therefore, Kaso Wasarbie is highly suitable kebele and constitutes largest area coverage of suitable site for housing while the left three kebeles moderately suitable.

5.2. Recommendation

Based on the findings obtained in this study, the researcher proposed the following suggestion:

- As it has seen that there has rapid population growth in the study area in the last thirty years; the regional government of Oromia and Sululta Town Administration should manage this and should give a serious attention in family planning in balancing the situation.
- We have known that one of the causes of the horizontal expansion of the town is rapid population growth resulting from natural increase and migration Therefore, improvements in spatial planning and urban planning should get considerable attention by Oromia Urban planning Institute and Sululta Town Administration.
- The Town is expanding from year to year because of various reasons .Hence the expanding areas are suffering from in adequate urban infrastructure and the burden of the provision of these urban infrastructure falls on the municipality. It is recommended that the municipality should form partnership between sectors to alleviate the problem.
- One of the objectives of this study is to select new sites for housing. Therefore, the identified highly and moderately suitable areas should get attention by sululta town administration during a new structural master plan and operation of new housing project.
- Finally, Expansion of sululta Town brings a number of problems of housing, infrastructure, services and loss of agricultural land and vegetation. These problems require immediate attention of the urban planners, decision and administrators.
- Safeguarding of fertile land around the town; Control of urban sorrow out into agricultural land; there is need for generation of digital topographical data base for sululta town; Use of high resolution data for planning and urban information generation are suggestions which are to be given keen interest for sustainable growth and balance of sululta Town and for further research problem

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Appendix I

i) Name ....sex..............level of education.......... way of livelihood...................

Interviews Questions

1. What is the root cause of Sululta town expansion?
2. When was the rapid change of expansion started ?
3. In past time before thirty years types of land cover existed in their kebeles?
4. Why other land cover classes change to other classes?
5. What is a problem of Sululta town expansion?

Appendix to II

Photo of sululta 01 kebele in past other land uses now converted to built up area