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**ENVIRONMENTAL IMPACTS OF URBAN LAND-USE CHANGES
IN KOLFE KERANYIO SUB-CITY, KEBELE 04 SELTI AREA, ADDIS ABABA
USING REMOTE SENSING AND GIS TECHNIQUES**

BY: BAMLAKE AMENTE

**ADDIS ABABA
JANUARY, 2009**



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By

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**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS
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ABBREVIATIONS

AACA	Addis Ababa City (Administration)
AALDA	Addis Ababa Land Development Agency
AU	African Union
CBO	Community Based Organization
CSA	Central Statistical Agency
Derg	Amharic term, which literally means committee
ECA	Economic Commission for Africa
EMA	Ethiopian Mapping Agency
EPA	Environmental Protection Authority
EPRDF	Ethiopian people revolution Democratic Front
GIS	Geographic Information System
ha	Hectare
IRS	Indian Remote Sensing
Km	Kilometer
LC	Land Cover
LISS	Linear Imaging Self Scanning
LU	Land Use
NGO	Non Governmental Organization
NUPI	National Urban Planning Institute
ORAAMP	Office for revision of Addis Ababa Master plan
RLDS	Rural Local Development System
RS	Remote Sensing
TM	Thematic Mapper
UDWB	Urban Development Works Bureau
UNCHS	United Nations Center for Human Settlements
UNECA	United Nation Economic Commission for Africa
WHO	World Health organization

ABSTRACT

This study attempted to analyze the process of land use change through informal land transactions and subdivisions in Kolfe Keraniyo sub-city of kebele 04, *Selti* Area which is locally known as *Selti sefer*. The study also explores the major impacts of informal urban expansion on the social and physical environments of the city in general and in the study area in particular. I have used both primary and secondary data for the purpose of this study. Aerial photographs of the study area of 1994 and 2002 at scale of 1:8000 and 1:2000 respectively, IKONOS image of the area (2007) and Google Earth image (2007) were used. Both qualitative and quantitative data were used and systematically analyzed using GIS and Remote Sensing techniques as analytical tools. In addition to these, the participatory mapping technique was used for the change of the area for the last seven decade in the study area. The analytical tools found out to be efficient to analyze land use change, pattern analysis and the extent of informal land conversion from agricultural use to urban land. The empirical finding revealed that the built up of the area between 1994 and 2002 was increased by 122.3 hectare which was 135.1 per cent. Similarly, the road (gravel and footpath) of the area increased by 4.7 km which was 20.4 per cent. On the contrary, agriculture land and forest were decreased from 159.8 and 12.2 hectare in 1994 to 27.3 and 11.3 hectare in 2002 which was 82.9 and 7.9 per cent respectively. According to this finding informal settlement in the area is a phenomenon seen after 1994 due to socio-economic and political reasons. The chronic shortages of housing, lack of access to urban land through the formal channel, poor and inefficient land management, lack of institutional capacity and administrative instability found out to be the major cause for rapid informal land subdivisions. My empirical observation revealed that the informal settlements in the *selti* area lack the basic urban social and environmental services. The area gets some of these services at best informally or uses its own mechanisms to cope with the problem. As a result, the area is facing serious environmental problems due to lack of water, road, and sanitation services.

Key words: - Land use/cover, Informal settlements, Environment.

CHAPTER ONE

1. INTRODUCTION

1.1. Background to the Problem

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 town 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. To prevent such problems from happening, urban planners need detailed updated maps for thorough effective and efficient planning and management. However, most city planners lack such maps and often they possess 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 (Amarsaikhan, et al. 2000).

Changes in urban land will take place as a result of implementation of new urban plans. Such plans may be prepared either to accommodate urban expansion, or to create new towns in accordance with resettlement scheme, or to improve the existing environmental infrastructure (Alain, 1996).

As knowledge has progressed and as science and technology have developed, society has achieved both an improved insight into the processes and consequences of environmental change and the means of altering the environment drastically. This can occur directly through activities such as habitat loss and urban expansion (Mannion, 1997).

The city of Addis Ababa has been developing progressively during the last 100 years, the city being a political and economic center, has attracted a large number of people from all over the country. Further industrial development in the town and its environs naturally resulted in a large number of people migrating into the city in searching of work.

Due to lack of access to urban land at affordable price for the lower and middle class many of the peripheries of the Addis Ababa city were occupied by informal settlers.

Alazar, 2004 stated that the 1986 Addis Ababa master plan had proposed compact urban growth in the three major directions: East (Kotebe), South (Akaki-Kality and Mekanissakotary) and West (Keraniyo). The same plan had put general development guide lines for the proposed expansion areas. In this regard, the strategy was to develop land for housing in the expansion areas with parallel provision of services and infrastructure. The main goal that was pursued in the expansion areas was that of fostering new and well-designed integrated development in a restricted number of vacant sites situated at the peripheral areas of the city with appropriate residential typologies to meet the housing needs. Studies done indicate that rapid population growth and the demand for housing have led to the expansion of cities at the cost of peripheral agricultural lands.

Commonly, people consider Addis Ababa as more attractive place to live in than the rural lands, (to me the rapid rural-urban migration which fueled the growth of the city is not the attractiveness of the city rather it is the deterioration of rural economy which forces the people to urban migration). The growth and current settlement patterns in Addis Ababa are likely to continue. Even though the city hosts several mid-rise hotels and commercial buildings in the inner city and commercial districts, the future growth of Addis Ababa is predicted to be largely horizontal. This is mainly due to the incapability of the urban residents to afford for high-rise buildings Baymot 2004, cited in (Kenate, 2005).

Miller (2000) mentioned that spatial activities such as building houses, infrastructure and industry may cause negative environmental impacts such as pollution, noise, land removal, loss of nature, changing of ground water table, hazardous etc. Though the studies conducted by the aforementioned individuals give us the major causes for the change of the land, expansion, population growth and informal settlements, much emphasis has not been given to the impacts of these changes on the surrounding local population and environment. Therefore, the purpose of this study is to assess trends of changes, causes and impacts of the changes on the local population and environment.

1.2. Statement of the Problem

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 metropolises. However, it is often the case that settlements grow irregularly under the pressure of masses coming to cities and these do not develop according to well-defined plans. Hence, it is necessary to monitor urban areas with frequent update Pradip, 1994, cited in (Seid, 2007).

Owing to high migration, natural increase and administrative reclassification of rural areas in the periphery to urban settlements, urbanization is creating continuing urban sprawl and associated problems in cities of developing countries. For instance, if one sees the urbanization trends in sub-Saharan Africa, because urban population is increasing at a highly accelerated rate, African cities are experiencing rapid urbanization which leads to unsustainable development.

Population growth is one of the most important factors causing the observed land use changes because of the increase of demand for shelter. Urban and industrial expansion has resulted in an increased pressure on important resources predominately in the metropolitan cities like Addis Ababa. Urban spread out has been blamed for inefficient use of land resource and large scale intrusion on to agricultural lands. As cities expand, agricultural land and habitats like forest are transformed into land for housing, roads and industry.

According to the study conducted by Urban Development and Works Bureau (UDWB, 2002), in the year 2000 the total area covered by squatter settlements in Addis Ababa was about 2,000 hectares and about 300,000 people were living in 60,000 squatter housing units (UDWB, 2002:2). Currently the number of squatter settlements and their area coverage are greater than the above mentioned figures (Minuieyelet, 2004).

This obviously led to changes in the urban land use patterns, causing loss of productive agricultural land, forest cover, other forms of greenery, loss in surface water bodies, depletion in ground water aquifers and increasing levels of air and water pollution; causing environmental problems. Thus the problem of expanding of city centers is complex and

complicated land use change is the end result of numerous interacting factors arising from different levels of associations of human environment systems, which differs in time and space.

Changes are generally driven by a combination of factors that work progressively and happen irregularly. Thus, it is necessary to measure and monitor land use changes over space and time for sustainability. The accessibility of high resolution data has been helpful for mapping spatial features, providing dependable, suitable, and precise data. GIS (Geographic Information System) and RS (Remote Sensing) techniques are used to create spatial planning and identify the pattern of settlements for decision making.

The increase of migration, lack of land for the housing of lower and middle class, an alarming rate of increasing of the rent house in the center of the city and the insufficient and delay of new construction of low house cost (condominium) are some of the factors aggravating the problems of inappropriate land use change in the study area. These all problems forced the people to purchase housing land from farmers at lower price in the outskirts of the Addis Ababa city especially in the study area of kolfe keraniyo sub-city of kebele 04. Due to the above reason of land use change from agricultural land to urban settlement, the former area has been negatively changing and this can result in loss of forest, pollution of rivers, construction of informal houses in the sloppy land and close to river bank which aggravate land slide and erosion. It is from this point of view that the research problem is selected. Thus, the magnitude of the problems seems very serious and needs urgent policy intervention based on proper research and policy intervention.

1.3. Objective of the Research

The general objective of the study is to analyze land use land cover changes, socio-economic change, and pattern detection with emphasis on the study area.

The specific objectives are:

- I. Mapping of the Land use Land cover (LULC) of the study areas at different periods and regimes,
- II. Analyzing the driving forces for the change of LULC,

- III. Exploring the implications of land LULC changes on the local population and environments, and
- IV. Extract some recommendations on policy issues and sustainable use of resources

On the basis of the given objectives, the following research questions are addressed in this study:

- i. What are the patterns of the LULC change in the study area?
- ii. What are the consequences of LULC change in the area?
- iii. How the LULC change affected the local population and environment?
- iv. What would be the possible solution to minimize the informal land subdivision?

1.4. Significance of the Research

This study is an attempt to extract useful information from remotely sensed images and analysis in the context of a given research problems. Hence, the out put of the study will be a methodological and empirical contribution of the significance of GIS and RS in the analysis of urban land use changes and pattern detection.

1.5. Site Selection

The researcher used purposive approach in selection of the study site for the following combination of factors:

- A. **Dynamic land use changes:** At first, all the expansion area of the sub-cities of the land use change of Addis Ababa were selected based on resource persons and then from these sub-cities Kolfe keraniyo was selected, because it is one of the areas in the city where the land use change and its impacts on the population and environment is more serious.
- B. **Prevalence of new settlements:** Again, from Kolfe Keraniyo sub-city, kebele 04 especially the *selti* area was selected that its problems were large concerning the scarcity of water and the unplanned occupation of land (According to the sub-city administration).
- C. **Existence of local people:** In spite of the land use dynamics and changes in the livelihoods of the local or indigenous people, still farming is practiced by the community.

1.6. Data Sources and Methods

For the purpose of analyzing LULC change, pattern detection and mapping this study utilizes different methods for data collection, data analysis and presentation. Among these, participatory mapping, GIS and RS are the main techniques. Data for this research are obtained from both primary and secondary sources.

1.6.1. Primary Data

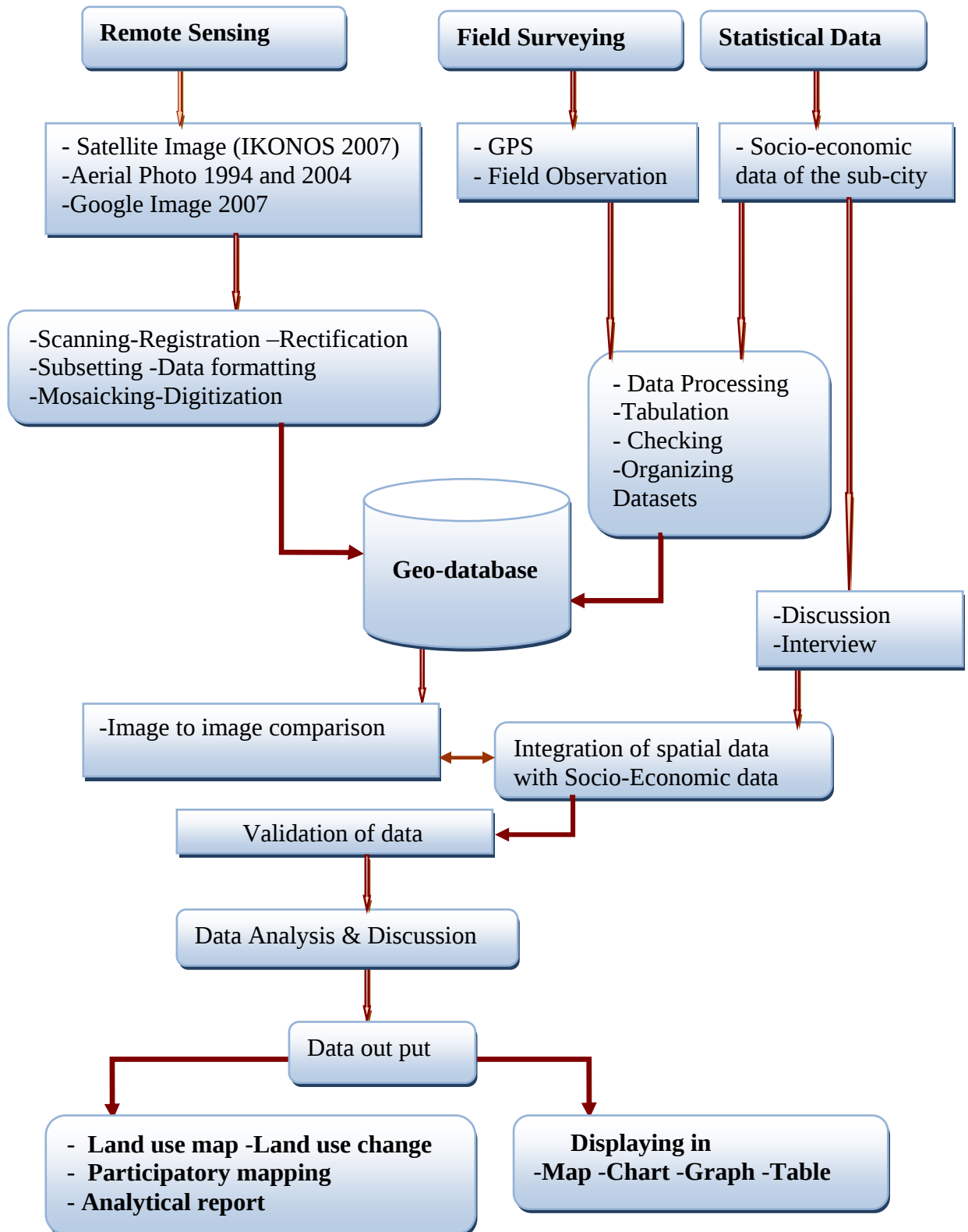
The primary data concerning the land use change and its impacts on local population and environment were collected from different sources using, participatory mapping of the different regimes, RS and GIS techniques and discussion and interview to different officials, elders and case study families from locals and settlers. I have also surveyed the different parts of the area to obtain first hand information.

1.6.2. Secondary Data

The secondary data used for this research is high resolution of satellite image of IKONOS of 2007 from Information Network System Agency (INSA) and Google Earth of 2007 image from kh. Google com. January 31, 2007, Aerial photo of the 1994 and 2002 at a scale of 1:8,000 and 1:2,000 respectively from Ethiopian mapping Agency (EMA), AutoCAD format of the study area data from kolfe keraniyo sub-city Land Administration office. Statistical data from Central Statistical Agency (CSA), kolfe keraniyo sub-city and Addis Ababa City Administration. Data on expansion of the city from Addis Ababa city Administration published and unpublished documents, thesis, books and browsing of internet.

All the data generated from land use change maps and respondents at various levels were sorted and summarized systematically to assess and explain the changes and its impacts on population and environment. Figure 1.1 below shows the flow of the thesis work.

Figure 1.1: Flow chart of the methodology



From the above flow chart, the researcher has used different methods to get the data analysis and final output of maps, charts, graph and table. The method which have been doing in the ERDAS IMAGINE 9.1 and ArcGIS 9.2 softwares are used for georeferencing (rectifying), subsetting, mosaicking, digitizing, classification, calculating areas, buffering, and building geodatabase. The technique which was used in the data analysis and discussion will be discussed in detail in the relevant chapters.

1.7. Limitation of the Study

Generally the study had some limitations, first due to the frequent change of the sub-city there was no well organized and reliable data of the study area. The researcher attempted to lessen this problem by generating original data. Secondly, during the survey some of the respondents were very reluctant due to the fear of the government as they believe they are illegal settlers. However, when they understand the objective of the study most of them were very cooperative. Thirdly, lack of access to different year's satellite imageries of high resolution, and finally, the problem of different scale of aerial photo is also a problem in LULC change analysis.

1.8. Organization of the thesis

The thesis is organized in such a way that the first chapter is focused on the introductory remarks of the thesis. The second chapter provides the review of literatures on the issue under discussion. In this chapter, land use policy of the country, land use change of Addis Ababa and the application of RS and GIS on urban land use change were reviewed. The third chapter describes the general overview of the study area and its demographic and socio-economic conditions of Addis Ababa in general and the study area in particular.

Chapter four deals with history of LULC, change analysis, discussion of the study area and the general image interpretation and analysis. The fifth chapter presents the main cause and implication of LULC change on local population and environment. Finally, the sixth chapter presents the findings and recommendations of the researcher.

CHAPTER TWO

2. Review of literature

2.1. The Concept of Land Use Change

Land use refers to the ways in which, and the purpose for which, human beings employ land and its resources (Briassoulis, 2000). Land use can be broadly defined as the level of spatial accumulation of activities such as production, transaction, administration and residence with highly dynamic relationships between them. Urban land use reflects the nature of social and economic activities in an area, as well as interactions with other areas. It results from the complicated interactions between the land system and the social economic systems (Jianquan, 2003).

Land use has been a concern primarily of social scientist: economists, geographers, anthropologists, planners, and others. The term denotes the human employment of the land. Land uses include settlement, cultivation, pasture, rangeland, recreation, and so on. Land use change at any location may involve either a shift to a different use or an intensification of the existing one.

Land cover is a concern principally of the natural sciences, denotes the physical state of the land. It embraces, for example, the quantity and type of surface vegetation, water, and earth materials. A land use change is likely to cause some land cover change, but land cover may change even if the land use remains unaltered. A forest will steadily shrink if a constant rate of timber extraction or shifting cultivation exceeding growth is maintained.

The realms of LULC are connected, in the terminology we adopt, by the proximate sources of change: those human actions that directly alter the physical environment. It is through the proximate sources that the human goals of land use translated into changed physical states of land cover. Example of proximate sources represents the point of intersection between the core concerns of the natural and the social sciences, between physical processes and human behavior. On one side, these proximate sources produce land cover changes, or alterations of the properties of the land surface. They may take the form of either conversion or modification, and they may lead as well to secondary environmental impacts: trace gas emissions, biodiversity loss, soil erosion and degradation, albedo

alteration and microclimatic change, and water flow and water quality changes are example. On the human side of the chain, the proximate sources reflect human goals mirrored in land uses (Turner and Meyer, 1994).

2.2. Review of the Related Literature

2.2.1. The Magnitude of Developing World Urban Expansion

The population of developing country cities is expected to double in the next thirty years, from some 2 billion in 2000 to almost 4 billion in 2030. The built up areas of developing country cities in 2000 is estimated to be 200,000 km². By 2030, the built up area of developing country cities will increase to more than 600,000 km². In other words, by 2030 these cities can be expected to triple their land area, with every new resident converting on average, some 160 m² of non urban land to urban land during the coming years (UNCHS, 2004).

By observing the facts cited above academicians and policy makers poses questions concerning the implementations of the accelerated rates of urban expansion in developing countries and what can or should be done about it? The basic dimensions of the policy debates on the expansion of cities are certainly not new. The age old question underlying this debate is still on whether expansion should be resisted, accepted, or welcomed? At one extreme, there have been those who fought to limit the growth of cities by any and all means. On the other hand, there were those who welcomed it and actively laid the foundation for cities to absorb the incoming waves of new migrant (Tseng yu.1988). This fundamental question on whether urban expansion should be resisted, accepted, or welcomed is still prevalent and unresolved. While many will readily agree that urban expansion is an issue of serious concern, there is no consensus among scholars, policy makers or urban residents themselves about whether further development should be restricted or encouraged.

Nowadays in industrialized countries, where migration is minimal and where population movements are inter-urban, there have been recent attempts to provide answers to these questions that are particularly relevant to their present level of urbanization and development. They concern more for unwieldy urban expansion typically criticized as 'sprawl' have recaptured the attention of both policy makers and academics and more

recently, voters during the last decade. In contrast, urban expansion debates in developing countries are still unresolved.

2.2.2. Forces Shaping Urban Expansion

What are the forces that are currently shaping urban expansion? The expansion of urban areas is determined by the interaction of the three broad types of phenomena. These are the physical or geographic factors, the demand for land by the households or firms who inhabit the city and the policy constraints that govern land use and spatial interactions in the city (Seto et al, 2003). More specifically, aspects of the natural environment that may affect urban expansion include those of climate, slope, mountain barriers, and the existence of drillable water aquifers. Demographic effects may include rural migration and natural population growth in the city, the level of urbanization and the rank of the city in the country's urban hierarchy.

Aspects of the economy that can affect the urban expansion include the level of economic development, difference in household incomes, exposure to globalization, the level of foreign direct investment, the degree of employment decentralization, the level of real estate finance markets, the level and effectiveness of property taxation and the presence of high inflation and acute shortage of housing (Angel et al 2005). The expansion of urban to the periphery largely depends on the second factor from the three mentioned above. These two conspicuous factors are urban development and urban population increase. The demand for land by various firms who inhabit the city can intensify economic development projects, which could be one cause for urban expansion to the periphery.

Space is needed for various economic and social infrastructures, cultural, and other purposes. Redevelopment and organization of inner cities again cause displacement of citizens. This in turn requires space, which invites extension of urban settlements to the rural territories (Cernea, 1995). Natural population growth is a major element in urban growth for all countries, but rural urban migration contributes more in many developing countries (Gugler, 1996). Migration contributes fast growth of urban population due to the relative economic development that attracts people to urban nuclei for commerce, employment, and education. Many believe that cities are expanding very rapidly and are growing for non productive reasons specifically, some scholars believe that new policies

and regulations on land acquisitions and illegal land markets might have encouraged the extensive shifts of cultivated area in to built up area (Yeh et al 2003).

A number of observers also suggest that housing price have risen unreasonably high in many cities of the developing countries and are inducing developers and investors to invest in more housing stock than would be rational in a purely market driven economy (Wu,F. 2000). In short, scholars believe that there are economic and non-economic factors that are encouraging the expansion of urban to non urban areas.

2.2.3. Forms of Urban Expansion

Does urban expansion takes place in substantially different forms, or is it essentially identical everywhere? Urban expansion takes place substantially in different forms. In any city, new urban expansion can take place with the same densities (person per square kilometers) as those prevailing in existing built up areas, with increased densities or with reduced densities. It can take place through the redevelopment of built up areas at high densities through infill of the remaining open spaces in already built up areas or through new “green field” development in areas previously in non- urban use. New green field development can either be contiguous with the existing built up areas or can leapfrog away from them, leaving swaths of undeveloped land that separate it from the existing built up areas. It can encroach upon wetlands, watersheds, forests, and other sensitive environments that need to be protected (Angel et al, 2005).

Expansion may take place along corridors resulting in a star shaped or elongated city, or in areas closest to the city center, resulting in a more or less circular or compact shaped city. The form of urban expansion can be orderly, properly laid out in simple geometric forms and it can be disorderly. It may leave adequate space for roads or other necessary infrastructure, or it may leave too little or too much space for roads. The infrastructure accompanying urban expansion may be of a varying quality, reflecting very different levels of investment, maintenance, and repair. New land development can be largely legally sanctioned, conforming to strict zoning and building codes. There are others who favor neither compaction nor expansion of cities. They are advocating for selecting elements from both outlooks. Their argument promotes urban regulation strategies and new intra-urban environmental initiatives and it goes in line with the compact city argument that

favors controlled direction of inevitable expansion to the periphery to support a full range of facilities and to the sites that causes the least environmental damage (Isaac et al, 2000).

