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Assessing the impacts of urbanization on agricultural land using Remote Sensing and GIS techniques: The case of Adet town, Ethiopia

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of Addis Ababa University in Partial Fulfillment of Degree of Masters of
Science in Geodesy and Geomatics**

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Declaration

I declare that this thesis which I submitted to the school of Civil and Environmental Engineering of Addis Ababa University Institute of Technology in partial fulfillment of Degree of Masters of Science in Geodesy and Geomatics is my own work.

The thesis has not been submitted previously to qualify for any academic award .I was cared for the academic rights of others in the processes of thesis work.

Yechale Mulu

June 2023

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List of Abbreviations

CSA	Central Statics Agency
ERDAS	Earth Resources Data Analysis System
ETM+	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization
GPS	Ground Control Points
GIS	Geographic Information System
GPS	Global Positioning System
LULC	Land use land cover Change
MLC	Maximum Likelihood Classifier
RS	Remote Sensing
TM	Thematic Mapper
UTM	Universal Transverse Mercator
GTP	Growth and Transformation Plan
Ha	Hectare
MUDHCo	Ministry of Urban Development Housing and Construction

Abstract

Urbanization was one of the main problems that threaten the limited highly fertile and very productive agricultural land in the periphery of Adet town for residential construction and its related infrastructure. The general objective was to assess the impacts of urbanization on agricultural land using remote sensing and GIS techniques and within it classified the land use land cover dynamics during the time periods of 2000, 2010 and 2020, mapped horizontal expansion of urban boundary and analyzed its effect on the surrounding agricultural land and identified the major trigger factors for horizontal expansion. By using Landsat satellite images generated change detection analysis and mapped horizontal expansions in this particular study. Additionally conducted interviews and identified the trigger socio-economic contributing factors of horizontal expansion. The supervised classification algorithm and Anderson (1976) land use/ land cover classification scheme were adopted and identified: agricultural land, built up area, vegetation and bare land. The result revealed that agricultural land coverage 66% in 2000, 64% in 2010 and 51% in 2020. The built up area coverage 29% in 2000, 27% in 2010 and 36% in 2020. The vegetation coverage increased 2% from 2000 to 2010, 5% from 2010 to 2020 and 8% from 2000 to 2020 and the bare land coverage 2% in 2000, 4% in 2010 and 5% in 2020. The factors that were responsible for horizontal expansion was increasing the demand for residential house of dwellers, growth and transformation plan (GTP), asphalt and gravel road construction, rural-urban migration, demographic dynamics, reclassification of the former rural settlement into new urban settlement, supporting housing policy and informal settlements. Generally urbanization was loss of agricultural land continuously. So, to prevent the loss of highly fertile and very productive agricultural land effective land use and land management strategies should be strongly encouraged. Furthermore, a sound policy at the local level is urgently needed. This study can be contributed to the government especially Adet town municipality and surroundings of Adet town, yilmana densa wereda, to ensure the developmental plans in certain areas other than highly fertile and very productive agriculture land and strengthen the zoning regulation and enact policies to reduce agriculture land losses and reclassification of the peripheral rural kebeles being as part of an administrative body to the town municipality. The finding of this study will also be significant in providing realistic information and initial input for urban planning experts, stakeholders, governmental and non-governmental organizations and other researchers.

Keywords: Urbanization, Agricultural land, Remote Sensing and GIS.

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1. Chapter One

1.1 Introduction

Urbanization is a development within the extent of a public living in urban ranges and encourages physical expansion (Alaci, 2010). Urban area may involve both horizontal and vertical expansion (Minwuyelete, 2004). However cities have been expanding at the expense of prime agricultural land which is the main livelihoods of peripheral community. Developing countries have higher uncontrolled rapid urbanization process than developed countries (Ramachandra and Kumar, 2004). This uncontrolled rapid urban expansion causes remarkable changes in the landscape as a result of rapid economic developments in those parts of the world (Deka, 2010). Effects of horizontal urban expansion include the loss of agricultural land, displacement of farmers and change of their livelihood (Minwuyelete, 2004). Uncontrolled change in landscape increases loss of green cover and forests, loss of fertile lands, environment degradation, violence of urban areas and many more (Al-Shalabi et al., 2006).

The impact of urbanization on peri-urban environment and occupations can be seen in two ways: positive and negative. Alaci, (2010) reported that well-arranged and overseen urban growth and advancement can serve as a positive advancement. The benefits may be seen in terms of tall request on rural produces, get to create extension services and openings to non-farm work (Diyamett, 2003). However, unguided urbanization, like in most developing countries, contrarily influences the natural environment in peri-urban regions (UN-HABITAT, 2007, 2010). This may be attributed to in utilizing, water resources, squander dumping, and increasing competition between rural and private utilize of common assets (Bah, et al, 2003). As a result, urbanization may bring an emotional increment within the concentration of poverty and natural corruption in peri-urban zones (Marshall et al., 2009).

The level of urbanization in Africa is low (37%) when compared with developed nations like Europe (72%) and North America (79%), (World Bank Group, 2016). In any case, urbanization within the developing world is advancing much speedier than in developed nations indeed 4 % a year (Soubotina, 2004). The high rate of urbanization in developing world is ascribed to rural–urban relocation, financial development and advancement, innovative alter and quick populace development (Marshall, et al., 2009).

Ethiopia is one of the slightest urbanized nations in the world. It has as it were 16% of its population living in urban centers (CSA, 2008). In any case, given the 2.73% add up to yearly

population growth rate, tall rate of in-migration to towns and increment within the number of urban centers, the rate of urbanization is expanding at a rate of 4.4% (MoFED, 2006). Moreover, the country's urban populace is anticipated to develop on average by 3.98% and by 2050, about 42.1% of the entire populace is anticipated to be possessed in urban centers (UN-HABITAT, 2007). Between 2003 and 2018, the urbanization level of Ethiopia rose from 15.31% to 20.76%, showing a 5% raise (Tsega, 2020).

Ethiopia has been experiencing a rapid urbanization process since the implementation of economic development and privatization policy (Angel et al., 2011), to stimulate national economic growth. However, as it is observed in numerous developing countries, the intensified constraints, following the fast urbanization processes in the country, are unplanned and uncontrolled that resulting in scattered urban growth, loss of farm land, and environmental degradation. In addition, the urban physical growth rate has been faster than the rise in infrastructures and service delivery in Ethiopian towns Ministry of Urban Development Housing and Construction national report on housing on housing and sustainable urban development (MUDHCo, 2014).

The general characteristics of rapid urban expansion experienced by most sub-Saharan countries, such as Ethiopia are uncontrolled changes in land and building uses (Zhang, 2001). Growth in urban population goes with no equivalent growth in land supply (United Nations Department of Economic and Social Affairs Population Division the World's Cities, 2018). Land is fixed in supply and does not increase with increasing population growth. The pressure exerted by increases in population and rapid urbanization deprives other sectors of the needed land. Agricultural lands are most affected by rapid urbanization and its functions of demand. Land uses for residential, industry and commercial, civic and culture tend to dominate agricultural lands in the bid for space in the urban place. This dominance tends to deprive farmers of arable land to built up area thereby reducing agricultural productivity. There is a clear description of this situation in the Adet town and its periphery areas.

1.2 Statements of the problem

Urbanization has negatively impact on peripheral areas of the town especially agricultural land. Reclassification of the rural areas being as part of an administrative body to the municipality is the main cause for the loss of agricultural land due to high demand of residential housing for the dwellers. According to Redman & Jones, (2004) many cities are fast developing at their periphery, swallowing of former villages and croplands, transforming them into industrial areas, shantytowns or less-dense suburban developments. As urban

centers, expand by occupying fertile farmland and displacing farmers cause to reduce the amount of production and number of family farmers and move to the nearby urban centers. In Ethiopia, as in several other African countries, urbanization is occurring at a more rapid rate and the competition for land between agriculture and non-agriculture is becoming intense in the peri-urban areas (Achamyeleh, 2014). Closely linked study, in Ethiopia, urban expansion leads to outward expansion of towns and results to change in land use where by the federal and regional agencies and the municipality are expropriating of agriculture land for public purposes (Solomon et al, 2006). This phenomenon is directly attributed to change in property rights and food securities such phenomenon (landlessness, loss of farmland and grazing land) made its impact on the farm livelihoods in the peri-urban areas and the transformation of agricultural land into residential areas has increased more and more, causing the change of land-use structure.

Abdissa, (2005) has recognized the effect of urbanization in terms of forest and soil degradation, water pollution, and overall decline in agricultural production, agricultural community displacement and squatter settlement. According to Leulseged et al, (2011) urban expansion was contributed by the conversion of croplands, forestlands, and grasslands in order. This implies the city's built-up area expansion is characterized by horizontal growth, leaving the peri-urban environment and livelihoods at risk. Rural-urban migration (Tegene, 2011) and recently infrastructural development (Ayele, 2017) accelerated urbanization processes. However, this expansion of urbanization is not well planned and horizontal expansion is the major challenges of towns and cities in the expense of other land uses. Most towns' in Ethiopia are expanding horizontally following the routes of roads (Teketel, 2015). According to Eyasu, (2007), the Ethiopian urban centers are expanding in unexpected rate resulting to peasant displacement with concomitant loss of agricultural land, loss of agricultural production and change of their livelihood. Urbanization was one of the main problems that threaten the limited highly fertile and very productive agricultural land in the periphery of Adet town for residential construction and its related infrastructure.

So far, money researches on urban expansion have been conducted in globally even if in Ethiopia, none has been done in Adet town as to the researcher knowledge. Furthermore, the extent, magnitude and potential effects of urban horizontal expansion on agricultural land in Adet town has not been investigated. In addition to this not focused the loss of fertile and very productive agricultural land due to urbanization. Therefore, this study aimed to assess the effects of urbanization on agricultural land using remote sensing and GIS techniques.

1.3 Objective

1.3.1 General Objective

The general objectives of this study was to assess the impacts of urbanization on agricultural land using remote sensing and GIS techniques in Adet Town, Ethiopia.

1.3.2 Specific Objective

The specific objectives of the study are to:

- 1) Classify the LULC dynamics during the time periods of 2000, 2010 and 2020,
- 2) Map horizontal expansion of urban boundary and analysis its effect on the surrounding agricultural land in study area
- 3) Identify the major trigger factors for horizontal expansion of the study area,

1.4 Research Questions

This study addressed the following research questions:-

- 1) How the LULC changed was classified during 2000 to 2020?
- 2) How urban boundary expansion on agricultural land in study area?
- 3) What are the main factors responsible for horizontal expansion of the study area?

1.5 Significance of the Study

One of the major impacts of urbanization was a reduction of agricultural land through the high needs of residential construction and in related to its development of infrastructure and various development plans such as health and education facilities, small enterprise and additional marketing place. This study assessed the impacts of urbanization on agricultural land in the Adet town over the three consecutive periods of 2000, 2010 and 2020.

The main findings of this study should be contribute to the Adet town municipality and surroundings of Adet town district (yilmana densa wereda) to strengthen their collaboration focusing on the preventing productive and fertile agriculture land and reduce agriculture land losses and reclassification of the peripheral rural kebeles being as part of an administrative body to the town municipality. The finding of this study should also be significant in providing realistic information and initial input for urban planning experts, governmental and non-governmental organizations. Hence decision-makers can take into account the situation of the urban planning process. Apart from this, the finding in this study will help academicians as baseline information for other related research topics.

1.6 Scope of the study

This research focused mainly to assess the impacts of urbanization on agricultural land using remote sensing and GIS in Adet town. Currently, most of the towns of the region even if in the country have little attention in terms of physical expansion and its effect on agricultural land which create a burden on basic supply of public services and infrastructural developments and loss of farm land. Given the fact of current and future unmanageable urban growth problems, there is a need of decision making and planning to maintain at least some control of urban expansion. Remote sensing and GIS techniques can help to get up-to-dated information of the urban expansion with frequent coverage and low cost. Horizontal urban expansion have been both negative and positive effects. But for this study focused on the negative effects especially on agricultural land.

1.7 Limitation of the Study

This research paper gives insights into how land use patterns changed from agricultural farm land to build up areas in the last 20 years in Adet town. The research is not completely free from limitation. LULC detection was difficult during interpretation and classification of images due to similarity of spectral signature of features. In order to overcome this problem, field data collection were undertook to verify actual LULC which in turn incurred me both time and energy expenditure. Other limitation of this study was some interviewee were not willing to give reliable information about contribute factors of horizontal expansions in the study area.

1.8 Organization of the study

The research paper is organized into six major chapters. The first chapter contains the introduction objective and significance of the study in which clear information to the readers has been provided. This part highlights the global status, prospects and problems of urban landscape dynamics. The second chapter is devoted to different worlds“ approaches, methods and mechanisms of urban landscape dynamics studies, which have assisted the researcher to produce different arguments on the selected topic. Here the concept, both global and national trends, causes and impacts of urban landscape dynamics have been stated in brief. The third chapter deals methodology and starts with the description of the study area followed by the methods employed including data types and sources, software and instruments utilized to carry out the research. In this part, image classification algorithms and data analysis techniques are briefly described. The forth chapter is dedicated to the results of the thesis. Results from classification of images, the analyses of LULC change and its impact on agricultural land and trigger socio-economic contribute factors of horizontal expansions have

been encompassed in this chapter part. The fifth chapter is deals about the discussion, which focuses on comparison of results obtained with existing theories and practices. The conclusion and recommendations are the sixth and the last chapter of the study. These have presented conclusive remarks based on the findings and the researcher's suggestions pertaining to the mechanisms of checking urban landscape dynamics impacts on the peripheral agricultural land of the study area.

2. Chapter Two

2.1 Literature Review

2.1.1 Land Use/Land Cover Description

Land cover is the observed (bio) physical cover on the earth's surface (vegetation and man-made features), whereas land use is characterized by the arrangements, activities and inputs people undertake in a land cover type to produce, change or maintain it. According to (Basudeb, 2011 and Bouque, 2000), the two terms are described as follows: Land cover is the biophysical coverage of land like natural areas, forests, buildings, lakes and roads. The term land cover describes the types of resources/features present on the surface of the earth. It is the observed (bio) physical over on the earth's surface.

Land use is the socio-economic use that is made of land for different purpose such as agricultural use, commerce, residential use, recreational area; at any place, there may be multiple and alternative land uses. It reflects the character of a society's interaction with its physical environment, fact that becomes obvious when it is possible to see different economic and social systems occupying the similar environments.

2.1.2 The Concept of Urbanization

The term urbanization as conventionally measured by demographers is urban population divided by total population of a region (Glenn, 2004). Urbanization also defined to a growth in the proportion of a population living in urban areas and the further physical expansion of already existing urban centers (Leulseged et al, 2011). Nsiah-Gyabaah, (2004) defined it as the shift from a rural population to an urban population and includes an increase in the number of people in the urban areas. Urbanization is the outcome of the social, economic and political developments that lead to urban concentration and growth of large cities, changes in land use and transformation from rural to urban. In effect urbanization affects all spheres of human life both in the rural and urban setting. The rising trend in urbanization has been driven by the following demographic factors: rural urban migration, natural increases in towns and reclassification.

2.1.3 Rapid Urbanization

High rates of urbanization (urban expansion) which is huge increases in population have outgrown the management capabilities of cities in the developing world (Efrem, 2007). Urbanization is one of the most obvious realities of the 21st century (Kashem, 2008). The bright lights of the cities, the perception that cities give greater opportunities and the desire to

be at the heart of a fast life is drawing people to cities. Doygun, (2009) stated the process of people transformation from a predominantly rural to a predominantly urban population is defined as urbanization .Urbanization leads to urban expansion due to the demand for development and housing growth, as well as facilities areas to serve human life (Doos, 2002). In the study area high demands of residential houses, currently the main factors for horizontal expansion in the five peripheral rural kebeles.

As demand for land increased over time, urban centers have been physically expanding their boundaries to surrounding rural and peri-urban areas by including additional land where people did base their lives in agriculture (Efrem, 2007). Urban expansion is practicing in planned and unplanned manner .This type of expansion is very common to urban Ethiopia especially in the study area is very affected.

2.1.4 Causes of Urban Expansion

It is widely recognized that demography and economies are the most important driving factors for urban expansion. Migration is one of the major reasons that contribute for increasing urban population. According to Gyabaah et al, (2006), migration mostly occurred by push and pull factors though varied in extent and motivational factors in developed and developing countries but both having common destination target that it is bringing people towards the urban areas.

