GEOSPATIAL ANALYSIS OF THE SPATIO-TEMPORAL PATTERN CHANGES AND DISTRIBUTION OF URBAN GREEN SPACES IN ADAMA, ETHIOPIA

AMINA SOLOMON TILAHUN

A THESIS SUBMITTED TO THE DEPARTMENT OF GEOMATICS ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENTS OF THE REQUIREMENT FOR THE DEGREE OF MASTERS IN GEO-INFORMATICS

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

August, 2022

Adama, Ethiopia

GEOSPATIAL ANALYSIS OF THE SPATIO-TEMPORAL PATTERN CHANGES AND DISTRIBUTION OF URBAN GREEN SPACES IN ADAMA, ETHIOPIA

AMINA SOLOMON TILAHUN

ADVISOR: TILAHUN ERDUNO (PHD)

A THESIS SUBMITTED TO THE DEPARTMENT OF GEOMATICS ENGINEERING

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S IN GEO-INFORMATICS

OFFICE OF GRADUATE STUDIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

August, 2022

Adama, Ethiopia

DECLARATION

I hereby declare that this Master Thesis entitled "Geospatial Analysis of the spatio-temporal Pattern changes and distribution of urban green spaces in Adama, Ethiopia". is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Amina Solomon Tilahun_____	____________________	__________
Name of student	Signature	Date

RECOMMENDATION

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled “Geospatial Analysis of the spatio-temporal Pattern changes and distribution of urban green spaces in Adama, Ethiopia” prepared under my/our guidance by Amina Solomon Tilahun. submitted in partial fulfillment of the requirements for the degree of Mater’s of Science in Geo-informatics. Therefore, we recommend the submission of revised version of the thesis to the department following the applicable procedures.

Tilahun Erdunu (phd)	______________________	_______________
Major Advisor	Signature	Date

APPROVAL SHEET

I, the advisors of the thesis entitled "Geospatial Analysis of the spatio-temporal Pattern changes and distribution of urban green spaces in Adama, Ethiopia" and developed by Amina Solomon Tilahun, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Tilahun Erduno (Phd) ____________________ ____________________

Major Advisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis by Amina Solomon Tilahun have read and evaluated the thesis entitled "Geospatial Analysis of the spatio-temporal Pattern changes and distribution of urban green spaces in Adama, Ethiopia" and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Geo-Informatics.

_________________________________ ______________ _______________

Chairperson Signature Date

_________________________________ ______________ _______________

Internal Examiner Signature Date

_________________________________ ______________ _______________

External Examiner Signature Date

Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

_________________________________ ______________ ________________

Department Head Signature Date

_________________________________ ______________ ________________

School Dean Signature Date

_________________________________ _______________ _________________

Office of Postgraduate Studies, Dean Signature Date

ACKNOWLEDGEMENT

I am so grateful to Thanks the almighty Allah for give me strength in doing the thesis from start to end. Next I would like to present my heartfelt gratitude to my Advisor Dr.Ir Tilahun Erduno (PhD) for his valued guidance for the completion of my thesis works. Thank you my advisors once again for you were nearby me in my difficulties and loneliness with your deserved knowledge. Finally my Special thanks go to Adama Science and Technology University for their study and related research activities to achieve my research objectives. Lastly, but not least my great gratitude goes to my family, for their encouragement and relentless help throughout my MSc study.

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS AND ACRONYMS

AOI	Area of interesting
CSA	Central statistical Agency
CMP	City Master Plan
ERDAS	Earth Resources Data Analysis System
ETM+	Enhanced Thematic Mapper Plus
ERDAS	Earth Resource Data Analysis System
GIS	Geographic Information System
GPS	Global Positioning System
GI	Green Infrastructure
GS	Green Space
LULC	Land Use Land Cover
RS	Remote Sensing
NDVI	Normalized Difference Vegetation Index
UTM	Universal transverse mercator
USGS	United States Geological Survey
UGI	Urban Green Infrastructure
UGS	Urban Green Space
UGSD	Urban green space development
SPSS	Statically Package for the Social Science
OLI	Operational Land Imager
NIR	Near Infrared Red
UDP	Urban Development and plan
WHO	World health organization

ABSTARCT

The urban green spaces are immensely significant to ensure quality of life in a city. However, their spatial distribution is found to be inequitable. As several reports indicate Green Infrustructure improves aesthetic value to one city, lack of attention,Rapid population growth and high reduction of GI resources are Africa's current major environmental issues. *As Adama city informal settlement has grown to wards peripheral area of the city at the outlay of existing green natural vegetation. This study investigated spatial distribution of green space through remote sensing data at different times in Adama. Methodologically data like satellite images Landsat7ETM+,8OLI with spatial resolution of 30m, structural plan of the city, and written documents are used. Spatial distributions and change analysis of LULC with NDVI from 2000 to 2020 with interval 10 years was done by ArcGIS and ERDASIMAGINE while questionnaire survey was analyzed using SPSSv26 and MS-Excell 2019. The results show decreasing of greenery was reducing in each year because of changing UGS to different landuse. Area of UGS estimated was approximately 2409.16ha, and GS actually utilized area of 448.16ha only accounted for 18.60 % while total area not utilized was(1961ha) 81.39%. This indicate the highest actual utilization value appeared in dembala subcity (172.94 ha), while the lowest value appeared in AbaGeda subcity 4.97ha coverage of(1%) from other subcity. The development and management of green spaces of the city was found to be poor both in terms of adequacy and from management point of view. Therefore the major challenges were lack of finance 22.2% due to less attention, lack of professionals 20%, lack of awareness 17.8% and 15.5%of low level of the community participation with municipality in green area development. Finally, the finding of this study will have a different beneficiary directly or indirectly.*

KeyWords:Geospatial Technologies, Green Space, Spatial-Analysis, Temporal.

CHAPTER 1: INTRODUCTION

1.1. Background of the Study

Urban green space (UGS) is the natural environment in city connecting humans with nature such as parks, forests, grasslands, river corridors, and wetlands (Chiesura, 2004; Dai, 2011; Wolch, Byrne, & Newell, 2014). UGS provides citys with many ecosystem services, including preventing urban waterlogging, reducing the urban heat island effect, and purifying air and water (Bolund & Hunhammar, 1999; Graca et al., 2018). These contribute to the resilience and sustainability of urban communities (Hartig et al., 2014; Zhang et al., 2020).

Urbanization is widely and increasingly accepted as an inevitable phenomenon .It refers to a process by which an increasing proportion of population comes to live in cities by growth and migration of population transformed from predominantly rural to urban area and closely associated with the level of economic activities, land use land cover, population distribution and urban facilities (Medina, 2015 cited in Berhanu, K. 2017). A well designed urban green space system is an essential part of the urbanization process (UFUG_2017).

Urban green space provides multiple functions such as regulating microclimate, providing residents' recreation space, and purifying the atmospheric pollutant (Larson et al. 2016; Ngom et al. 2016). Further, urban green space plays an important role in solving many environmental problems, such as loss of biodiversity, water pollution, soil erosion, and rising temperatures associated with city heat-island (Lee &Maheswaran 2011; Lovell & Taylor 2013; Adinolfi et al. 2014).

In addition, planning and construction of urban green space are not only the direct embodiment of city’s soft power, but also the momentous symbol of urban civilization level (Swanwick et al. 2003; de la Barrera et al. 2016). Therefore, scientific planning and management of urban green space is essential for the benefit of urban development both ecologically and social-economically. With the development of green space assessment and planning theory, urban green space assessment and optimization have attracted more attention recently (Jansson 2013; 39 Yao et al. 2014).

The urban green space suitability evaluation approach is a critical tool for selecting suitable locations for UGS planning and construction. Farther it is used for quantitative analysis that traditional planning has found hard to achieve it is also a more practical planning scheme than the traditional approach (Li et al., 2018).One of the essential components of the urban environment is green spaces. Green space reference to those land uses in the built-up and planning areas which contain natural or man-made vegetation in it (Manlun, 2003).

Green infrastructure varies in scale, habitat density, species resources, environmental quality, public transport proximity, facilities, and services (Fuller & Gaston, 2009). Urban green infrastructure(UGI) includes parks and forests, sports fields, green lakes, streams and river banks, greenways and walks, community gardens, street trees, and nature conservation areas, as well as less traditional areas such as green walls, green streets, and cemeteries(Planning & Resources, 2017).

Accordingly, in the developed countries of Europe and North America, urbanization has been a consequence of industrialization and has been associated with economic development. While, in the developing countries of Latin America, Africa, and Asia, urbanization have occurred as a result of high natural urban population increase and massive rural-to-urban migration (Kelemu, F. 2016).

On the other hand, rapid urbanization has been resulted in urban expansion which is an uncontrolled and dispersed process of urban growth. According to (Tulu, T.2017), unplanned urban growth brings long lasting and irreversible impacts such as degradation, loss and fragmentation of habitat, loss of water resource, heat island effect, air quality degradation, greenhouse gas emission and climate change. In additions to this, unplanned urban growth characterized by illegal settlers, unhealthful urban planning, environmental degradation which suffer from social, economic, and physical problems. Similarly in our country, unplanned urban expansion is outward expansion in the peripheral's areas of the town (leapfrog types of urban expansion) and along roads or infrastructures (linear strip types of urban expansion).

Ethiopia, as one of the developing countries has intensified with the unplanned urban expansion and rapid urbanization processes in many of its towns and cities (Berhanu, K.2017). This kind of problem has been faced byAdama city.

Adama is the most populous city in Ethiopia and one of the fastest growing cities in the country. It is the largest city in the Oromia Region, which features industries and manufacturing enterprises, and is strategically located on the main road linking Addis Ababa to Djibouti. There are several factors that explain Adama's migration trends. The main push factors include environmental degradation, low agricultural productivity, inadequate social services, demographic pressure, land shortages, lack of rain, recurrent drought and conflict. Pull factors include public services, security and job opportunities.

Adama is characterized by unplanned urban expansion and rapidly growing population in the form of urban sprawl. This is due to factors that contribute to the growth of informal settlements like population growth, rural to urban migration, poor land management, urban poverty, lack of affordable urban housing, unemployment and other related factors.

As a result, the growing unplanned urban expansion rather than environmental problems it is the major driving force identified behind changes LULC patterns. Urban expansion has significant implications for resource extraction and use, waste generation, and land transformation through built footprint expansion and changed LULC patterns (Sewunet, 2017). The shift of LULC changes can be incorporated by using remote sensing data and GIS software application for the identification and analysis of patterns of land use cover change over in a given timings and data from RS were used to analyze the land cover change pattern of land use. These technologies have been proven to provide a cost effective and accurate method for the analysis and understanding of land dynamics (Zhang, 2016).

Green infrastructure improves aesthetic value to one city which is shown to decrease stress, whereas, inadequate planning and lack of attention Rapid population growth and high reduction of green infrastructure resources are Africa’s current major environmental issues(M. B. Molla, 2015). This study aimed to assess the spatial distribution of urban green space in Adama city using geospatial technology, analyzing both primary and secondary data.

1.2. Statement of the problem

Adama city is located in central Ethiopia where relatively bounded by mountain ridges that covers by forest and shrubs. But in recent time, there is very high informal settlement growth that is resulted from urban expansion which in turn brought rapid Land use Land cover change in the study area. This informal settlement has grown to wards peripheral area of the town at the outlay of existing green natural vegetation and surrounding farm lands.
In addition to these the expansion of informal settlement will cause increasing cost of infrastructure and basic urban service provision.

The coverage of greenry in Adama city show Poor per capita greenery distribution of green spaces about 0.78m^2 (Mohammed,2017). It implies that the per capita green spaces of the city is by far less than the standard set by NUGIS Manual (2014) which is 15m^2/person. When comparing to other the position of the case city in contrast with other cities in the country; the per-capita distribution of green spaces for Addis Ababa & Bahir-Dar was found to be 17m^2 and 41m^2 respectively SECR, (2015).

Another problem studied by researcher (Esmo,2017) Nevertheless, in reality for Adama city what is on the ground is far from what is stated in the country's greenery strategy. For example, the revised master plan of Adama city has designates parks for different functions to be developed in different parts of the city. But, their implementation is not yet put on the ground. Particularly, land use type changes, from green space to other use is also another major challenge in the city. Other neighborhood parks were also converted to residential houses areas. As a result now a day, there is not enough functional public park in the city except less than proposed recreational parks by city which are found at the verge of the city and are not accessible and affordable by majority of the downtown low income residents to enjoy there. It implies that equitability and accessibility for green spaces in the city is under question.

The situation accelerating LULC is changing from different natural vegetation and agriculture to other uses of land such as residential, industrial and commercial developments, as well as other social services. Unless the occurrence of this situation is revealed, the rapid Land use Land cover change will inevitably bring the problems like unnecessary loss of urban green area, fertile agricultural lands and environmental degradation/damage of ecologically sensitive area as well as climate change, ranging from the local to the global. Therefore, studies on LULC with regard to informality have become a central component in current strategies for managing land as a resource and in monitoring environmental changes.

Due to the above mentioned problems, the researcher is motivated to study the major factors affecting and assess the spatial distribution of urban green space in the city. As a result, the unhealthy urban expansion and lack of green space trends in Adama city and the lack of relevant studies on the issue, initiated the researcher to fill this gap by studying the assessment of urban green space and Evaluate spatial distribution of urban green space at level of subcity and also examine utilization of existing urban green space through the use of Remote Sensing and GIS technology.

1.3. Objective of the study

1.3.1. General objective

The general objective of the study is to Analyze the spatio-temporal Pattern changes and distribution of urban green spaces in Adama.

1.3.2. Specific objectives

The specific objectives are to;

1. Determine the appropriate indicators of green space Adama city.
2. Estimate the amount of green spaces per-capita in Adama city.
3. Identify major factors affecting green spaces in Adama city.

1.4. Research Questions

The following research questions are designed as follows. This study is expected to answer the following key questions

1. What are the appropriate indicators of green space in the local context?
2. How to estimate the amount of green spaces in the local context?
3. What are the major factors affecting the Distribution of green space in Adama city

1.5. Significance of the study

The outcome of the study could help to enable local decision makers and urban planners to assess and identify opportunities and priority areas that require green space intervention. Besides, the intended outcome of the study could help to promote equitable spatial distribution and maximum human proximity to green space in the study area. It would also give a direction for the town administrators to pay a necessary attention on the issue in the study area. In general the following are some of outcome of the study; To help urban planners in developing intervention to improve green space access, To improve methods for measuring green space access. The study makes recommendations and suggestions about urban green space.

1.6. Scope of the study

In terms of spatial coverage, the study is conducted geographically bounded to Adama city, which is the next largest city in the Oromia National Regional State of Ethiopia. The study use all the six urban subcity and sub urban surrounding city . In terms of thematic scope, the study focuses on assessment of urban green space distribution and land use land cover change analysis using geospatial technology.

1.7. Limitation of the study

This study certainly has some limitations that could be solved through future researche in the study area. One of the major limitations was the data sources that were Landsat imageries used for LULC analysis. The Landsat imageries were of 30 m resolution which are not high resolution and incurred to some LULC classification errors that were indicated in error matrixes of accuracy assessment. Getting high resolution satellite imageries such as IKONOS and QuickBird was not possible.

Another limitation was participants from different organization and households refrain to respond for the given questions due to less understanding, afraid of their saying and get tired to go through the entire questionnaire and do not hit the target of the questions. But, the researcher tried to accommodate most of the questionnaires through repeatedly contact and fill the gap continuous field observation.

1.8. Organizations of the Thesis

The thesis paper generally comprises of five chapters beginning from introduction (explaining backgrounds of the study, setting purpose and objectives) and ends at analysis, results and discussion. Chapter two reviews of literature terminologies and technical problem solving methods from the literatures. In Chapter Three, Historical, Physical and backgrounds of the study area is explained in detail. In this chapter also presents the research design, methodology and methods followed as well as the backgrounds of implemented data are involved. Brief description of data and datasets used as inputs of analyses is also specified in the same chapter. Chapter four analyses and discusses the practical solutions of the problem towards the achievement of the designed purpose and objectives set in chapter one. The thesis is finalized in chapter five by Summarization, conclusions and Recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1. Theoretical Framework

2.1.1. Concept of Urban Green Infrastructure and Urban Green Space

Green infrastructure has been defined as “a strategically planned network of natural and semi- natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services” (EC, 2013, p. 3). As more and more of the world’s population is becoming urban and challenges such as maintaining a high quality of life and adapting to climate change are occupying political agendas for cities, the concept of GI for urban areas has been gaining more attention. This has led to a new urban agenda where promoting environmental sustainability can foster a transformative change when a critical connection is established between the environment, urban planning, and governance (UN, 2016).

More recently, urban green infrastructure (UGI) planning has emerged as a distinct subset of GI aimed at creating and managing networks of green space in urbanized environments through the application of certain planning processes, approaches and policy themes (e.g., Ahern, 2007; Mell, 2009; Pauleit et al., 2011; Davies et al., 2015). Conceptually, UGI is linked to neighboring GI at the landscape scale whilst simultaneously focusing on creating and managing networks of multifunctional green space in the urban context (EC, 2011). Planning a UGI network involves linking green spaces at multiple scales whilst addressing groundwater, surface water, and air movement systems (Young et al., 2014).

Green Infrastructure consists of a diverse set of environmental features that can work at various scales, ranging from small linear features like hedgerows, fish ladders, and green roofs to whole functional ecosystems like intact floodplain forests, peat lands, and free flowing rivers (Development & Ababa, 2018). Not all green spaces or environmental featuresare eligible to be included in GI. They must not only be of high quality but also be a part of an integrated GI network and capable of providing more than just "green space."(Haq, 2011).

According to (Mulatu, 2019) citing an urban green space can be defined as formal and informal. Formal green areas: such as protected public parks, street gardens, playgrounds, sports fields, squares, private gardens, and vegetation cover in schools, hospitals, churches, mosques, embassies, cemeteries, parking lots, pedestrian lanes, etc. and; Informal green areas: encompasses forest areas, river valleys, reserved expansion areas, agricultural lands, open leftover spaces, steeper degraded areas, etc.