2.2.4. Consequences of Urban Expansion

As the World Bank transport and urban Development Department indicated, even though, the available evidences are spotty, controversial and not necessarily applicable to developing country cities, suggest that the above mentioned differences in the growth and expansion of cities are associated with both positive and adverse outcomes that affect the welfare and well being of the citizens.

The available literature concerning urban expansion is rife with blame for its inappropriate and unnecessarily costly for developing world cities. Most blame is directed at expensive leapfrogging green field development. It is claimed that such development reduces both access and view of open space. It encroaches on sensitive environments and on scarce farmlands. It requires long journeys to work; it leads to higher levels of car use and therefore, to higher levels of air pollution, energy use, and the production of green house gases; it increases dependence on vehicles; it makes public transport less attractive and less efficient. It also requires longer and more costly extensions of public infrastructure networks and it imposes additional costs on residents of new expansion sites. It also diverts construction away from the central parts of the cities that needs to be redeveloped. As a result of urban expansion social interaction between people reduces and urban lifestyle becomes less exciting resulting in alienation, social fragmentation, and both economic and social segregation and unplanned changed of farming land into urban land (Durlauf, et al,1995).

2.3. Land Use Policy

The land policy of the country states both rural and urban lands to be the property of the state and ensures the use right by renting urban land for definite period of time. The policy allows that the government can retain land needed for public interest and use individual holdings for the better development activities by paying compensation to the owners for the properties stationed on such lands. The policy also helps to stabilize the price of land and houses and equitably distribute land to both the rich and poor. The leasing of urban

land to users at a reasonable rate through long time installment saves the beneficiaries from expending large sum on purchase of land at once and the use of money for other development activities (Urban Development 2005).

Since the nationalization of extra houses and land in 1975 land is a public property and it is in the hands of government and again, in the constitution it is clearly stated that land is public property and owned by the Ethiopian people and government. The right to use land is given to individuals in lease terms. In December 1994, the constitution approved land under the control of the people and government of Ethiopia thus prohibiting land selling (EPA, 1997)

Lease law was enacted in 1994 and revised in 2002. The main goal of lease is

- Promote lease system, collect lease payments so as to address infrastructure demands of the city dwellers
- Address housing problems of the city by providing lease holding to capable private dwelling houses
- Encourage investment so as to alleviate economic and social problems of the city.
- Ensure fairness (justice) in administrating urban lands.

Three types of land lease processes

1. Land lease on auction basis for
 - Investment and residence exceeding 175 m²
2. Land lease without auction potential for investment
3. Land lease for residence (73 -175 m²) AACA (2002)

According to (Solomon, 2006) the AALDA (Addis Ababa Land Development Agency) has incorporated extensive agricultural land to urban expansion mainly to provide plots below 73 m² free of charge for low cost housing. Lands above 175 m² could be acquired at market prices through public tenders. Real state developers are allowed 60 year lease terms and other ventures may involve leaseholds varying from 50 to 99 years (Alain 2004).

2.4. The Informal Settlements

2.4.1. Informal Settlements in Urban Expansion

In this research the informal settlements is considered as one of the cause for the urban land use change and its impacts to the local population and environment in the study area and the expansion areas of the eastern and southern part of Addis Ababa.

Informal, or spontaneous, settlements are settlements whereby persons, or squatters, assert land rights to or occupy for exploitation land which is not registered in their names, or government land, or land legally owned by other individuals (Kibwana, 2000). Squatters are people who occupy land or buildings without the explicit permission of the owner (HABITAT, 2003).

It is mentioned that in many cities of the developing world, 40-50% of the population live in slums and informal settlements as much as 85% in the case of Addis Ababa, 59% for Bogotá and 51% for Ankara (UNCHS, 1986). It was also stated that the informal settlements are observed in agricultural lands in the vacant spaces between the new-planned development and the existing old residential areas, in which, relatively few basic infrastructure and services are available.

In most developing countries, poor economic performance caused by both internal and external factors have led to the growth of informal settlements in the outskirts of urban areas parallel to the formal one. Informal settlements provide cheap accommodation and economic opportunities for a large part of the population meaning that these settlements respond both to housing needs and to the search of economic activities.

People living in the informal settlements seem to be more innovative than the planners and managers of large cities in most cities and towns of the developing nations (Freihage, 1987) cited in (Alazar, 2006). They have come up with innovative solutions that are able to accommodate and provide services for the majority of urban residents. A growing number of land seekers find the informal sector more responsive to their demands of land for housing while the public sector finds it increasingly difficult to manage urban growth according to its legal norms and the needs of the citizens (Wilbard, 2000).

Informal settlements do not grow in a linear pattern, or house construction activities do not occur uniformly and systematically over the settlement lifetime, but explode at a certain time of growth. This gives rise to three phases of informal settlement growth:

- **Infancy or starting stage**—prospective house seekers are converting peripheral agricultural land to residential use.

- **Booming stage**—land markets have heated up primarily because land has become attractive to high and middle income households. At this stage, housing densities are higher than at infancy stage.
- **Saturation stage**—a settlement development phase where open land for house development is more or less depleted and additional units are primarily a result of plot densification and extension or encroachment on the limited open spaces including public and semi-public areas (Wilbard, 2000).

The urban poor in most cities of developing countries have occupied land illegally and built their houses with their own resources without following the building codes and other governmental regulations. This has led to the proliferation of squatter settlements (Cheema, 1993). On the other hand Fernandes (1998) has stated that urban researchers should not forget that the phenomenon of illegality is not restricted to the urban poor. Many more privileged groups of the society are also observed in squatter settlements Fernandes and Varley, 1998: cited in (Minuieyelet, 2004).

2.5. Application of Remote Sensing & GIS on Urban Land Use Change

2.5.1. Urban Expansion and the Urban Land Use Change

The urban boundary is uncertain. Official urban boundaries rarely match the exact extent of built up areas, they may be too small (as urban development has spilled over boundaries set many years ago) or too large (as urban boundaries have been defined that encompass large area of agriculture, forest and water). In addition, urban systems in developed countries have become more spread; supported by more extensive high way system, better communication and industrial structures that encourage more decentralized production systems. An aerial View of most major cities is no longer one of a concentrated urban centers surrounded by countryside but of complex spatial patterns of urbanized and non urbanized areas with urbanized areas often stretching along major transport corridors for long distances beyond city boundaries. In addition, it is common for residential communities and industrial and commercial concentrations to develop close to major cities but separated from the built-up area (WHO, 2001).

2.5.2. Some Experience about Urban Land Use Change Detection Studies

The development of RS and GIS eased the process of LULC change detection of both urban and rural land uses. A study carried out by (Nigam, 2000) underlined that RS as monitoring technique and urban planning requires data on changing LU, urban sprawl and the environment. In this study, LULC change analysis using remotely sensed data has been applied to discover the trend of development of the rural–urban fringes of Enschede city, Netherland. The city of Enschede is experiencing physical expansion along with its horizontal intensification. The study used COSMOS data (merged with TM of the 1993 and IRS pan data (merged With LISS-111 of 1996) coupled with GIS technology can provide important information about the development which are taking place in the rural urban fringe of the city and thereby can play an important role in planning and managing the city. The first target was examining the LULC changes which occurred during the period from 1993 to 1996 and 1996 to 1998. Second, he tried to develop the hot links and user interface allowing accessing the required information to the user. Accordingly, the land use change analysis has shown that there is higher magnitude of change in residential and industrial land use during the period 1993 to 1996 which constitute 37.1 hectare and 9.7 hectares respectively of the total area change. Also during the same period 10.5 hectares of cropland was included in to the construction site. Between 1996 and 1998, 10.5 hectares of constructions sites is changed in to residential and new construction sites have come in to picture (Nigam, 2000).

CHAPTER THREE

3. BACKGROUND OF THE STUDY AREA

3.1. Physical and Socio-Economic Background of Addis Ababa

Addis Ababa, the capital of Ethiopia, which is by far the largest in the country located almost at the geographical center of the national territory, covers an area size of 530.21 square kilometers and a population of 3,059,000 million persons (CSA, 2006). Addis Ababa has a history of a little more than 100 years. It is a young city in comparison to several other urban centers of the country. The actual date of the initial settlement of the city is a little obscure and is difficult to determine the exact date when it was founded by Emperor Minilik II and Queen Taytu. Emperor Menilik constructed a palace North of the hot spring of Filwoha and gave the name Addis Ababa (Amharic equivalent for New Flower) to the city. Thus, one can say with assurance that it had its earliest beginnings in the mid 1880s and had evolved to be the capital of Ethiopia around 1886/87 City Council of Addis Ababa, 1986, (Johnson, 1974).

In this short span of time, the city grew from a small traditional Ethiopian town to one of Africa's metropolises. A closer survey of its history, however, indicates that the process of its growth portrays some differences from other African capitals. This is due to its resistance to the colonial powers. This situation minimized foreign domination of Addis Ababa in comparison to the capitals of other colonized countries. Astronomically, Addis Ababa is located at 09⁰ 02' N Latitude and 38⁰ 44' E Longitude. It is built on the steep escarpment of Mt. Entoto in the North (2900 meters) to the South with an average altitude of 2400 meters. This varying topography of the city has affected its spatial expansion favoring the relatively flat landscape in the south as a major factor contributing to the unsafe housing condition in the city, as cited in (Hadgu, 1988).

The city is crossed by streams namely Kechenie, Kebena, Ginfile and Akaki and their tributaries all rising from the steep slopes of Mt. Entoto in the North and following southwards to join the Akaki river, the tributary of the Awash river. Thus, Johnson had amply described "...the site of Addis Ababa is overwhelmingly made up of slopping terrain, deeply incised by swiftly flowing streams, with scattered hills, ridges and eroded land predominating. The nature of the topography of the city coupled with deforestation,

considered to be the main factors for land degradation and soil erosion.” Despite the fact that Addis Ababa is located within the tropics, it has an ideal climate throughout the year. Furthermore, due to its location on a relatively high plateau, the city experiences a temperature of moderate type of climate with an average maximum of 24 °c to an average minimum of 11 °c in 2004 and 22 °c and 10 °c in 2005 respectively (CSA, 2006).

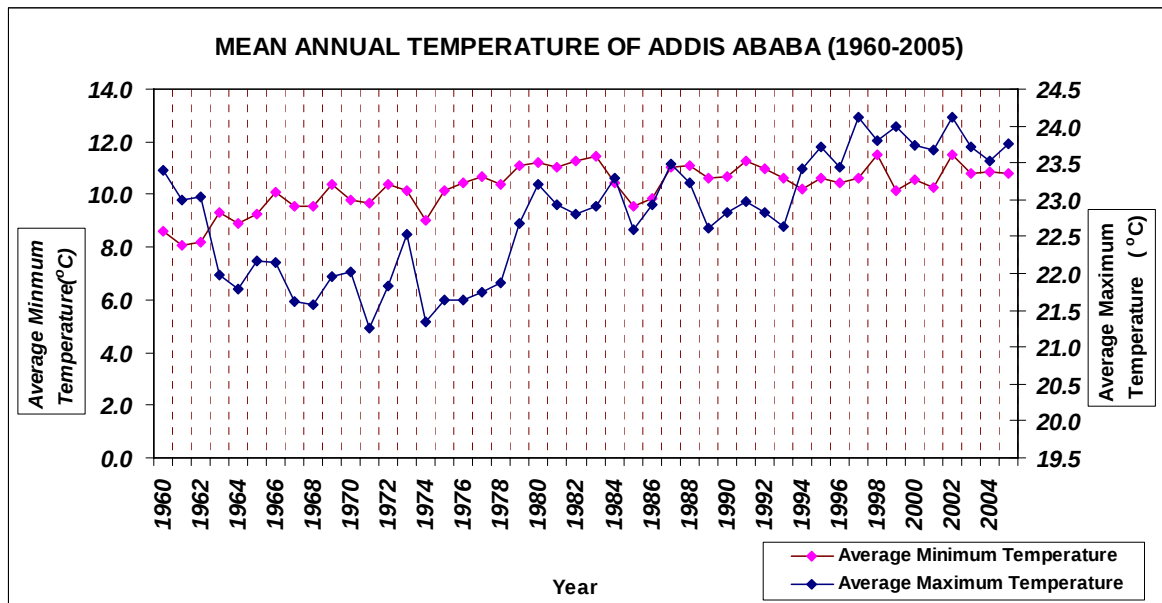


Figure 3.1 Temperature of Addis Ababa. (Source: National Metrological Agency)

The city’s mean annual rainfall is about 1179.6mm (CSA, 1999). However, due to relief variability micro-climatic differences are visible within the city limit. In other words, thus, the relatively elevated of the northern part of the city is comparatively wetter and cooler than the South.

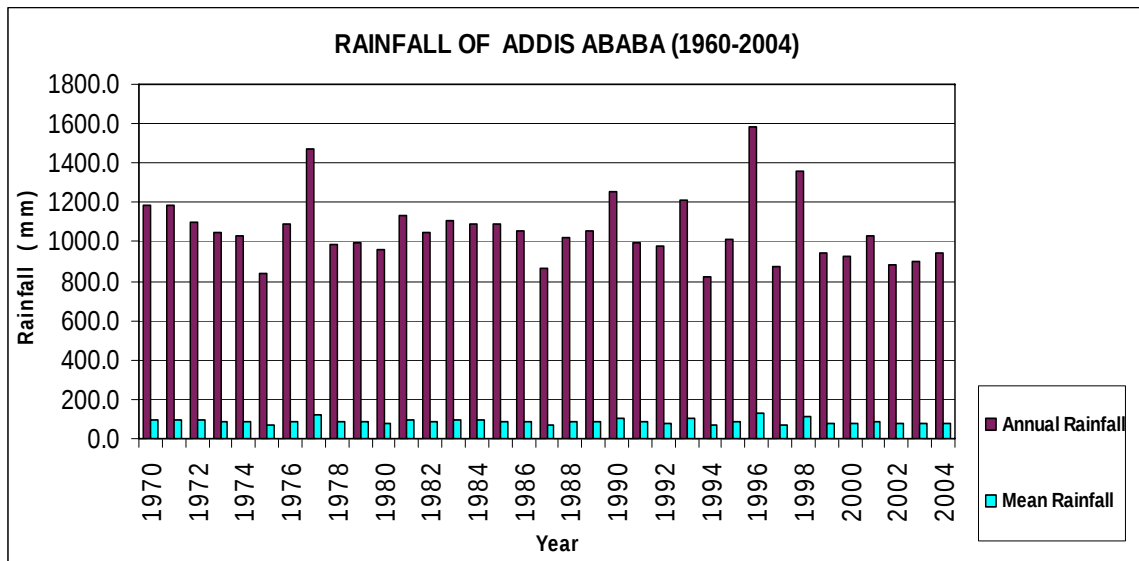


Figure 3.2 Rainfall of Addis Ababa. (**Source:** National Metrological Agency).

Due to the change of the climate and rainfall of Addis Ababa, it might also be a change in rainfall and climate in the particular study area of the research. This change can lead to the agriculture system changed into other activities.

The role of Addis Ababa as a seat of government has helped the city to undergo various alterations. It has emerged as a city that has both international and national significance. The international significance of the city is revealed that the city has been serving as seats of various international organizations and embassies. These include as a diplomatic capital of Africa which houses various international agencies or organizations such as AU (Africa Union), UNECA (United Nations Economic Commission for Africa,) more than 100 embassies, and consulates of various countries, several governmental and Non-governmental offices. The national significance of the city comes as the city is the major commercial and business establishments, industrial, education and political center of the country. All these contributed to the special attention given to the city. Five major radiating highways, such as Dessie road, Jimma road, Hararge road, Gojjam road, and Nekemte road lines link the city with the rest regional part of the country. The only railway line in the country runs between the city and the Republic of Djibouti.

The city also has various national and international connections via Bole international air port and competent airlines. The city of Addis Ababa is relatively better endowed in terms of different kinds of infrastructure like social services such as education, health, roads,

industrial establishments and commerce, etc. It hosts the largest open market in Africa, known as Merkato, covering a substantial proportion of its municipal area. The city has a lion's share of large and medium-sized manufacturing establishments of the country. However, compared to manufacturing, trade, and service sector are the dominant economic activities in the city. They generate a large proportion of employment opportunities and the city's income. In this case, the city has a higher supply of these services compared to the national standard. This is one of the reasons for the influx of people to the city. This does not however mean the city is adequately supplied with these facilities. The adequacies of these facilities are far from the actual demand and standard.

As a capital city, Addis Ababa is a seat for the Federal Government of Ethiopia. The constitution of the Federal Democratic Republic of Ethiopia recognizes Addis Ababa as a chartered city and national capital situated within the Oromia regional government. The Addis Ababa City Administration is accountable to the Prime Ministers office and the public.

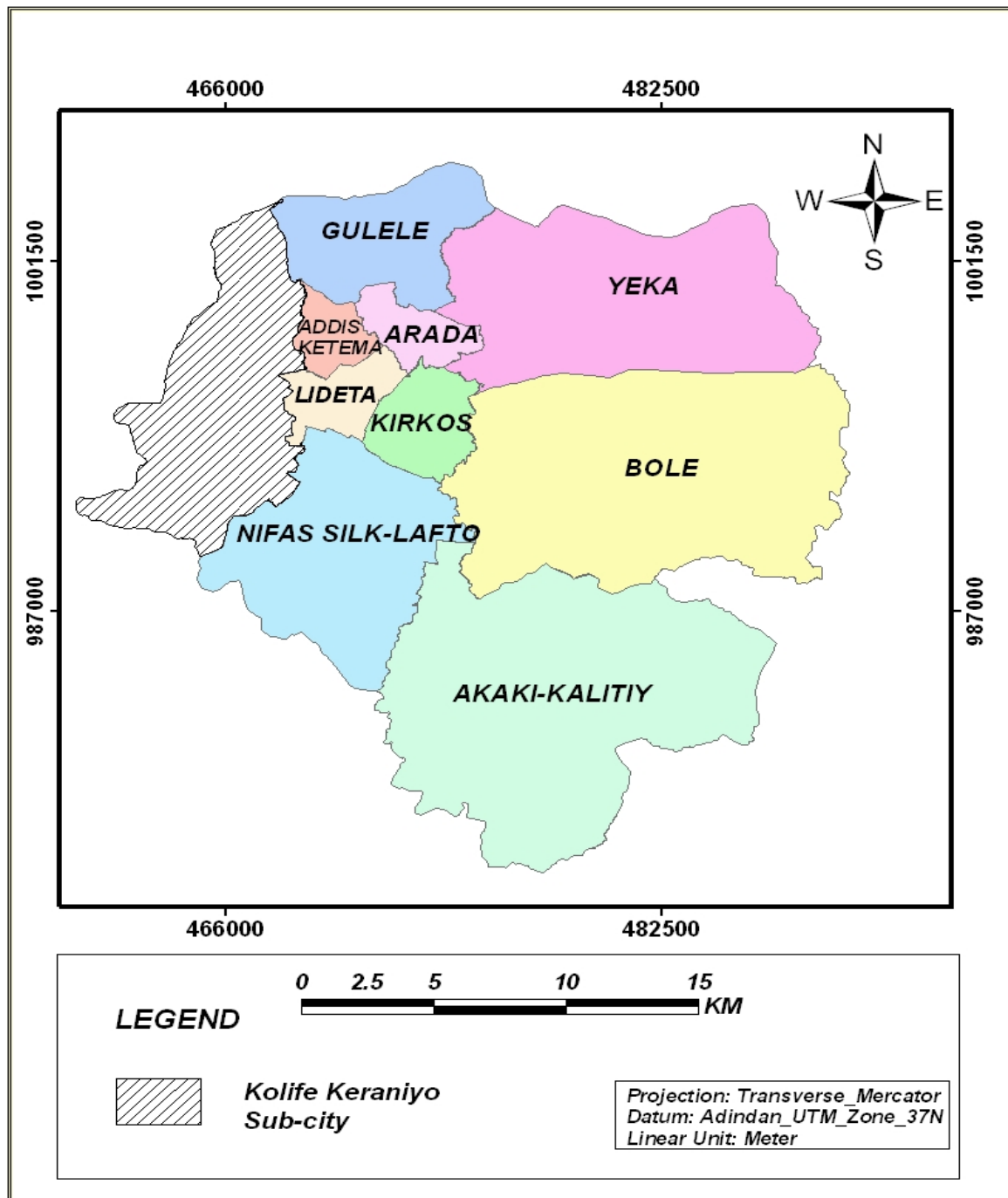


Figure 3.3 The Location of Kolfe Keraniyo sub-city in the city Administration of Addis Ababa

The structure of a new geographic sub-division, resulting from this reform, has profoundly altered the territorial asset of the capital. In the course of its development, the city showed a modest and irregular town-planning. The main reason for the irregular development of the city is not lack of plan rather it is the poor implementation of plans. Addis Ababa had many plans but it has never brought effective changes on the ground. Even today the

growth of the city is not the outcome of modern planning but it is due to relative economic growth.

Table 3.1 Addis Ababa sub-city population and area 2007/08

Sub-City	Population		Total	Area In Sq. Km	Density (pop/area)
	Female	Male			
Arada	169,020	189,591	358,611	9.5	37,749
Addis Ketema	212,957	218,442	431,399	7.4	58,297
Lideta	174,152	188,401	362,554	10.9	33,262
Kirkos	194,012	212,905	406,916	14.7	27,681
Yeka	179,869	206,132	386,001	82	4,707
Bole	165,999	186,835	352,833	117.3	3,008
Akaki-Kality	115,770	123,858	239,628	124.1	1,686
Nifas Silk-Lafto	190,252	207,877	398,129	58.5	6,806
Kolife Keraniyo	167,807	171,379	339,186	62.1	5,462
Gulele	183,629	192,002	375,631	31.1	12,078
Total	1,753,467	1,897,422	3,650,888	517.6	190,736

Source: Addis Ababa Bureau of Finance and Economics and computed by the researcher.

3.2 Demographic Background of Addis Ababa

According to the 1994 census result, Addis Ababa accounts for about 4 percent of total population of the country and 28.5 percent of the national urban population. The growth rate of the population between 1984 and 1994 census was 3.25 percent. According to the census, the sex ratio of 94 males per 100 females, indicate excess of females over males. The age structure of the population in Addis Ababa combines about 32 percent of children below age 15 and very small about 3 percent of old age people above 64 years. The proportion of the population aged 15-64 is usually high and constitutes about two-third of the total population. This could be partly due to high in-migration of population in the working age group (CSA, 1999).