The search for higher paying employment, better quality of life in terms of health and education, greater diversity of entertainment and lifestyle are grouped as pull factors, (2007). On the other hand, migrants influenced in the interpretation of urban life in media or success story of relatives previously moved to urban cities and rural poverty considered as push factors. Reclassifications of the rural areas being as part of an administrative body to the urban municipalities are another cause for population increase in cities. According to Drencher & Laquinta, (2002) reclassification is most likely occurred in places with a supposed economic advantage and the capacity to absorb non-agricultural labor as a direct result of occupation of areas that are markedly non-urban. Many cities are fast growing at their periphery, swallowing former villages and croplands, transforming them into industrial areas, shantytowns, or less-dense suburban developments Redman and Jones, (2004). Thus, by administratively incorporating inhabitants with non-urban lifestyles into the political authority, all of the residents become urban. This implies that, urban population increases is likely associated with urban land extension towards the peripheral rural farmland in need of space for construction of residential houses, industrial and commercial enterprises and infrastructure that leads to the conversion of extensive arable land .These dramatic demographic shifts towards urban areas

driven by the urban expansion across the world have different rates among developing and developed countries (Gyabaah, 2004).

2.1.5 Effects of Urban Expansion

Urbanization has negative effects to its surrounding peri-urban areas in different aspects especially, in relation to displacement of farmers from their farmland and to degradation of valuable agricultural land (Marshall et. al, 2009). Because of as the nation's population increase, cities must grow spatially to their peri-urban areas to accommodate more people and to serve different services for them.

Ethiopia is the second most populous country in Africa, with a total population of 112 million and a 2.4% growth rate in 2019 (Nations, 2019). Although modern urbanization started in the nineteenth century (Pankhurst, 1985), Ethiopia's level of urbanization was only 21.2% in 2019. Nonetheless, the annual urban growth rate of 4.5% is faster than Sub-Saharan Africa average of 4% (Bank, 2014) and expected to continue at faster rate of 5.4% (World Bank, 2015).

Projection made by Ministry of Urban Development and Housing indicates that, the number of urban population by 2025 is expected to reach between 30-35 million (27 to 30% of a total population). By 2037 the urban population will be 42.2 million (40% of the total population). This means that the urban population of Ethiopia will increase between 2015 and 2037 by as much as 39 million, and that the urban population expansion accounts for around 75% of the total population increase of over 50 million during this period (MUDHo, 2015). Due this predication towards urbanization is that it is the following harmful effects of urban expanding on their peri-urban areas such as loss of farmland, solid waste disposal and land degradation, enclosed surrounding villages for urban territory. Date back to the country level of urbanization, it was about 5% in the 1950s, and 10% in the 1970s and by 1984 was about 13%, and reached 19% in 2014 having grown by 6% between 1984 and 2013 and this reflects an average increase of 2% per decade (MUDHo, 2015).

2.1.6 Effects of Urban Landscape Dynamics on Agricultural Activities

According to Kassahun, (2018), when urban expansion takes place at the periphery of a certain locality it has direct or indirect impact on other parts of the same locality within its border or on a neighboring community and the consequences of rapid urbanization on peri-urban areas include changing labor and market conditions, loss of farmlands, changes in social, cultural

and lifestyles .Thus, urban expansion consequently results social, environmental and economic problems to the society (Abdissa, 2005).

2.1.7 Conceptual Framework

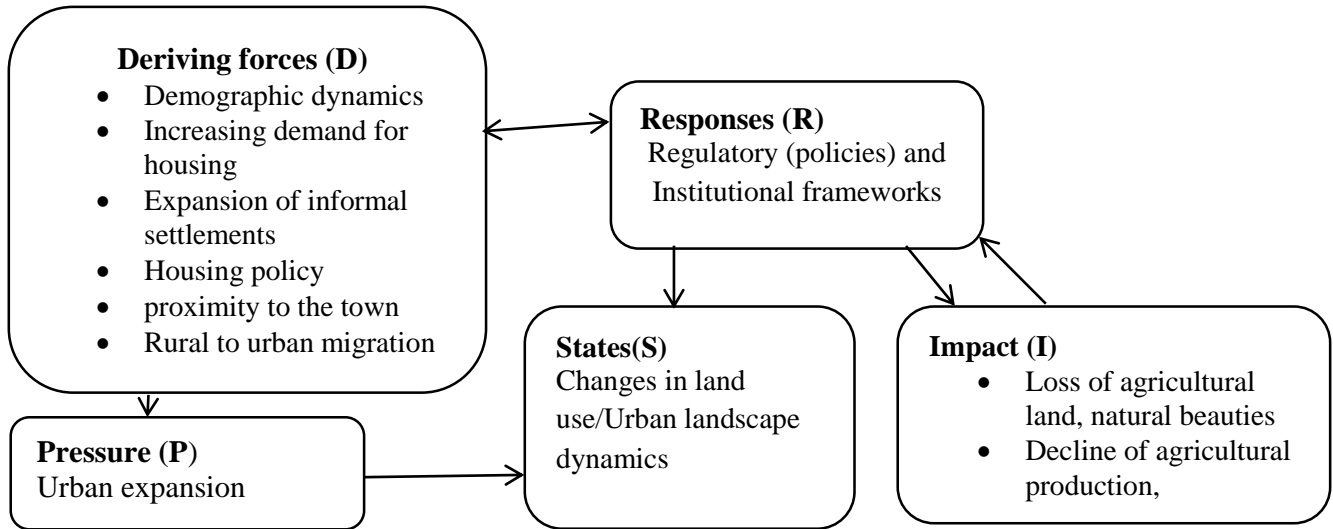


Figure 2-1: Conceptual framework

Source: Developed by author from different literature concepts and legal legislations.

The factors that contribute for urban expansion in Amhara regional state are economic policy reform, the creation of enabling the environment for private investors, the unsatisfied demand of urban dwellers for residential and expansion of public sector projects (Indris, Abdella and Nuredin, 2020). Population dynamics is the drivers of population changes which is changes in population size, rate of change in population size, population composition (by age and sex, basically, but the process of demographic change can also modify the composition of social groups as a result of differential dynamics) and it is the result of interactions of a set of drivers such as mortality, fertility and migration (UNFPA, 2014). According to UNFPA, (2014) urban expansion is increasing in the number of people living in the town. Whereas, in the study area population dynamics was the main driving forces of horizontal expansion. When the numbers of population was increased, horizontal expansion occurred formally and informally approach due high demand of living houses. Informally expansion especially occurred in the east and south direction of the study area followed gravel the road.

The intervention of central government was considered as the primarily factor for expansion of urban to peripheral areas (Jongkory, 2009). According to Jongkory (2009), the intervention of central government for instance through public policy such as large scale infrastructure development which aims to reduce congestion in inner zone of city is the primary driving force

for the growth of urban centers. Accordingly, large parts of predominantly agricultural lands have therefore converted to residential, commercial, industrial and other urban land use purposes.

2.1.8 Integration of Remote Sensing and GIS

Remote Sensing and GIS are tools for detecting objects and phenomena change. Remote Sensing is the ability to detect change on the earth's surface through space-borne sensors (Ramachandra and Kumar, 2004). Temporal and spatial resolutions allow scientists to monitor and detect changes over a broad scale and help planners to obtain or maintain information on various phenomena, such as shifting agricultural patterns, crop stress, disaster monitoring, land use and land cover changes (Rogan and Chen, 2004). GIS has the ability to incorporate multi-sources of data into a change detection (Alqurashi, 2013).

In recent years, remote sensing and GIS have been integrated for analyzing and mapping land use and land cover changes (Murayama and Thapa, 2009). Driving LULC change maps has been done using supervised classification algorithms through remotely sensed software (Gajbhiye and Sharma, 2002). Utilizing ancillary data with satellite Landsat imagery provides more accuracy in the detection of change. The use of GIS has also been recognized for detecting and mapping LULC changes.

Chapter Three

3. Methodology

3.1 Description of the Study Area

The study was conducted in Adet town which was established over 150 years ago in the name of haylu gebeya and its coverage reached 2115 hectares. It is a town in northwestern Ethiopia and located south of Bahir Dar city. The study area extends between 11°14'29''N to 11°16'44''N and 37°28'25''E to 37°29'00''E. Attitudinally, it is found between 2,238 to 2,278 meters above sea level.

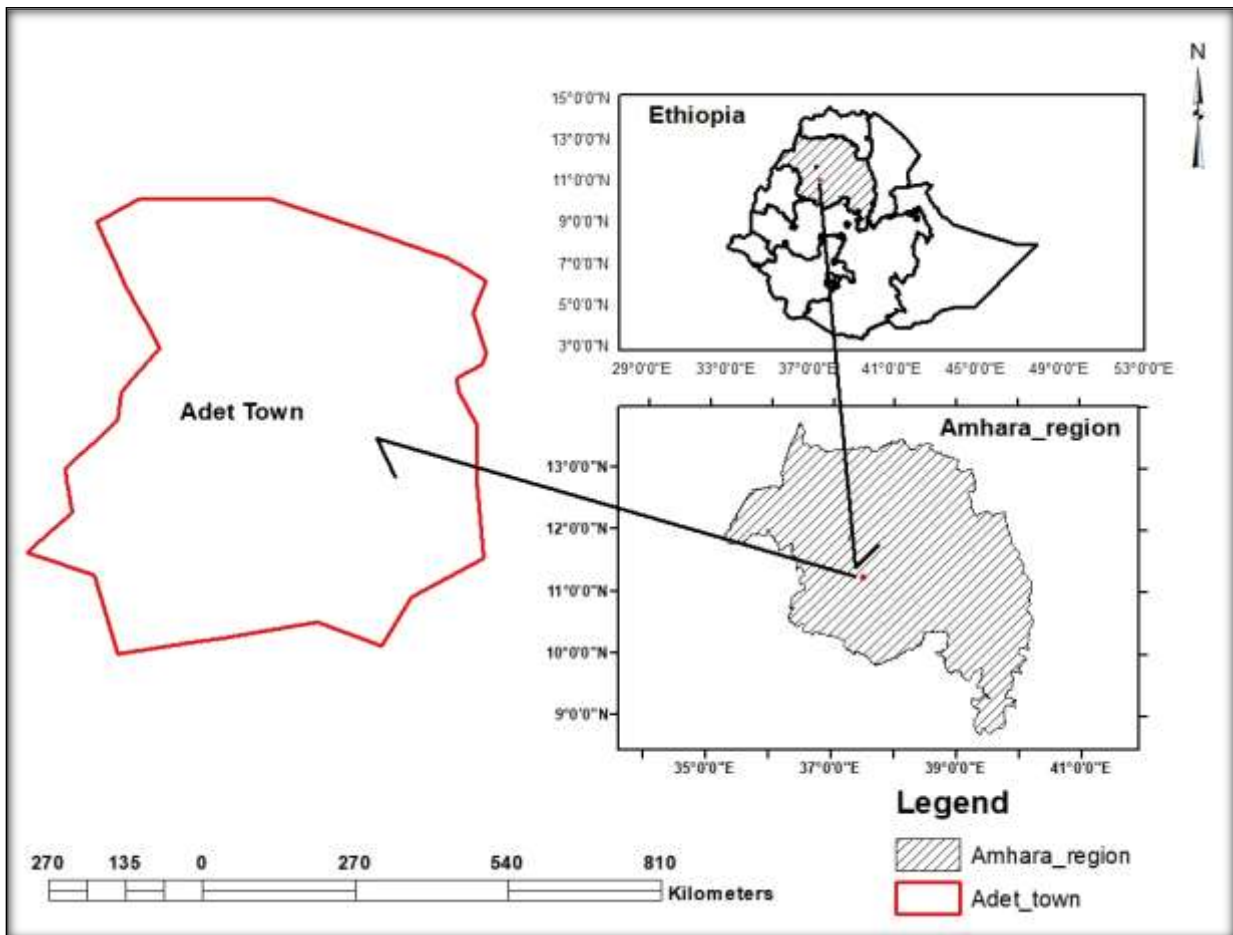


Figure 3-1: Locational map of the study area

The center of this town is surrounded by two rivers, called Shenna and Shegize. The southern part of Adet is called Felseta Mariam deber and Zerabruke (Anbesit Mewucha). The northern part is called Kurrastiyon or Ersha Mermer. The southeastern part is called Ereberbe Gabriel (Yegetoch Bahir zafe). The west of Adet is called Mender Eyesus, and the east is Adet Hanna. Adet town is the main town of Yilmana Densa woreda. Yilmana Densa woreda is endowed with fertile and very productive agricultural lands which are suitable for high-value crops,

livestock and agriculture. A mixed farming system involving both crop production and livestock rearing activities is the dominant type of farm production system. The major crop production in the district is teff (*Eragrostis tef*), maize (*Zea mays*), wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) and finger millet (*Eleusine coracana*) the major cereal crops and potatoes from the vegetables in the area. Livestock production is the major livelihood next to crop production. In the study area, different types of livestock products such as cattle, goats, sheep, equine and chickens are important livestock species reared by farmers.

3.2 Research Design

The study employed a descriptive (observational method) research design to make intensive investigation of the impacts of urban expansion on agricultural land. Hence, to maintain triangulation in its findings, the design manifested the basic features of both the qualitative and quantitative research. The quantitative methods involved the usage of GIS and remote sensing data to produced maps of 2000, 2010, and 2020 and calculated the urban expansion within the study area from the Landsat classified images. The GIS allowed for reclassification of land cover data into categories appropriate for the purposes of this study urban landscape dynamics and its impact on agricultural land. Whereas qualitative approach was used to assess on the ground regarding socio-economic contributing factors of urban expansion in Adet town setting and its periphery area. Due to this conducted 35 interviews, 6 municipality officials, 12 well known educated households, 5 urban kebele's work managers, 5 peripheral rural kebele's work managers, 7 old indigenous households by purposive sampled which was critical case sampling to get the most relevant information on open ended interviewee

3.3 Data sources

This study was done by using both primary and secondary data sources. Primary data was collected through interviews and filed observation such as topography, infrastructure, services and the environment. This study was based on remotely sensed data (Landsat images within spatial resolution 30m) combined with extensive field checks and surveys. In addition to this the study was done using interviews using purposeful sampled and investigated the socio-economic contributing factors of urban expansion in the study area (Figure 3).

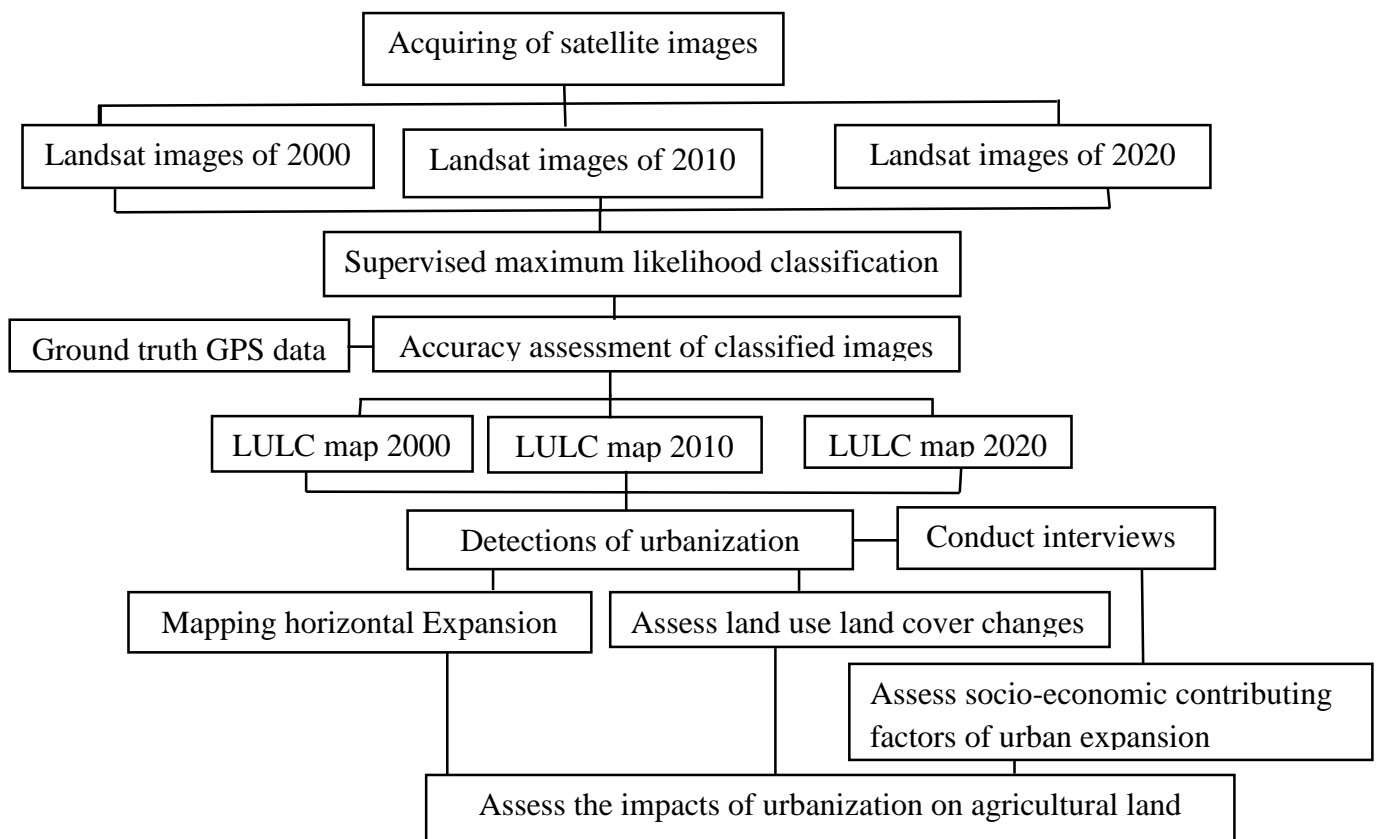


Figure 3-2: The general work flows of the research

3.4 Processing software

ArcGIS 10.8 and ERDAS IMAGINE were used for displaying and subsequent processing and enhancement of the image. The land LULC classes were also developed using this software.