2.1.2. Definition and concepts of Terms

Urban Green Spaces (UGS) There is no single universally accepted definition for the term green Spaces. Many scholars tried to define the term from their respective research area point of view. (Alamrew 2002 as cited in Gebeyehu 2014) has defined green areas as:

Formal green areas: such as protected public parks, street gardens, play grounds, sport fields, squares, private gardens, and vegetation cover in schools, hospitals, churches, mosques, embassies, cemeteries, parking lots, pedestrian lanes, etc.

Informal green areas: encompasses forest areas, river valleys, reserved expansion areas, agricultural lands, open leftover spaces, steeper degraded areas, etc. (Haq and Shah Md. Atiqul 2011) also stipulated the definition of urban green spaces which is agreed on by ecologists, economists, social scientists and planners as: Public and private open spaces in urban areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users.

Public City Park: IFPRA (2013) defined as delineated open space areas, mostly dominated by vegetation and water, and generally reserved for public use. City parks are mostly larger, but can also have the shape of smaller 'pocket parks'. Public parks are usually locally defined as 'parks'.

(Lozano 1992) depicted in his study that Public areas and facilities can be publicly and privately owned or owned through a public-private partnership explained them as follows:

Public Area: Public area, as the name suggests, are spaces where anyone regardless of race, age, income or gender can partake in a variety of activities. They are built with the intention to serve the common good and to be accessible and shared by all. Public area is an environment where aspects and functions of life are played out (Lozano 1992).

Private Area: Private area often appears to be public, but public does not necessarily mean public ownership. Some spaces are privately owned, but are made for public use. Parks fall into this category. Areas like Disneyland in California are places where the success of the park is totally reliant on the public but the park itself is privately owned. They are reliant on the public because they charge user fees for the services they provide and work on a cost recovery and profit basis. Within the park they can set standards and control what people can and cannot do where people can go and when they can be there. (Lozano,1992) also divided these public areas broadly into two families of spaces Parks, Plazas and Streets and elaborated as follows:

Park: (Sadeghiyan and Vardaniyan, 2015) in their study of urban park history ,classification and functions broadly defined and discussed Park as an area of natural, semi-natural, or planted space set aside for human enjoyment and recreation or for the protection of wildlife or natural habitats. It may consist of grassy areas, rocks, soil, and trees, but may also contain buildings and other artifacts such as monuments, fountains or playground structures.

Plazas and Streets: In modern usage, a plaza can be any meeting place on a street or between buildings, a street crossing with a statue, etc. Now day urban landscapes often integrate the "plaza" as a design element, or as an outcome of zoning guidelines. Squares and streets have been part of the city since early Greek and Roman times. Their forms have changed dramatically, but their function as public spaces have remained constant (Lozano 1992).

Street Trees: Are trees growing along public street right-of-way and managed by the city, account for a relatively small fraction of the entire urban forest, but are prominent because of their visual and physical impacts on the quality of urban life (McPherson et al 2016). Street Tree Manual of the City of Vancouver, Washington (COVW 2011) defined Street tree as any woody vegetation, generally single-stemmed, and is recognized by the City as a tree, and in which the trunk is wholly or partially located within the right of- way or any easement granted for the purpose of public tree management.

Open Spaces: Refers to non-built areas dominated by a “natural” environment, composed of abiotic and biotic elements. Typically, it represents low human intervention that does not radically change its intrinsic naturalness and can keep its continuous functioning and inherent values (Maruani and Amit-Cohen, 2007). Open space could be defined as any un built land within the boundary of a village, town or city which provides, or has the potential to provide, environmental, social and/or economic benefits to communities, whether direct or indirect(Kit Campbell 2001). (Maruani and Amit-Cohen 2007) defined and categorized, open space into five types: urban open space, agricultural land, rural non-agricultural land, countryside (natural areas) and wilderness areas.

Arboriculture **-** the planting and care of trees and, to a lesser extent, shrubs, vines and ground cover; focuses on small groupings of trees and plants.

Focus Groups - informal meetings where people freely give their opinions in response to prepared questions or guided discussion.

Greenbelts - large parcels of land in and around cities where urban development is totally prohibited through zoning, public ownership, easements or development restrictions in order to preserve natural aspects of the landscape and/or vegetation.

Greenhouse Effect - the warming of Earths surface due to pollutants that form a layer of heat-trapping gasses in the atmosphere,thereby creating a heating effect similar to a greenhouse.

Greenways - narrow vegetated corridors that can have multiple uses and functions such as improving environmental quality, providing recreation, and serving as alternative transportation (bicycle and foot paths). Greenways are often sited along natural systems such as rivers, ravines, ridgelines and floodplains.

Informal Settlements - migrant communities, usually unplanned and unauthorized,where the residents settle without title to their land; often called squatter settlements, slums or illegal occupations.

Nurseries - a location where seeds, seedlings, and mature plants are cultivated in greenhouses or plots prior to being transported to their ultimate planting site (e.g., city park or greenway); good for trees and shrubs as well as herbaceous species.

Pioneer Species - plants that colonize an area in the early stages of ecosystem succession and facilitate the subsequent colonization of transitional or climax species in that area.

Rural Forestry **-** planting trees in rural areas principally for wood production and recreation.

Stakeholders - people or groups who directly or indirectly benefit from a green area, such as local residents, businesses, farmers, neighborhood associations, government agencies, nongovernmental organizations, schools, investors and others who share a common interest in the area.

Suburban - areas of mostly-residential urban sprawl on the perimeter of urban centers; sometimes referred to as peri-urban.

Suburban Forestry - planting and managing trees and other vegetation in suburban or peripheral areas of a city; a mixture of urban and rural forestry.

Urban - settlements of over 20,000 people; cities have over 100,000 inhabitants and big cities have over five million.

Urban Agriculture - food grown within a city or suburban area; produced directly for market or for home consumption and frequently sold by the farmers themselves.

***Urban Forestry*:-** planting and managingtrees and other vegetation within a city=s limits; focuses on larger groupings of trees and vegetation such as in parks.

Urban Greening - an integrated, city-wide approach to the planting, care and management of all vegetation in a city to secure multiple environmental and social benefits for urban dwellers; projects may involve planting of trees, shrubs, grass, or agricultural plots.

2.2. Urbanization effects on urban green space development

According to Mensah (2014), urbanization has been increasingly a predominant factor in imparting stress on urban green spaces. Urbanization remains a main factor that has been mainly linked to causing green space destruction (Mensah, 2014). Urbanization takes place in the form of either densification of urban core or spatial expansion of urban areas outwards (urban sprawl).

Densification of the urban core refers to high population density and an increase in the built environment (building structures) in relation to open spaces (Mensah, 2014). The urban sprawl on the other hand, relates to the outward expansion of urban areas often taking place in the urban fringe, peri-urban lands and former agricultural lands (Mensah, 2014). (Honu et al., 2009), argued that rapid urbanization has resulted in the conversion of several urban lands into built up structures and excessive destruction of the natural ecosystem, including green spaces.

Changes in land use, particularly the replacement of green space by buildings, parking lots and roads causes urban areas to become warmer than surrounding areas because these impermeable materials absorb heat and release it more slowly.

2.3. Types of urban green space and Infrustructure

Urban green spaces have different forms and types of open spaces, community parks, gardens and landscaped areas (Vargas et al., 2018). Some types of urban green spaces are formal green space, informal green space, natural green space, public participation, children's space, active sports space and recreation activities. Urban green spaces exist in a variety of types, structures, and shapes (Vargas et al., 2018). According to (Roy et al. 2012), urban green spaces include public parks, reserves, sports fields, streams, river banks and other riparian areas, greenways, walkways and trails, communal shared gardens, street trees and bushes, nature conservation areas and less conventional spaces such as green walls, green alleyways and cemeteries (Vargas et al., 2018).

As green spaces exist in a great variety of shapes, structures and types within the city, they can be classified in various ways based on vegetation type, size, intended function, landscape context, location, form and scale. In fact, the identification of green space typologies could vary depending on the purpose of classification. Accordingly, different cities use different green space category. What is important is that the typology should allow collecting information about the quantity and quality of green space, assessing ecosystem services and preparing development plan and strategy, In the literature, urban green spaces have been worked out in various ways and grouped according to the functions they perform in three domains: environmental, economic and social (Irene L.& Ralucal D, 2011) In figure 2.1 below some of the infrastructure types are presented in support of photo.

Table: 2.1. Types and Description of Urban green space *Sources (Hunegnaw,2017)*

Green space category	**Description**	**Examples**
Urban green	Urban land covered by vegetation,which does not fall in one of the other categories such as parks or gardens	Street trees, green vegetation coverage in the city,informal green spaces
Park	An are of vegetation used for recreation.	Urban park,district park, neighbourhood park.
Garden	An area where plants and flower are cultivated.this can be either a private(surrounding the house) or a public garden.	Playground or botanical garden
Forest and woodland	An area mainly covered with trees and undergrouwth cover.	Desidous,coniferous,mixed forest
Grassland and meadews	An area mainly covered with grass	Improved grassland (used for grazing),semi-natural grassland.
Trees and other plants	Studied with a specific focus on plants,shrubs,or vegetation cover	Tree canopy cover,vegetation cover shrubs.

A Green Street: is a street right-of-way that through a variety of design and operational treatments gives priority to pedestrian circulation and open space over other transportation uses. The treatments may include sidewalk widening, landscaping, traffic calming, and other pedestrian-oriented features(Josh. F& et al.,2011).

Bio-swales: broad and shallow vegetated, mulched, or channels that provide storm water treatment and retention. They slow water flows and allow for infiltration, thereby filtering storm water flows. As linear features they are appropriate along streets and parking lots (Girling and Kellett, 2005)

Figure 2.1: Types of green infrastructure photo.

(source: Green Surge project,2015)

Land Conservation: open spaces and natural areas within, and adjacent to, cities can protect water quality, mitigate flooding impacts, and provide recreation space (Girling and Kellett, 2005).

Permeable Pavements: porous paved surfaces that allow rain to infiltrate into soils. Permeable pavements can be constructed from various materials such as pervious concrete, porous asphalt, and permeable interlocking pavers (Albanese and Matlack, 1999).

Figure 2.2: Types of Green Space (Sources adopted from Adama city,2019)

2.4. Benefits of urban green spaces

Well developed and managed open green spaces in housing areas provide a variety of interrelated social, economic and ecological benefits to the inhabitants as well as for the society at large. Some of the most recognised benefits of green spaces around areas built up for human habitation include (MUDH,2016). Nowadays, urban green space is increasingly gaining attention as a source of multiple benefits (Jorgensen and Gobster, 2010; Byrne JA. et al., 2015).

Different authors (Ahern, 2013; Roe and Mell, 2013) defined multi-functionality of green space as composite functions that include environmental, socio-cultural, and economic benefits. It supports many of the components of ecosystem services as defined by the

Millennium Ecosystem Assessment (Forest Research, 2021). Ecosystem services include: Supporting services (habitat provision, nutrient cycling, soil formation, primary production), Provisioning services (fresh water, wood), Regulating services (climate, flood, disease) and Cultural services (aesthetic, educational, recreational). These are intrinsic to biodiversity, and provide for people's well-being, security, basic materials for good life, health, and good social relations (Diaz S. et.al. 2006). As most of our communities exist within the urban environment the provision of green space is essential for the wellbeing of society (Forest Research, 2021).

I) Public health and well-being: which can be expressed in the form of increased life expectancy and reduced health inequality, improvements in levels of physical activity and health; and promotion of psychological health and mental well-being.

II) Moreover, the provision of recreational spaces is also believed to contribute to the reduction in crime rate and vandalism and to the development of stable communities.

III) Open green spaces also provide visual breaks within and between residential areas.

2.4.1. Environmental Benefits of urban green space

The environmental benefits of green space include local temperature moderation during hot weather cooling of the air temperature through shade provision and mitigation of urban heat island effects (Cao X.et al., 2010; Bowler DE.et al., 2010; Mullaney, 2015; Nowak DJ.et al., 2006). The roles of green space in reducing noise pollution, in mitigating floods in enriching biodiversity and improving ecosystems are also taken as environmental benefits (Haq, 2011; Bolund and Hunhammar, 1999; European Commission, 2013).

According to Heidt and Neef (2008), solar radiation, air temperature, wind speed and relative humidity vary significantly due to the built environment in cities. The urban heat island outcome is caused by the large areas of heat absorbing surfaces, in a combination of high energy use in cities. Consequently, adequate forest, plantation and vegetation around urban dwellers and management of water bodies can help to mitigate the situation. Urban green spaces are not only improving the whole ecological environment of the city region and its neighbors but also provides important support for urban environmental improvement. Additionally, introduction of sub-urban green space into the city also acts as the base of ecological balance (Sadeghian & Vardanyan, 2013).

Socio-cultural benefits are the non-material benefits people obtain from green space (Mullaney J.et al., 2015). These include educational values, aesthetic values, social relations, sense of place, cultural heritage values, recreation, ecotourism and psychological well-being (O'Brien L.et al., 2017). Socio-cultural benefits of green space for urban residents include mental and physical health improvements such as stress reduction and relaxation (Hansmann R.et al., 2007; Konijnendijk CC.et al., 2013).

Further, green space directly increases the quality of life through active and passive recreational social benefits (Kabisch and Haase, 2014). Physical activities such as sports, playing with children etc., signify active benefits while the passive ones include relaxations, meeting with friends or experiencing nature and the like (Byrne and Wolch, 2009). In addition, green space acts as a meeting place for local residents and facilitates social interaction (Wolch JR.et al., 2014). These elements illustrate the range and the breadth of socio cultural benefits of green space and they cover two specific elements (Hansmann R.et al., 2007): first benefits people derive from their feelings of being connected to green space and, second benefits people derive from diversity and complexity of green space. Unfortunately, the socio cultural dimensions of green space have received much less attention than the environmental considerations in infrastructure planning and development endeavors (Byrne and Yang, 2009; Hitchings, 2013).

2.4.2. Economic benefit of urban green space

In Economic growth and investment the positive impacts urban green spaces can make on local economic regeneration, especially for job creation, business start-up, increased land values and inward investment. In the Ethiopian context, for instance condominium apartment buildings are provided with rooms that can be used for small businesses that provide recreational services like cafés, kiosks and small restaurants. Thus greening the available space around such service areas greatly enhance business opportunities.

Economic benefits of green spaces come from the increased values of properties near green spaces and the increased sales of properties along green commercial corridors (Heckert and Mennis, 2012). In this line, studies in China (Jim and Chen, 2010) and Adelaide in Australia (Mahmoudi P.et al., 2013) indicated that higher housing prices and property values are evident for sites situated in the vicinity of accessible green space. In addition to this, the economic benefits of green space include its contributions to tourism and its link with urban food (Heckert and Mennis, 2012). Pitman and Ely (2013), explained that green space and urban food are intimately related through the perceived needs to retain productive agricultural land on the urban fringe and to integrate food production into urban areas.

2.4.3. Urban green space interventions and the benefits they provide

Urban green space interventions are defined as actions that significantly modify the quality, quantity and accessibility of urban green space. This can be done by establishing new urban green spaces or by changing the characteristics and functions of existing ones. UGS Benefits Through improved air and water quality, buffering of noise pollution and mitigation of impacts from extreme events, urban green spaces can reduce environmental health risks associated with urban living. A broad range of intervention types can be implemented at different scales in private or public spaces as shown in (figure 2.3).

Figure 2.3: Urban green space Interventions and benefits. *Source: (WHO, 2017)*

In the Above figure 2.3 (A) show greenways and corridors (such as green trails for walking/cycling), (B) coastal, riverside or lakeside trails, linking green with blue spaces, (C) facilitated access to urban woodlands, forests and natural wildlife areas and (D) recreational and urban gardening facilities (such as community gardens, sport and play areas and school grounds).

In addition, they support and facilitate health and well-being by enabling stress alleviation and relaxation, physical activity, improved social interaction and community cohesiveness.

Health benefits include Improved levels of mental health, physical fitness and cognitive and immune function, as well as lower mortality rates in general. Everyone can benefit from urban green space interventions, but they can be of particular relevance for socially disadvantaged or underserved community groups, which often have least access to high quality green spaces.

2.5. Emperical review

(Botzat et al., 2016) stated that A very recent review article has highlighted a research gap by pointing out that most studies on urban green spaces do not represent the diversity of modern urban societies and that survey-based research on park visitors and residents omits social groups with more limited physical access to urban green spaces. Especially for city dwellers with impaired physical mobility and limited access to public transportation, including on grounds of travel costs, park accessibility is an important spatial constraint. (Neuvonen et al., 2007) The frequency of walking for pleasure or fitness is a typical close-to-home activity that is affected by both the amount of green space and the distance to it Analyses utilizing Geographic Information Systems (GIS) have shown that equity in accessibility of urban green space is limited.

(zuvela-Aloise et al.,2016) Urban green spaces are not only the major locality for recreation of city dwellers. They also have a ‘Cool Island’ effect on surrounding built-up areas. The spatial range of the result of evaporative cooling, shading and thermal admittance is related to park size as well as to the density, direction and vertical extent of built-up areas.

(Gill et al., 2007) according to this author Parks therefore provide regulating ecosystem services by cooling the surrounding built-up areas. In the literature, there is a general consensus that climate change adaptation in urban areas calls for the protection of existing green spaces and, ideally, the creation of more green spaces. Yet, it is unanimously accepted that space is limited and contested, so that competing land uses curb the implementation of planning recommendations, and compact cities tend to have smaller and more disconnected green spaces.

2.5.1. Status of Urban Green Infrastructure in World Wide

Green infrastructure (GI) is commonly used as a term associated with strategic approaches to green space planning that focuses on network connectivity (Benedict and McMahon, 2002; Rouse and Bunster-Ossa, 2013; Lennon, 2015). In Europe, the GI concept has become widely recognized for its potential to contribute towards ecosystem services preservation and restoration and is now embedded in European policy (EC, 2013); it has also been linked to territorial planning and cohesion (EEA, 2011, 2014). GI has been defined as “a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services” (EC, 2013, p. 3).

The diversity and quality of urban green spaces (UGS) such as parks, forests, green roofs, or community gardens are tightly linked to human well-being as UGS provide a number of ecosystem services for people. In recent years, many studies advanced our understanding of UGS in their biophysical, economic and socio cultural dimensions. The crucial ecosystem service of urban vegetation is its regulatory effect on the urban microclimate (CLC 1990).

