



**URBAN EXPANSION AND SUITABILITY ANALYSIS FOR
HOUSING OF ADAMA CITY USING REMOTE SENSING AND
GEOGRAPHIC INFORMATION SYSTEMS TECHNIQUES**

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ABBREVIATIONS

amsl.....	Above mean sea Level
DEM.....	Digital Elevation model
GIS -----	Geographic Information System
GPS.....	Global Positioning System
ha.....	Hectare
Km2.....	Square Kilometer
LULC.....	Land Use land Cover
RGB.....	Red Green Blue
AMRP----	Adama Master plan Revision Project
UN-----	United Nations
CSA-----	Central Statistical Authority
AMPP----	Adama Municipality Planning and Programming
TM.....	Thematic Mapper
MSS.....	Multi Spectral Scanner
TM.....	Thematic Mapper
UTM.....	Universal Transverse Mercator
MER.....	Main Ethiopian Rift
ETM.....	Enhanced Thematic Mapper
TIN-----	Triangular Irregular Network
GCP.....	Ground Control Point
GDP.....	Gross Domestic Product
RS-----	Remote Sensing

NAMES OF ORGANIZATION

CSA..... Central Statistics Authority

EMA..... Ethiopian Mapping Authority

NMSA.... National Meteorological Services Agency

OBPED---Oromiya Bureau of Planning and Economic Development

HEC-----Highway Engineering Consultancy

AM-----Adama Municipality

ACP-----Adama City Project

ABSTRACT

The rapid urbanization and urban expansion in the developing world require a scientific understanding of complex urban growth patterns and processes. This knowledge is highly crucial to sustainable land management and urban development planning. Progress in modern Remote Sensing and GIS techniques have opened up great opportunities, and significant success has already been achieved in monitoring and managing fast urban growth.

This study focuses on mapping urban expansion and site suitability analysis for housing in Adama city. It analyzes the cause and its direction of expansion. The basic data used are topographic map (1:50,000), Aerial photographs of the city of (1965 and 1972), IKONOS image of the city (2004) and GIS data layers like Road, railway, River, Population, Land use, slope and Soil. It has been found that the built up area expansion of the city between 1965 and 1972 was 120 hectare which was 48% expansion and the built up area expansion of the city between 1972 and 2004 was 704 hectare which was 290.3% expansion.

The road length of 1965 and 1972 was calculated out as 41.1 km and 72 km respectively .Hence the road was increased by 30.9 km (54.8%) between 1965 and 1972. Moreover, the road length of 2004 was measured as 160.3km. The road network expansion of Adama city from 1972-2004 was increased by 88.3km. This attempt has also been made to propose new sites for housing expansion based on local and other countries criteria's using seven parameters, Land use, population density, road, railway, river, and slope. Using ArcGIS 9.1 of spatial analysis weighted overlay analysis have been carried out by giving weights for each parameter using pair wise method and produce new sites for housing . Once suitability for housing expansion has been completed sites were evaluated with respect to the availability of utilities like electric, telecommunication and water supply utilities, to support the proposed sites to be more comfortable and safe in terms of these basic infrastructures.

The study strongly supports the usefulness of advanced technologies like Remote Sensing and GIS for Urban expansion study and selection of best sites suitable for housing expansion based on certain criteria.

Key Words: *Urban Expansion, Remote sensing, Geographical Information System, Multi criteria analysis (MCA) and Housing Site Selection*

CHAPTER ONE

INTRODUCTION

1. 1 BACKGROUND OF THE STUDY

Urban areas, According to the Cambridge dictionary urban describes a town, and a town is a place where people live and work, containing many houses, shops, places of work, places of entertainment, etc. Literature refers to urban as a term, which is used to describe areas of high concentration of human activities at a particular location.

Urban places represent built environments that are physically distinguishable from the natural environment, and are thus potentially identifiable through the use of remotely-sensed sources such as satellite images, aerial photography.

Nowadays, most of the world population lives in cities and metropolis. However, it is often the case that settlements grow irregularly under the pressure of masses coming to cities and these do not develop according to well-defined plans. Hence, it is necessary to monitor urban areas with frequent update (Pradip, 1994). As cities grow and expand it is expected that economic growth and development will progress and act as a driver for social transformation and improvement of not only in urban areas but the greater rural hinterland served by the urbanized region.

At the global scale, urbanization has shown no sign of slowing since World War II and is likely to continue unabated into the twenty-first century. In 1950, only 29% of the world's 2.5 billion population were urban dwellers. By 2005, it is predicted that half of the 6.5 billion people of our planet will be living in cities for the first time in human history (United Nations, 1997).

Monitoring 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 past thirty years. With time series satellite data we may detect long -term changes (Tran and Yasuoka, 2000).

Due to the effects of continued growth and expansion of cities, rural communities residing in the out lying areas have been subject to increasing eviction and adverse effects such as pollution, environmental, social and cultural disturbances. The measures are being taken to manage the undesired effects, though not adequate. In this respect one of the typical manifestations of the undesired effects of urbanization is informal and/or illegal ownership of land and housing which are particularly intensified in the peripheral areas.

Access to safe and healthy shelter and basic services is essential to a person's physical, psychological, social and economic well-being. Decent housing contributes much to personal health as well as confidence and security. The ways in which housing is produced and exchanged have also an impact over development goals such as equity and poverty-reduction. Housing construction and location can influence environmental sustainability and the mitigation of natural disasters. Besides, the design of dwellings both reflects and protects something important about culture and religious beliefs.

Urban housing contributes to economic development by directly increasing the productivity of individuals, households, community and the urban population. It creates jobs for skilled, semi-skilled and unskilled labor in the construction industry, materials production and supply and other related areas (Meysam, 2002).

Like in most other developing countries, in Ethiopia, the housing sector has been given a fairly low priority in the national socioeconomic development planning process. Several studies show that the housing sector in Ethiopia has suffered from different causes (Kebede, 1991).

The integration of Remote Sensing and Geographic Information Systems (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).

Land suitability analysis is the process of determining the fitness of a given tract of land for a defined use (Pradip, 1994). In other words, it is the process to determine whether the land resource is suitable for some specific uses and to determine the suitability level. 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 elected Officials and land managers to make decisions and establish policies in terms of the specific land uses (Malczewski, 1999).

Adama is among the fast growing urban centers in the country .The city has attractive potential that contributed for its accelerated growth .Hence the expansion of the city is becoming irregular, uncontrolled and often resulting in creation of slums (Daniel, 2000:5). Adama, being one of the cities in the developing countries has never been in a position to escape the forgoing undesired realities of rapid urbanization. Principles and guidelines fundamental to ensure healthy urban growth have never been put in place.

An ever-increasing share of housing in developing countries is provided through informal-sector activities. Like in many other cities in the developing countries, the majority of the urban poor in Adama live in informal and illegal settlement either as owner-occupiers or as renters. Several studies show that the production and occupation of housing in this sector is a rational response to the shortage of effective housing supply within the formal or controlled sector (AMPR, 2004).

The form of tenure affects incentives of residents to improve their homes, social stability and homogeneity. It is generally agreed that the more secure the tenure and the more stable

the economy, the more networks of kinship and mutual support will run through the neighborhoods. In other words the more control people have over their homes, their environment and their sources of livelihood, the better they would be able to cope and improve their living environment in a gradual process (AMPR, 2004).

1.2 STATEMENT OF THE PROBLEM

Adama is characterized by low density and low-rise development. Like any third world city, leap frogging and sporadic developments are common in Adama. There has not been institutional and legal framework capable of managing informalities in trade and physical developments. Excessive alteration of land use has been taking place without formal procedures, and this could lead to imbalance between land uses, which gave Adama an image of much of a city of stores (Habtom, 2007).

The importance of putting in place planning principles to be referred to in the planning process is not well recognized. This could give way to haphazard planning and subsequent ineffective implementation. In view of potentials and constraints, vision for city development are not put in place and shared among stakeholders.

More than 49 percent of the housing units in the center of Adama are owned by the Kebeles. As it is observed in other urban areas in Ethiopia, there is problem of management of these units in Adama also. In terms of housing condition, there is a clear distinction between Kebele and private owned houses with the former ones being highly deteriorated. A look at the percentage distribution of the housing units by tenure can easily explain the magnitude of the housing units that are continuously deteriorating for lack of appropriate action regarding the housing ownership (AMPR, 2004).

Physical characteristics of housing units constitute the most visible indicators of the type and level of development of the settlements as well as the overall physical environment of an urban area. Housing units and services in the city especially the core are deteriorated due to lack of improvement and upgrading. The majority of the populations live in areas where the housing condition has deteriorated significantly with associated degree of lack of necessary facilities (AMPR, 2004).

Regarding settlement development two basic processes are identified in Adama. The first step includes the development of rural settlements and/or informal and illegal land occupation, which usually starts, with the establishment of small rural/semi rural housing units and settlements. The second step consists of informal land transfer from these original settlers to others. Informal land tenure rights especially that claimed by farmers have contributed to all the above processes to a great extent.

The result of the land use and housing ownership survey shows that there are informal housing constructions and extension in all areas of the city especially at the peripheries.

The population of the city has been raised and consequently the need for homes became serious. In addition to this the growth of the city is a continuous process so that it is important to identify suitable housing areas for future development. Selecting the location for housing sites is a complex process that involves not only technical requirement, but also physical, economical, social and environmental requirements (AMPR, 2004).

This paper will try to assess urban expansion of Adama city using Remote Sensing (RS) and Geographical Information Systems (GIS) and finds suitable sites for housing expansion.

1.3 OBJECTIVES OF THE STUDY

General objective

- Mapping urban expansion of Adama city

Specific objectives

- Identify suitable sites for housing expansion of the city.
- Estimate urban expansion of the city in 2020
- Identify the factors (cause) responsible for urban expansion and its direction
- Delineating major urban land use classes of the city
- Compare the rate of population growth and urban growth

1.4. SCOPE OF THE STUDY

This study is an urban level study and thus focuses mainly on issues that are within the city of Adama. However, implications of some issues on the level of the study region and the hinterland of Adama have been considered.

The study specifically gives emphasis on spatial expansion of the city and its direction of expansion and proposing suitable sites for housing using local and other countries experience criteria.

1.5 LIMITATION OF THE STUDY

To conduct research the study had the following constraints:

- Time constraint
- Financial constraint
- Data constraint
- Fail to conduct Orthorectification for the Aerial Photographs

1.6 DATA SOURCES, MATERIALS AND METHODS OF THE STUDY

DATA SOURCES

Reliable data is necessary to realize the designed objectives and hence the study is based on both the primary and secondary data. In addition to this, frequent field observations using GPS have been carried out to generate primary information regarding the ground truth for Land use classification.

The topographic map, aerial photographs and/or satellite image of the study area at different years to assess the urban expansion have been accessed from the authorize body. Population and Population density data were collected from the office of the Central Statistical Authority (CSA), whereas, other socio economic data have been collected from the various concerned offices. Table 1.1 shows the list of data used in the present study and sources from which they were obtained.

Table 1.1 Primary and Secondary data details of the study

MATERIALS USED	DATA SOURCES
• Topographic maps • Satellite Imagery (Ikonos) • Aerial photographs • Drainage (River) • Contour • Roads and Railway network • Land use	Ethiopian mapping Authority Highway engineering consultancy Ethiopian mapping Authority Extracted from Topographic map (Digitized) Extracted from Topographic map (Digitized)) Extracted from Topographic map (Digitized)) Extracted from Ikonos image
• Demographic details (Pop.) • Soil Description map • Administrative boundaries • Master plan 2004(Revised) • Documented reports (unpublished)	Central Statistical Authority (CSA) Adama city project Adama municipality and Adama city project Adama municipality and Adama city project Adama municipality and Adama city project
FACILITY AND SOFTWARES • ArcGIS 9.1,ERIDAS 8.6, IDRISI 32 • Mirror Stereoscope, GPS • Digital camera	

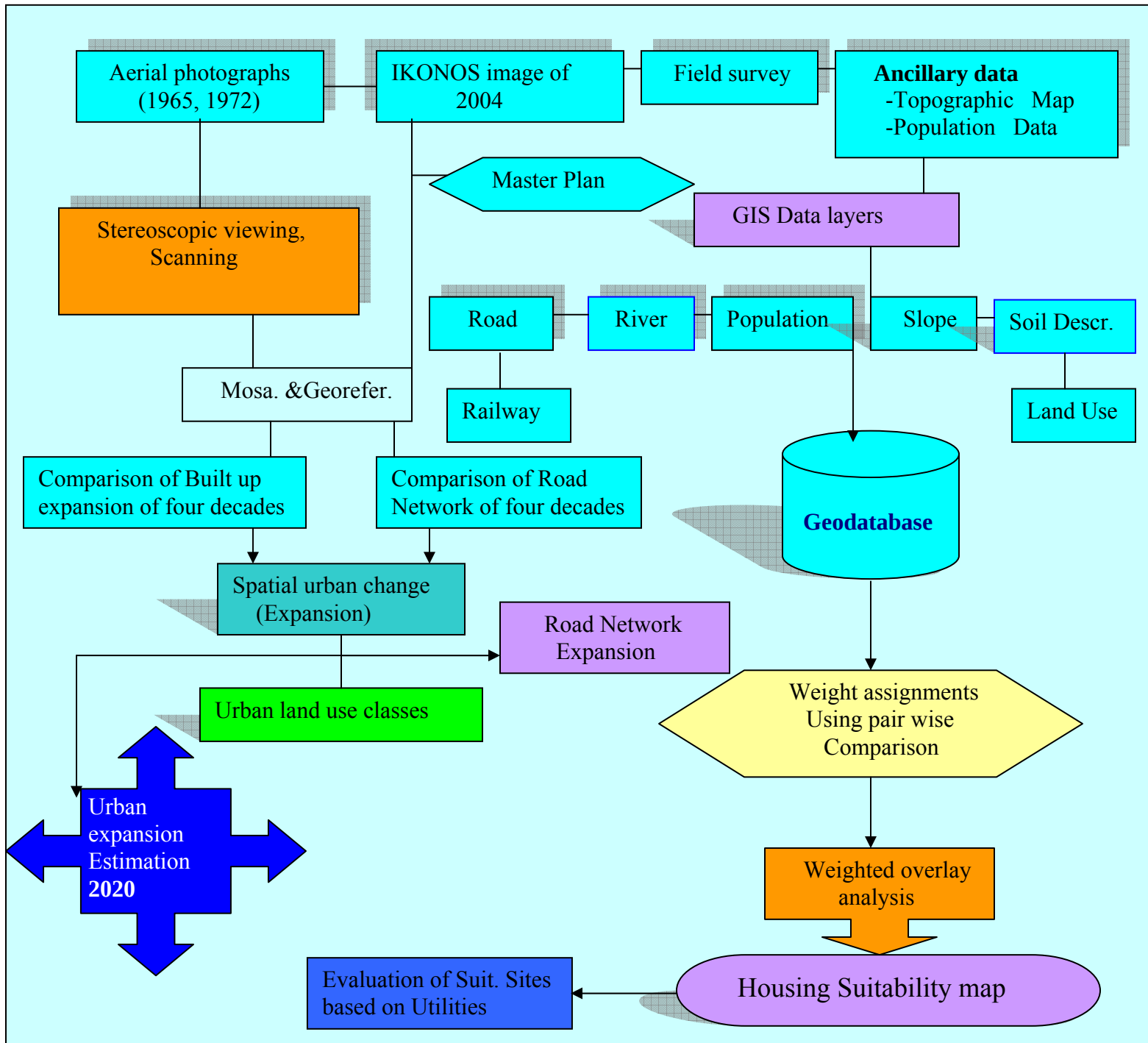


Figure 1.1 General Methodology

CHAPTER TWO

LITRUTURE REVIEW

2.1 GENERAL REVIEW

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).

To prevent from such occasions urban planners need detailed updated maps for thorough planning and management. However, most city planners have a lack of such maps and often they posses old data which is not relevant for current decision making. Even if they do not hold a detailed updated map of the city area a regularly updated map with an acceptable resolution can at least give them an impression about the changes in the city area.

The growth of cities and towns are considered as one of the processes of development. Cities are centers of civilization, generating economic development and social, cultural, spiritual and scientific advancement (UNCHS, 1996).

It is often argued that urbanization is a continuous process, from being rural to becoming urban. Urbanization, in its simplest form, is the movement of the nature of production from primary to secondary activities. Along this line, it involves not only technological changes but, human behavior too, transform from face to face personal, intimate, kin and clan based pre-agricultural and agricultural relations to impersonal, individualistic and complex industrial and modern societies. That appears why the growth of cities and towns are considered as one of the processes of development.

Cities are centers of civilization, generators of economic development and social, cultural, spiritual and scientific advancement (UNCHS, 1996).

The detection and analysis of land use changes in the urban environment is an important issue in planning. Remote sensing and geographic information systems are considered as the most efficient techniques for this type of studies. These techniques had been applied to investigate the effects of urbanization on fertile lands and to quantify urban growth.

2.2 RESEARCH LITRATURES

Using satellite imaging (Remote sensing) and Geographic Information Systems (GIS) techniques, Ji(2006) has been able to illustrate land cover changes caused by urban sprawl in greater Kansas City over the period of nearly three decades from the early 1970s to the early 2000s.

Fabiyi Oluseyi conduct analysis of land use change of Ibadan city from 1975 to 2003 using a combination of Landsat, MSS, Landsat TM and Nigerian SAT 1.he computed the spatial growth at each data intervals and projected the land use change in Ibadan city to the year 2015 using marcov change analysis techniques.

According to Meysam Argany, reports on preliminary results from a study applying the technique of spectral mixture analysis (SMA) to the measurement of temporal changes in the composition of urban land use in the area of Greater Karaj, Iran, between 1987 and 2000.

Ashok Hanjagi use remote sensing IRS ID large scale satellite imagery create boundaries, roads, railway lines of Mandya city with the help of GPS; to understand temporal expansion of the city during the study period i.e. from 1971 to 2005; to generate up-to-date information of the city's physical growth.

According to Zing Shan (1999), Multi-temporal land use information of the central city of Shanghai was obtained by the interpretation of aerial photos in 1958, 1984 and 1996. In ArcView[®] GIS, the quantitative and structural characteristics of land use change are analyzed through concentric and sector methods.

Walsh et. At (1990) have shown that the thematic overlays contained within GIS could be used as reference sources for defining the spatial location of phenomenon and also for comparing such phenomenon against identified features employing digital processing of Remote Sensing images and selected thematic overlays integrated with in GIS, where digital enhancements are appraised with greater capability then by use of Remote Sensing for GIS alone.

2.3 URBAN STUDIES

Population growth and urban expansion have advanced at an unprecedented pace over the past few decades. Although cities occupy only a very small portion of the Earth's total land surface, almost half of the world population lives in urban areas (United Nations, 2007).

Urban growth has had increasingly significant socioeconomic and environmental impacts at local, regional and global scales (Meysam, 2002). The rapid expansion of urban centers and their peripheries has led, in many cases, to a series of complex problems related to loss of agricultural land and natural vegetation, uncontrolled urban sprawl, increased traffic congestion and degradation of air and water quality. Such impacts affect not only the local environment, but also have consequences for more distant regions. Changes in vegetation cover, air and surface temperature and air and water quality induced by urban expansion influence the microclimate of the human habitat, as well as climate dynamics and environmental changes at local and regional scales.

Urban growth has also significant impacts on the social structure of the cities and their surroundings, in terms of population distribution or land use characteristics. In addition to local impacts, the emergence of mega-cities (with more than 10 million people) is considerably influencing the social, economic and political systems on global levels, due the demographic and economic importance of such cities and their interconnectivity at large scales.

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)

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 socioeconomic 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 (Landsat MSS) in the 1970s and the subsequent Landsat 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).

2.3.1 IDENTIFICATION AND DELINEATION OF URBAN AREAS

Identification, delineation and classification of urban areas have typically been the realm of the technical Remote Sensing community. Much of the social and demographic information social scientists require can be more easily obtained from traditional government and private sector sources. Nonetheless Remotely Sensed data may provide a physically meaningful way to define urban areas that can then be utilized in social science studies.

The main problem in delineation of urban areas in the social science context is the lack of a consistent definition of what is urban. Definitions vary from country to country (United Nations, 2007) and are often based on different parameters. Urban areas may be defined by administrative boundaries, or by population density, and this varies from country to country.

It is easy to understand the limitations in these approaches: the majority of urban areas have boundaries that don't coincide with administrative divisions, and defining cities based on a population density threshold that differs by country makes comparative studies more difficult. Furthermore, such approaches do not include spatial extents of built-up areas. Satellite imagery may be used to define urban areas in a more consistent way and to produce spatially georeferenced urban extents.

2.3.2 CLASSIFICATION OF URBAN AREAS

If delineating urban areas is a difficult task, classifying different types of urban land use is even more so. The urban environment is characterized by a mixture of diverse material and land use classes, such as buildings, commercial infrastructures, transportation networks, and parks. Because they are combinations of spectrally distinct land cover types, mixed pixels in urban areas are frequently misclassified as other land-cover classes. Similarly, the definition of an "urban" spectral class will usually incorporate pixels of other non-urban classes. Such spectral heterogeneity severely limits the applicability of standard classification techniques, where it is assumed that the study area is comprised by a number of unique and internally homogeneous classes.

Many authors (Walsh, 1990) have discussed in detail the issues associated with spatial and temporal requirements for urban studies. For example, to be able to identify urban classes down to Level III of the Anderson classification system (that is, to differentiate between single-family and multi-family residential, for instance) a minimum ground resolution of 1-5 m is required. Commercial satellites, like IKONOS and Quick Bird, as well as aerial photography, are being used for Level IV classifications (identification of duplex, triplex or condominium units), while satellites like Landsat will allow a Level I classification (Residential vs. Commercial, for instance). Higher spatial resolution normally comes at the price of lower temporal resolution and smaller aerial coverage. For studies of urban growth or over large areas, such high ground resolutions might not be necessary.

Urban classifications are often improved by integrating satellite-derived classifications with ancillary data in a GIS environment. Ancillary data might include a range of socioeconomic variables, such as population or housing density, derived from the census or similar data sources or variables like land use and digital elevation models (Fabiya, 2004).

2.3.3 MONITORING URBAN GROWTH

Monitoring urban growth is one of the questions social scientists, urban planners and decision-makers deal with most frequently. The direct impacts of urban expansion on physical, ecological and social resources have made research on urban sprawl of increased interest. Traditional census sources are extremely useful in that they capture changes in the socioeconomic and demographic structure of cities, but they lack spatial details and are not frequently updated (CCR, 2004).

Remote sensing, on the other hand, makes available a vast amount of data with continuous temporal and spatial coverage and can therefore provide a successful means for monitoring urban growth and changes. Using remote sensing for change detection studies naturally requires that the different temporal images are atmospheric and zenith-angle corrected and carefully co-registered, in order to avoid errors in the estimation of land cover changes.

Both social and physical scientists deal with the issue of integration of physical variables derived from remote sensing and traditionally collected socioeconomic and demographic data. Such integration might eventually lead to a better understanding of urban impacts and urban drivers of environmental and social changes, bringing benefits to both communities. Some of the past and on-going initiatives, especially in the Remote Sensing community, are focused on the integration of remote sensing with socioeconomic data to improve classification in urban areas (NRC, 2000).

Remote sensing provides repeat coverages of a given area, allowing great data availability, but often at moderate spatial resolutions, while some ancillary data may provide levels of detail that are not available through the satellite data.

Other studies reflect the growing need of the social science community to use Remotely Sensed data in conjunction with demographic and socioeconomic data to study urban change dynamics or to better understand the spatial distribution of population and socioeconomic phenomena. Several authors studied the correlation between population data from the census, or collected from social survey at the village level, and land cover characteristics derived from satellite imagery. In addition to examining the correlation between biophysical and social variables, Walsh *et al.* (1999) show the importance of scale dependence on the selected variables and that the relationships are not generalize able across the sampled spatial scales. Many cities in developing countries are experiencing rapid increase in population and consequential urban expansion. Remote sensing may provide fundamental observations of urban growth that are not available from other sources (Burrough, 1998).