3.5 Data Acquisition

In order to assess the impacts of urbanization on agricultural land in Adet town Landsat images of 2000, 2010 and 2020 and interviews were used. For this research purpose, Landsat satellite images have been chosen that could be available in free public-domain. Another reason for choosing these images is that the time interval is found equal 10 years of interval (2000, 2010, and 2020).

The images were acquired in February, as this was a clear sky season in the region. Only images with high quality standard and Zero cloud cover with good cloud qualities were considered. The images with good cloud qualities were then stacked together (band combination) and prepared for classification after downloading. The Landsat images were taken at visible and infrared wavelength with 30mx30m spatial resolution. The images were of high quality as well as taken during clear sky days. For this study used Landsat satellite

images because it provides high-quality, multi-spectral imagery of the Earth's surface in moderate-resolutions. Using Landsat 5, Landsat 7 and Landsat 8 detected agricultural land, built up area, vegetation and bare land, land use type in the study area.

For accuracy assessment used Google earth map for 2000 and 2010 and Garmin handheld GPS for 2020 by created a set of random points from the ground truth data and compare that to the classified data in a confusion matrix. For the three study period collected for agricultural land 232, for built up area 254, for vegetation 175 and for bare land 130, total 791 sampled representatives of LULC class for accuracy assessment of the classified images. The numbers of this testing points was depends on how the interpretation difficulty. Accuracy assessment compares the classified image to another data source that is considered to be accurate or ground truth data. Satellite images permit accurate mapping of land cover and make landscape features understandable on the study area about temporary phenomena, such as agricultural lands, built-up areas, vegetation and bare lands could be studied by comparing images acquired at 2000, 2010 and 2020.

For the purposes of this study, three periods of freely available Landsat images would be use. The raw Landsat images obtained from earth explorer (<http://earthexplorer.usgs.gov>) for free website which were selected based on; (i) availability of the data, (ii) cloud cover percentage which were 0 percent cloud cover, and (iii) association with years of major actions in the study area. All the three image acquisition was taken in the dry and clear sky season 03/02/2000, 08/02/2010 and 10/02/2020 Landsat 5 thematic mapper(TM), Landsat enhanced thematic mapper (ETM+) and Landsat 8 operational Land Imager (OLI) respectively.

Year	Date of Image Acquisition (dd/mm/yyyy)	Sensor	Cloud cover (%)	Spatial resolution	Path/Row	Source
2000	03/02/2000	Landsat 5 Thematic Mapper (TM)	0	30	170/052	USGS
2010	08/02/2010	Landsat 7 Enhanced Thematic Mapper Plus (ETM+)	0	30	170/052	USGS
2020	10/02/2020	Landsat 8 Operational Land Imager (OLI)	0	30	170/052	USGS

Table 3-1: Specifications of Landsat thematic mapper (TM) images

3.6 Spatial data analysis

The satellite imageries acquired were already Georeferenced and Radiometric corrected. The image processing was then started by image classification within the administrative boundary of Adet town. Depending on the scope of the study and visual interpretation of satellite imageries only four classes were taken. There were agricultural land, built up area, vegetation and bare lands. Supervised classification algorithms especially the maximum likelihood approach was used because it gave better results for the study area. Supervised classification involves selecting pixels that represents land cover classes that are recognized by the analyst. This requires, however, prior knowledge of the area by the researcher. Because it gives good results about similar spectral characteristics of grass land, crop and bush lands and maximum likelihood algorithm was used. Regarding urban land use/cover classification, supervised classification method with maximum likelihood algorithm is one of the most popular widely used.

3.7 Land use/land cover change analysis

The classified images were compared in three periods i.e. 2000-2010, 2010-2020 and 2000-2020. Change detections was computed by comparing values of area of one data set with the corresponding value of the second data set in each period. The values were presented in terms of hectare and percentage. Quantification of the rate of change has been applied to generate information about the land use/land cover dynamics of the study area.

3.8 Development of classification scheme

Based on the prior knowledge of the study area, a brief reconnaissance survey was carried out using Subset image (based on the shape of the study area) and a classification scheme was developed land are used to produce the final land use/land cover map of the study area.

Accordingly four classes were identified namely agricultural land, built up area, vegetation and bare land (table 3.2).

Land use class	Description
Built up area	All residential, commercial and industrial areas, villages, settlements and transportation infrastructures.
Agricultural land	Including crop fields, grazing land and fallow land.
Vegetation	In this study the vegetation includes planted of trees around compounds, eucalyptus wood lots and road side tree plants and parks.
Bare land	All vacant spaces, sands, rocky areas, cleared land

Table 3-2: Details of the land cover types

The type and number of land use classes are determined by a number of factors. The contribution of the land use type on the recorded change is the primary determinant reason. This is directly related to the area the land use shares in the town the other is land use types that its change easily recognizable and identifiable. Again, typical land features of the area are taken as a class. In order to make sample collection and classification easy, land use/land cover nomenclatures are required to create and define the possible land use/land cover classes first. The land use/land cover classes applied in this paper are adopted from Anderson land use/land cover classification scheme which is widely applied in East African Countries (1976). For the sake of simplicity, the researcher modified the descriptions of some of the land use/land cover classes considering the land use/land cover diversity of the study area. Therefore, four major land use/land cover classifications: agricultural land, vegetation, built up area and bare land.

3.9 Training and Test point Collection

Training areas/sample objects which are typical representatives of the classes were collected using personal experiences and local knowledge of the physiographical nature of the area. In addition, image enhancement and composition were applied for better discriminating the land cover classes. Training samples for 2000 and 2010 from Google Earth map (created random point in ARCGIS and convert to kml format then takes a value of each random points) and 2020 using hand held GPS for each classes were collected randomly.

Land use	2000	2010	2020
Agricultural land	81	92	59
Built up	85	103	66
Vegetation	58	60	57
Bare land	51	29	50
Total	275	284	232

Table 3-3: Random Test Points

As the above table 4 shown 791 points were collected and used, to test the accuracy of the classified images of the 2000, 2010 and 2020. This study accuracy assessment was done by using these points to find out those errors so as to make the produced land cover maps become reliable and easily interpretable by users. Once the classified image is incorporated into a GIS, to become an information source for urban planners and researchers, accuracy assessment is supposed to process as it limits the classification results of a remotely sensed imagery data (Landsat image). To do so, the accuracy of a classified map has to be assessed and compared with a referenced data using an error matrix.

3.10 Image Classification

Image classification is the extraction of differentiated classes or themes of land use and land cover categories, from raw remotely sensed digital satellite data. It is a technique to identify different features such as urban land cover, vegetation types, anthropogenic structures, mineral resources, or changes in any of these properties from the satellite image. In order to improve the classification accuracy, selection of appropriate classification method is required.

Supervised classification was much more accurate for mapping classes, the strategy was simple: the specialist recognized conventional classes (real and familiar) or meaningful (but somewhat artificial) classes in a scene from prior knowledge, such as personal experience with what's present in the scene, or more generally, the region it's located in, by experience with thematic maps, or by onsite visits. This familiarity allows the individual(s) making the classification to choose and set up discrete classes (thus supervising the selection) and then, assign them category names. As a rule, the classifying person also locates specific training sites on the image - either a print or a monitor display - to identify the classes.

In this study, supervised classification approach was used and passed through the steps such as: select training samples which were typical representative for the land cover classes; perform classification using maximum likelihood algorithm and finally assess the accuracy of the classified image through randomly generated training samples. There are different types of image classification techniques. However, in this study was conducted by using Supervised Maximum Likelihood Classification type applied. It requires the manual identification of Point of interest areas as reference (Ground Truth) within the images, to determine the spectral signature of identified features. It is one of the most common types of classification techniques in which all pixels with similar spectral value are automatically categorized into land cover classes or themes.

3.11 Accuracy Assessment

Accuracy assessment is a general term for comparing a classification to geographical data that are assumed to be true, in order to determine the accuracy of the classification process. The results of the land cover classifications derived from remotely sensed data are compared by an accuracy assessment. An accuracy assessment analysis was performed by producing an error matrix that compared the interpreted land cover map and a map contains the result of ground truth investigation. To perform accuracy assessment Google earth map and handheld GPS was used for random testing point's collection. Ground truth would be performed by going into the field at the location of each randomly collected point. The classification result would then be compared to actual land cover at each point's location.

In this study the following error assessment steps was implementing. These were, determine the total number of samples to be collected for each category, design an appropriate sampling scheme, obtain ground reference information at sample locations, produce error matrix and evaluate the error matrices, producer accuracy, user accuracy, commission and omission.

The error matrix allows us to be able to calculate a variety of accuracy metrics from our data. The columns normally represent the reference data, while the rows indicate the classified image. It also provides an excellent summary of the two types of thematic error that can occur, namely, omission and commission. Errors of omission occur when a feature is left out of the category being evaluated and errors of commission occur when a feature is incorrectly included in the category being evaluated. An error of omission in one category will be counted as an error in commission in another category.

Most of the classification accuracy measurements are derived from confusion matrix. However, the most popular one is the correctly allocated cases in a percentage. Based on this, the user or consumer accuracy (CA) is computed using the number of correctly classified pixels to the total number of pixels assigned to a particular category. It takes errors of commission into account by telling the consumer that, for all areas identified as category X, a certain percentage are actually correct (schuckman, 2018). The producer's accuracy (PA) informs the image analyst of the number of pixels correctly classified in a particular category as a percentage of the total number of pixels actually belonging to that category in the image. Producer's accuracy measures errors of omission.

3.11.1 Accuracy Assessment of the Classification

User accuracy sometimes consumer accuracy refers to the number of appropriately classified pixels in each class grouping divided by the total number of pixels that were classified in that category of the classified image (row total). It represents the probability that a pixel classified into a given category actually represents that category on the ground.

Producer's accuracy refers to the number of correctly classified pixels in each class (category) divided by the total number of pixels in the reference data to be of that category (column total are classified). Overall accuracy is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix it is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels.

3.11.2 Overall Accuracy

It is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix it is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix

As mentioned by Anderson et.al, (1976) for a reliable land cover classification, the minimum overall accuracy value computed from an error matrix should be 85%. However, Foody, (2002) showed that this baseline makes no meaning to be internationally acceptable standard for accuracy. This is because a universal standard is not precisely related to any specific study area. Foody, (2002) also, illustrious that Anderson et.al, (1976) do not explain in detail about the criteria of map evaluation for universal applications. Moreover, (Lu.D., 2007) noted that the accuracies of change detection results highly depend on many factors, such as: availability and quality of ground truth data, the complexity of landscape of the study area, the change detection methods or algorithms used as well as classification and change detection schemes. So, the overall accuracies for both maps were above 85% based on Anderson's criteria. The first step or tasks were collection of test points for each LULC classes using Google earth and handheld GPS and then calculating the accuracy of classified and reference points.

3.12 Process of urbanization in the study area

The process of urban expansion takes place horizontally which is attributed to high expansion to the land surrounding urban areas and loss of agricultural land, natural beauties and rangelands (Feleke, 2004). In the study area rural-urban migration and natural population increasing causes Adet town population increased, due to this demand of residential house for dwellers and informal settlement existed. In addition to this growth and transformation plan, supportive housing policy, asphalt and gravel road construction and reclassification peripheral area within the study area boundary are causes of horizontal expansion. The expansion of Adet town look liked as bellow shown figure 3.3.

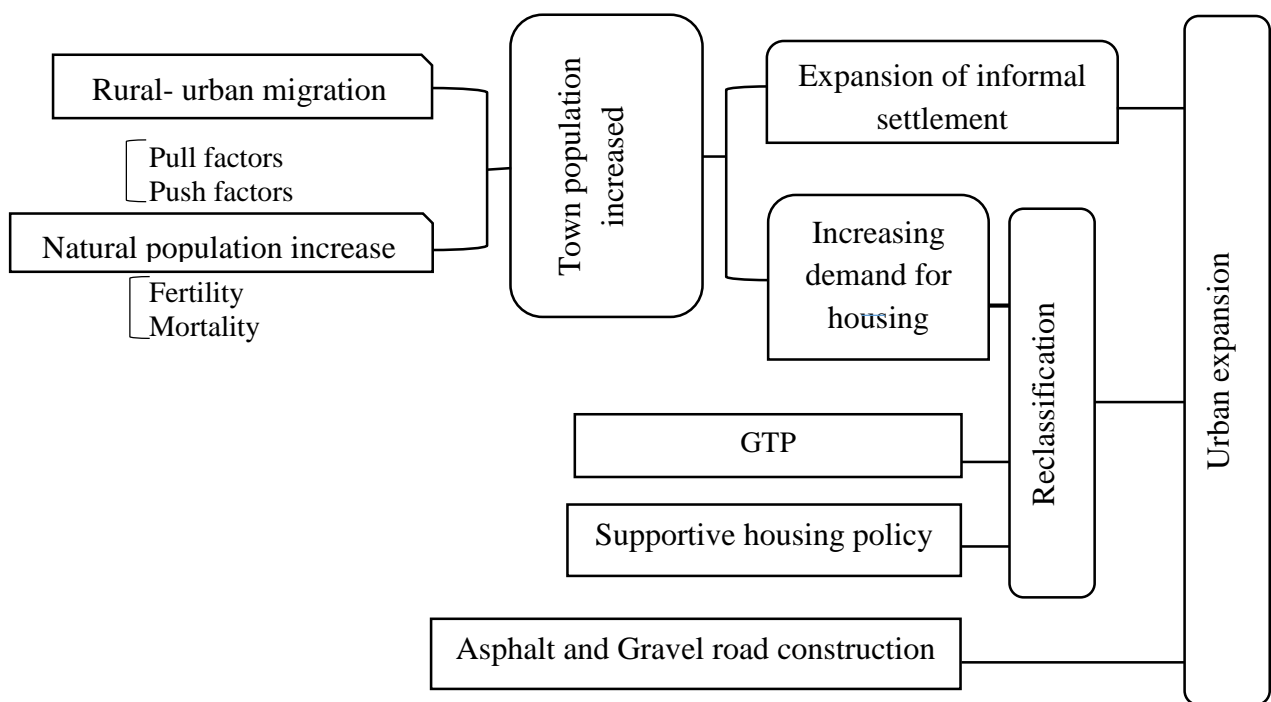


Figure 3-3: The process of urban expansion in Adet town (Author produced)

Chapter Four

4. Results

4.1 Confusion Matrix

4.1.1 Confusion matrix for land cover map of 2000

Producer's accuracy of agricultural land 84.15%, built up area 91.14%, vegetation 85.71% and bare land 75.86% and user's accuracy agricultural land 84.19%, built up area 84.71%, vegetation 82.76% and bare 86.27%. The overall accuracies in the study period 2000 was 85%. As shown this result the highest user's and producer's accuracies were vegetation and built up area and the lowest user's and producer's accuracy were vegetation and bare land. The lowest values of class accuracies were misclassified due to spectral property similarities among other land cover classes.

4.1.2 Confusion matrix for land cover map of 2010

Producer's accuracy of agricultural land 91%, built up area 94.95%, vegetation 85% and bare land 85% whereas user's accuracy of agricultural land 76%, built up area 91%, vegetation 93% and 90%. The overall accuracies in the study period 2010 was 87%. The highest user's and producer's accuracies were vegetation and built up area and the lowest users and spectral producer's accuracies were agricultural land and bare land. The lowest values of class accuracies were misclassified due to property similarities among other land cover classes.

4.1.3 Confusion matrix for land cover map of 2020

Producer's accuracy of agricultural land 88%, built up area 97%, vegetation 90% and bare land 82% whereas user's accuracy of agricultural land 83%, built up area 86%, vegetation 95% and 94%. The overall accuracies in the study period 2020 was 89%. The highest user's and producer's accuracies were vegetation and built up area and the lowest users and producer's accuracies were agricultural land and bare land. The lowest values of class accuracies were misclassified due to spectral property similarities among other land cover classes.

