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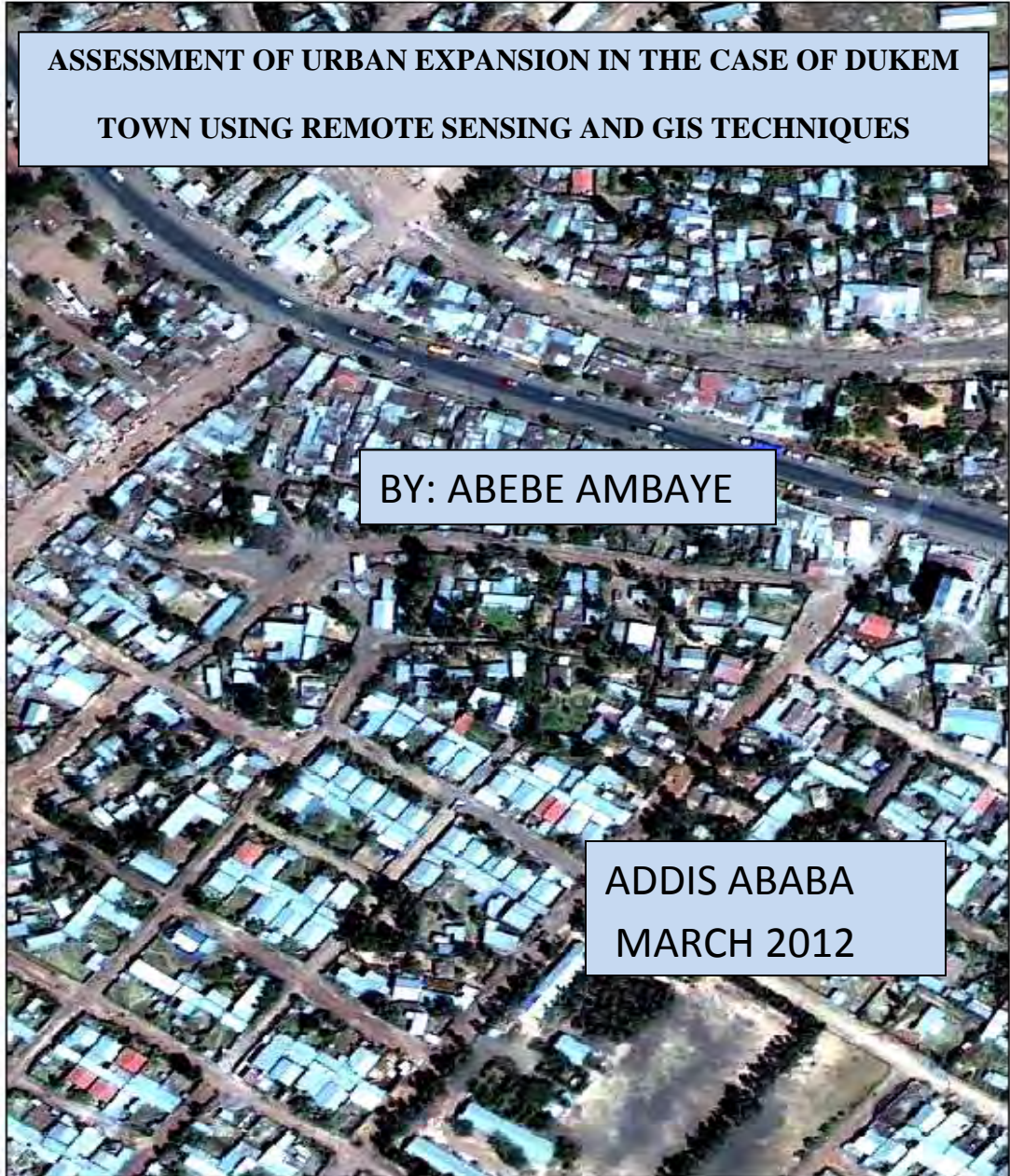
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**ASSESSMENT OF URBAN EXPANSION IN THE CASE OF DUKEM
TOWN USING REMOTE SENSING AND GIS TECHNIQUES**

BY: ABEBE AMBAYE

**ADDIS ABABA
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USING REMOTE SENSING AND GIS TECHNIQUES

By
Abebe Ambaye

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ADVISOR: Dr. K.V. Suryabhagavan

Approved by the Examining Committee

1. Name	Signature	Date
1. Dr.K.V.Suryabhgavan (Advisor)	_____	/ / / /
2. Dr.Mekuria Argaw(Examiner)	_____	/ / / /
3. Dr.Tilahun Mamo(Examiner)	_____	/ / / /
4. Dr.Tigistu Haile (Chairman)	_____	/ / / /

_____ / / / /
Chairman, Faculty Academic Commission

Prof.Masresha Fetene / / / /
Chairman, Council of Graduate Studies

MARCH, 2012

ADDIS ABABA

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ABBREVIATIONS

CSA	Central Statistical Agency
EMA	Ethiopian Mapping Agency
GCP	Ground Control Point
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
Km ²	Square Kilometre
Lulc	Land Use land Cover
NMSA	National Meteorological Services Agency
NUPI	National Urban Planning Institute
OUPI	Oromia Urban Planning Institute
UN	United Nations
UTM	Universal Transverses Mercator
WHO	World Health Organization

ABSTRACT

Urban environments are among the most dynamic systems on earth. Rapid urban expansion necessitates proper planning to avoid profound negative environmental and socioeconomic impacts. Geographic Information Systems (GIS) and Remote Sensing technologies provide very efficient tools to collect and analyse the information necessary to detect changes in urban areas that conventional surveying technology can't deliver in a timely and cost effective manner. GIS and Remote Sensing techniques were used in this work to locate and estimate the expansion of urban areas in Dukem town. Rapid urban expansion has caused not only social problems, but also environmental and socioeconomic problems in the town. The results show massive urban expansions during the study period. The population dynamics are the factors that make the population of certain area to change over time. In this case in 1986 the population of the town was 3736 and the built up area 43 hectare. The population was increased to 6356 in 2005 likewise the built up was expanded to 505.3 hectare. In 2010 the population became 25214 and the built up was expanded to 1095.44 hectare. From 1986-2005, the population of the town was increased by 2620 i.e. 70.13% and 2005-2010 it was 8858 i.e. 275.2%. The built up area of the town was increased by 462.3ha i.e. 1075% from 1986-2005 and it was expanded to 590.14ha i.e. 116.8% from 2005-2010. Population, nearness to Addis Ababa, and poor policy implementation are the major factors that derive horizontal expansion in the town.

Keywords: Urban expansion, Remote Sensing, GIS, Urban Change Detection.

1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Urbanization, which can be defined as a local increase of inhabitants density coupled with increased per capita energy consumption and extensive modifications of the local environment, represents an important type of land use and cover changes (Lulc) and is considered to be an inevitable tendency in today's world (Pickett et al., 2001).

The world's urban population is estimated at 3 billion in 2003, and is expected to rise to 5 billion by 2030 by then, almost two thirds of the world's population will be living in towns and cities i.e.the rate of the urban population growth is more than that of the rural population. More importantly, the speed and scale of this growth have usually been concentrated in developing countries which are characterized by larger metropolitan areas and great number of mega cities. Urbanization is one of the most important anthropogenic activities that create significant and extensive environmental implications at both local and global scales (Herold et al., 2003).

Inevitably, population growth leads to a rapid expansion of urban growth, causing changes in land use land cover in many metropolitan areas. The rate of such change is obvious in developing countries with high population growth rates like Ethiopia. These uncontrollable urban changes around the Ethiopian towns can intensify a large number of social and physical problems, in addition to the agricultural lands changed. Due to the effects of continued growth and expansion of cities, rural communities residing in the outlying areas have been subjected to increasing eviction and adverse effects such as pollution, environmental, social and cultural disturbances. The measures are being taken to manage the undesired effects, though not adequate. In this respect one of the typical manifestations of the undesired effects of urbanization is informal and/or illegal ownership of land and housing which are particularly intensified in the peripheral

areas. Rapid urban development and increasing land use changes due to increasing population and economic growth is being witnessed of in Ethiopia and other developing countries. The measurement and monitoring of these land use changes are crucial to understand land use cover dynamics over different spatial and temporal time scales for effective land management.

Dukem is one of the fast growing urban centres“ in the Oromia regional state. Hence the expansion of the town is becoming irregular, uncontrolled and often resulting in creation of fragmented development. The town’s growing industry, manufacturing sector, service and its proximity to Addis has led to increased investments and has resulted in high-speed economic and social development. Dukem, being one of the towns in the developing countries has never been in a position to escape the forgoing undesired realities of rapid urbanization. Urban planning implementation principles and guidelines fundamental to ensure healthy urban growth have never been put in place. In this study, the spatial analysis functions of GIS and remote sensing techniques to specify the urban expansion characteristics of the town have been used.

1.2. STATEMENT OF THE PROBLEM

Dukem is characterized by low density and low-rise development. Like any third world town, leap frogging and sporadic developments are common in Dukem. There has not been institutional and legal framework capable of managing informalities in trade and physical developments. Excessive alteration of land use has been taking place without formal procedures, and this could lead to imbalance between land uses, which gave Dukem an image of much of a town of stores (Shiferaw, 2006).

The importance of putting in place planning principles to be referred to in the planning process is not well recognized. This could give way to haphazard planning and subsequent ineffective implementation.

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

The result of the land use and housing ownership survey shows that there are informal housing constructions and extension in all areas of the town especially at the peripheries. The population of the town has been raised and consequently the need for homes became serious. In addition to this the growth of the town is a continuous process so that it is important to measure its horizontal expansions in order to recommend possible solutions for future development. This paper will try to assess urban expansion of Dukem town using Remote Sensing and Geographical Information Systems and recommend possible solutions.

1.3. OBJECTIVES OF THE STUDY

1.3.1. GENERAL OBJECTIVE

- ❖ Analyzing horizontal expansion of Dukem town using remote sensing and GIS techniques between 1986 and 2010.

1.3.2. SPECIFIC OBJECTIVE

- ❖ Mapping horizontal expansion of the study areas at different periods
- ❖ Estimate urban expansion of the town for 2020
- ❖ Delineating urban land use classes of the town between 2005 and 2010
- ❖ Identify major incompatible land uses
- ❖ Identify the factors responsible for urban expansion and its direction.

1.4. SIGNIFICANCE OF THE RESEARCH

The study attempts to extract useful information from remotely sensed images and analysis in the context of a given research problem. Hence, the output of the study will be a methodological and empirical contribution of the significance of GIS and remote sensing in the analysis of urban expansion.

1.5. LIMITATION OF THE STUDY

The study had some limitations, among this lack of access to satellite imageries of high resolution as well as appropriate financial support to purchase the required satellite images.

1.6. ORGANIZATION OF THE THESIS

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

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

2. REVIEW OF LITERATURE

2.1. GENERAL REVIEW

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

The built-up is generally considered as the parameter of quantifying urban Expansion (Epstein et al., 2002). It is quantified by considering the impervious or the built-up as the key feature of sprawl, which is delineated using toposheet or through the data acquired remotely.

Previous attempts to study urban expansion at the expense of agricultural land in Ethiopia were not introduced to the dynamics of urban development, in order to try to predict future urban expansion. Also, no approach has been made to make a model or even calibrate an existing model to fit the Ethiopian context. Further, no approach has handled the problem using accurate data acquired from historical and recent satellite images using dynamic analysis techniques. Finally, no simulation attempt has been made to test the effectiveness of different planning actions that can help hindering future urban sprawl within the country context. The detection and analysis of land use changes in the urban environment is an important issue in planning. Remote sensing and geographic information systems are considered as the most efficient techniques for this type of studies. This technique has been applied to investigate the urban expansion and quantify urban growth.

2.2. URBANIZATION

Urbanization or urban drift is the physical growth of urban areas as a result of global change. Urbanization is also defined by the United Nations as movement of people from rural to urban

areas with population growth equating to urban migration. Urbanization is the outcome of social, economic and political developments that lead to urban concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and governance.

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

2.2.1. TRENDS OF URBANIZATION IN AFRICA

Urbanization is increasing in both developed and developing countries. However, rapid urbanization, particularly the growth of large cities, and the associated problems of unemployment, poverty, inadequate health, poor sanitation, urban slums and environmental degradation pose a formidable challenge in many developing countries. Although urbanization is the driving force for modernization, economic growth and development, there is increasing concern about the effects of expanding cities, principally on human health, livelihoods and the environment. The implications of rapid urbanization and demographic trends for employment,

food security, water supply, shelter and sanitation, especially the disposal of wastes (solid and liquid) that the cities produce are staggering (UNCED, 1992). The question that arises is whether the current trend in urban growth is sustainable considering the accompanying urban challenges such as unemployment, slum development, poverty and environmental degradation, especially in the developing countries.

Natural population increase (high births than death) and migration are significant factors in the growth of cities in the developing countries. The natural increase is fuelled by improved medical care, better sanitation and improved food supplies, which reduce death rates and cause populations to grow. In many developing countries, it is rural poverty that drives people from the rural areas into the city in search of employment, food, shelter and education. In Africa, most people move into the urban areas because they are „pushed“ out by factors such as poverty, environmental degradation, religious strife, political persecution, food insecurity and lack of basic infrastructure and services in the rural areas or because they are „pulled“ into the urban areas by the advantages and opportunities of the city including education, electricity, water etc. Even though in many African countries the urban areas offer few jobs for the youth, they are often attracted there by the amenities of urban life (Tarver, 1996).