2. 2 URBANIZATION

In the past few decades urbanization and urban growth have accelerated worldwide. Within two decades, the population of cities has doubled or even tripled. At the beginning of the nineteenth century, only about 3 percent of the world's population lived in urban places [Lug hood and Hay, 1977]. In 1970s and 1990s the proportion rose to 37 percent and 45 percent respectively. This proportion is expected to pass 50 percent by 2005 and it is expected that by the year 2030, the proportion will rise to more than 60 percent UN-Habitat (2002). Although the proportion of the world's urban population is increasing over time; there is a striking variation in the rates of urbanization between the developed and developing countries. Accordingly, while urban growth is occurring and will occur in the cities of the developing world (in Asia, Africa, and Latin America), in the developed countries the great period of urbanization has already gone. In

the case of the latter, 76 percent of the population has already lived in urban places and "people and jobs are moving out away from the big cities to smaller towns" (Hall and Pfeiffer, 2000).

This century is dubbed, by most, as the urban century, with almost 50 percent of the population of the world living in urban areas and the other half being increasingly dependent on cities and towns for economic survival and livelihood. Further more the population of the cities is expected to double in the coming 30 years (NRC, 2000).

This continuous urban growth, particularly in developing country cities, is neither anticipated nor strategically planned for. Therefore, the cities face high risks and problems, which result in a conflict between their environmental resource base and development needs. Ultimately neither the human population nor the environmental resource base escapes the detrimental effects of unsustainable resource consumption and degradation.

Cities face, not only the long term environmental problems related with the natural resource consumption and degradation, that have global impact commonly called the green agenda- (which is concerned with loss of pristine ecosystems, threats to biodiversity, the depletion of the ozone layer or global warming)-but also the brown agenda.

2.2.1 URBANIZATION IN AFRICA

At the onset of twenty first century, Africa faces major challenges, which include rapid urbanization with out meaningful industrialization of the countries economy. The current rates of urbanization in Africa, exceeding 4 to 5 % per annum in most countries, are close to those of western cities at the end of the nineteenth century (Cope, 1995).

Sub –Saharan Africa is least populated and urbanized region in the world, with towns and cities hosting less than 40% of the continents population. However, urbanization is too fast. During the next two decades, around 87% of Population growth in Africa will happen in urban centers and urban transition will be reached around 2030, when dwellers will began to out number rural inhabitants. Nevertheless, urbanization patterns show tremendous difference between countries.

Rapid urbanization without economic growth, increase in slums and the lack of basic criteria amenities leading to adverse living condition and rapid urbanization call for decisive and effective planning, policies and large scale investments. Without investment in a region where only 13% of roads are paved and less than 3% of the populations have access to telephone or mobile phone, cities may just remain mega –villages offering no comparative advantage for private investment to pioneer and for production to increase and bring the promises of economic growth and development. Assertive pro-poor policies, sustained by effective and transport governance and involving the community should also be backbone structure for the development of sustainable urban center (Cope, 1995).

2.2.3 URBANIZATION IN ETHIOPIA

Like most African countries, in Ethiopia large-scale urbanization is fairly a recent phenomenon. However, the history of town dwelling in the country extends back to the Axumite Kingdoms of 4th century, when Axum, the first political, commercial and religious center in the north of the country, was established. Despite this long urban history, however, Ethiopia remains one of the least urbanized countries of Sub-Saharan Africa. Its current population of about 65 million people is overwhelmingly (about 82 percent) rural (Habte, 2001).

Prior to the 20th century, the establishment and growth of the Ethiopian cities are said to be in response to indigenous political, religious, economic as well as military strategic requirements. Despite its failure to build well organized and large size urban settlements, the constant shifting of the locations of capital cities of the empire during this period had accounted for the establishment and growth of a number of towns particularly in northern Ethiopia. For instance, Axum, Lalibela, and Gondar – founded in the 4th, 11th and 17th century, respectively - are some of the urban centers that served as capitals of the nation. In addition to these government administration centers, there were also indigenous and historically significant towns in the south and east, such as Harar and Jimma.

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 the rate of urbanization in Ethiopia is well below the African average, which is about 30 percent in 1996.

2.5 URBAN GROWTH

One of the principal challenges facing fast urbanizing countries with serious resource and development constraints in the twenty-first century is to meet the housing needs of their urban population. Housing is a universal need like food and clothing, and well-built shelter provides a healthy environment for today's citizens and the upbringing of the next generation. However, the 1996 Global Report on Human Settlements points out that "the central importance of housing to everyone's quality of life and health is often forgotten" (UN, 2001).

Well-planned housing and infrastructure of acceptable standard and affordable cost when combined with essential services contributes much to personal health and well-being, affords dignity, security and privacy to the individual, the family and community as a whole. Moreover, the ways in which housing is produced and exchanged have an impact over development goals such as equity and poverty-eradication.

Despite these positive contributions of decent housing, the access to any form of housing in most cities of developing countries is getting beyond the reach of the majority.

Hence, one of the principal challenges facing fast urbanizing countries with serious resource and development constraints is to meet the housing needs of the urban population.

This is an issue that has attracted heated debate and controversy among scholars of various disciplines during the past four decades.

2.5.1 URBAN EXPANSION IN DEVELOPING COUNTRIES

As (Redman and Jones, 2004) cited in (Lwasa, 2004) indicates that the process of rapid urbanization taking place in developing countries significantly contributes to bring opportunities to new urban developments. The problem comes with this rapid urbanization are serious like loss of the surrounding arable land, degradation of ecosystem as well as social and environmental changes and along with the urban expansion there is no parallel expansion of urban infrastructure to the urban population. Thus, the current urbanization process that is taking place in developing countries indicates that this process needs considerable attention not only as a basis for transformation of societies in the developing countries but also for sustainable development. The expectation with the growth of cities and their expansion is to be followed by economic growth and development which acts as a driving force in the social transformation and improvement of not only in urban areas but the greater rural hinterland served by the urbanized region. However, experiences of developing countries show that rate of urbanization is not accompanied with expected socio-economic transformation. This also resulted in problems of urban infrastructure in cities of developing countries particularly the most vulnerable areas of recent urban expansion and settlement of the urban poor (Lwasa, 2004).

The nature and the product of urban expansion in developing and developed countries are not similar. Urban expansion in developed countries is driven mainly by private development interests and globalization (WEGENER, 2001) cited in (Lwasa, 2004). However, as (Wagener, 2001; Lwasa, 2002) cited in (Lwasa, 2004) urban expansion of Kampala, was driven by demographic shifts in the form of rural –urban migration that has led to creation of unplanned settlements within the city and at its periphery.

2.5.2 THE MAGNITUDE OF EXPANSION IN DEVELOPING COUNTRIES

As the urban population projection of the UN, the developing country cities population is expected to double in the next thirty years: from some 2 billion in 2000 to almost 4 billion in 2030 (Fabiya,2004).According to estimates of some scholars, cities with populations in their total built-up area at average densities of some 8000 square kilometers at the annual rate of 1.7% as they have during the past decades –the built –up areas of developing country cities will increase to more than 600,000 square kilometer by 2030. In other words, by 2030 these cities can be expected to triple their land area, with every new resident converting, some 160 square meters of none –urban to urban land during the coming years. This implies that the horizontal expansion of these cities incorporate several surrounding farming villages and eating huge amounts of arable lands in to urban land use . The already existing urban centers infrastructures falls under pressure by rapid increase of urban population, on top of these new infrastructures, that imposes additional costs, which is of course a serious problem that the nations of developing countries today faces.

2.6 THE ROLE OF REMOTE SENSING AND GIS IN URBAN 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 locational 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 Geographic Information system (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).

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA

3.1 LOCATION

Adama city is located about 100km South East of Addis Ababa along the main road to Harer, enclosing between $8^{\circ} 35' 00''$ to $8^{\circ} 36' 00''$ North latitude and $39^{\circ} 11' 57''$ to $39^{\circ} 21' 15''$ East longitude. It is located at an average altitude of 1620m above sea level. East shewa zone, in which Adama is located, form a part of the mid central plateau physiographic unit.

It is found on a nodal location along main national and regional transport lines from the capital Addis Ababa to other important towns. It is also situated close to natural recreational sites such as 'SODORE', "BOKU" etc.

The proposed multi centered hierarchical system is not delineated on maps showing the proposed land use. On the map the city is divide in to four woredas following the main Addis Ababa – Harar Road in the east-west direction, the Assela road to the south and the 1st avenue to the north. The location of the city main center is described to be in the 'core area' on the executive summary, this can be presumed to be at the meeting point of the four woredas – around the main street junction. The location of the sub centers is not readily apparent, however it is possible to establish the general area by locating the functions proposed at the sub center level using the proposed land use map.

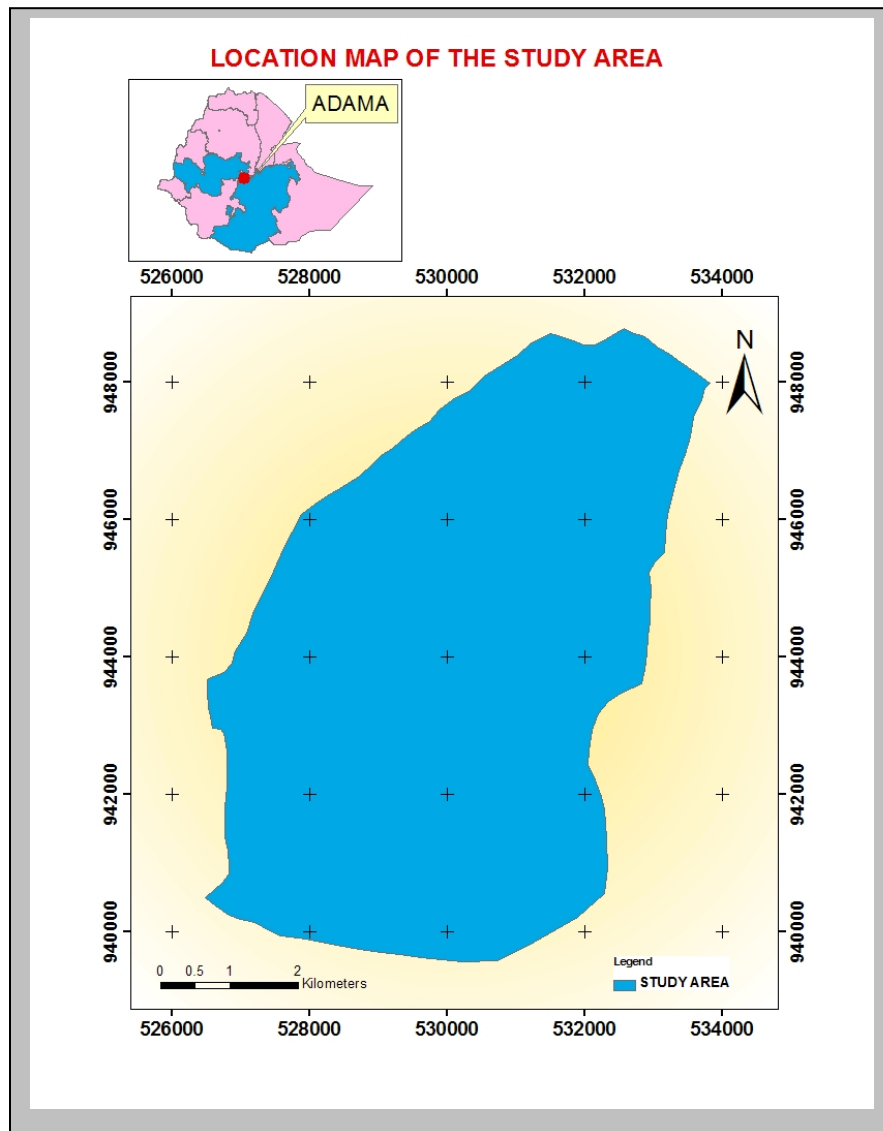


Figure 3.1 Location of the study area

3.2 GEOLOGY SETTING, SOIL AND HYDROLOGY

3.2.1 GEOLOGY SETTING

The city lies on Quaternary volcanic rocks and sediments that are formed in association with the formation of the rift. The sediments that dominate the floor of the city are alluvial and lacustrine deposits (Alula, 1992).

The volcanic products from the Boku volcano can be grouped as alkaline and peralkaline rhyolite lava domes, flows, and pyroclastic falls, which cover the floor complex ignimbrite deposits. The major products are rhyolite lava flows, obsidian flows, pumice falls, and spatter cones with associated basaltic lava flows. After the emission of these products, the caldera has been collapsed and given rise to post-caldera (intra-caldera) products such as scoria cones with associated basaltic lava flows. The Boku ridge forms the maximum peak in the area rising from 1600 m above sea level to 1800m above sea level. . (Alula, 1992)

The major tectonic lines, which are aligned in NE-SW direction in the Rift floor, form numerous local graben and horst structures (Rift-in-Rift structures). Consequently, the city is bounded by NE-SW aligned tectonic lines and lies within the graben structure .The faults are younger than the outcropping volcanic rocks and are grouped as Wonji Fault Belt. The central volcanoes are rooted along these tectonic lines and are characterized by collapsed calderas, among which the Boku caldera occupies the southern part of Adama in the Main Ethiopian Rift (MER).

3.2.2 SOIL COVER

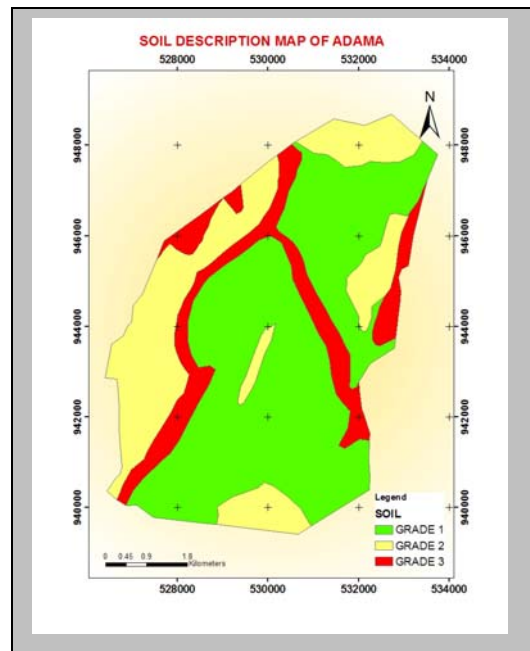
The analysis to be made on the soil varies in accordance with the purpose of study. Agricultural study focuses on the performance of soil in supporting plant life while for engineering purposes it deals with the performance for supporting civil structures. On the other hand for hydrological purpose the emphasis is given on the water holding, transmitting and retaining capacity. The characteristic of soil is a result of topography, climate and type of parent material, age and environment. The soil development in the Adama catchments is mostly due to the physical disintegration and decomposition of volcanic rocks, deposition of alluvial and ashes. The weathering products are either remain in places and form residual soils or transported and deposited in the lowland central and southern parts driven by overland flow(Teshome, 1999).

Although there is significant difference in the degree of weathering on the slopes of ridges, the soils formed there will be rapidly eroded and result in thin soil cover. In the localities where the topography is plain to gentle, the soil has thick profile. The type of parent

material and the length of time to which the parent material is subjected to weathering, control the variation in the thickness of soil.

Generally, the soil deposited on the plain land of Adama is alluvial sediment and has longer deposition time. As can be deduced from the well log data of boreholes drilled in the town, the depth of the soil reaches up to 20meters around Melka Hida. (Teshome, 1999). According to the research done by Adama city project office the soil is analyzed and they classified the city in to zones (Grades) as the following:

- o *GRADE 1-plain to gentle slope covered with grayish soil and less susceptible to natural hazards.*
- o *GRADE 2-plain to gentle slope, covered with grey and reddish soil, rarely cut by gullies.*
- o *GRADE 3- gentle and undulating slope, highly dissected by gullies and covered with gray and black soil.*



Source: Adama City Project

Figure 3.2 Soil description map of Adama city

3.2.3CLIMATE AND HYDROLOGY

The Adama city is located within the Awash River basin. The main parameters considered hydrological Aspect are rainfall, humidity, sunshine hours and wind speed.

3.2.3.1 RAINFALL

The rainfall recorded at Adama meteorological station for the past 49 years (1953- 2001) indicated that the average annual rainfall is about 866.25 mm. The maximum monthly average rainfall is about 200 mm. Most of the rain occurs in summer season (June to September). Rainfall intensity data is not available for Adama city. Thus, the data recorded at the nearby station of Bishoftu, Kulumsa and Metehara is adapted. Accordingly, the average of maximum intensity of rainfall in the three stations for the past 27 years (1975-2002) is about 39.7 mm/hr (NMSA, 2002).

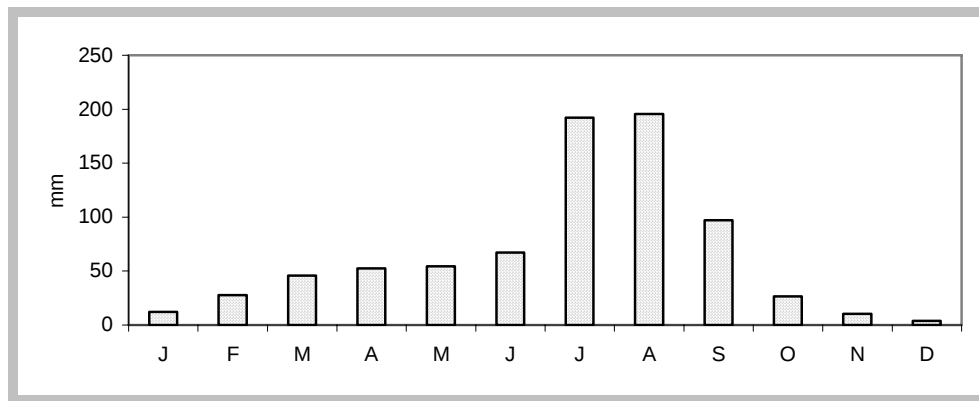


Figure 3.3 Mean monthly rainfall of Adama

3.2.3.2 TEMPERATURE

The mean annual temperature is 21°C. It can be classified as semi-humid to semi-arid climate, which characterizes the altitude range between 1300 to 1800m a.s.l. In Adama the hottest month with the maximum mean temperature of 31°C is May. The monthly minimum mean temperature is Nov & Dec with the temperature of 11.5°C. The maximum temperature varies between 25.8°C and 31°C while the minimum monthly values vary

between 11.5°C and 17°C .At Adama, the heavy truck movements could contribute to the increment of temperature due CO₂ input into the air (NMSA, 2002).

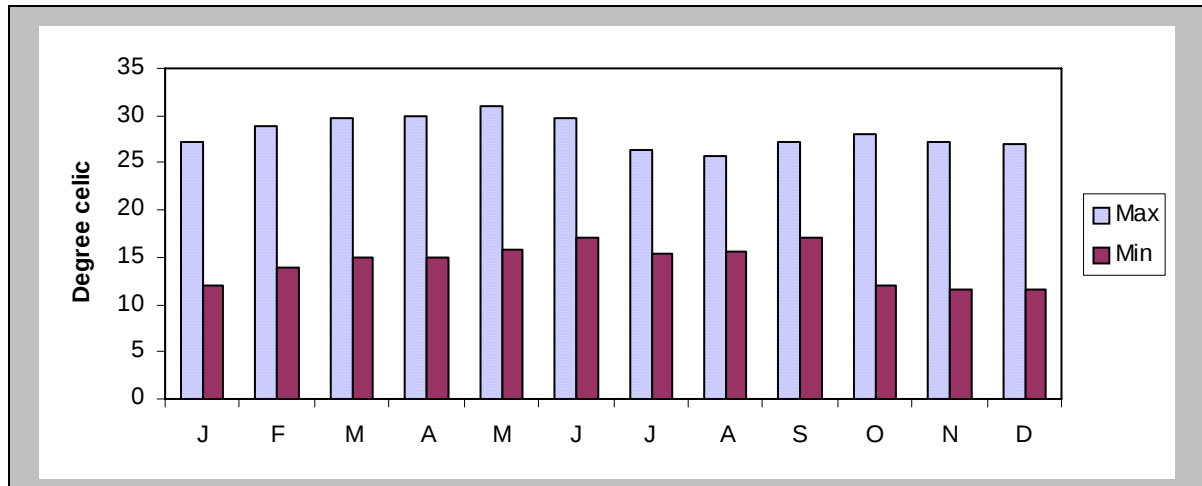


Figure 3.4. Minimum and maximum monthly temperature at Adama

3.2.3.3 WIND SPEED AND DIRECTION

The available wind speed measured five times a day at Adama station indicates that wind with minimum speed occurs during September (1.65m/s), while the wind with high velocity occurs during December, January and February (3.05-3.2 m/s). The values calculated over 10 years (1990 to 1999) indicate that mean is 2.31 m/s. Generally the wind speed at Adama is high. During summer month the wind speed portrays decreasing trend .In ten years period (1990-1999), the maximum wind speed recorded was about 10m/s.

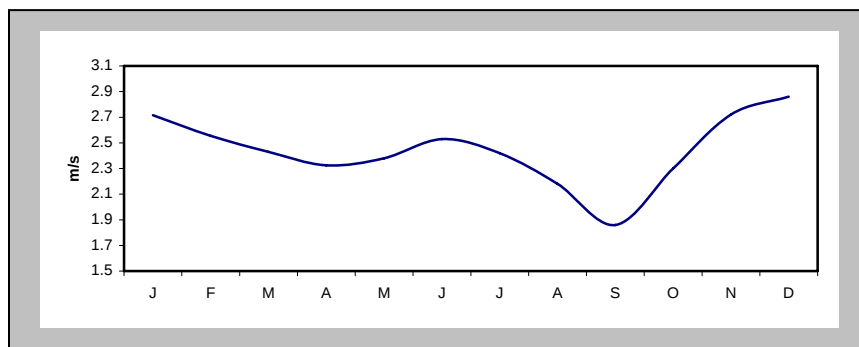


Figure.3.5 Monthly mean wind speed at Adama

The wind direction recorded five times a day in the past 10 years (1990-1999) indicates there is seasonal variation of wind direction. However, the prevailing wind direction of the town is North-easterly.

3.3 NATURAL HAZARDS

3.3.1 LANDSLIDES

Rockslides are common features observed around the city of Adama especially along the ridges exploited by quarrying activity. Small-scale rock fall at fault escarpment and continuous slump at valleys and stream channels are common. The presence of many fault escarpments, loose alluvial deposit and internal tectonic. In the city of Adama landslide prone areas are those located along ridges where quarrying activity is taking place (Alula, 1992).

The city and its environs are characterized by deep gullies called inverse gullies that are deep up stream and shallowing downstream that cut through loose tuff deposits. Since the nature of gullying is deep around the city, there is serious risk of sliding along the gullies that cause gully widening. Such activity consumes farmland by increasing soil erosion. The areas affected by erosional gullies are located around Boku, north of Adama (around cemeteries), and behind Migira ridge on the way to Wolenchiti (Teshome, 1999).

3.3.2 FLOODING

Adama is bounded by Kechema ridge in the west, Kurfagutu peaks on the north, Dibibisa and Migra ridge in the east and Boku ridge in the south. The city can be seen clearly from the surrounding ridges that provide fascinating panoramic view. It is located within the structural depression bounded by parallel scarps running in NE-SW direction (Getahun, 1987).

Generally elevation in the Adama catchment ranges from 1972 m a.s.l around Kechema ridge to about 1588m a.s.l. at the foot of Migra ridge. Many other scarps, ridges and domes stand above the low-lying land with significant elevation contrast.