4.1.4 Overall Accuracy

Overall accuracy is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix it is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows overall results of the tabular error matrix. The

overall accuracy of classified LULC result shown that 85% in 2000, 87% in 2010 and 89% in 2020.

4.1.5 Area information of the LULC Units during the three time periods in the study area

Land use /land cover categories	2000		2010		2020	
	Area in (ha)	Area in percent	Area in (ha)	Area in percent	Area in (ha)	Area in percent
Agricultural land	1396	66	1348	64	1079	51
Built up area	613	29	571	27	761	36
Vegetation	43	2	106	5	169	8
Bare land	63	3	90	4	106	5
Total	2115	100	2115	100	2115	100

Table 4-1: Land use/ land cover distribution for each study years

As above table 4.1 shown, the study area has a total of 2,115 ha. Indeed, the area has four land-use types with different proportions, these are agricultural land, built-up area, vegetation, and bare land which has a land-use value of 1,396 (66%), 613 (29%), 43 (2%), and 63 (3%) respectively in 2000. From this result, larger parts of the study area were covered by Agricultural land use 66 %. So, the study area was dominated by agricultural land and the minimum was bare land. In 2010 agricultural land, built-up area, vegetation, and bare land with a value of 64%, 27%, 5% and 4% respectively. This result shown the majority of the study area was covered by agriculture and the minimum was as the same as the previous period bare land. In 2020 agricultural land, built-up area, vegetation, and bare land covers of 51%, 36%, 8% and 5% of the study respectively. This result shown the majority of the study area was covered by agriculture and the minimum was as the same as the previous period bare land. The coverage of agricultural land in decreased 2% from 2000 to 2010 and 13% from 2010 to 2020 and 15% from 2000 to 2020 due to transformations of other land use. From 2000 to 2010 Built up area decreased by 2% because of irregular settlements to change regularization and from 2010 to 2020 increased by 9% due to new built up construction by syndications as obtained respondent's information. So, the result revealed that the loss of fertile and very productive agricultural land in the effect of uncontrolled horizontal expansion in Adet town peripheral rural kebeles. On the contrary, the vegetation coverage increased as shown the above table 5, 2%, 5% and 8% from 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively due to peripheral landholders expected high compensation planted eucalyptus as obtained respondent's information. Lastly the bare land coverage increased 3%, 4% and 5% from 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively.

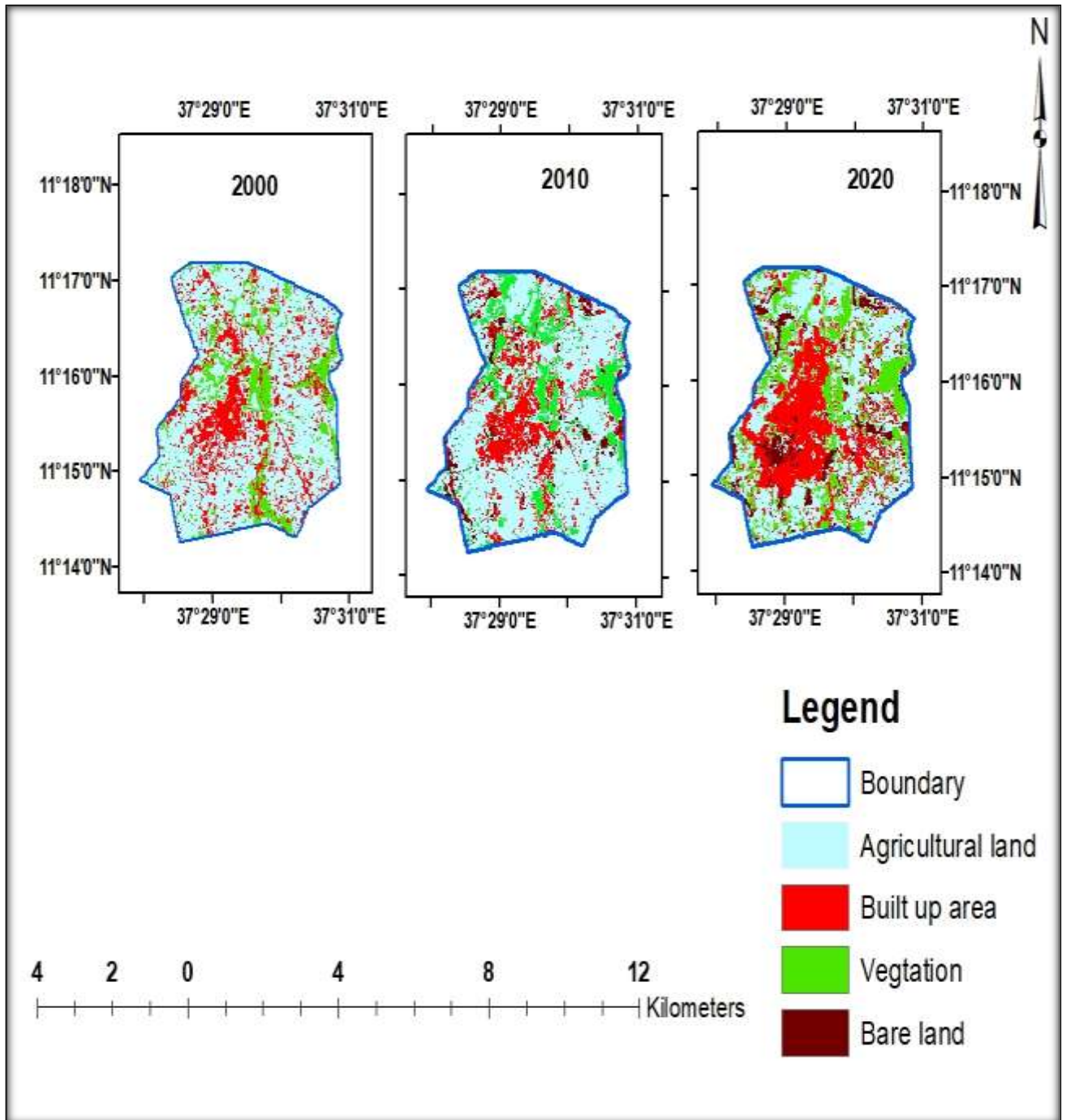


Figure 4-1: LULC for 2000 (left), 2010 (middle) and 2020 (right) respectively.

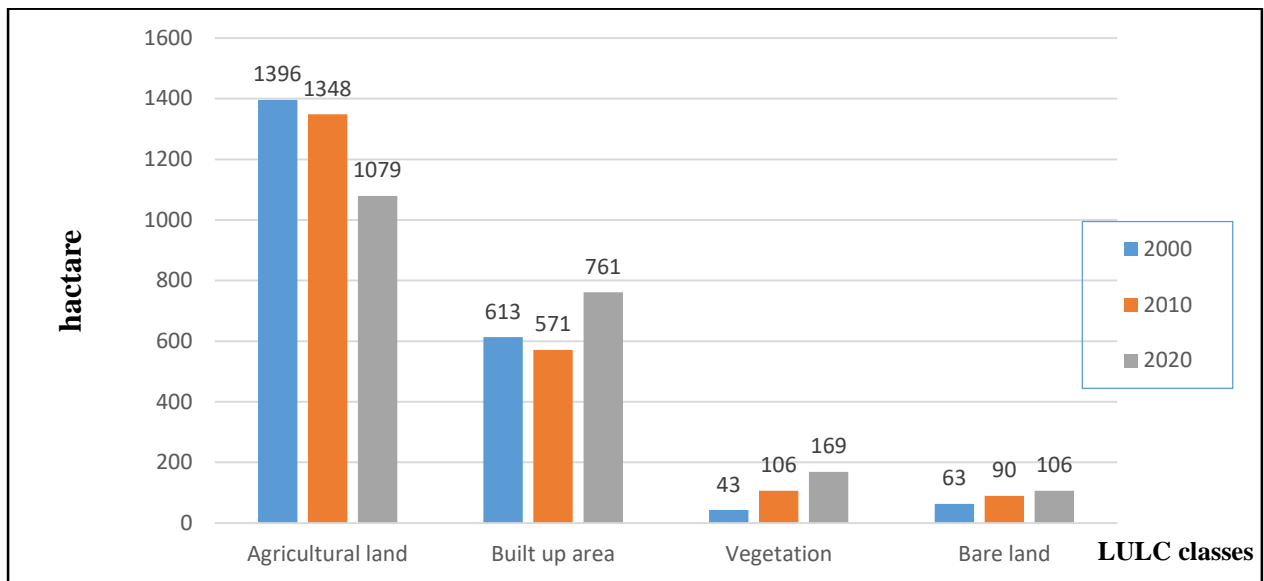


Figure 4-2: LULC proportion in the study periods of time

4.1.6 Change Detection

Change detection was the process of determining and monitoring the changes in the LULC types during time periods in the study area. It provides the quantitative analysis of the spatial distribution in the peripheral areas. This was done change detection to understand and monitor the land cover change pattern. The accuracy of change detection was dependent on the accuracy of each land cover type. Therefore, performing change detection analysis should be done after land cover classification. Considering all these things post-classification method has been applied for this research. Because post-classification is the most common and suitable method for detecting land cover change analysis. Using this method detected changes between the time periods of 2000 to 2010, 2010 to 2020 and 2000 to 2020. The details as the following:

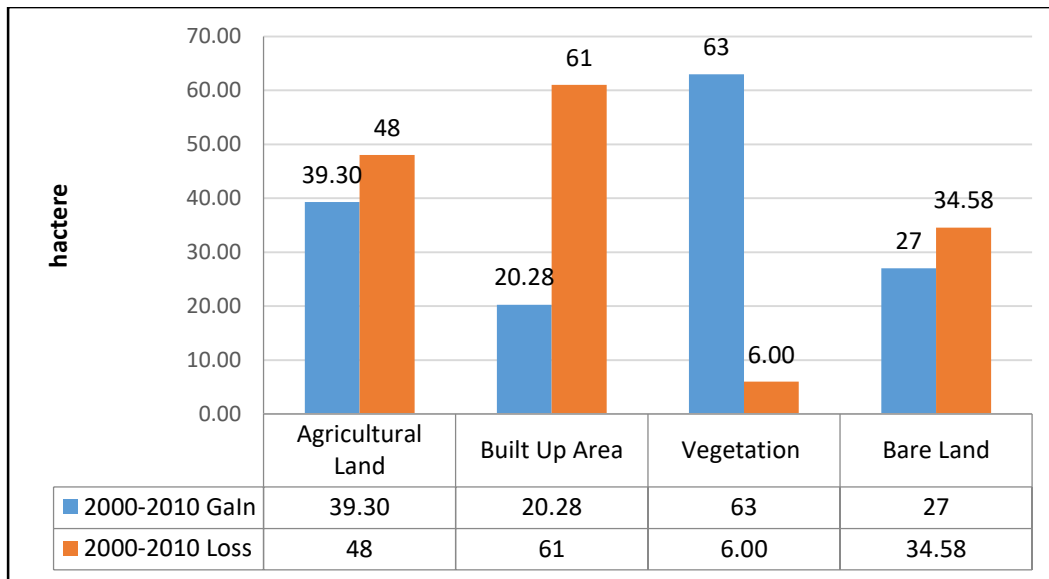


Figure 4-3: Land use/ land cover transformation from 2000 to 2010

As above figure 4.3 change detection result shown from 2000 to 2010 maximum loss was built up area 61ha and the maximum gain was vegetation 63 ha. Hence the minimum gain was built up area and the minimum loss was vegetation. In other hand the minimum gain was built up area 20.28 ha and the minimum loss vegetation 6 ha.

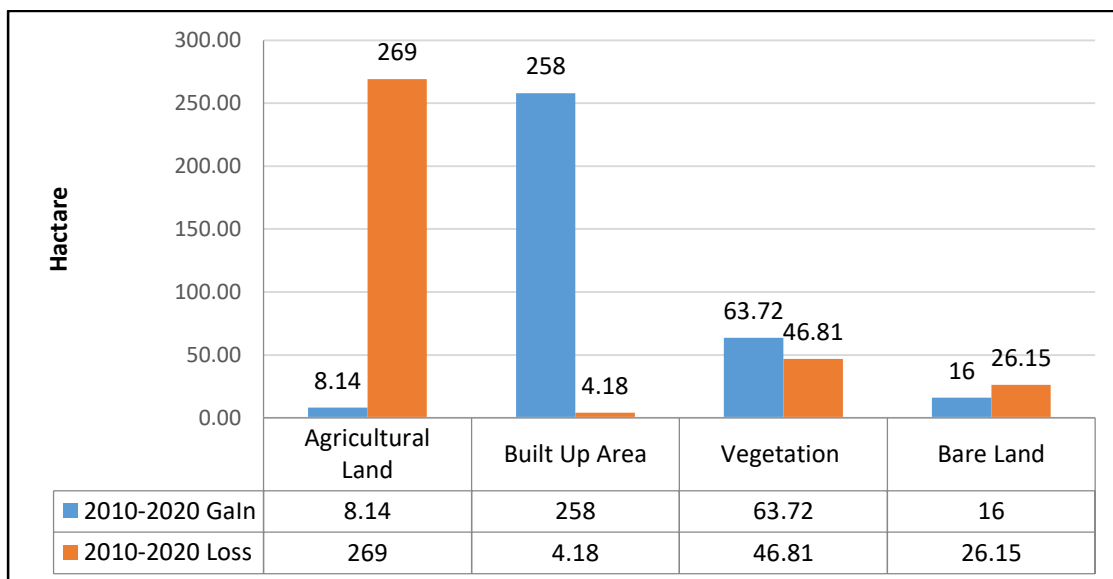


Figure 4-4: LULC transformation from 2010 to 2020

As above figure 4.4 result shown from 2010 to 2020 maximum loss was agricultural land and the maximum gain was bare land 269 ha and 16 ha respectively. This result revealed that the loss of agricultural was maximum from other classes 269 ha and the maximum gain was built up area 258 ha. However the minimum loss was bare land 26.15 ha and the minimum gain was agricultural land 16 ha.

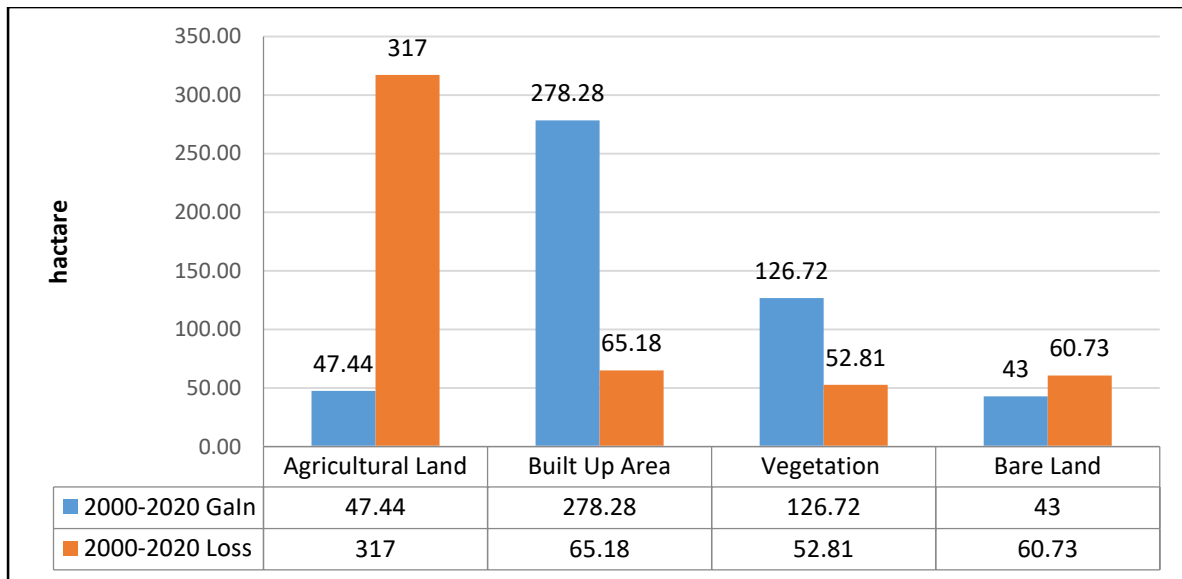


Figure 4-5: LULC Transformation from 2000 to 2020

As above figure 8 result shown from 2000 to 2020 maximum loss was agricultural land and the maximum gain was built up area 317 ha and 278.28 ha respectively. Whereas the minimum loss was bare land 60.73 ha and the minimum gain was 43 ha agricultural land.