Table 3.2 Population size, annual absolute change, and average annual growth rate of Addis Ababa (1900-2002)

Year	Population size	Annual absolute change	Average annual growth rate (%)
1900	50,000	-	-
1907	60,000	1428.57	2.3
1910	65,000	1666.67	2.5
1912	80,000	7500.00	9.3
1935	100,000	869.57	0.9
1941	143,000	7166.67	5.0
1946	180,000	7400.00	4.1
1956	318,000	13800.00	9.4
1961	443,728	25145.60	5.6
1967	683,530	39967.00	5.8
1978	1,167,315	43980.45	3.8
1984	1,423,111	42632.67	3.0
1994	2,112,737	68962.60	3.3
2002	2,905,103	99045.75	3.4

Source: Compiled and computed from data found in Yirgalem M. 2008

From the above table 3.2 the Addis Ababa population has increased in the last 100 years by about 2,855,103 people which shows that it has not increased much as compared with other developing countries. In Lagos, the capital city of Nigeria, the population has increased to 7 million in 1987, from 329,000 in 1952 which was in a 35 years (James,1987) Furthermore, according to the census of 1994, 53 percent of population was born in the city while 46.7 percent were migrants. This indicates that nearly half of the population was migrants. It was also indicated that 51.7 percent of migrants were female, 48.3 per cent were male, and most of which were in the age group 10-39. Unemployment rate is high; the demobilized army of the Derg government further aggravates this. According to the two consecutive census of 1984, unemployment rate in the city increases from 10.5 to 35.1 per cent. (CSA, 1999).The rapid growth of the city continued in the late 1980s and early 1990s. Hence, population growth of Addis Ababa recorded more than doubling growth

within a short period of time. This implies that more has to be done in rural Ethiopia to minimize the out migration to urban centers.

3.3. Population Trends of Addis Ababa

Population growth in Addis Ababa was fairly slow during the first half of twenty century. But as the migration to cities and establishment of industry in cities of Addis Ababa started, many of the countryside people migrate to the city and population growth began to increase rapidly. The population of Addis Ababa was 1,423,111 in 1984. Today, the population tops about three million. It is the fastest growing metropolitan in the country. Based on the current growth rate the city populations will double itself within two decades.

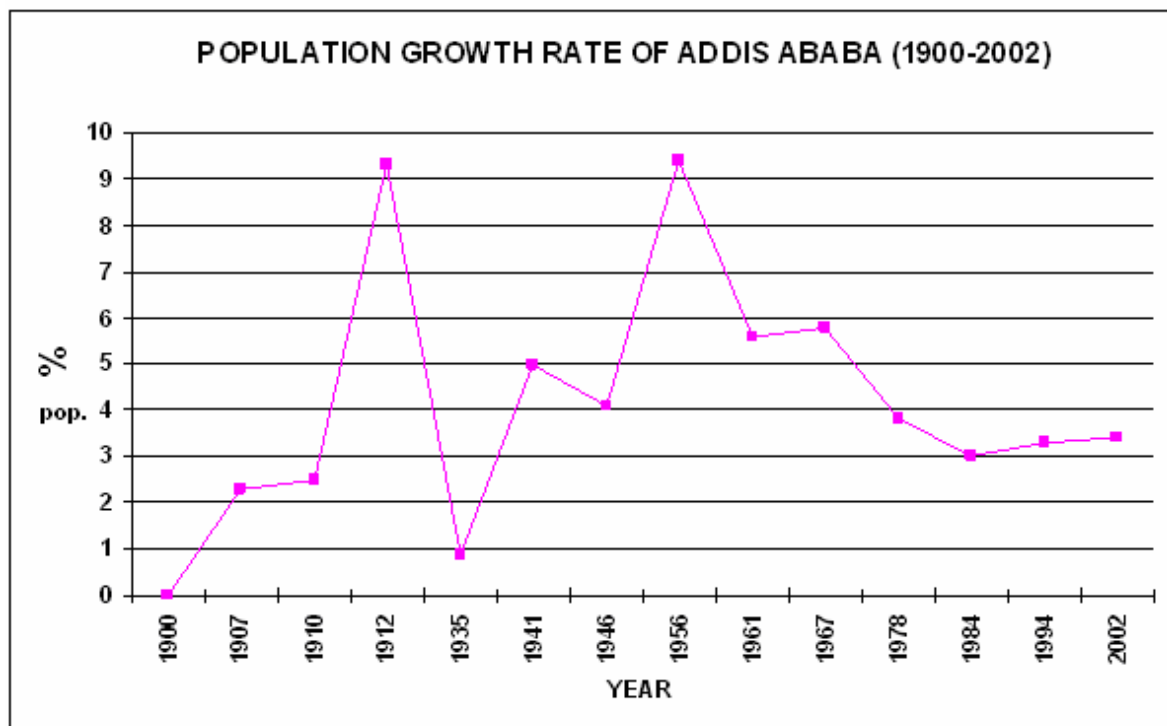


Figure 3.4 Population growth of Addis Ababa (1900-2002)

Source: Data from Yirgalem, 2008

From figure 3.4 shows the population growth of Addis Ababa varies in different time due to different reason. (Yirgalem, 2008) stated that a sharp decrease between 1912 and 1935 due to the out break of the Spanish flu in 1918/19, which killed more than 8 per cent of the population. Thereafter, there was a new increase until the period of Italian occupation (1936-1941). During the Italian occupation, there was a slight decline, followed by a sharp

increase soon after the liberation in 1941. After 1941 up to 2002 there was a high increase of the population in the 1956 and decreased in 1961 and moderately some change from 1984 to 2002.

3.4. Background of the Specific Study Area (Kolfе Keraniyo Sub-city)

3.4.1. Overview of the Kolfе Keraniyo sub-city

The former City Administration unit of woreda 8, 23, 24 and 25 were restructured and formed as a new administration part, which was Zone 2 of Addis Ababa City Administration. In 1995, some of the kebeles, and the above mentioned woreda were again restructured and introduced as a single administrative unit, which today is called as Kolfе Keraniyo Sub-City in 2003.

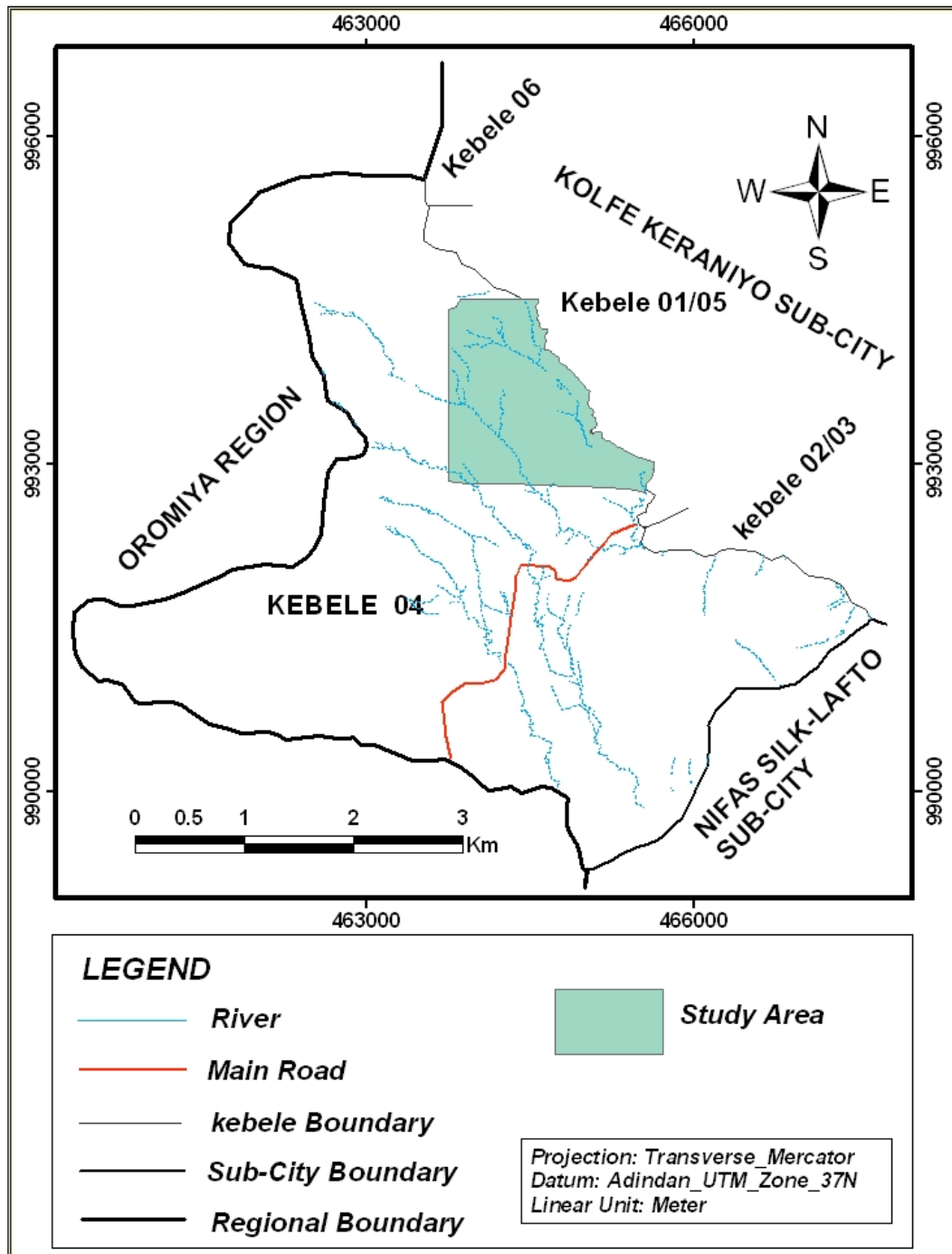


Figure 3.5 Location of the study area

The sub-city is one of the ten sub cities established under Addis Ababa City Administration. It is about 9.6kms away from center of the city and about 13 kms the western side of the sub-city reaches from the center. It is located at the western part of Addis Ababa, between the road to Jimma and Ambo towns. The sub-city shares boundary

with Gulele and Addis ketema sub cities in the north, Lideta sub city in the east, Nifas Silk-Lafto sub city in the south, and Oromiya regional estate of government in the west. The sub-city is divided in to ten kebeles.

It has an area of 5471.31 hectares from this about 1334 hectares was covered with forest and included prominent feature of Mount Jemo, Jemo River and Repi Medhanealem Mountain. The sub city has almost similar elevation above sea level between 2400-2500 meters. The population of the sub-city is more than 339,186. According to a report from the city Administration and officials in the sub city it is one of the rapidly expanding sub-cities of Addis Ababa where intensive housing construction is taking place and nowadays its population and areal extent is increased than the previous.

3.4.2. Population of the Sub-City and the Study Kebele

According to Addis Ababa Bureau of Finance and Economics report (2007/8) the populations of Kolfe Keraniyo sub-city were about 339,186 in the year 2007/8. The sub-city stands the eighth largest populous sub-city in Addis Ababa. The gender proportion reveals that the females out numbers the males (Table 3.3).

Table 3.3 Population distributions of Kolfe Keraniyo sub-city by kebele

kebele	Male	Female	Total	Total Area Km ²	Population/Density (p/km2)
02/03	22,840	25,375	48,216	3.34	10,605
04	6,209	6,670	12,879	19.52	2,078
01/05	22,840	25,375	48,216	6.86	3,711
06	6,209	6,670	12,879	6.29	7,829
07	11,027	11,556	22,583	7.77	2,906
08/09	22,547	21,572	44,120	2.51	17,578
10/11	25,517	23,727	49,245	4.87	2,645
12	12,326	13,130	25,455	1.27	37,965
13/14	18,030	17,390	35,420	2.12	22,743
15/16	19,790	20,771	40,561	7.97	1,616
Total	167,335	172,236	339,574	62.52	101,855

Source: population data from Addis Ababa Bureau of Finance and Economics
(as computed by the researcher)

Population density of the sub-city in general, is about 43.2 person/km² while the annual growth rate was about 3.2 per cent. Out of the total population of the sub-city, 44.5 percent is males and 55.5 percent cover the females' population.

From the above table 3.3 population density map of the sub-city of kolife keraniyo, the study area of kebele's 04 is the largest areal extent and the smallest population density which is the range between 1616-2078 population per Km² of all other kebeles' in the sub-city. The low population density and the strategic location between the urban and rural or forested area and agricultural land might be the force of attraction to accommodate the ever increasing population of Addis Ababa

3.4.3. Household Size

In the area, the average household number of one family of the local settlers is different from that of the settlers. In the local settlers the range is 3 to 6 whereas the range of the settlers is 6 to 8. The settlers are Muslims and practice polygamy, and thus have an extended family.

3.4.4. Housing, Settlement Type and Built-up Condition

Shelter is one of the basic necessities for human beings. Currently, about 56,224 housing units are found in the sub-city. Out of these 6208 houses belong to kebele, while 377 of them are possessed by Ethiopian Rental Housing Agency. The rest 50,679 houses are privately owned. In general, there is a wide gap between the housing demands and supplies in the sub-city. This is because of the rapid population growth and partly also due to an increased cost of constructional materials. In the study area the settlement and housing type was different. Previously, the settlement type was sparse. The houses were located here and there and were made from thatched roof and mud wall.

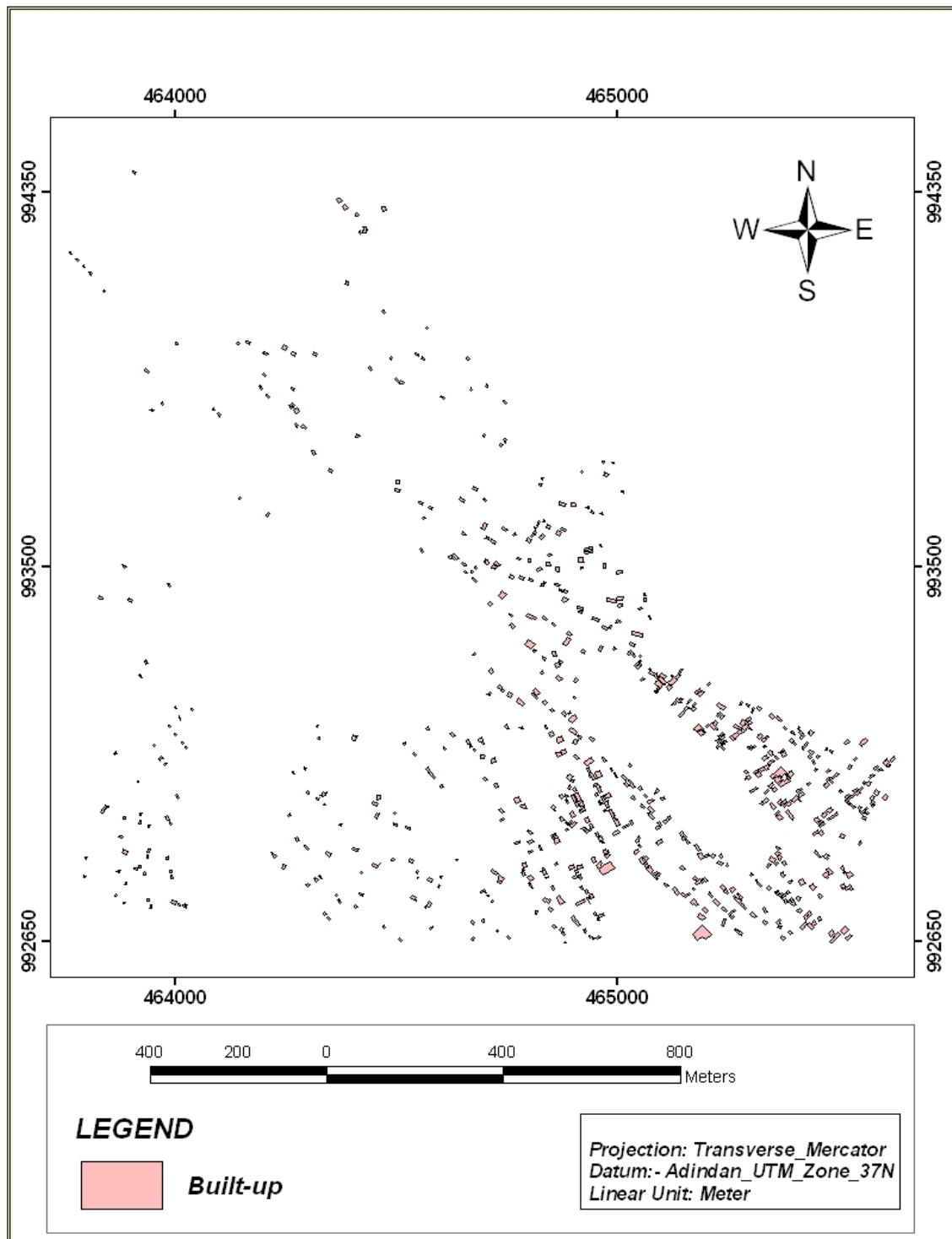


Figure 3.6 Built up in selti area 1994

In recent time, especially after the new settlers came to the area, there have been significant changes in the pattern of the settlement and the type of houses constructed. Currently, most houses are made from corrugated roof and mud wall. In some cases brick walls are used.

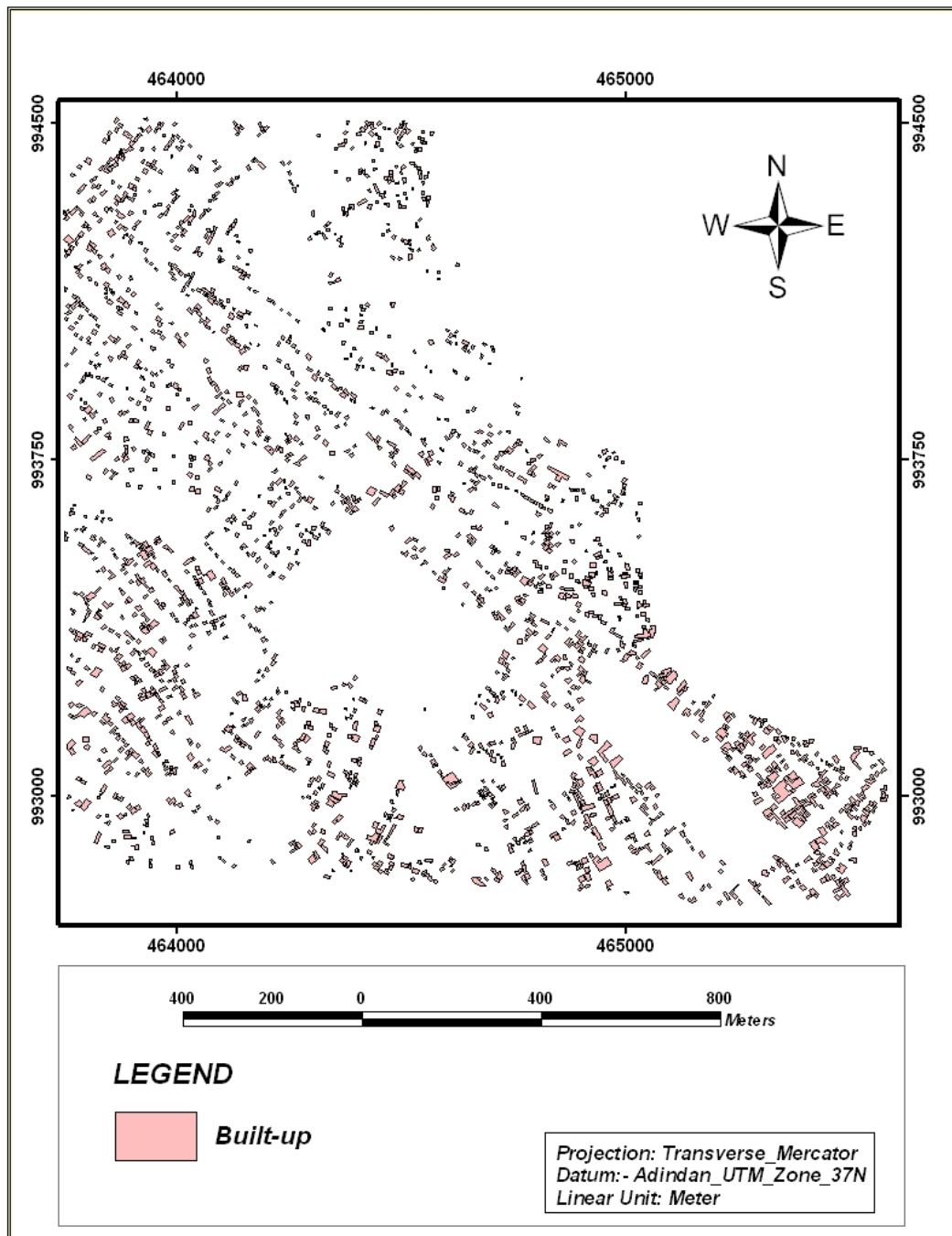


Figure 3.7 Built up in *selti* area 2002

From the above figures (i.e. 3.4 and 3.5) the built –up is 690 and 2238 houses in the year 1994 and 2002 respectively. The percentage change is 224.3 percent which shows how alarmingly the land use of the area has changed.

3.4.5. Land Ownership

There are three major types of land holdings in the area. These are:

Private ownership: - a type of ownership possessed by the prime settlers who have a title deed. These groups pay land taxes to the government.

Government ownership: - a type of ownership where by the government is the proprietor of the land.

Private ownership without a title deed: - a type of ownership where 99.5 percent of the land holding falls in this type of holding. These holders are people that came from the central Addis and adjacent areas. Most of them came after 1995 and purchased agricultural land from the farmers, and now have a document signed by the seller and the witness.

To grant title deed to the above third type of ownership holders, the Land Administration and Development Authority had provided some criteria to be fulfilled by holders in 2005.

The conditions set forth were:

- i) If a person has 175 m² lands, he / she must pay 10 birr for each m²
- ii) If a person has 175 m² and more, he / she must pay 400 birr for each extra Sq. m beyond 175 m²

But the local people disagreed saying that the demanded cost was too much as they first obtained the land by paying some amount of money to the sellers. They demanded the revision of the regulation. However; the settlers were not only denied title deed but also the right to construct any thing in the holding as well as renovating their houses. This is said to have prevented the locals earning more rent.

3.4.6. Wildlife, Vegetation Cover and Biodiversity

3.4.6.1 Wild life

The wild life habitat of the study area used to be very much wider. In earlier times, the area was covered by forests, bushes and the number of the population was very small .More over; the type of settlement was fragmented. These all were suitable for the wildlife habitat. The different species of wildlife which existed were rabbit, mongoose, hyena, leopard, duiker, and guinea fowl birds, all except the hyena are nonexistent now (group discussion with elders, 2008).

3.4.6.2. Vegetation Cover and Bio-diversity

Nowadays the sloppiest part of Mount Jemo and its foot hill is covered by the eucalyptus tree the reason being the area was very difficult for construction of houses. This has resulted in protecting the land from becoming eroded .It has also resulted in making the surrounding breezy.

3.4.7. Socio-Economic, Infrastructures and Livelihood

3.4.7.1 Education

Currently 39 governmental, 18 public, 99 private schools, 14 Muslim Mission, 2 Orthodox Christian Church Schools and 9 Non-governmental schools are found in the sub-city. Among these, 50 of them are primary school (Grade1-8) while 11 are secondary schools (Grade 9-10) and 4 of them are preparatory schools (Grade 11-12). Likewise there are 76 KG, 26 evening schools, and 16 basic educations centers in the sub-city. In addition there are two technical colleges and one police-training center in the sub-city. According to Kolfe Keranyio sub-city educational office; the numbers of students enrolled in 2006/2007 were 57,372 students at primary schools, and 12,393 students at secondary schools. The numbers of female students were 30,183 in primary school and 6,426 in secondary schools. The female students in both primary and secondary schools are more than the male counterparts. The numbers of teachers in primary and secondary schools in the sub-city, are 1414 and 395 respectively, out of which 1176 are males while 633 of them are females. In the study area one government junior secondary school, which was opened in 2006/7 and four private kindergarten schools.