2.2.2. TRENDS OF URBANIZATION IN ETHIOPIA

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

pace of urban development continued until the 1935 Italian invasion. Urban growth was fairly rapid during and after the Italian occupation of 1936-41. Urbanization accelerated during the 1960s, when the average annual growth rate was about 6.3 percent. Urban growth was especially evident in the northern half of Ethiopia, where most of the major towns are located.

Addis Ababa was home to about 35 percent of the country's urban population in 1987. Another 7 percent resided in Asmera, the second largest city. Major industrial, commercial, governmental, educational, health, and cultural institutions were located in these two cities, which together were home to about 2 million people, or one out of twenty-five Ethiopians. Nevertheless, many small towns had emerged as well. In 1970 there were 171 towns with population of 2,000 to 20,000; this total had grown to 229 by 1980.

The period 1967-75 saw rapid growth of relatively new urban centers. The population of six towns--Akaki, Arba Minch, Awasa, Bahir Dar, Jijiga, and Shashemene--more than tripled, and that of eight others more than doubled. Awasa, Arba Minch, Metu, and Goba were newly designated capitals of administrative regions and important agricultural centers. Awasa, capital of Sidamo, had a lakeshore site and convenient location on the Addis Ababa-Nairobi highway. Bahir Dar was a newly planned city on Lake Tana and the site of several industries and a polytechnic institute. Akaki and Aseb were growing into important industrial towns, while Jijiga and Shashemene had become communications and service centers.

Urban centers that experienced moderate growth tended to be more established towns, such as Addis Ababa, Dire Dawa, and Debre Zeyit. A few old provincial capitals, such as Gonder, also experienced moderate growth, but others, such as Harer, Dese, Debre Markos, and Jima, had

slow growth rates because of competition from larger cities. By the 1990s, Harer was being overshadowed by Dire Dawa, Dese by Kembolcha, and Debre Markos by Bahir Dar.

Overall, the rate of urban growth declined from 1975 to 1987. With the exception of Aseb, Arba Minch, and Awasa, urban centers grew an average of about 40 percent over that twelve-year period. This slow growth is explained by several factors. Rural-to-urban migration had been largely responsible for the rapid expansion during the 1967-75 periods, whereas natural population growth may have been mostly responsible for urban expansion during the 1975-84 periods. The 1975 land reform program provided incentives and opportunities for peasants and other potential migrants to stay in rural areas. Restrictions on travel, lack of employment, housing shortages, and social unrest in some towns during the 1975-80 period also contributed to a decline in rural-to-urban migration. Although the male and female populations were about equal, men outnumbered women in rural areas. More women migrated to the urban centres for a variety of reasons, including increased job opportunities.

As a result of intensified warfare in the period 1988-91, all urban centres received a large influx of population, resulting in severe overcrowding, shortages of housing and water, overtaxed social services, and unemployment. In addition to beggars and maimed persons, the new arrivals comprised large numbers of young people. These included not only primary and secondary school students but also an alarming number of orphans and street children, estimated at well over 100,000. Although all large towns shared in this influx, Addis Ababa, as the national capital, was most affected. This situation underscored the huge social problems that the Mengistu regime had neglected for far too long (Asefa, 1993).

According to a report in 1996, since 1940 the proportion of urban population to the national has grown 5 times. While the rate was only 3 per cent in 1940, it was almost tripled and reached 8.5 per cent in 1967. In the year 1970 about 9.7 per cent of the population was living in urban areas, while in 1984 and 1994 it reached 11.4 and 15.7 per cent respectively. Today, about 17.6 per cent of the total population is estimated to live in urban areas and this is expected to reach about 29 per cent by the year 2020. These figures display the fact that the rate of urbanization in Ethiopia is well below the African average, which is about 30 per cent in 1996 cited in (Seid, 2007).

2.2.3. TRENDS OF DUKEM TOWN EXPANSION

The settlement of Dukem town was influenced by the railroad, the main high way and the feeder roads that connected the rural areas with the town. The first is the southern portion of the hill slope facing the market place. Then, to the south following the railroad and the main right way, settlement pattern were regulated. This continued until 1980's. Later on, because of the change of market place the direction of expansion was also changed following the bank of Dukem River. Some quarter names such as "Yerer Bar," and cuqqala Bar were created. Expansion to south ward direction is also resulted in the formation of a neighbourhood called "Quallaa Dhaab" (OUPI, 2008).

2.3. IMPACT OF URBAN EXPANSION

As the World Bank transport and urban Development Department indicated, even though, the available evidences are spotty, controversial and not necessarily applicable to developing country cities, suggest that the growth and expansion of cities are associated with both positive and adverse outcomes that affect the welfare and wellbeing of the citizens. The available literature concerning urban expansion is rife with blame for its inappropriate and unnecessarily costly for developing world cities. Most blame is directed at expensive leapfrogging green filed

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

2.4 MONITORING URBAN EXPANSION

Monitoring urban growth is one of the questions social scientists, urban planners and decision-makers deal with most frequently. The direct impacts of urban expansion on physical, ecological and social resources have made research on urban sprawl of increased interest. Traditional census sources are extremely useful in that they capture changes in the socioeconomic and demographic structure of cities, but they lack spatial details and are not frequently updated. Remote sensing, on the other hand, makes available a vast amount of data with continuous temporal and spatial coverage and can therefore provide a successful means for monitoring urban growth and changes. Using remote sensing for change detection studies naturally requires that the different temporal images are atmospheric and zenith-angle corrected and carefully co-registered, in order to avoid errors in the estimation of land cover changes.

Despite the extensive literature of change studies available, most of these studies are based on more traditional land cover classifications and only a few report developments of integrated datasets that can be used in planning and urban monitoring efforts. Many cities in developing countries are experiencing rapid increase in population and consequential urban expansion. Remote sensing may provide fundamental observations of urban growth that are not available from other sources.

2.5 GIS AND REMOTE SENSING APPLICATIONS IN URBAN STUDIES

Population growth and urban expansion have advanced at an unprecedented pace over the past few decades. Although cities occupy only a very small portion of the earth's total land surface, almost half of the world population lives in urban areas (United Nations, 2001).

Remote sensing provides spatially consistent data sets that cover large areas with both high spatial detail and high temporal frequency. Dating back to 1960, remote sensing can also provide consistent historical time series data. The importance of remote sensing was emphasized as a "unique view" of the spatial and temporal dynamics of the processes in urban growth and land use change (Herold et al., 2003). Satellite remote sensing techniques have, therefore, been widely used in detecting and monitoring land cover change at various scales with useful results. Recently, remote sensing has been used in combination with Geographical Information Systems and Global Positioning Systems to assess land cover change more effectively than by remote sensing data only (Weng, 2002). It has already proved useful in mapping urban areas, and as data source for the analysis and modelling of urban growth and land use/land cover change.

The increasing demands in urban planning and management sectors call for co-ordinate application of remote sensing and Geographic Information Systems for sustainable development of urban areas. Thus, there is an urgent need to adopt Remote Sensing and Geographic

Information System approaches in urban studies and development processes. If this is done, it will certainly help in evolving efficient and economical models for the development and the allocation of industries, education, housing, water supply, service facility, and disposal systems that is related to urban studies.

3 MATERIAL AND METHODS OF THE STUDY

3.1 DESCRIPTION OF THE STUDY AREA

3.1.1 LOCATION

Dukem town is located at 37km South East of Addis Ababa along the main road to Adama. Geographically, the study area located by latitude 8°45'25"N-8°50'30"N and longitude 38°51'55"E - 38°56'5" E covering a total area of 35.96 km² (Figure 3.1). It is located at an average altitude of 2100m above sea level. Progresses have been seen in the town since a number of houses, manufacturing, service sector and institutions have been constructed. The population is also rapidly growing because of its nearness to Addis Ababa and economic importance. The development plan has not been implemented properly. Population growth, coupled with industrial and commercial expansion has resulted in intense competition for land.

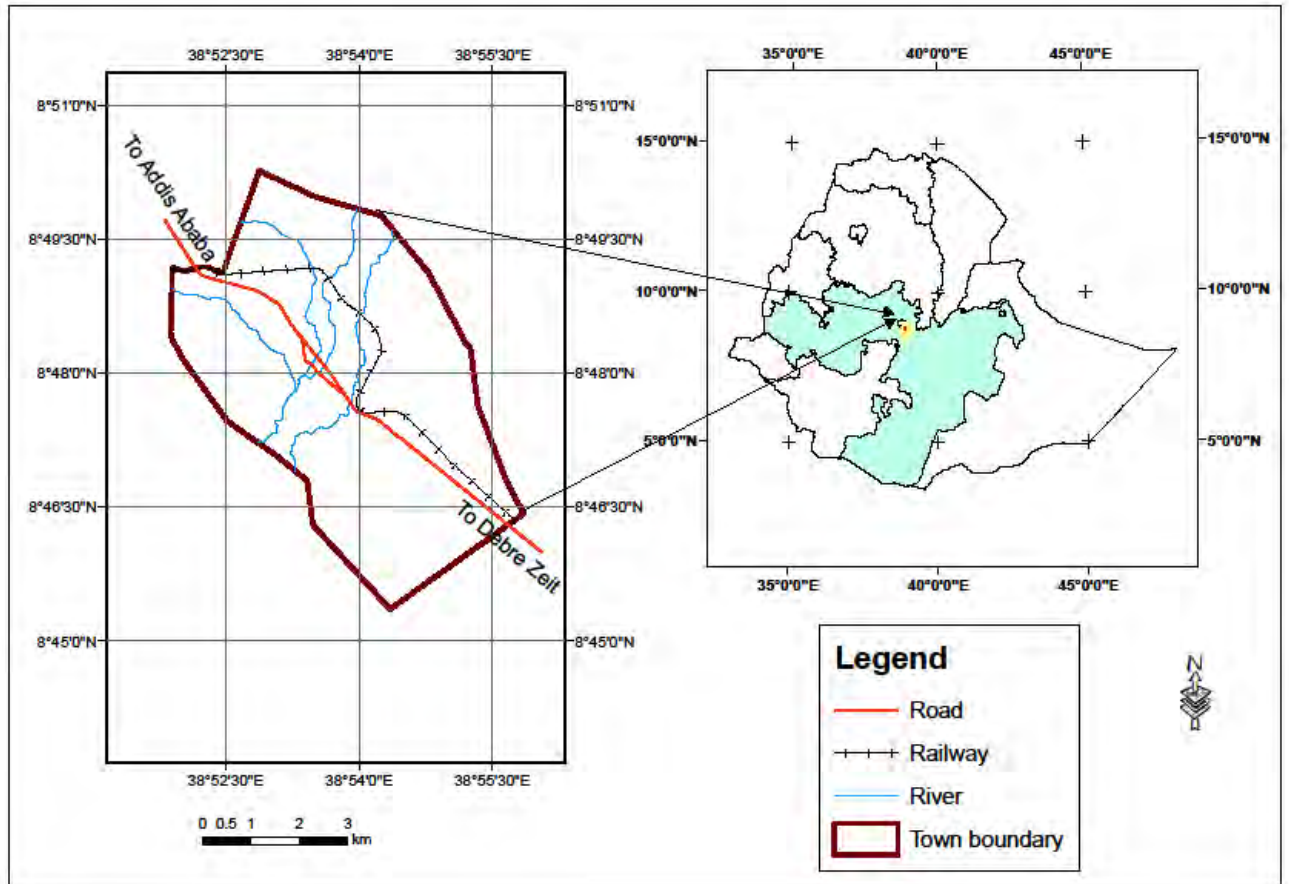


Figure 3.1 Location map of the study area

3.1.2 CLIMATE, VEGETATION AND TOPOGRAPHY

The area is located near the western border and experiences temperate climate of the central Rift valley of Ethiopia. The mean annual rainfall of the area according to 1996 to 2003 year's meteorological data at Bushoftu station is 606.13 mm, and the mean maximum and mean minimum annual temperature of the area are 25.83 °C and 11.9 °C respectively. The maximum temperature is during February to May and the minimum temperature is from mid-October to January.

Except planted trees, particularly eucalyptus trees found in the village and some sporadically scattered Acacia, existing in the farmland, the area is totally devoid of natural vegetation. The study area has flat topography generally possesses east and southeast and south west of Dukem

Town extends to Bushoftu Town and the known Chukala mountain. The existing landscape of the area is formed by the formation of the great east African rift formation and subsequent volcanism, erosion and deposition. A ridge extends northeast and southwest to Yerer Mountain in the north east and to Guji and Bilbilo Mountain in the southwest (Abduletif, 2011).

3.1.3 SOIL

According to Dukem town development plan team report the soil of the town is vertisol. This type of soil forms deep cracks during the dry season but logs water during the rainy season. The cracking of the soil during the dry season facilitates soil erosion. As a result, there are deep gorges in different parts of the town, especially along the courses of seasonal streams and Dukem river valley because of the very nature of the soil. Activities like quarrying and extraction of soil and also sand from the valleys of streams and river play their contribution for the formation of deep river gorges in different parts of the town. People dig out soil and also stones from the banks of Dukem River to provide soil for the construction of mud houses.



Plate 3.1 Soil Erosions along Dukem River



Plate 3.2 Sand quarrying along the valley of Dukem River.