The slope also varies between less than 1% around Migra plain to greater than 30 % around Kechema ridge. The average slopes of the city could be taken as 4 %. Many localities in the city are known to have zero slopes. The major proportion, more than 75 % of the city, can be represented between 1 to 10% slopes.

Flooding is a significant natural hazard in the Adama city attributed to its location within the flat lying rift. The main causes of flooding are heavy rain, high water table, and culvert damage or blockage (Getahun, 1987).

3.4 SOCIO ECONOMIC DESCRIPTION

3.4.1 POPULATION CHARACTERISTICS OF ADAMA CITY

Information on the size of the population of a region has become a very important tool on various grounds. This is mainly because of the fact that population has direct relationship with any development endeavor. Planning and implementation of development programs in health, education, infrastructure provision such as water, road, power, housing, etc requires data on the size and structure of the population of an area.

3.4.1.1 POPULATION SIZE AND DISTRIBUTION BY KEBELES

Population distribution by Kebele presented showed that the population of the City is unevenly distributed. Kebele 011 accounts the highest population size making 14.7 % of the total urban population followed by Kebele 010 (13.24 percent); Kebele 09 (9.26 percent) and Kebele 016 (6.54 percent). On the other hand, Kebeles accounting less than 3 percent of the total population are Kebele 05 (2.03 percent); Kebele 08 (2.36 percent) Kebele 018 (2.75 percent) and Kebele 019 (2.78 percent). As you can see on the table Most of the Kebeles account less than the average (5 percent) of the total urban population. (CSA, 1996)

Table 3.1. Population Distribution of Adama by Kebele, 1994

Kebele	Both Sex		Males	Female
	No	%		
01	3,744	2.93	1,807	1,937
02	4,672	3.65	2,102	2,570
03	4,895	3.83	2420	2,475
04	4,747	3.71	2177	2,570
05	2,595	2.03	1562	1,033
06	4,117	3.22	2089	2,028
07	4,251	3.33	2170	2,081
08	3,014	2.36	1473	1,541
09	11,838	9.26	5633	6,205
010	16,930	13.24	8459	8,471
011	18,843	14.74	9171	9,672
012	5,473	4.28	2508	2,965
013	5,671	4.44	2722	2,949
014	5,744	4.49	2665	3,079
015	5,886	4.60	2586	3,300
016	8,360	6.54	4180	4,180
017	4,297	3.36	2077	2,220
018	3,519	2.75	1528	1,991
019	3,548	2.78	1692	1,856
020	5,698	4.46	2944	2,754
Total		100.0		

Source: - CSA, 1994 Census

Previously there were 20 kebele in the city, this restructured into 14 kebeles currently kebele boundary of the city is structured in new kebele boundary, the populations of the city in the new kebeles are mentioned in table 3.2.

Table 3.2: Population and Population density per kebele in the year 2003

No.	Kebele Name	Population	Population density
1	1	12,580	0.0017
2	2	15,505	0.0036
3	3	9,364	0.0069
4	4	15,757	0.0095
5	5	11,501	0.037
6	6	13,534	0.025
7	7	11,883	0.014
8	8	18,960	0.038
9	9	18,981	0.0049
10	10	18,127	0.0023
11	11	18,209	0.0037
12	12	13737	0.0033
13	13	12,401	0.0066
14	14	17,577	0.0036
Total		208,116	

Source: computed from document of AMPPD, 2003

3.4.1.2 HOUSEHOLD SIZE

Data on household size and distribution of persons per household can be used as a proxy measure of crowdedness of a population and has a great implication to housing problem. The 1994 Census results presented in Table 3.2 for Adama City shows that there were 26,516 conventional households and 25015 housing units accommodating 127, 842 persons. Thus, the average households in Adama City were found to be 4.82 persons per household which is relatively larger than the average number of household size for urban areas of Oroimya that is 4.5 (CSA, 1996).

The distribution of households and housing units by Kebele as provided below in Table 3.2 indicates that, Kebele 05 has the highest average household size followed by Keble 016,

19, and 20. The remaining Kebeles more or less has average household size not very much different from the average household size of 4.82.

Table 3.2 Distribution of Households and Housing Units of Adama by Kebele, 1994

Kebele	Population	Households		Average Household Size	Housing Units		Households Per Housing Unit
		No	%		No	%	
01	3,744	785	2.96	4.77	763	3.05	1.029
02	4,672	1030	3.88	4.54	1003	4.01	1.027
03	4,895	1027	3.87	4.77	990	3.96	1.037
04	4,747	1073	4.05	4.42	1043	4.17	1.029
05	2,595	463	1.75	5.60	367	1.47	1.262
06	4,117	857	3.23	4.80	836	3.34	1.025
07	4,251	882	3.33	4.82	743	2.97	1.187
08	3,014	662	2.50	4.55	600	2.40	1.103
09	11,838	2432	9.17	4.87	2351	9.40	1.034
010	16,930	3542	13.36	4.78	3209	12.83	1.104
011	18,843	3784	14.27	4.98	3631	14.51	1.042
012	5,473	1193	4.50	4.59	1141	4.56	1.046
013	5,671	1158	4.37	4.90	1120	4.48	1.034
014	5,744	1228	4.63	4.68	1085	4.34	1.132
015	5,886	1282	4.83	4.59	1227	4.90	1.045
016	8,360	1633	6.16	5.12	1545	6.18	1.057
017	4,297	903	3.41	4.76	878	3.51	1.028
018	3,519	760	2.87	4.63	740	2.96	1.027
019	3,548	697	2.63	5.09	675	2.70	1.033
020	5,698	1125	4.24	5.06	1071	4.28	1.050
Total	127,842	26,516	100.00	4.82	25018	100.00	1.060

Source: - CSA, 1994 Census

3.4.1.3 MIGRATION

Information on migration of a population is of direct interest to planning and implementing agencies, because migration has a direct effect on the geographic distribution of a population. Moreover, it has an interaction with other demographic forces as well as other aspects of socio-economic change. In the 1994 census two, migration related questions

were asked. These questions were length of continuous residence and place of previous residence. Both questions are useful to measure the magnitude of migrant population to the city (CSA, 1996).

In this study migrant and non-migrant population of Adama City are classified by considering these questions. The level of migration and its demographic implication to the growth of the population of Adama City is therefore inferred from this premise.

According to the 1994 census the total migrant population to Adama City was 67,632 while non-migrant was 58,459. This means that migrant population constituted about 53 percent of the total population of Adama. This implies that migration contributed large to the population growth of the City in the period stated. The level of internal migration by sex showed that 46 percent of the males and females were non-migrants, while the remaining 53 percent were migrants (CSA, 1996).

Table 3.3 Population Distribution of Adama City by Migration Status, 1994.

		Migration Status					All persons
		Non-migrant		Migrant		Not stated	
1984	Male	17381	(48%)	18932	(52%)	53	36,366 (100.00)
	Female	18374	(45)	22550	(55%)	29	40953 (100.00)
	Total	357, 55	(46%)	41,482	(54%)	82	77,237 (100.00)
1994	Male	28,219	(46%)	32,561	(53%)	504 (0.8%)	61,284 (100.0)
	Female	30,240	(46%)	35,071	(53%)	506 (1%)	65,817 (100.0)
	Total	58,459	(46%)	67,632	(53%)	1,010 (.8%)	127,101 (100.0)

Source: - CSA, 1994 Census

CHAPTER FOUR

URBAN GROWTH OF ADAMA CITY

4.1 ESTABLISHMENT AND GROWTH OF ADAMA CITY

Adama was established as a Railway station depot in 1916. It is located at a distance of 100km south east of Addis Ababa. Its establishment and location have been influenced by many different factors. Conducive economic, social and geographical conditions are the crucial factors for the rise and development of the city. The Italian occupation, which lasted from 1936-41, made a great deal of contribution to the development of Adama. During their stay in the town, the Italians carried out a number of construction works such as road, transport, communication and the likes, which accelerated the growth of the town.

The expansion of transportation and communication and the development of infrastructure services and facilities such as education, health, water supply, electricity supply, and recreation, have contributed a lot to the development of the city. The construction and improvement of roads from Addis Ababa via Adama to Wonji, Assela and Harar made the town a focal point of communication for travelers. It also created a favorable condition for city expansion and has greatly influenced its development pattern. In addition to these, the construction of the

- Tractor, and Garment Factory and RRC store;
- Adama (Abebe Bikila) Stadium,
- International standard hotels such as-Adama Ras, Bekele Mola etc; and Services such as Technical Teachers Training College, TTI the following important landmarks that influenced the development of Adama.

The good geographical location and favorable climatic situations of Adama have contributed to the rapid expansion of the city as commercial, industrial, residential and recreational center. Among the major factors which have contributed to the growth and development of the city and the neighboring region at large are also the Awash valley and its economic potential and prospective development. The construction of the Koka Hydro Electric power station in 1958 had also positive impact on the city. It improved the

agricultural economy and also met the electricity demand of industrial and urban users in Adama and its surroundings.

From time to time modernization in different fields particularly in the field of health, education and communication which led to the erection of new buildings. For instance, Galawdiwos School and Hailemariam Mamo Hospital were built in 1948 and 1964 respectively.

Adama has now developed into a sizeable town of area 4320 ha. Due to its strategic location along the railway line that connects the port of Djibouti with Addis Ababa and at the junction of major routes to Addis Ababa, Arsi, Harar and other hinterland areas of high economic importance, Adama has a great development potential and is also expected to play a major role in the systematic and integrated development of the nearby urban and rural areas.

In view of above factors, in the present study an attempt has been made to assess the city expansion over a period of 40 years and to evaluate the impact of change using GIS and Remote Sensing techniques. The results and discussions are summarized in the following sections.

4.2 ANALYSIS AND RESULTS

4.2.1 BUILT UP EXPANSION OF ADAMA CITY (1965-2004)

The city of Adama is rapidly expanding since its establishment. In this study, an attempt has been made to compute the built up expansion of the city between from 1965 to 2004. To identify the magnitude of the city's area expansion multi temporal Aerial photographs and Satellite image (IKONOS) were used to identify the horizontal expansion of the city. Hence the built up area of the city was extracted (digitized) from Aerial photograph of 1965 taken on 20 February, 1965, R-157, Aerial photograph of 1972 taken on 10 January, 1972, 123 ET16 and from IKONOS image 1m resolution of the year 2004.

▪ **Stereoscopic Viewing , Georeferencing, Subsisting and Mosaicing**

The Aerial photographs of 1965 were first viewed stereoscopically through mirror stereoscope to generate 3D model to see the features of the city and to view the built up areas. After careful observation of the extent of the built-up area, these photographs are scanned to bring in GIS and Digital Image Processing (ERDAS) environment. Each of the scanned photographs was referenced using geo-referenced topographical maps of the study area. Common features both on maps and photographs are selected as ground control points and image to image rectification has been carried out using nearest neighborhood re-sampling technique. Same procedure is followed to geo-reference second photograph. The two geo-referenced consecutive photographs are mosaiked to make a single photo and extracted with respect to the city area boundary eliminating out side area. Figure:-4.1 show the aerial photograph of the year 1965 showing city area.

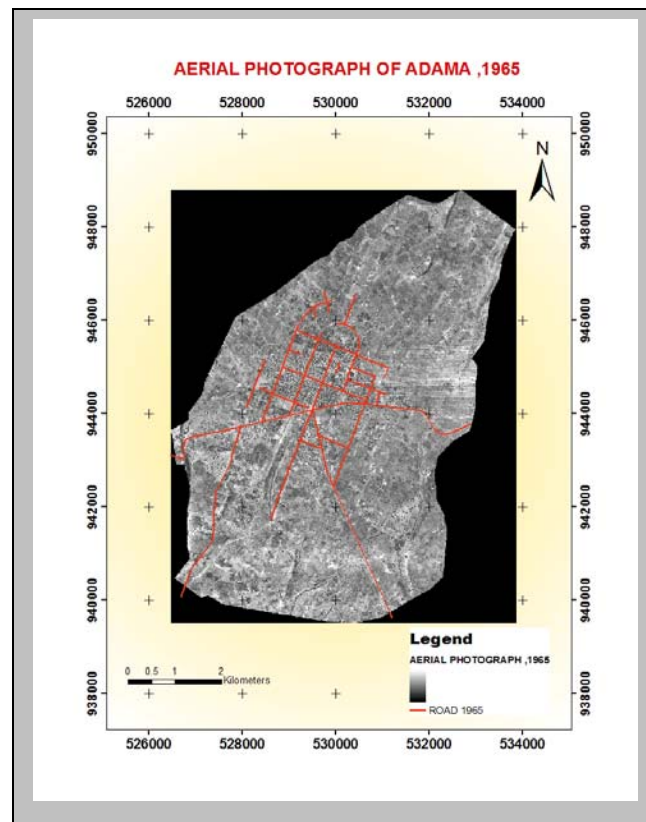


Figure 4.1: Aerial photograph of Adama, 1965

Similarly, 1972 Aerial photograph of the city has been viewed stereoscopically using mirror stereoscope and interpreted to identify different features and their spatially extent. These photographs are again scanned to bring in GIS and DIP domain and geo-referenced using topographic map of the city on 1: 50,000 scale (of 1986). Two referenced photos are mosaiked and again extracted with respect to city boundary as done in previous case removing external areas. Figure: 4.2 show the aerial photo of the year 1972.

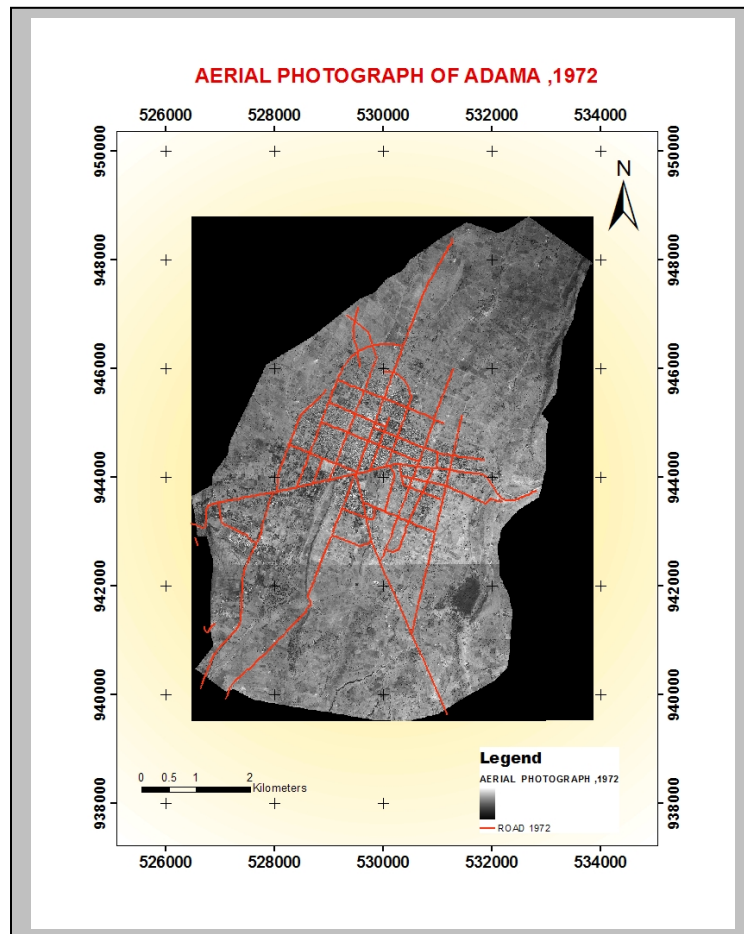


Figure4.2: Aerial photograph of Adama city, 1972

The other source of data that was used in this study for horizontal urban expansion is satellite image (IKONOS image:-3 bands - blue, green and red, 1 meter spatial resolution)

of the city taken in the year 2004. This image was first georeferenced using topographic map of the city on 1: 50,000 scale (Topographic map to image registration) and then mosaic ked and clip with the existing city boundary.

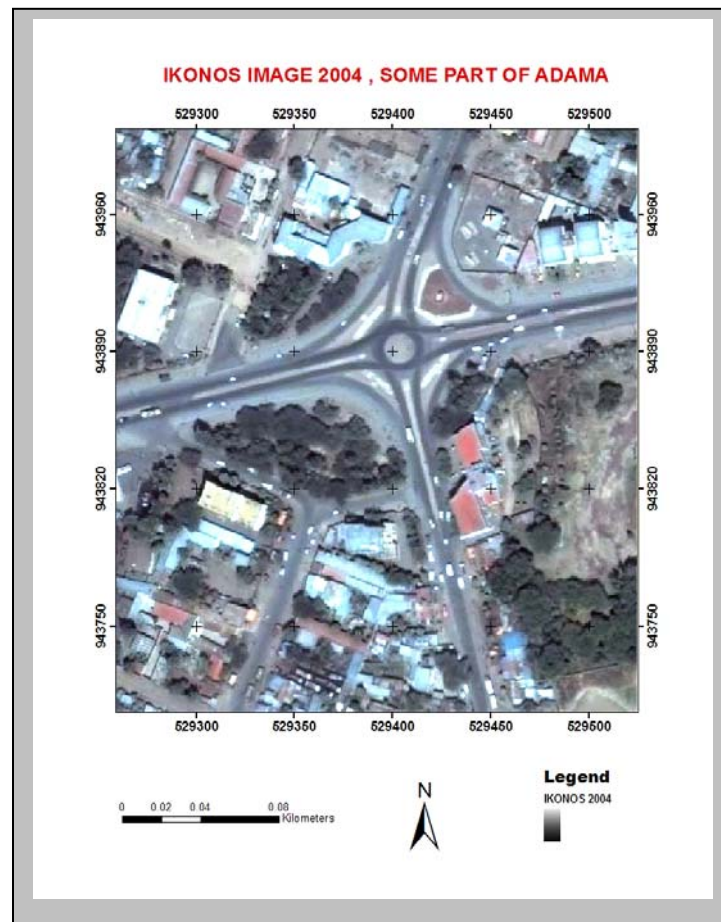


Figure4.3: IKONOS image some part of Adama city, 2004

4.2.1.1 MAGNITUDE OF URBAN EXPANSION (1965-1972)

Geo-referenced and mosaiked aerial photograph of the year 1965 was used to extract information i.e. built up area of the city. This photograph was opened in ArcGIS as a backdrop and entire built up area were digitized to produce the urban spatial structure of

the city (built up area of the city) in the year 1965. The digitized layer was edited to remove any errors and subjected to topology creation in order to create boundary relationships between different built-up areas followed by area calculation for each built up land using ArcGIS 9.1. Figure 4.3 shows the distribution of built-up area in 1965.

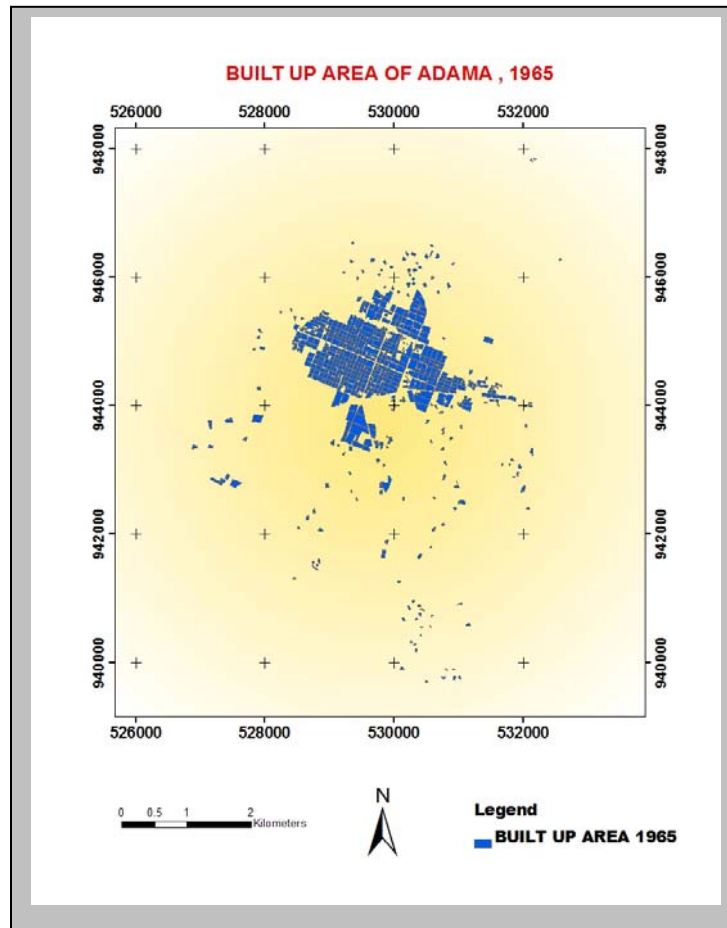


Figure4.4: Built up area of Adama city, 1965

Built up area of the city in 1965 was calculated to be 250 hectare (2.5 square kilometer) which is 5.6% of the total area of city i.e. 4460 hectare (44.6 square kilometer).

Similar techniques were followed on aerial photograph of 1972 to digitize the magnitude of built up land and to calculate its area using ArcGIS 9.1 in hectare. Figure: 4.4 show built-up land in 1972.

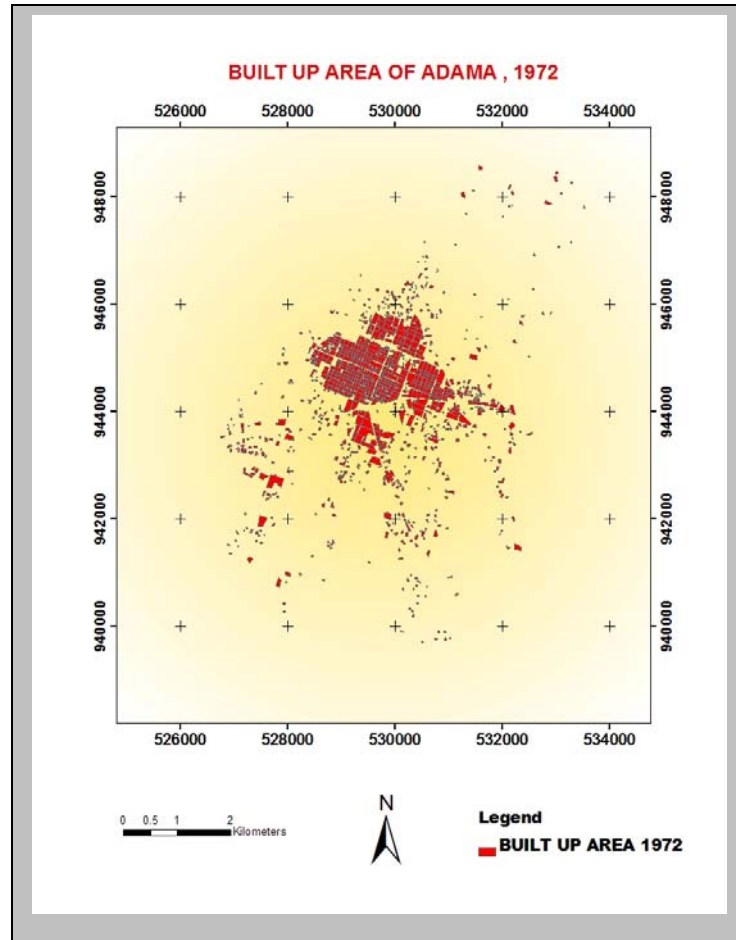


Figure: 4.5. Built up area of Adama city, 1972

The area of built up of the city in 1972 was calculated as 370 hectare (3.6 square kilometer) which is 8.3% of the total area of city i.e. 4460 hectare (44.6 square kilometer). The digitized output from the year 1965 and 1972 were compared to find the changes in the built-up area in a span of 7 years. The built up area expansion of the city between 1965 and 1972 was 120 hectare which is nearly 48% expansion. Figure 4.6 shows the built-up expansion map of the study area from 1965 to 1972.