3.4.7.2 Health Service

Currently 2 Hospitals, 6 Health Centers and 56 Clinics of different size are serving the existing community in the sub-city. Similarly about 67 health personnel and supporting staffs are serving in all governmental health institutions. Surprisingly, according to information obtained from the sub-city's Health Office, out of the health personnel serving health centers in the sub-city, there are only one doctor and one health officer. In the study area there is only one medium level private clinic and one traditional health center has been served the population (map 3.6)

3.4.7.3 Road and Transport Service

Recently asphalt and gravel roads are almost constructed in most parts of the sub-city. Among asphalt roads the ring road covers the largest part of the sub-city. It extends from the southeast kebele 02/03 tip point to the North kebele 13/14, which is about 12.5 kms. All internal asphalt and gravel roads are connected to the ring road. The major internal asphalt road are Asko to the end of kebele 15/16, which is about 8 km long; Kolfe High School to Lukanda square, about 3 km long; Tateke Square to Holland Embassy, about 6.5 km; Agusta to Bethel Hospital about 3.4 km; Ayer-Tenan to Alem Bank, about 4km; and Ayer-tena to Welete Safer, about 3km. Therefore, out of the total roads in the sub-city about 40.4 kms are asphalt while others are gravel. However, the types of road facilities are very poor in terms of quality and are in need of maintenance. They impede the transport service and affect the day-to-day activities negatively. Hence, transportation is one of the critical social problems of the community in the sub-city today.

As it was observed during the field survey, city bus, taxi, carts, and donkeys are major transportation system that people largely use. Some local traders widely use donkeys as means of transport for loading their goods and services, mainly from Merkato to their locality along asphalts and gravel roads and uses for carrying of water. On the other hand, city-bus, and sometimes taxies connect Kolfe-Keranyo sub-city to other sub-cities. Mainly city buses give service between Merkato to Asko (North of sub-city), Merkato to Kara Kore (south west of the sub-city), Merkato to Alem-bank (West of the sub-city), Piazza to Bethel and Lagare to Bethel (West of the sub-city). In the study area the road infrastructure were made by the government and the community. The community of the area were collected money from each individual and used for construction of gravel road.

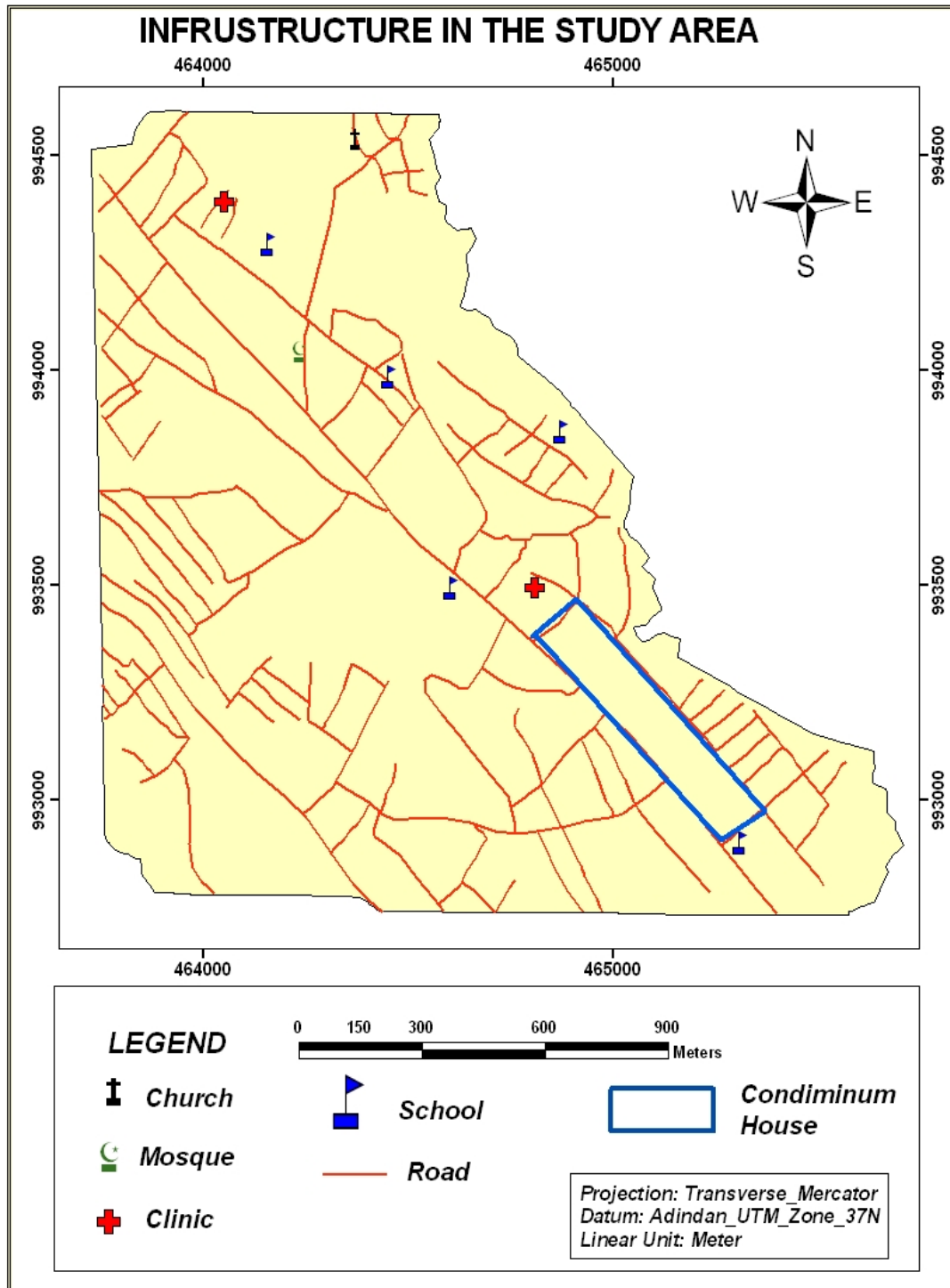


Figure 3.8 Infrastructures in the study area

3.4.7.4 Water Supply

In addition to problems of physical setting, rapid population growth brought about mismatch between the demand and supply of potable water. Moreover the existing

distribution of water in the sub-city is uneven. Even the water provided currently is not clean and the supply is irregular based on shift. Water vending is an important activity in kebele 06, 01/05, 02/03 and kebele 04. In areas like Bethel and Alem-bank water is the critical social problem that people are forced to buy 20 liters of water at the cost of 0.50 Birr from areas about 3-4 kms away. Thus, people regularly go for long distance searching for water. In the study area the water service is available in four places (map 3.7) which serve the people once a week at a reasonable price. The pressure of the water was very low and people had to stand in a very long queue. The people were not provided with pipe lines because the settlements were not formal and the water capacity was not sufficient for all the population.

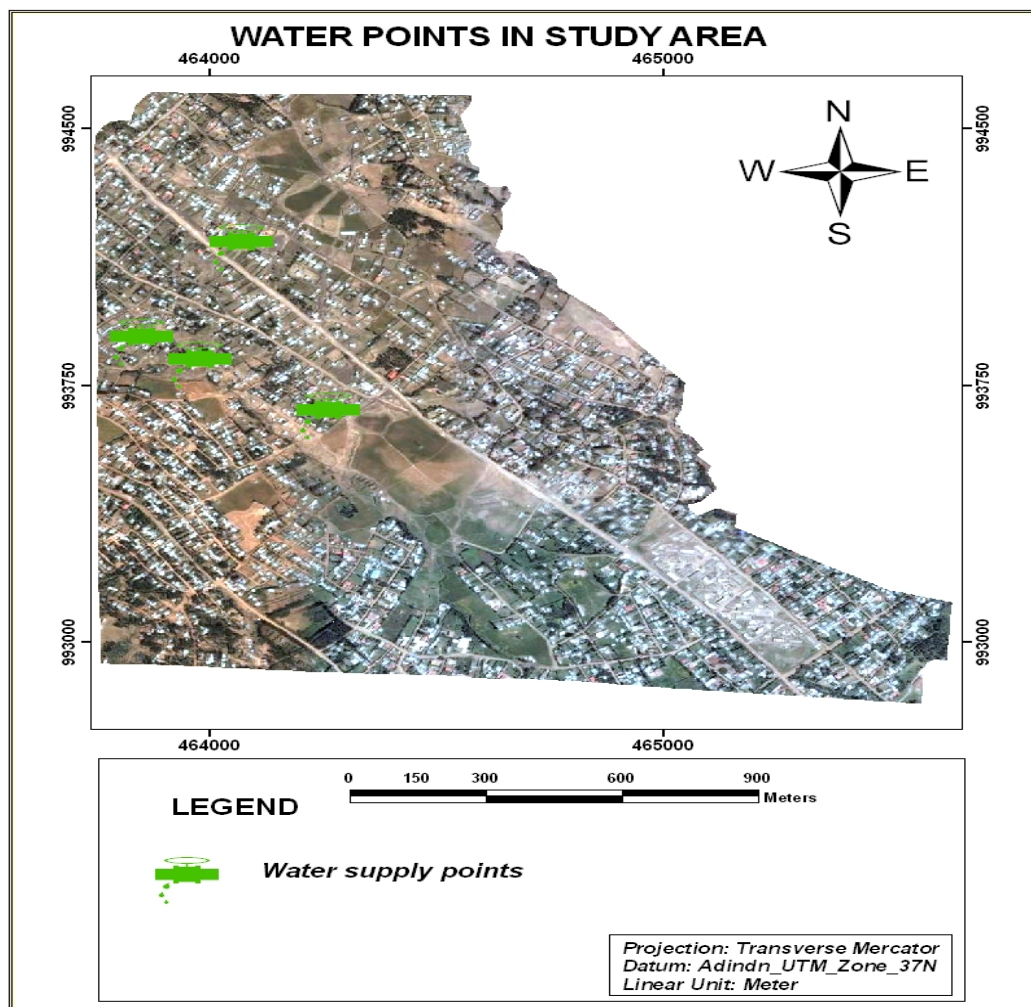


Figure 3.9 Water supply points in the study area.

3.4.7.5 Industries

According to the sub-city's Trade and Industry Office, there are a number of industries with different scale found in the sub-city. Tannery, Shoes factory, Soap factory, Plastic factory, Tin factory, and Glass factory are some of medium scale industries. Metal work, woodwork grain mill and wood enterprise are some of the small-scale industries widely found in the sub-city (table 3.4 and figure 3.10). Regarding spatial distribution, kebele 04, 10/11, 08/09, and kebele 15/16 have large number of industries while kebele12, kebele 13/14, 1/9, kebele 02/03 have a few industries.

Table 3.4 Factory/industry in the sub-city

No	Type	Quantity	(%)
1	Glass	1	1.61
2	Plastic	7	11.29
3	Tannery	3	4.84
4	Soap	1	1.61
5	Sweet	2	3.23
6	Edible oil	8	12.90
4	Dry food and flour	6	9.68
5	Furniture	11	17.74
6	Precast and Bricks	11	17.74
7	Corrugated and nail	1	1.61
8	Others	11	17.74
Total		62	100.00

Source: - “Yekolife Demitse” magazine march, 2008 and computed by the researcher

The spatial distributions of industry in the sub-city in general are random and uneven. However, there is no statistical data on share of the sector, yet according to Trade and Industry Office of the sub-city, the sector provides a wide range of employment opportunity.

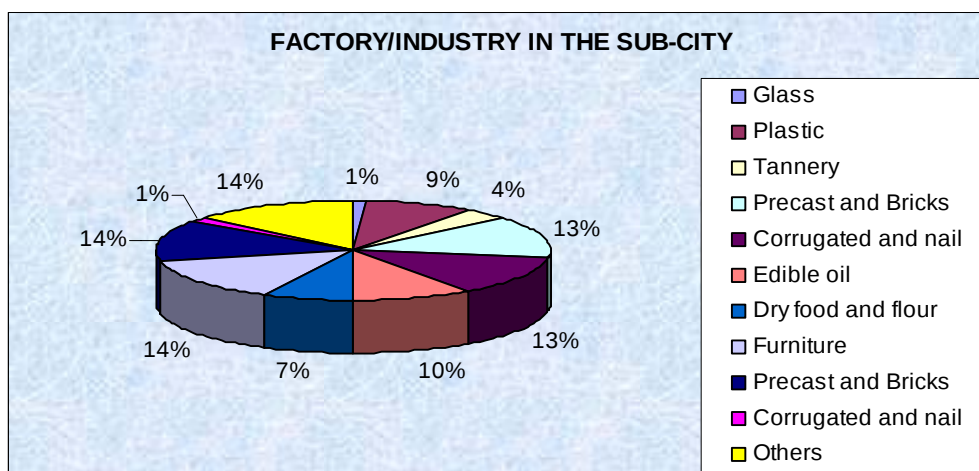


Figure 3.10 Factory/Industry in the sub-city

3.4.7.6 Community Based Organization (CBO)

Community based organization is an association established to organize and facilitate the local community's developmental activities with limited government support. The CBO facilitators are nominated from the local community based on the merits of honesty and good performance in their duties. The CBOs are: *Ider*, *Iqueb*, *Mahber* and developmental association. The local settlers have the custom of helping each other in time of difficulty.

The CBO has carried out the following useful developmental works:

- A. It involved in the design and construction of the existing infrastructure such as main and feeder roads, bridge, and as well as the installation of electricity and telephone lines (plate 3.1)



Plate 3.1 Construction of bridge and road in the study area

- B.** took part in the effort to alleviate the shortage of water by arranging a weekly water provision service for the population at a reasonable service charge,
- C.** facilitated transport service for the business people from their residential area to *Merkato* in morning and evening time every day at a reasonable fee,
- D.** is also involved in the prevention of the spread of HIV/AIDS and provision of support for carriers, and
- E.** In the near future, the CBO is planning to establish a library in the area.

3.4.7.7 Livelihood

Trade and industry are the main economic activities that the majority of people in the sub-city are engaged in. Cropping, dairy and beef farming as well as apiculture are also carried out at the periphery and pocket areas of the sub-city. In the study area the local settlers' livelihood had depended on agriculture and dairy farming during the time of Haileselassie regime. These people used to get large amount of yield from agriculture because of large size of farm land.

During the Derg regime the agricultural activities and dairy farm works continued but the amount of yield decreased due to the confiscation of large amount of farm land (proclamation 47/1975).

The local people were more involved in dairy farm. They produced and sold milk, butter, cheese, and dung to the people of the adjacent areas and residents of Addis. The case studies would clearly show the situation of the area in the past and present (Appendix III-IV).

In the current EPRDF regime many of the agricultural land were changed into houses therefore, dairy farm activities have continued but to a lesser extent. Some of the former farmers' sons bought business vehicles by selling their farmland.

The settlers are engaged in the sector of business economic activities. They are involved in small business as well as import-export. Many of the people do their business in *Merkato*

market place. The other settlers depend on small business, working in their homes. Some are self employed and others work in governmental institution.

There is no conflict between the locals and settlers; rather, a harmonious life .This is because the number of houses increased and the social services were very functional and the infrastructure [road, water, electricity, telephone, school, transport and health center] were put in place.

CHAPTER FOUR

4. LAND USE HISTORY, DATA PROCESSING, ANALYSIS, RESULT AND DISCUSSION

4.1. Land Use History of the Study Area

The study area, which is locally known as *selti* is located in kolife keraniyo sub-city of kebele 04. Originally it was an agricultural area and now is changed into urban land. The area was covered by dense forests and agricultural land. The first settlers were from the indigenous Oromo tribe (group discussion with elders, 2008). The information obtained from the discussion with local elders, indicates that the dense forests began to be destroyed after the nationalization of land by the Derg regime in 1975.

The vast tracts of land found both in *selti* and its surrounding were delimited as a protected forest zone under the supervision of the Menagesha Awraja Agriculture Department until 1988 (NUPI 1998). In September, 1988 the administration and supervision of the forest was transferred to the Addis Ababa city Agriculture office. The Derg regime delimited the whole Menagesha Awraja under the Addis Ababa city and its surrounding Administration. Due to the political vacuum and instability created during the 1993 government transition, there was high rate of deforestation carried out by local people and urban residents for housing and fuel (discussion with elders, 2008). Still there are remaining vegetations here and there that indicate that the area was once covered by various species of trees as observed by the researcher.

It was after 1993 that the area started to be inhabited by the *selti* people who informally bought plots from the local farmers and land speculators. Now almost more than 95 percent of the settlers are *selti* ethnic people. The area which covers the whole kebele is unique in terms of the ethnic homogeneity of the occupier's *selti* and the informality of the land tenure in the area. Hence, the area is given the name *ketena 7* or *selti* area for administrative purposes (discussion with kebele 04 Administration, 2008). The human activities have significantly changed the distribution and allocation of land resources in the area over the last two decades due to unplanned construction of houses.

4.2. Data Processing

The land use land cover (LULC) change maps and other different maps of the study area were created using ArcGIS 9.2 and ERDAS 9.1 analysis tools. The researcher used the 1994 and 2002 aerial photos, 2007 IKONOS image, 2007 Google Earth image, AutoCAD shape file and population data. The 1994 and 2002 aerial photo was georeferenced using the GCP (Ground Control Point) in GPS (Global Position System) receiver taking points of road cross, river cross and prominent feature. In the 1994 aerial photos, I could not identify the GCP point on the existing ground due to the rapid change of the area; therefore, the researcher used the IKONOS image of the area which was already georeferenced and used to rectify the aerial photo using image to image georeferencing techniques. The georeferencing, Reproject with the same projection, Subsetting, mosaicking, creating the shape file, rasterization and calculating the digitized LULC area were done using ArcGIS 9.1 and ERDAS IMAGIN 9.1 analysis tools.

Different land use categories were digitized from the aerial photo followed by building the topology to minimize errors during digitizing and to ensure that the entire polygons are closed. In the process of screen digitizing some features in the aerial photo did not properly identified. To solve this problem the researcher used the mirror stereoscope and the image interpretation techniques of patterns, tones, textures, shapes, and site associations to derive information about LULC activities and identified the feature properly.

Furthermore, to create the different maps such as study area, water supply point, high tension cable, solid waste collection container site, road network, infrastructures, master plan, participatory mapping and population density the researcher used ArcGIS 9.2 extension tools and techniques. To create the participatory mapping, the researcher used information obtained through discussion with community leaders in the field. They were asked what the area looked like during the different regimes.

4.3. Land Use Change of the Study Area using Aerial Photo

Selti area has been transformed from agricultural area to residential area. There is a significant land use change since 1993. (Ian, 1994) stated in his research of human settlement that the land uses are constantly changing, tending to intensify as land value increases. In the pre 1993 years there were no considerable land use classes in the *Selti* area. Most of the areas were under agriculture land, farmers' houses and forest cover. The political transition in Ethiopia which created a political vacuum served as a favorable ground for informal land transaction and occupation. This also further aggravated deforestations in peripheral areas of Addis Ababa.

In the study area in the year of 1994 aerial photo there are about 690 built up and also in the year 2002 about 2238 built up which have corrugated roof and some tached roof in the 1994 houses. There was a difference of 1548 houses built within eight years.

In the aerial photo of the 1994 (figure 4.1) there were insignificant houses here and there except near to the main road of Jimma. At this time the area is used for farming activity and settled by farmers and many of the areas were covered by forests.

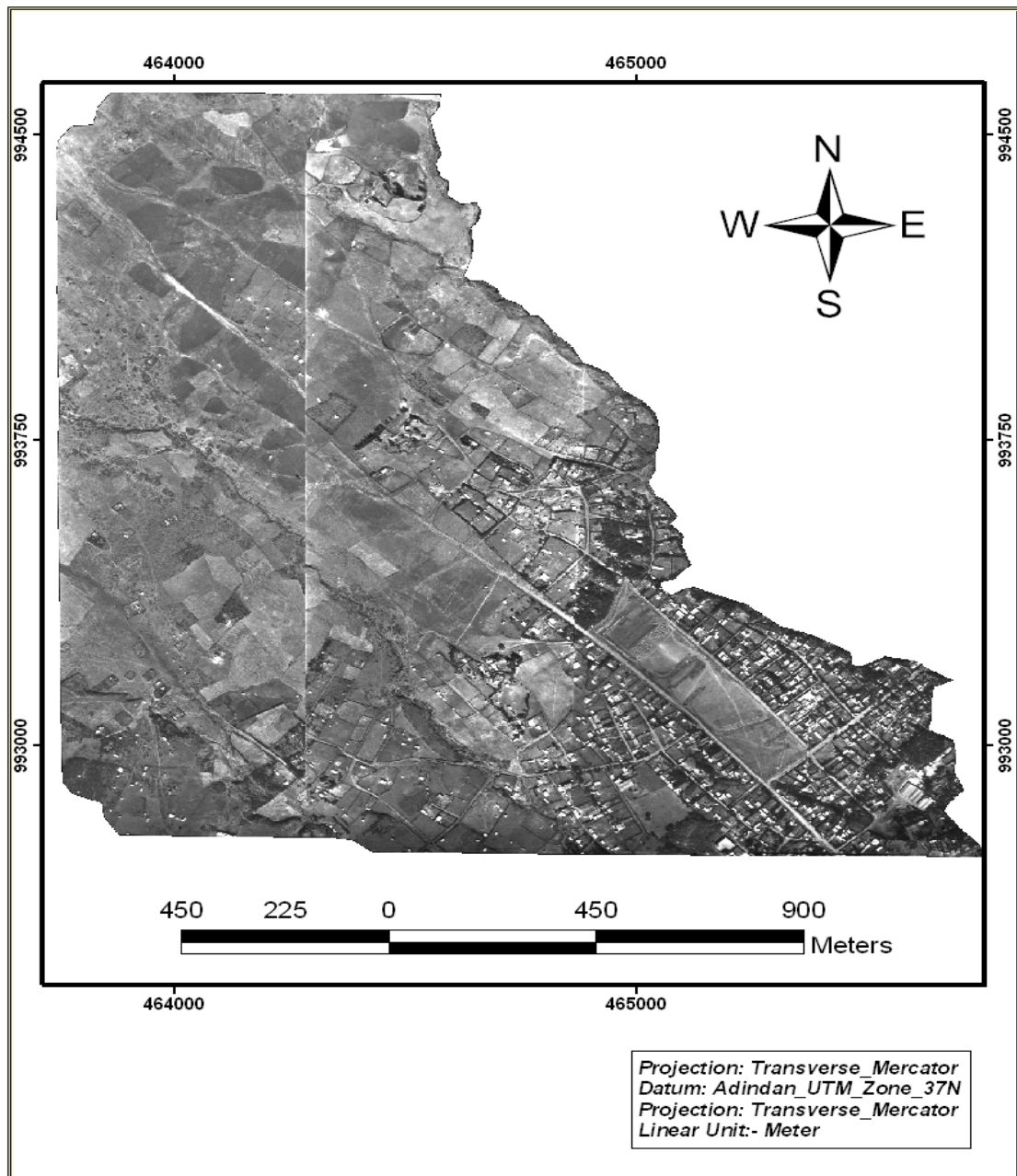


Figure 4.1 Study area in 1994 (aerial photo)

The aerial photo from 2002 depicts the emerging of informal settlements in the area. The settlements were designed with out considering the infrastructure that would be needed such as water, sewerage, electricity and telephone. The pattern of the settlements can be easily recognized from the aerial photos as unplanned and having irregular structure (figure 4.2).