3.1.4 GEOLOGY

Dukem is found in the main Ethiopian rift valley near the western escarpment. Volcanic rock materials of various compositions cover the area. Due to weathering of the rock, and subsequent erosion and deposition, thick residual clay and silty clay soil covered most part of the plain topographic landforms. The volcanic rocks found exposed along Dukem stream, Mandalo stream, Gogecha stream, rigs and slopes. According to the litho logical log of existing borehole, near Dukem stream ,(488800mE, 972368mN), that was drilled in December 2002 the area can be depicted by alternating layers of ignimbrite, scoracious Basalt, aphanitic Basalt, scoria and clay .

Litho logical log of the newly drilled borehole in September 2005 for Bishoftu town, in the plain land of Garbi Ballo, at the distance of 5km from Dukem, located at the geographic grid coordinate 969255mN and 492816mE, shows from top to bottom, the area formed from thick clay deposit, scoriaceous basalt flow (14meters), and reworked pyroclastic deposits of different size, fine to medium grained sand of different composition, and medium to fine gravel of different rock type. Due to the location of the study area in the main Ethiopian rift valley near the western escarpment parallel faults and step faults are prevalent in the area, which are governing ground water flow directions at depth and the flow of drainage pattern. A ridge extends northeast and southwest to Yerer Mountain in the north east and to Guji and Bilbilo Mountain in the southwest demarcated the western escarpment of the rift (Abduletif, 2011).

3.2 DATA AND METHODS OF THE STUDY

Reliable data is necessary to realize the designed objectives and hence the study is based on both primary and secondary data. In addition to this, frequent field observations using GPS have been carried out to generate information about Land use classification. The topographic map and satellite images of the study area at different years to assess the urban expansion and Population data have been accessed from different sources as indicated in table 3.1. Table 3.1 shows the list of data used in the present study and sources from which they were obtained.

3.2.1 DATA PROCESSING

The urban expansion maps and other different maps of the study area were created using ArcGIS 10.0 and ERDAS 9.2 analysis tools. In this research Landsat TM (1986), SPOT (2005), Geoeye (2010), AutoCAD shape file of the study area master plan and population data were used. For the sake of accuracy, Geoeye (2010) was georeferenced using the GCP (Ground Control Point) in GPS (Global Position System) receiver taking points of road cross, river cross and prominent

feature. Due to rapid change of the area, Geoeye (2010) image was used to rectify Spot (2005) image using image to image georeferencing techniques. Landsat TM was also georeferenced and finally clipped with the existing shape file of the study area. Different land use categories were digitized from the satellite imageries followed by building the topology to minimize errors during digitizing and to ensure that the entire polygons are closed. In the process of screen digitizing some features in the imageries did not properly identified. To solve this problem the researcher used the image interpretation techniques of patterns, tones, textures, shapes, and site associations to derive information about Lulc.

Table 3.1 Primary and Secondary Data source

Data/material	Source
Landsat TM 1986	-AAU GIS laboratory
SPOT 2005	-OUPI
Geoeye1 Dec 2010	-Corporate GIS & Image processing centre (3C) Plc.(purchase)
Demographic data	-Central Statistics Agency
Administrative boundaries	-Dukem Town Administration
Master plan of the town	-Dukem Town Administration
Meteorological data	-National Meteorological Agency
Urban planning Implementation Manual	-Regional urban planning Institute

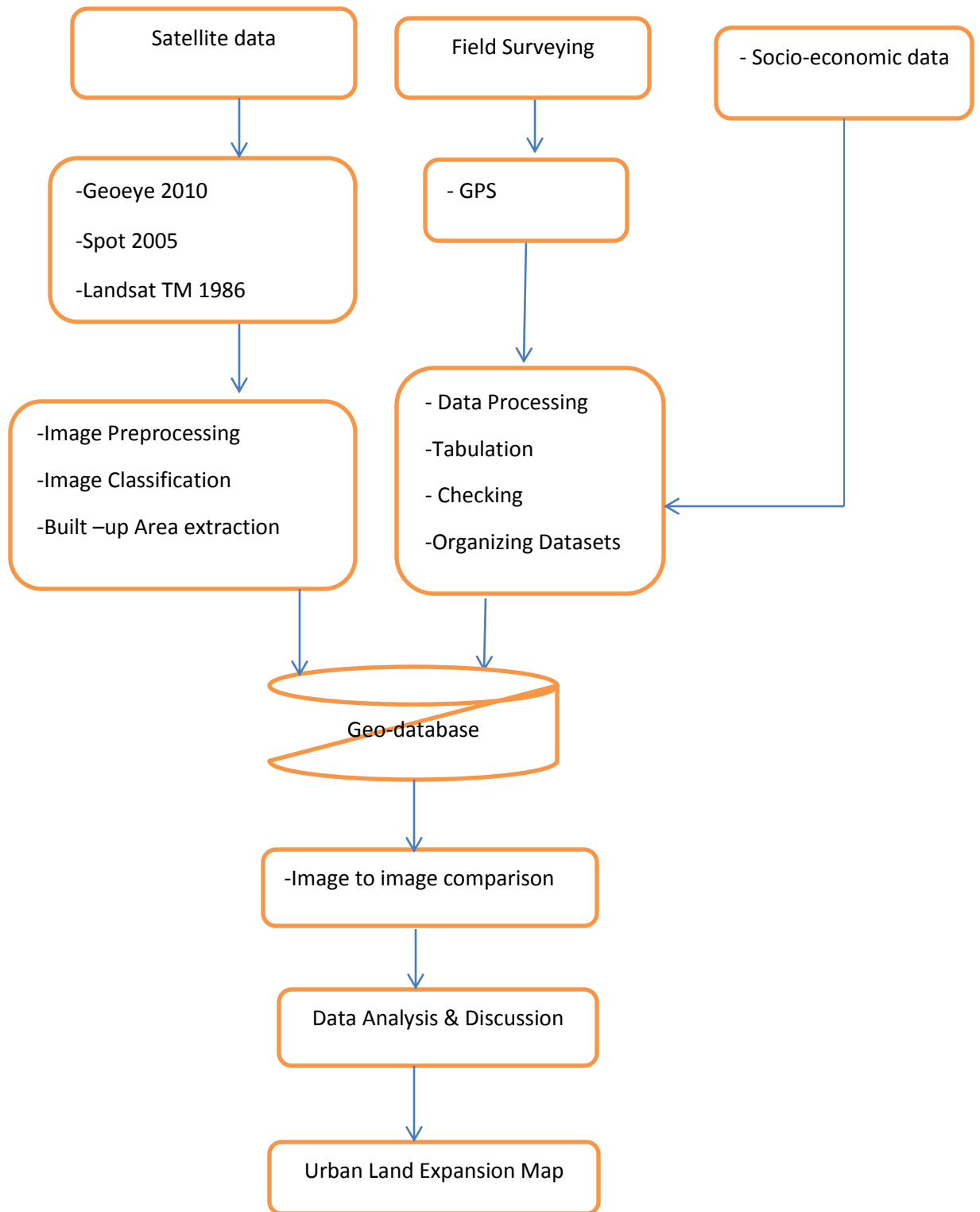


Figure 3.2 Flow chart of the Methodology

4 RESULTS AND DISCUSSION

4.1 ASSESSMENT OF BUILT UP AREA EXPANSION OF DUKEM TOWN

Dukem is rapidly expanding since its delineation to industrial zone. In this study, an attempt has been made to compute the built up expansion of the town from 1986 to 2010. To quantify the magnitude of urban area expansion toposheet and Satellite images were used.

4.1.1 MAGNITUDE OF BUILT UP AREA (1986-2010)

Only the built up area digitized from the toposheet 1986 to quantify its magnitude. The digitized layer was edited to remove any errors and subjected to topology creation in order to create boundary relationships between different built-up areas followed by area calculation for each built up land (Figure 4.1). Built up area of the town in 1986 was calculated to be 43 hectare (0.43km^2) which is 1.2% of the total area of the town i.e. 3596ha (Table 4.1). The magnitude of built up land for 2005 was extracted on SPOT(2005) (figure 4.1). Built up area of the town in 2005 was calculated as 505.3 hectare which is 14.1% of the total area of town i.e. 3596 hectare (Table 4.1). To quantify the built up area (2010) of the town Geoeye (2010) image was used (figure 4.1). The built up area of the town in 2010 was calculated as 1095.44 hectare which is 30.5% of the total area of the town i.e. 3596 hectare (Table 4.1).

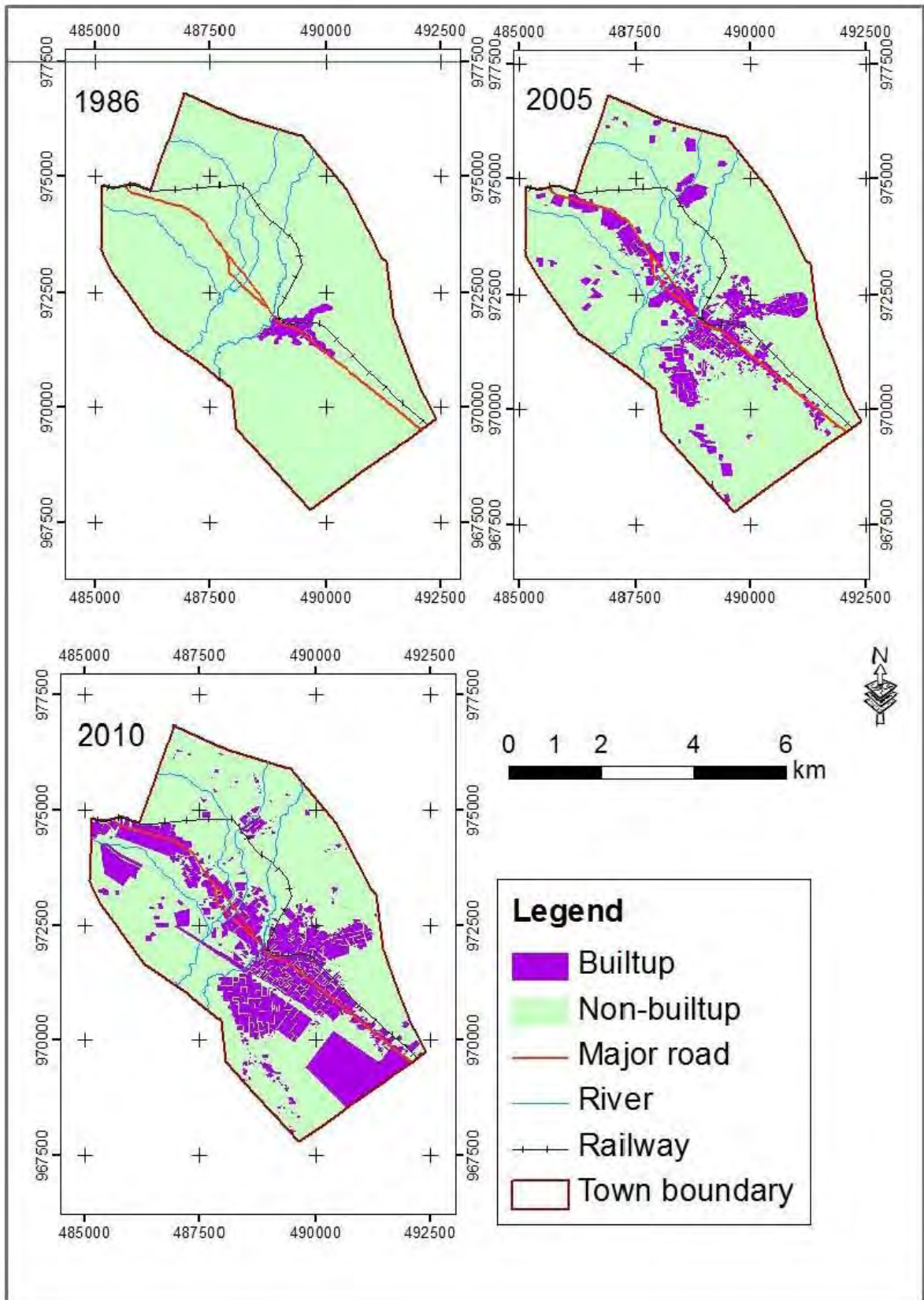


Figure 4.1 Built up and non-built up area (1986, 2005 and 2010)

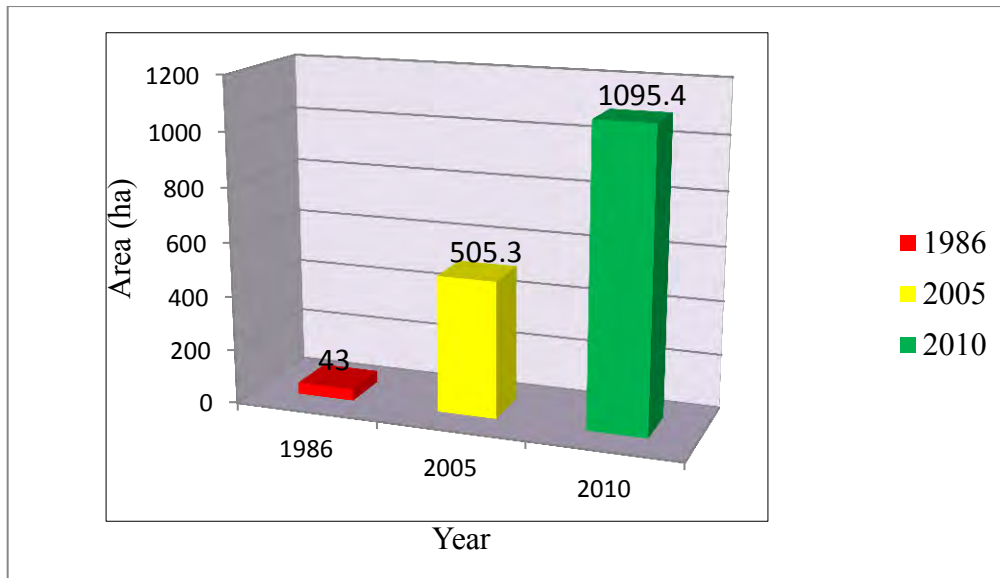


Figure 4.2 Built up area (1986, 2005 and 2010)

4.1.2 MAGNITUDE OF BUILT UP AREA EXPANSION (1986-2010)

The built-up area in a span of 19 years between 1986 and 2005 were compared to find the changes (figure4.3). The built up area expansion of the town between 1986 and 2005 was 462.3 hectare which is 1075% expansion (Table 4.1). The output between 2005 and 2010 were compared to find the changes in the built-up area (figure4.3). The built up area expansion of the town between 2005 and 2010 was 590.14 hectare which is nearly 116.8% expansion (Table 4.1).