More recently, urban green infrastructure (UGI) planning has emerged as a distinct subset of GI aimed at creating and managing networks of green space in urbanized environments through the application of certain planning processes, approaches and policy themes (e.g., Ahern, 2007; Mell, 2009; Pauleit et al., 2011; Davies et al., 2015). Conceptually, UGI is linked to neighboring GI at the landscape scale whilst simultaneously focusing on creating and managing networks of multifunctional green space in the urban context (EC, 2011). Planning a UGI network involves linking green spaces at multiple scales whilst addressing groundwater, surface water, and air movement systems (Young et al., 2014). Hence, a UGI typology will include many types of features encompassing both the natural and man-made (e.g., river corridors, parks, forests, green routes).

(Forest Research, 2010) studied in Los Angeles, Quantified the percentage of vegetation cover within each area, and found that the region with the lowest tree cover 47% was 3 F warmer on average than the area with the highest cover 55%. In many cities, Europe, North America, South America, Asia, and Africa, urbanization harms the natural environment (green space), with the situation in Africa being serious (Addo-fordwuor, 2014).

2.5.2. Status of urban green spaces in Ethiopia

The Urban Development Policy of Ethiopia has concerns with incorporating the issue of green areas, considerations of the compatibility of various land use activities, incorporation of generalized environmental objectives and identification of hazardous areas. The policy has also recognized cities as entities that strive to work towards minimizing serious urban environmental causes (Tesfaye, 2016). According to Aravadinouet and Evmorphopoulou (1999) urban greenery is the overall extent of planted outdoor spaces (with trees, bushes, ornamental plants, or grass). Examples of such spaces are squares, parks, rows of trees in, groves, planted spaces in yards of public or private buildings (schools, residential complexes).

Ministry of urban development, housing and construction is trying to address the green space problem by producing National Urban Green Infrastructure Standards (NUGIS) which create the framework for municipalities to provide effective and sustainable urban green infrastructure (UGI) for their residents to protect public health and environmental quality (MoUDC, 2014).

MoUDC has concerns with incorporating the issue of green areas, considerations of the compatibility of various land use activities, incorporation of generalized environmental objectives and identification of hazardous areas. It has also recognized cities as entities that try to work towards minimizing serious urban environmental causes.

Furthermore, the Environmental Policy of Ethiopia has documented the importance of Planning of green spaces within urban areas. This gives room for various stakeholders to develop and manage urban forests, street trees and so on as elements of urban green areas. The urban planning, preparation and implementation strategy allocated 30% of the land for roads and infrastructure, 30% for green areas and shared public use and 40% for building construction in their urban land management plan (MoUDH, 2015).

2.6. Land use and land cover

The assessment of land-use/land-cover serve as a preliminary means of investigating Urban green space change (Opeyemiand Trina, 2014) because land cover/ land use changes associated with urbanization are important drivers of local geological, hydrological, ecological, and climatic change.

2.6.1. Urban green space and vegetation density

Green space is an important part of complex urban ecosystems that give environmental, esthetic, recreational and economic benefits to the urban dwellers. Vegetation provides cooling through shading and enhanced evapo transpiration (Christian and Ugoyibo, 2013). In spite of this, urban green space and vegetation density had been emphasized as the major index of air freshening, which will generally improve the urban environmental quality (Faryadi and Taheri, 2008).

2.6.2. Land Cover Types and Image classification

Land cover corresponds to a physical description of Earth leading to a simple definition the observed physical cover of Earth's surface. This is what is overlaying or currently covering the round. This description enables various physical categories to be distinguished basically, areas of vegetation (trees, fields and lawns), bare soil (even if this is a lack of cover),hard surfaces (rocks, buildings), and, according to the accepted concept of land, wet areas and bodies of water (sheets of water and watercourses, wetlands) land use, and land cover.

The Earth's surface is experiencing rapid LULC changes as a result of numerous socioeconomic activities and natural phenomena (yergalem, 2021) sited in (Cheruto M.C. et al., 2016). Nowadays the rapid growth and expansion of urban areas, rapid population growth, land scarcity, increasing production demands and growing technology are some of the drivers of LULC change (Barros, 2004). Changes in Land Cover (LULC) can also affect biological diversity, alter ecosystem services, lead to soil erosion, disrupt socio-cultural practices and increase natural disasters, like flooding.

LULC change particularly in urban areas is becoming the major factor in reducing green spaces extent. LULC change needs global attention for continuous monitoring of the changes. Up-to-date datasets on land use land cover change provide critical inputs to evaluate complex causes and responses in order to project future trends. They are also prerequisites for making development plans. However, according to (Mengistie et al., 2013), the magnitude of LULC change differs with the time period being examined, geographical location, slope gradient and elevation range.

2.7. The Role of Geospatial Technologies in the UGS

2.7.1. Application of Geographic Information System (GIS) in UGS

The integrated framework of RS techniques and GIS framework greatly reduces time, effort and expenses in using geographical data. Remote sensing with its advantages of spatial, spectral and temporal availability of data coverage large and inaccessible areas within short time has become a handy tool in assessing, monitoring and conserving urban greenery. Satellite Remote Sensing, with its repetitive coverage together with multi-spectral (MSS) capabilities is a powerful tool to map and monitor the emerging changes in the urban core as well as in the peripheral areas of any urban areas (Akanbi et al., 2013).

Satellite images enable us to better understand some of the intrinsic components of the ecosystems and the interactions within the whole environment. The relevance of remote sensing in urban environmental quality is further enhanced by geographic information system (GIS) which makes it possible to integrate remote sensing data with socio-economic variables and in situ data.(Opeyemiand Trina, 2014).The use of a GIS system in this research, is gives the opportunity to combine a set of data, dissimilar to each other, to find relations and differences and to classify the urban greenery into different categories and for overlay analysis and for this preparation the concerned map.

A geographic information system (GIS) is a computer-based tool for mapping and analyzing geographic phenomenon that exist, and events that occur, on earth. Geographic Information System technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable for a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

2.7.2. Application of Remote Sensing (RS) in urban green space.

Geospatial technology is a multidisciplinary field that includes disciplines such as photogrammetry, remote sensing, mapping, geographic information systems (GIS), geodesy, and global navigation satellite system (GNSS) (PunCheng, 2001). As the U.S. Department of labor defined, the geospatial industry can be considered as “an information technology of practical fieldwork that acquires, manages, interprets, integrates, displays analyzes, or otherwise use data focusing on the geographic, temporal, and spatial context” (Klinkenberg,2007). Ethnological progress relates to geospatial software and analyzes of geospatial data are some of them. The integrated approach of geospatial technologies such as GPS data, remote sensing imagery, aerial photographs, Google Earth and GIS are valuable in the development of modern Geoinformation.

2.8. Conceptual frame work

Urbanization is drawing attention since they become major causes for anthropogenic disturbance to the environment and microclimate changes. The city and surrounding areas have experienced massive changes led by excessive agricultural, industrial and urban expansion activities. These land use modifications damaged the ecosystem in terms of weather and climate, land cover, land quality and strength, land quantity that can be maintained, population and socioeconomic determinants (Tadesse et al., 2001). This is Mostly because of The rapidly increasing construction and infrastructure development that occupied large tracts of natural green spaces and prime agricultural lands (Mohamed & Worku, 2019).

Different authors (Ahern J., 2013; Roe M. & Mell, 2013) defined multi-functionality of green space as composite functions that include environmental, socio-cultural, and economic benefits. Moreover, green spaces sequester CO_2 ; they reduce air pollution and noise; regulate microclimates; reduce the heat; maintain diversity; have recreational and social values and produce a vitamin "G" for health, well-being and social safety (Uy & Nobukazu, 2008).

Generally, there are many determinant factors (main factors and sub factors) that affect urban green space development. Main factors are accessibility, physical, environmental and socioeconomic. Sub-factors include road, railway, slope, soil type, stream, park, LULC, population density, noise influence and historical and cultural area etc.

2.8.1. The Typology of Urban Green Spaces

Natural green space focuses on naturalness- implying the exclusion of artificial or managed vegetation in cities. Beyond natural green space, green space takes a wider perspective to cover natural and managed green elements. The second group is Open space which concentrates on outdoor space as opposed to the built indoor environments, whether built-up or natural. For scope of definitions, therefore, open space is the broadest, whereas natural green space is the strictest, with green space falling somewhere. (Nicol and Blake, 2000).

Table 2.2: The Typology of Urban Green Space (Source: Swan wick et al, 2003:99)

Urban Green Spaces	Amenity green spaces	Recreation green spaces	Parks and gardens
			Informational recreation, Outdoor sports areas, Play areas
		Incidental Green spaces	Housing green spaces, Other incidental spaces.
		Private green spaces	Domestic gardens
	Functional Green spaces	Productivegreen space	Remnant farmlands, City Farms
		Burial grounds	Cemeteries, Church yards
		Institutional grounds	School grounds, Other institutional grounds
	Semi-natural habitts	Wetland	Open/running water, Marsh, fen
		Other habitats	Moor/heath, Grassland, Disturbed grounds
	Linear green spaces		River and canal banks, Transport corridors, linear features (e.g., cliffs)

There are great varieties of places that can be described as UGS. Different classification systems may generate slightly different results. (Swan wick et al. 2003) provided a more relevant typology of UGS with 25 types found in England.

2.9. Lessons drawn from the literature review

The literature review conducted as part of this study covers both theoretical (conceptual) and empirical literature. The theoretical part provided clear insight to understand the conceptual background on green space, land use land cover temporal analysis/change particularly in urban areas is becoming the major factor in reducing green spaces extent. Land use land cover change needs global attention for continuous monitoring of the changes. Up-to-date datasets on land use land cover change provide critical inputs to evaluate complex causes and responses in order to project future trends.

The empirical review parts reveals the experience of different countries on the best practice of green space procedures,standards and maintenance related support provided to sustain affected Green space/infrustructure. Well developed and managed open green spaces in housing areas provide a variety of interrelated social, economic and ecological benefits to the inhabitants as well as for the society at large. The major lesson learnet from both review parts includes, Definition and concepts of Terms about different types of green space, factor affect urban green space are well discussed.

CHAPTER 3: MATERIALS AND METHODS

3.1. Description of study area

3.1.1. Location Description

Adama is a city and woreda in eastern part of Oromia Located in Rift valley founded in 1920s and its geographic location is between 523000m and 536500m East and 935000m and 950800m north. The study area, Adama city, is positioned at crossroads in the southeast of Addis Ababa at 100 km and 84.7 kilometers distance via old and express road respectively along the all-weather road which connects the city with Addis Ababa and the seaport of Djibouti. Adama city is a busy transportation centers.

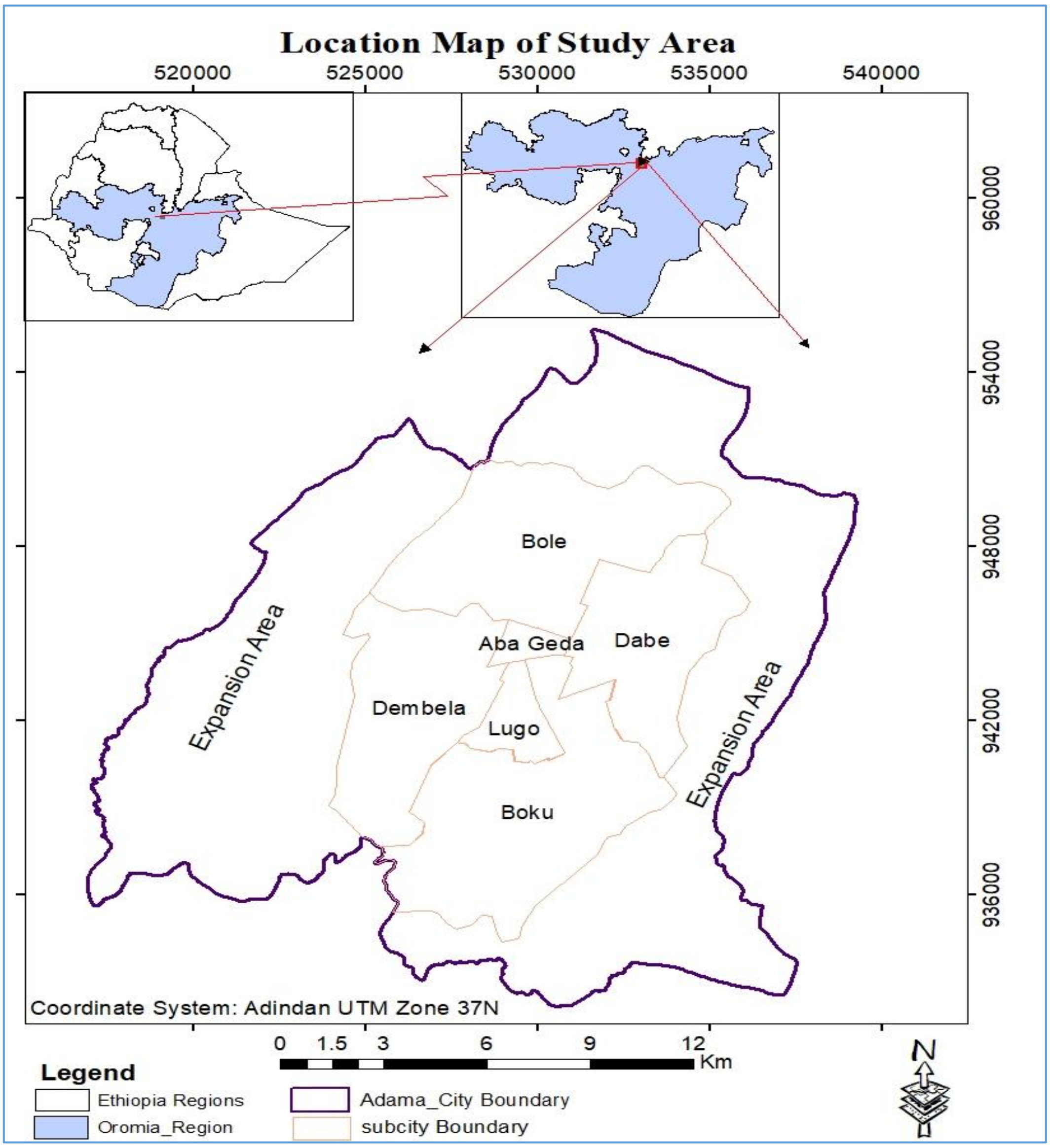

Figure 3.1. Location map of Study area

3.1.2. Topography of the study area

The topography of Adama city is characterized by flat land that is surrounded by ridges. Adama is particularly flat with slopes varying between 0 and 46.98%. According to topographical information obtained from satellite images and aerial photos, the topography of the city is invariably mosaic and divided into low-lying center and hill slopes, as Adama city was established in flat and undulating fertile land that ranges from a completely low-lying center of the city to hilly ridges overlooking the city with their unique landscape sceneries circumscribing the city.

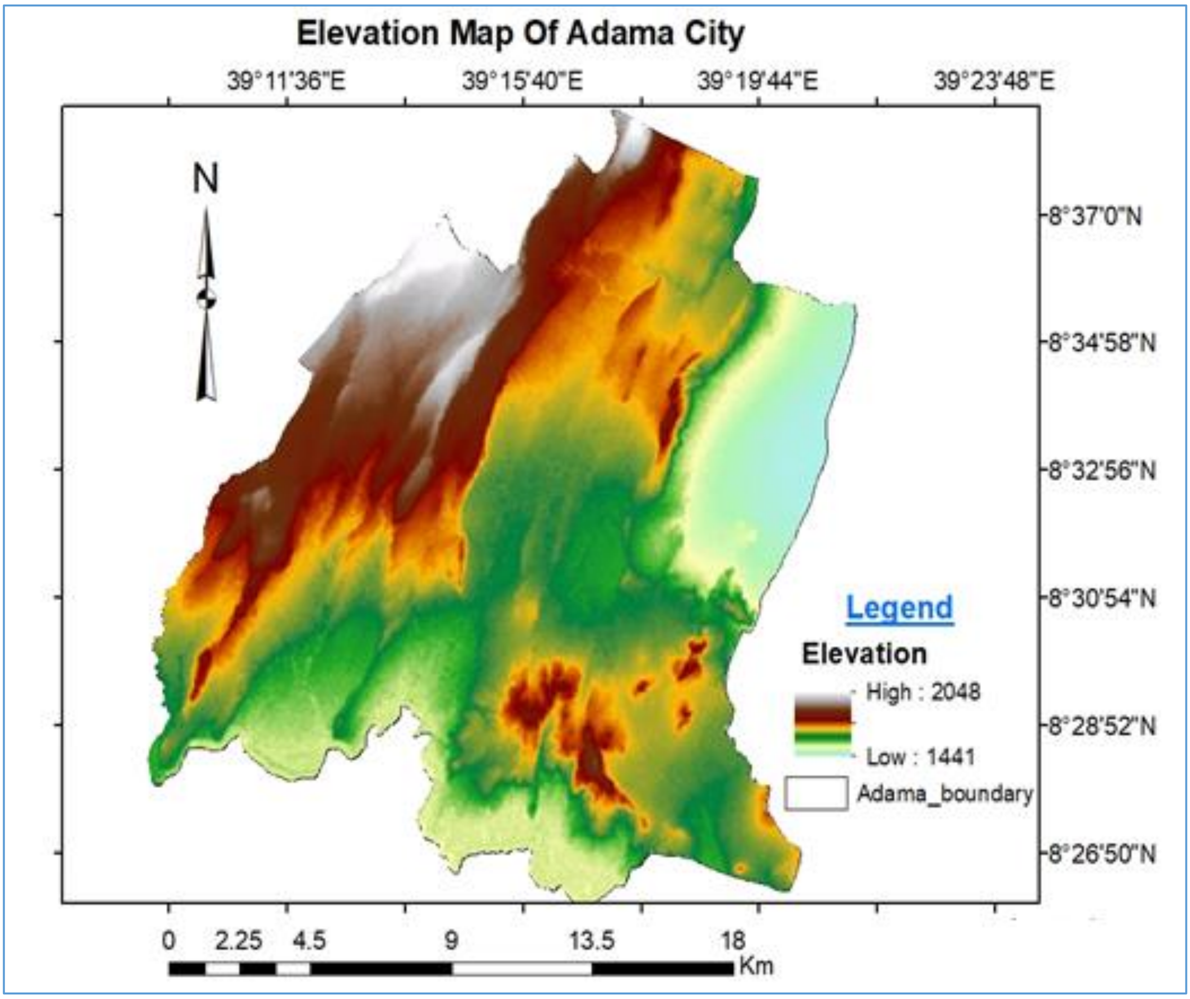

Figure 3.2. Elevation map of Adama city

The above map show elevation of the city in different hight with white color show low 1441m elevation and from blue to dark green medium and red dark to white show high elevation 2048msl. The altitude drops/declines gradually from all its peripheries to the center of the city where the slopes become gentle in the heart of the city that holds large swathes of the city. The city is lies at an altitude at the 1500-1900 meters above mean sea level, according to the present master plan of the city 2017. The average elevation/altitude of the city is 1700m above mean sea level.