4.1.7 LULC class conversion to Built-up area in hectares

The LULC conversion to build up area as table 6 and figure 9 revealed that agricultural land converted 13.30 ha, 190 ha and 203.30 ha between the time periods of 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively. This result shown that the conversion of agricultural land to build up area is extremely increased. The vegetation converted 0.40 ha, 45 ha and 45.40 ha between the time periods of 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively. This indicates vegetation to build up conversion is increased time to time. Bare land to build up converted 6.58 ha, 23 ha and 29.58 ha between the time periods of 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively. it is less converted relatively from others.

Land use/land cover	2000-2010		2010-2020		2000-2020	
	Area (ha)	percent	Area (ha)	percent	Area (ha)	percent
Agricultural land to build up area	13.30	66	190	74	203.30	73
Vegetation to built up area	0.40	2	45	17	45.40	16
Bare land to built up area	6.58	34	23	9	29.58	11
Total	20.28	100	258	100	278.28	100

Table 4-2: LULC class conversion to Built-up area in hectares

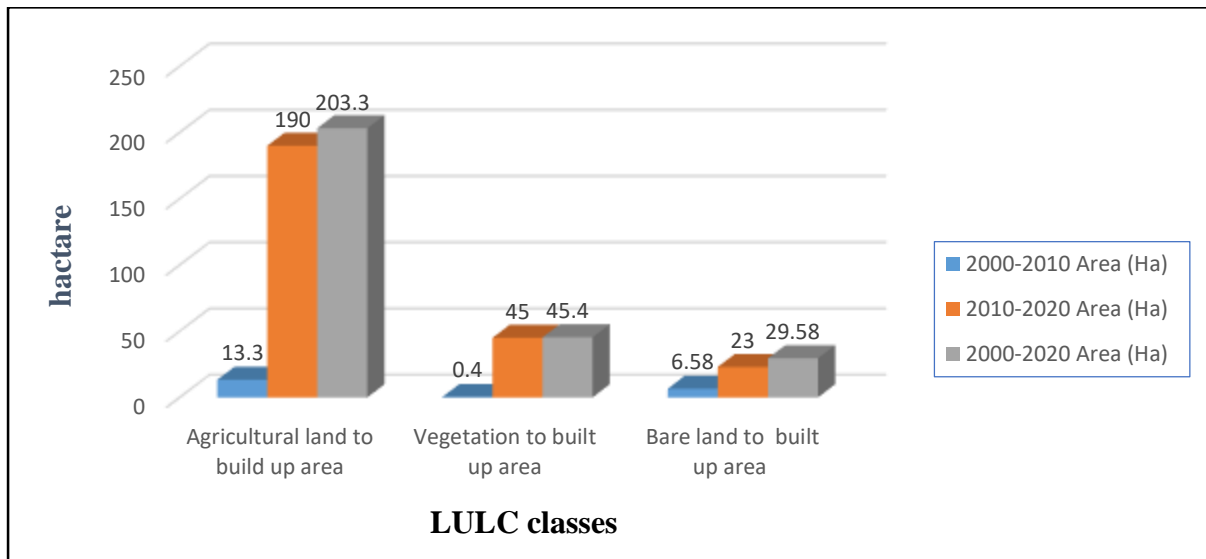


Figure 4-6: Others LULC conversion to built up area

4.1.8 Built up proportion in the reclassified image of Adet town

In order to visualize and examine the spatial expansion of the built up areas during the three time periods, the LULC map was reclassified into built up and non-built up area (figure 4.7). The main focus of this study was assessing the effects of urbanization on agricultural land and examining the spatial extents of built up areas within the three study periods. To achieve this, a reclassification was made to generate land use and land cover maps of built up and non-built up areas as shown in figure 10 below. These maps show a clear pattern of increased urban expansion prolonging both from urban center to adjoining non-built up areas along major transportation corridors. The maps show the spatiotemporal urban growth pattern in the study area. As clearly seen in table 7, the proportion of built up areas in 2000 was 19.95% of the entire study area. In 2010 the percentage of built up areas showed less than from the previous 3.17% and it was 16.78 % and in 2020 it reached to 27.14% of area coverage. Non-built up areas were 80.05%, 83.22% and 72.86% during the time period of in 2000, 2010 and 2020 respectively. As this result shown built up area coverage in 2010 decreased by 3.17% from 2000, as the information obtained from interview respondents which was occurred due to regulation of informal settlements in Adet town peripheral areas. But from 2010 to 2020 increased by 10.36% mainly for residential house construction and its related infrastructures and other socio-economic contributing factors such as grow and transformation plan, asphalt and gravel road construction etc. The detail discussed below.

Land cover class	2000		2010		2020	
	Area (ha)	percent	Area (ha)	percent	Area (ha)	Percent
Built up areas	422	19.95	355	16.78	574	27.14
Non built up areas	1993	80.05	1760	83.22	1541	72.86
Total area (ha)	2115	100	2115	100	2115	100

Table 4-3: Built up proportion in the reclassified image of Adet town

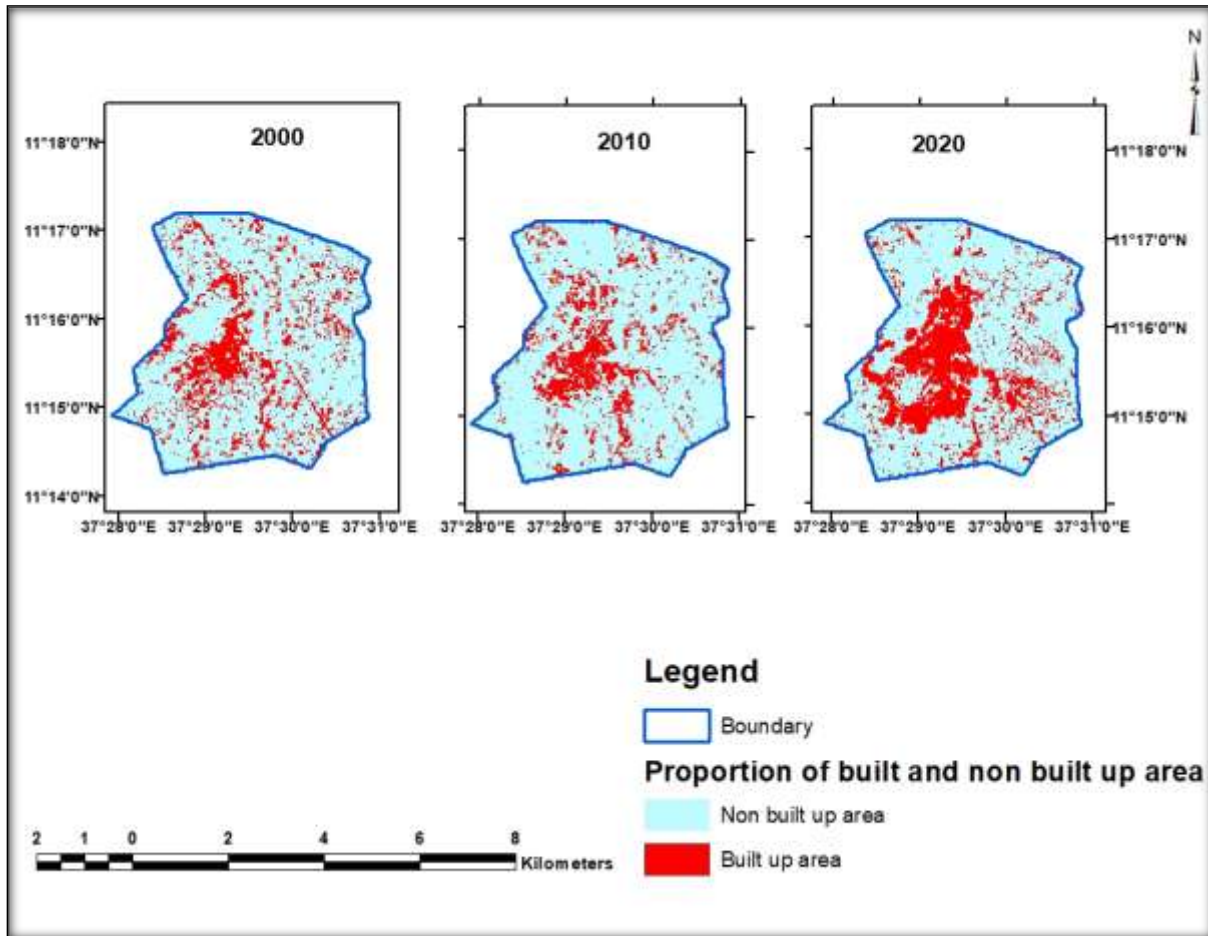


Figure 4-7: Built up and none built up areas for 2000 (left), 2010 (middle) and 2020 (right) respectively.

4.1.9 The major trigger factors for horizontal expansion of the study area

The analysis based on 35 conducted an interview with 6 municipality officials, 12 well known educated households, 5 urban kebele's work managers, 5 peripheral rural kebele's work managers, 7 old indigenous households by purposive sampled which was critical case sampling to get the most relevant information on open ended interviewee. This survey method was very important to assess on the ground regarding socio-economic contributing factors of urban expansion in Adet town setting and its periphery area.

4.1.9.1 Backgrounds of the respondents

No	Age	Sex		Percent (%)
		Male	Female	
1	25-35 years of old	10	4	40
2	35-45 years of old	5	4	25.7
3	45-55 years of old	3	2	14.3
4	55-65 years of old	5	1	17.14
5	Above 65 years of old	1	-	2.86
Total		24	11	100

Table 4-4: Age and sex of the respondent's

As above table 8 shown the proportion of respondents were male 69% and female 31%, this indicated much of them younger.

Educational level	Frequency	Percent (%)
Grade 8-12 class	7	20
Diploma	14	40
Degree	12	34.29
MSc and above	2	5.71
Total	35	100

Table 4-5: Educational level of respondents

As above table 4.5 shown most respondents were well educated. Among this 80% of respondents have college diploma and above and the remaining 20% were educated up to grade 8 to 12. For this study purpose respondents was selected purposively by this criteria to get accurate answers of the prepared open ended interview check list.

4.1.9.2 Factors that contributes to Adet town expansion

An interview conducted result shows there are number of factors contributing to the horizontal expansion in the peripheral areas of the study area. The conducted 35 interview response result revealed that the major contributing factors of horizontal expansions in Adet town, put orderly in the following ways:

No	Contributing factors of Urbanization	Reponses	
		Number	Percent
1	Increasing the demand of residential houses	21	60%
2	Growth and transformation plan	17	49%
3	Asphalt and Gravel road construction	16	46%
4	Rural urban migration	14	40%
5	Demographics	13	37%
6	Reclassification	12	34%
7	Supportive housing policy	10	29%
8	Informal construction of housing	9	26%

Table 4-6: Factors of horizontal expansions in Adet town

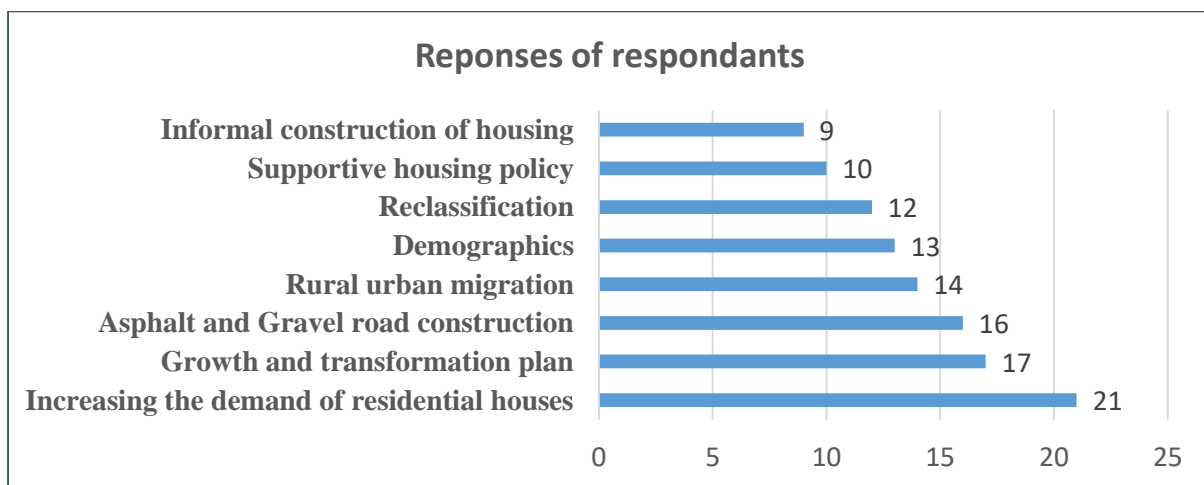


Figure 4-8: Contribute factors of horizontal expansion

The main determinant factor for urban expansion in all sampled in Adet town was increasing the demand for residential house of the dwellers and the municipality has been given the request organized by syndication for housing association. The second factor is the growth and transformation plan (GTP). It encourages expansion of micro and small enterprises, expansion of education institutions and health stations. Such as southern part of Adet constructed one hospital and one high school and in the eastern part of Adet also constructed high school. In addition to this in the center of Adet town constructed high rise buildings organized by different axon and from one market place added two other market places in the northern and southern in part. The third main factor for urban expansion was asphalt and gravel road construction. Due to this informal settlement occurred specially follows asphalt road Adet town to mota and Adet town to Bahir Dar and gravel road Adet to gosheye birr-gebiya and Adet to Agta. The fourth factor was rural-urban migration. Immigration was a major contributor to the increase in the population of a place. Due to rural-urban migration population of Adet increased time to time and now increasing quickly by pulling and pushing

factor. Search for daily job and employment, better quality of life in terms of health and education, the choice of basic town infrastructures are grouped as pull factors. On the other hand, migrants influenced in the interpretation of town life in success story of relatives previously moved to town and rural poverty considered as push factors.

The fifth factor is demographics that mean high birth and low death rate. The rate of death and births characterizes the natural expansion of an area. In areas where births are more than the deaths, the population is bound to increase. The sixth factor was reclassification of the former rural settlement and including the town administration boundary and changed new urban settlement. The seventh factor was supportive housing policy. In addition to the above seven factors, as the interviewee replied, there are informal constructions of houses in Adet town due to the expansion of the town; the farmers construct houses on their farm lands to protect their land from government influence.

4.1.10 Impacts of urbanization in Adet town

As the interview respondents information obtained the impacts of urban expansion is both positive and negative. The negative effects are loss of agricultural land, displacement of peoples, housing problem, service provision problems, environmental pollution and expansion of crime. Positive effects are creation of job opportunity, electric power and health access, transportation and education services and advance in communication and etc.

4.1.10.1 Negative Impacts of Urbanization in Adet town

The higher horizontal expansion of urban zones in Ethiopia leads to greater demand for land around the peripheral areas for different buildings and this, in turn, causes loss of agricultural land, natural beauties and rangelands (Meles and Vanum, 2012). As pointed out Dayong, (2004), uneven urban expansion will occupy considerable valuable farmland around urban centres, which becomes a source of conflicts with the farmers who are displaced from their farmland. Similarly, Fikadu, (2021)urban expansion leads to the loss of agricultural and forest land with valuable ecological functions. According to Adugna, (2016), urban expansion led to a loss of farmland and displacement of the households who had been involved in farming activity. Urban expansion is a cause for the decline of natural assets and mainly agricultural land, causing inadequate food, poor nutrition and poor health.

The expansion of the Adet town has several negative consequences on the surrounding physical and human environments. According to the interview respondents, these negative effects are loss of agricultural land, displacement of people from their original area, housing

problem, environmental pollution and expansion of crime. In addition to these problems of service provision associated with urban expansion is another factor. According to the interviewee, due to geographical configuration and number of population of the town it was difficult to conduct different services like education, health, water and other facilities.

Negative impacts	Frequency	Percentage
Loss of agricultural land	14	40
Displacement of people	9	26
Housing problem	4	11
Problems of service provision	3	9
Environmental pollution	3	9
Expansion of crime	2	6
Total	35	100

Table 4-7: Negative Impacts of Adet Town Expansion Sources: field survey (2022)

According to the respondents obtained information loss of agricultural land is the major impacts of urban expansion in study area that is 40%. The next was displacement of peoples from their original area 25.71%. As shown the above table the remaining negative effects of urban expansion were housing problem 11.43%, Problems of service provision 8.57%, environmental pollution 8.57% and expansion of crime 5.71% from the total interviewee. The loss of agricultural land due to urban expansion also results and land use change of the surrounding people. The peoples particularly farmers in the surrounding Kebeles are highly affect by this problem.

The other most impact was displacement of people from their original and due to urban expansion. The rural peoples that found on the surrounding of the town forcedly displace from their original land and they gave their land and their resource freely or in a low compensation to others. This result the surrounding peoples on poverty according to the interview respondents. Some respondents suggest that the other major factor that results from urban expansion is environmental pollution and housing problem. They states two rivers (such as shina and shigeth) are mostly affected or polluted by these urban expansion. The people carry their waste to these rivers and consequently these rivers were out of home consumption. The housing problem is one of a major consequence which results from high rural to urban migration and high land value according to the respondents.