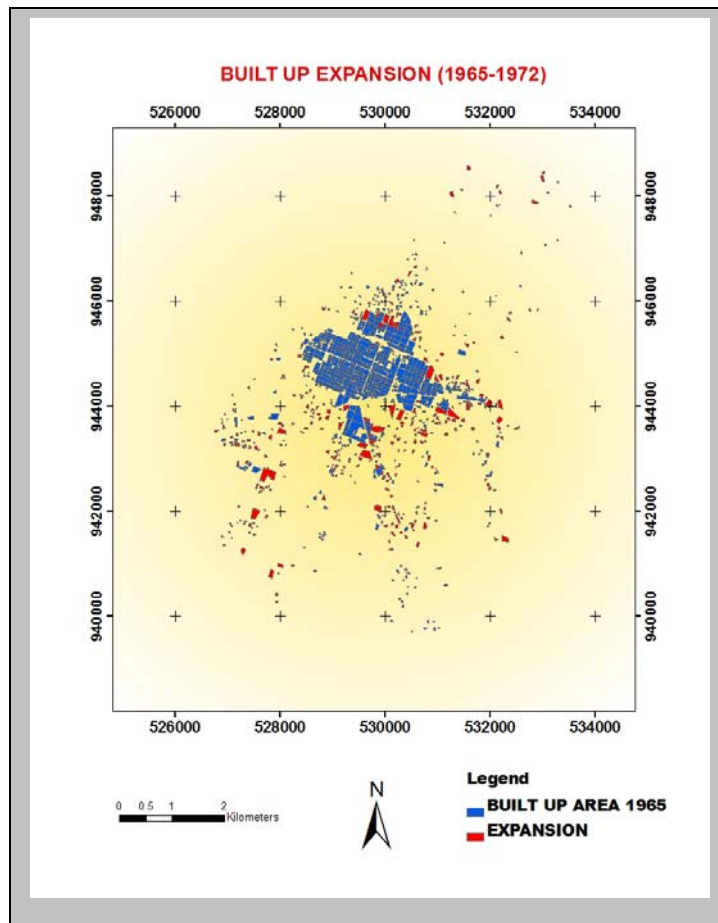


Figure4.6: Built up expansion of Adama, 1965-72

4.2.1.2 MAGNITUDE OF URBAN EXPANSION (1972-2004)

To quantify the built up area of the city same procedure was followed similar to that of extraction of built-up area for 1965 and 1972. From IKONOS image and master plan , structural plan of the city, 2004, entire built up area of the city in GIS atmosphere were digitized followed by area calculations for each digitized area using ArcGIS 9.1. Figure: 2.6 show the built-up area in 2004.

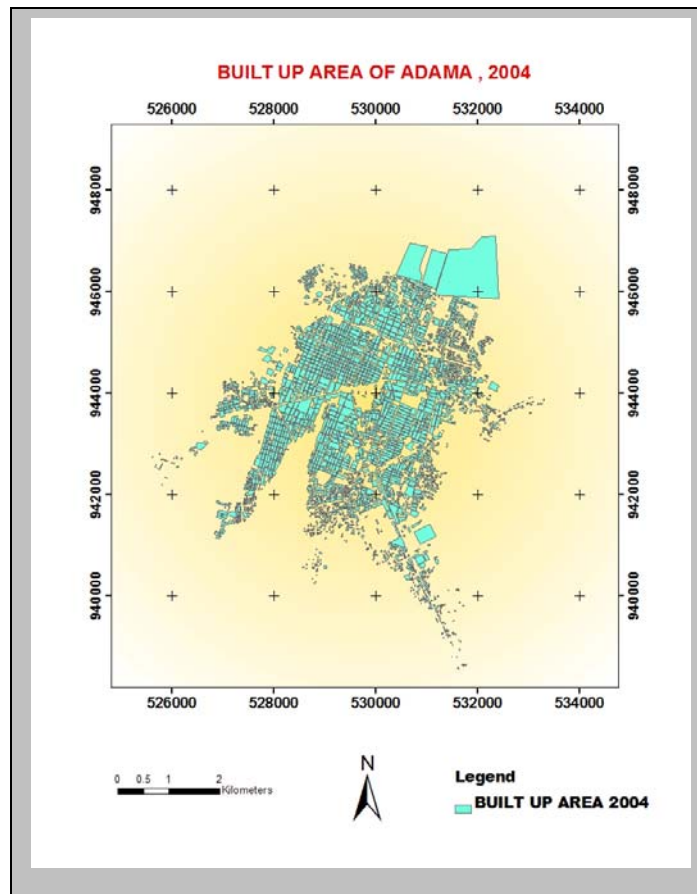


Figure 4.7 Built up area of Adama, 2004

There fore the area of built up of the city in 2004 was calculated as 1074 hectare (10.74 square kilometer) which is 24.1% of the total area of city i.e. 4460 hectare (44.6 square kilometer).

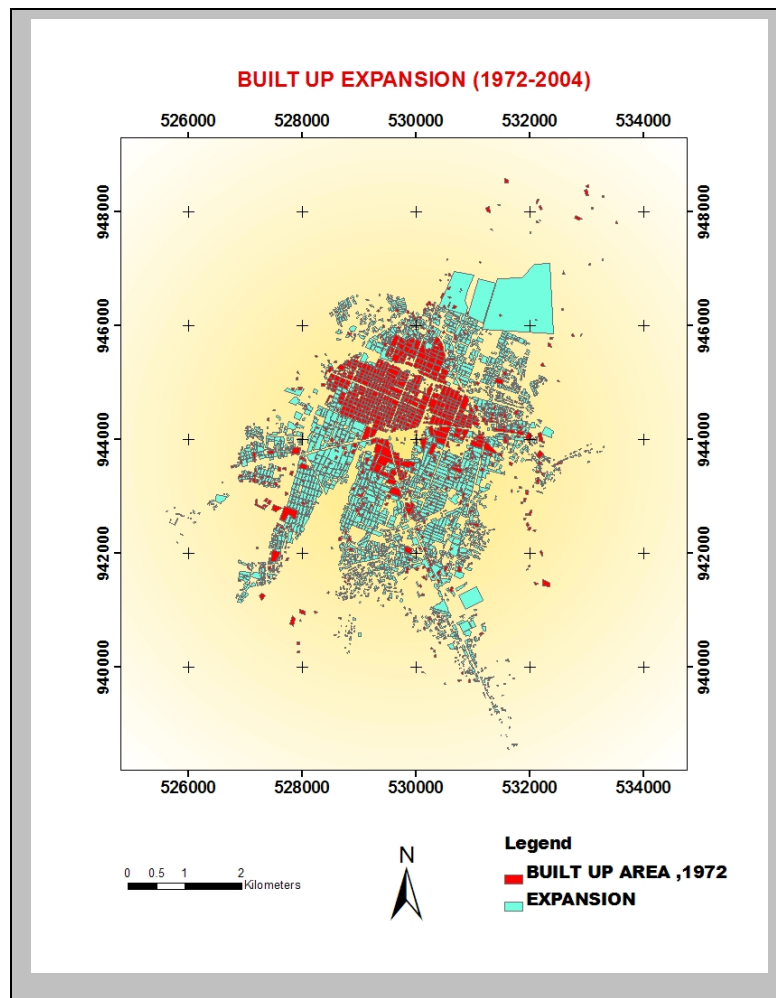


Figure4.8: Built up area expansion of Adama, 1972-2004

The built up area expansion of the city between 1972 and 2004 was 704 hectare which is 290.3% expansion. Table 4.1 shows the built-up area, their expansion and percentage expansion from 1965 to 1972 and from 1972 to 2004.

Table 4.1 Built up area Expansion of Adama city

NO.	YEAR	BUILT UP AREA	EXPANSION	EXPANSION%
1	1965	250 hectare	-	-
2	1972	370 hectare	120 hectare	48%
3	2004	1074 hectare	704 hectare	290.3%

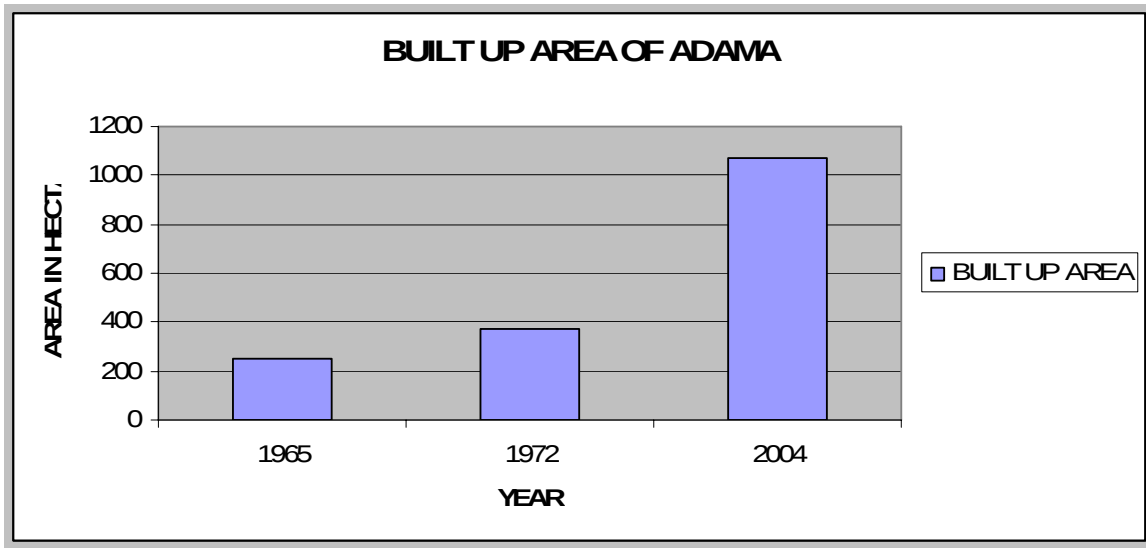


Figure 4.9: Built up area of Adama (1965-2004)

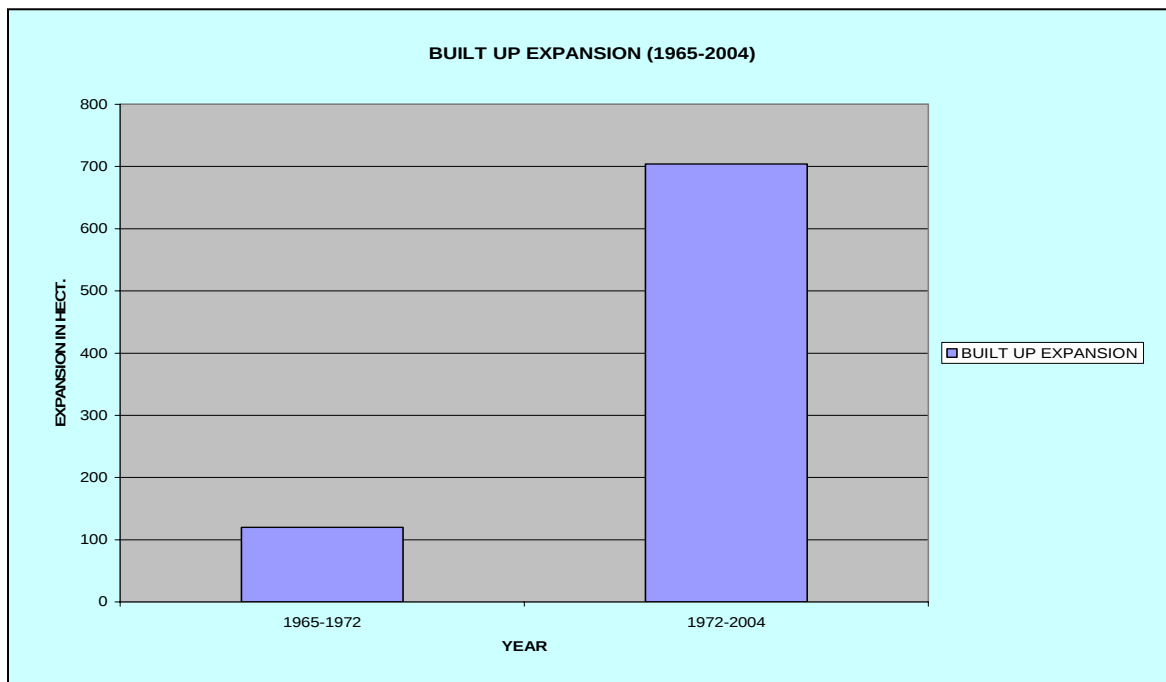


Figure: 4.10 Built up expansion of Adama (1965-2004)

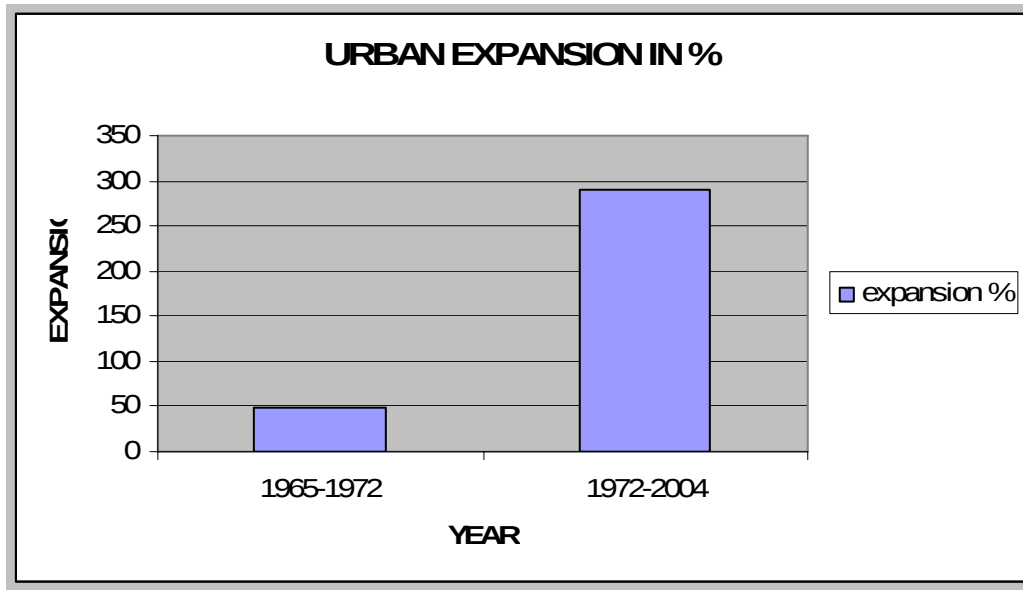


Figure4.11: Built up expansion in %

4.2.1.3 URBAN EXPANSION ESTIMATION IN 2020

Based on the urban expansion of city for the last 39 years the average growth rate of the expansion has been calculated .The average growth rate of the expansion is calculated as 4.07%. The Urban expansion of the city is estimated for 2020 by using the exponential growth formula:

$A_f = A_b * (1 + \% / 100)^{(f-b)}$ where: A is the Built up area, f is the future year, b is the base year and $\%$ is the average growth rate per year. There for the urban expansion of the city is estimated as 1905.158 Hectare in the coming 2020 it is increased by 831.158 hectare from 2004 which means 77.4 % expansion. To see the trends of the expansion from 1965-2020 it is presented as line graph in the Figure: 4.12 below.

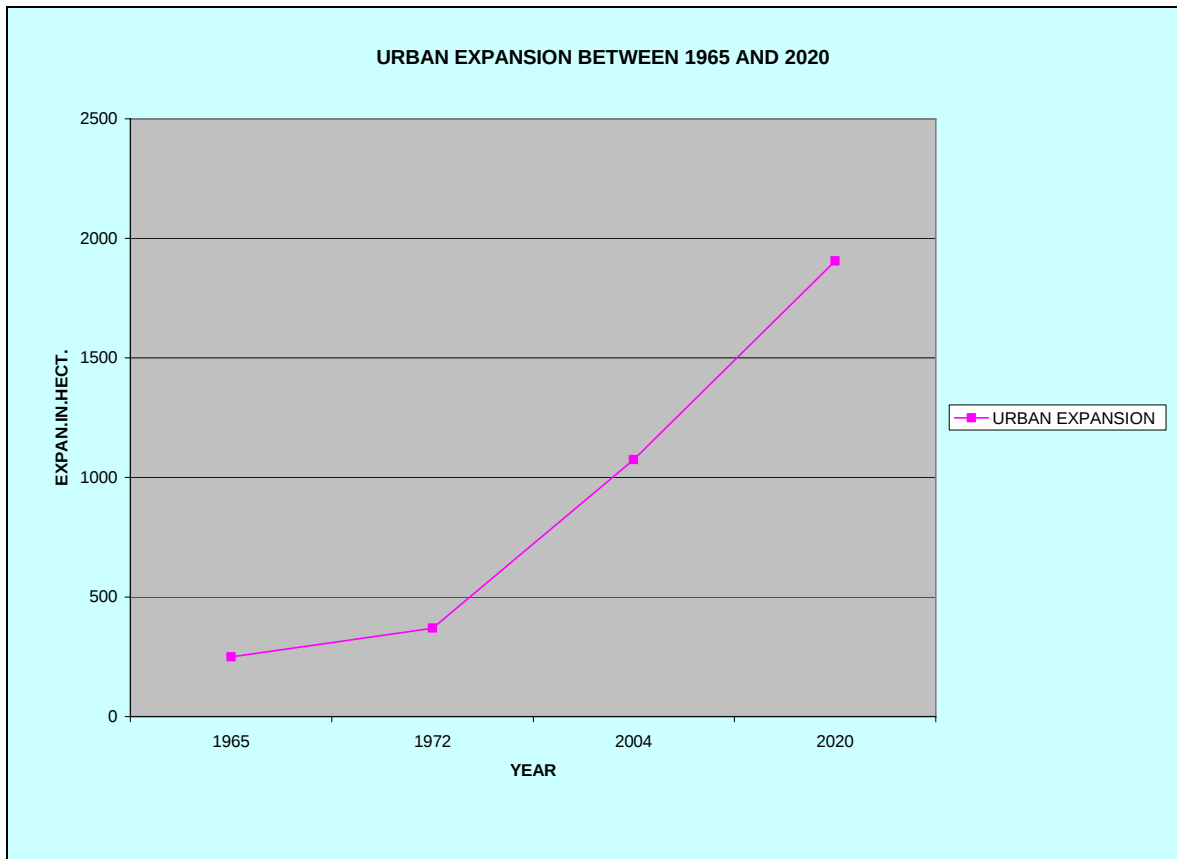


Figure 4.12 Urban expansion estimation for 2020

4.2.2 ROAD NETWORK EXPANSION (1965-2004)

Road network is one of the elements of structure of a city where transportation network, especially, passenger transport has strong impact on the patterns of urban land use. Healthy development of any urban center basically requires well-structured transport Infrastructure or network of roads and effective services of transportation. The general street pattern of Adama is an iron-grid type of network, which is based on the alignment of the railway line from where the city's establishment is originated (AMRP, 2004).

In the general pattern of street hierarchy, the north- south direction is dominant in having major streets of the network. Accordingly, the southern part of the city has two principal arterial streets branching from the Addis Ababa -Dire Dawa Road and two roads of sub-arterial level where the northern part has one principal arterial and two sub-arterial roads again branching from the Addis Ababa -Dire Dawa road. In addition, there are about 10 collector streets linking different parts of the city from north and south to the main east–west line.

On the other direction or in the east-west direction of the network, the single most important road is the Addis Ababa -Dire Dawa regional line where there is no continuous arterial or sub arterial road except some four-collector roads which lack continuity and resulted in missing links in the network. In general, the southern part of the city is very weak in east-west directed roads (AMRP, 2004).

4.2.2.1 MAGNITUDE OF ROAD EXPANSION (1965-72)

To quantify the road net work expansion of the city from 1965-1972, Aerial photograph of 1965 and 1972 were used. Once the 1965 Aerial photograph was georeferenced, mosaic and clipped with city boundary, the road network was digitized from the photo followed by building the topology to clear errors during digitization and to ensure that all the roads are linked at the intersection point. Figure: 4.14 show the road network in the year 1965.

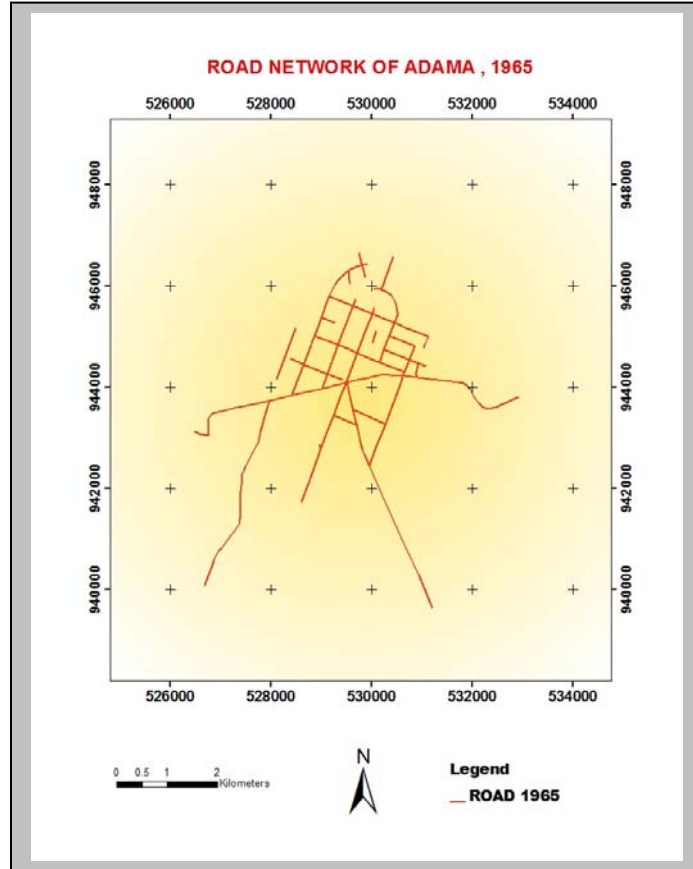


Figure4.13 Road network of Adama, 1965

Similarly, road network of 1972 was digitized using Aerial photograph of the same year followed by editing and topology creation. Figure: 4.15 show the road network in the year 1972.

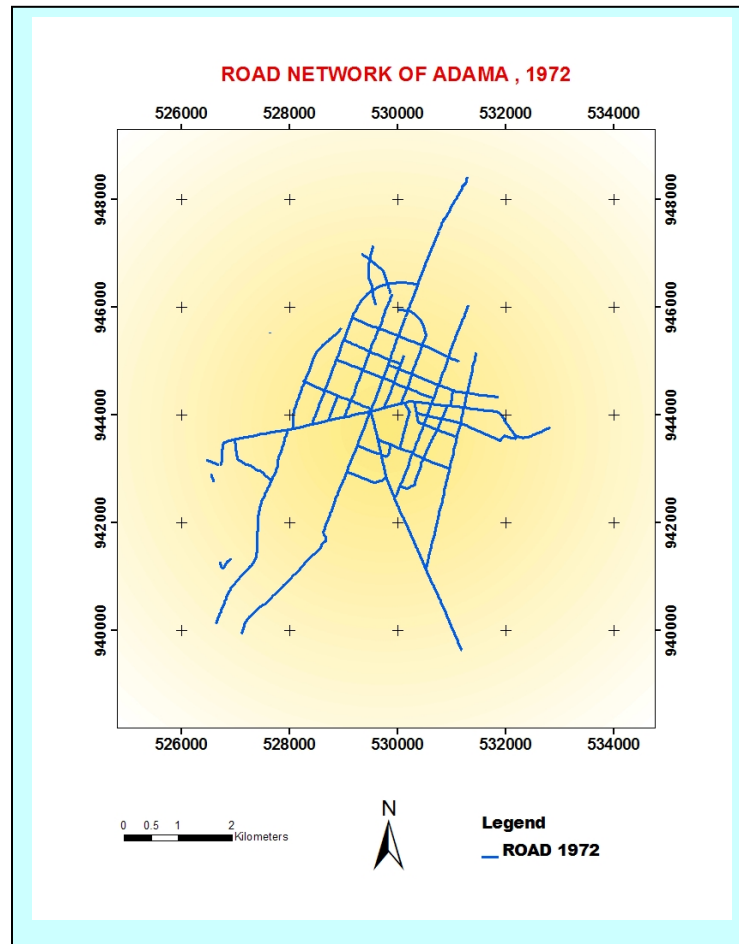


Figure4.14 Road network of Adama, 1972

After digitizing road network of Adama city of 1965 and 1972, road lengths were calculated using ArcGIS 9.1 and the road length of 1965 and 1972 were found to be 41.1 km and 72 km respectively, that is, the road length was increased by 30.9 km (54.8%). The two roads were superimposed one over another and new roads appeared on 1972 photo were marked as road expansion. Figure: 4.16 show the road expanded in the year 1972 as compared to that of 1965.