3.1.3. Climate and Rainfall of Adama city

Adama city has a hot and dry climate with sparse rainfall in the winter and milder conditions in the summer. There are two distinct seasons of the wet season and dry the summer. There are two distinct seasons of the wet season and dry season. Adama district has modal a Bi-modal modal rainfall pattern with mean annual rainfall 897.9mm and 18.5% coefficient of Adama Average monthly temperatures and weather, sunny and cloudy days. In general the City enjoys favorable climatic conditions due to its geographical locations surrounded by plateaus that experiences moderate temperature and rainfall which is favorable for life. Rainfall mostly occurs in the summer season. It receives abundant and heavy rainfall every year during this season. As report on socio economic of adama city during the past five consecutive years the maximum average and minimum average annual temperature was 29.4^{o} c and 15.8 c in the year 2014/15 and 2012/13 (2007 and 2005 E.C) respectively. Similarly, the maximum annual total and minimum annual total rainfall was 934.8 mm and 736.5 mm in the year 2016/17 and 2012/13 (2009 and 2005 E.C) correspondingly *sources (Socio-economic profile of Adama, 2020/2021).*

3.1.4. Population of Adama city

According to the last three consecutive censuses conducted in the country, Adama Town showed a large increase in population. In the first Ethiopian population and housing census, which was held in May 1984, Adama had a population of 77,237. The second population and housing census conducted in 1994 reported that Adama had a total population of 127,842 of whom 61,965 were males and 65,877 were females. According to the third Ethiopian population and housing census which was conducted in 2007 (the most recent year for which data are available), 220,212 people of whom 108,872 males and 111,341 females were inhabited in Adama. Based on this the projected population of Adama Town including four subs urban Ganda’s under the City administration in 2018/19 (2011 E.C) was 433,046 of whom male 216,046 and female 217,000 (Socio-economic profile of Adama, 2020).

With an area of 35.1164 square Kilometers, Adama has a population density of 2002.794; all are urban inhabitants. A total of 60,174 households were counted in this city, which results in an average of 3.66 persons to a Household, and 59,431 housing units. (Wikipedia)

3.1.5. Land Use Pattern of Adama City

The term "Land use" used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Public and private lands frequently represent very different uses. Urban land use comprises which activities are taking place where and their level of spatial accumulation, which indicates their density, intensity, and concentration *(International Encyclopedia of Human Geography Second Edition*, 2020).

According to Adama City report land use in Adama city is total cover 3175.82 hectare which highly coverd by Open space, Green, Reserved Areas, Recreation and Enviromental Sensetetive Area cover **53%** of other land use exceeding with residential land use which is 30.3% Table (3.1).land use of study area show (fig#3.3).

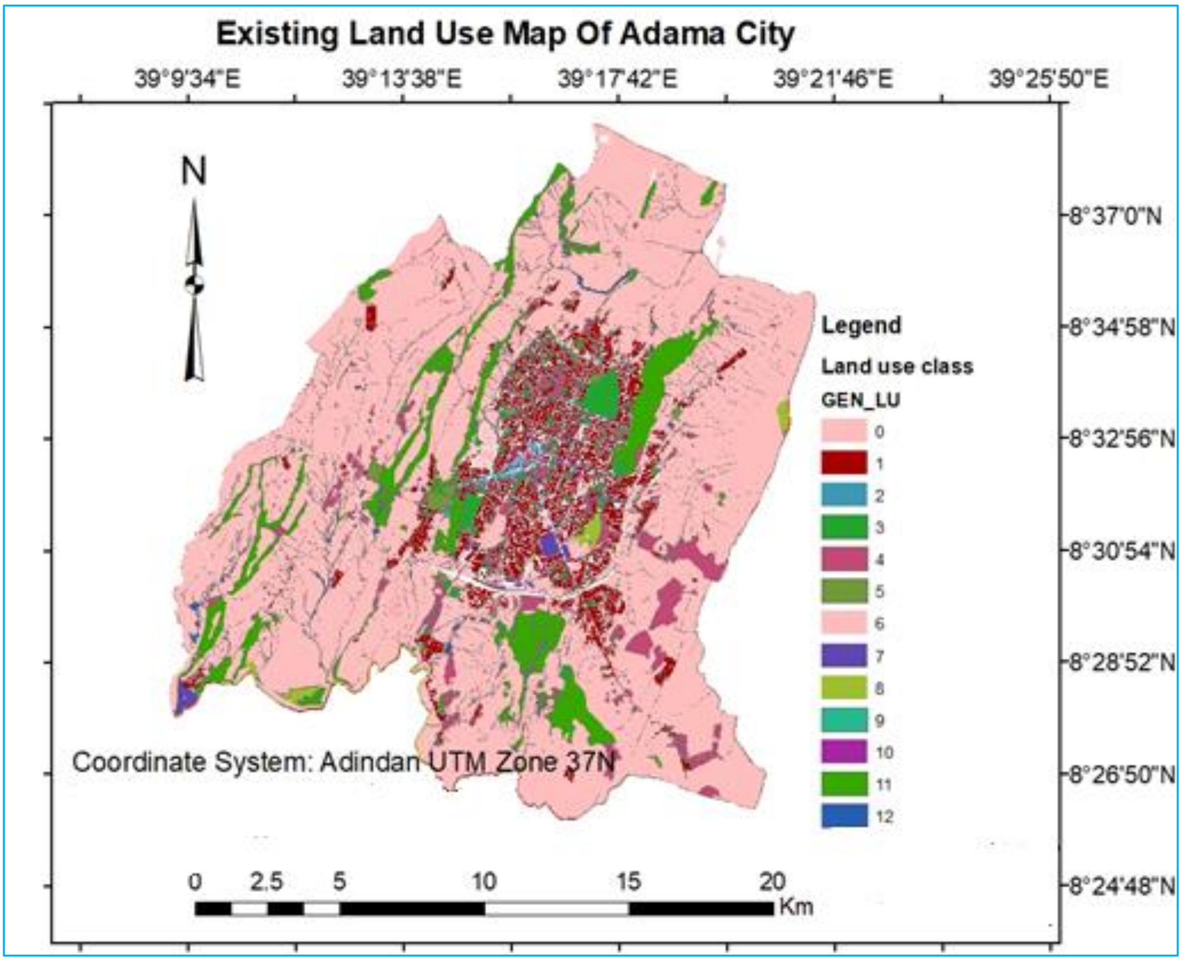

Figure 3.3. land use of Adama City (Sources AdamaCity structural plan,2018).

Table 3.1: Description of existing land use types.

Labeled	Land use types description
0	Agreculture
1	Residence
2	Commerce and Businness
3	Service
4	Open space, Green, /Reserved Areas, Recreation and Enviromental Sensetetive Area
5	Administration
6	Industry and Manufacturing, Ware House, Dipots and Workshop
7	Road, Transport, Utilities and Infrastructure
8	Water Bodies
9	Under Construction
10	Mixed use
12	Gorge

(Sources AdamaCity structural plan,2018).

From an urban planning point of view, many studies proved that urban planning is a prerequisite for any socio-economic development and modern urban management system of any urban area elsewhere which are engines of national economic development, the center of tourism, innovation, diverse services and industries. (Adama City land development and Management Agency, 2020).

According to the master plan revision made by Oromia project office in 2004, the area coverage of the city is 13,665.5 hectares. According to the urban development policy of Ethiopia the proportion of land reserved for built-up area, urban greenery and road infrastructure is 40%, 30% and 30% respectively, despite the fact that the present land use pattern of *Adama* city is different (Adama city socio economic profile, 2020) .

3.2.Methods of data collection and Sources

The data sources for this research are both from primarily and secondary sources ;Landsat satellite images from usgs of The three years included TM 2000, Landsat 2010 and ETM+ 2020. All images were georectified to a common UTM coordinate system. The distribution and quantity of land-use/land-cover patterns, distribution and density of vegetation cover

Normalized Difference Vegetation Index (NDVI) ,built up density were measured, evaluated and compared for each of the sub-cities in study area.

3.2.1. Data Sources and Types of data

For this research both primary and secondary sources are used. The primary data includes questioners and interview. The secondary data sources include secondary document such as UGS standards, masterplan of the city and others described in table:3.2

Table 3.2. Data types and sources.

Data required	Types of data	Sources of data	Software process
Topographic map	Shapefile	Adama Municipality	ArcGis and Erdas
Satellite image	Raster	USGS	ArcGis and Erdas
Masterplan of adama city	Scanned (2018)	Adama Manucipality	ArcGis and Erdas
DEM	Raster/grid	USGS	ArcGis and Erdas
X,Y data of existing green space	Vector(point)	Field survey	Ms_Excell&ArcGis

3.2.2. Material and Software used

Different software and materials were used to analyze the research. Data and software used in this study include the following; ArcGIS desktop is widely used software for this study. The three components of ArcGIS desktop like Arc Map, Arc Catalog, and Arc Toolbox have been used to create the geodatabase, editing, data management and storage, geo referencing data from different sources, performing spatial analysis, and finally maps layout.

ERDAS imagine 2015 was also another software used to process satellite images and prepare land use land cover of study area which was then became input for analysis in GIS environment. Garmin handheld GPS was utilized in this study for collection of spatial data (X,Y) and identification existing urban green space area during field survey.

Table 3.3: Software and Material used for this study

Software/equipment	Software version	Purpose of software's
ArcGIS	v10.8(ESRI)	Data analysis, store, process, digitize, edit and map preparation
Erdas Imagine	V2015	Satellite Image processing
Google earth pro	V 7.3	Check updation of land cover
MS-Office, Excel	2019(Microsoft)	Writing thesis reports
GERMIN Handheld GPS (2m) accuracy		Field data collection (x,y)

3.3. Sampling Design

3.3.1. Methods of Sampling Techniques

The sampling technique selected for this study was Non-probability sampling which is often associated with case study research design and qualitative research. With regards to the latter, case studies tend to focus on small samples and are intended to examine a real life phenomenon, not to make statistical inferences in relation to the wider population (Yin, 2003). Non-probability sampling is a technique in which the researcher selects samples based on the subjective judgment of the researcher rather than random selection. It is carried out by observation, and researchers use it widely for qualitative research. Non-probability sampling is a sampling method in which not all members of the population have an equal chance of participating in the study. This sampling is most useful for exploratory studies like a pilot survey (deploying a survey to a smaller sample compared to pre-determined sample size). Researchers use this method in studies where it is impossible to draw random probability sampling due to time or cost considerations.

3.3.2. Sample size determination

In order to generalize from a random sample and avoid sampling errors or biases, a random sample needs to be of adequate size. The aims of the researcher and the kinds of statistical manipulation that will be used in data analysis. For this research we use a convenience samping which is a non-probability sampling technique where samples are selected from the population only because they are conveniently available to the researcher. Researchers choose these samples just because they are easy to recruit, and the researcher did not consider selecting a sample that represents the entire population. Ideally, in research, it is good to test a sample that represents the population. But, in some research, the population is too large to examine and consider the entire population. It is one of the reasons why researchers rely on convenience sampling, which is the most common non-probability sampling method, because of its speed, cost-effectiveness, and ease of availability of the sample. Getting responses using non-probability sampling is faster and more cost-effective than probability sampling because the sample is known to the researcher. The respondents respond quickly as compared to people randomly selected as they have a high motivation level to participate. The issue of sample size in non-probability sampling is rather ambiguous and needs to reflect a wide range of research-specific factors in each case. Nevertheless, there are some considerations about the minimum sample sizes in non-probability sampling as illustrated in the table below.

Table 3.4: Sizes of non-probability sampling.

Sources: Saunders, M., Lewis, P. & Thornhill, A.et.al (2012)

Nature of study	Minimum sample size
Semi-structured, in-depth interviews	5 – 25
Ethnographic	35 – 36
Grounded theory	20 – 35
Considering a homogeneous population	4 – 12
Considering a heterogeneous population	12 – 30

The sample population selected for this research included households near green space, kebele administrative expert and experts related to urban green space in municipality level.

3.4. Methods of Data Analysis

In data analysis method the first step to achieve the stated specific objective is to determine indictors based on the contemporary theoretical framework of urban ecosystem services and within the context of the aspiration. Following the determination of indicators, the next major step is to develop an analytical method for estimating and evaluating spatial distribution of green space in Adama city.

The spatial green space will be extracted and integrated from geospatial information for comprehensive analysis. For Land use land cover change landsat Time series analysis was performed using Landsat 7ETM+ and Landsat 8 OLI/TIRS imagery from 2000 to 2020 with an approximate 10-year interval (3 images in total). Spectral vegetation indices and supervised land cover classifications were used to examine changes of green spaces.

Once the analytical method is developed, the amount of green space in Adama city will be evaluated and characterized. Thereafter, major factors affecting green spaces in Adama city will be identified using questionnaires, key informant interview and critical literature review.

3.4.1. Questionnaire survey and key informant interviews

Questionnaire Survey was conducted with visitors,experts and households in the study areas. Collecting relevant data for analyzing the factors affecting green space development in Adama city urges for using or applying site visits, observe and questionnaires which were the best way of methodology for the research. The study area has six subcitys. The unit of observation in the study covers both the institution and the residents accommodated in Adama city. Institutions were the one which engaged in assessing factors which affects green area development. Thus the observation unit of the study constitutes two organizations (2), six subcity (6) and households. The research was used a non probability sampling technique of households who were living near and around the proposed kebeles, and for those whose home was presented within or near the proposed green areas in subcity, Bole, dabe, Boku, Lugo, AbaGeda, and Migira Subcity.

The target population of the study was those households which were situated six(6) green areas. From each green area five (5) households were taken as a sample for the study. Therefore, from the 6 green areas 30 households were taken. And the remaining 15 respondents were from Adama city in different organization experts. The total households surrounding the green areas were the sampling frame of the study. Therefore the total respondents were 45 in total.

3.4.2. Datasets Preparation and Image Pre-Processing

The data sources for this research primarily came from landsat images and secondary data from different organizations used to extract parameters for the environmental variables. The population census data were collected from (CSA, 2007) 2020 projected. for change detection landsat Time series analysis was performed using Landsat 7ETM+ and Landsat 8 OLI/TIRS imagery from 2000 to 2020 with an approximate 10-year intervals was selected. These images used for extracting information on and cover and NDVI in Adama city Collection 2 Level-2 Landsat products were acquired from the USGS through the EarthExplorer data portal https://earthexplorer.usgs.gov/. Below figure show methods for image classification and procedure folloed in LULC change. In total, three year images were downloaded for the selected years captured under clear atmospheric conditions during the growing season (September-April). Important details of Landsat data products used in this study, are presented in Table 3.4 satellite image description.

Table 3.5: Description of satellite images used for this this study

Satellite	swath	Path/row	Acquired date/year	Resolution/ Source	Data format
Landsat 7 ETM +	185 km	168/54	nov 19, 2000&	30m	Tiff
Land sat 7ETM+	185 km	168/54	dec,02, 2010	30m	Tiff
Landsat8(OLI)	185 km	168/54	dec,11, 2020	30m	Tiff

(Sources Usgs.gov.org)

3.4.3. LULC image Classification and Accuracy Assessment

In order to visualize and estimate changes of green spaces in Adama city during the last three decades, land cover classification was performed for selected images from 2000, 2010, and 2020 (nearly the beginning and end of each decade). The selection of land cover classes mainly depends on the aim of the study, the study area and the resolution of the input data. Given that the focus of this study is vegetated areas, and the spatial resolution was constrained to 30 m, the following land cover classes were selected: Vegitation/green space, bare land, water, farm land, and built-up land. For the future relevance of this research, it is very important to specifically define the land class "green space". In this study the considered green space a land covered with some form of vegetation including forests, parks, grasslands and crops. One uncertainty that arises from this classification is related to agricultural areas under rotation systems used for annually harvested crops and fallow lands. If such an area is under crop at the time of observation, it will be classified as "green space", otherwise it will be classified as "bare land". Built-up land cover is characterized as an artificial and/or impervious cover, and it includes residential, commercial, industrial, transportation and communication utilities.

Training samples were selected directly from the Landsat images using a priori knowledge of the land use and Google Earth historical imagery. The samples of different land covers were randomly chosen using the polygon of pixels sampling procedure. Around 50 training polygons/area of interesting(AOI) were collected for each Landsat image. Supervised classification was performed in ERDAS IMAGINE 2015, employing the maximum likelihood algorithim. The result of an accuracy assessment typically provides the users with an overall accuracy of the map and the accuracy for each class in the map. Producer’s and user’s accuracy are derived from following formula:

User’s Accuracy: user’s accuracies are computed by dividing the number of correctly classified pixels in each category by the total number of pixels that were classified in that category (the row total). This result is a measure of commission error. It is calculated as:

$User's\ accuracy = (\frac{\mathrm{Ri}}{\mathrm{Rt}}) * 100$……………………………………………..equation (1)

Where, Ri = correctly classified samples in the row and

Rt = total number of samples in the row.

Figure below show LULC classification procudere followed in the study.