Crimes would intensify in every corner of the town, slams, robbery and theft would which may complicate with business activity in the formal sector and even attract the market and weaken the others. Illegal construction of houses to accommodate the incoming people and would accelerated pressure on public utilities like health, schools water supplies...etc that would alarmingly increase and so forth.

4.1.10.2 Positive Impacts of Urban Expansion in Adet town

The expansion of urban area has many advantages for the society of Adet town as well as for surrounding peoples. These advantages are Creation of job opportunity, Electric power and health access, Transportation and education services and Advance in communication.

Positive impacts	Frequency	Percentage
Creation of job opportunity	13	37.14
Electric power and health access	11	31.43
Transportation and education services	7	20
Advance in communication	4	11.43
Total	35	100

Table 4-8: Positive impacts of Adet town expansion Sources: field survey (2022)

According to the respondents obtained information the largest advantage in urban expansion is to creation of job opportunities 37.14%. The next was electric power and health services 31.43%, the third transportation and educational services 20% and the last was advance in communication 11.43%. In the same manner the respondents suggested that the positive consequence of urban expansion is creation of job opportunity for unemployed youth and other age group populations of the town as well as for peoples in surrounding area. The creation or expansion for all type of infrastructure in the town employs some unemployed people as a permanent or daily paid workers and this supports their living conditions.

Adet town has electric power supply for 24 hours from chis-abay hydroelectric power station. This power is not only shared for the town dwellers, but some surrounding rural peoples also use it from the town such as Adet hana, Fisleta Debir Mariam and Ribrib Gebrial.

5. Chapter Five

5.1 Discussion

Change detection studies were showed that urban expansion in the town peripheral area. This urban expansion and land use changes in the town were converting Agricultural land into nonagricultural land in the alarming ways. This study has using Landsat image detection result revealed that agricultural land loss and changed to built up area and its interrelated infrastructures. From 2000 to 2010, 2010 to 2020 and 2000 to 2020 decreased 13.30 ha, 190 ha and 203.30ha respectively. In addition to this vegetation 0.4 ha, 45 ha, and45.40 ha and bare land 6.58 ha, 23 ha and 29.58 ha converted to built up area from 2000 to 2010, 2010 to 2020 and 2000 to 2020 respectively. According to this result the most affected LULC change was agricultural land.

The coverage of agricultural land was decreased 2% from 2000 to 2010 and 13% from 2010 to 2020 and 15% from 2000 to 2020 due to transformations of other land use. Earlier studies also support the finding of the current research such as Kassahun, (2016), a study conducted in Bahir Dar city shows built-up area was increasing by 38% (634 ha) in the period 2000 to 2016. Hence, the land-use change would result in numerous negative consequences such as loss of prime agricultural farmland. Sathiamurthy, (2008) also showed a large productive agriculture area in Penang Malaysian was converted due to the construction of new infrastructural development or built-ups. Thus, due to rapid urban expansion, agricultural land has become scarce and many people moved to another area.

Eyaya, (2014) according to him the rate of urban expansion over the agricultural land use is 113.32 km² within 33 years interval changes from 1966 to 1999 and 106.26km² within 5 years intervals changes from 1999 to 2004 in Gondar city. He generally, concluded that the higher rate of urban expansion, leads to the higher loss of agricultural land. Similarly Shahab, (2000) studied urbanization is reducing the supply of high quality agricultural land and it's resulting in heavy losses of fertile agricultural land in Saharanpur city, in India between 1988 and 1998.

From 2000 to 2010 Built up area decreased by 2% because of irregular settlements to change regularization and from 2010 to 2020 increased by 9%. This result supported by Ayele, (2014), according to him the built-up area increased six fold (about 3000 ha) and about 88% of the gain in built-up area was from conversion of agricultural lands from (1984 to 2014) in Mekelle city and Bayan et al, (2011) studied result revealed the central part of Jordan in japan,

built up areas increased 86 km² from 1987 to 1999 and 134 km² from 1999 to 2005, showing an expansion of built up areas of 220 km² from 1987 to 2005.

In contrast, agricultural land occupied about 205 km² in 1987, decreased to 115 km² in 1999 and then to 106 km² in 2005, indicating a decrease of 99 km² from 1987 to 2005 and Other study result revealed in Debre Tabor town from 1997 to 2017, the amount of urban or developed land increased from 8.12% to 52.4% of the total area, while agriculture land, plantation, water body and pastureland decreased from 91.88% to 47.6% from the entire study area (Afera H., et al 2018). He concluded that the urban (highly built-up) area increased dramatically. Inversely, agricultural land, decreased obviously from the period of 1997 to 2017. Those all researches agreed within the results of this study, agricultural land loss due to urbanization (urban expansion).

As information obtained from interview respondents the socio-economic contributing factors of urban expansion was increasing the demand for residential house of the dwellers, growth and transformation plan (GTP), asphalt and gravel road construction, rural-urban migration, demographic dynamics and reclassification of the former rural settlement into new urban settlement (which is mainly occurred three peripheral rural kebeles Adet hana, Fisleta Debir Mariam and Ribrib Gebriel), supporting housing policy and informal settlement. This result supported as the following.

According to Gyabaah et al, (2006), migration mostly occurred by push and pull factors though varied in extent and motivational factors bringing people towards the urban areas. Reclassifications of the rural areas being as part of an administrative body to the urban municipalities are another cause for population increase in cities as (Drencher & Laquinta, 2002). According to UNFPA, (2014) urban expansion is increasing in the number of people living in the town. According to Jongkory (2009), the intervention of central government for instance through public policy such as large scale infrastructure development which aims to reduce congestion in inner zone of city is the primary driving force for the growth of urban centers. Accordingly, large parts of predominantly agricultural lands have therefore converted to residential, commercial, industrial and other urban land use purposes. Other study concluded that uncontrolled urban Population growth is other factors for the spontaneous development of urban fringes as (Ergando, 2011). Because of the lack of appropriate land use planning and the measures for sustainable development, uncontrolled urban growth has been creating severe environmental consequences.

In the study area did not conduct similar studies. Hence this study was assessed the effects of urbanization on agricultural land in the town of Adet. The results clearly shows that there was an increase in urban expansion and agricultural land has been converted in to built-up areas due to the increase in urban activities. Currently, ongoing urban expansion and strong population growth, the town of Adet needs to consider smart growth policies to encourage the effective and efficient use of newly developed urban land-use of established land. This study noted that, the expansion of the built-up areas is predominantly at the expense of Agricultural land. The limitations of the study was interpretations of spectral signature of features, some reactance of the interviewees to give reliable information and using Landsat images in some extent within its low resolution. This study can be contributed to the government especially Adet town municipality and surroundings of Adet town wereda (yilmana densa wereda), so collaboration to the zonal, regional and within other respected authority to ensure the developmental plans in certain areas other than very productive and fertile agriculture land, strengthen the zoning regulation and enact policies to reduce agriculture land losses and reclassification of the peripheral rural kebeles being as part of an administrative body to the town municipality. The finding of this study will also be significant in providing realistic information and initial input for urban planning experts, governmental and non-governmental organizations and other researchers.

6. Chapter Six

6.1 Conclusion and Recommendations

This study has been carried out to assess the impacts of urbanization on agricultural land in Adet town using remote sensing and GIS technique. This study was detected LULC change based on Landsat satellite image were applied to generate land cover maps through a maximum likelihood supervised image classification algorithm. Landsat imageries of 2000, 2010 and 2020 were utilized to follow the effects of urbanization on agricultural land in the study area through analysis of LULC changes during these periods.

6.1.1 Conclusion

Urbanization has its own negative impact on agricultural land. Results had been revealed that in the study area LULC was occupied by agriculture, which covers 66%, 64% and 51% in 2000, 2010 and 2020 respectively. As this result shown from 2000 to 2010, 2010 to 2020 and 2000 to 2020 agricultural land loss 42.3 ha, 274.95 ha and 317.25 ha respectively. The coverage of agricultural land was decreased 2% from 2000 to 2010 and 13% from 2010 to 2020 and 15% from 2000 to 2020 due to transformations of other land use. Earlier studies support this finding as shown in the discussion part at the above.

However built up coverage in was 29%, 27%, and 36% in 2000, 2010 and 2020 respectively. Hence 2000 to 2010 the built up area decreased by 2% as interviewer information obtained because of irregular settlements made regularization by the municipality especially in the southern and eastern direction of the town. Whereas from 2010 to 2020 built up area increased by 9% due to high residential house and its related infrastructure constructed in the peripheral of the study area and from 2000 to 2020 increased by 7%.

As classified Landsat image result indicated that vegetation coverage 2%, 5% and 8 % in 2000, 2010 and 2020 respectively. This result shown from 2000 to 2010 and 2010 to 2020 increased by 3% and from 2000 to 2010 increased by 6%. Similarly bare land coverage increased 3%, 4%, 5% in 2000, 2010, and 2020 respectively. So, this result revealed that increased in the three LULC classes rather than the affected agricultural land during in the study period of time.

As respondent's information obtained from interview the trigger socio-economic contributing factors of Adet town expansion was the demand of residential houses of the dwellers increasing, growth and transformation plan, asphalt and gravel road construction, rural-urban migration, demographic dynamics and reclassification of the former rural settlement into

urban settlement. Reclassification of the former rural settlement in new urban settlement especially it occurred eastern and southern part of Adet Adet-hana, Ribrib-Gebriel and fisleta deber mariyam respectively.

From obtained respondents information the impacts of urban expansion is both positive and negative. However for the purpose of this study more emphasis negative impacts. Negative impacts were loss of agricultural land, displacement of peoples, housing problem, service provision problems, environmental pollution and expansion of crime. The classified Landsat images overall accuracy assessments have been gotten 85% in 2000, 87% in 2010 and 89% in 2020.

In the study area horizontal urban expansion was increased rapidly. Due to this more agricultural land from the peripheral rural kebele area was required and included in the town administration boundary. As a result of a sharp decrease agricultural land, it threatens the livelihood of the farming communities. In addition to this urban expansion of the town (both built-up and non-built-up) has destroyed fertile agricultural land which cannot be recovered and the study area is losing agrarian characteristics. Therefore, to prevent the loss of these fertile and very productive agricultural lands against the rapid horizontal expansion of town, effective land use and land management strategies should be strongly encouraged. Furthermore, a sound policy at the local level is urgently needed. This policy should give attention to public participation and inclusiveness, not only to facilitate approval of the plan but also to help oversee the effects of the implemented development plan on the local communities.

6.1.2 Recommendations

Impacts of horizontal urban expansion include not only the loss of agricultural land but also displacement of peasants and change of their livelihood to this effect, many peoples were displaced in the periphery of Adet town especially in the east, west and south direction because of residential house and related infrastructure constructed.

There is a need to plan for balanced physical urban growth and its impact on fertile and very productive agricultural land in Adet town. Urban planning authorities and town planners should think about the future growth of the town and should understand the consequence of uncontrolled horizontal expansion and uncontrolled loss of fertile and very productive agricultural land for the high needs of residential house construction and public service and related infrastructure supply.

The urbanization and socio-economic contributing factors were not studied in the context of Adet town. However these factors can help decision makers and urban planners to gain a deeper and clearer understanding of urban expansion for setting efficient policies based on real needs and put alternative solutions of the loss of fertile and very productive agricultural land in the study area.

Due to this I recommended the following:-

- ❖ Adet town municipality and Yilmana Densa Wereda agricultural office should be give attention to prevent the loss of fertile and very productive agricultural land for the ongoing horizontal urban expansion.
- ❖ Yilmana Densa Wereda agricultural office and Adet town municipality collaboration within the regional government especially urban development and housing construction bureau should enact policies and regulations regarding the conversation of fertile and very productive agricultural land to urban land use.
- ❖ Instead of new housing development on the peripheral areas of fertile and very productive agricultural land, renewal of older buildings and infill development of high rise buildings to meet the demands and needs of the increasing number of population in the town. In addition to this construction of condominium houses is another solution and Adet town municipality see it as alternative rather than focusing horizontal expansion.
- ❖ The respective government authority should be put restrictions about horizontal expansions of towns not only the study area but also others depend on peripheral agricultural land fertility and productivity.

6.1.3 Areas of further study

So far, many researches have been done on urban expansion in globally, even if in Ethiopia. But in the study area especially the extent, magnitude and potential effects of urban horizontal expansion on agricultural land has not been investigated. In addition to this not focused the loss of fertile and very productive agricultural land due to urbanization. Therefore, I suggested that researchers will be done this on issues again and again because the problem is huge.

7. References

- Gajbhiye.S. and Sharma.K. , 2002. Land Use and Land Cover Change Detection of Indra River Watershed through Remote Sensing Using Multi-Temporal satellite Data. *International Journal of Geomatics and Geosciences*, Volume Vol. 3, pp. No. 1, pp. 89-96.
- Meles and Vanum, 2012. GIS and Remote Sensing Based Urban Sprawl Detection and its Implications on Sustainable Development.. pp. 2 (9), 454-455. .
- Abdissa, F., 2005. Urban Expansion and the livelihood of the peri- Urban Agricultural community. The case of Addis Ababa.
- Achamyeleh, 2014. The Challenges of Land Rights in the Peri-Urban Agricultural Areas of Ethiopia in the Era of Urbanization: A Property Rights Approach. Institute of Land Administration, Bahir Dar University. Conference `on Land Policy in Africa. November 11-14, 2014, Addis Ababa, Ethiopia. .
- Adugna, E., 2016. Livelihood Strategies and Food Security in Wolayta, Southern Ethiopia: The Case of Boloso Sore District. Haramaya University.
- Afera Halefom, Asirat Teshome, Ermias Sisay, Imran Ahmad , 2018. Dynamics of Land Use and Land Cover Change Using Remote Sensing and GIS: A Case Study of Debre Tabor Town, South Gondar, Ethiopia. *Journal of Geographic Information System*, Volume 10, pp. 165-174.
- Alaci, D., 2010. Regulating Urbanization in Sub-Saharan Africa through Cluster Settlements:.
- Alqurashi, A. F., 2013. Investigating the Use of Remote Sensing and GIS Techniques to Detect Land Use and Land Cover Change. *Advances in Remote Sensing*, 2(June 2013), pp. 193-204 .
- Al-Shalabi, M. A., Bin Mansor, S., Bin Ahmed, N and Shiriff, R., 2006. GIS based multicriteria approaches to housing site suitability assessment.. In XXIII FIG Congress, Shaping the Change, Issue October, p. 8–13.
- Anderson.J.R.,Hardy.E.E,Roach J.T.,and Witmer R.F, 1976. A land use A land cover classification system for use with remote sensing data. *geological survey*, Volume N.964,u.s.
- Angel, S., Parent.J. , Civco.D. L., Blei.A. , and Potere.D., 2011. The dimensions of global urban expansion: 2000-2050. ... estimates and projections for all countries, 2000-2050, Volume *Progress in Planning* 75 (2), p. 53–107.

Araya, Y., 2009. Urban Land Use Change Analysis and Modelling: A Case Study of Setúbal and Sesimbra, Portugal.. Thesis: Master of Science in Geospatial Technologies, Institute for Geoinformatics, University of Münster, Germany.

Ayele, A., 2017. The dynamics of urban expansion and land use/land cover changes using remote sensing and spatial metrics: the case of Mekelle City of northern Ethiopia. INTERNATIONAL JOURNAL OF REMOTE SENSING, Volume 38, NO. 14, p. 4107–4129.

Bah, M et al, 2003. Changing Rural-Urban Linkages in Mali Nigeria and Tanzania, Environment & Urbanization. pp. 15 (1): 1-24.

Bank, W., 2014. Global Monitoring Report 2013: Rural-Urban Dynamics and the Millennium Development Goals. The World Bank. Washington, DC..

Basudeb B.,2011 and Bouque M., 2000. Remote Sensing and GIS ,from (peg 361_378). Policy option for urban agriculture, Volume 2nd edition textbook.

Bayan Alsaaidh1*, Ahmad Al-Hanbali1 and Ryutaro Tateishi1 , 2011. Assessment of Land Use/Cover Change and Urban Expansion of the Central Part of Jordan Using Remote Sensing and GIS. Center for Environmental Remote Sensing (CERes), Chiba University.

Bloom, D. E. and Khanna, T, 2007. The Urban Revolution, France and Development. pp. 2-6.

Coppin P, Jonckheere I, Nachaerts K, Muys B, Lambin E , 2004. Digital change detection methods in ecosystem monitoring:. Volume a review. Int J Remote Sens 25:1565-1596.27.Boakye E,Odai N,Adjei A,Annor O (2008).