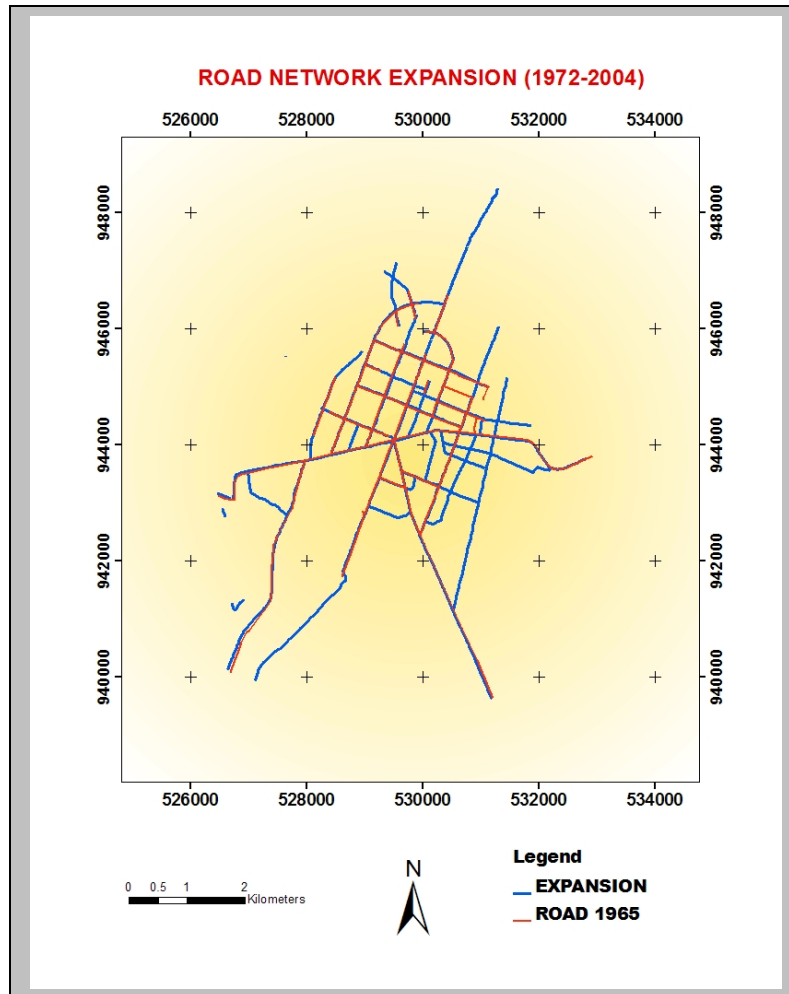


Figure4.15 Road expansion in length of Adama city, 1965-1972

4.2.2.2. MAGNITUDE OF ROAD EXPANSION (1972-2004)

For road network of 2004 IKONOS image of the city was used. After all pre processes done the roads were digitized followed by categorizing various road sub type in order to differentiate the types of roads in the city. Total road lengths were calculated to be 160.3 km out of which 45.2 km were Principal Roads, 86.4 km were Collector Roads and 28.7 km were Local Streets. The following classifications of road types were based on the master plan of Adama city policy.

Principal arterial streets are those for higher traffic volume and speed. The right of ways of these roads varies from 25m to 50m depending on the level of importance of the road and existence of constraints.

Collector roads are partially controlled streets and are intended for medium level traffic volumes.

Local streets are access roads where there is variation between those sharing services of collector road and the cul de-sac.

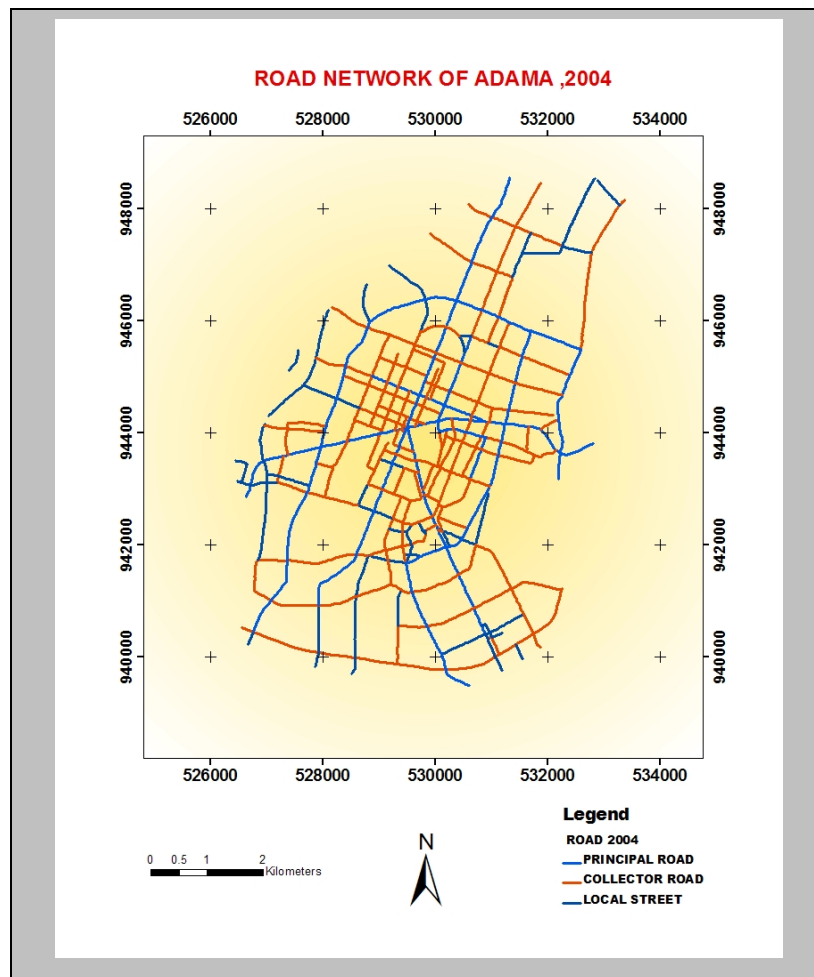


Figure4.16 Road network of Adama city, 2004

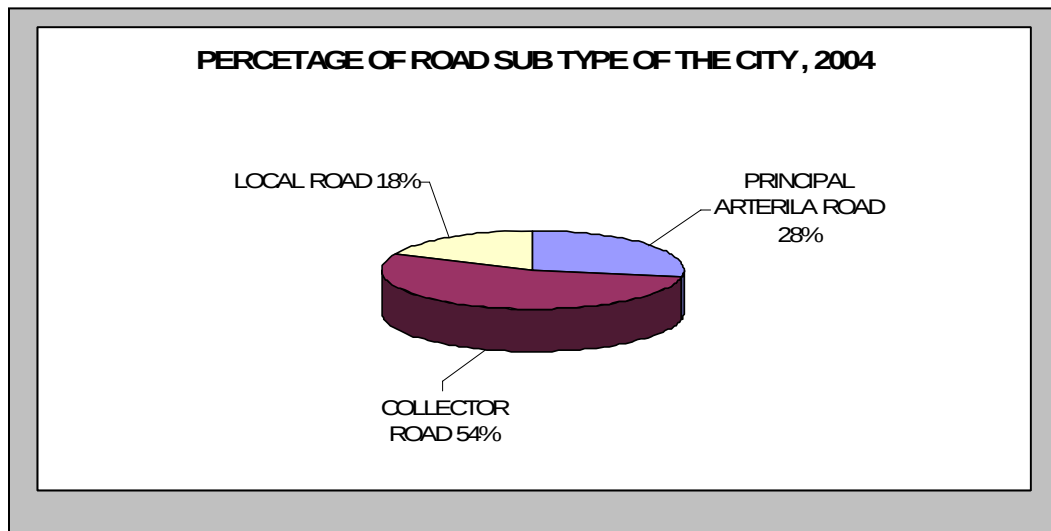


Figure 4.17 percentage of Road sub type of the city, 2004

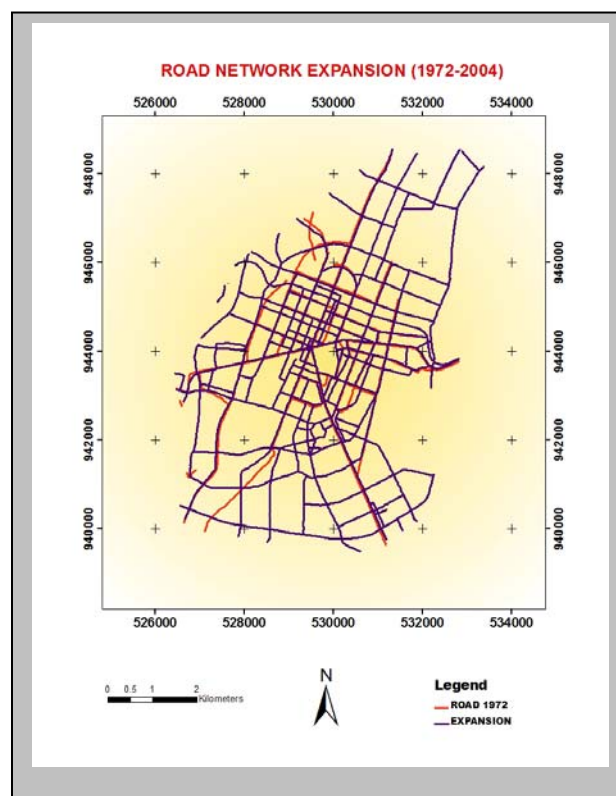


Figure 4.18 Road expansions in length, 1972004

The road Network expansion of Adama city from 1972-2004 was quantified in terms of length. From 1972-2004 the road length was increased by 88.3km.

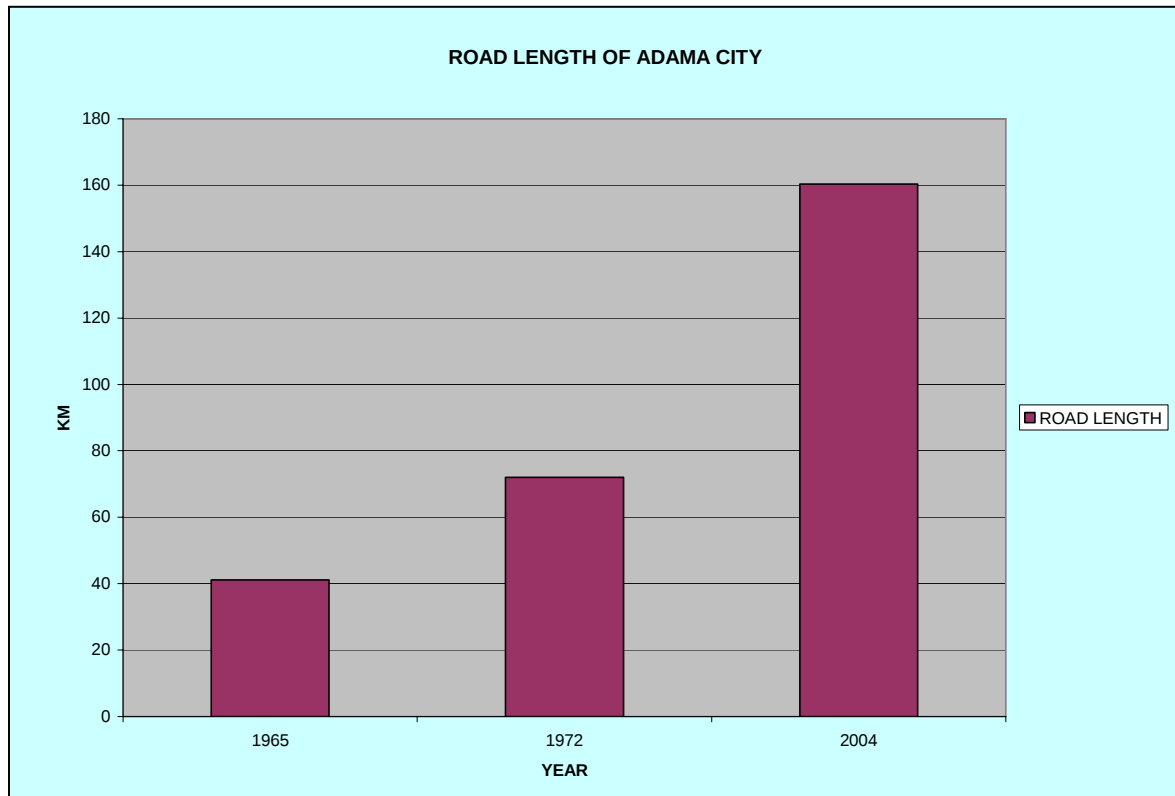


Figure4.19 Road network in length of Adama city (1965-2004)

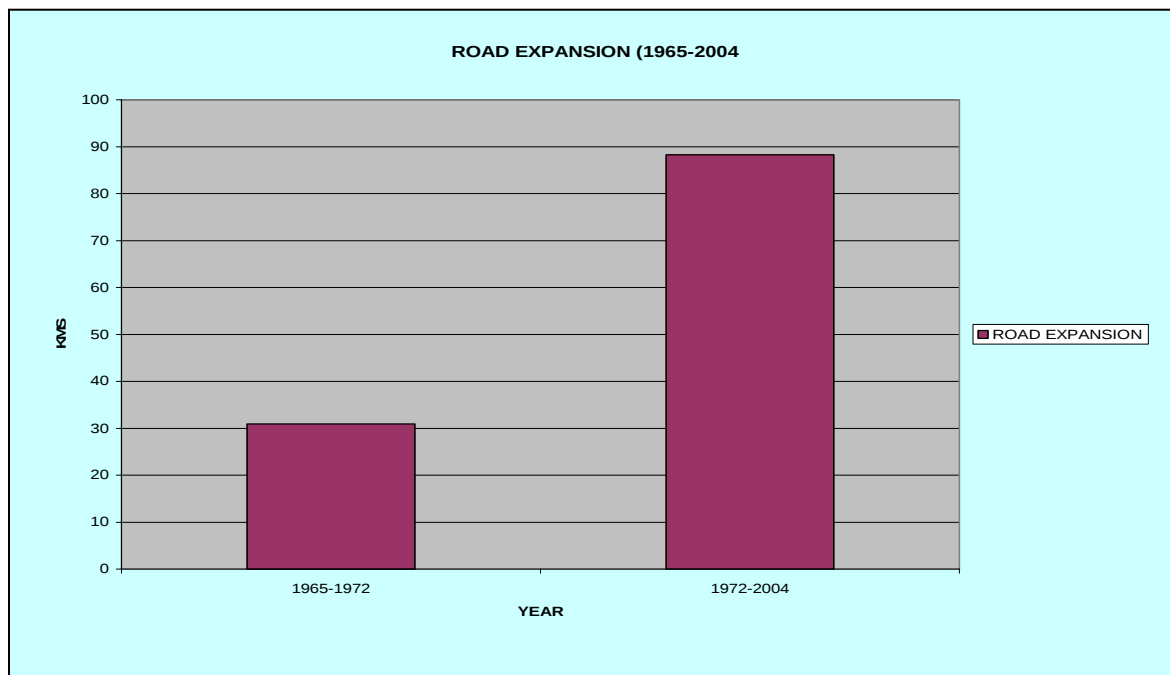


Figure 4.20 Road expansions in Length

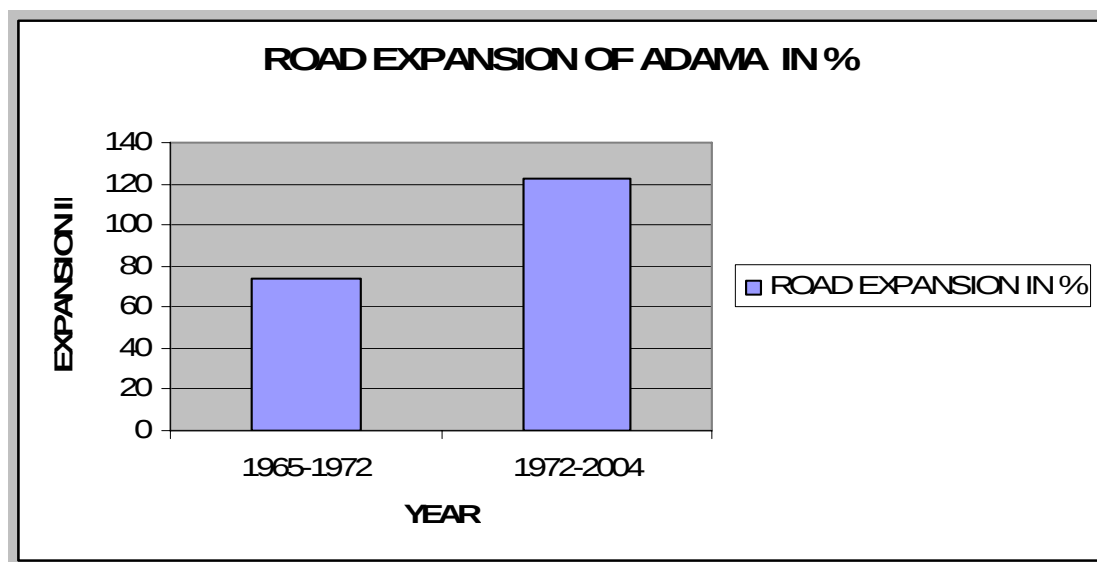


Figure4.21 Road expansion in %

Table 4.2 Road network in Length of Adama

NO.	YEAR	ROAD IN LENGTH	EXPAN.IN.LEN.	EXPANSION%
1	1965	41.3km	-	-
2	1972	72km	30.3km	74.3%
3	2004	160.3km	88.3km	122.6%

4.2.3 POPULATION GROWTH IN THE CITY (1965-2004)

In this sub topic, it has been attempted to show population growth as the underlying causes for the expansion of the city .Because of proximity to Addis Ababa, relatively developed transport network, trade, commercial and small scale manufacturing industries and other factors Adama attracted large number of population from different part of the country.

In 1964 the population of the town was estimated to be 27,812. This figure reached about 39,221 in 1977. The results of the 1984 census revealed that the population of Adama reached to 77,237, while the 1994 census counted a total population of 127, 842. This would mean that with an average growth rate of 5.4 percent per annum, the population of the city grew by 50,605 between the two census periods. The population of the city had been growing at a rate of 6.1 and 3.6 percent within the periods 1964-1977 and 1977-1984 respectively. The average growth rate for the entire period (1964-1994) was 5.1. The trends in the rate of growth generally indicate the persistence of high population growth of the city, which is likely to continue given the prevailing rate of growth.

Table 4.3 Population and Rate of growth in Adama

Population						Rate of Growth percent)			
1964	1970	1977	1984	1989	1994	1964-77	1977-84	1984-94	1964-94
27,812	39,221	61,510	77,237	94,184	127,842	6.1	3.6	5.4	5.1

Source: Adama Project Office

The Demography and Population Study of Adama Project Office shows that the population of the city will continue to increase at a rate of 3.8% until the end of the planning period, which is decided to be 10 years after the completion and approval of the revised Structure Plan.

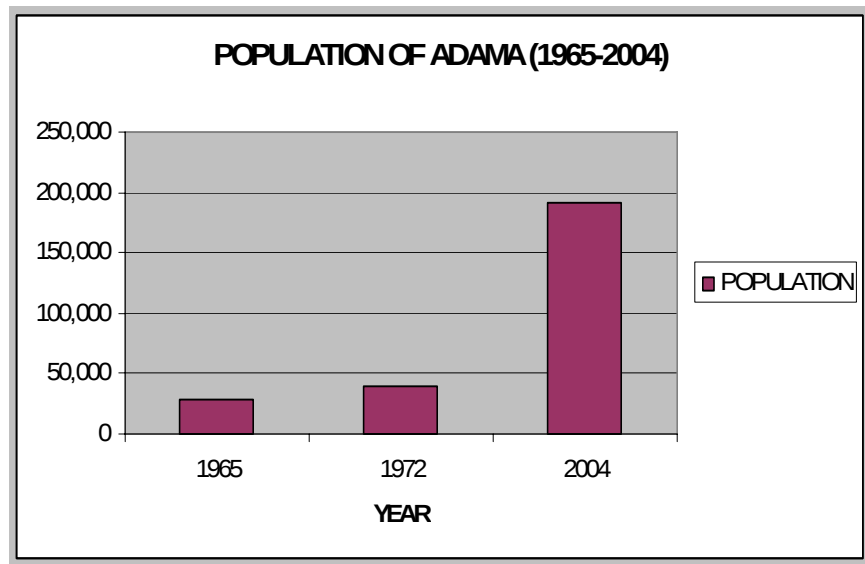


Figure 4.22 Population of the city (1965-2004)

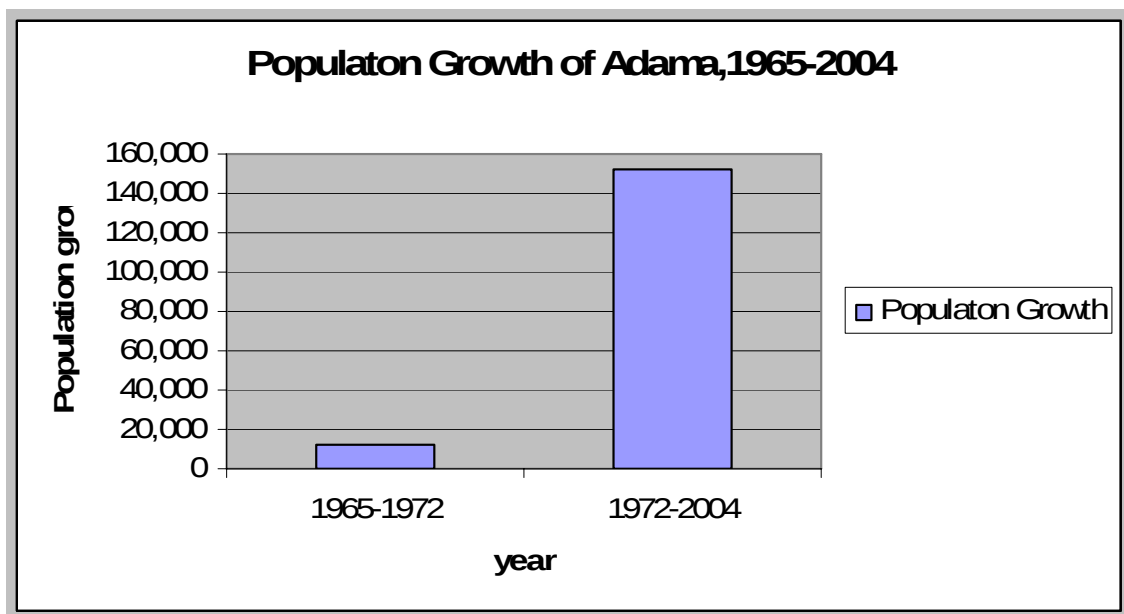


Figure4.23population growth between 1965 and 1972

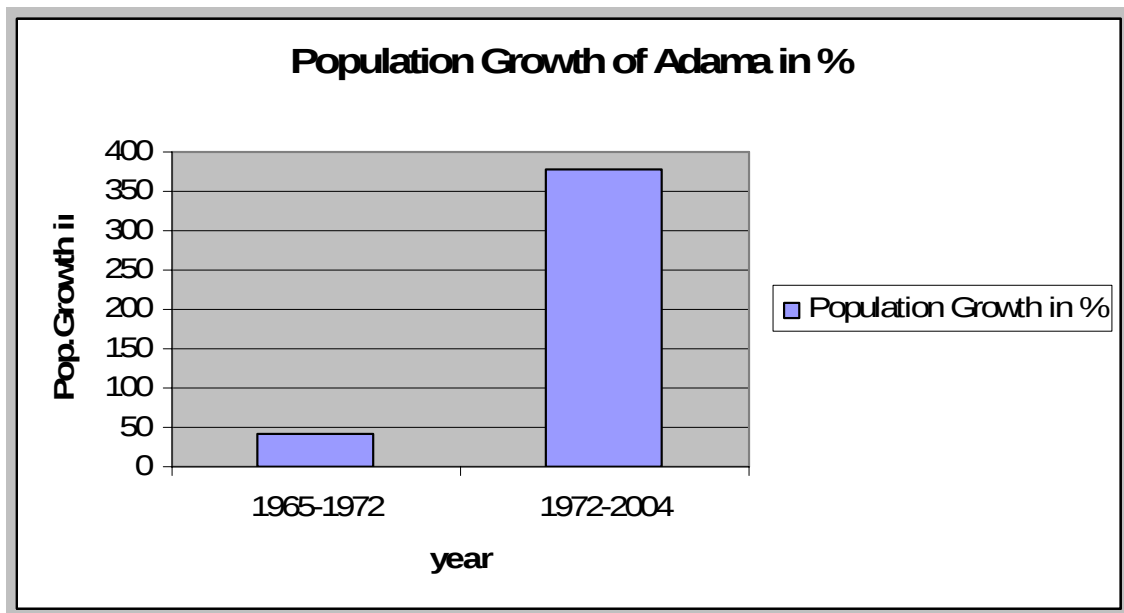


Figure 4.24 Population growth of Adama in %

4.2.3.1 COMPARISON OF POPULATION GROWTH VS URBAN EXPANSION

It is obvious that population growth has a direct impact on urban expansion. In this case when the population of the city in 1965 is 27,812 the built up of the city was 250 hectare. The population was increased to 40,221 in 1972 like wise the built up was expanded to 370 hectare. In 2004 the population becomes 208,116 and the built up was expand to 1074 hectare. From 1965-1972, the population of the city was increased by 44.6%. From 1972-2004 it was projected by 377.7%. The built up area of city was increased by 48% from 1965-1972 and it was tremendously expanded by 190.3% from 1972-2004.