Table 4.1 Built-up Area Expansion (1986-2010)

NO.	YEAR	BUILT UP AREA(ha)	EXPANSION(ha)	EXPANSION%
1	1986	43	-	
2	2005	505.3	462.3	1075
3	2010	1095.4	590.14	116.8

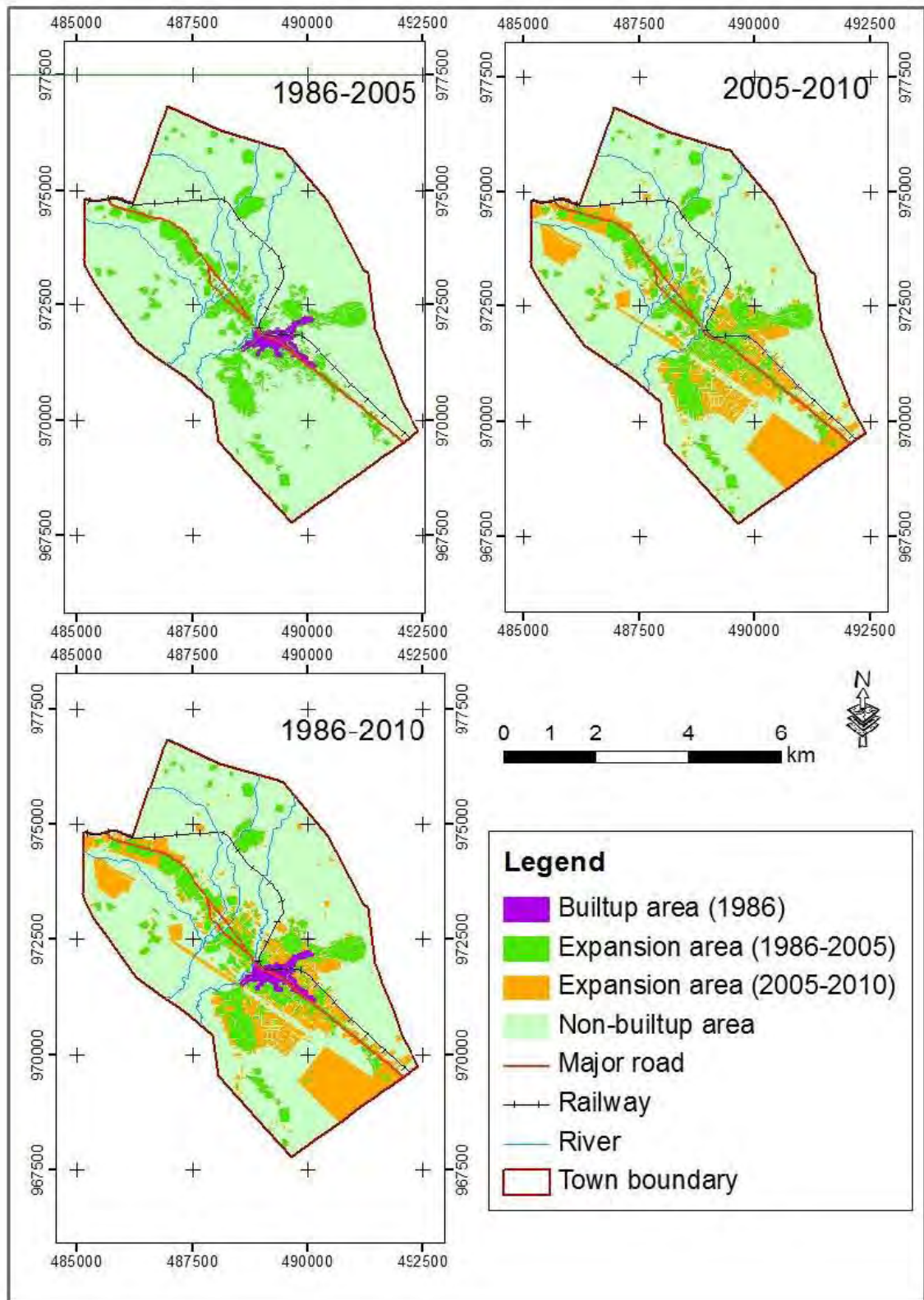


Figure 4.3 Built up area expansion (1986 -2010)

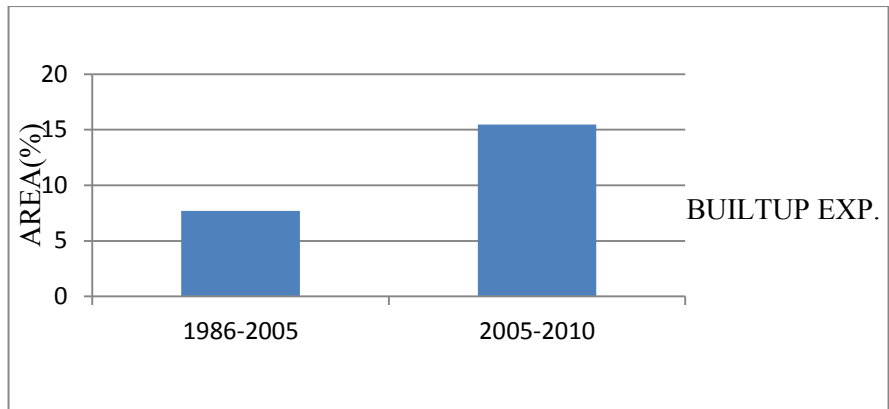


Figure 4.4 Built up area expansion (1986 -2010)

4.1.3 ESTIMATION OF BUILT UP AREA FOR 2020

Based on the urban expansion of town for the last 24 years the average growth rate of the expansion has been calculated .The average growth rate of the expansion is calculated as 9.1%.

The Urban expansion of the town is estimated for 2020 by using the exponential growth formula:

$$A_f = A_b * (1 + \%/100)^{(f-b)}$$

Where: A is the Built up area,

f is the future year,

b is the base year and

% is the average growth rate per year cited in (Sied, 2007). There for the urban expansion of the town is estimated as 2617.09 Hectare in the coming 2020 it is increased by 1521.7 hectare from 2010 which means 138.9 % expansion. To see the trends of the expansion from 1986- 2020 it is presented as line graph in the figure: 4.5 below.

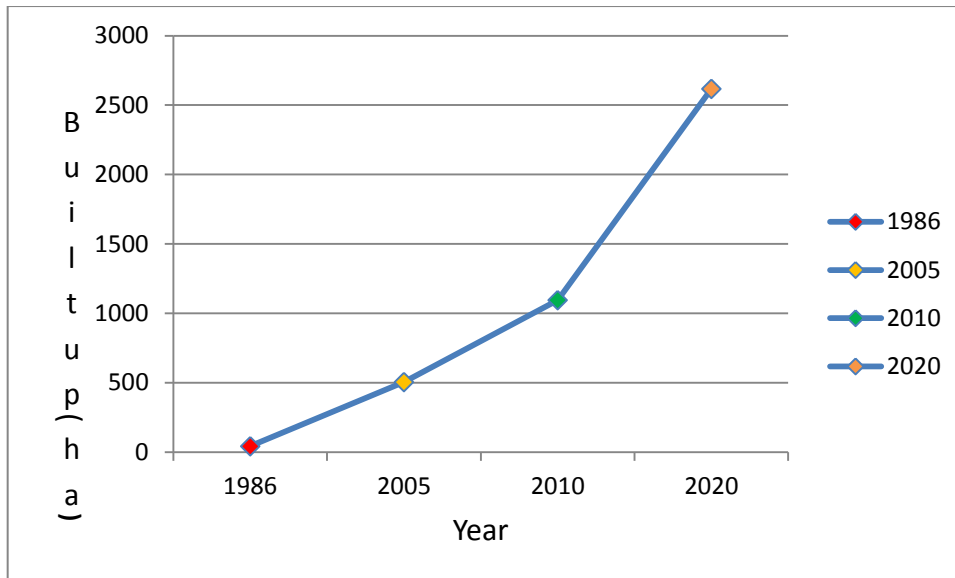


Figure 4.5 Urban expansion estimation for 2020

4.2 ASSESSMENT OF ROAD NETWORK EXPANSION OF DUKEM TOWN

4.2.1 MAGNITUDE OF ROAD NETWORK (1986 – 2010)

To quantify the road network 1986, Landsat TM (1986) was digitized and then followed by building topology to clear errors during digitization and to ensure that all the roads are linked at the intersection point and the road network of 2005 was extracted from SPOT 2005 (Figure: 4.5).

The road length of 1986 and 2005 were found to be 16 km and 45 km respectively (Table4.4).

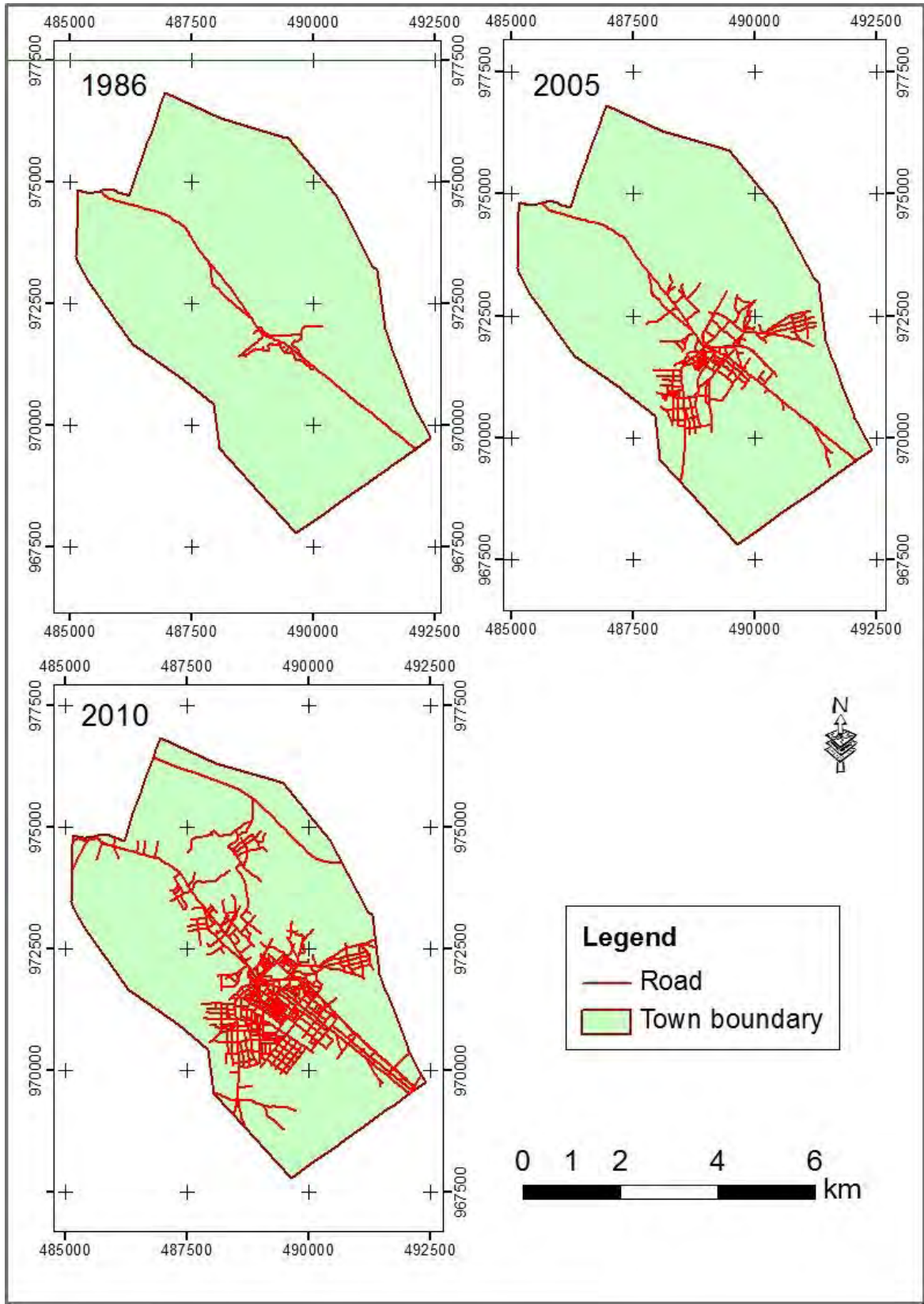


Figure 4.6 Road network (1986 -2010)

4.2.2 ROAD NETWORK (2010)

The 2010 road network is dominantly grid superimposed by radial major roads. Major roads that are coming from Addis Ababa, Adama and Adjacent Woreda directions are inter connected at the centre of the town and form radial structure. These roads especially Addis Ababa to Adama highway have intensive traffic loads. The other collector and access roads have grid form. The radial roads have regional and intra-town connection, whereas the grid system has intra-town connection. The general structure of the road creates fair connectivity and accessibility among different land uses. However, the connectivity varies across the centre and periphery. The 2010 road network in the town varies in width from six meter width to 30 meter and most of the roads have no good accessibility in terms of connectivity, integrity, narrowness, etc. The road does not encourage pedestrian because it does not have pedestrian walk ways. The road interaction and their patterns are relatively grid type and have not such good interaction between arterial, collector roads and local roads. Also there is a problem of immediate access because of long blocks.