CSA, 2008. Population statistical abstract. , Addis Ababa: Ethiopia: Federal Democratic Republic of Ethiopia, Population Census Commission.

Dayong, N., 2004. Several acute issues in china's urban planning.

Deka, J., 2010. Urban growth trend analysis using Shannion Entropy approach.A case study in North. East India,International Journal of Geometrics and Geosciences, Volume vol2.

Diyamett, 2003. Changing Rural-Urban Linkages in Mali Nigeria and Tanzania, Environment & Urbanization. pp. 15 (1): 1-24.

Doos, B., 2002. Population growth and loss of arable land. Global Environmental Change.Human and Policy Dimensions 12 (4), 303–311.

- Doygun, H., 2009. Effects of urban sprawl on agricultural land: A case study of Kahramanmaraş, Turkey: *Environmental Monitoring and Assessment*, 158, 471-478.
- Drencher, A. W. & Laquinta, D. L. , 2002. Urbanization - Linking Development across the Changing Landscape Final Draft ROME January 18, 2002.
- Efrem, 2007. Urban and peri-urban development Dynamics in Ethiopia.
- Eyasu, S., 2007. The Impact of Urban Expansion On the Livelihood of Peri-Urban Farming Communities in Alamgena Town; Msc. Thesis Addis Ababa University, Addis Ababa, Ethiopia..
- Eyaya.B., 2014. Impact of Urban Expansion on the Agricultural Land Use a Remote Sensing and GIS Approach: A Case of Gondar City, Ethiopia. *INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT*, Vol 3(6).
- Fekadu, T., 2015. Urban Expansion and Its Effects on the peripheral farming community. Hossana Ethiopia.
- Feleke, T., 2004. Urban Development and the displacement of rural communities around Addis Ababa', in Pankhurst, Alula and Piguet Francois (eds.) *People, Space and the State: Migration, Resettlement and Displacement in Ethiopia*, Proceedings of the Workshop held.. The ESSWA and the UNEUE. Addis Ababa.
- Fikadu, M., 2021. Analysis of urban horizontal expansion and its impact on the surrounding land using GIS and remote sensing: a case of Werabe town. Volume 1.
- Foody, G. M., 2002. Status of land covers classification accuracy assessment. *Remote Sensing of Environment*, Volume 80(1), p. 185–201.
- Foody, G. M., 2002. Status of land covers classification accuracy assessment.. *Remote Sensing of Environment*, Volume 80(1), p. 185–201.
- Glenn, A., 2004. Urbanization of the Non-Farm Population. A Research Note on the Convergence of Rich and Poor Nations". Koninkhijke Brill NV. Leiden..
- Group, W. B., 2016. Ethiopia Economic Update: Why So Idle? Wages Employment in a Crowded Labor Market. The World Bank, Washington DC.

Gyabaah, K. N., Beall, J. and Fox, S., 2006. Urban Poverty and Development in the 21st Century Development Studies Institute, London School of Economics..

Hope Sr.K.Roland and le korwe H. Mogopodi , 1999. Urbanization and the Environment in Southern Africa: Towards a managed Framework for the Sustainability of cities .. London, Rutledge.. Journal of Environmental Planning and Management, p. 42 (6).

Indris, Abdella and Nuredin, 2020. economic linkage between urban development and livelihood peri-urban farming communities in ethiopia (policies and practices). agricultural and food economics.

Kashem, M., 2008. Simulating Urban Growth Dynamics of Dhaka Metropolitan Area: A Cellular Automata Based Approach. Master's Thesis, Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh.

Kassahun, T., 2018. The Impact of Urban Expansion on the Livelihood of Farming Communities in Peri-Urban Area of Bahir Dar City Amahara, Ethiopia. Economics and Sustainable Development , Volume Vol.9, No.9.

Kumar, T. a. R. ., U., 2004. Geographic Resources Decision Support System for Land Use, Land Cover Dynamics Analysis,” Proceedings of the FOSS/GRASS Users Conference. Bangkok, s.n., pp. pp. 2365-2401.

Leulseged Kasa , Gete Zeleke, Dawit Alemu, Fitsum Hagos and Andreas Heinemann, 2011. impact of urbanization of addis ababa city on peri-urban environment and livelihoods.

Lu.D., W., 2007. A survey of image classification methods and techniques for improving classification performance. international Journal of Remote Sensing.

Marshall, F., L. Waldman, H. MacGregor, L. Mehta and P. Randhawa , 2009. On the Edge of Sustainability:. Perspectives on Peri-urban Dynamics, Volume STEPS Working Paper 35, Brighton: steps Centre.

Minwuyele, M., 2004. City Expansion, Squatter Settlements and Policy Implications in Addis Ababa: The case of Kolfe keranio sub-city M.A thesis, Addis Ababa University.

MoFED, 2006. A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005/06-2009/10). Building on Progress, Volume Volume I.

- MUDHO, 2015. Urban Development Spatial Planning (Addis Ababa).
- Murayama.Y. and Thapa.B. , 2009. Urban Mapping, Accuracy, & Image Classification: A Comparison of Multiple Approaches in Tsukuba City, Japan. Applied Geography, Volume Vol. 29, pp. No. 1, pp. 135-144.
- Nagarajan and Poongothai, 2012. Effect of Land Use/ Land Cover Change Detection of Ungauged Watershed. World Applied Sciences Journal, Volume Vol. 17, pp. No. pp. 718-723.
- Nations, U., 2019. World Population Prospects 2019: Highlights. Department of Economic and Social Affairs, Population Division, (ST/ESA/SER.A/423).
- Nsiah-Gyabaah, K., 2004. The changing urban-rural interface of African cities. Environment and Urbanization, Issue definitional issues and an application to Kumasi, Ghana, pp. 16(2), 235-248..
- Pankhurst, R., 1985. History of Ethiopian Towns from the Mid-Nineteenth Century to 1935. Wiesbaden: Franz Steiner Verlag.
- Ramachandra and Kumar, 2004. "Geographic Resources Decision Support System for Land Use, Land Cover Dynamics Analysis," Proceedings of the FOSS/GRASS Users Conference, Bangkok pp. 2365-2401..
- Redman, C. L., & Jones, S. N., 2004. The Environmental, Social, and Health Dimensions of Urban Expansion, Produced for a Population-Environment Research Network cyberseminar, 29, November – 15 December 2004.. p. 3.
- Rogan and Chen, 2004. Remote Sensing Technology for Mapping and Monitoring Land-Cover and Land-Use Change. Progress in Planning, Volume Vol. 61, No. 4, 2004., pp. pp. 301-325..
- Ruiz, N., undated: 5. Urbanization in the regional periphery of central Mexico.
- Shahab, F., 2000. Urban expansion and loss of agricultural land – a GIS based study of Saharanpur City, India. Environment&Urbanization, Volume 12 No 2, pp. 133-135.
- Simon, D., McGregor, D., and Nsiah-Gyabaah, K. , 2004. The changing urban-rural interface of African cities: definitional issues and an application to Kumasi, Ghana. Environment and Urbanization, Volume 16(2), pp. 235-248.

Solomon et al, 2006. Removing limitations of current rural land policy and land administration. the World Bank, Washington D.C.

Soubbotina, P. T., 2004. Beyond Economic Growth. An Introduction to Sustainable Development. , Volume Second Edition, the World Bank, p. 205.

Tegene, B., 2011. Land-cover/land-use changes in the Dere kolli catchment of the South Welo zone of Amhara region, Ethiopia. Eastern Africa Social Science Research Review. Volume 18(1), 1.20.

Teketel, F., 2015. Urban Expansion and Its Effects on Peripheral Farming Communities (Harmaya university 2015): in hadiya hosaena.

Tsega, G. M., 2020. Urbanization and Development in Ethiopia: Policy Issues, Trends and Prospects.

UN-HABITAT, 2007. State of the World Cities 2010/2011: Bridging the Urban Divide. United Nations Human Settlements Programme, Nairobi, Kenya.

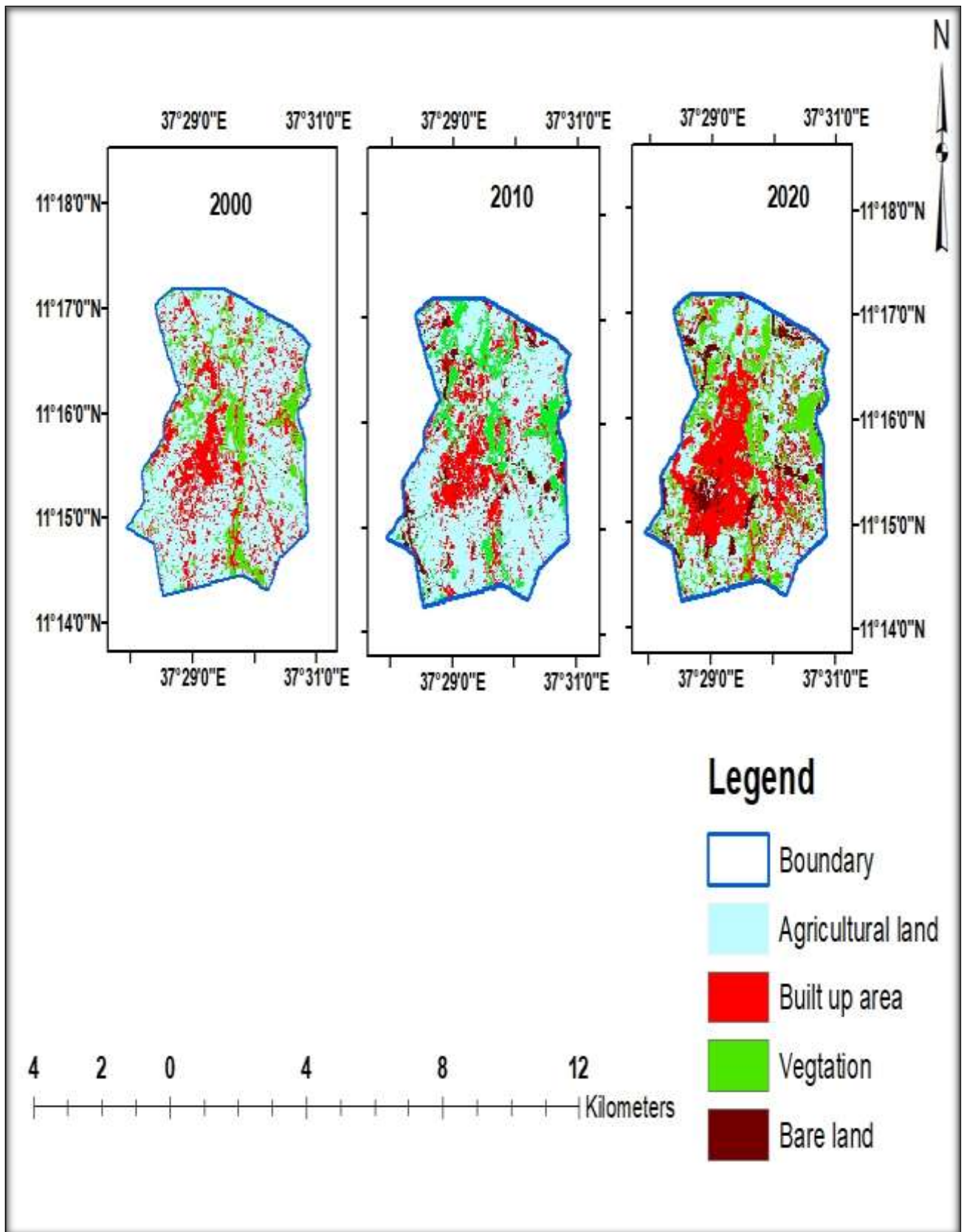
Weng, 2007. A survey of image classification methods and techniques for improving classification performance. international Journal of Remote Sensing.

World Bank, G., 2015. "Ethiopia Urbanization Review: Urban Institutions for a Middle - Income Ethiopia". World Bank Other Operational Studies 22979. The World Bank.

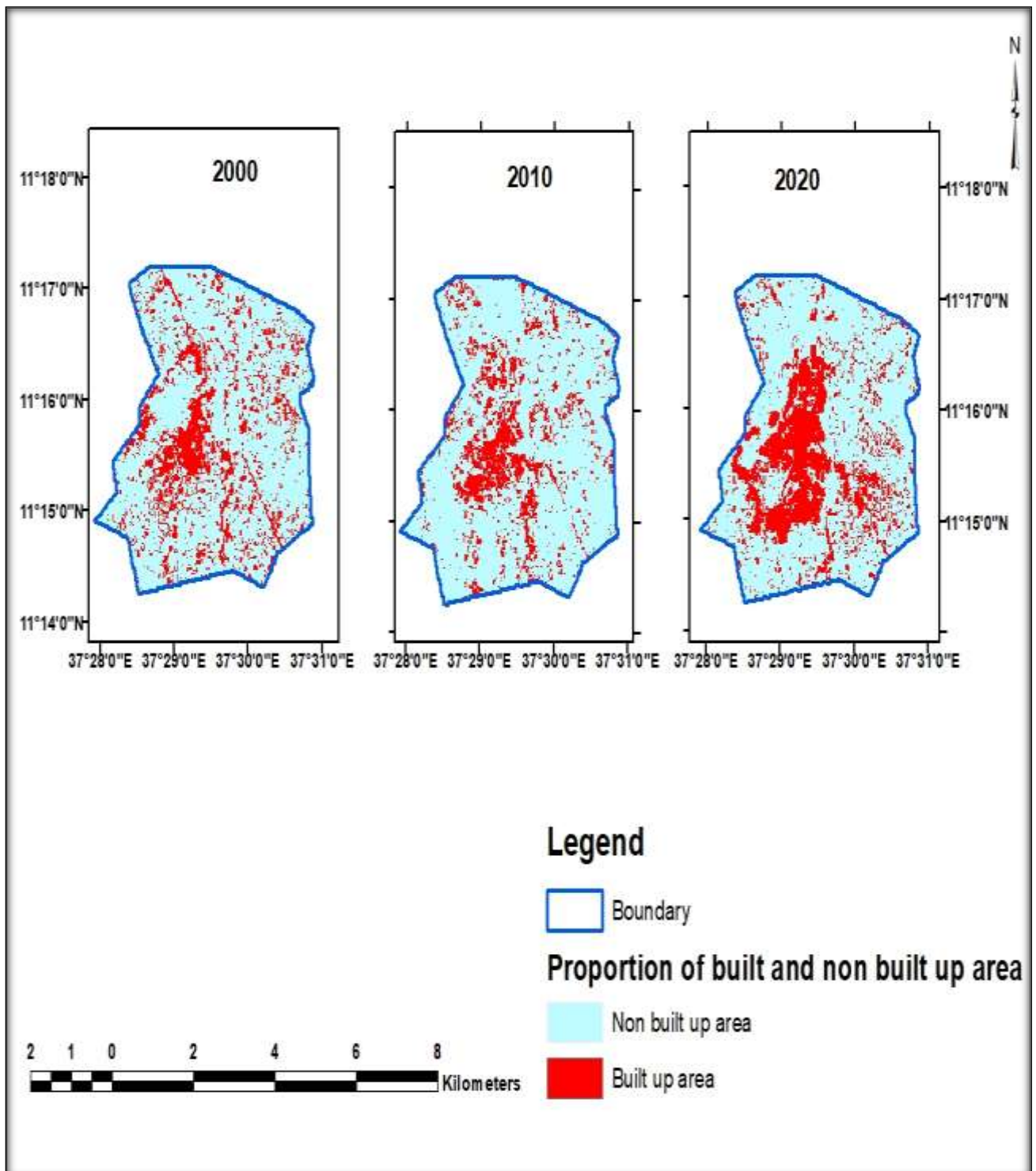
Zhang, 2001. Community features and urban sprawl: the case of the Chicago metropolitan region. , Land Use Policy, pp. 18: 221-232.