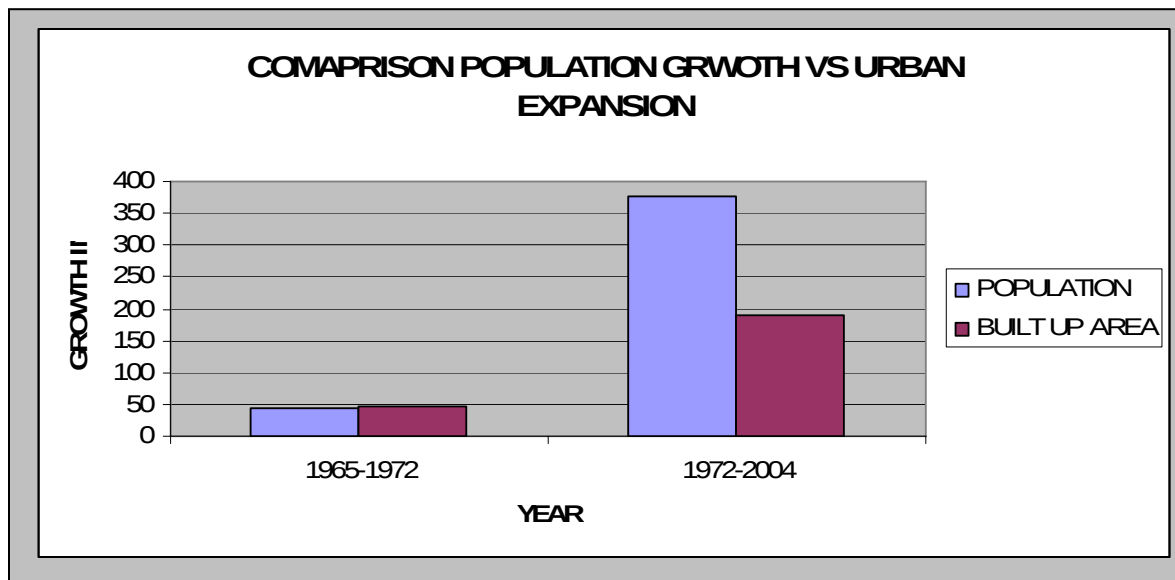


Figure4.25 Comparison population growth vs. urban expansion in %

Table 4.4 Growths of built up area, population and road length

No.	Decades	Area (hect)	Rate of growth%	population	Rate of growth %	Road length	Rate of growth%
1	1965-1972	120 hectare	6.05	11,860	5.42	30.9km	9.72
2	1972-2004	704 hectare	3.48	151,920	5.01	88.3km	3.12
Total							

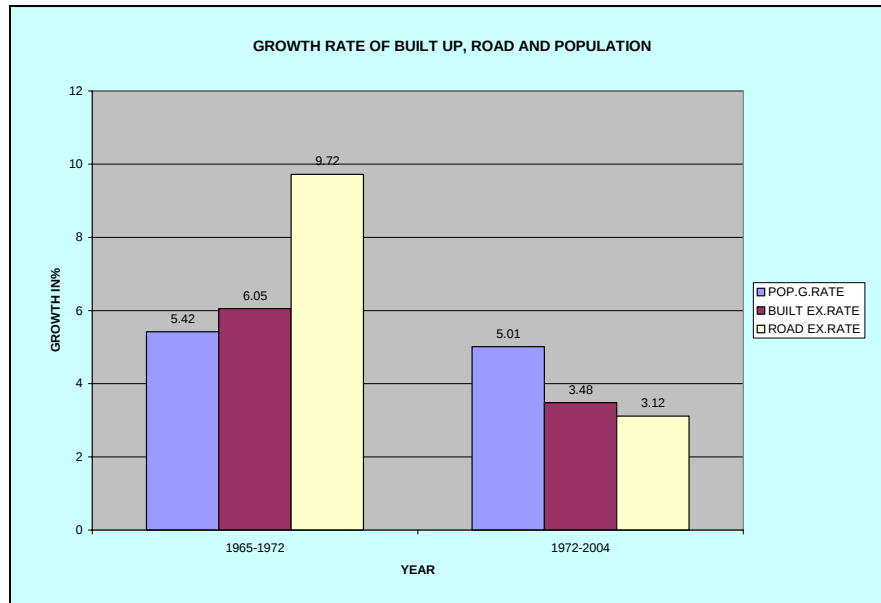


Figure4.26 Rate of growth of Population, Road, and Built up area

4.2.4 FACTORS RESPONSIBLE FOR URBAN EXPANSION

There are various and interrelated factors responsible for the expansion of Adama city. Among them rapid population growth is the major. However there are also other important factors contribute for the expansion of the city. According to Adama municipality planning and programming (AMPRP) department these factors are site and situation (Location), urban planning, and regulation used by the municipality, land Acquisition methods and reclassification of rural lands as urban area are other very important factors identified.

The rapid population increase causes demand intern increases for housing for residential area that cause to expand the city horizontally. The big population in the city contributes for the expansion of the city.

Location is one factor that influences the site and situation of particular place since it decides the “where” of a place. Like wise the location of Adama contributes for its rapid expansion (AMPRP, 2004).

According to AMPRP the location opportunities that contribute for the growth of Adama includes:

- Proximity to Addis Ababa
- Transport facility , the railway , to Djibouti and the highway to Harer pass by Adama:
- Surrounded by Agricultural productive weredas.
- The hot springs around the city makes it center of recreation and tourist attraction ,

Urban planning and regulation: Adama city passes through different municipal administration and governed under different master plan. In 2004 Adama's master plan was revised and prepares norms and standards for services, utilities and facilities and proposed land uses for different activities and residential areas from the total areas (AMPRP, 2004).

As population increases demand for land also increase. The construction of houses requires land. The methods of urban land acquisition have is won impact on horizontal expansion of the city towards the periphery.

Reclassification of land from rural to urban area have significant role in the population growth and horizontal expansion of Adama .Recently a number of farming villages and farmland surrounding the city has been reclassified in to urban area and put under the administration of the city. The incorporated in to the expanding urban kebeles.

4.2.4.1 DIRECTION OF URBAN EXPANSION

Using Aerial photographs of 1965, 1972 and IKONOS image of 2004 it was possible to identify the direction of urban expansion in Adama city. Adama is a city established on a flat land, with average slope of 1.3%, especially around the Railway station. The original expansion directions were dictated by the existence of the railway line, specifically the rail way station and the main high ways crossing the area. The Addis Ababa -Harar road is the most influential one while Assela and Wonji roads take the next level respectively. In addition to this infrastructure influence, the development of different services has also important contribution in the overall growth directions of the city. The general expansion

depicts that there are all round growth around the rail way station to the main traffic axis and the south.

The recent developments of the city exhibit the continuation of the earlier growth trends. However, due to the existence of high slope ridges especially, on the western and eastern sides, the expansion directions are more or less limited to the north and southern directions. In this respect, the Adama ridge that extends from Wonji out let area in the south to Kurfa Gutu area in the north has strong influence on the western side while the Migira-Dibibisa ridge has strongly bounded the growth of the city on the eastern side.

In the future expansion directions, there are certain topographical constraints in all directions. However, the strong effect of Boku ridge is the most dominant in the near future. The rest are high rising conical hills and deep gully and gorges. The land, which is prospective expansion area in all the directions mainly on the southern and northern directions, is found with an average slope of 5%. The land use proposal is limiting developments to the foot of Boku in the south, Hada gully in the north.

The furthest built up area in 1965 was towards East direction following the main road Djibouti and in 1972 south east: the main possible reason could be the flat topography that attracts residence since flat area created conducive condition for construction purpose and facilitates easy movement. The current furthest expansion of built up area of the city is towards the north , the main reason are plain topography and institutional factors like the presence of Adama University , Hospital, railway station , and presence of different institutions and newly constructed houses that have good standards and due to favorable environmental conditions. Currently the lowest expansion is towards the North West due to the escarpment that borders the city hence contributes to hinder the expansion of the city in this direction.

4.2.5 URBAN LAND USE CLASSES OF ADAMA CITY

To delineate urban land use classes of the city IKONOS image (2004) of the city was used and master plan revised, 2004 of the city. Based on the master plan of the city all land use

classes are extracted from IKONOS image 2004. Hence the city is classified in to 16 land use classes.

Accordingly, Central part of the Adama along the road to Assela, Dire Dawa, and Wonji are dominated by mixed land use consisting of residences, commercial, business, offices, services, manufacturing and storages. Manufacturing and commercial uses are concentrated along major roads and residential uses dominate within the blocks. Most big hotels are located along the Addis Ababa-Dire Dawa Street. After the first block most buildings have mixed use characteristics. Markets and large business activities are concentrated at the city core only. Other parts of the city lack or are in dire shortage of such functions. Schools and health services are distributed within housing areas. The analysis of the existing land use of the city shows that there is shortage and unbalanced distribution of social services. Most main social services and facilities are located in the northern part of the city. For instance the main hospital and municipal cemetery are located in the northern part of the city.

Land use of expansion areas at present is dominantly residential and farming. They are invaded by informal and illegal settlements. Low rise development and low dwelling density is the main character of these areas. Excessive land area occupation and fencing by residences and other establishments is also observed.

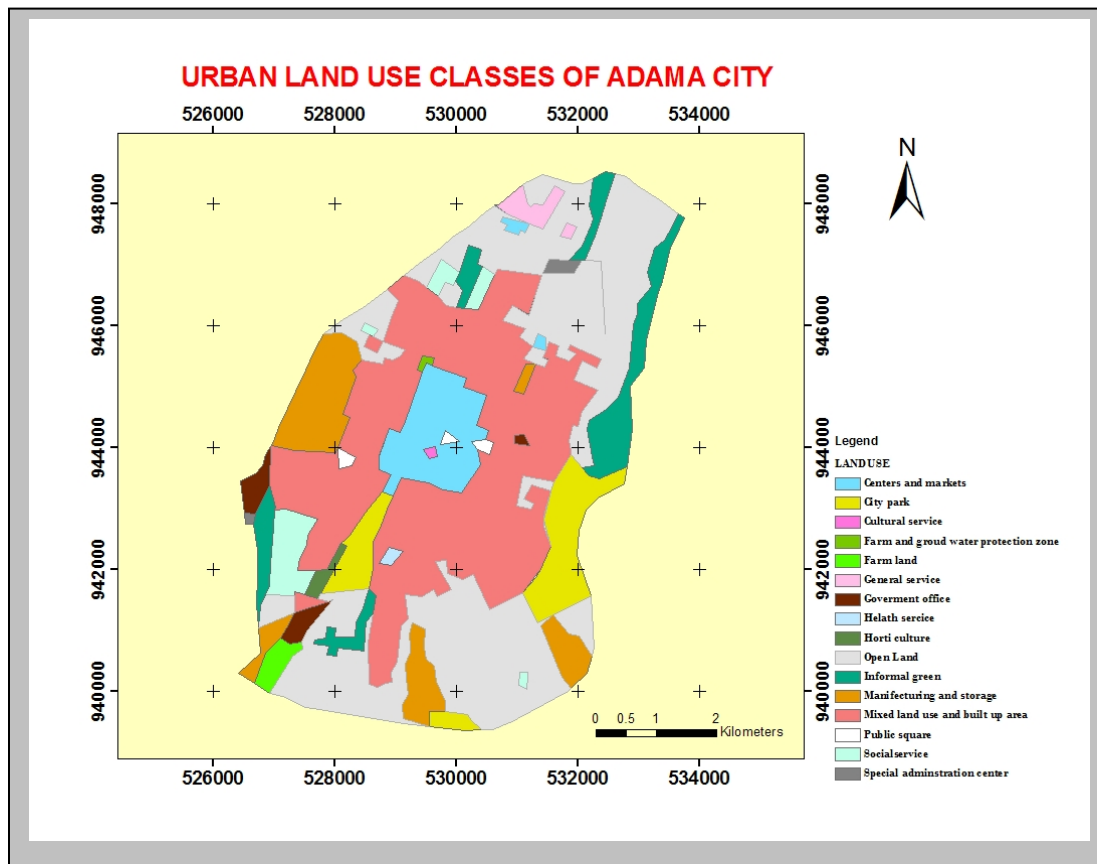


Figure4.27 Urban land use classes of the city, 2004

Table 4.5 Area of Land Use classes of the city

No.	Land Use Type	Area in Hectare	Percentage (%)
1	Commercial and markets	250	5.6
2	City park	276	6.2
3	Cultural service	2.7	0.06
4	Farm and ground water protection zone	3.9	0.087
5	Farm land	32.3	0.72
6	General service	39.9	0.89
7	Government office	53.8	1.2
8	Health service	6.1	0.14
9	Horti culture	16.8	0.38
10	Open land	1509	33.8
11	Informal green	270.7	6.07
12	Manufacturing and storage	327.7	7.35
13	Mixed land use and built up	1519.4	34.08
14	Public square	15.2	0.34
15	Social service	119.6	2.68
16	Special administration center	14.9	0.33
Total		4458	100

As it is shown in the above table the largest land use class in the city is mixed land use and built up which constitute 34.08255 % followed by open land constitute 33.84926%, Manufacturing and storage (7.35083%), City park (6.191117%), Informal green (6.07223%) and the rest of the classes constitute around 12%.

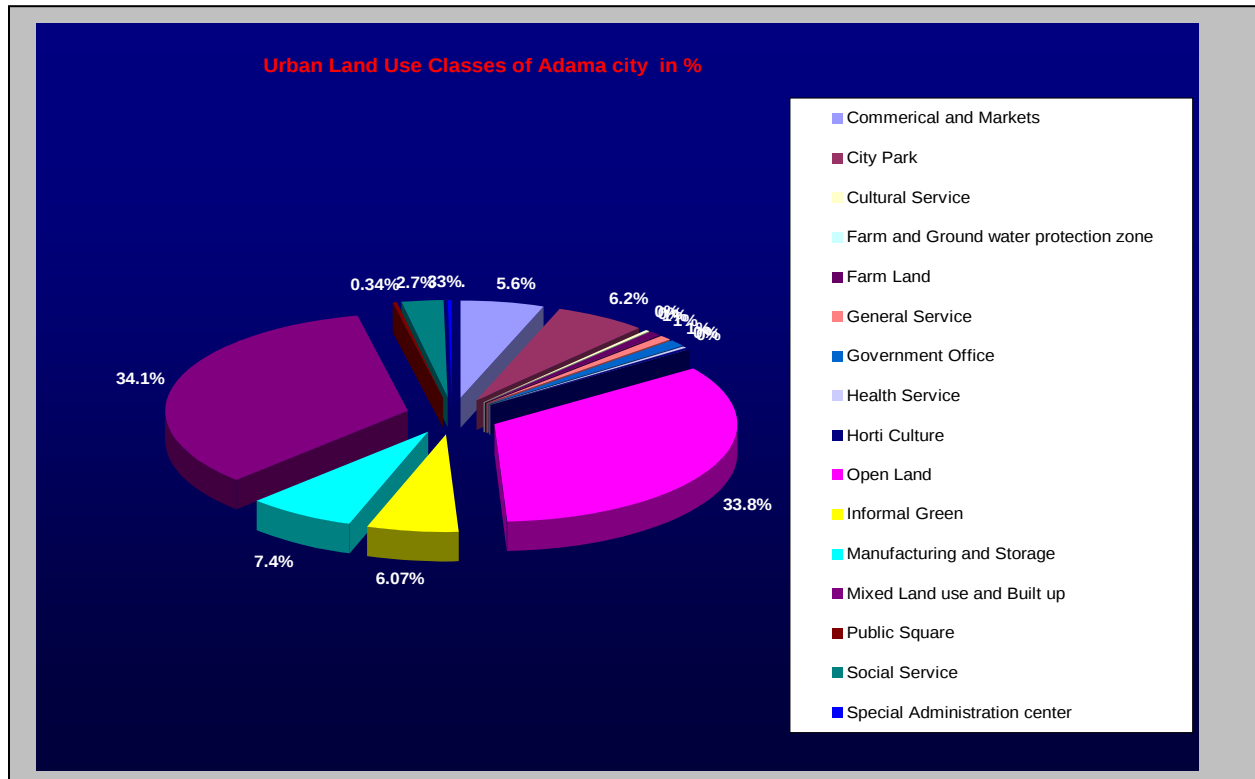


Figure 4.28: Urban Land use classes of Adama in %

CHAPTER FIVE

HOUSING SUITABILITY ANALYSIS

5.1 SITE SELECTION CRITERIAS

Selecting the most appropriate site for Housing is an important consideration for dwellers of the city. The selection must be based not only on current needs but also on projected needs. It is not a simple task. The primary purpose of this sub topic is to identify suitable criteria for selecting new sites for housing.

Sites must be appropriate for residential use, in proximity to downtown or commercial centers. Parcels must be near existing residential uses, which reinforce the feeling of "neighborhood." The residential uses should be in good condition or the subject of a realistic plan to improve them to a good condition. Areas impacted by high concentrations of very low income housing, which is deteriorating. There fore based on different countries experience and master plan policy of Adama city, Oromyia housing and urban planning .The following criteria's are identified:

- The proposed site should be on a slope range of 2-6% (> 10% slope is unsuitable).
- The proposed site be placed on vacant (open area) followed by mixed land use.
- For accessibility for transportation, the proposed site should not be far from major road.
- For safety, the proposed site should be away from river (flooding during summer season) i.e. it should be 200m away from river.
- The presence physical hazard reduces the suitability of a site. For Selecting safe housing sites and a void the risks. i.e. it should not be located on risk areas (susceptible for natural hazard).
- The proposed site should be located in area of low population density.
- For safety and nose, it should be away from railway line .i.e. 200m away from it.
- Some protection areas should be masked like parks ,Industries etc

5.2 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).

5.3 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.

5.3.1 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Geographic information systems (GIS) have emerged as useful computer-based tools for Spatial description and manipulation. Although often described as a decision support system, there have been some disputes regarding whether the GIS decision support capabilities are sufficient (Jankowski 1995). Since current GIS do not provide decision-making modules that reason a decision and are primarily based on manual techniques and human judgments for problem solving, the individual should have the decision rules in place before GIS can be utilized. Other limitations in current GIS approaches include the incapability of processing multiple criteria and conflicting objectives (Carver 1991). They are also limited in integrating geographical information with subjective values/priorities imposed by the decision maker (Malczewski 1999).

5.3.2 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 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 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.

5.4 ANALYSIS AND RESULTS

5.4.1 FACTORS FOR SUITABILITY ANALYSIS

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 (master plan) of Adama city and in the other countries. These factors include:

5.4.1.1 FROM THE GOAL OF SAFETY

The presence of physical hazard reduces the suitability of a site. For Selecting safe housing sites avoid the risks.

RIVER

Flooding in the rain water season whether from adjacent streams or other channels or low-lying land may happen. Therefore the longer the distances from this water bodies (rivers) the safer the sites will be so that distances from the rivers were calculated by proximity analysis techniques and reclassified according to their preferences. In this study straight line distance is calculated with maximum of 200 meter and Reclassified. Figure: 5.1 shows the reclassified river map of the city area.

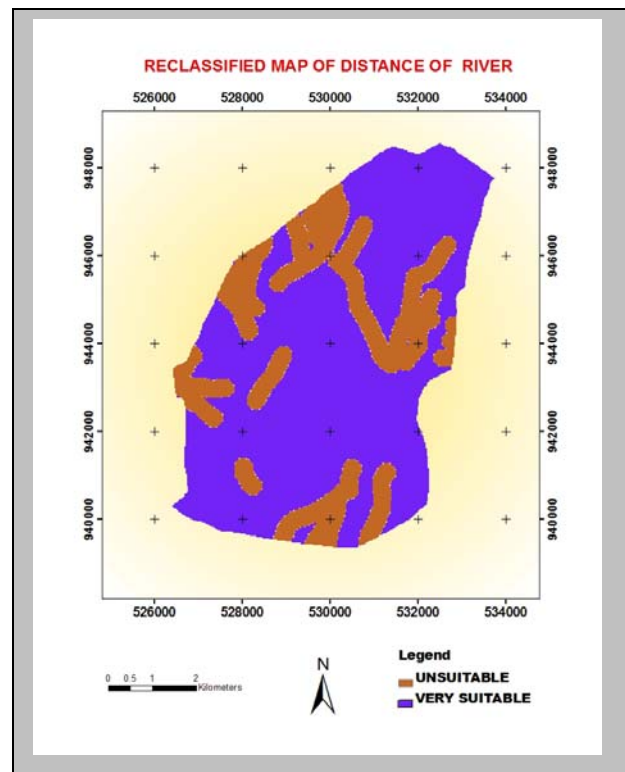


Figure5.1 Reclassified map of distance of River

RAILWAY

According to the master plan policy of Adama city, for safety of the residents and nose, the proposed housing sites should be placed some distances from the railway line .i.e. it should be 200 meters away from rail way line .There fore straight line distance with maximum of 200 meters was calculated and Reclassified accordingly. Figure: 5.2 shows the reclassification map of railway line in the Adama City area.