4.2.2.1 ROAD HIERARCHY

Roads based on their width classified into different hierarchy. The hierarchical classification of the 2010 road network of the town is arterial, collector and local (figure 4.6). The high way that passes through the town is serving as arterial road. Express way covers a total length of 4.57km as well as arterial; collector and local roads constitute 15km, 22.7km and 79.84km respectively (Table4.2).

Table 4.2 Road Hierarchy

S. No	Hierarchy of road	Width(m)	Length in km
1	Express way	40-80	4.57
2	Arterial	30	15.00
3	Collector	15,20	22.70
4	Local	7-12	79.84
5	Footpath	<7	13.30
	Total		135.41

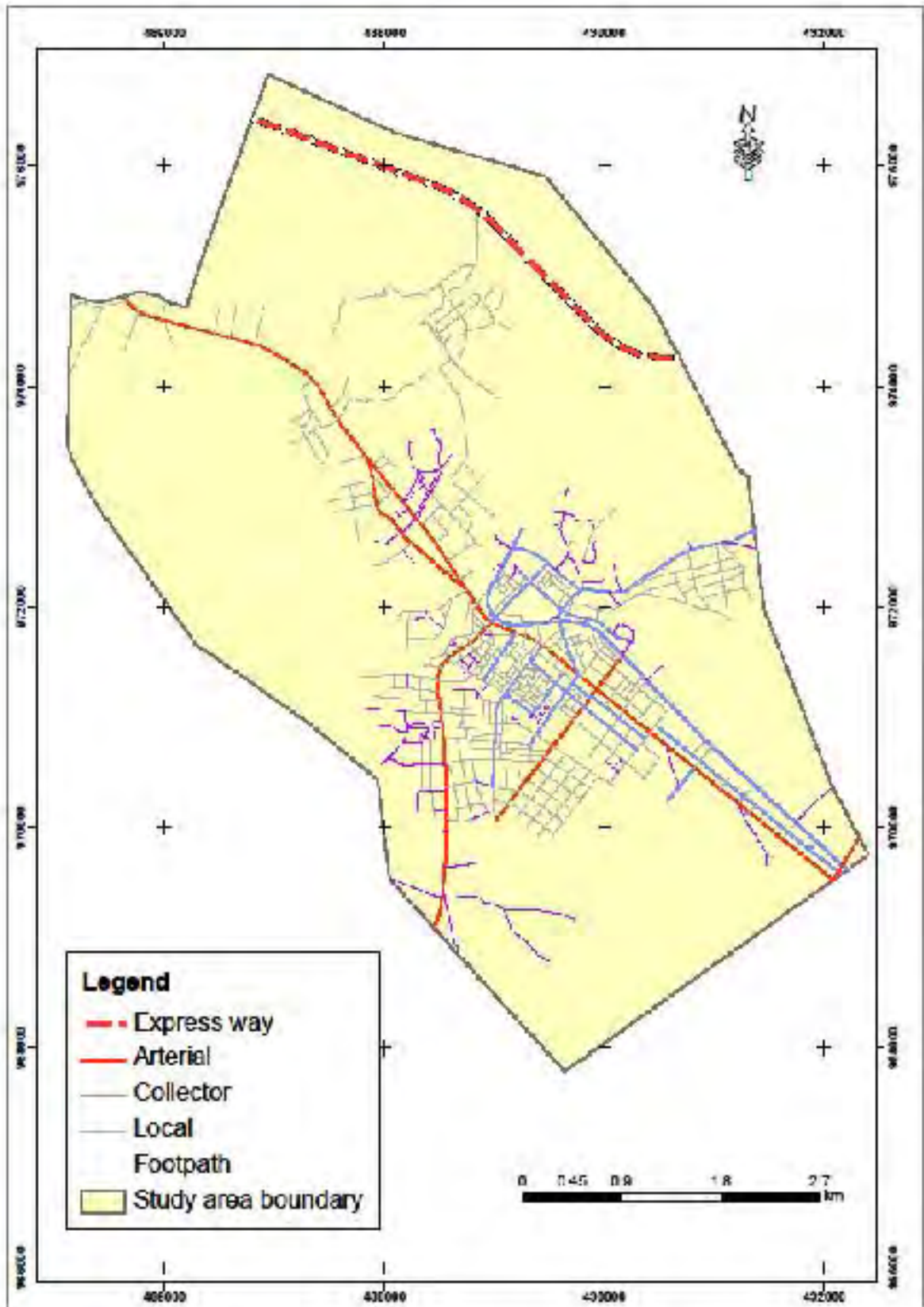


Figure 4.7 Road Hierarchy (2010)

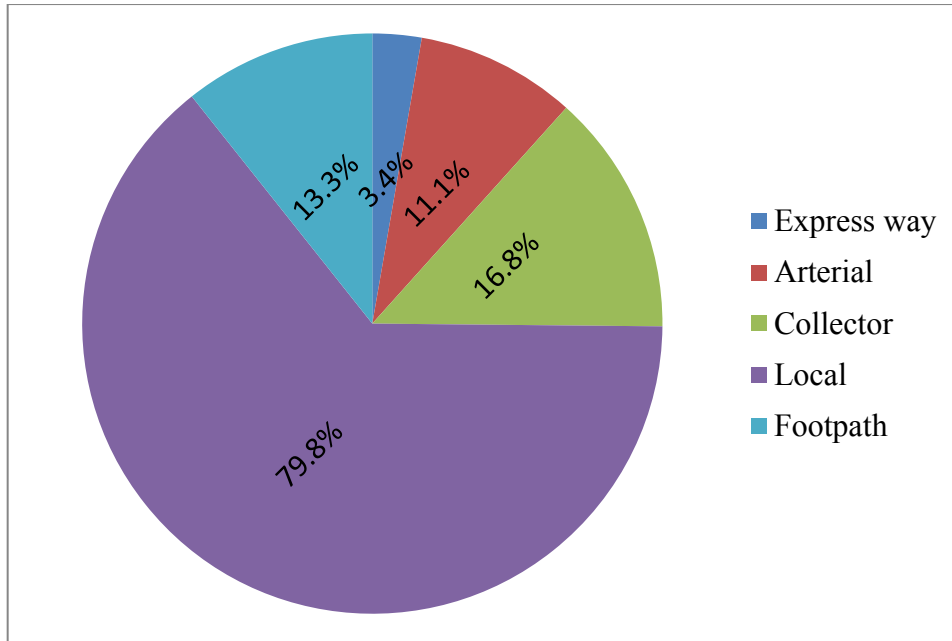


Figure 4.8 Road Hierarchy (2010)

4.2.2.2 ROAD SURFACE

The road surface of the town varies with hierarchy, farness from the centre and intensity. The road surface categorized as asphalted, paved, gravelled and earthen (figure 4.8). The earthen road surface covers about 38.8% of the total road length in 2010, however, the gravelled, paved and asphalt road constitute 52.5%, 0.98% and 7.66% in length respectively (Table 4.3). Especially, the earthen surface needs greater attention because during the summer season most of these roads are inaccessible due to the nature of soil.

Table 4.3 Road Surface

S. No	Road surface	Length (km)	Percentage
1	Asphalted	10.02	7.66
2	Paved(Coble)	1.29	0.98
3	Gravel	68.71	52.5
4	Earthen	50.82	38.84
5	Under construction	4.57	3.3
	Total	135.41	100

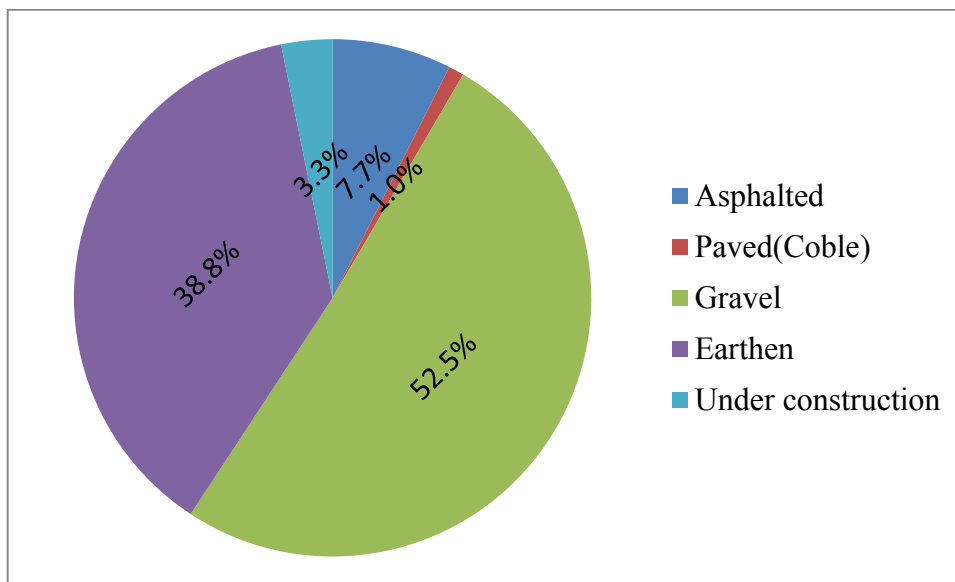


Figure 4.9 Road Surface (2010)

Road network 2010 was extracted from Geoye(2010) by digitizing, editing and topology creation (Figure: 4.5).After digitizing road network 2010, road length was calculated using ArcGIS 10.0 and its length found to be 135.41 km(Table 4.4).

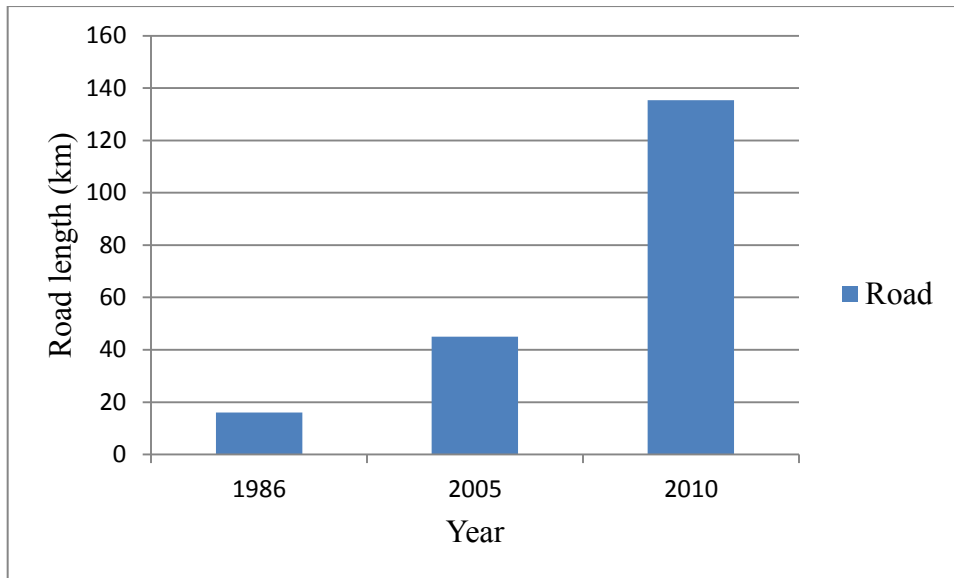


Figure 4.10 Road lengths (1986-2010)

4.2.3 MAGNITUDE OF ROAD NETWORK EXPANSION (1986 – 2010)

The road length 1986 and 2005 were found to be 16 km and 45 km respectively, that is, the road length was increased by 29 km (Table 4.4). The two roads were superimposed one over another and new roads appeared on 2005 image was marked as road expansion (Figure4.10). Figure: 4.10 show the road expansion of the year 2010 as compared to that of 2005 and the road length of 2010 was found to be 135.41 km, that is, the road length was increased by 90.41 km (330%) from road 2005(Table 4.4). Generally, the length of the road network increase by 846.3% between 1986 and 2010.