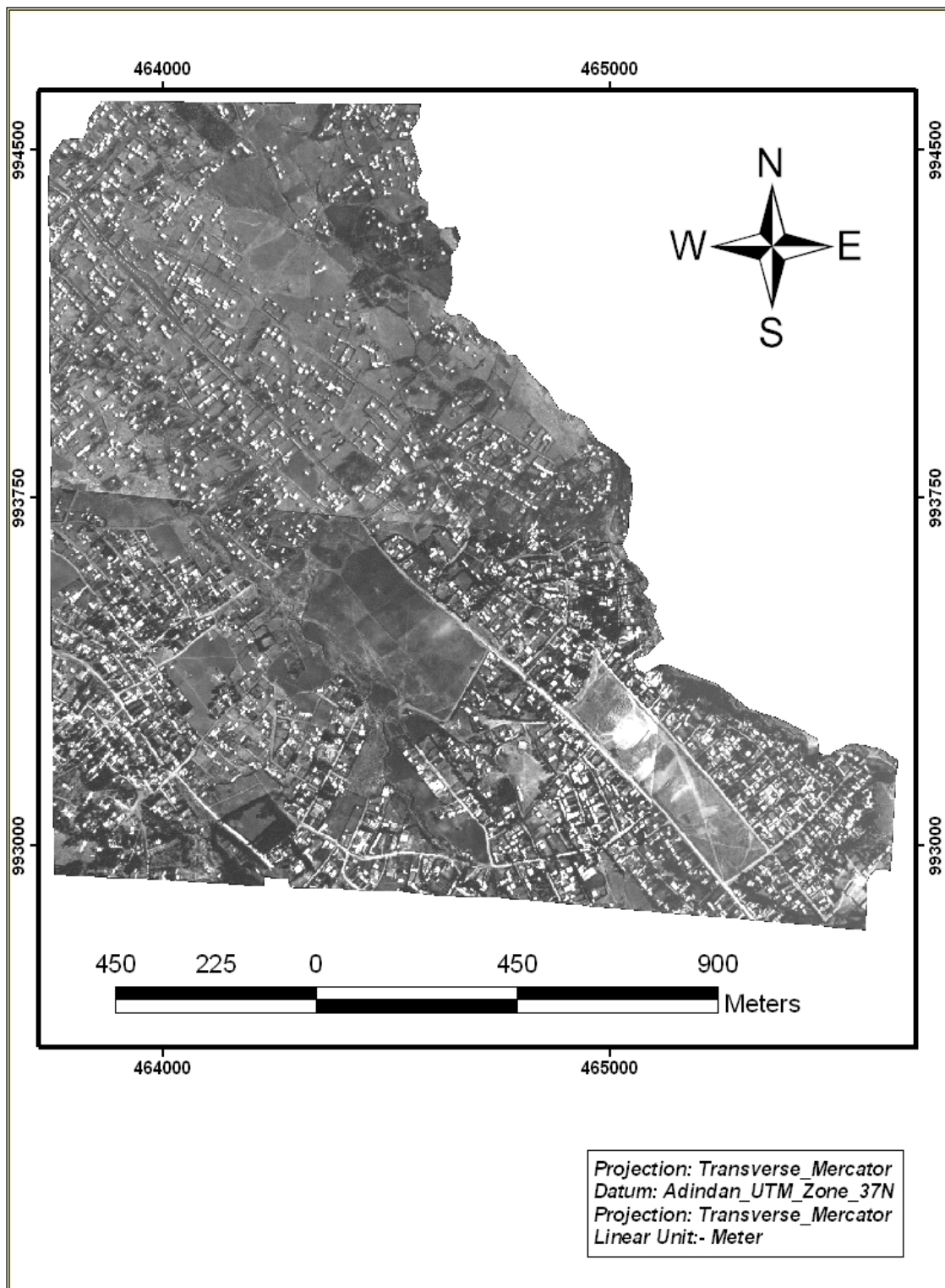


Figure 4.2 Study area in 2002 (aerial photo)

4.3. Participatory Land use/Cover Mapping

As has been mentioned in the methodology section, with the assistance of the elderly and resource persons of the locality, the LULC during the different regimes (1930 to 2008) has been created and is indicated below:

A. Haileselassie Regime (1930-1974)

During the reign of Haileselassie, most of the area was covered by agricultural land, forest and shrubs (figure 4.3)

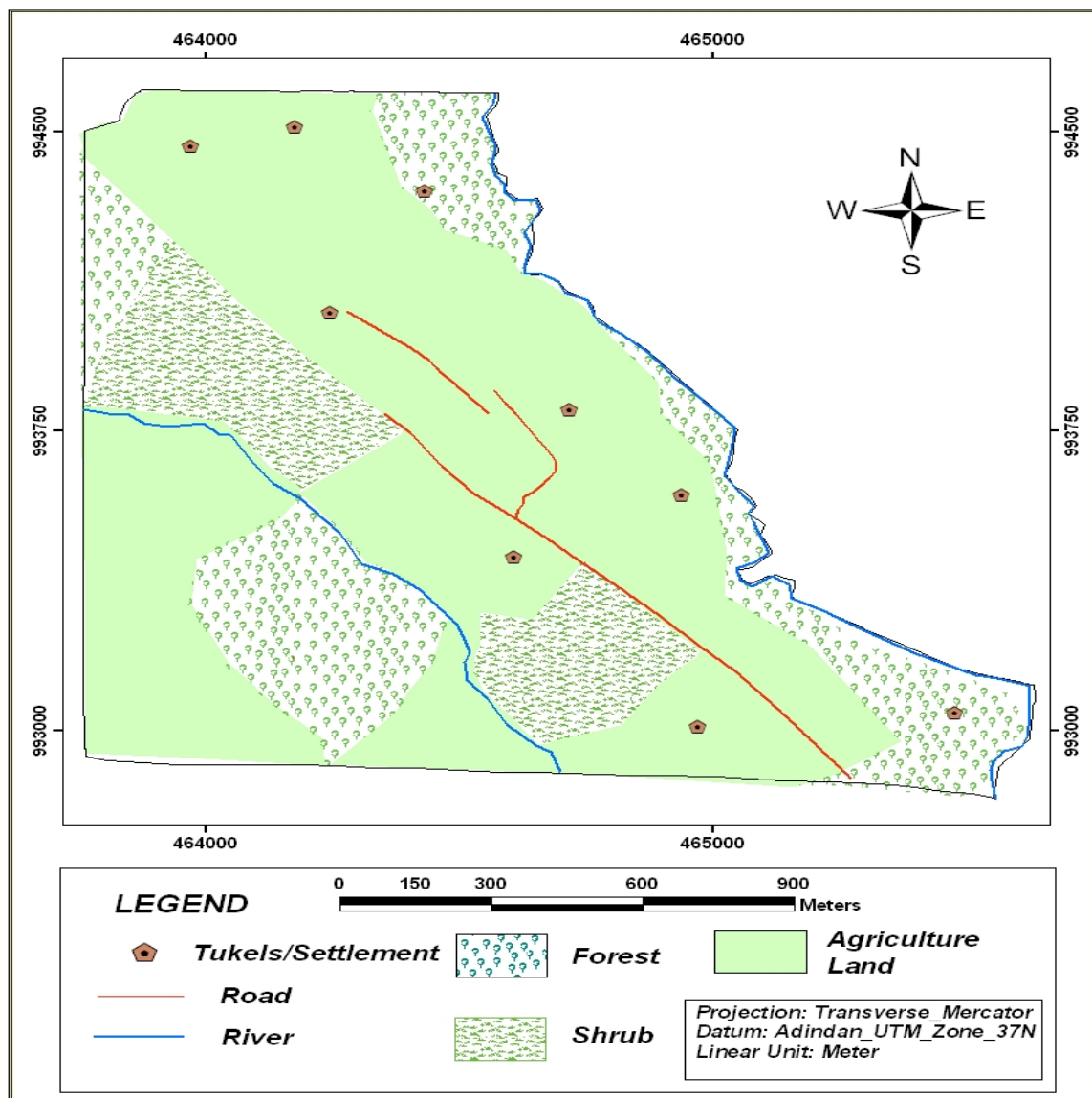


Figure 4.3 Participatory land use/cover mapping in Haileselassie regime (1930-1974)

This LULC was agriculture 64.1, forest 22.5 and shrub 13.4 percent respectively. The tukules were 9 in number and are scattered here and there. All of them have thatched roof (table 4.1)

Table 4.1 Land use/cover in Haileselassie regime

Land use/cover	%
Agricultural	64.1
Forest	22.5
Shrub	13.4
*Tukules/Settlement	9

*Tukules/settlement mentioned in number

B. Derg Regime (1974-1991)

There was not a significant change during the Derg regime except that a few roads and houses have been built, and some forest grew. The number of houses increased. The form of the houses also changed from thatched to corrugated roof (Figure 4.4) .

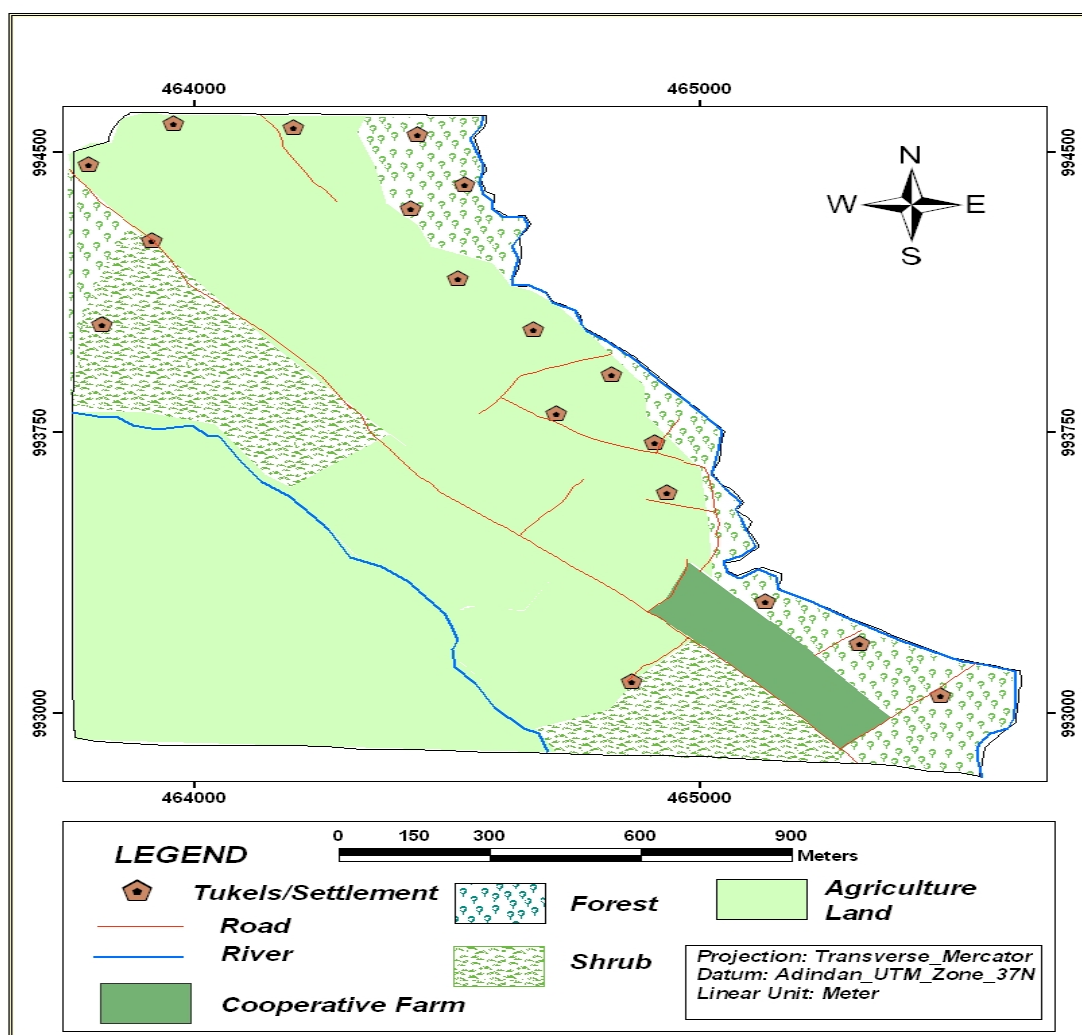


Figure 4.4 Participatory landuse/cover mapping in Derg regime(1974-1991)

The LULC was agriculture 65.8, forest 12.7, shrub 18.1 and cooperative farm 3.4 percent respectively. The tukules were said to be about 18 in number. They are found in scattered pattern have thatched roof (table 4.2)

Table 4.2 Land Use/Land Cover in Derg regime

Land Use/Land Cover	%
Agriculture	65.8
Forest	12.7
Shrub	18.1
Cooperative Farming	3.4
*Tukuls/Settlements	18

*Tukuls/Settlements mentioned in number

When we compare regimes of the Hailesellase and Derg (table 4.3). The LULC change of agriculture and shrub is increased in the Derg regime by 1.7 and 4.7 percent respectively but forest was decreased by 9.8 percent. The main reason for these was those who have not their farm land in the Hailesellase regime can have farm land in the Derg regime and practiced farming in their land. The forest which was owned by the government was easily destroyed by the people in the Derg regime. The tukules/settlement was increased by 11 houses which were changed from thatched roof in the Hailesellase regime to corrugated roof in the Derg regime.

Table 4.3 Land use/cover in Hailesellase and Derg regime

Landuse/cover	Regime		Changes (+ -)
	%		
	HaileSellassie	Derg	
Agricultural	64.1	65.8	- 1.7
Forest	22.5	12.7	+ 9.8
Shurb	13.4	18.1	- 4.7
*Tukules/Settlement	9	20	+11
Cooperative farm	-	3.4	No change

*Tukules/ Settlement was mentioned in number

Note: + = increase, - = decrease

C. EPRDF Regime (1991-2008+)

In the current EPRDF (Ethiopian People Revolution Democratic Front) regime, a total change of the agricultural and forest land into built-up area has been witnessed. The construction of roads has increased in number. And the quality of the roads has also improved significantly. Further more, one can see eucalyptus trees in residential compounds. There are also some agricultural plots of land (figure 4.3).

In the early time of EPRDF some part of the area which was not suitable for agriculture was granted freely to the demobilized Derg regime soldiers to be used for the construction of houses. This has also led to population increase.

From 1995 onwards, the local settlers and soldiers sold some part of farm land and portion of their houses to the people who used to pay expensive house rent in the center of the city and the adjacent area. In addition to these, land speculators were engaged in the activity of buying a large area of farm land, dividing and selling it. All these factors have led to the increase of the population.

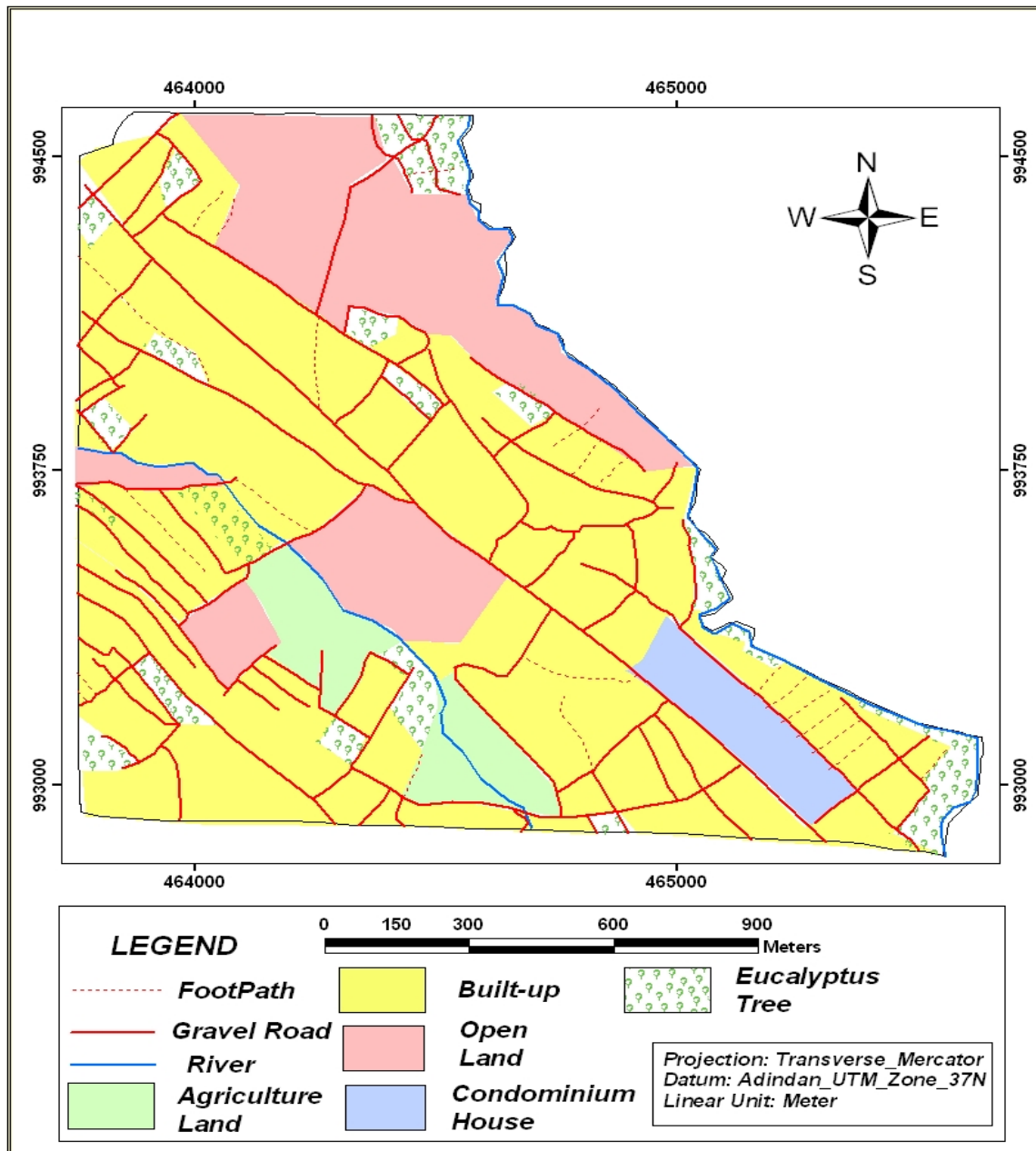


Figure 4.5 Participatory Landuse/Cover mapping in EPRDF regime (1991-2008+)

In the year 2004 the community based organization (CBO) of the area tried to count the number of houses and house hold heads for their development plan. The number of houses was found to be 4000 .In average six people lived in one family; as a result, it has about 24,000 people residents. There are also small numbers of people belonging to other ethnic groups (i.e. other than *Selti*.) - Oromo, Amhara, Tigray and others.

The *Selti* people have its own special lifestyle - living in groups, following the same religion, working in the same place and supporting one another. Their population increased so much that people began calling the area *Selti sefer*.

Table 4.4 Landuse/cover in the three regimes

*Tukules/settlement/built up in the Hailesellasi and Derg regime mentioned in number

Landuse/cover	%		
	Hailesellasi	Derg	EPRDF
Agricultural	64.1	65.8	5.8
Forest	22.5	12.7	6.9
Open Land	-	-	21.2
Cooperative farm	-	3.4	-
Shurb	13.4	18.1	-
*Tukules/Settlement/Built up	9	20	66.1

4.5. Land use/ cover Change Result using Aerial Photo (1994-2002)

To quantify the land use/cover change of the *Selti* area from 1994 and 2002 aerial photographs were used. Finally, I have got seven LULC and the size of these LULC categories were calculated and depicted in Figure 4.6, 4.7, 4.8 and table 4.5 and 4.6 respectively.