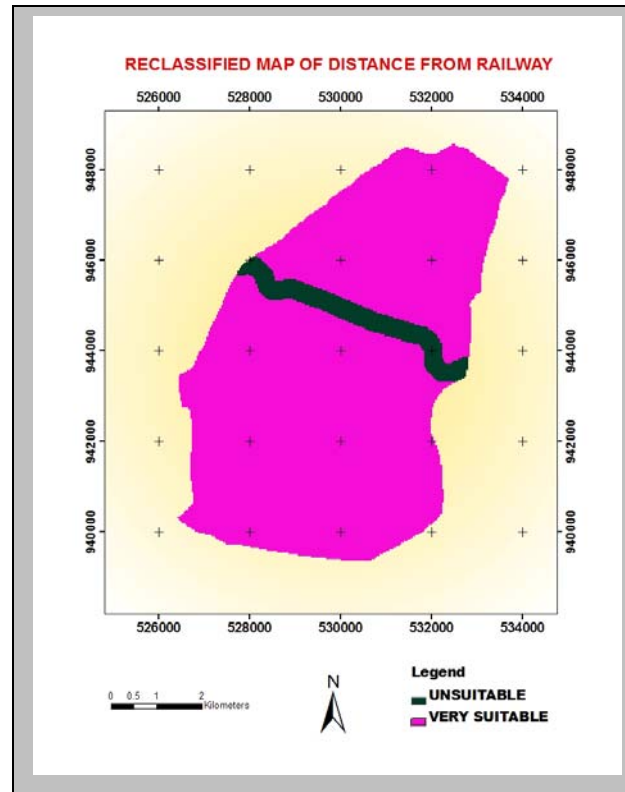


Figure5.2 Reclassified map of distance of railway

SOIL ANALYSIS MAP

The city of Adama is located in high-risk zone. Areas where there are fault lines and loose sediments are more susceptible for earthquake damage. There fore according to the research done by Adama city project office the soil is analyzed and they classified the city in to zones (Grades) .Thus based on the criteria the soil reclassified according its importance.

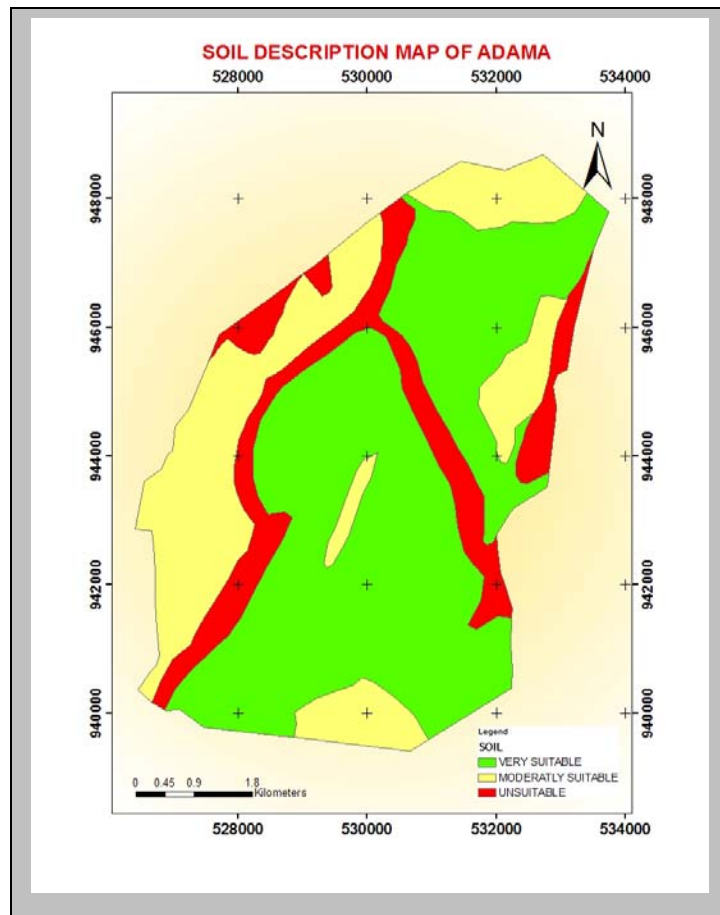


Figure5.3 soil description map of Adama

5.4.1.2 FROM THE GOAL OF ACCESEBILTY

SLOPE

Among topographic factors that affect the land use planning, slope is considered for this study. From the master plan policies, it is known that the sites on or near cliffs is not suitable for housing development as these areas costs a lot to the government, particularly when supplying facilities like roads, water supply, electricity, and so on, are much more costly in comparisons with the flat areas. There fore for this case it was considered that areas with slopes exceeding 10° are usually not suitable for residential development (Chapin and Kaiser 1978).

According to them the idlest areas for housing of residential use are areas with 2-6 % slopes. In our case (according to master plan policy of Adama), >10% slope is unsuitable.

For TIN and DEM and Slope Map, contours of 20m interval from topographical sheets were digitized. Each contour has been given corresponding elevation value in a separate attribute field. With this elevation value, TIN and DEM were generated using Spatial Analysis extension of ArcGIS 9.1. The slope thus obtained was reclassified into four classes such as less suitable, suitable, moderately suitable and most suitable classes. Figure: 5.4, Figure: 5.5 and Figure: 5.6 show the TIN, DEM and reclassified slope map of the city area respectively.

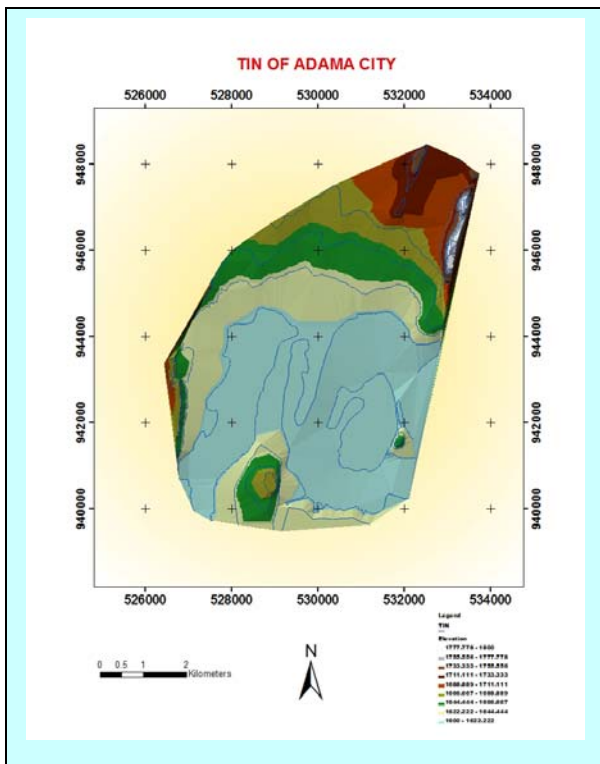


Figure5.5 TIN of Adama city

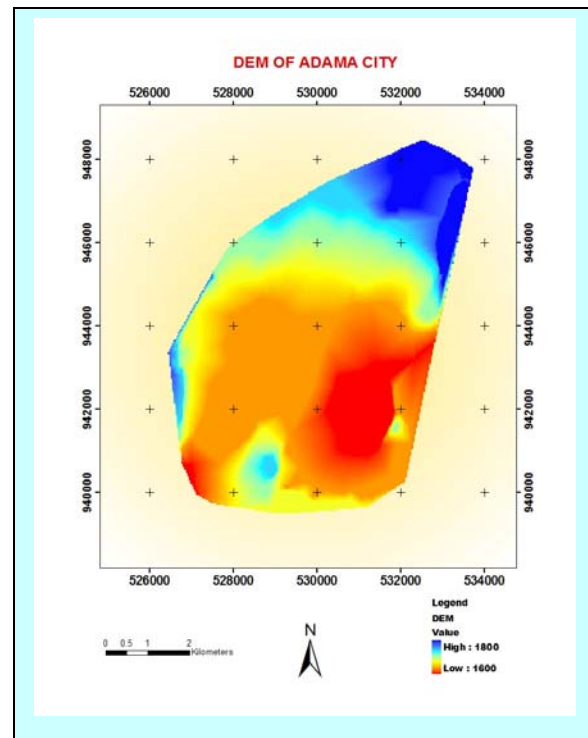


Figure5.4 DEM of Adama city

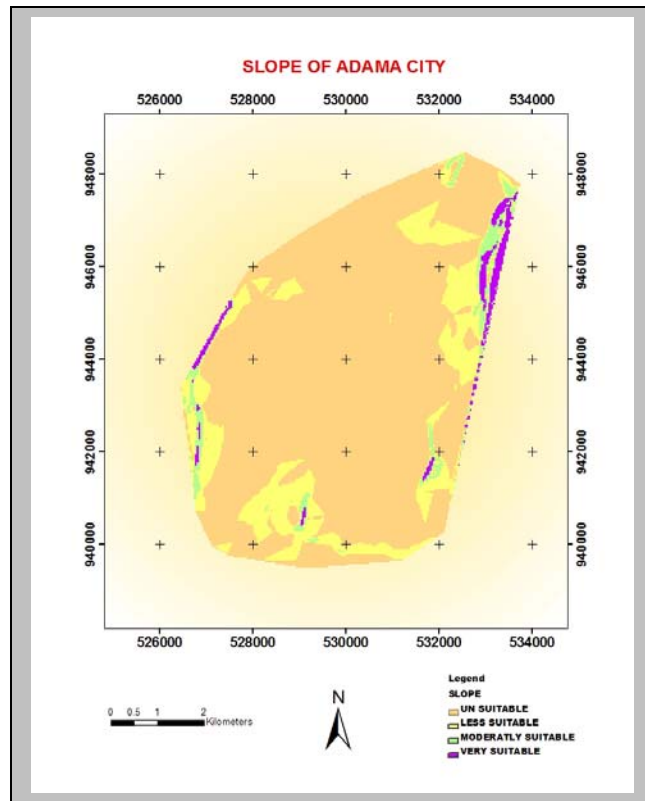


Figure5.6 Reclassified slope map of Adama

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. The locations must be adjacent to built up areas (existing neighborhood), in the low-density population areas, within 1-5 km from the major road. (A G-o Yeh, 1999). According to master policy of Adama city the proposed housing sites should not be far away from 5 kilometers. Therefore in this study straight line distance with maximum of 5 kilometers is calculated and reclassified accordingly. Figure: 5.7 shows the reclassified road map of Adama city area.

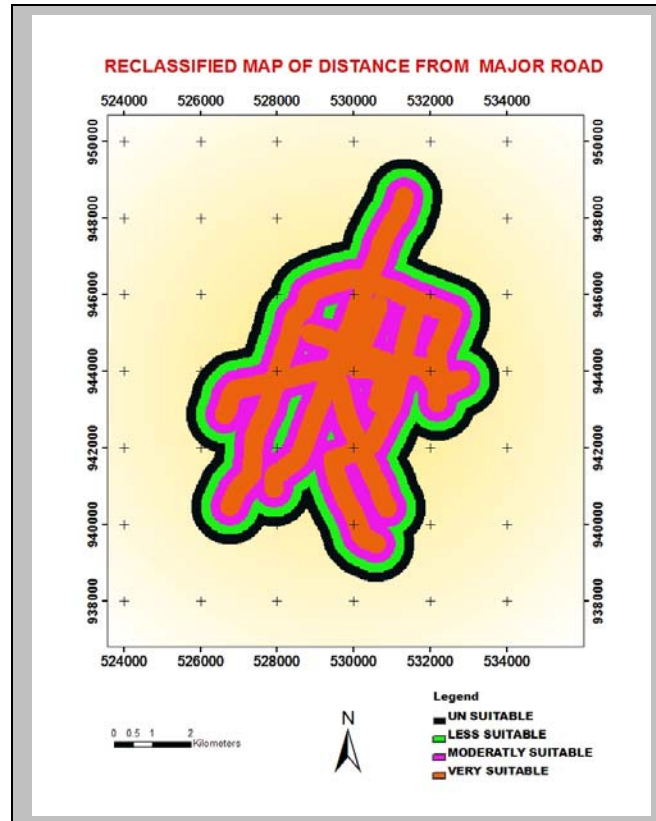


Figure5.7 Reclassified map of distance of major road of Adama

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 Table 5.1. So sites with low densities are more appropriate to the suitability values of the lands.

Table 5.1 Population and Population Density per kebele

No.	Kebele Name	Population	Population density
1	1	12,580	0.0017
2	2	15,505	0.0036
3	3	9,364	0.0069
4	4	15,757	0.0095
5	5	11,501	0.0365
6	6	13,534	0.0253
7	7	11,883	0.0140
8	8	18,960	0.0377
9	9	18,981	0.0049
10	10	18,127	0.0023
11	11	18,209	0.0037
12	12	13,737	0.0033
13	13	12,401	0.0066
14	14	17,577	0.0036
Total		208,116	

Source: Computed from document of AMPPD, 2003

Hence the Kebeles with respect to their population densities were reclassified into highly suitable, moderately suitable, suitable and less suitable and reclassification map was prepared as shown in Figure: 5.8.

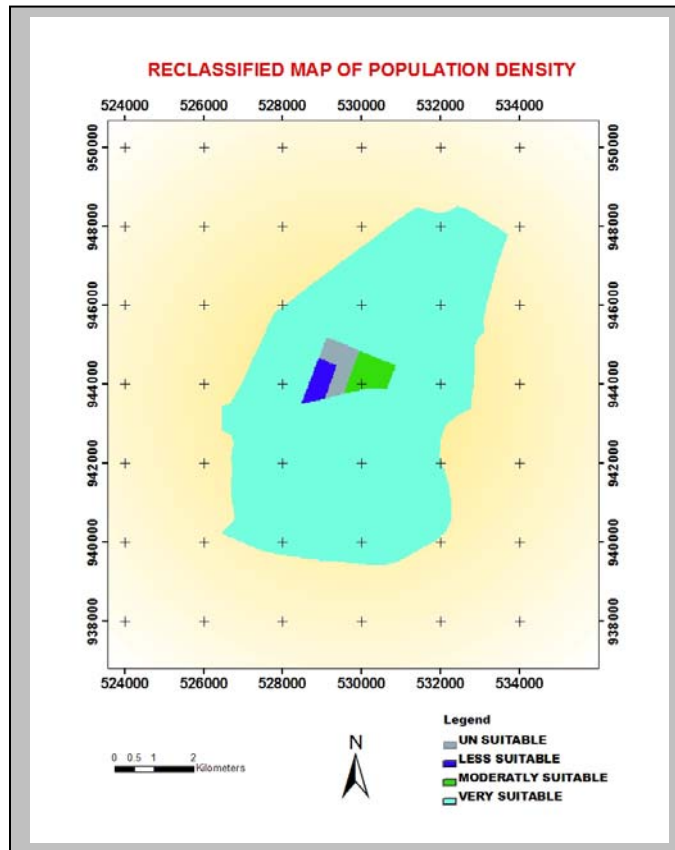


Figure 5.8 Reclassified map of Population Density

LAND USE

Using IKONOS 2004 image of the city and master plan 2004 land use classes of the city was generated. According to the master plan policy the proposed housing site should be placed on open land (vacant land) followed by mixed land use, social service and general service. There fore only four land use classes have been used and reclassified these are: Open land (vacant land), mixed land use, social service and general service and the rest are masked accordingly.

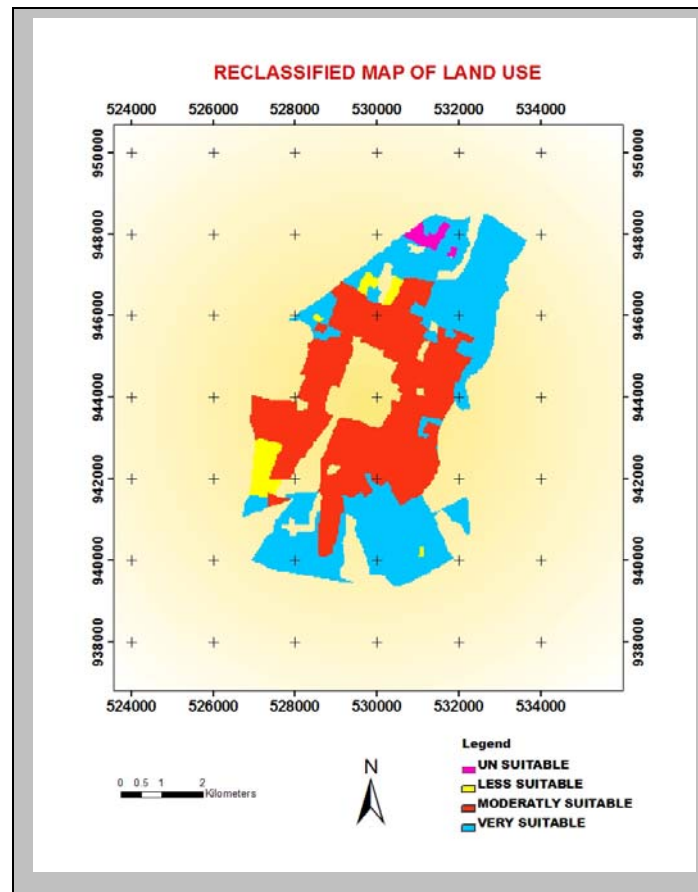


Figure5.9 Reclassified land use map of Adama

5.4.2 TECHNIQUES FOR WEIGHTING

5.4.2.1 THE ANALYTICAL HIERARCHY PROCESS (AHP)

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. The AHP allows decision-makers to model a complex problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives, and alternatives. Uncertainties and other influencing factors can also be included. It is not only supports decision makers by enabling them to structure complexity and exercise judgments, but also allows them to incorporate both objective and subjective considerations in the decision process (Saaty, 1980).

5.4.2.2 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 5.2 PAIR WAISE COMPARISON MATRIX

<i>INTENSITY OF IMPORTANCE</i>	<i>DEFINITION</i>
1	<i>EQUAL IMPORTANCE</i>
2	<i>EQUAL TO MODERATE IMPORTANCE</i>
3	<i>MODERATE IMPORTANCE</i>
4	<i>MODERATE TO STRONG IMPORTANCE</i>
5	<i>STRONG IMPORTANCE</i>
6	<i>STRONG TO VERY STRONG IMPORTANCE</i>
7	<i>VERY STRONG IMPORTANCE</i>
8	<i>VERY TO EXTREMELY VERY STRONG IMPORTANCE</i>
9	<i>EXTREMELY IMPORTANCE</i>

5.4.3. 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 IDRISI 32 software after they get prioritized and the consistency ratio found to be acceptable.

WEIGHT - AHP weight derivation

Pairwise Comparison 9 Point Continuous Rating Scale

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely	very strongly	strongly	moderately	equally	moderately	strongly	very strongly	extremely
Less Important					More Important			

Pairwise comparison file to be saved :

	landu	soil	population	slope	road	rail
landu	1					
soil	1/2	1				
population	1/4	1/3	1			
slope	1/4	1/3	1/2	1		
road	1/3	1/3	1/2	2	1	
rail	1/3	1/3	1/2	2	1/2	1

Figure 5.10 Pair Wise Comparison Matrix and Weights of Importance for the Evaluation Criteria

Table 5.3 weights calculated by IDRISI Soft ware

The eigenvector of weights is:

Land use: 0.3151
Soil: 0.2367
Population: 0.1263
Slope: 0.0558
Road: 0.1067
Rail: 0.0718
River: 0.0876

Consistency ratio = 0.04
Consistency is acceptable.

NO.	FACTORS	WEIGHT GIVEN
1	LAND USE	31.51%
2	SOIL	23.67%
3	POP.DEN.	12.63
4	SLOPE	5.58%
5	ROAD	10.67%
6	RAIL	7.18%
7	RIVER	8.76%
TOTAL		100%

5.4.4 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;

$$\text{Suitability Map} = \sum [\text{factor map } (c_n) * \text{weight } (w_n) * \text{constraint } (b_{0/1})]$$

Where,

c_n = standardized raster cell,

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

$b_{0/1}$ = Boolean map with values 0 or 1

Using Idrisi 32 software all factors has been given specific weights and the weighted overlay analysis has been conducted and produce housing suitability map using model builder.

Suitability map = Reclassified River* 0.0876 + Reclassified Railway*0.0718 + Reclassified Major Road*0.1067 + Reclassified Land use * 0.3151 + Reclassified soil *0.2367 + Reclassified Population Density*0.1263 + Reclassified slope*0.0558

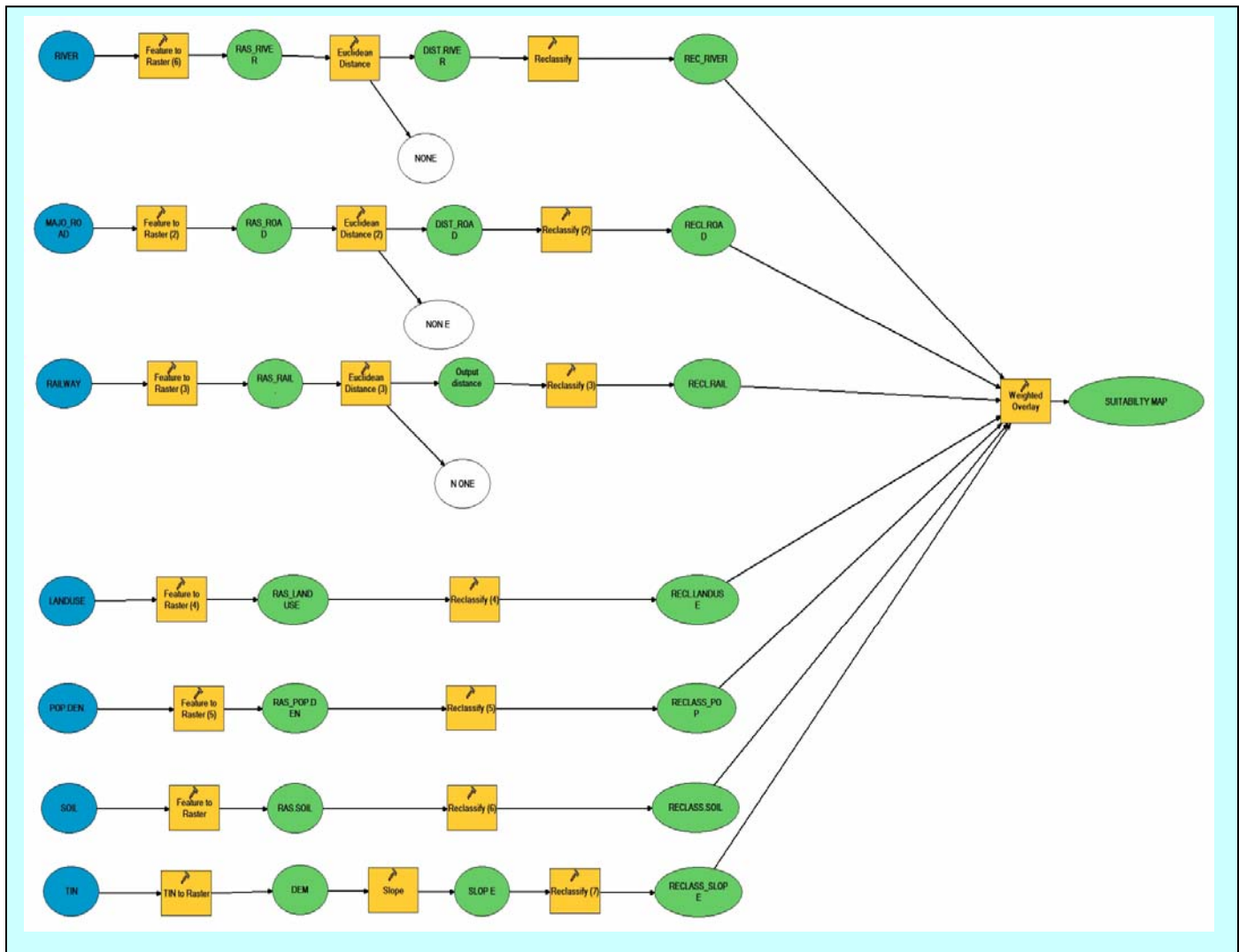


Figure5.11 Model builder for the whole analysis

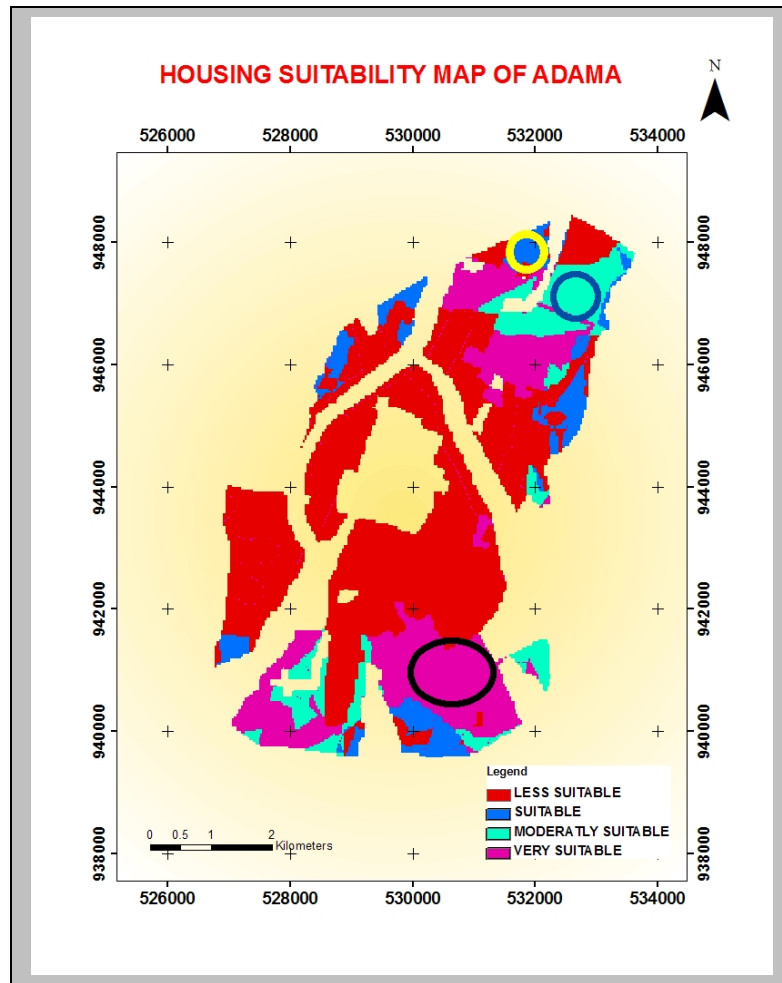


Figure5.12 Housing suitability map of Adama

Table 5.4 Area of suitable sites

No.	Suitable sites	Area in Hectare	Remark
1	Very suitable	642 hectare	-
2	Moderately Suitable	288 hectare	-
3	Suitable	232 hectare	-

The areas of the proposed sites were calculated in GIS environment .as it is shown in the table 5.4 the very suitable sites has the highest area value followed by moderately suitable

site. The very suitable site constitutes 14.5 % of the total area of study followed by moderately suitable i.e. 6.5% of its total. The suitable site constitutes 5.2% of its total.