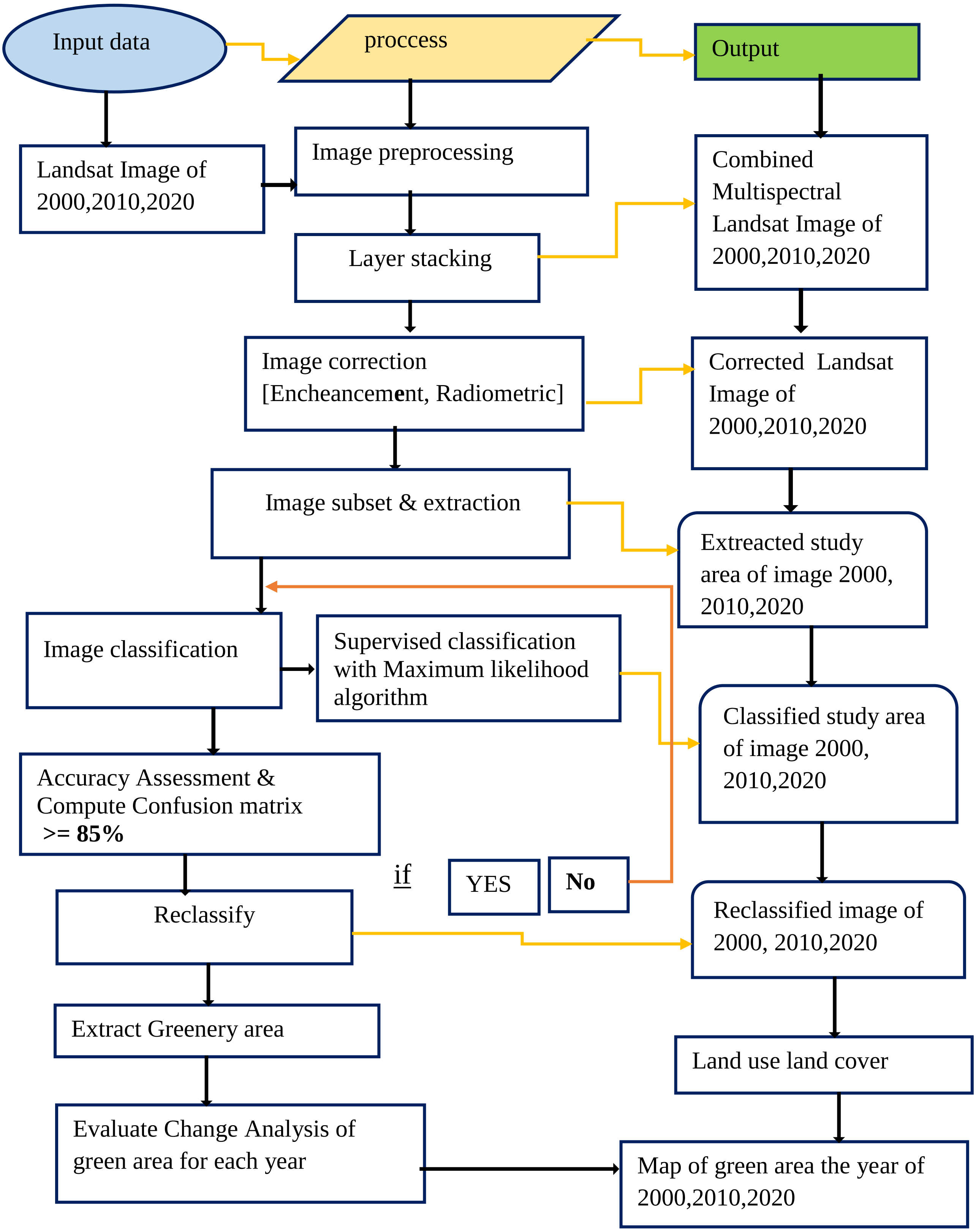

Figure: 3.4 Work flow of LULC classification methods

Producer's Accuracy: Producer's Accuracy measures the percentage of correctly classified pixels from a sample data or indirectly indicates errors of omission for a particular class. it was calculated from dividing the number of correctly classified pixels in each category (on the major diagonal) by the number of training set pixels used for that category (the column total).

$Producer's\ accuracy = (\frac{\mathrm{ci}}{\mathrm{ct}}) * 100$…………………………………………equation(2)

Where, Ci = correctly classified sample locations of the reference data or column and

Ct = total number of sample locations of the column.

Overall Accuracy: Overall accuracy was computed by dividing the total diagonal (i.e., the sum of the correctly classified sample units) by the total number of sample units in the error matrix.

$Overall\ accuracy = (\frac{\mathrm{sd}}{\mathrm{n}}) * 100$……………………………………………equation(3)

Where, Sd = sum of values along diagonal and,

n = total number of samples.

Kappa Coefficient: Kappa coefficient can be used as another measure of agreement or accuracy. Kappa was used to measure the agreement or accuracy between the remote sensing derived classification map and the reference data as indicated by the major diagonals and the chance agreement. a value greater than 0.80 (i.e., 80% andabove) represent strong agreement; a value between 0.40 and 0.80 (i.e., 40%–80%) represents moderate agreement; and a value 0.40 (i.e., 40% and below) represents poor agreement.

$K\hat{} = \frac{\mathrm{n}\sum_{i=1}^{r}\mathrm{xii} - \sum_{i=1}^{r}(\mathrm{xi+.x+i})}{\mathrm{N}^2 - \sum_{i=1}^{r}(\mathrm{xi+.x+i})}$ ……………………………………equation(4)

Where r = number of rows in the error matrix;

Xii = number of observations in row i and column i (on the major diagonal);

Xi+ = total of observations in row i (shown as marginal total to right of the matrix);

X+i = total of observations in column i (shown as marginal total at bottom of the matrix)

N = total number of observations included in matrix.

a random of 100 points was used as a classifier, for Accuray assessment. Accuracy assessment was done by using above equation:

Based on land cover classification maps, land cover change maps were produced for two decades: 2000–2010 and 2010–2020. Land cover change maps are a very useful instrument to assess and visualize where green spaces are under pressure or where additional green spaces are needed in order to create an interconnected system. The general work flow followed in this research illustrated on bellow figure.

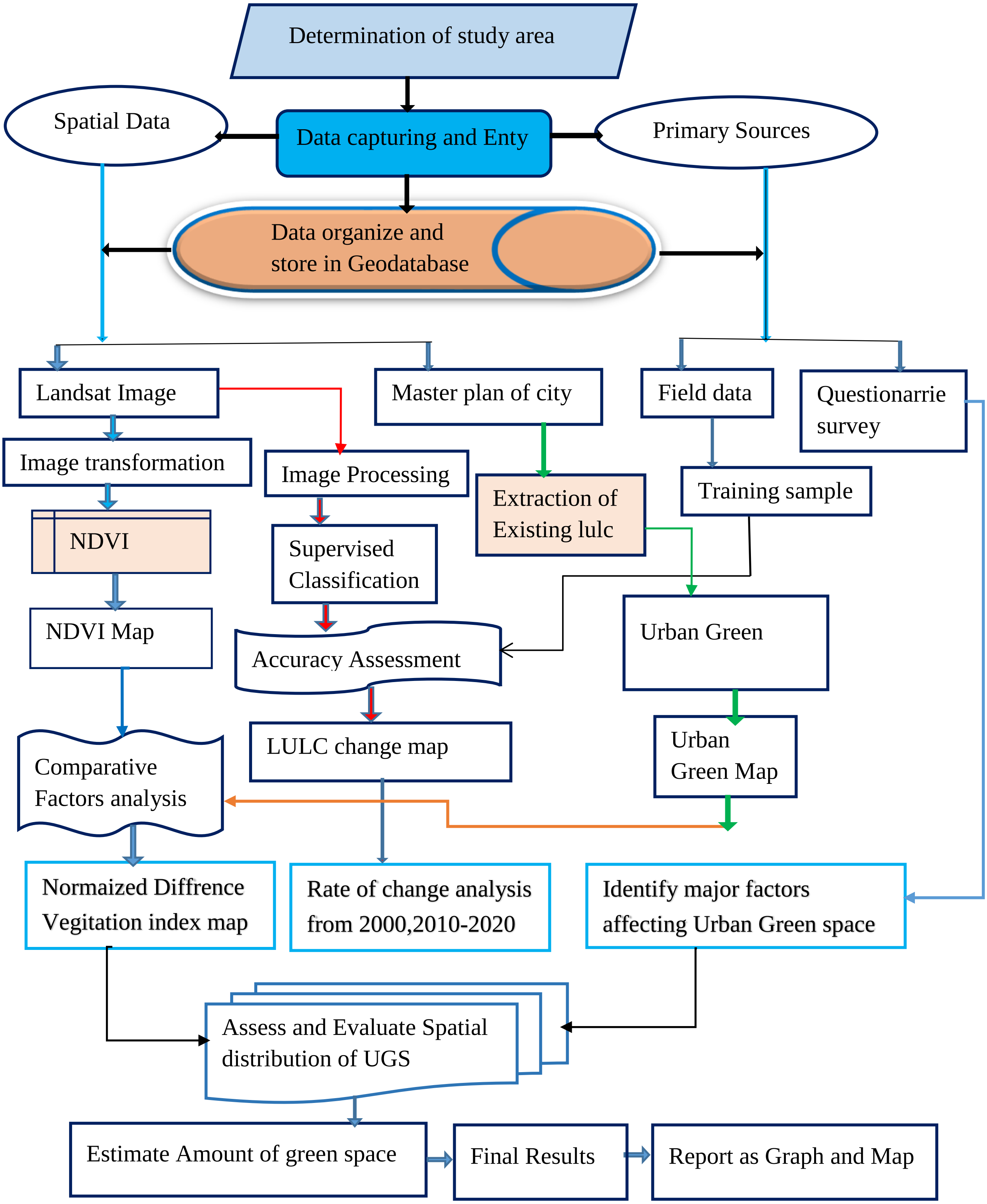

Figure 3.5. Technological scheme of the study

3.5. Spatial Distribution and Density of Vegetation Cover (NDVI indices)

Normalized Difference Vegetation Index (NDVI) has been applied for measurement of vegetation distribution and density in this research. Vegetation has a high reflectance in the Near Infrared Red (NIR) bands of a sensor system because of the internal reflectance by the spongy mesophyll tissue of a green leaf (Campbell, 1987). The NDVI separates the soil vegetation from other ground cover materials. Then its ratio is calculated through the difference of near infra-red NIR) and red band (RED) which would be normalized by summing up these two bands in the following equation (1) (Lillesand and Keifer, 1994).

For landsat 7 the formula was given as below equation :

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(equation 5)}$$

Where, NDVI→ Normalized Difference Vegetation Index

RED →Stand for the spectral reflectance measurements acquired in the red

NIR →Stand for the spectral reflectance measurements acquired in the near-infrared regions. for LandSat 8 the NDVI formula was the same but differ in bands; NIR(Band5 and Red(Band4) but in land sat 7 NIR(Band4) and Red(Band3)

3.6. Data preparation for Urban Green Space indicators

The set of indicators elaborated to evaluate GS consider the three main dimensions quantity, quality and spatial distribution. This is to develop a set of indicators for GS that allows recognizing inequalities in different subcity. The quantity refers to the total area of GS in relation to population and urban context. The quality is evaluated through GS and vegetation cover. Especially, the spatial distribution tested the accessibility of public service residents and existing territorial inequalities.

*Indicators associated to the quantity of GS:*The total area of GS is respectively compared to the sum of land cover per impervious cover, per vegetation cover (according to FAO land cover classification system; FAO, 2005), for a better understanding of the urban structure and the location of the GS.

*Indicators associated to the quality of GS***:** to know the quality of GS we evaluate the quality of GS using physical attributes. The mean size per subcity is based on the individual size of each GS. Finally to estimate amount and evaluate the actual utilization of UGS in study area I have used point of interseted in each subcity structural plan of Adama 2018 from the Urban green space development of Adama city and the other points were collected using Hand held gps from site. The collected point of intersected data contained different layers (Appendix 1) and 127 existing green space points, and 148 point of interesting. each POI has four items of information: name, category, coordinate, and classification (Appendeix 1). We selected and extracted POI points that were closely related to the actual utilization status of UGS services. We selected POI points related to the actual utilization status of UGS according to the following criteria. When there is UGS near to facility represented by POI, people will prefer to choose the facility. This is because people who use the facilities can access the UGS to get services, such as relieving stress, strengthening physical exercise, and UGS provides additional values for the facility.

Therefore, we think the facility has used UGS services. If there are corresponding facilities near by the UGS, we think the UGS has been used. In making this calculation, existing UGS and UGS points collected from site are combined together were individually evaluated in ArcGIS10.8 spatial analysis tools.

CHAPTER 4: RESULTS AND DISCUSSION

In the earlier chapters, it was tried to explain the importance and the spatial distribution of urban green space in Adama city. To assess the performance of the recommended methods described in the previous chapter three, as well as to provide a better understanding of the spatial distribution of urban green space development in Adama city, the methods have been applied based on the data gathered and available data. This chapter presents major findings of the methodologies undertaken in the research also discusses different data sets that were used to examine changes in the land use land patterns of urban green space.

4.1. Spatial analysis of LULC classification and Accuracy Assessment

Land use land cover classification maps were presented in (Figure 4.1 and 4.2) and spatio-temporal LULC dynamic process was analyzed (Table 4.3). Based on the LULC classification, the major part of the area was covered by Farm land in year of 2000 later shifted to another land area. in 2000 farm land, vegetation, Built-up covered 76.01%, 12.48%, and 5.76% total area respectively. The remaining parts of the area were covered with covered Bare land (5.65%), and water body area (0.1%) respectively. In the year of 2010 land class area vegetation, farm land, Built-up area are covered 11.34%, 71.77%, and 13.16 % total area respectively. The rest of the areas were covered with Bare land (3.61%), and water body (0.12%) respectively.

Table 4.1: LULC class areas and accuracy assessment for 2000

Year	LULC Class Types	Area		Accuracy			
		Absolute (HA)	Relative [%]	User's	producer	Overal	Kappa
2000	Bareland	1776.76	5.65	78.14%	96.52%	86.89%	0.836
	Builtup	1811.75	5.76	92.23%	88.55%		
	Farmland	23903.27	76.01	86.36%	89.47%		
	Vegetation	3924.63	12.48	91.18%	97.35%		
	Waterbodies	30.40	0.10	89.10%	95.26%		
Total		31446.81	100.0				

(Sources own analysis in Erdas imagine V2015,and ArcGis)

In 2020 Farmland area had the largest area coverage (53.1%) and the remaining Builtup area (20.9%), Bareland (15.0%),Vegetation (10.9%), and Waterbodies (0.1%) show the same percentage with respective year was the share of other LULC classes (Table 4.3 and Figure 4.2). To some extent in the classification, the plantation/vegetation LULC type was generalized to other classes, but, as evident in the field observation, green Vegitation is highly diminished due to urbanization. The vegetation cover has been declining since the year 2000 in the order of 12.48% for 2000, 11.3% for 2010 and 10.9% for 2020.

4.1.1. Accuracy assesmemt

The overall accuracies for the three reference years: 2000, 2010 and 2020 are 86.89%, 95.97% and 96.69% with the Kappa statistics of 0.84, 0.91 and 0.95 respectively (Table 4.1). The Kappa statistics value greater than 0.80 (i.e., 80%) represents a strong agreement and a value between 0.60 and 0.80 represents a substantial agreement (Landis and Koch, 1977) sited in (Tesfaye.T, 2016). Hence, the maps met the accuracy requirements for change detection analysis (Anderson *et al*., 1976), and there is a positive correlation between the remotely sensed classified samples and the reference data. For each land class image classification The Producer’s accuracy calculated which is the probability of a reference pixel being correctly classified and is a measure of omission error while User’s accuracy describes the probability of a pixel classified on the map actually representing that category on the ground (Commission error) Table 4.2 are summarized.

Table 4.2: LULC class areas and accuracy assessment for 2010
(Sources own analysis in Erdas imagine V2015,and ArcGis)

Year	LULC Class Types	Area		Accuracy			
		Absolute (HA)	Relative [%]	User's	producer	Overal	Kappa
2010	Bareland	1136.20	3.61	90.00%	69.23%	95.97%	0.914
	Builtup	4138.48	13.16	92.31%	90.22%		
	Farmland	22569.06	71.77	98.11%	99.05%		
	Vegetation	3565.56	11.34	90.00%	94.74%		
	Waterbodies	37.63	0.12	89.66%	100%		
	Total	31446.94	100.0				