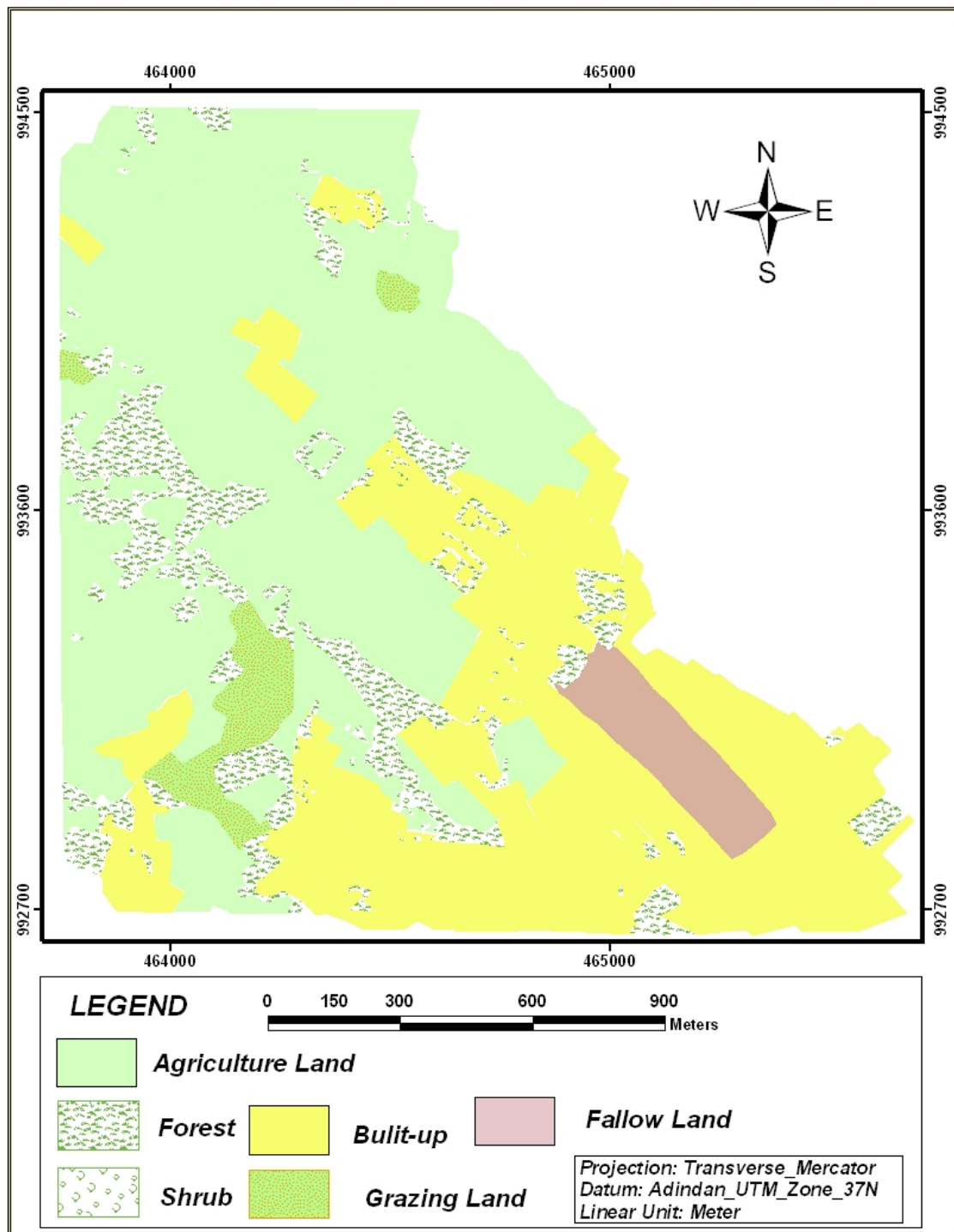


Figure 4.6 LULC of the study area in 1994

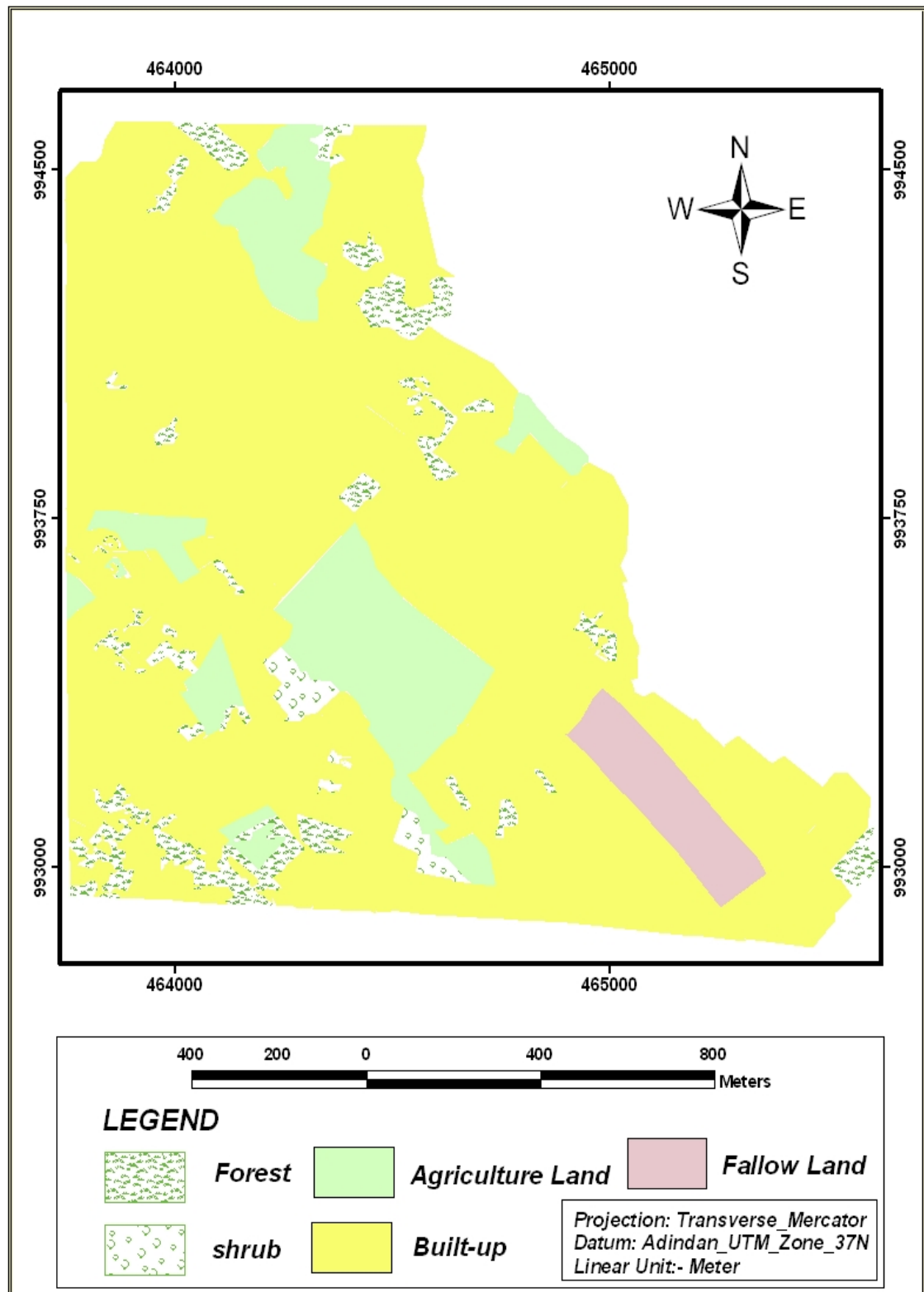


Figure 4.7 LULC of the study area in 2002

The length of the gravel road increased by 0.91 km from 4.35 km in 1994 to 5.26 km in 2002 and in a percentage change of 20.9% (figure 4.8) and (table 4.5). These changes of gravel road were constructed by local people and government.

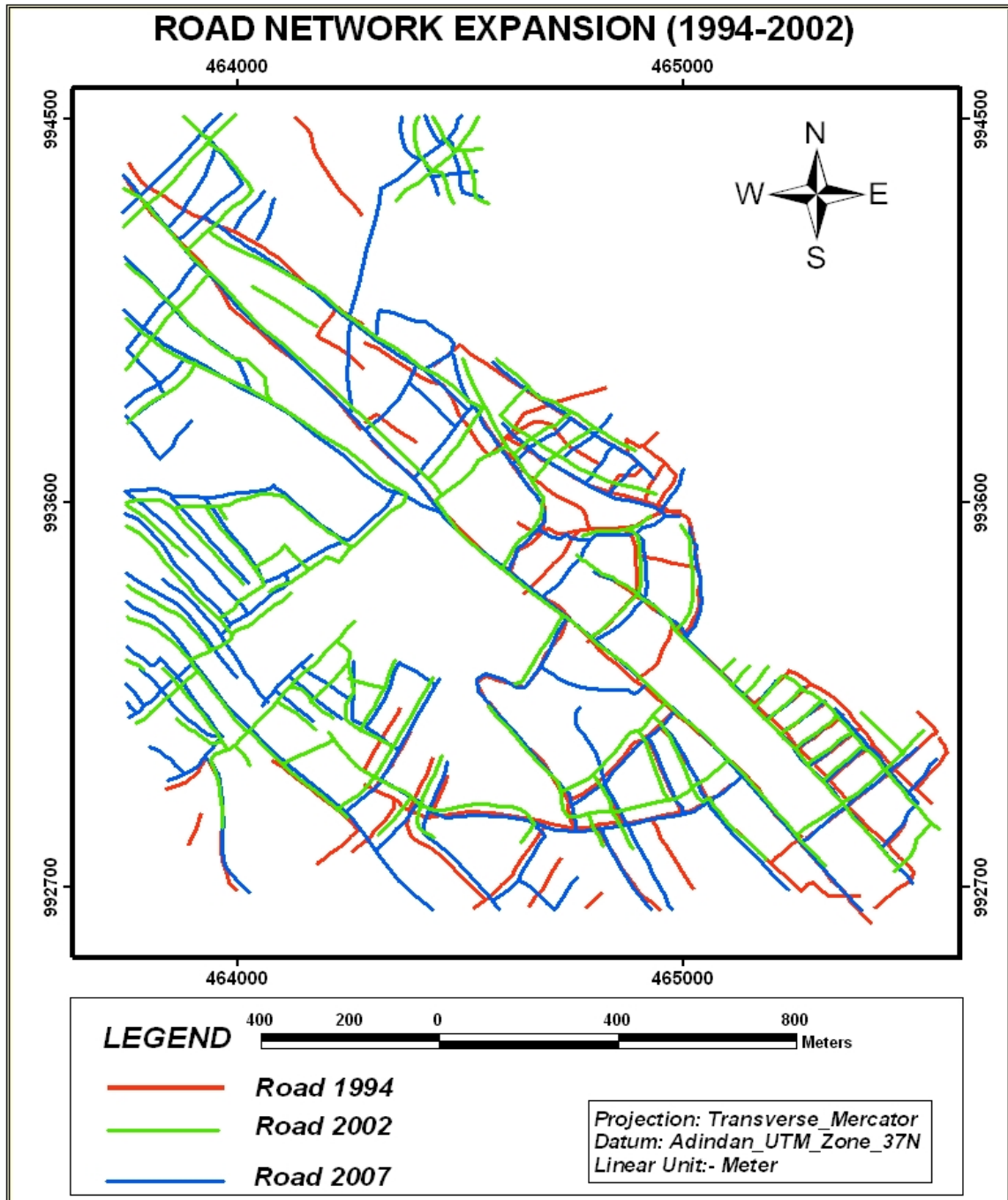


Figure 4.8 Road network expansions in the study area (1994-2007)

Table 4.5 Roads classification of the 1994 and 2002

Class	Unit	1994	2002	Change	Change (%)
Gravel Road	Km	4.4	5.3	0.9	20.5
Footpath	Km	12.8	16.6	3.8	29.7

Table 4.6 Land use/cover classification of the 1994 and 2002

Class	Unit	1994	2002	Change	Change (%)
Agriculture Land	ha	159.8	27.3	-132.5	-82.9
Forest	ha	11.3	12.2	0.9	7.9
Shrub	ha	8.0	2.5	-5.5	-68.8
Grazing Land	ha	5.5	0.0	-5.5	-100.0
Built up	ha	90.5	212.8	122.3	135.1
Fallow Land	ha	7.7	7.7	0.0	0.0

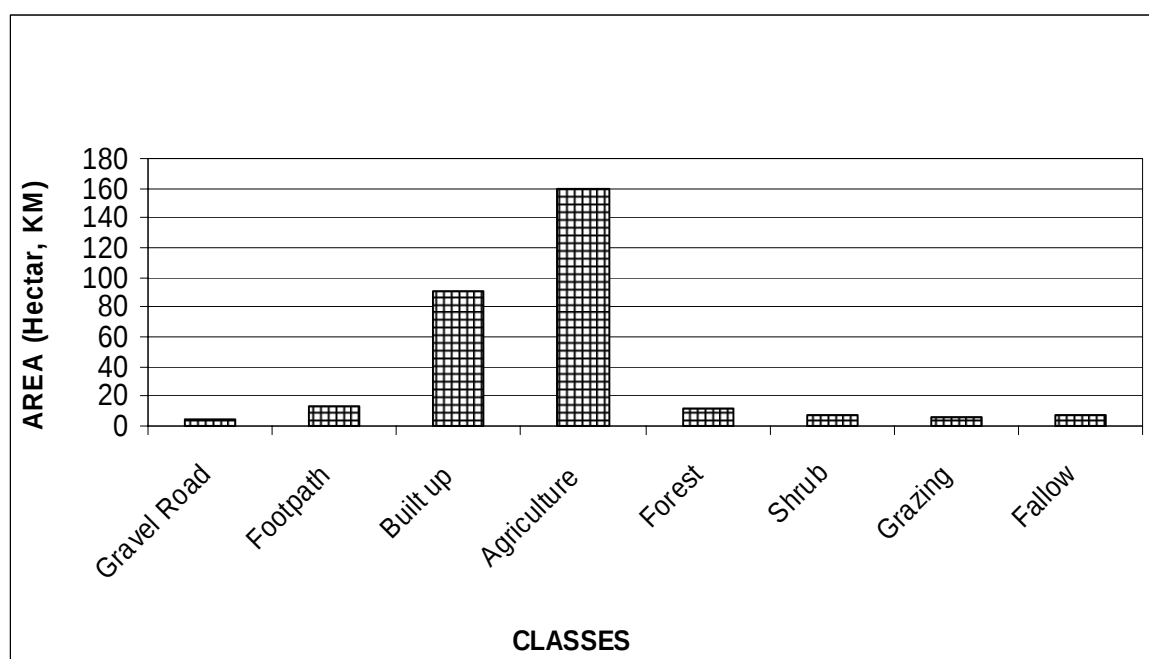


Figure 4.9 LULC classes in 1994

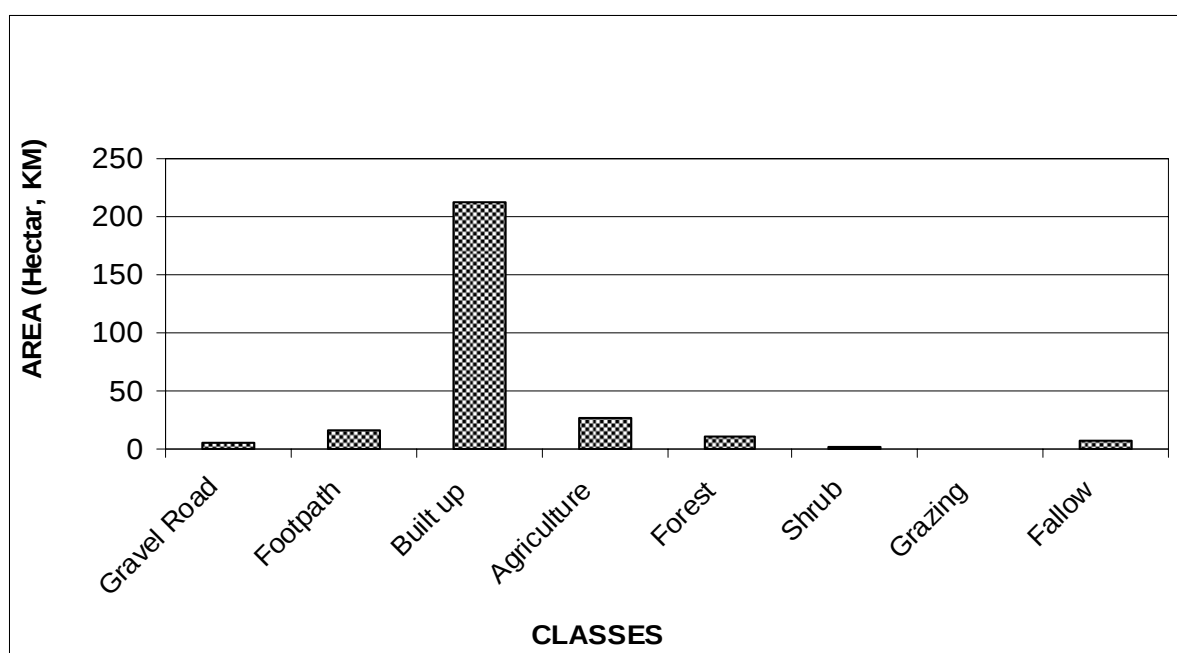


Figure 4.10 LULC classes in 2002

4.5.1 Rate of Land use/Cover Changes

The rate of land use changes for each class was calculated as follows

$$\text{Rate of change (Hectare (Km) / Year)} = (A-B) / C$$

Where **A**= Recent land use in hectare

B= Previous area of land use in hectare

C= Interval between A and B in year

Table 4.7 Rate of roads changes of the 1994 and 2002

Class	Unit	1994	2002	Rate of change
Gravel Road	Km	4.4	5.3	0.1
Footpath	Km	12.8	16.6	0.5

Table 4.8 Rate of land use/cover changes of the 1994 and 2002

Class	Unit	1994	2002	Rate of change
Built up	ha	90.5	212.8	15.3
Agriculture Land	ha	159.8	27.3	-16.6
Forest	ha	12.2	11.3	-0.1
Shrub	ha	8.0	2.5	-0.7
Grazing Land	ha	5.5	0.0	5.5
Fallow Land	ha	7.7	7.7	0.0

Coming to the more important point, agriculture land and forest has decreased increasingly from 159.8 and 11.3 in 1994 to 27.3 and 12.2 Hectares in 2002 (table 4.8) with the percentage change of -82.9 and 7.9 % respectively (table 4.6).

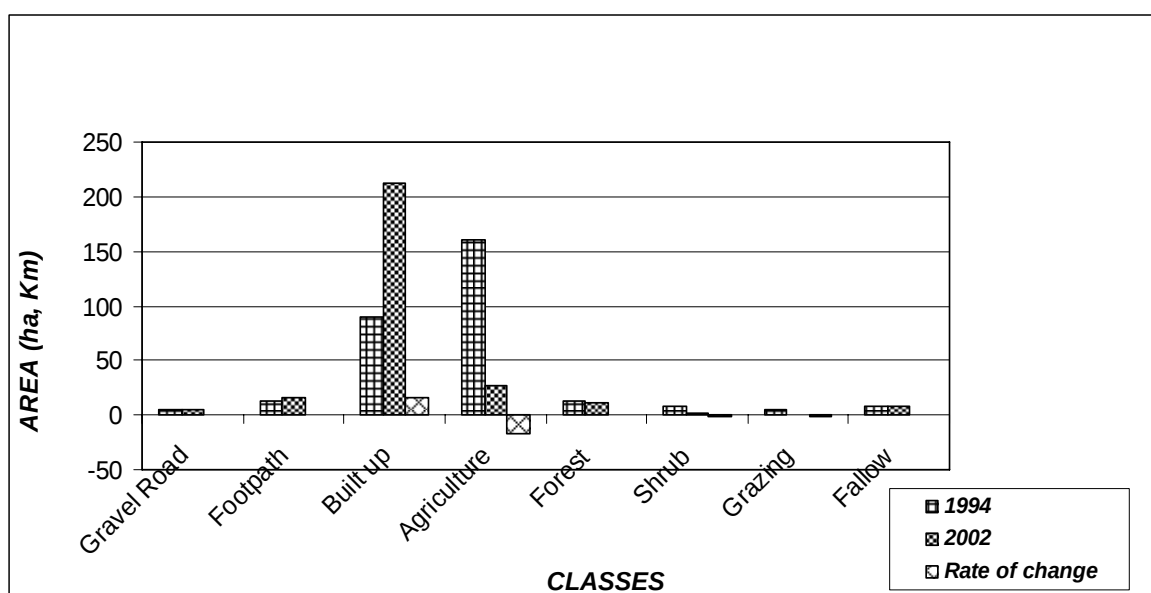


Figure 4.11 Rate of LULC changes (1994-2002)

Theoretically such vast and rapid land transformation could occur only through formal land transformation from rural to urban land use. However, in the study area this happened without the intervention of the city Administration. This implies that informal land use subdivision is becoming beyond the control of the city administration. Hence, the situation is becoming a big concern both for the government and other actors involved in the formal land management system.

It is obvious that there is a rapid change of agricultural and forest land to urban settlement. Despite this change there are still people who are depending on small farming in the area. On the contrary, built up area has increased by 122.3 Hectares from 1994 to 2002 and a percentage change of 135.1 % and the rate of change was 15.3 (table 4.5 and 4.8). As the process of land speculation and informal transaction continues, it is evident that the city could not manage to monitor the growth of the city and land transformation using the existing master plan.

Besides the informal land use change in the area, the Addis Ababa Administration Office changed the area's fallow land which existed for a period of 16 years into a sight for 1230 condominium houses. (Figure 4.12 and plate 4.1)

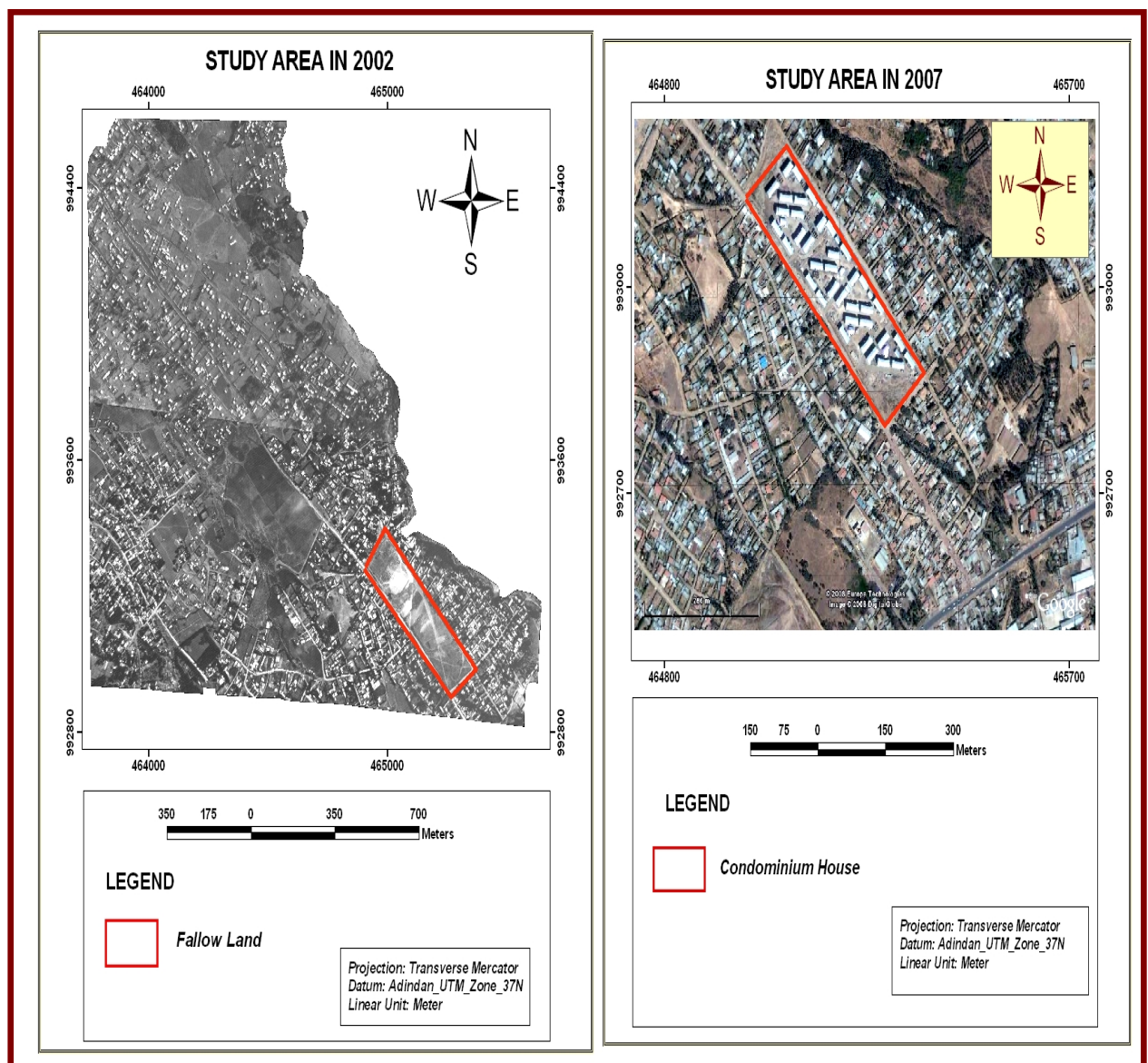


Figure 4.12 Fallow land Vs Condominium Houses

The main reason for this was in the time of Derg regime the area served as an agriculture land for the farmers' association. From 1991 onwards the organization was not functional and the land became fallow.



Plate 4.1 Construction of Condominium houses in the fallow land

In the study area, the land use policy was contradictory to the master plan of the city. On the master plan of the Addis Ababa, many of the study area were supposed to be reserved area, expansion area, green area, proposed road and industrial and terminal areas (Figure 4.13).