Appendixes

Appendix A: LULC maps of 2000, 2010 and 2020 respectively from left to right



Appendix B: Built up and non-built up areas for 2000 (left), 2010 (middle) and 2020 (right) respectively



Appendix C: Appendix C: Ground truth points collected by handheld GPS in 2020

no_	X	Y
1	333698.688	1247293.656
2	333698.688	1247459.006
3	333771.45	1247578.059
4	333619.311	1247680.576
5	333986.429	1247670.655
6	334317.165	1247826.084
7	334452.465	1247959.141
8	334912.49	1247677.269
9	335190.309	1247836.005
10	335077.858	1247961.672
11	335706.258	1247743.408
12	336007.228	1247677.268
13	335841.86	1247386.251
14	335696.336	1247201.058
15	335722.795	1247078.699
16	335600.422	1247078.699
17	335395.366	1247277.12
18	335272.993	1247131.611
19	335144.006	1246959.646
20	335048.093	1246658.708
21	335077.859	1246774.454
22	334737.472	1246977.649
23	334606.129	1246966.965
24	334215.411	1247053.215
25	334039.347	1247230.822
26	334112.109	1246797.603
27	333864.056	1246890.2
28	333797.909	1246774.454
29	334167.461	1246499.972
30	334107.46	1246304.858
31	336243.374	1246057.492
32	336267.502	1246257.71
33	336487.584	1246657.754
34	336950.939	1246657.945
35	336888.971	1246861.758
36	336197.231	1245274.371
37	333676.861	1244922.527
38	334646.845	1243484.372
39	334809.567	1243420.877
40	334821.474	1243611.361
41	333952.299	1243508.183
42	333761.795	1243389.13

43	333741.951	1243182.773
44	334031.676	1243103.404
45	334257.899	1243079.594
46	334801.63	1243119.277
47	335015.947	1243123.246
48	335222.327	1243222.456
49	336365.351	1243210.55
50	334416.652	1243912.961
51	335436.644	1243274.045
52	335504.077	1243611.506
53	335697.492	1243977.906
54	334310.888	1244198.158
55	334631.865	1244396.66
56	334710.346	1245036.023
57	334174.553	1244599.497
58	334099.145	1244385.203
59	333946.369	1244514.165
60	333841.171	1243857.404
61	333987.458	1244097.897
62	333767.184	1244344.453
63	333567.45	1244607.853
64	333297.444	1244877.83
65	333372.446	1245019.395
66	334341.244	1245143.17
67	334674.626	1245214.602
68	334873.068	1245246.349
69	333822.649	1245405.086
70	334309.493	1245582.342
71	334955.09	1245452.706
72	335042.405	1245217.247
73	335015.946	1245050.573
74	334904.819	1244894.482
75	335111.198	1245333.654
76	335232.909	1245386.566
77	335304.348	1245291.324
78	335444.58	1245299.261
79	335351.974	1245495.036
80	335095.322	1245595.569
81	334976.257	1245622.025
82	334886.297	1245680.229
83	334851.901	1245603.506
84	334857.192	1245457.998
85	334754.003	1245579.696

86	334648.167	1245571.759
87	334531.748	1245460.644
88	334354.473	1245661.71
89	334645.521	1245809.864
90	334645.521	1245809.864
91	335275.243	1245659.064
92	335375.787	1245836.32
93	335419.444	1246225.225
94	335022.56	1246288.719
95	334752.679	1246193.478
96	335262.482	1247359.193
97	335650.028	1247326.234
98	335509.932	1247748.171
99	335367.848	1247620.388
100	335410.712	1247677.533
101	335296.409	1247682.295
102	335232.908	1247773.569
103	335238.464	1247647.373
104	334617.473	1247991.038
105	334845.02	1247977.81
106	334918.047	1247977.281
107	333959.6	1246630.295
108	333908.799	1246789.032
109	333920.068	1246948.866
110	333535.728	1247247.626
111	333523.979	1247410.011
112	335462.796	1243114.626
113	335710.451	1243316.222
114	335639.012	1243608.297
115	335604.086	1243746.398
116	335972.394	1243652.743
117	336097.809	1243678.141
118	335277.054	1243424.163
119	334875.408	1243484.483
120	334908.746	1243627.346
121	335113.538	1243721
122	335461.208	1243317.809
123	335494.546	1243422.575
124	335334.205	1243706.714
125	336175.599	1243159.072
126	335858.092	1243628.933
127	332846.142	1243797.195
128	332785.286	1243858.044
129	332932.772	1243934.529
130	332975.914	1243890.737

131	332937.438	1243799.841
132	332844.819	1243814.392
133	332814.391	1243798.518
134	332860.694	1243672.852
135	332977.113	1243711.213
136	333027.44	1243677.934
137	333309.173	1243696.662
138	333301.235	1243795.872
139	333111.862	1243877.787
140	333253.609	1244027.363
141	333202.014	1244097.472
142	333229.796	1244143.77
143	333220.535	1244211.233
144	333315.581	1244174.444
145	333549.948	1244127.895
146	333635.94	1244219.17
147	333567.147	1244031.331
148	333563.178	1243946.672
149	333478.51	1243881.854
150	333447.448	1243797.923
151	333627.452	1243691.37
152	333684.622	1243773.769
153	334326.516	1245839.606
154	334001.072	1245918.975
155	333870.1	1245752.301
156	334437.643	1246707.367
157	335710.318	1245102.803
158	335578.023	1245489.062
159	335578.023	1245743.041
160	335697.635	1246107.304
161	336662.838	1245621.342
162	336985.637	1245679.545
163	337091.472	1245928.233
164	337354.738	1246023.475
165	337262.132	1245805.212
166	337440.73	1245329.002
167	337467.527	1244637.849
168	336403.597	1242985.707
169	335817.495	1243257.968
170	335817.495	1243527.945
171	337043.902	1244072.392
172	336868.612	1244096.202
173	336777.99	1244112.737
174	336668.759	1244107.271
175	336064.833	1247328.169

176	336083.883	1247115.462
177	336045.783	1246975.774
178	335866.391	1246972.599
179	335552.059	1246996.41
180	335458.395	1247185.307
181	336477.592	1247055.142
182	336287.088	1247267.849
183	334952.977	1246840.161
184	334186.992	1246266.592
185	334199.692	1246329.029
186	334238.851	1246379.825
187	334245.201	1246435.912
188	334275.894	1246514.222
189	334290.711	1246596.765
190	334267.427	1246706.822
191	334254.726	1246780.899
192	334326.695	1246750.21
193	334627.268	1246752.326
194	334693.944	1246352.31
195	334587.469	1246264.476
196	334564.053	1246334.57
197	334104.016	1246926.232
198	333902.929	1247118.832
199	333718.775	1247180.21
200	333621.406	1247220.424
201	333809.793	1247313.549
202	334056.919	1247392.917
203	334088.67	1247450.856
204	334160.903	1247502.446

205	334213.291	1247534.193
206	334264.092	1247535.78
207	333972.78	1247515.938
208	334093.432	1247589.751
209	334092.242	1247740.154
210	334161.696	1247773.489
211	334210.513	1247796.505
212	334984.039	1247907.569
213	335257.889	1247922.965
214	335292.144	1247709.605
215	335320.932	1247655.423
216	336485.6	1247233.43
217	336495.125	1247330.788
218	336599.902	1247315.973
219	336786.173	1247215.44
220	336861.317	1247155.12
221	336883.674	1247019.135
222	336704.283	1246963.974
223	336674.804	1247104.388
224	336405.563	1244917.462
225	336704.549	1244840.739
226	337223.143	1244732.269
227	337665.007	1244930.689
228	334266.802	1244277.931
229	335612.237	1244266.025
230	335032.788	1243432.658
231	335182.015	1244025.539
232	333528.334	1244406.508

Appendix D: Details of accuracy assessment

Ground truth

Ground truth is information that is collected on location which the study area. It is especially important in order to relate image data to real features on the ground. The collection of ground truth data enables calibration of remote-sensing data, and aids in the interpretation and analysis of what is being sensed.

Overall accuracy

It represents the percentage of correctly classified pixels Canada center for remote sensing (2010). It is achieved by dividing the number of correct observations by the number of actual observations. It is represented by the following equation National Oceanic and Atmospheric Administration (NOAA), (2008):

$$O = \frac{\sum A}{\sum B} * 100$$

Where, O = Overall Accuracy

A = the number of pixels assigned to the correct class

B = the number of pixels that actually belong to the class

Producer's accuracy

It is a measure of how accurately the analyst classified the image data. It shows what percentage of a particular ground class has been correctly classified. It is calculated by dividing the number of correct pixels for a class by the actual number of reference/ ground truth pixels for that class. Producer's Accuracy is the map accuracy from the point of view of the map maker (the producer). This is how often are real features on the ground correctly shown on the classified map or the probability that a land cover of an area on the ground is classified. The Producer's Accuracy is complement of the Omission Error, Producer's Accuracy = 100% - Omission Error.

User's accuracy

The User's Accuracy is the accuracy from the point of view of a map user, not the map maker. The User's accuracy essentially tells us how often the class on the map will actually be present on the ground. This is referred to as reliability. The User's Accuracy is complement of the Commission Error, User's Accuracy = 100% - Commission Error. The User's Accuracy is calculating by taking the total number of correct classifications for a particular class and dividing it by the row total.

Errors of Omission

An error of omission is reference sites that were left out (or omitted) from the correct class in the classified map. The real land cover type was left out or omitted from the classified map. Omission errors are calculated by reviewing the reference sites for incorrect classifications. This is done by going down the columns for each class and adding together the incorrect classifications and dividing them by the total number of reference sites for each class. A separate omission error is generally calculated for each class. This will allow us to evaluate the classification accuracy and error for each class.

Errors of Commission

Commission errors are calculated by reviewing the classified sites for incorrect classifications. This is done by going across the rows for each class and adding together the incorrect classifications and dividing them by the total number of classified sites for each class. The details of calculations of overall accuracy, user's accuracy and producer's accuracy of 2000, 2010 and 2020 have been described as follows respectively:

Ground truth								
Classified	Land use	Agricultural land	Built up area	Vegetation	Bare land	Grand Total	Commission	User's accuracy
	Agricultural land	69	4	3	5	81	14.81%	85.19%
	Built up area	6	72	2	5	85	15.29%	84.71%
	Vegetation	4	2	48	4	58	17.24%	82.76%
	Bare land	3	1	3	44	51	13.79%	86.27%
	Grand Total	82	79	56	58	275		
	Omission	15.85%	8.86%	14.28%	24.13%			
	Producer's accuracy	84.15%	91.14%	85.71%	75.86%			
	Over all accuracy	84.73%						

Omission:Agricultural land= $13/82*100=15.85\%$ Built up area= $7/79*100=8.86\%$ Vegetation= $8/56*100=14.28\%$ Bare land= $14/58*100=24.13\%$ **Commission:**Agricultural land= $12/81*100=14.81\%$ Built up area= $13/85*100=15.29\%$ Vegetation= $10/58*100=17.27\%$ Bare land= $7/51*100=13.72\%$ **Producer's accuracy:**Agricultural land= $69/82*100=84.15\%$ Built up area= $72/79*100=91.14\%$ Vegetation= $48/56*100=85.71\%$ Bare land= $44/58*100=75.86\%$ **User's accuracy:**Agricultural land= $69/81*100=86.19\%$ Built up area= $72/85*100=84.71\%$ Vegetation= $48/58*100=82.76\%$ Bare land= $44/51*100=86.27\%$ **Over all accuracy**= $(69+72+48+44)/275*100=84.73\%$

Land use	Agriculture land	Built up area	Vegetation	Bare land	Grand total	Commission	User's accuracy
Agricultural land	70	3	8	11	92	23.91%	76.1%
Built up area	4	94	2	3	103	8.74%	91.26%
Vegetation	1	1	56	2	60	6.67%	93.33%
Bare land	2	1	0	26	29	10.34%	89.65%
Grand Total	77	99	66	42	284		
Omission	9.1%	5.05%	15.15%	38.10%			
Producer's accuracy	90.91%	94.95%	84.85%	61.90%			
Over all accuracy	86.62%						

Omission:Agricultural land= $7/77*100=9.10\%$ **Commission:**Agricultural land= $22/92*100=23.91\%$

Built up area=5/99*100=5.05%

Built up area=9/103*100=8.74%

Vegetation=10/66*100=15.15%

Vegetation=4/60*100=6.67%

Bare land=16/42*100=38.10%

Bare land=3/29*100=10.34%

Producer's accuracy:

User's accuracy:

Agricultural land=70/77*100=90.91%

Agricultural land=70/92*100=76.10%

Built up area=94/99*100=94.95%

Built up area=94/103*100=91.26%

Vegetation=56/66*100=84.85%

Vegetation=56/60*100=93.33%

Bare land=26/42*100=61.90%

Bare land=26/29*100=89.65%

Over all accuracy= (70+94+56+26)\284*100=86.62%

Land use	Agriculture land	Built up area	Vegetation	Bare land	Grand total	Commission	User's accuracy
Agricultural land	49	1	3	6	59	16.95%	83.05%
Built up area	4	57	3	2	66	13.63%	86.36%
Vegetation	1	0	54	2	57	5.26%	94.74%
Bare land	2	1	0	47	50	6%	94%
Total	56	59	60	57	232		
Omission	12.5%	3.39%	10%	17.54%			
Producer's accuracy	87.50%	96.61%	90%	82.46%			
Over all accuracy	89.22%						

Omission:

Commission:

Agricultural land=7/56*100=12.50%

Agricultural land=10/59*100=16.95%

Built up area=2/59*100=3.39%

Built up area=9/66*100=13.63%

Vegetation=6/60*100=10%

Vegetation=3/57*100=5.26%

Bare land=10/57*100=17.54%

Bare land=3/50*100=6%

Producer's accuracy:

User's accuracy:

Agricultural land=49/56*100=87.50%

Built up area=57/59*100=96.61%

Vegetation=54/60*100=90%

Bare land=47/57*100=82.46%

Agricultural land=49/59*100=83.05%

Built up area=57/66*100=86.36%

Vegetation=54/57*100=94.74%

Bare land=47/50*100=94%

Over all accuracy=(49+57+54+47)\232*100=89.22%

Appendix E. Land use land cover conversion

LULC Conversion from 2000-2010		Area
1	Agricultural land - Agricultural land	1308.70
2	Agricultural land - Bare land	12.70
3	Agricultural land - Built up area	13.30
4	Agricultural land - Vegetation	22.00
5	Built up area - Agricultural land	28.00
6	Built up area - Bare land	11.00
7	Built up area - Built up area	550.73
8	Built up area - Vegetation	22.00

9	Vegetation - Agricultural land	2.30
10	Vegetation - Bare land	3.30
11	Vegetation - Built up area	0.40
12	Vegetation - Vegetation	43.00
13	Bare land - Agricultural land	9.00
14	Bare land - Bare land	63.00
15	Bare land - Built up area	6.58
16	Bare land - Vegetation	19.00
Grand Total		2115

LULC Conversion from 2010-2020		Area
1	Agricultural land - Agricultural land	1070.86
2	Agricultural land - Bare land	15.99
3	Agricultural land - Built up area	190.00
4	Agricultural land - Vegetation	63.00
5	Built up area - Agricultural land	3.74
6	Built up area - Bare land	0.12
7	Built up area - Built up area	503.00
8	Built up area - Vegetation	0.32

9	Vegetation - Agricultural land	1.65
10	Vegetation - Bare land	0.16
11	Vegetation - Built up area	45.00
12	Vegetation - Vegetation	105.28
13	Bare land - Agricultural land	2.75
14	Bare land - Bare land	89.72
15	Bare land - Built up area	23.00
16	Bare land - Vegetation	0.40
Grand Total		2115

LULC Conversion from 2000 to 2020		Area
1	Agricultural land - Agricultural land	1031.56
2	Agricultural land - Bare land	28.69
3	Agricultural land - Built up area	203.30
4	Agricultural land - Vegetation	85.00
5	Built up area - Agricultural land	31.74
6	Built up area - Bare land	11.12
7	Built up area - Built up area	482.73
8	Built up area - Vegetation	22.32

9	Vegetation - Agricultural land	3.95
10	Vegetation - Bare land	3.46
11	Vegetation - Built up area	45.40
12	Vegetation - Vegetation	42.28
13	Bare land - Agricultural land	11.75
14	Bare land - Bare land	62.73
15	Bare land - Built up area	29.58
16	Bare land - Vegetation	19.40
Grand Total		2115

Appendix F: Questionnaire for open ended interviews

Dear respondent:-The main aim of this interview questionnaire is to collect data as input for the study titled as “The impacts of urbanization on agricultural land in the case study of Adet town, Ethiopia.” whose sole purpose is to investigate the socio-economic factors that contributing urban expansion in the study area. These studies qualify the requirement for awarding the Master’s Degree of Geodesy and Geomatics specialized to Geomatics in Addis Ababa University, College of Institute of technology. Therefore, I thank you in advance for your cooperation; I assure you that each pieces of information answered via this tool are to be very much confidential.

1. Backgrounds of the respondents

1.1 Sex male female

1.2 Age

25-35 years of old 35-45 years of old 45-55 years of old 55-65 years of old

Above 65 years of old

1.3 Educational level of respondents

Grade 8-12 class Diploma Degree Msc and above

2. What does the urban expansion of Adet town look like starting from 1992 E.C?

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3. What factors, do you believe the major socio-economic contributing factors of Adet town expansion? Or the major Causes of Urbanization?

-----.

4. What are the negative impacts of this horizontal expansion on agricultural land surrounding peripheral areas?

5. For those negative impacts what is the short and long term solutions?

6. What are the positive impacts of this horizontal expansion on agricultural land surrounding peripheral areas?

Appendix G: Some photos of the study area