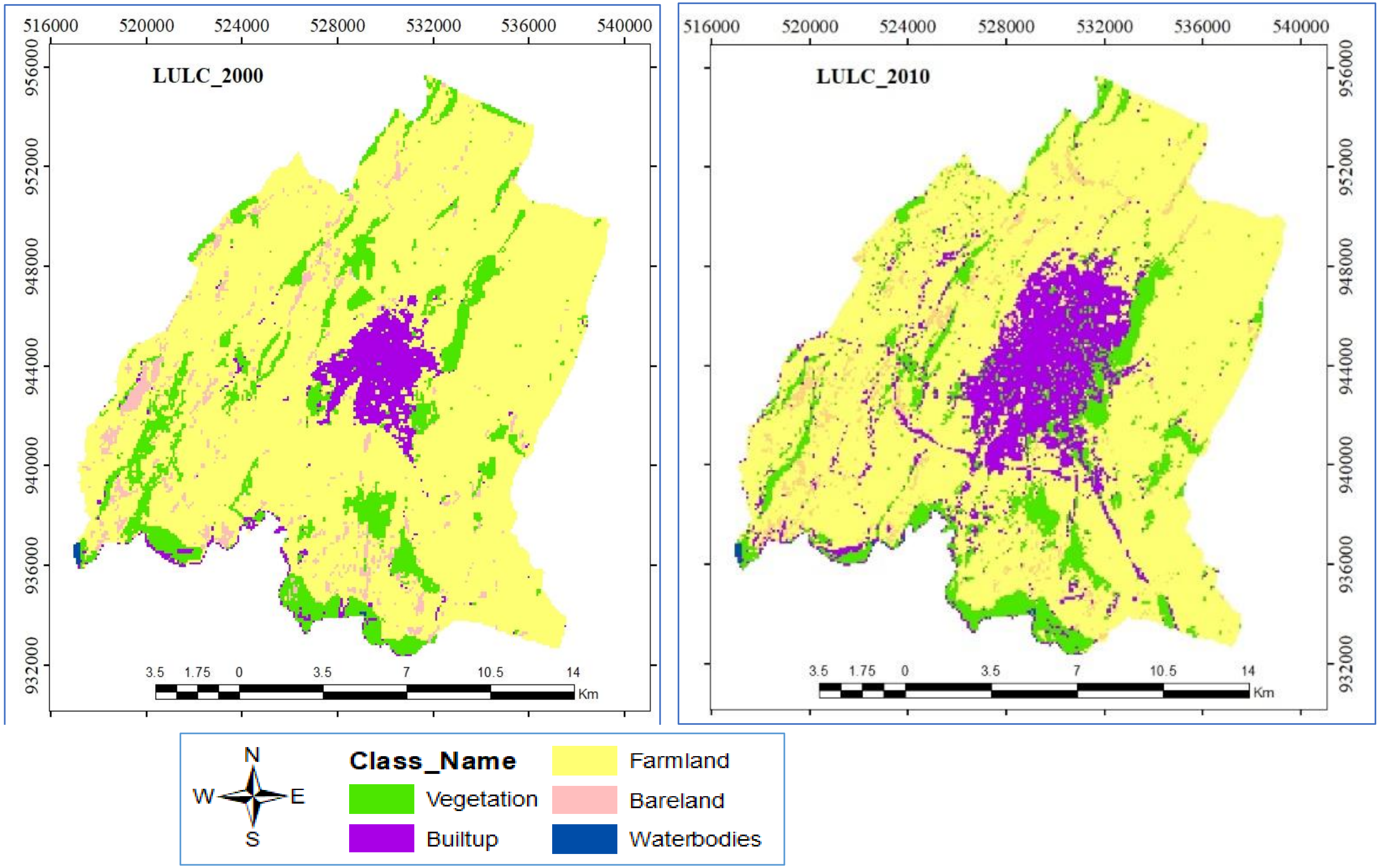

Figure 4.1: LULC Maps of Adama city in 2000 and 2010

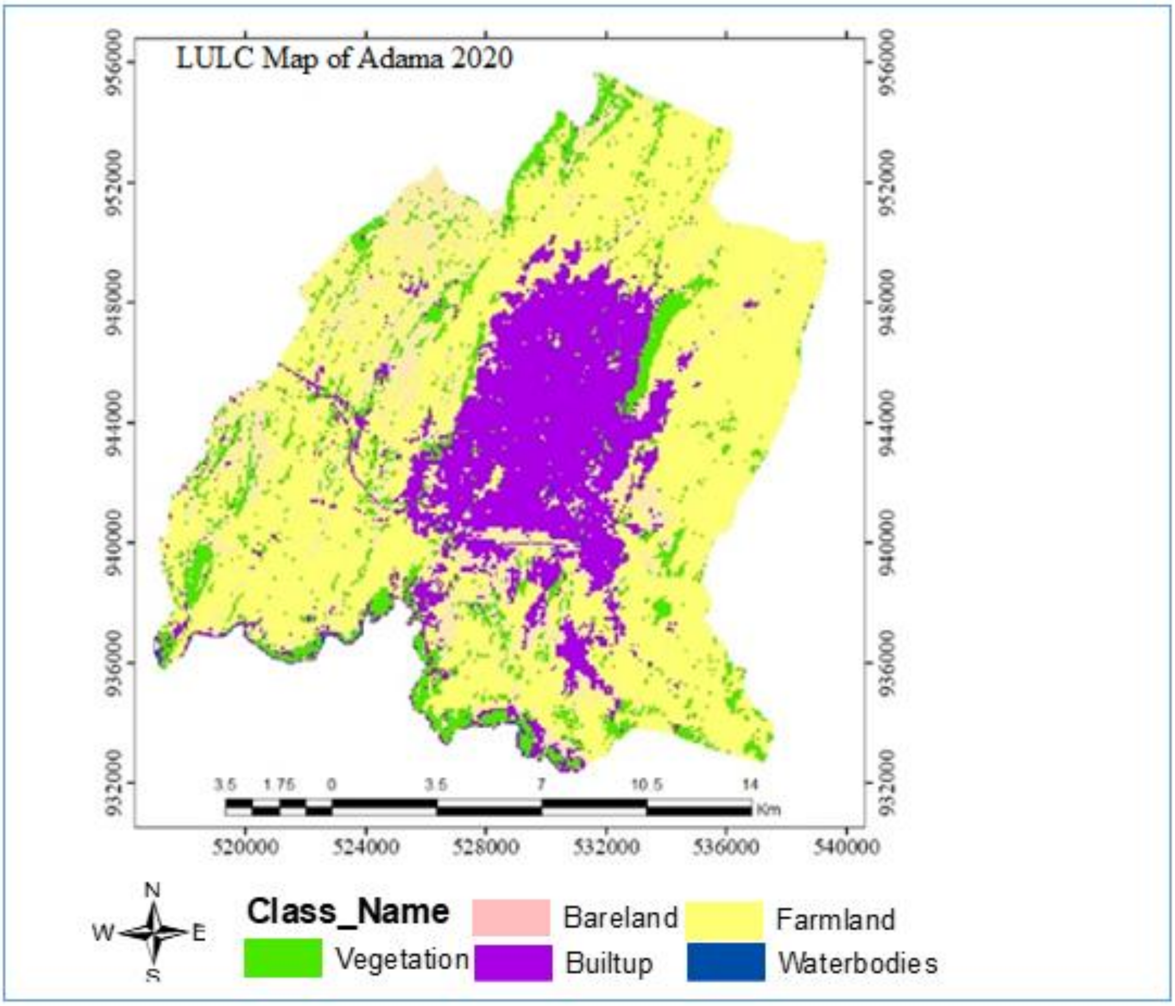

Figure 4.2: LULC Maps of Adama city in 2020 G.C

Table 4.3: LULC class areas and accuracy assessment for 2020

(Sources own analysis in ERDAS IMAGINE 2015,and ArcGis)

Year	LULC Class Types	Area coverage		Accuracy			
		Absolute (HA)	Relative [%]	User's	producer	Overal	Kappa
2020	Bareland	4703.22	15.0	96.44%	96.43%	96.69%	0.952
	Builtup	6563.32	20.9	96.55%	93.33%		
	Farmland	16691.50	53.1	95.59%	98.48%		
	Vegetation	3442.31	10.9	96.30%	91.35%		
	Waterbodies	46.12	0.1	69.18%	66.12%		
Total		31446.47	100.0				

4.1.2. Land Use Land Cover Change Analysis

The land cover analysis can serve as a appropriate tool to analyze ecosystem changes and their environmental implications at various temporal and spatial scales. The basic idea in using remote sensing data for change detection is that the process can identify the change between two or more dates that is uncharacteristic of normal variation. It is true that varieties of land-use/land cover changes spatially in vegetation,farm land, Bare land, Built up and water body are seen with the area during the period between 2000 to 2020. For land use land cover change the gain values computed by subtracting the persistence value from the total area of final year and the loss value also computed by subtracting the persistence value of the total area of the initial year. The net change was calculated as the difference between gain and loss. The values were presented in terms of hectares and percentages. The percentage LULC changes were calculated using the following equation.

$$\text{Percentage LULC change} = \frac{\text{Area final year} - \text{Area initial year}}{\text{Area initial year}} \times 100 \quad \text{……………………..equation(2)}$$

Where area is the extent of each LULC type. Positive values suggest an increase whereas negative values imply a decrease in extent. The LULC change rate was computed using the formula suggested by Puyravaud (2003):

$$r = \left(\frac{1}{\Delta t}\right) ln\left(\frac{A2}{A1}\right) * 100 \quad \text{………………………………..……………equation (3)}$$

Where r is the annual rate of change in %, Δt is the time interval in years during the LULC change being assessed, ln is the base of the natural logarithm function, and A1 and A2 are initial and final LULC areas respectively. Table 4.3 shown the detail overall changes analyses of LULC of study area.

Gains, losses and persistence: As can be observed from Table 4.3, in the period 2000 to 2010, land cover such as Vegetation, Bare land and farm land had losed -359.1 ha, -640.6, and -1334.2 hectares of land respectively, and gained 2326.7ha and 7.2 ha of built up area and water bodies respectilvely. However, change area of 2926.46 ha, 4751.58ha and 15.72 hectares of bare land,built up and waterbodies are gained in 2010 to 2020respectively while farm land and vegetation lost -7211.78 and -482.32 hectares respectively. this show vegetation and farm land highly changed to other LULC class.

Table 4.4: Change analysis loss gain of LULC area between 2000,2010 and 2020.

LULC Class Types	2000 - 2010		2010 - 2020		2000 – 2020	
	Change (Δ/ha)	%	Change (Δ/ha)	%	Change (Δ/ha)	%
Bareland	-640.6	-2.0	3567.02	11.3	2926.46	9.3
Builtup	2326.7	7.4	2424.84	7.7	4751.58	15.1
Farmland	-1334.2	-4.2	-5877.6	-18.7	-7211.78	-22.9
Vegetation	-359.1	-1.1	-123.25	-0.4	-482.32	-1.5
Waterbodies	7.2	0.02	8.48151	0.0	15.72	0.0

The detail land use land cover cause result change describe in discussion part classification maps were generated for 2000, 2010,and 2020, practically the beginning and end of each of the three decades. a rapid and unplanned expansion and commercial development, along with population pressure, has negative impact on the green space (Eyob, 2008). Generally, this analysis show At present the green spaces of Adama city are almost transformed to urban habitats accommodating an excessive population due to a high rate of rural-urban migration.

4.1.3. Analysis coverage of Spectral Vegetation Indices

The NDVI analysis was employed in order to show the vegetation cover transition. The Normalized Difference Vegetation Index (NDVI) is one of the commonly used indicators for monitoring green coverage. It has been used to study changes in vegetation coverage in recent years. For the remote sensing of vegetation, the most useful spectral radiances are in the red and near-infrared (NIR) regions.

Healthy vegetation: strongly absorbs visible light for photosynthesis and has high reflectance in the NIR region. Unhealthy or sparse vegetation, on the other hand, will generally reflect more visible light and less NIR light. As the NIR, red and short-wave infrared (SWIR) spectral regions are the most sensitive for green vegetation and vegetation changes, these bands are employed to calculate the NDVI (Holben, A.N ,2012). below maps in figure 4.3 – 4.5) the NDVI indices were calculated using (equation 1) in previous section.

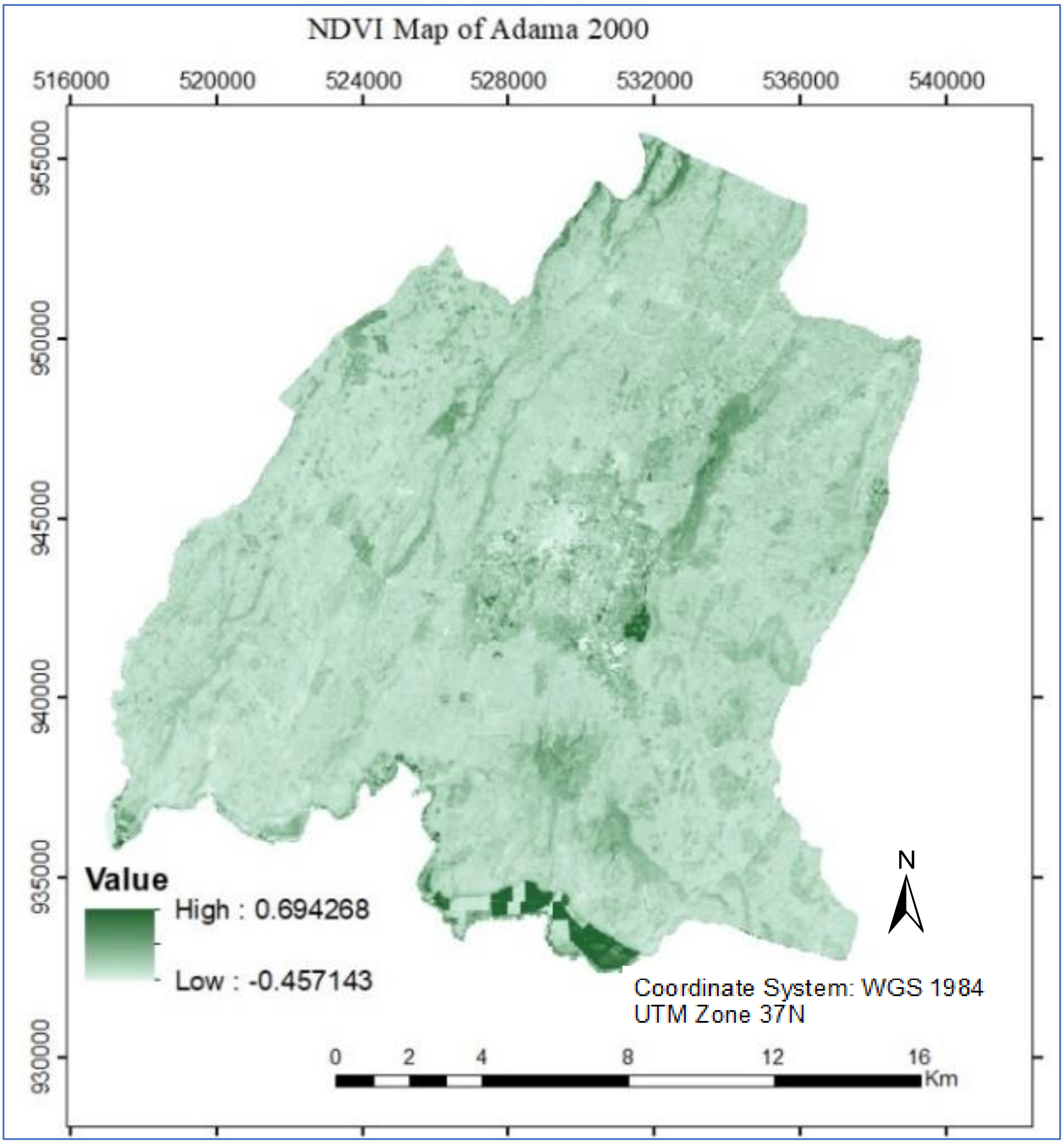

Figure 4.3: Normalized difference vegetation index maps of 2000

From the above map The pixel values of 2000 NDVI image ranges from around -0.45 for not very vegetated surfaces to values of 0.69 for vegetated surfaces. Images shows the greenness information derived from the landsat images, generated NDVI images.

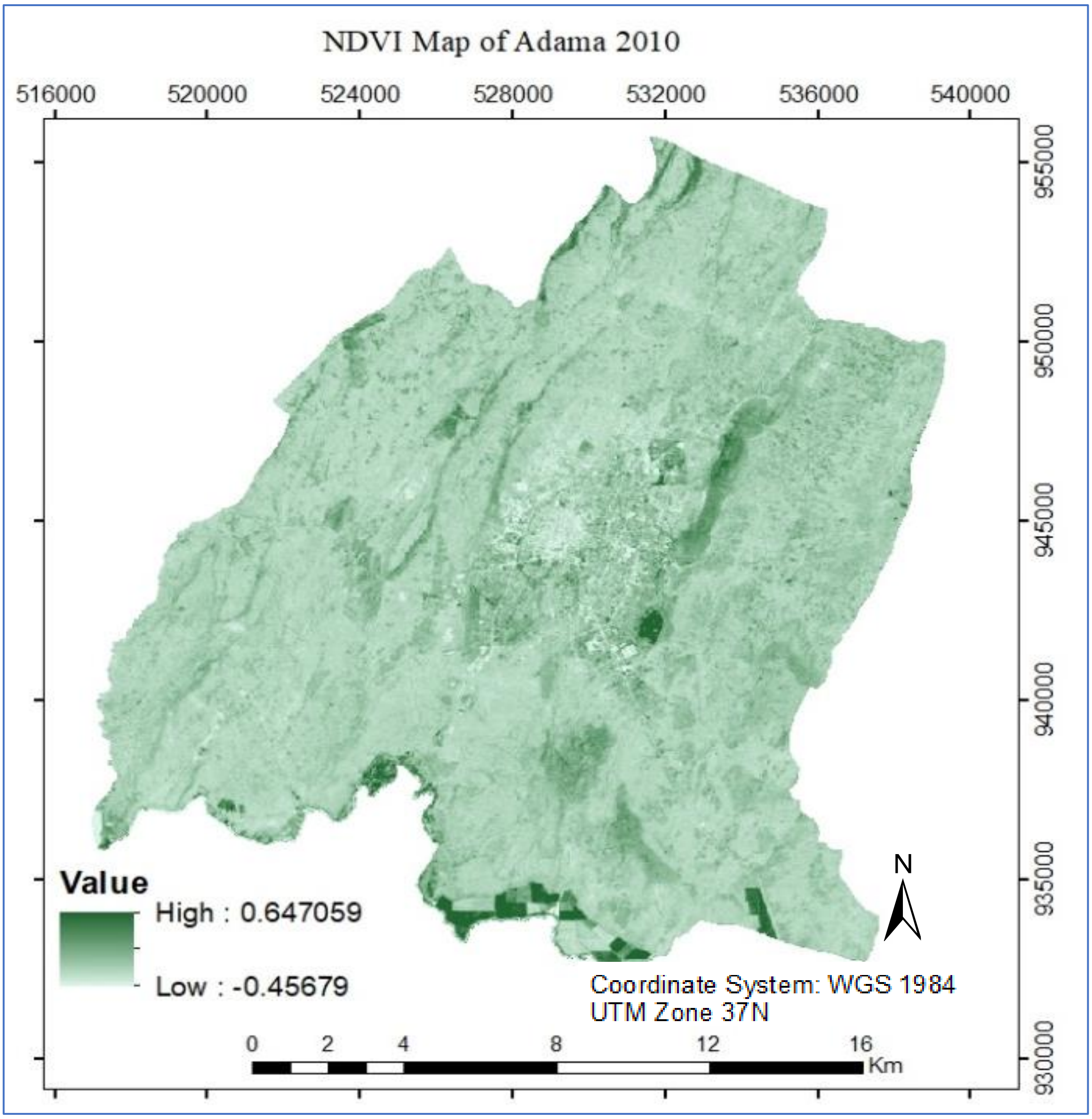

Figure 4.4: Normalized difference vegetation index maps of 2010

For 2010, the pixel values for the NDVI images ranged from -0.456 for not very vegetated surfaces to values of 0.64 for vegetation surfaces. The results indicate that for 2020 (figure 4.5) the pixel values for the NDVI image ranged from -0.157 for none and not very vegetated surfaces to values of 0.46 for vegetation surfaces. The maps shown in Figure 4.3-4.5 shows the greenness information derived from the landsat images, generated NDVI images. The images in the shades of white represent man-made surfaces (concrete, roofs, and roads) and water bodies, light green represents grassy fields of varying health, and dark green represents healthy vegetated area).