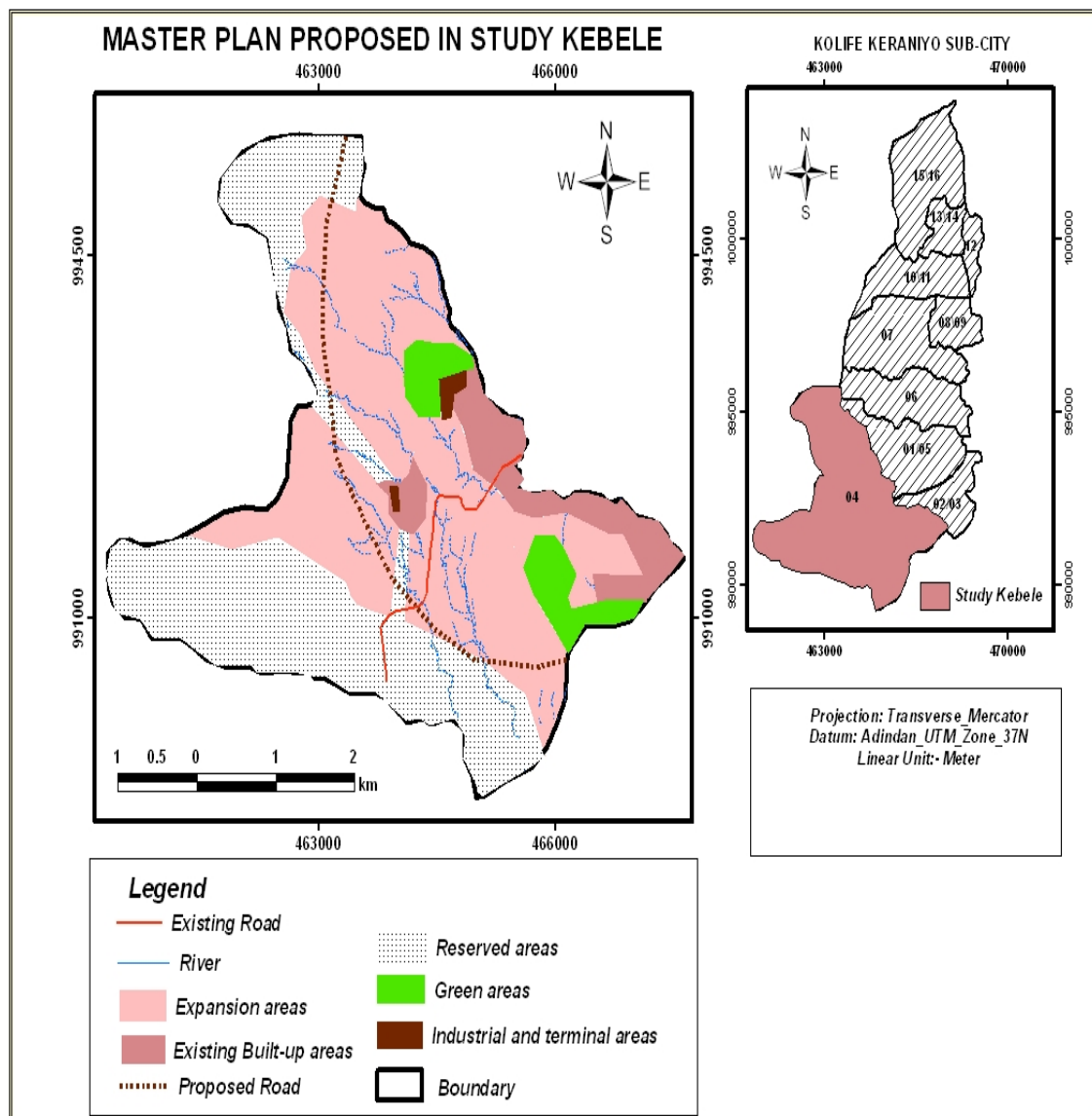


Figure 4.13 Master plan of the study kebele in 2002

But now the area is covered by unplanned and informal houses. The informal houses are accounts about 75 % from the total kebele's houses. This change implies that houses constructed informally by far greater than houses constructed formally in the period considered above.

CHAPTER FIVE

5. CAUSES AND IMPLICATION OF LAND USE/COVER CHANGE

5.1. Driving Forces of Land Use Change

The driving forces for the land use change include are rapid population growth, informal settlements, unplanned development and absence of clear policy of the city Administration. These factors caused rapid rural land conversions to urban settlements. Due to lack of the necessary services in newly developing areas of the city such as in *selti* areas there is a huge implication on the local environment and people. It has been observed that there is a critical shortage of water which has a direct implication on the health and sanitation of the local people. Moreover, the poor waste management and lack of collection services depilated the local environment causing a health threat to the residents. The following are the major driving force of the land use change causes in the study area.

5.1.1 Rapid Population Growth

The population growth of Addis Ababa has shown a dramatic increase over the years since its foundation in 1886. According to (Techeste 1987), “it is reported that the city had a population of 65,000 inhabitants in 1912 which grew to 100,000 in 1935. In a little over three years, it had increased to 143, 000”. From 1886 to 1961, it has taken about seven decades to reach half a million, while it took it to reach a million city populations in less than two decades between 1961 and 1978 (Ibid). The population of the city of Addis Ababa has grown to about 2,112,737 in 1994 in about three decades doubling almost five fold in an interval of 6.8 years. (CSA, 2006).

The populations of the Addis Ababa city were mainly settled in the center of the city in the early time. In every time the populations of the city were increased and need infrastructure of houses, water, road etc. The capacity of the city Administration would not constructed the infrastructure as the same increased of the population. These people would found there means to live in a better situation so one of the means was to settle in the outskirts of the city in the expense of the agriculture land.

Due to the rapid population growth in the city, Addis Ababa has also experienced rapid physical expansion. Addis Ababa is expanding fast in all directions except to the northern part due to topographic features. As a result, it is creating a sprawl to the west, south and east directions. This horizontal expansion is both legal and squatter. This rapid expansion is on the expense of forest, agriculture land, water, etc. Throughout its development history of Addis Ababa never satisfied the growing demand of house. As a result, people designed their own strategy to cope with the problem that is why informal settlements in the peripheries of the city is a pervasive phenomenon. Consequently considerable size of agricultural land is converted to urban land implying the unsustainable growth of the city.

5.1.2 Informal Settlements and Unplanned Development in the Area

The expansion of informal settlement in the study area is generally taking place on agricultural land occupied by peasant association. The process of land transaction takes place either through direct negotiations of the buyer with the farmers or the buyer may buy the plot from land speculators who are seeking profit from informal land subdivisions. On the top of consuming fertile agricultural land the process of informal land transaction results in the loss of farmers' livelihood, which is based on farming.

In the process of land transaction, some actors also have been doing the transaction under the cover of family ties. A land buyer may come and stay in already built up areas and buy land from the host person and do the informal building progressively. Land speculators also buy land from the local farmers who are afraid of being displaced from their occupations as a result of formal urban expansion. As a local elderly man stated, local farmers are always afraid of displacement from their land as they have no security guarantee for the plot they occupied. Hence farmers are preferred to sell their land at any cost.

This informal and unsustainable process of land transaction and transformation has led to loss of local livelihood of farmers and destruction of biodiversity which has as a long ranging negative ecological effect.

This informal and unplanned development settlement in the area also led to the occupation of marginal and incompatible land which exposes the settler to hazards and vulnerability. A typical example is housing developed a long high tension power transmission cable. According to Ethiopian electric power corporation, high tension cable (HTC) should be at the minimum distance of 30 meter from settlement.



Plate 5.1 The high tension power lines near to house (photograph by the researcher, 2008)

Regardless of this regulation HTC in the area is passing on the roof of many settlements (map 5.1). As a result of this those settlements closer to HTC are vulnerable to any health effects that may caused by proximity to high tension cable line (plate 5.1).

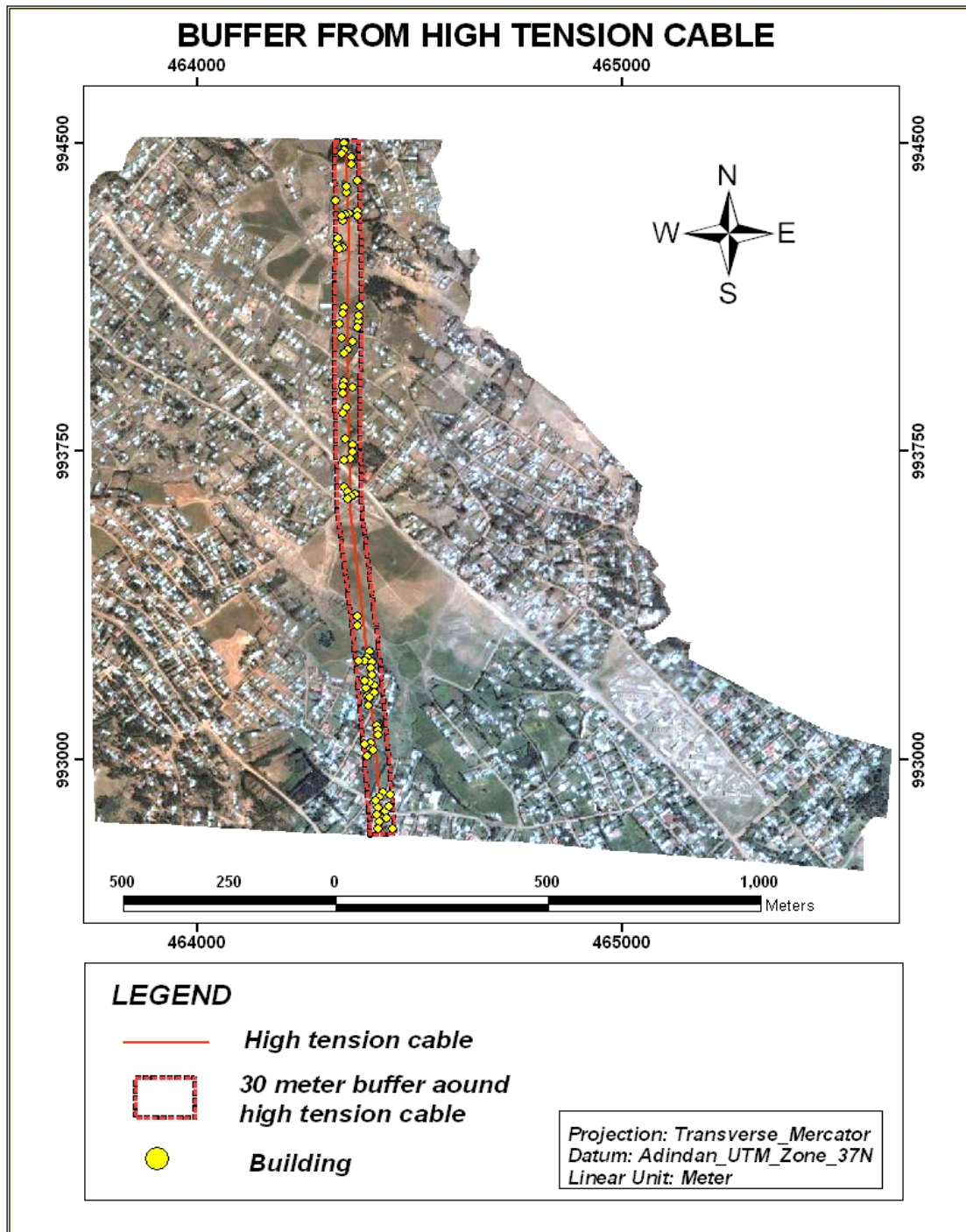


Figure 5.1 30 meter buffer from high tension power lines

What is generally observed in the case study area is the increase of informal settlements from time to time despite some efforts made to stop the construction of informal houses. According to sources from the kebele task forces office has been tried to demolish informal settlement in the locality. However, the action never stopped or minimized the informal construction. Regarding the number of houses built informally in the area it varies from year to year. As it is depicted in table 5.1 the number of houses built in a certain year is

higher or lower than the other years. This variation is mainly the outcome of the coordination of demolishing task forces of the administrative and political stability of the city. When there is poor coordination and poor logistic supply for the task forces, there will be more informal house construction. Unstable administration or political vacuum also gives more chances for the emergence of informal housings.

Table 5.1 2002/2003 to 2007/08 The kebele 04 code enforcement service report about the construction of the informal housing, fence and store and its measures.

Year	House		Fence		Store		Church		Mosque	
	Under study	Demolished	Under Study	Demolished	Under study	Demolished	Under study	Demolished	under study	<i>Demolished</i>
2002/2003	54	54	81	81	6	6	-	-	-	
2003/2004	221	221	275	275	3	3	-	-	-	
2004/2005	472	472	116	116	2	2	-	-	-	
2005/2006	536	536	383	383	-	-	2	-	-	
2006/2007	581	560	364	364	-	-	-	-	-	
2007/2008	397	395	437	437	3	3	-	-	-	<i>1</i>

Source: - Kebele 04 code enforcement service office unpublished material (Amharic version) 2008.

My informal discussion with local elderly men revealed that most of the informal settlements built at the foothill of Jemo Mountain forced local farmers to settle in sloppy and flood risk areas (Plate 5.2). Consequently poor farmers are vulnerable to environmental and economic insecurities.



Plate 5.2 constructions of houses in the sloppy area (photograph by the researcher (2008))

5.1.3 Absence of Clear Policy of the City Administration

One of the major problems that aggravated informal land transformation in Addis Ababa is lack of clear policy and directives on how to deal with informal settlements. In plate 5.3 to see the planned and unplanned construction of houses are not more than 15 meters apart each other. In fact some policies became part of the problem rather than solving the problem. For example during the mayor ship of Ali Abdo lack of appropriate policy and action highly aggravated informal land occupation. In the mean time the situation continued after Ali despite series reforms and action taken by mayor Arkebe. During the mayor ship of Arkebe he tried to formalize more than 300,000 houses by giving title deeds (Addis Admas, 2008) however, this led to further aggravation of informal land occupations with the anticipation of second round regularization.

With the intension of solving the chronic shortages of houses in the city which is one of the major causes for the informal settlement, the city administration somehow succeeded to make considerable number of people home owners through condominium housing scheme.

Despite all these efforts the issue of informal land transformation is on going phenomena which needs sound policy, directives and urgent intervention.



Plate 5.3 The planned and unplanned construction of houses (photograph by the researcher, 2008)

5.2. Implication of Land Use Change on the Environment

Urbanization greatly contributed to the loss of agricultural land in *Selti* area and is generally seen as one of the most important factors of land use change. These changes can not considering the natural condition of the land. Therefore, the river side and the sloppy area were used as construction sites for houses (Plate 5.4). This situation can lead to change in the direction of rivers and the soil is degraded. The implications of land use change on the environment are many. Some of the implications are poor solid waste management and others incompatible land use activities.



Plate 5.4 Constructions of houses in the river side (photograph by the researcher, 2008)

5.2.1 Establishment of Informal Business which can Cause Hazard for Health in the Area

In the area different plastic materials cleaning activities are taking place. Materials which collected are different plastic shoes, Plastic jar and sheet of plastic from market place of *Merkato*. These plastic materials are cleaned in the encompassing of the surrounding and used for other purposes (plate 5.5). I have observed this activity during my field survey and the cleaning activity adds significant amount of chemicals from those containers during cleaning processes.



Plate 5.5 The informal business of plastic cleaning (photograph by the researcher, 2008)

5.2.2 Poor Solid Waste Management

Inadequate municipal and industrial solid waste collection and disposal creates a range of environmental problems in Addis Ababa and in the study area. A considerable amount of waste ends up in open dumps or drainage system, threatening both surface water and ground water quality which provides a breeding ground for diseases - carrying pests. The adverse effect of inadequate solid waste service on productivity and economic development of the city expected to be significant.

In the study area kebele 04 there are only three places of solid waste collection container (Figure 5.2). These solid waste collection containers are served for about 35,000 to 40,000 people (personal communication to kebele 04 cleaning and beauty facilitator Ato kassahun Birru, 2008). Due to the nature of landscape and the settlements structure which is unplanned, collection of waste is difficult and domestic refuses are left on open land and in river valleys. Some private collectors who are involved in collection of the dry waste from household to municipal container they charged 10 birr per a month but those people who live far from the main road are not getting the service due to difficulties to collect waste. On top of this as Ato kassahun stated;

- I. Many of the people have excess land and they throw house hold garbage on open land.
- II. The upper part of the area is near to the main river of Jemo so they can throw the waste in the river.

- III. The North, North West, South, and South West part of the area were not accessible for the vehicle track to take off solid waste.

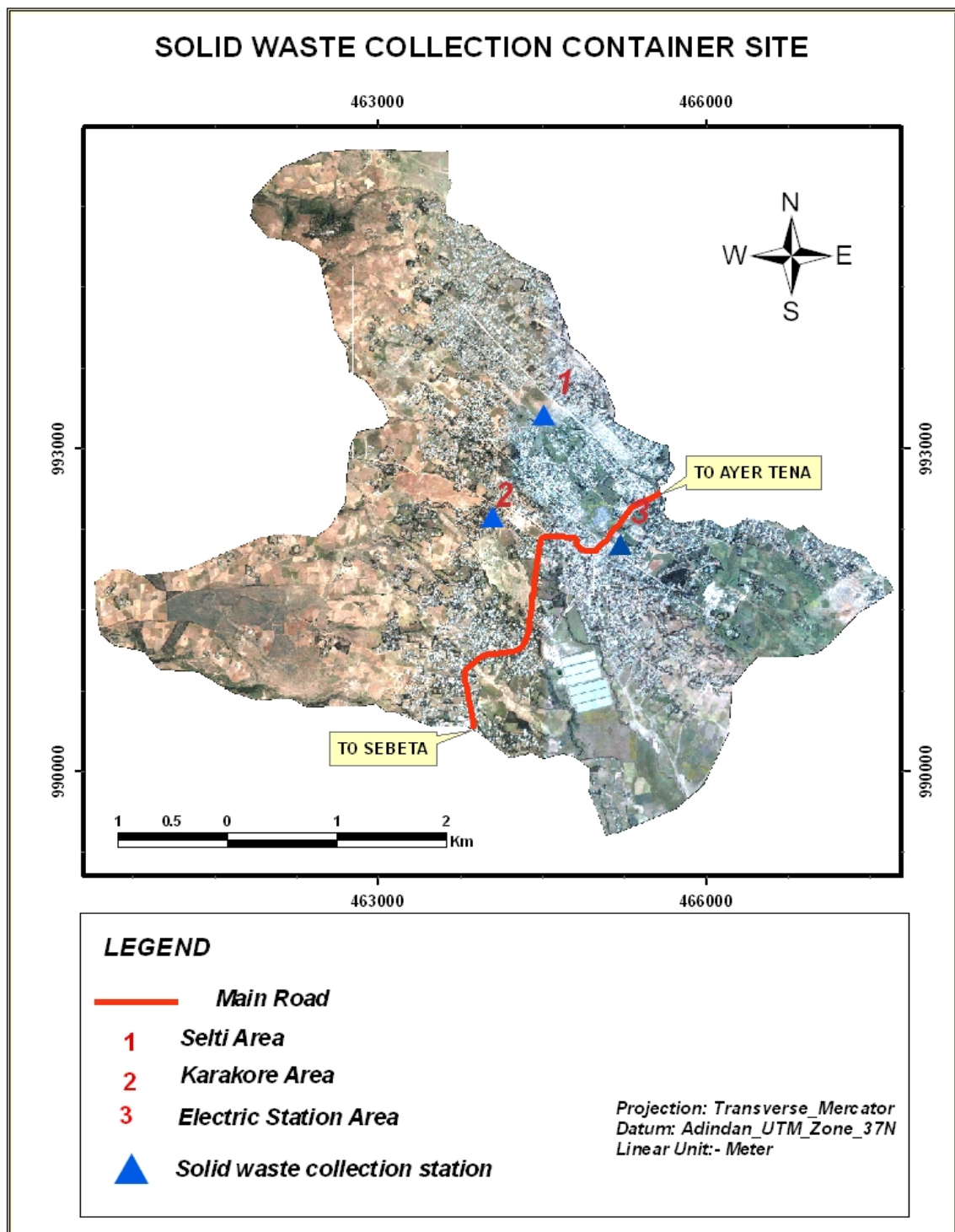


Figure 5.2 The location of solid waste collection container in study kebele

The location of these containers are not evenly distributed (figure 5.2). Many of the people especially those who live in the periphery of the area are far from their closest container about 2 km. As a result people tend to throw their waste in river and open land (Plate 5.6).

To reduce the amount of solid waste generation and informal dumping the government enacted a law. According to the proclamation No. 513/2007 of solid waste management of household solid wastes stated:-“The head of each household shall ensure that recyclable solid wastes are segregated from those that are destined for final disposal and are taken to the collection site designated for such wastes.” But this law cannot be implemented in the area due to the shortage of solid waste collection container in the area in relation to the geographical extent.



Plate 5.6 Solid waste disposal site in open land and river. (Photograph by the researcher, 2008)

5.2.3 Loss of Agricultural Land

The demand for urban land use is increasing, as a result, (ORAAMP, 2001) indicated that between 1995/96 and 1999/2000 the cultivated area in the fringes of Addis Ababa decreased from 11,743 hectares to 9,411 hectares in which currently even the rate is very high. The decrease of cultivated land is resulted from the city's rapid expansion towards the farm land.

In the study area many of the local population were changed their livelihood activity due to fear of their land taken by the city administration for expansion of housing. This further forced aggravated the farmers to sell part or their entire farm land to land seeker and land speculator. But still some of the local people were doing some activities such as crop production and dairy farming for the local supply.

5.2.4 Shortage of Water

The major water supply sources for the area are the water taps in the four places which come from the main line of water to the *Sebeta* line. The water is stored in a tanker and is distributed to the four water taps. These water tap points provide water only once a week. The reason for this water shortage in the area was discussed with the settlers, they stated that they didn't know the reason but they think that it is because they do not have a title deed. The impact of the water shortages was particularly severe for women and children who are traditionally responsible for water collection. During the dry season, the shortage of water is very grave (Plate 5.7).



Plate 5.7 Seeking of water (photograph by the researcher, 2008)

In general the area has low public water supply in the locality despite high demand for human and domestic animals consumption. As a result, women and children need to wait long time to get water.

CHAPTER SIX

6. Conclusion and Recommendation

6.1. Conclusion

Pertaining to the research questions posed in the objectives of the study, the following major conclusions were made:

- The capability of GIS and remote sensing technique in data acquisition, data analysis, interpretation, and result presentation play a vital role in studying the urban land use change and its impacts on the population and environment problems.
- The study, clearly indicated that in most periphery of Addis Ababa there is a dynamic change of the agriculture land into settlements and rural to urban.
- The main factors aggravating the problems of inappropriate land use change in the study area is attributed due to combination factors such as the increase of rural-urban migration, lack of land for housing for the lower and middle class, an alarming rate of increasing of housing rent in the center of the city and the insufficient delay of new construction of low cost housing (condominium).
- The inappropriate land use change has resulted in negative consequences on the environment of the study area. These are informal settlements where large plots of land are occupied by individuals, construction of houses on marginal land such as riverside and hillside, establishment of informal business which could pose health threat for local community, poor solid waste management, loss of agricultural land and shortage of water.
- From the LULC change of the study area it was obviously known that the agriculture land, forest, shrub and grazing land decreased by the amount of 132.5, 0.9, and 5.5 Hectares respectively on the contrary, road and built up were increased by 4.7 km, and 122.3 Hectares respectively.

6.2 .Recommendations

Based on the outcome of this research findings, the researcher would like to forward the following suggestions to mitigate informal land subdivision and its negative consequences on the sustainability of the city.

- There should be a clear and effective policy with the necessary institutional set up to guide the growth of the city and monitor the proper implementation of the master plan.
- There is also a need to design enabling mechanisms for formal accessing of land for low and middle income people who usually access land through the informal channels.
- The city administration should establish partnership among different actors involved in land transaction and management to find a possible way of managing land in the most possible efficient way.
- There is also a need to integrate different plans such as environmental plan, infrastructures plan, and service provision plan with land use plan to make land use management cost effective.
- The city Administration should have clear and consistent policy and directives towards regularization of already existing informal settlements and put in place possible and effective controlling mechanism to prevent or minimize further informal land transaction.
- The root causes of the housing problem is the high rate of rural –urban migration, Therefore, the government needs different development interventions to improve the livelihoods of the rural population to minimize out migration.
- Finally there should be participatory urban land use management which involves all actors to minimize the negative consequences of rapid and uncontrolled urban growth which affects the socio-economic and environmental sustainability of the city.