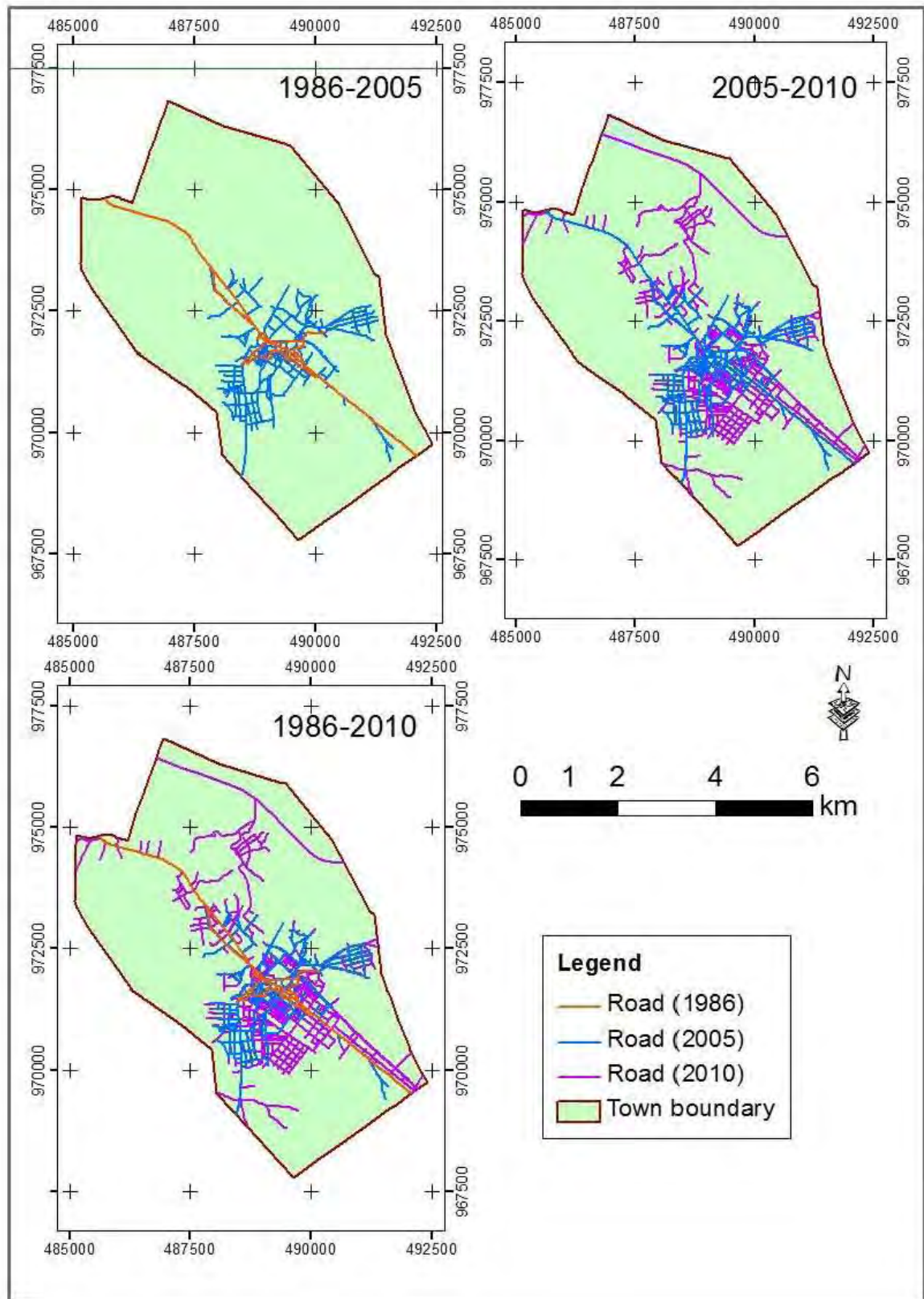


Figure 4.5 Road network expansions (1986-2010)

Table 4.4 Road network (1986-2010)

NO.	YEAR	ROAD IN LENGTH	EXPANSION	EXPANSION%
1	1986	16 kilometre		
2	2005	45 kilometre	29 kilometre	181.3
3	2010	135.41 kilometre	90.41 kilometre	300

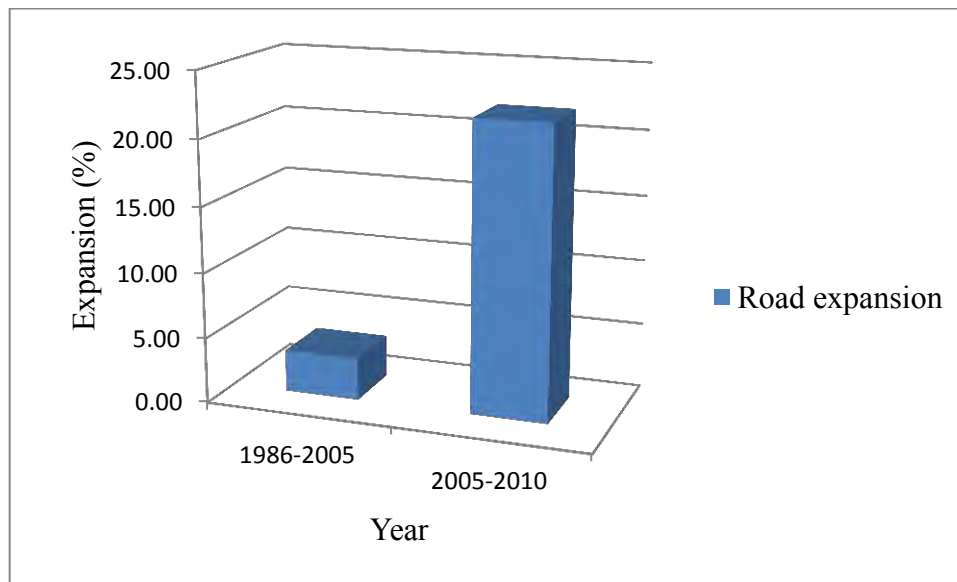


Figure 4.6 Road expansions in Length

4.3 POPULATION GROWTH (1986-2010)

Population growth of Dukem town was fairly slow before five years ago. But as the establishment of different level manufacturing and storages started, neighbouring countryside and other urban area people migrate to the town and population growth began to increase rapidly. In 1986 the population of the town was estimated to be 3736. This figure reached about 2959 in 1979. The results of the 1984 census revealed that the population of the town reached to 3495, while the 1994 census counted a total population of 4876. This would mean that the population of the town grew by 1382 between the two census periods. The 2007 CSA data revealed that the

total population of the town had reached 24024. The trends generally indicate the persistence of high population growth of the town, which is likely to continue given the prevailing rate of growth (Abduletif, 2011). By taking data for the projection from the census directly and assuming that the growth rate should be constant throughout the projection period the following information obtained using exponential growth method.

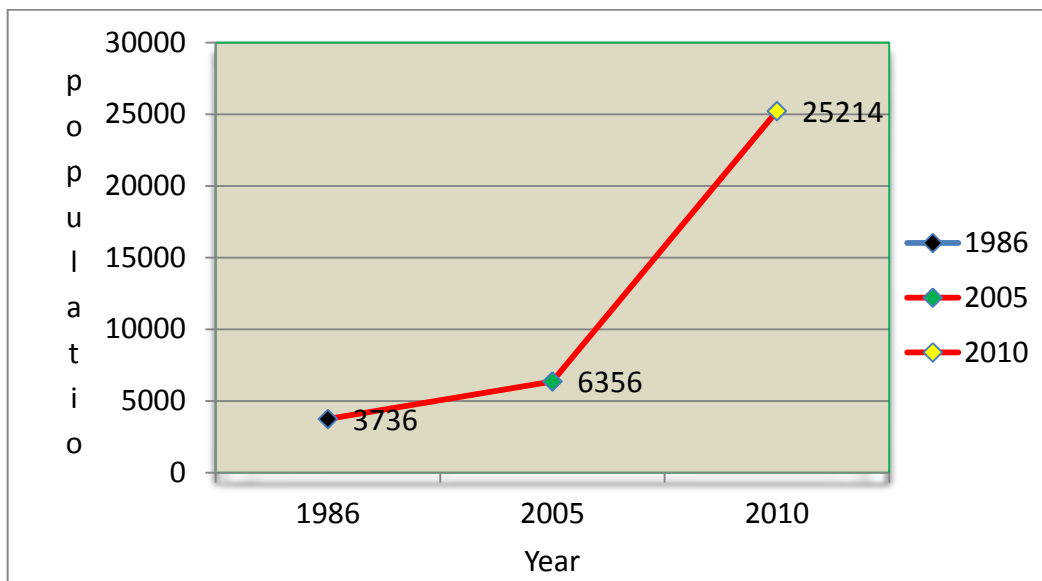


Figure 4.13 Populations, 1986- 2010

4.4 COMPARISON OF URBAN EXPANSION AND POPULATION GROWTH

The population dynamics are the factors that make the population of certain area to change over time. These factors are fertility, mortality and migration. It is obvious that population growth has a direct impact on urban expansion. In this case when the population of the town in 1986 was 3736, the built up area of the town was 43 hectare. The population was increased to 6356 in 2005 likewise the built up was expanded to 505.3 hectare. In 2010 the population became 25214 and the built up was expand to 1095.44 hectare. From 1986-2005, the population of the town was increased by 2620 i.e. 70.13% and 2005-2010 it was projected to 8858 i.e. 275.2%. The built up

area of the town was increased by 462.3ha i.e. 1075% from 1986-2005 and it was expanded to 590.14ha i.e. 116.8% from 2005-2010(Table 4.5).

Year	Built-up(ha)	Population	Built-up Growth (%)	Population Growth (%)
1986	43	3736		
2005	505.3	6356	1075	162.32
2010	1095.44	25214	116.8	296.7

Table 4.5 Built-up Area and Population Growth (1986-2010)

4.5 DRIVING FACTORS OF 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).

Urban expansion and subsequent landscape changes are governed by geographical and socio-economic factors, such as population growth, policy, and economic development. In most cases, urban expansion and associated land use/cover changes resulted from a combination of these factors. For example, socioeconomic policy can strongly affect urban expansion, and under the changes driven by urban expansion, the land use patterns of the urban outskirts are altered or adjusted in pursuit of high economic returns.

Dukem found in Oromia Regional state. Since the headquarters of the Oromia Regional state is found in Addis Ababa there is a direct administrative linkage between the town and Addis Ababa city. On the other hand since many industries are on the process of establishment and numerous constructional activities are taking place, in search job high number of population are migrating

from different part of the country to the town. There are various and interrelated factors responsible for the expansion of Dukem town. Among them rapid population growth is the major. It is known that demography and economies are the two driving factors for urban expansion. Demands for space by humans are the original force for urban expansion. However, urban expansion may not happen without economic supports. High economic growth may also promote the demands. According to OUPI team report the location opportunities that contribute for the growth of Dukem town includes:

- Proximity to Addis Ababa
- Transport facility and the highway to Southern and eastern part of the country pass through Dukem town
- Surrounded by Agricultural productive weredas.
- Poor policy implementation which results in squatter settlements

Constructions of houses require land. The methods of urban land acquisition have its own impact on horizontal expansion of the town towards the periphery. Reclassification of land from rural to urban area have significant role in the population growth and expansion of the town .For example recently a number of farming villages and farm land surrounding the town has been reclassified in to urban area and put under the administration of the town.

4.6 DIRECTION OF URBAN EXPANSION

Using satellite images of 2005 and 2010 it was possible to identify the direction of urban expansion in Dukem town. It was established on a flat land, especially around the Railway station. The original expansion directions were dictated by the existence of the railway line, specifically the rail way station and the main high ways crossing the area. The Addis Ababa - Adama road is the most influential one. In addition to this infrastructure influence, the

development of different services has also important contribution in the overall growth directions of the town. The general expansion depicts that there are all round growth around the high way station to the main traffic axis and the south. The furthest built up area in 1986 was towards following the main road and rail way and in 2005 south and south western: the main possible reason could be the flat topography that attracts residence since flat area created conducive condition for construction purpose and facilitates easy movement. Currently built-up area increased in all direction but it was more pronounced along the major roads, south and south-western part of the town.

4.7 LAND USE CLASSIFICATION OF DUKEM TOWN (2005-2010)

To delineate urban land use classes of the town SPOT (2005), Geoeye (2010) and master plan (2000 and 2008) of the town were used. Based on the master plan of the town all land use classes were extracted from satellite images. Hence the town was classified in to different land use classes. Finally, different Lulc and the sizes of these categories were calculated and depicted (Figure 4.15).