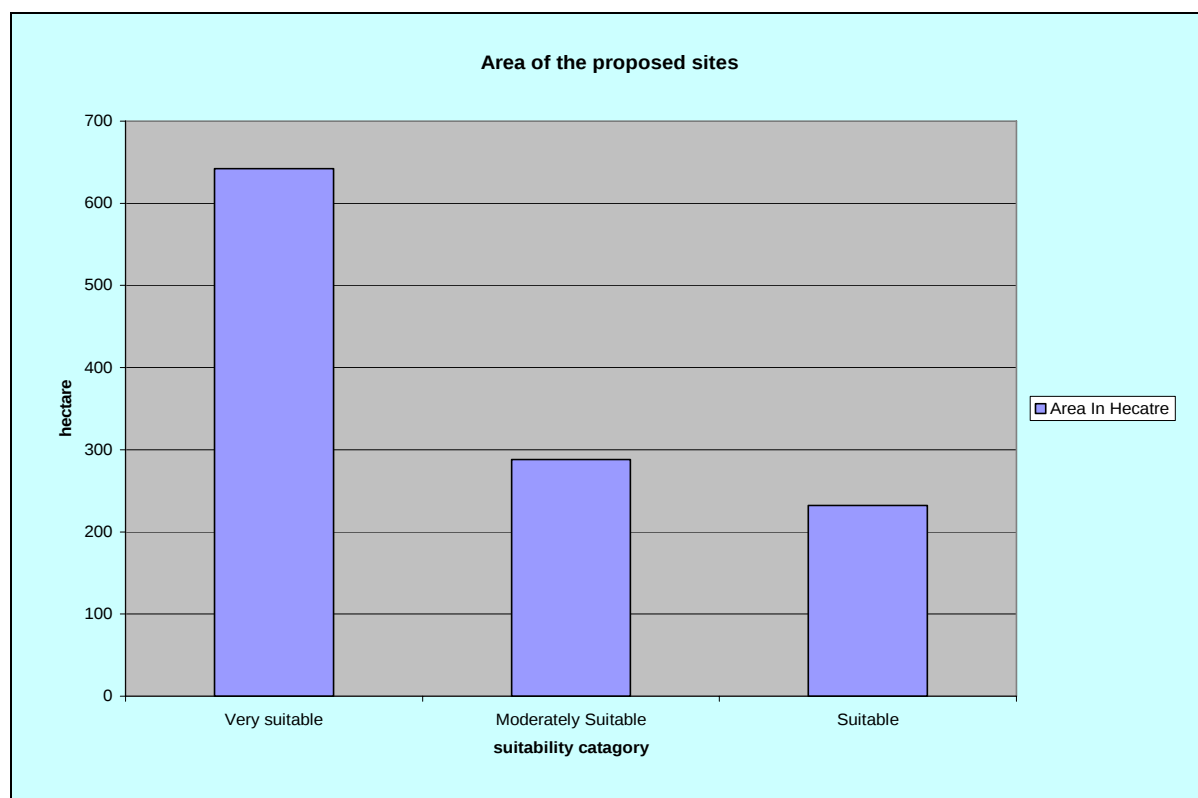


Figure 5.13 Area of the proposed sites

Table 5.5 Area of the proposed sites per kebele

No.	Kebele Name	Area in Hec.
1	kebele 1	406.6
2	kebele 2	28.7
3	kebele 3	10.5
4	kebele 10	339.5
5	kebele 11	68.3
6	kebele 12	137.1
7	kebele 14	185.71

As it is shown in the table 5.5 the proposed sites have been placed only on seven kebeles i.e. kebele1, 2,3,10,11,12,14. Among seven kebeles kebele 1 has highest area of suitability followed by kebele 10, kebele 14, etc.

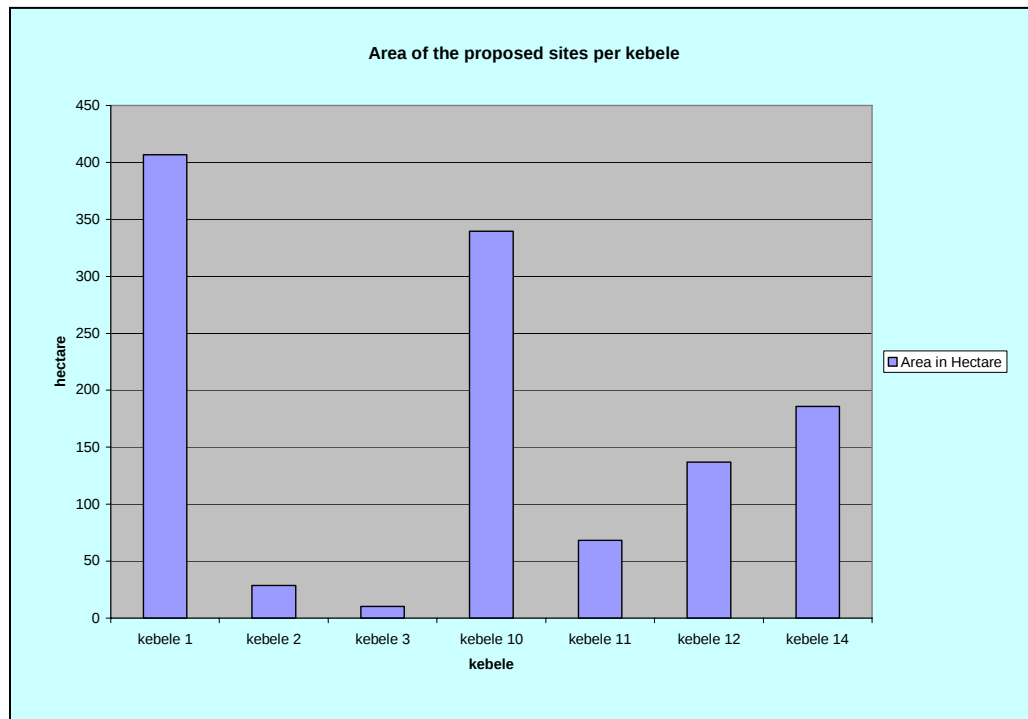


Figure 5.14 Area of the proposed sites per kebele

5.4.5 EVALUATION OF THE PROPOSED SITES IN RESPECT TO UTILITIES

5.4.5.1 ELECTRIC UTILITY

Electricity has a key role in sustainable development; it powers economic and social progress. From an economic perspective, electricity utilities are part of the commercial matrix that comprises a modern economy. Electricity supply is even a factor in maintaining national and global stability and peace, while electricity can't be stored for latter use; a consistent, reliable supply of electricity is a prerequisite for economic development. Social security and public welfare are constrained in many developing countries, where access to electricity remains low. Hence as you can see on the map below except the proposed sites

of the moderately suitable category the rest of suitable area don't doesn't have any problem of electric utility.

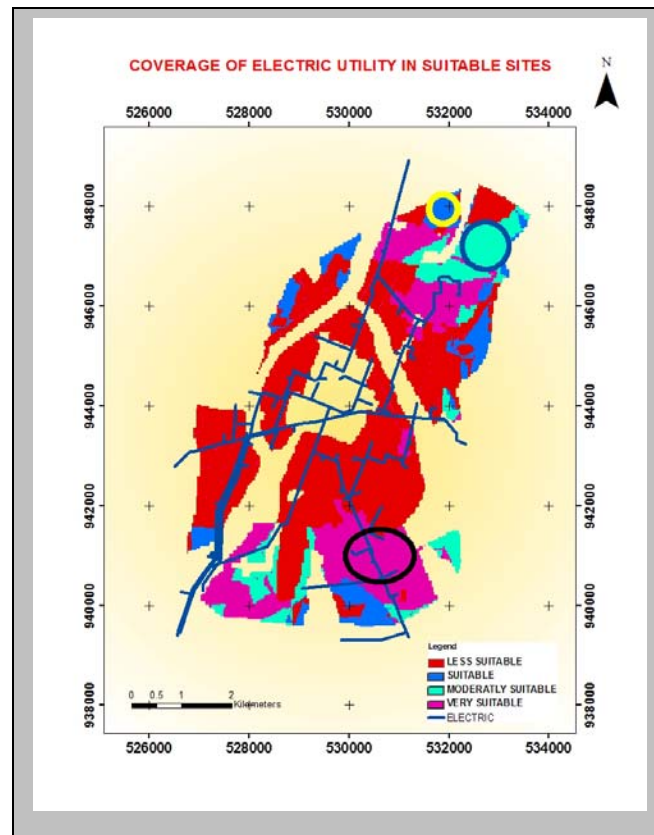


Figure5.15 Coverage of electric utility of Adama

5.4.4.2 TELECOMMUNICATION UTILITY

Information and communications technologies supported by telecommunications infrastructure are important components of the government's framework for social development, economic growth and innovation. ICT unquestionably contributes substantially to innovation and economic development (world resource, 1998).

Urban areas want telephone mainly for business, social and security reasons. The efficiency of often-inadequate public services, such as education, health care, security, transport and processing of information, records, and general statistics, could be enhanced by improved

access to telemetric services. So in the case of Adama telecommunication utility distribution does not cover the whole city .Hence As you can see on the map below only on some part of the proposed sites will cover the telecommunication utility like small coverage of very suitable category and in moderately suitable category.

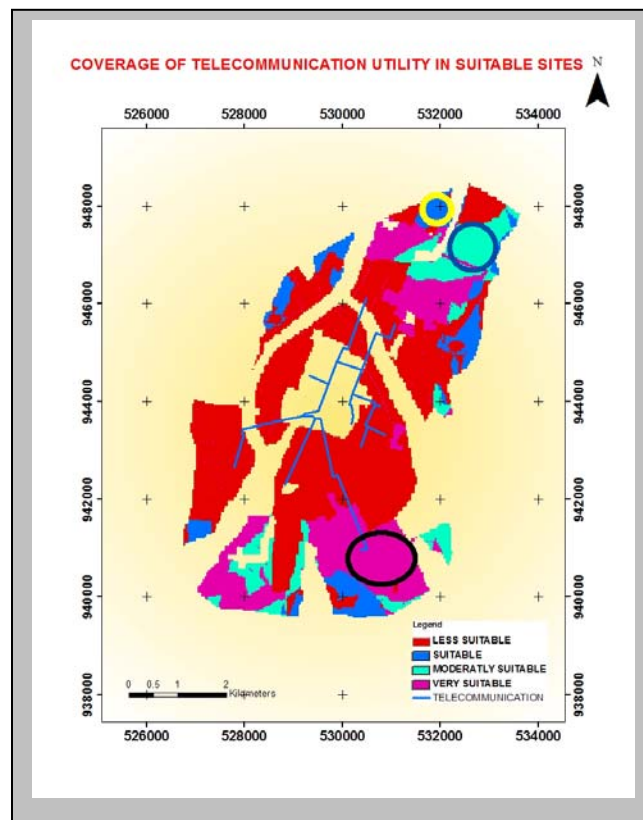


Figure5.16: Coverage of Telecommunication utility of Adama

5.4.4.3 WATER UTILITY

Level of water service can be expressed in technical design terms, for example, as the quality and quantity of water available with in a given distance. The level of service differs in terms of convenience and health benefits as well as cost.

A minimum level of service is vital to meet people's basic needs such as water for drinking, washing, and cooking and for disposal of excreta and other wastes in a safe manner, for direct beneficiaries and the wider community. The sustainability of this basic- needs (level

of service) depends on users willingness- to- pay the costs, or if failing the government's willingness to subsidize the service over the medium term.

The CSA (1994) reports that out of 30,227 housing units in the Adama Woreda during the time 95.98% had access to protected well/spring. Hence as you can see on the maps below all most all the proposed sites have an access of water supply except the upper north east part.

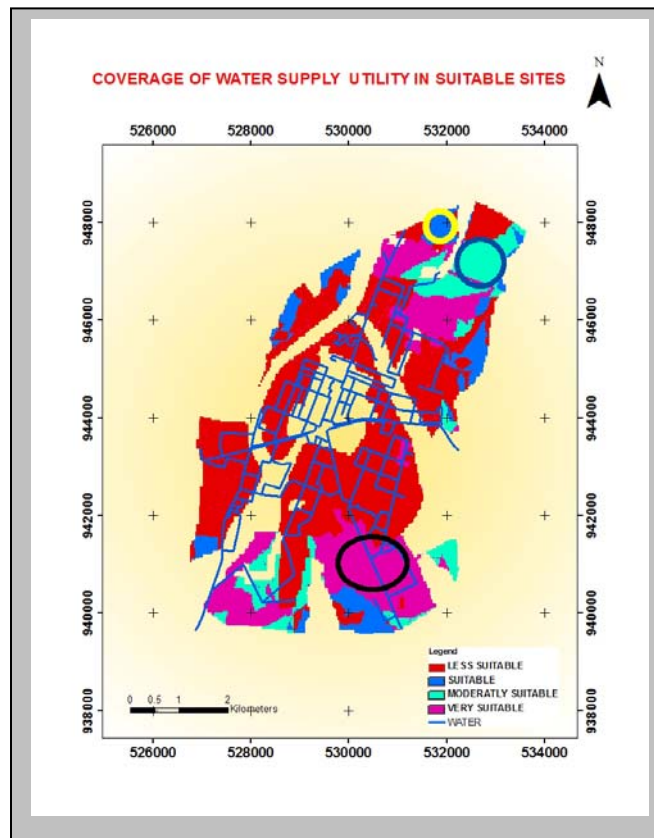


Figure5.17 Coverage of water supply utility of Adama

Table 5.6 Evaluation of coverage of Utility in the proposed sites

No.	Site suitability Category	Electric Ut.	Telecommun.Ut	Water Supp.Ut.	Remark
1	VERY SUITABLE	Very Good	Good	Good	-
2	MODERATLY SUITABLE	Good	No Coverage	Almost no coverage	-
3	SUITABLE	Almost no coverage	No Coverage	No Coverage	-

As it is shown in the tables above the infrastructure utilities of the city do not cover the suitable sites, for instance in the suitable category the electric, telecommunication, and water utilities don't have coverage where as in the very suitable category the utilities are relatively better followed by moderately suitable sites.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This century is dubbed, by most, as the urban century, with almost 50 percent of the population of the world living in urban areas and the other half being increasingly dependent on cities and towns for economic survival and livelihood. Further more the population of the cities is expected to double in the coming 30 years. At the onset of twenty first century, Africa faces major challenges, which include rapid urbanization with out meaningful industrialization of the countries economy. The current rates of urbanization in Africa, exceeding 4 to 5 % per annum in most countries, are close to those of western cities at the end of the nineteenth century.

As (Redman ad Jones, 2004) cited in (Lwasa, 2004) indicates that the process of rapid urbanization take place in developing countries significantly contributes to bring opportunities to new urban developments. The problem comes with this rapid urbanization are serious like lose of the surrounding arable land , degradation of ecosystem as well as social and environmental changes and along with the urban expansion there is no parallel expansion of urban infrastructure to the urban population.

Adama, being one of the cities in the developing countries has never been in a position to escape the forgoing undesired realities of rapid urbanization. Principles and guidelines fundamental to ensure healthy urban growth have never been put in place. It is among the fast growing urban centers in the country .The city has attractive potential that contributed for its accelerated growth .Hence the expansion of the city is becoming irregular, uncontrolled and often resulting in creation of slums (Daniel,2000:5).

This study assessed urban expansion of Adama city by integrating GIS and Remote Sensing techniques. 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 Aerial photograph of 1965, 1972 and IKONOS image of 2004 urban expansion of the city has been assessed. The area of built up of the city in 1965 has been calculated as 250 hectare (2.5 square kilometer) which is 5.6% of the total area of city i.e. 4460 hectare (44.6 square kilometer). The area of built up of the city in 1972 has been calculated as 370 hectare (3.679 square kilometer) which is 8.3% of the total area of city i.e. 4460 hectare (44.6 square kilometer). The built up area expansion of the city between 1965 and 1972 is 120 hectare which is 48% expansion.

The area of built up of the city in 2004 was calculated as 1074 hectare (10.74 square kilometer) which is 24.1% of the total area of city i.e. 4460 hectare (44.6 square kilometer). The built up area expansion of the city between 1972 and 2004 was 704 hectare which is 190.3% expansion.

Using Aerial photographs of 1965, 1972 and IKONOS image of 2004 I have tried to assess road expansion of the city in terms of length. The road length of 1965 and 1972 was calculated as 41.1 km and 72 km respectively. Hence the road was increased by 30.9 km (54.8%) between 1965 and 1972. Moreover, the road length of 2004 was quantified as 160.3km. The road network expansion of Adama city from 1972-2004 was increased by 88.3km.

It is obvious that population growth has a direct impact on urban expansion. In this case when the population of the city in 1965 is 27,812 the built up of the city was 250 hectare. The population is increased to 40,221 in 1972 like wise the built up is expanded to 370 hectare. In 2004 the population becomes 192,141 and the built up is expanded to 1074 hectare. From 1965-1972, the population of the city is increased by 44.6%. From 1972-2004 it is projected by 377.7%. The built up area of city is increased by 48% from 1965-1972 and it is tremendously expanded by 190.3% from 1972-2004.

The rapid population growth of the city as a result of natural increase and the addition of large number of in-immigrants every year have possibly compounded the urban problem. Thus, the physical expansion of the city with the fast growing population does not appear to match with infrastructural development in the city.

There are various and interrelated factors responsible for the expansion of Adama city. Among them rapid population growth is the major. However there are also other important factors contribute for the expansion of the city. According to Adama municipality planning and programming (AMPRP) department these factors are site and situation (Location), urban planning, and regulation used by the municipality, land Acquisition methods and reclassification of rural lands as urban area are other very important factors identified.

The furthest built up area in 1965 was towards East direction following the main road Djibouti and in 1972 south east: the main possible reason could be the flat topography that attracts residence since flat area created conducive condition for construction purpose and facilitates easy movement. The current furthest expansion of built up area of the city is towards the north , the main reason are plain topography and institutional factors like the presence of Adama University , Hospital, railway station , and presence of different institutions and newly constructed houses that have good standards and due to favorable environmental conditions. Currently the lowest expansion is towards the North West due to the escarpment that borders the city hence contributes to hinder the expansion of the city in this direction.

As per the objective of this project the urban land use classes have been delineated using 2004 IKONOS image of the city and the city was classified into eighteen classes.

The Population of the city has been raised and consequently the need for homes became serious. In addition to this the growth of the city is a continuous process so that it is important to identify suitable housing areas for future development. Selecting the location for housing sites is a complex process that involves not only technical requirement, but also physical, economical, social and environmental requirements. Hence in this study I have proposed new sites for housing based on local and other countries criteria's using seven parameters , Land use , population density , road, railway, river, and slope. Using Arc GIS 9.1 of spatial analysis weighted overlay analysis has been conducted by giving weights for each parameter using pair wise method and produce new sites for housing with a category of very suitable, moderately suitable , suitable and less suitable . The very suitable site

constitutes 14.5 % of the total area of study followed by moderately suitable i.e. 6.5% of its total. The suitable site constitutes 5.2% of its total area .After proposing sites I have evaluated the sites based on the availability of utilities like electric, telecommunication and water supply utilities. Hence except the Electric utility which covers the very suitable category, the rest of the utilities are not satisfactory in its coverage.

6.2 RECOMMENDATIONS

Based on the findings obtained in this study I have tried to recommend the following points.

- As we have seen there is rapid population growth in the city in the last four decades therefore the regional government 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 city is rapid population growth result from natural increase and migration therefore improvements in spatial planning and urban planning should get considerable attention.
- The city is expanding from year to year because of various reasons .Hence the expanding areas are suffering from inadequate 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.
- The road network of Adama in the expansion area, being based on the nature of existing network, therefore the regional government should design new road network which cover the entire expansion.
- As one of the objectives of this study is to select new sites for housing based on the local criteria, some the proposed site does not get the necessary infrastructure Utility like telecommunications, electric and water supply utility. The regional government should consider the infrastructure for the proposed sites.

- It is known that some of part of the city of Adama is located in high-risk zone. Areas where there are fault lines and loose sediments are more susceptible for earthquake damage (AMPR, 2004). Therefore for the safety of people the regional government should relocate the people settled there.
- Finally, Expansion of Adama city brings a number of problems of housing, infrastructure, services and loss of agricultural land. These problems require immediate attention of the urban planners, decision and administrators. Following are the suggestions which are to be given keen interest for sustainable growth and balance of Adama city.
 - Safeguarding of fertile land around the city.
 - Control of urban spreading out into agricultural land,
 - There is need for generation of digital topographical data base for Adama city.
 - Use of high resolution data for planning and urban information generation.

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