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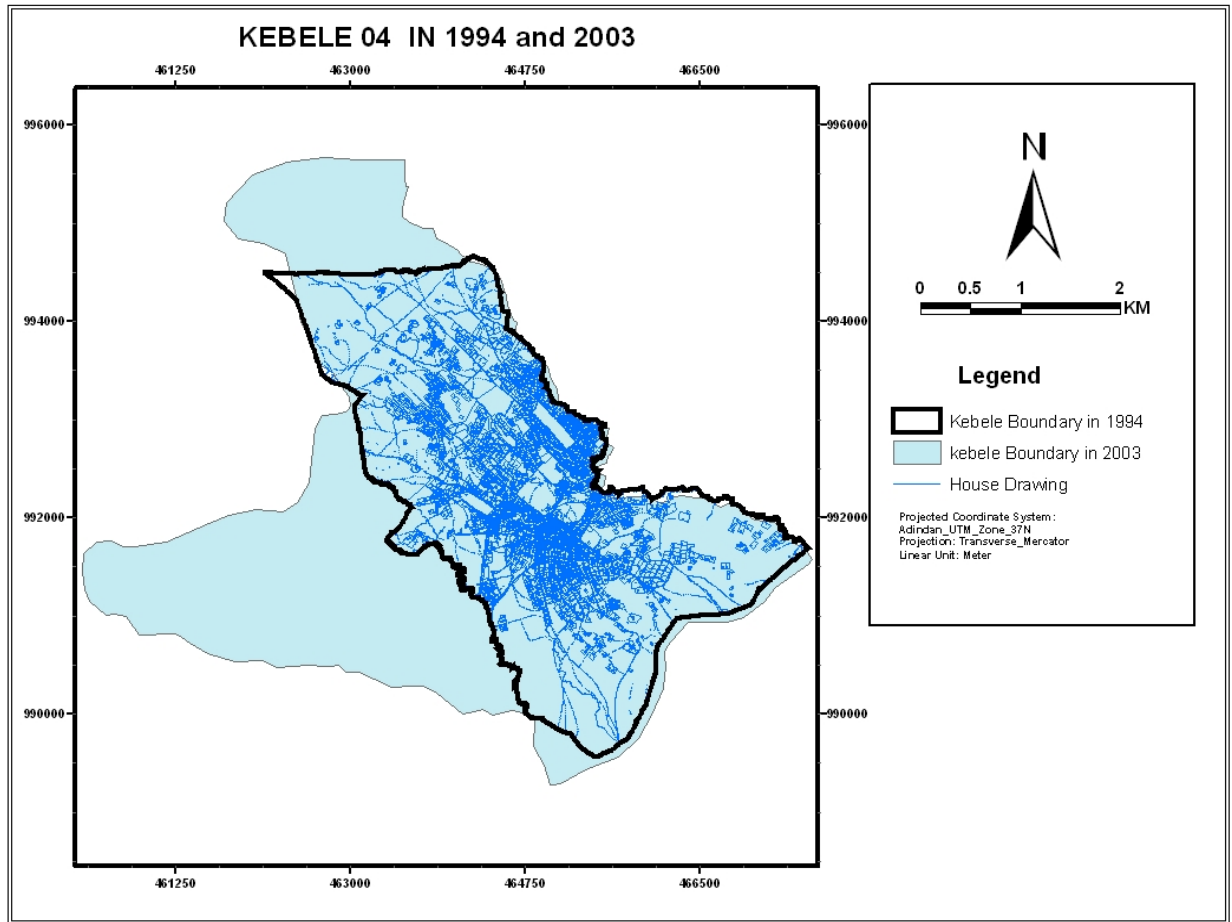
APPENDICES

Appendix I: Summary of primary and secondary data collection and sources

Material used (year)	Data sources	Scale/Resolution	Coverage
Aerial photographs (1994)	Ethiopian Mapping Agency	*B/W 1: 8,000	100%
Aerial photographs (2002)	Ethiopian Mapping Agency	*B/W 1: 2,000	100%
*IKONOS image (2007)	Information Network System Agency	*XS, 1.6 pixel	100%
Google Earth image (2007)	Google Earth kh. Google com. January 31, 2007	Unknown	100%
Map of Addis Ababa boundary in 2003	Kolfe keraniyo sub-city	GIS file (shp.)	100%
Map of Addis Ababa sub-city boundary in 2003	Kolfe keraniyo sub-city	GIS file (shp.)	100%
Map of Addis Ababa kebele boundary	Kolfe keraniyo sub-city	GIS file (shp.)	100%
Study kebele NORTEC map	Kolfe keraniyo sub-city	CAD format	100%
Land use map	Extracted from Aerial photo	GIS file (shp.)	100%
Drainage (River) map	Extracted from Aerial photo (Digitized)	GIS file (shp.)	
Road net work map	Extracted from IKONOS image, Aerial photo and Google Earth (Digitized)	GIS file (shp.)	
Documented reports (unpublished)	The Sub-city office, Addis Ababa city Administration documentation center and CSA, Questioner, Interview		
FACILITY AND SOFTWARES ArcGIS 9.2 ERDAS IMAGINE 9.1 GPS Receiver GARMIN GPS_{map}76CS Mirror Stereoscope Pocket stereoscope Digital camera			

* B/W= Black and white * X/S = Multi spectral * IKONOS Image is degraded for security.

Appendix II: Study area in 1994 and 2003



Appendix III: Local settler discussion

Box 1 Local settler discussion

My name is Guta Kelecha, I am about 80 years old. I was born here and have been working on my family's farmland and dairy farm. I also sell milk to urban people. Ten years back, I sold my extra farm land because the adjacent area was covered by houses for settlement. I changed my houses which was made from corrugated roof and mud wall into corrugated roof and bricks wall. Also my children bought a transport car and involved in transport business. I have 3 females and 3 male children. All live in their own houses in the adjacent kebele but I live with my 2 grandsons. I have a small plot of farmland far from my home and in my garden I still engage in dairy farm activities.

Appendix IV: Settler discussion

Box 2 Settler discussion

My name is Mulugeta Yemame. I am 38 years old. I was born in Addis Ababa *Aware* area. I used to live in Ayer *Tena* in a rented house. There, the owner of the house forbade me not to use electricity for radio and tape. I was angry and decided to have my own house. I purchased a plot of land which was a property of dispossessed Derg soldier area of 280 m² for 9000 birr in three installments period at the end of 1996. I got married after a year and have 1 female and 2 male children. Also 3 relatives live with me. Now I have a diploma in building and work in different construction sites. I have a machine and make iron doors and windows in my home.

Appendix V: Settler discussion (women)

Box 3 Settler discussion (women)

My name is Etaghengh Assefa. I am 35 years old and was born in the surrounding of Repi Medehanealem church. It is 3km far from my home. My husband was a Derg soldier and during the time of the transitional period of EPRDF all the surrounding area of the Derg soldiers asked the government to give them the land. The government granted 280 m² land for each in 1993. My 2 male and 1 female children were dependent on the income of my husband who worked in the construction of houses. In 2004 my husband was seriously sick and visited a doctor but he had contracted HIV/AIDS virus. The children and I were also treated by the doctor. While the children became negative, I was found to be positive. On the course of time, my husband's situation deteriorated. I was in a better health situation. In order to solve the problem, and live a better life, I sold half part of the land and constructed a rent house. Now I am in very better condition in all aspects and involved in kebele women association forum, women *Edier* in the area as leader. In addition to these, I have been working in the newly established buyer association as a store keeper.

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Appendix VI – Maximum Temperature of Addis Ababa

Station Addis Ababa Temperature Maximum												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960	23.7	25.8	24.5	25.5	24.2	23.9	20.3	20.9	21	23.3	24	23.8
1961	25.1	25.2	25.2	23.8	25.6	23.3	19.9	19.8	20.6	22.6	21.7	23.1
1962	24.1	26	24.8	25.7	26.1	24.4	20.4	19.7	20.3	21.4	21.4	22.1
1963	ND	23.3	24.5	22.4	22.3	21.8	19.9	20.1	21	22.8	22.2	21.4
1964	23	24.4	25.4	23.5	24.4	21.6	19.3	19.2	19.5	20	21.1	20
1965	21.6	23.4	24.1	23.1	25.1	23.6	20.3	19.9	21.2	20.9	20.9	22
1966	22.6	21.8	23.3	23.2	25.3	22.2	20.5	20.7	20.7	21.7	21.6	22.2
1967	22.4	24.5	24.2	22.9	22.5	22.5	19	19.3	19.8	20.7	20.5	21.2
1968	22.7	20.3	22.5	21.5	23.5	21.8	19.9	20.1	20.9	21.9	21.5	22.4
1969	22.1	21.6	21.8	23.5	23.3	21.4	19.8	19.9	21.2	22.8	22.9	23.3
1970	22.3	24.2	22.2	23.7	25.4	23.7	20.1	19	20.1	21.2	21	21.4
1971	21.5	23.4	23.2	23.5	22.1	20.7	19.4	19.1	20.1	21.2	20.7	20.2
1972	22.5	21.4	23.3	21.3	23.4	22.2	20	20.1	20.8	22.2	22.4	22.3
1973	23.7	25.2	26.3	26.2	23.5	22.5	20.4	19.2	20.2	21.2	21.5	20.5
1974	21.8	22.9	ND	23.6	23	21.2	19.1	19	19.7	21.6	21	21.8

1975	22.4	23.2	24.7	23.7	23.8	21.2	19.2	18.5	19.6	21	21.1	21.4
1976	22	23.3	23.4	22.1	21.8	21.9	19.4	19.6	20.9	22.7	20.7	21.9
1977	21.4	22.3	23.4	24.4	23.2	21.7	20.1	20.3	20.2	21	21.1	21.8
1978	22.5	22.8	22.7	23.6	23.5	22.3	19.3	20.4	19.9	21	22.2	22.3
1979	20.9	23.2	23.6	24.3	24.3	23.6	21	21.1	21.5	22.7	22.9	23
1980	23.6	24.9	25.2	24.6	25.6	22.9	20.6	20.8	21.9	22.2	22.8	23.4
1981	24.4	24.7	22.4	22.7	25.3	25.3	20.4	20.9	20.8	22.3	22.9	23
1982	23.4	23.7	24.8	23.1	24.2	24	21.1	20.4	21.6	21.8	22.7	22.8
1983	23	24.3	25.3	24.1	23.9	23.4	22.3	20.3	21.2	22	22.8	22.4
1984	23.4	25.1	26.1	27.2	24.2	21.7	20.3	21.2	21.5	23	23.2	22.5
1985	23.8	24.3	24.9	22.9	23.4	23.4	20	20.1	20.9	22	22.8	22.6
1986	23.9	24.5	23.9	22.5	24.4	21.8	21.4	21.2	21.9	22.8	23.4	23.6
1987	23.4	24.5	23.2	23.5	23.7	22.8	21.9	ND	23	24	24.1	24.1
1988	24.2	24.6	27	24.9	25.8	23.2	19.9	20.9	21.1	22	22.5	22.6
1989	23	23	24.5	22.4	24.8	23.5	20.4	21.3	21.1	22.3	22.8	22.3
1990	23.3	22.6	23.6	23.5	25.4	23.5	21.2	20.9	21.2	22.5	23	23.1
1991	24.5	24.4	24.3	25	ND	ND	20.5	20.9	22.1	22.9	22.8	22.3
1992	22.4	23.3	25.7	25.5	25.5	23.7	20.7	19.7	21	21.7	22	22.8
1993	23.2	22.7	25.8	23.2	23.6	22.2	20.9	20.9	20.7	22.4	22.8	23.2
1994	24.6	26.2	25.3	24.9	25.6	22.4	20.3	20	21.6	23.4	23.3	ND
1995	24.7	25.5	25.5	23.5	25.2	24.4	20.4	21	22.1	23.8	24.6	24
1996	23.2	26.7	24.7	24.5	24.3	21.7	20.9	21.3	22	24	23.8	24.1
1997	24.2	25.5	26.5	24.4	26.8	24.6	21.8	22	23.6	23.3	22.6	24.1
1998	24.4	25.7	25.4	26.8	25.4	24.8	21.5	21.4	21.8	22.2	23.1	23.1
1999	24.4	26.6	25.2	27.2	26.2	24.7	21.2	21.5	22.5	21.9	23	23.5
2000	24.9	26.1	27.3	25.7	25.3	23	21.6	20.5	21.5	22.2	23	23.8
2001	24.5	25.9	23.7	25.4	24.5	22.5	21.6	21.2	22.6	23.9	24	24.3
2002	24	26.2	25.1	25.7	26.2	24.2	22.6	21.2	22.3	24.2	24.3	23.5
2003	24.4	26.3	25.3	24.6	26.7	24	21	21	21.6	23.5	23.4	22.8
2004	24.5	24.9	25.7	23.7	26.1	23.1	21.3	21.4	21.8	22.5	23.5	23.7
2005	23.8	26.5	25.8	25.6	24	23.7	21.4	22.1	21.4	ND	23.3	ND

Source: National Metrological Agency

ND= No data

Appendix VII – Minimum Temperature of Addis Ababa

Station Addis Ababa_ Minimum Temperature												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960	5.8	7.8	9.7	9.5	10.5	9.6	10.1	9.9	9.4	7.3	6.5	7.4
1961	6.5	6.7	9	10.1	9.9	8.9	9.5	9.3	8.7	6.7	6.3	5.4
1962	4.7	5.5	8.8	9.6	10.3	9.3	10	10.2	9.6	6.5	6.7	6.7
1963	ND	8.3	8.2	10.9	10.2	9.4	10	9.9	9.8	8.8	8.7	8
1964	7.6	8	10	10	10.5	9.6	9.8	9.8	9.2	8.2	6.5	7.6
1965	8.2	6.8	9.4	11.1	10.8	9.9	9.7	10.7	10.2	8.7	8.5	7.1
1966	ND	10.6	10.4	11.9	11.7	10.4	11.1	10.9	10.7	9.2	7.6	6.3
1967	5.9	9.4	11.2	11.2	11.8	10.6	11	10.4	10.4	8.6	8.7	5.6
1968	6.2	10.2	8.7	10.9	11	11	10.8	10.8	10.6	9	7.8	7.6
1969	10.1	10.4	11.6	12	12.1	10.9	11.2	10.9	10.7	9.4	8.4	6.8
1970	10.5	10	11.1	11.7	12	10.9	10.4	10.2	9.6	8.9	6	6.2
1971	8.2	7.8	10.4	11.1	11.5	10.7	10.3	10.4	10.5	9.4	8.2	7.3
1972	8.7	10	10.7	11.9	11.7	11.3	11.4	10.9	11	9.6	8.8	8.5
1973	9.1	9.8	11.8	13.2	12.4	11.1	11.3	10.9	10.8	8.9	7.1	5.5
1974	7.7	8.7	ND	10.6	11.4	9.9	9.9	10.4	9.9	8.8	5.6	6.4
1975	7.6	10	11.7	12.1	12.8	11	10.9	11.4	11	9.2	7.1	7.1
1976	8.2	10.4	11.3	11.1	11.5	10.6	11.3	10.8	11.1	10.8	9.6	8.8
1977	10.4	10.3	10.6	11.8	12	11.5	11.1	11.3	11.1	11.1	9	7.9
1978	8	10.7	11.2	11.9	11.7	11.2	11.3	11.1	11.1	9.5	7.9	9.1
1979	10.6	10.7	11.5	11.9	13.1	11.6	11.7	11.7	11.7	10.8	8.8	9.1
1980	9.9	11.3	12.6	12.5	13.1	11.9	11.5	11.5	11.8	10.8	9.4	7.9
1981	9.9	10.4	12.3	12.4	12.7	11.9	11.7	11.7	11.4	10.3	9	8.7
1982	10.4	11.7	11.7	12.3	12.7	11.6	11.3	11.3	11.7	10.3	10.1	10
1983	9.1	11.7	13.1	13	13.1	12.4	12	12.4	11.8	10.7	9.7	8.7
1984	7.9	8.3	12.4	12.5	13.1	11.5	11.2	11.4	11.2	10	8.5	7.3

1985	8.2	8.3	11	11.2	11.2	10.5	9.8	9.9	10.1	9.3	7.9	7.5
1986	7	10.5	10.4	11.3	11.7	10.8	10.4	10.3	10	9	8.4	8.4
1987	7.8	10.1	11.9	12.3	12.4	11.9	11.8	11.9	12.5	11	9.3	9.2
1988	10.2	12.5	11.9	12.8	12.5	11.7	12.1	11.7	11.5	10.5	7.8	7.8
1989	7.8	9.9	11.5	11.8	12	11.2	11.3	11.2	11.3	10.2	8.9	10.5
1990	9.1	11.9	11.4	11.9	12.4	10.9	11.4	11.1	11.3	9.5	9.2	7.7
1991	10.4	11.6	12.4	13.0	13.3	12.3	12	11.9	11.6	9.7	8.3	8.9
1992	10	11.2	12.4	12.4	12.7	11.3	11	11.8	10.9	10.1	8.8	9.2
1993	10	10.8	11	12.2	12.3	11.4	11.3	11.3	11	10.1	8.2	7.5
1994	7.8	9.2	11.9	12.1	12.1	11.2	11.5	11.1	10.6	9.3	8.5	7
1995	7.4	10.4	11.4	12.6	12.3	11.4	11.7	11.8	10.6	10	8.5	9.2
1996	9.9	9.8	11.9	11.5	12.2	11.5	11.4	11.2	10.9	9	8.2	7.8
1997	10.3	7.9	11.7	11.5	11.6	12	11	11.1	11.4	11	10	8.1
1998	10.6	12	12.7	12.8	13.2	12	12.1	12	11.2	10.6	7.7	ND
1999	8.5	9.6	11.4	12.0	12.2	11.2	10.9	10.9	10.9	9.5	7.3	7.2
2000	7.4	8.2	10.2	12.1	11.7	10.6	11	11	11.3	12.3	12.1	8.9
2001	8.5	9.2	11.7	11.9	11.8	10.8	11.1	11.6	10.6	10.1	7.8	8.4
2002	8.7	10.2	11.7	12.3	12.9	11.4	11.3	13	14.5	12.8	8.7	10.4
2003	9.7	10.9	11.3	12.4	13.3	11.7	11.7	11.8	11.4	9.3	8.4	7.7
2004	10.3	8.9	10.3	12.2	12.2	11.3	ND	ND	ND	ND	ND	ND
2005	8.3	9.3	11.8	12.5	12.5	11.4	11.3	11.4	11.3	ND	7.9	ND

Source: National Metrological Agency

ND= No data

Appendix VIII– Monthly Rainfall of Addis Ababa

STATION:-ADDIS ABABA _MONTHLY RAINFALL												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1970	0.0	52.3	176.4	39.5	31.5	61.7	340.6	311.3	165.5	2.9	0.0	0.0
1971	7.2	0.0	36.8	67.9	154.1	123.1	303.4	300.7	161.3	8.4	4.2	16.0
1972	7.7	103.4	82.4	162.8	83.3	91.4	268.9	152.0	134.1	3.2	6.4	0.0
1973	0.0	0.0	0.0	25.3	68.8	117.6	266.3	333.7	130.8	31.1	0.0	74.6
1974	0.0	15.7	6.4	5.0	142.2	140.3	269.8	237.4	203.3	10.0	0.0	0.0
1975	5.7	0.0	26.7	79.2	8.6	112.9	292.7	155.2	128.8	29.5	0.0	0.0
1976	23.6	9.2	50.4	99.1	129.2	106.3	249.7	236.9	102.3	0.0	78.3	3.4
1977	64.0	46.8	95.2	76.5	104.8	151.7	222.8	300.3	168.5	227.1	9.3	0.0
1978	0.0	71.6	28.9	92.0	46.2	101.6	162.3	244.5	195.8	44.8	0.0	0.0
1979	91.0	7.2	91.0	31.4	139.5	119.9	249.2	164.2	85.0	15.2	0.0	5.8
1980	23.6	26.8	64.3	74.3	44.4	129.1	268.1	214.8	118.6	0.0	0.0	0.0
1981	0.0	42.6	217.5	79.0	18.4	56.9	273.9	256.1	162.5	24.7	0.0	2.7
1982	26.6	96.4	90.2	48.1	73.5	63.6	220.3	221.6	142.8	19.0	40.7	4.9
1983	12.4	41.2	28.9	113.7	186.9	56.1	217.9	213.7	202.2	35.9	0.0	1.5
1984	0.0	0.4	11.6	11.6	135.0	334.2	313.7	180.4	98.8	0.0	0.0	7.0
1985	35.1	0.0	49.1	130.3	92.8	110.9	209.8	260.8	168.6	29.8	0.0	0.4
1986	0.0	37.6	56.2	216.6	37.7	175.2	167.9	222.3	107.4	31.6	0.0	2.5
1987	0.0	49.1	180.1	85.7	154.6	71.9	155.9	98.1	57.0	16.6	0.0	0.4
1988	4.7	33.4	6.7	157.9	34.7	93.2	181.4	265.3	187.3	57.3	0.0	0.0
1989	3.4	33.7	58.4	143.3	0.0	88.1	218.1	318.6	150.0	36.8	0.0	7.9
1990	3.2	161.1	60.4	144.5	25.2	48.3	204.2	413.4	143.0	46.1	2.1	0.0
1991	0.2	29.6	134.1	15.0	7.7	107.5	279.4	287.9	123.1	4.4	2.1	0.0
1992	14.5	28.0	35.0	58.6	55.0	82.2	254.2	223.3	157.0	64.4	2.2	0.4

1993	11.7	52.1	11.6	168.3	91.5	157.2	209.5	291.7	190.1	24.1	0.0	0.0
1994	0.0	0.0	52.9	70.0	31.7	112.9	242.2	199.3	100.9	0.5	11.0	0.0
1995	0.0	81.3	73.3	140.3	95.9	78.2	165.1	256.9	97.0	0.0	0.0	28.6
1996	20.5	5.8	176.2	95.4	128.1	289.7	346.3	312.7	211.4	0.2	0.4	0.0
1997	29.1	0.0	22.1	66.8	44.8	128.0	257.0	160.7	94.7	58.6	15.3	0.0
1998	63.1	40.0	43.8	87.8	193.1	111.6	257.8	236.8	185.2	139.5	0.0	0.0
1999	4.4	0.0	35.0	17.8	30.5	104.6	194.0	270.5	62.8	227.1	0.0	0.0
2000	0.0	0.0	17.6	109.9	95.2	102.1	192.9	221.9	157.5	19.6	13.5	0.0
2001	0.0	10.3	165.3	14.8	106.7	163.0	274.4	179.1	107.3	10.6	0.0	0.0
2002	30.6	25.9	79.4	36.6	49.6	109.0	213.9	233.6	72.6	0.5	0.0	32.8
2003	4.8	34.1	48.9	121.9	33.0	128.0	226.4	238.4	30.2	4.6	0.0	33.8
2004	26.1	11.7	32.4	104.2	7.0	120.6	240.6	230.1	122.1	50.0	0.0	0.0
MEAN	13.9	34.3	62.7	84.8	71.1	111.3	224.1	231.0	131.6	32.6	5.3	5.3
MEDIAN	4.6	26.4	49.0	79.1	52.3	110.7	224.4	236.8	130.8	19.0	0.0	0.0
SKEWNESS	1.3	0.6	0.7	0.3	1.0	0.0	0.0	-0.2	0.0	0.8	1.1	1.2
STD	21.3	40.3	56.0	60.6	56.5	59.0	62.5	78.2	51.8	50.3	14.1	13.5

Source: National Metrological Agency

ND= No data

Appendix IX Computing Percentage of the Population

$$= \left[\frac{p_t - p_o}{p_o} \right] \times 100$$

Where p_t - Total population in the current year

p_o - Total population in the previous year

2. The growth rate of population

$$r = \left[\frac{p_t + n}{p_o} \right]^{\frac{1}{n}} - 1 \times 100$$

Where: r - Rate of population growth p_t - The recent population in X year p_o - The previous population in Y year

n - Range of year between X and Y years