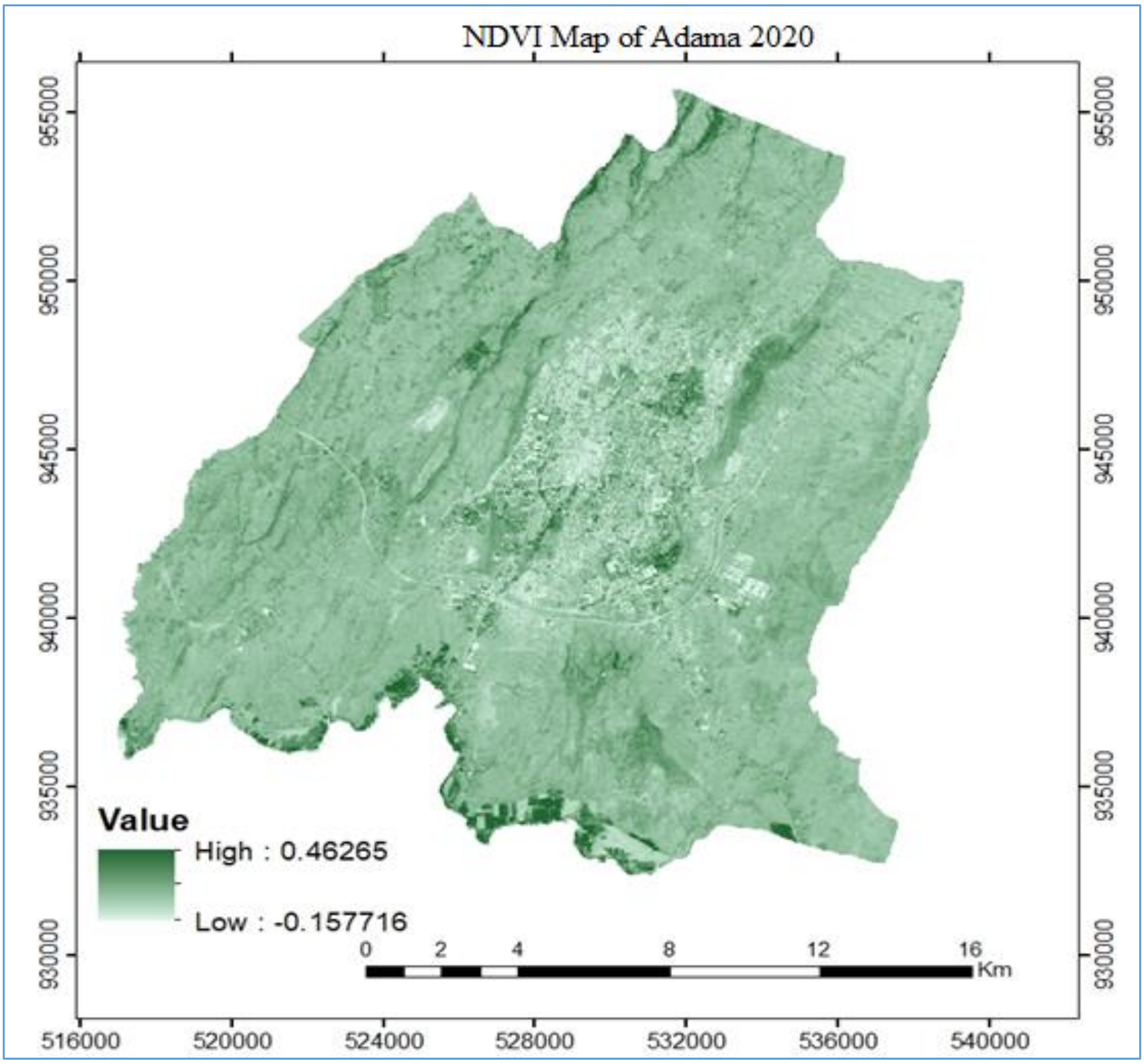

Figure 4.5: Normalized difference vegetation index maps of 2020.

4.1.4.Urban Green Spaces Extraction

The spatial distribution of urban green spaces in Adama is shown in Figure 4.6 green space is distributed across 2409.158 area covers, and all are located As shown in (Table 4.5) The statistical information of the urban green spaces from total area. sub urban area contains about 55.35% of green space area, while in other subcity Boku cover 11.76 % and Dembela sub-city 11.60% green area coverage. Dabe and bole, sub city contain moderate 10.32%, 9.44% respectively while lugo and abageda sub-cities contain less coverage to very low 1.33 and 0.21% green space per area.

Table4.5 Spatial distribution of green space by subcity

(Sources own analysis,2020)

Adama Subcity	UGS Area coverage (ha)	percentage(%)
Dabe_subcity	248.74	10.32
Lugo_Subcity	32.13	1.33
Dembala_Subcity	279.34	11.60
AbaGeda_Subcity	4.97	0.21
Bole_Subcity	227.32	9.44
Boku_Subcity	283.28	11.76
Sub_Urban	1333.38	55.35
total	2409.158	100.00

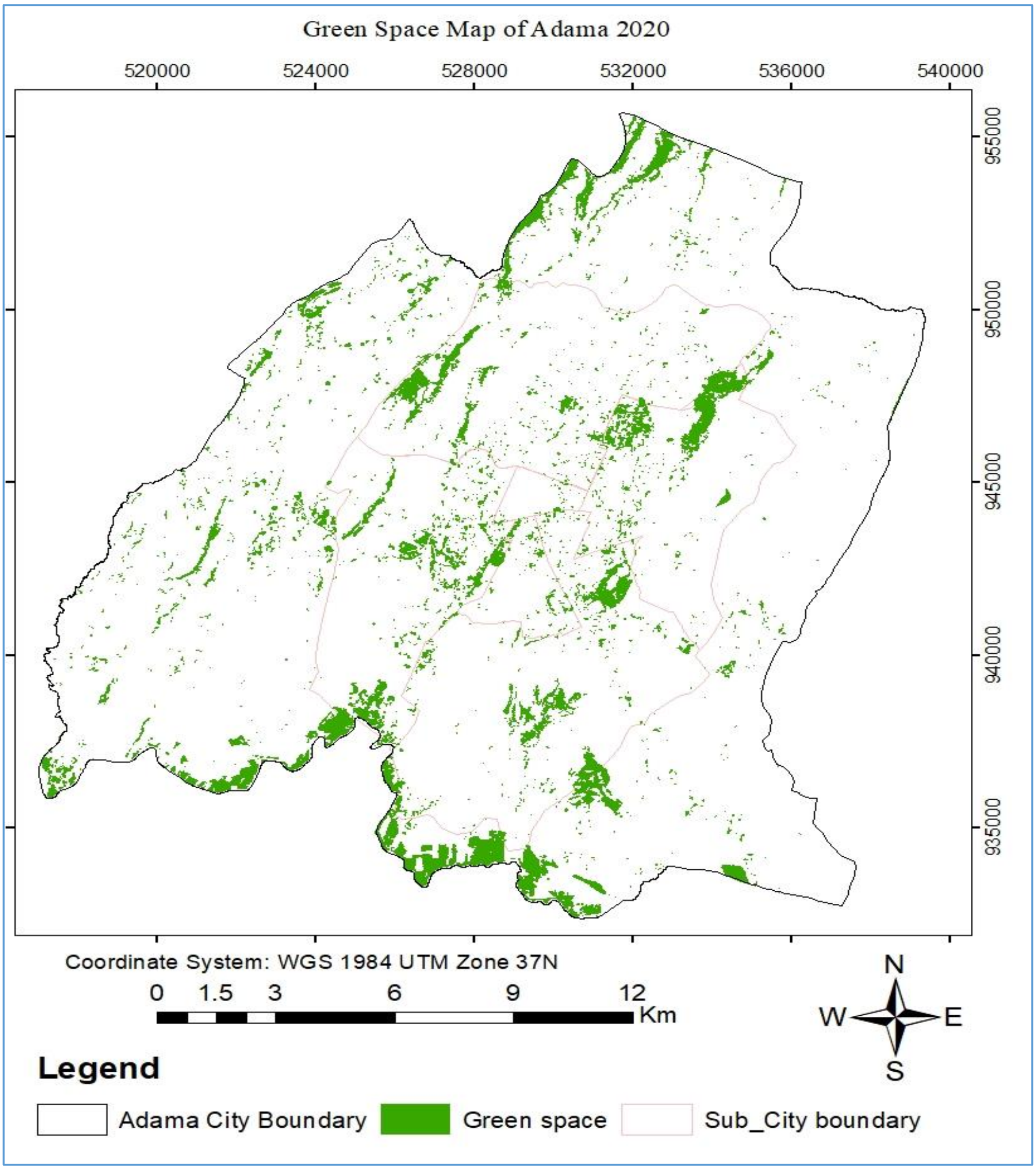

Figure 4.6: Distribution of urban green space map of Adama in (2020)

4.2. Urban Green Space indicators and spatial pattern

4.2.1. Urban green space indicators

The majority of the natural indicators such as LULC and NDVI have been derived from the classification of satellite imagery. The information obtained from these often serves as the basis for which environmental variables that will show the condition of the spatial distribution of UGS. The GS indicators considered; the total area of GS in relation to urban context, the quality of GS based on its (size,shape and vegetation cover), and spatial distribution and accessability of green space.

After data prepared for GS indicators Land use land cover and point of intersection area are combined together and constructed three indicators for evaluating the actual utilization of UGS and estimate its amount (Figure 4.6) Identified indicators as follows.

(A) Stock(standard): The first indicator was stock, related with quantity of UGS which represented the total area of UGS within the administrative boundary of a city (i.e. the sum of areas existing ugs figure 4.6).

(B) Actual Utilization: The second indicator was actual utilization, relatd with quality of GS which represented the total area of UGS actually used in a city.

The quality of GS was evaluated using physical attributes. To know the actual utilization of GS researcher defined the UGS grid actually utilized as follows: a buffer zone with a radius of 1 km was generated surrounding the center of each UGS center (1km^2). If any Point of intersecting related to UGS actual utilization (Table 4.8) was in the buffer zone, then the UGS grid was regarded as being actually utilized.

Finally, We took 1km is as the radius of the UGS grid buffer zone because it represented the distance accessible by a person walking daily for approximately 10 minute this ensured good pedestrian accessibility between the UGS and the supporting facilities.

(C) Actual Utilization rate: The third indicator was actual utilization rate, which

Represented the actual rate of utilization of UGS in a study area. (i.e. the percentage of total UGS in the sum of buffer zone for each subcity (figure 4.4). The ratio of the used UGS area and the total UGS area in each city was calculated to obtain the actual utilization rate indicator. In making this calculation, existing UGS were individually evaluated in ArcGIS10.8.

Table 4.6: Categories and description of Points of interest related to the actual utilization status of urban green space.

s/n	Category	Subcategories
1	Community and cultural	Children and youth center
2	Education	Colleges and universities Scientific and cultural services
3	Commerce and Business	Hotels, bars, restaurants
4	Cemetery	
5	Governmental institution	Televesion station, Monument
6	Health	General hospitals, Specialized hospitals, Health care services
7	Industry and manufacturing	Industrial Park
8	Sport and recreation	Stadium, Sport field
9	Worship area	Church and Mosque

(Sources Adama city Report, 2012).

4.2.2. Spatial patterns of UGS and its actual utilization in Study area

The Indicators associated to the spatial distribution and the accessibility to GS How the GS are distributed in the subcity boundary is important to complement the indicator of the total area of GS. The spatial patterns of the stock indicator showed that the UGS resources in Adama city were higher in the area indicated by the dark umber color than in the area indicated by yellow color area (figure 4.8). The result showed that area of GS estimated was approximately 2409.16 hec, and that the GS actually utilized area was 448.16ha only accounted for around 18.60 % while total area not utilized was 1961Ha accounted for around 81.39%. below graph show spatial pattern of GS by subcity level.

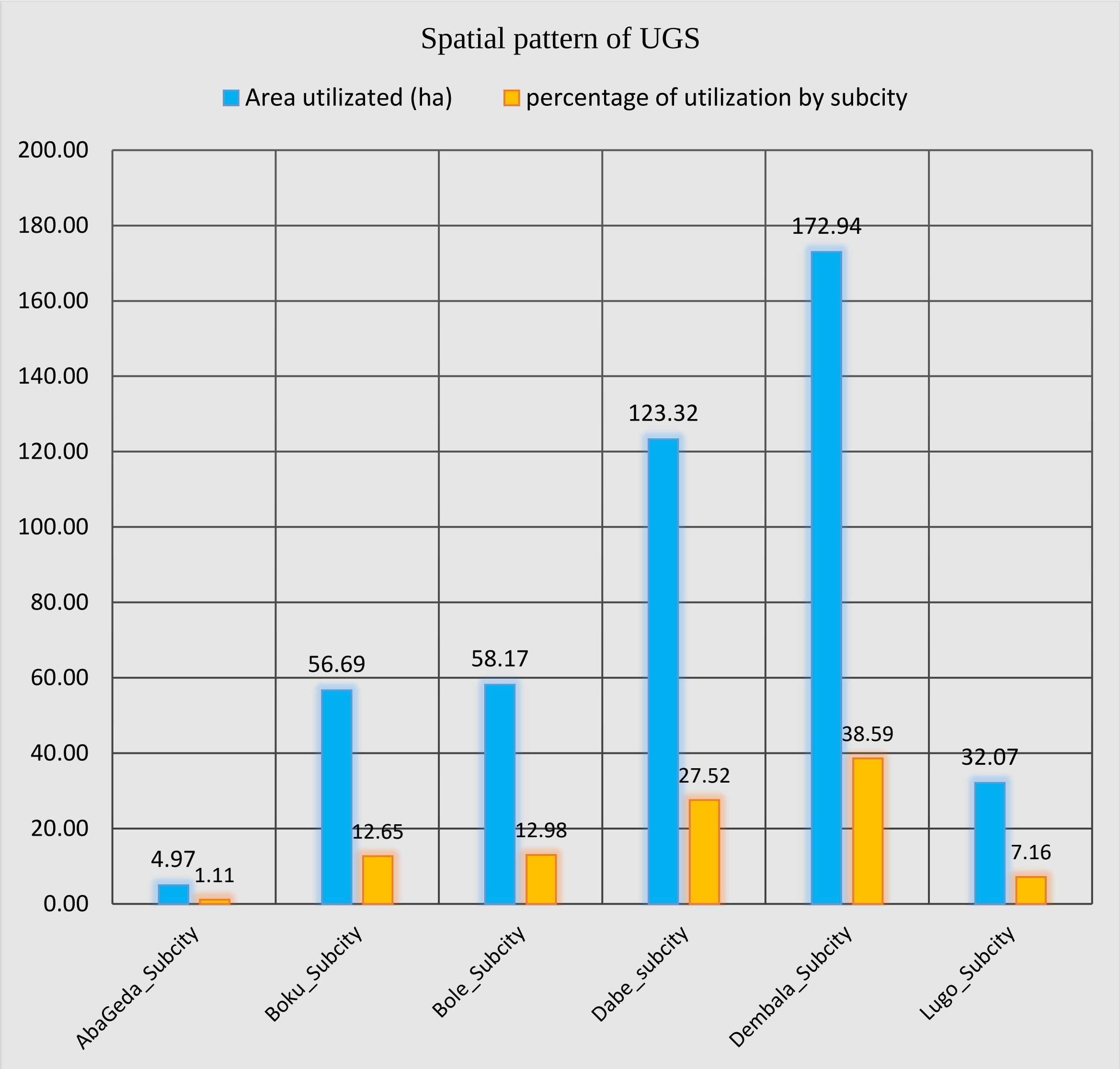

Figure 4.7: Spatial patterns of UGS and percentage of utilization at the sub city level

The results indicate that the highest actual utilization value appeared in dembala subcity (172.94 ha), while the lowest value appeared in AbaGeda subcity 4.97 ha coverage of (1%) from other subcity figure 4.7. The results of the analysis also showed that area of the moderate actual utilization indicator appeared in inner of Bole and Dabe subcity.

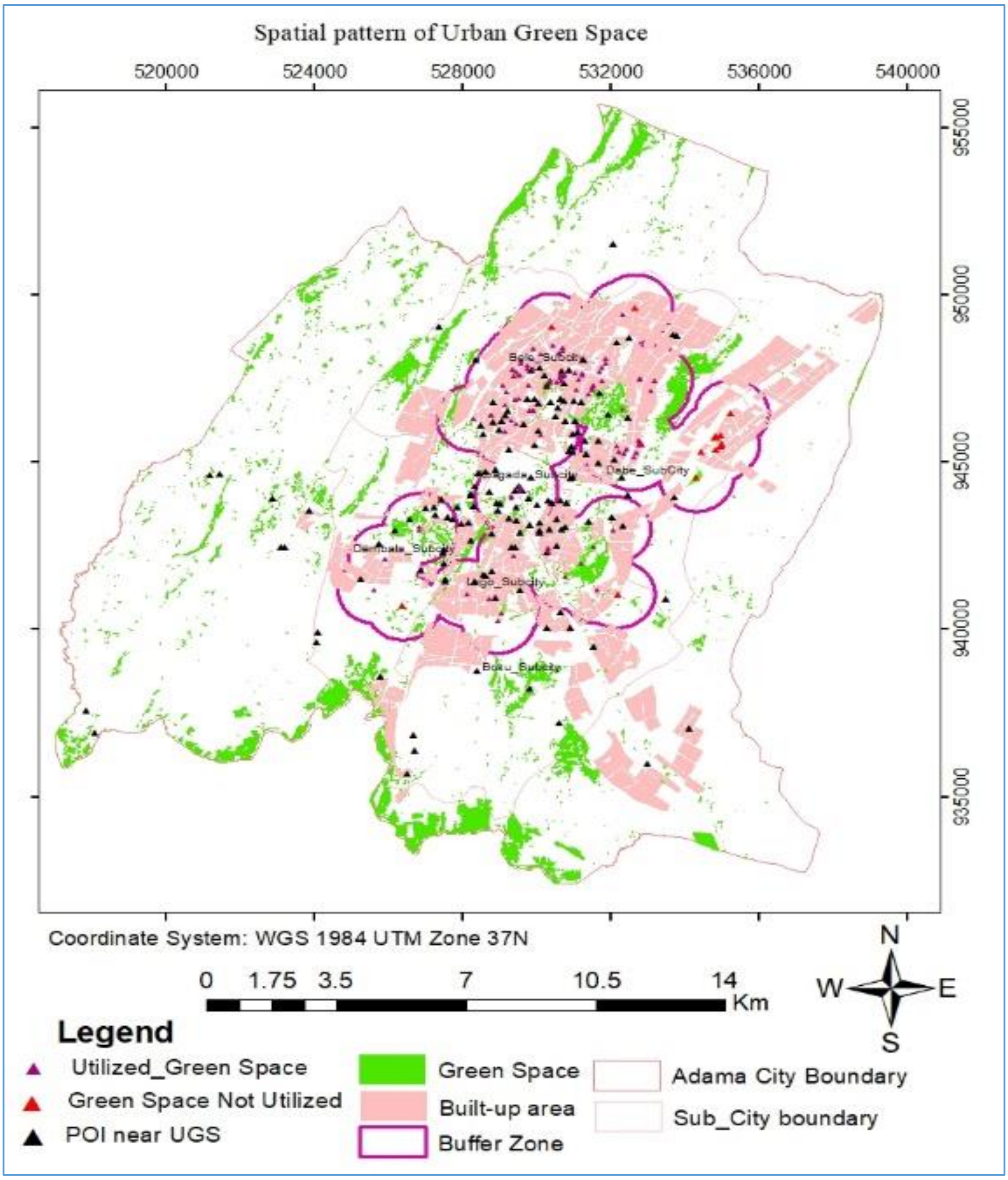

Figure 4.8: Spatial patterns of urban green space and its actual utilization map.