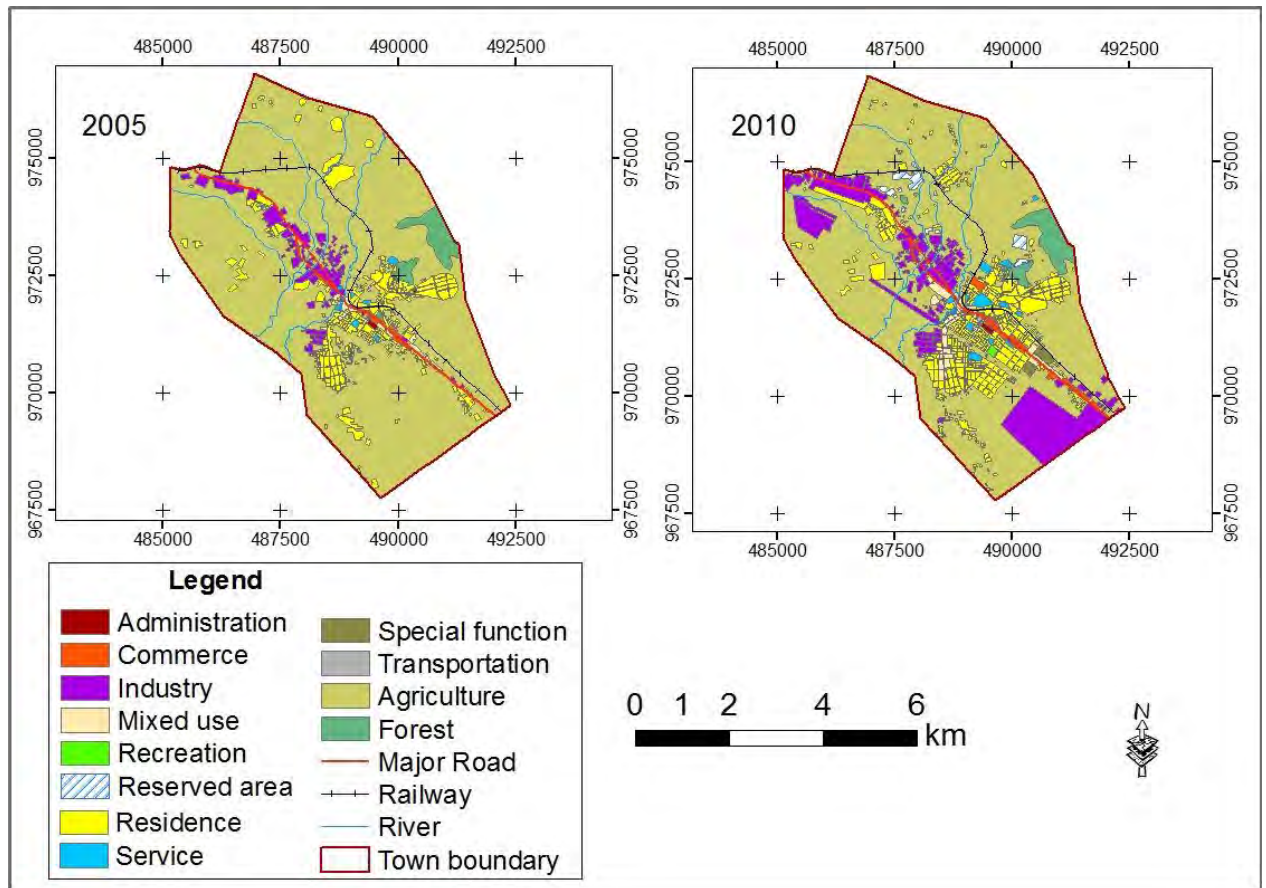


Figure 4.7 Land Use land cover (2005 and 2010)

4.7.1 RESIDENCE

The residential area in the town ranged from a densely populated in the center of the town, which is next to the commerce from the arterial roads and back to the main activity areas. These areas are dense as there is mixed use of lands for residence and commercial activities. The informal settlements observed in the town are few relative to other towns in the country; though there is a high demand of land to construct houses. Most of the residential units that are located at the centre are old and deteriorating. Residential area was increased from 308.4 ha to 415.3ha between 2005 and 2010 which covers about 11.5% of the total area of the town (Table 4.6).

4.7.2 ADMINISTRATION

The administrative institutions were located at the center of the town. The kebele offices were however, scattered. It constitutes about 3.1 and 3.6 hectares respectively between 2005 and 2010 with no significant increments in area (Table 4.6).

4.7.3 COMMERCE

Most of shops, hotels, restaurants, and commercial activities in general are concentrated at the central part of the town and along the main axes. The general market of the town is found at the back of Oda Nabe high school. It is accessible from any part of the town. It has reasonable size compared to the commercial activities under taken at the site. There are no shops along the sides of the general market. This has affected the people selling different products and wants to buy consumer goods within a short distance. So, there should be sound free commercial shops in different parts of the general market to minimize the risk of movement of people in search of different products. Commercial activities constitute about 14.5 hectares and 31.1 hectares of land respectively within span of five year with an increment of two fold between 2005 and 2010 (Table 4.6).

4.7.4 SERVICE

This land-use activity includes educational, health, civic and cultural, social welfare, utility, municipal services and etc. The central area is better served and has good accessibility to the available social services and facilities. There is somehow, inequitable distribution of educational facilities on the northern and north western part of the town; however, in the south western part of the town there is fairly distribution of service.

Health institutions are one of the fundamental social services for the society. As Dukam is a town located in close proximity to the capital city of the country neighbored with other growing

towns, there are few health institutions in the area. This is because the local people get the required health services from the capital and neighboring towns. In general within the span of five year service land use categories were increased by 22.2ha.of the built up area of the town (Table 4.6).

4.7.5 INDUSTRIAL DEVELOPMENT IN THE TOWN

Industrial development is one and the primary elements of the economic development goals. In line with this, since sustainable live is also one part of the development goal; industrial development should be based on environmental friendly manner in order not to disturb the life of current residents as well as future generation.

The town is characterized by one of those towns with high concentration of industries which are found at Addis Ababa boundary (Burayu, Laga Xaafu-Laga Daadhi, Galan, Sululta, Sabbata, and Bishoftu) due to its high proximity to the national market. Currently, there are many types and stages of manufacturing activities in the town with other small scale industries. These land use projected to 437.7 hectare of land i.e. 35.15 percent in 2010 from that of 127.4 hectare of the built up area of the town in 2005.

Table 4.6 Comparisons between 2005 and 2010 land uses

S. No	Land Use Type	2005		2010	
		Area (ha)	Area (%)	Area (ha.)	Area (%)
1	Administration	3.1	0.1	3.6	0.1
2	Agriculture	3025.8	84.1	2466.7	68.6
3	Commerce	14.5	0.4	31.1	0.9
4	Forest	85.9	2.4	94.8	2.6
5	Industry	127.4	3.5	437.7	12.2
6	Mixed Use	19.8	0.6	60.5	1.7
7	Reserved	-	-	33.9	0.9
8	Recreation	-	-	4.6	0.1
9	Residence	308.4	8.6	415.3	11.5
10	Service	10.1	0.3	32.3	0.9

11	Special Function	-	-	14.7	0.4
12	Transport	1.0	0.0	0.8	0.0
	Total	3596	100	3596	100

Source: Based on master plan extracted from satellite images

4.7.6 RECREATION AND FORMAL GREENERY

There are few recreational areas in the town like: playground, open spaces in some part of the town. The playground is not in good condition and all of them occupy 4.57 hectare of land (Table 4.6). Agricultural land use decreased from 84.1% in 2005 to 68.6% in 2010 due to horizontal expansion while manufacturing and storage increased tremendously by 12.2%.

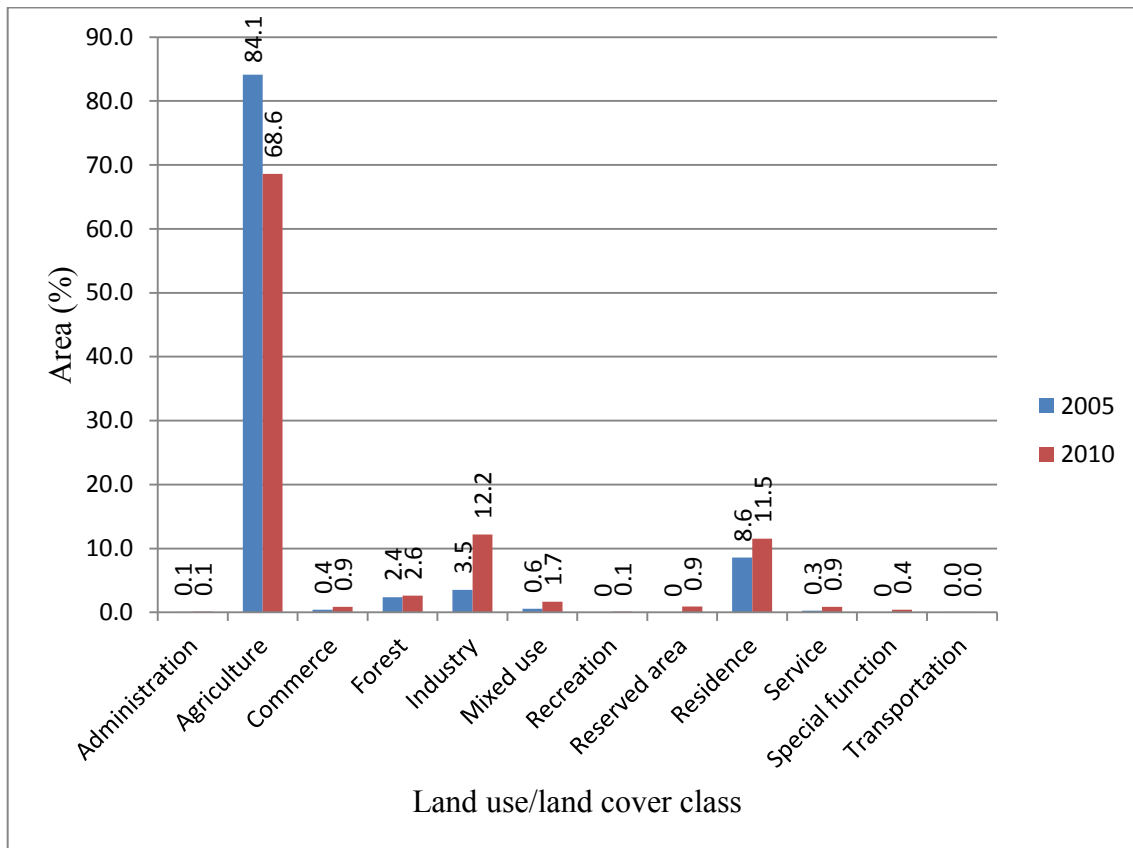


Figure 4.8 Urban Land use / Land cover of 2005 and 2010

4.7.7 AGRICULTURE

Urban agriculture is part of the urban ecological system and can play an important role in the urban environmental management system. Economically growing towns like Dukam can produce more and more organic wastes and wastewater that become a serious problem. Urban agriculture can help to solve such problems by turning wastes in to a productive resource if it is none toxic. Urban agriculture may also have positive impact up on the greening and cleaning of urban centers by turning deplete open spaces in to green zones and maintaining buffer and reserve zones free of housing with positive impacts on the micro climate (shade, temperature, sequestration of CO₂). Both farming and livestock rearing activities are under taken within the town and its peripheries not in normal forms of urban agriculture but in rural farm style with some good starting in animal rearing but not widely as expected with availability of market access. The current situation of urban agriculture is simply fragmented throughout the town without separation from other land use types. This by itself results the dispersion of their by-products and wastes throughout the town and polluting the neighbourhoods. Using Geospatial analysis tools agricultural land use changed into different categories depicted in table 4.7 below show a decline by 657.2 ha within a span of five year between 2005 and 2010. Generally, agricultural land use category in 2005 which was 3025.8ha changed into different land uses and covers a total of 2368.60 ha in 2010 including formal farming and nursery activities in some part of the town (Table4.7).

Table 4.7 Land use/land cover change from Agriculture to other classes

Land use/land cover change from Agriculture	Area (ha)	Area (%)
Agriculture to Commerce	14.20	0.47
Agriculture to Mixed use	14.75	0.49
Agriculture to Residence	204.79	6.77
Agriculture to Industry	337.37	11.15
Agriculture to Recreation	4.10	0.14
Agriculture to Service	18.93	0.63
Agriculture to Special function	14.10	0.47
Agriculture to Administration	0.54	0.02
Agriculture to Transport	0.05	0.00
Agriculture to Forest	15.31	0.51
Agriculture to Reserved area	32.97	1.09
Remained as Agriculture	2368.60	78.28
Total	3025.71	100.00

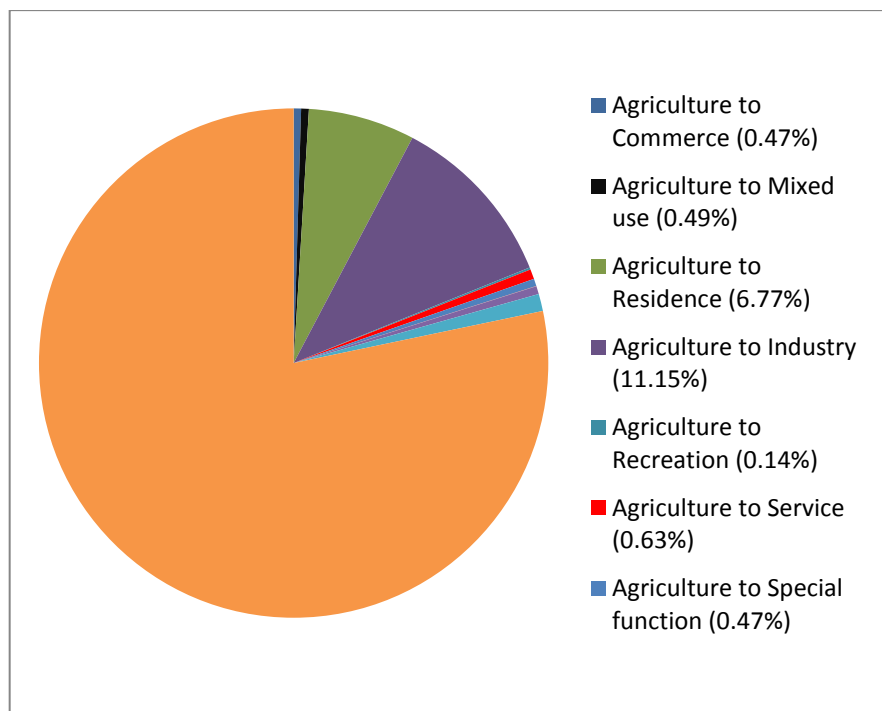


Figure 4.9 Land use change from Agriculture to other classes

The general urban land use of the town comprises different categories: residence, commerce, mixed, service, recreation and open spaces, agriculture and manufacturing and storage. The

nature of land use in location, which activities are taking place where, and the level of spatial accumulation, which indicates their intensity and concentration. Central areas have a high level of spatial accumulation and corresponding land uses, such as retail, while peripheral areas have lower levels of accumulation which is concentrated on residential, different services like education and religious institutions. The transport infrastructures are supporting urban movements of passengers and freight. It is known that due to horizontal expansion of the town fertile agricultural land changed into different land use classes. Among these, manufacturing and storage was taken the largest portion between 2005 and 2010, which accounts about 11.15 percent from the total share of agricultural land. Residence was next to industrial land use in portion of land use changed from agriculture use, which accounts about 6.77 percent. Service, mixed use and commerce, constituent about 0.63, 0.49 and 0.47 percent respectively from the total agricultural land use changed into different categories within the span of five year while the share of agricultural land decreased by 21.72 percent during this period(Table 4.7). The current situation of agriculture is simply fragmented throughout the town without separation from other incompatible land use types.

4.8 MAJOR INCOMPATIBLE LAND USES

4.8.1 ABATTOIR

The abattoir area has the capacity to attract more residences as it is surrounded by residences and not very far from the centre of the town and also found near to the Dukem River. Generally, land use conflict exists among the abattoir, river, health centre and the residential house as well as the abattoir has no enough space to dig more septic tanks for its waste disposal. The existing location of the abattoir may affect people with its pollutant gasses and the like. Because of these the abattoir should be relocated to other site which is compatible to adjacent land use.

4.8.2 MUSLIM CEMETERY

The existing Muslim cemetery is found adjacent to the general market. It is located comparatively in the central part of the town surrounded by industry in one side and neighbouring the general market on the other side. At the same time its land holding is small.

4.8.3 THE HIGH TENSION ELECTRIC LINE

High-tension electric lines pass through the town occupies the valuable land available in residential areas with station and buffer zone. It also has dangerous effect on human life. They can be protected from different activities or relocate to peripheral area to avoid potential danger for economic efficiency.

4.8.4 THE SOLID WASTE COLLECTION AREA

Solid waste collection site is located along Dukem river as well as adjacent to Oda Nabe high school also within residential and commerce areas where ever in the town. Waste is not collected in proper condition so that some of this waste enter to Dukem river and other wastes like plastic and light materials are dispersed to the nearby residential and other land use areas. Besides, the municipality does not properly make secondary collection site for disposal. Generally, the waste causes health hazards and environmental pollution, which reduces the aesthetic value of the area.

4.8.5 TRANSPORTATION FACILITY

The existing bus station has incompatibility because it creates traffic congestion as it is located along Addis Ababa to Adama road. Therefore, the bus station of the town should be relocated to another place so as to minimize traffic congestion along the main road and to get the utmost use of the land value of the existing bus station. In connection with traffic flow of the town; the problem of road narrowness should be explained. Because of large flow of vehicles crossing the town, there is serious road congestion in the town. This is true especially during the day time

when the town accommodates large number of vehicles. On certain cultural holidays like Irreechaa of Bishoftu, the numbers of vehicles passing through the town are larger than those vehicles which pass through the town on working days. There is no freight terminal in the town and many heavy trucks line up along the highway. This has created serious traffic congestion in the town. This can also attribute to traffic accident in the town. The town being crossed by the Djibouti-Addis Ababa high way has contributed a lot for traffic congestion in the town. Heavy trucks from Djibouti, the eastern and southern parts of Ethiopia cross the town and this necessitated the road to be widened up to the standard. Therefore, it is necessary to establish freight terminal in an industrial location to facilitate loading and unloading of different products from the industries of the town. It is also important to think of selected parking sites for vehicles outside the freight terminal or bus station. This minimizes traffic congestion and also accident. Additionally it is also necessary to design alternative roads that cross the town and relieve the traffic congestion along the highway. There should also be road connection from the town to the high speed motor way whose plan touches the town in the eastern part. Figure 4.18 shows major Incompatible land use of Dukem town.

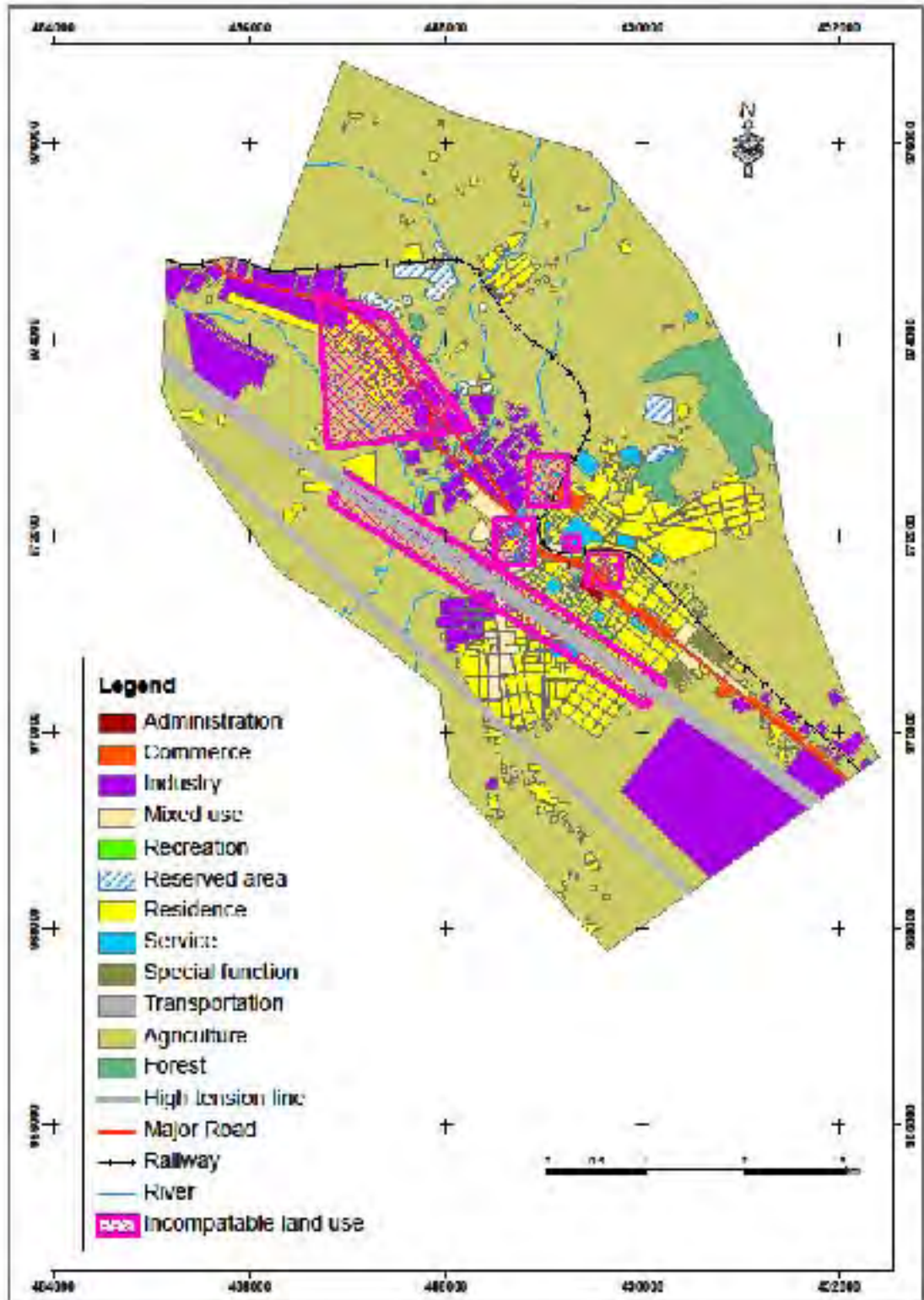


Figure 4.10 Incompatible Land Use, 2010

5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Dukem is one of the urban centers in Oromia special zone, which is known with relatively rapid urbanization process. This rapid urbanization and high population pressure coupled with limited capacity of the town created challenge for both the resident and town administration to provide basic services and facilities. Pertaining to the objectives of the study, the following major conclusions were made:

- The study clearly indicated that in most periphery of Dukem town there is a dynamic change of the agriculture land into settlements i.e. rural to urban.
- Agriculture land was decreased by 559.11ha whereas road and built up area were increased by 90.41km, and 590.14 ha respectively between 2005 and 2010.
- The built-up area between 1986- 2005 was increased by 462.3ha and it was tremendously expanded by 590.14ha between 2005 and 2010.
- Commercial area increased in the central part of the town, along the roads. These areas are in very high land value zone that is why commercial area replaced residential area.
- The road network of the town from 1986-2010 was increased by 119.41km.
- Residence and industrial land uses were increased by 106.9ha and 310ha between 2005 and 2010 respectively
- The population of the town was increased by 162.3% between 1986 and 2005 within five year from 2005- 2010 it was projected to 296.7%.
- Built-up area increased in all direction but it was more pronounced along the major roads, south and south western part of the town

- The existence of incompatible land uses which did not consider prevailing wind direction like abattoir, health centre, river and waste disposal site.
- Inappropriate land use change has resulted in negative consequences on the environment of the study area. These are large plot of land are occupied informal 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.

5.2 RECOMMENDATIONS

The researcher would like to suggest the following recommendations to mitigate the problems mentioned above based on the findings obtained from the study in case of Dukem town.

- The town is expanding from year to year because of various reasons .Hence the expanding areas are suffering from in adequate urban infrastructure and the burden of the provision of these urban infrastructure falls on the municipality. It is recommended that the municipality should form partnership between sectors to alleviate the problem
- Implementing GIS and remote sensing technique in monitoring and managing urban land use change and its proper implementation. Use of high resolution data for planning and urban information generation
- Lastly, although urban expansion cannot be restricted but with proper management and planning, we can restrict and direct this expansion in desired and sustainable way, protecting the fertile agriculture land. Multi-storey residential complexes should be promoted so that only this will occupy area but proper services and infrastructure can also be provided at lesser investment

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APPENDICES

Appendix I Computing Percentage of the Population

$$= \left[\frac{Pt - Po}{Po} \right] \times 100$$

Where Pt- Total population in the current year

Po- Total population in the previous year

2. The growth rate of population

$$r = \left[\frac{Pt+n}{Po} \right]^{1/n} - 1 * 100$$

Where: r - Rate of population growth

Pt- The recent population in X year

Po - The previous population in Y year

n - Range of year between X and Y years

3. Counted and Projected Population of Dukem 01 and three kebeles

Counted and Projected Population of Dukem Town and three kebeles			
kebeles			
1. Population 1984-1993	Male	Female	Total
1984	1592	1903	3495
1985	1646	1967	3613
1986	1702	2034	3736
1987	1759	2103	3862
1988	1819	2174	3993
1989	1880	2248	4128
1990	1944	2324	4268
1991	2010	2403	4412
1992	2078	2484	4562
1993	2148	2568	4716
2. Population 1994-2006			

1994	2506	2370	4876
1995	2567	2428	4995
1996	2630	2487	5117
1997	2694	2548	5242
1998	2760	2610	5369
1999	2827	2674	5500
2000	2896	2739	5635
2001	2966	2806	5772
2002	3039	2874	5913
2003	3113	2944	6057
2004	3189	3016	6205
2005	3267	3089	6356
2006	3346	3165	6511
3. Population of Dukem including three Kebeles 2007-2011			
2007	12185	11839	24024
2008	12488	12308	23794
2009	12855	12670	24494
2010	13234	13043	25214
2011	13623	13427	25956
Population of rural Kebeles 2007-2011			
a. Tedecha Yatu			
2007	2726	2591	5317
2008	2764	2724	4486
2009	2845	2804	4618
2010	2929	2887	4753
2011	3015	2972	4893
b. Wajituna Debandebe			
2007	3792	3629	7421
2008	3858	3802	7659
2009	3971	3914	7885
2010	4088	4029	8117
2011	4208	4147	8356
c. Gogecha			
2007	2308	2308	4616
2008	2399	2365	4764
2009	2470	2434	4904
2010	2543	2506	5049
2011	2618	2580	5197

Note:-

METHOD: EXPONENTIAL GROWTH METHOD

ASSUMPTIONS:

1. The data for the projection should be obtained from the census directly.
2. The growth rate should be constant throughout the projection period.

DECLARATION

I hereby declare that the dissertation entitled “**Assessment of Urban Expansion in the Case of Dukem Town using Remote Sensing and GIS Techniques**” has been carried out by me under the supervision of Dr. K. V. Suryabhagavan, Department of Earth Sciences, Addis Ababa University, Addis Ababa during the year 2011-2012 as a part of Master of Science programme in Geo-information Science. I further declare that this work has not been submitted to any other University or Institution for the award of any degree or diploma.

Abebe Ambaye

Signature _____

Place: Addis Ababa

Date: March 2012

CERTIFICATE

This is certified that the dissertation entitled “**Assessment of Urban Expansion in the Case of Dukem Town using Remote Sensing and GIS Techniques**” is a bonafied work carried out by Abebe Ambaye under my guidance and supervision. This is the actual work done by Abebe Ambaye for the partial fulfilment of the award of the Degree of Master of Science in Geo-information Science from Addis Ababa University. Addis Ababa.

Dr. K. V. Suryabhagavan

Assistant Professor

Signature _____

Department of Earth Sciences

Addis Ababa University

Addis Ababa