As shown in fig 4.8 The highest actual utilization value appeared in dembala sub city (172.94 ha). while the lowest value appeared in AbaGeda sub city 4.97 ha coverage of (1%) from other sub city. The result showed that area of GS estimated was approximately 2409.16 ha. The GS actually utilized area was 448.16 ha only accounted for around 18.60 %. while total area not utilized was 1961 Ha accounted for around 81.39%.

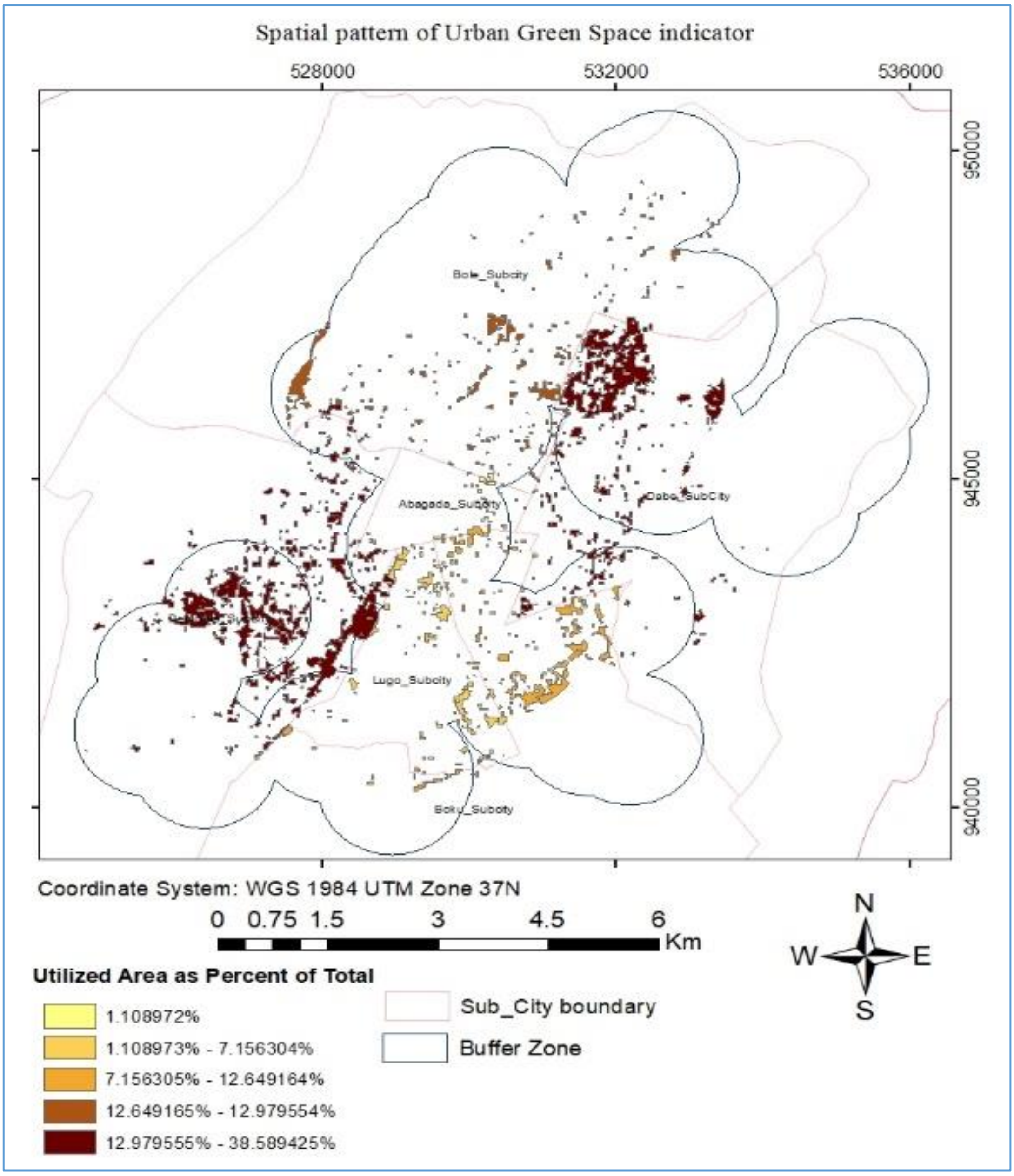

Figure 4.9: map of Spatial patterns of urban green space and its actual utilization by sub city

The above figure show that The spatial patterns of GS indicator showed that the UGS resources in Adama city were higher in the area indicated by the dark umber color than in the area indicated by yellow color area see map in figure 4.9. Finally, this show area of the moderate actual utilization indicator appeared in inner of Bole and Dabe sub city. The areas of actual utilization mainly appeared in boku subcity,lugo and abageda were low utilization percentage of 12.65%,7.16% and 1% respectively. This indicated that the low actual utilization was, to some extent, due to the lack of UGS resources.

4.3. Major factors affecting green spaces and Challenges

This sub chapter aims in presenting the findings and results and relevant discussion from the collected data to answer the research question raised, through closed ended questionnaire and semi structured interview. The findings are analysed order to assess and identify factors affecting green spaces. As discussed in methodology part we use a questionnaries and interview from the respondents see (Appendix 2).

Response rate: Response rate is the number of cases agreeing to take part in the study. These cases are taken from original sample. In reality, most researchers never achieve a 100 percent response rate. Reasons for this might include refusal to respond, ineligibility to respond, inability to respond, or the respondent has been located but researchers are unable to make contact. Therefore, 45 respondents were selected in the survey. General categories of respondents we used in survey analysis are; 30 Households (near green space), 9 respondents were from Municipal experts (Urban Development and plan) and 6 respondent from Sub city administrators in total average used are 67%, 20%, 6% respectively.

Based on questionnarie filled by respondents on Appendix:2 (Do you think that factor affect Urban green area facing any problem to give satisfactory provision for community?)

Table 4.7 summary of responses on Factors that affect green area development

No	Factors	Frequency	Percentage (%)
A	Existing structural plan	5	11.1
B	Lack of awareness	8	17.8
C	Lack of controlling and monitoring the privaten developers	4	8.9
D	Lack of coordination between community and municipality.	2	4.4
E	Lack of finance/budget	10	22.2
F	Lack of professionals	9	20.0
G	Low level of community participation	7	15.6

(Sources own survey analysis,2021)

Urban green Area spaces were developed by the municipality in collaboration other stakeholders, others by the individuals which was developed in their compound; but there was lack of appropriate plan and budget at the town level for the sectors for the development of green areas because of different factors. Therefore, according to the responses from the table above,10(22%) lack of finance, 16(17.8%) lack of awareness, 7(15.5%) low level of the community participation with municipality in green area development, and 9(20%) lack of professionals were the major challenges for the development and management of green areas.

Lack of awareness: Green areas need to be uniformly distributed and developed throughout the city area, and the total area occupied by green spaces in the city should be large enough to accommodate the city population needs (Haq, 2011).The community, civil servants, the officials and even professionals were not aware of about the values or simply ignored them. Because of this low awareness, the community has the habit of using green spaces for illegal purposes like for dumping of solid wastes, grazing, Agreculture production, storing and selling construction materials. As some respondents said during the time of questionnaires distribution, the awareness problem is not only for the people but is also an issue among officials.

The municipal authority plants seedlings at the beginning of each summer, but none of the seedlings had developed well because they were not taken care of and maintained regularly. The town administration should provide environmental education and discuss clearly the values of green areas to the general public. The respondents also pointed out that, they want to use the green areas for For holyday ceremony, Burial and meeting ; dumping solid wastes; storing and selling construction materials; and grazing and agricultural production rather than the unknown and invisible benefits of green areas. Response from Respondents for what purpose use green areas was summarized below table.

Table 4.8: Choices of respondents to use green areas(purpose)

No	Factors	Frequency	Percentage (%)
A	Agricultural production	6	13.3
B	Animal Grazing	10	22.2
C	Damping solid waste	7	15.6
D	For holyday ceremony, Burial and meeting	8	17.8
E	Storing and sealing for construction materials	14	31.1
Total		45	100.0

(Sources own survey analysis,2022)

From the responses given in table 4.8 above and the figure below one could understood that the awareness of the community about the real and intrinsic benefits was not that much developed in the town concerning green area development and management. There were different implications that were observed from the societies. From this point of view, according to the community, if the urban societies were not use green areas for social gathering or other good purposes lead to weak cultural cohesion but it leads the loss of the eco-system and aggravates environmental degradations.

*Problems Related with the Existing Structural Plan***:** Demands for green area should first of all be met in terms of number, size and quality of green areas inside cities and towns (Grahn, &Stigsdotter, 2003). According to questionnary distributed for respondents 11.1% of respondents agree that there are problem with structural plan. During plan preparation, the professionals or the plan makers should have a clear and precise know-how and understanding about the people's culture and settlement pattern of the people who were living in the city for which the plan was prepared (VROM, 2000). Their failures to visit the sites to be planned has resulted in the preparations of plans in which certain area have been prepared for green areas development on the plan but in actual fact were already built up areas.

Financial Problems(Lack of budget): the results show (table 4.7.) 22.2% of respondents are agree that Local authorities may lack the financial means to establish new or modify existing green areas, or municipally owned land that can be devoted to public open spaces may be limited. In this situation, it is most important to protect existing urban green spaces and make them accessible to as many residents as possible. specially in disadvantaged urban areas, further reduction of green areas may result in negative social and health problems (WHO, 2017).

The financial problem for green space development was critical for both developed and developing countries for developing, maintaining and administering green spaces. Although in Adama city, the problems have two faces, according to the municipality responces: lack of budget for physically development of green areas, and lack of attention and negligence when budget was prepared and allocated for green space development. Even if the budget constraint was visible at all, less attention and lack of awareness about the benefits or values of green spaces have affected budget allocation for green spaces. The actual budget constraint and lack of awareness and attention has resulted in the problem of under development of the green spaces in the city (table 4.9).

Table 4.9: Causes of financial constraints as responded by officials

No	Causes of financial constraints	Frequency	Percentage (%)
A	Less attention had given	12	26.7
B	Real lack of budget	24	53.3
C	Non-inclusion green areas in budget allocations	9	20.0
Total		45	100.0

From the above (table 4.9), over 53 percent of budget constraints emanated from ignorance and negligence of officials about green areas development and management. This also led to low public participation because the administration couldn't take the initiative to inform and educate the public about the importance of green areas. Officials have to gain understanding about what was a livable and competitive city. To develop their awareness, the city authorities had to learn from the experiences of other cities which had better experiences in the green area development.

Lack of Qualified Professionals: the results show (table 4.7.) 20% of respondents are agree that Urban policy-makers and practitioners are advised to consider four practical implications for the planning and design of urban green areas identified from the review of evidence and practice (WHO, 2017).Town that is livable, neat, suitable and attractive for residents, guests and tourists, increases its competitiveness. This attractiveness and competitiveness results from qualified and committed officials, as well as professionals who work day and night for achieving the goals of making the town more competitive and attractive. The nature of green areas is multifunctional which requires multidisciplinary professionals for well green area development. Without qualified and committed professionals, better awareness, and sufficient budget or modern and best plan cannot be achieved. Therefore, professionals were irreplaceable for green space development in the study area.

Lack of Participatory Planning: Urban green area is an important investment that local authorities can make on behalf of citizens and their well-being. Urban green area interventions improve the quality of life for the whole city, and a wide range of community groups and stakeholders need to be involved in their planning. Such interventions provide opportunities specifically to support disadvantaged or underserved areas and to reach out to individual population groups. For this, there must be consultation, participation, evaluation and monitoring of any development plan by all stakeholders, and had taken the priority according to the need and interest of the stakeholders. Priorities must set to solve the existing problem and brought prosperity. As the level of participation of the people increases, the level of contribution for implementation and sense of ownership increases. To summarize, the main causes for the challenges and constraints of urban green areas in Adama city are:

- Lack of proper planning, implementation, monitoring and evaluation of the activities related to the use and conservation of green areas.
- A wrong perception by decision makers in particular and the public in general about the purpose of green areas and their relation with other development spaces.
- A tragedy of common's situation in which a resource that belongs to everybody is nobody's responsibility.
- Invasion of urban green areas by residential and/or commercial development activities.

In order to see the major challenges for the development and management of UGSs of the city assessment on the plan versus implementation, confrontations on right of way for space between trees and development, lack of green spaces and the driving forces for the challenges have been thoroughly dealt in sequential order here under. The overall challenges to green space planning and implementation in Adama city fall into different categories: institutional, social, and economic.

i) *Institutional Challenges.* According to the key informants, institutional challenges are the major challenge facing the implementation of green space policy and the planning on the ground. The inclusion of institutions in the planning process of green space plans is vital even though their direct contribution to the implementation is very low. The lack of fully engaged institutions during plan preparation is an ongoing challenge for the green space development plan and its implementation in the city. The segregated plans issued by different institutions implementing the city's masterplan fail to recognize milestones achieved by other institutions executing implementation on the same site. Institutions also fail to communicate activities realized on the ground. Miscommunication among institutions is mentioned by all key informants as a major challenge for green space development in the city.

ii) *Social Challenges:* Society's lack of awareness of green spaces is aggravated by the ongoing rapid urbanization taking place, with it encroaching on green spaces. As described in previous section lulc the urban population settlement critically reduces the existing green space as people move to the periphery at the expense of green areas (peri-urban forest areas). Development, including a highway and Housing, is driving the expansion of the city into agricultural green space around the city.

iii) Economic Challenges: The economic development has direct and indirect impacts on the city's green spaces. As per the discussion with the key informants, the riverside of Adama city is encroached upon illegally by the poor, while drainage/gourge development is challenged by the economic situation of city residents.

4.4. Discussion

According to the master plan revision in 2019 revised strategic structural plan of the city depicts that the total area of Adama city was 31,300 ha green area, market places, artificial ponds, and recreational centers with distnict name have been incorporated in the plan (Adama city Adminstartion, 2019). However, the consequences of poor implementation of this plan have resulted in frequent flood risk for the city year after year. Destruction of infrastructure and dwellers properties and accumulation of silt in the city during rainy season is a common tragedy for Adama city because of poor vegetation coverage of surrounding hills. Urban plan preparation & Implementation Strategy, (2014) recommends the competent authority (municipality) to allot and implement 30% of land for green spaces. It implies that the extent to which the urban green space plan implemented was very poor. This poorly implemented plan also resulted in poor per capita greenery coverage.

There are green spaces in the city that can be used as a base to build more expansive green spaces. There are also initiatives at the local administrative level, woreda, and local community level that take a leading role in protecting open areas and turning abandoned lands into green areas. Building on the existing large green spaces and small patches of green spaces across the city will enhance the availability, accessibility, and use of the green spaces in the city. As the discussion with key informants, different principles in green space planning have been considered during the planning phase. Multiple benefits and functions provided by different green spaces have been taken into account during the preparation of different planning documents, which are related to green spaces.

During the present study, a comparison was made between the increase in impervious surface against the reduction in greenness in Adama city areas that might signify deterioration in the environmental quality of city. Vegetation, Agriculture land/grassland, bare land, settlement and water bodies were either increased or decreased in extent in different rates during 2000-2020 in Adama city area. Greenness of the area serves as a means of urban environmental quality (Tongliga, 2016). From 2000 to 2010, Adama city green space was reduced to 359.1 ha due to land conversion to different land land uses. In 2020, 3442.31 ha area coverage of vegetation/green space was reduced -123.25 from total area in 2010 to 2020. it is clear that the proportion of green areas has decreased, with the large-scale elimination of green spaces, including by the public sector.

Normalized Difference Vegetation Index is a spectral index that takes into account the amount of infrared rays reflected by plants. Green plants absorb solar radiation, as a source of energy in the process of photosynthesis (Agyepong.G,2016). The reason for the relationship of NDVI to vegetation is due to the property of green leaves to reflect 20% or less in 0.5 to 0.7 microrange (green to red) and about 60% in 0.7 to 1.3 microrange (near-infrared) (Nhamo,2016). Normalized Difference Vegetation Index itself varies between -1.0 and +1.0. Negative values of NDVI (values approaching -1) correspond to deep water. Values close to zero (-0.1 to 0.1) correspond to bare land areas of rock and sand. The nature and extent of these changes show variations across time and space. Changes attributed to socio-economic and environmental parameters reflect a host of other factors.

Information on green area in cities is important for maintaining urban environmental quality. Vegetation is very useful in filtering air, water and sunlight, cooling urban heat, recycling pollutants, moderating local urban climate and providing recreational areas for the people. The National Urban Green Infrastructure standard of Ethiopia proposes 15m Per capita public green open spaces within city boundaries, with every resident living within 500 m from a public green open space that is at least 0.3 hectares in size.

However, the proposed standard has never been implemented accordingly in the city. Using content analysis data from documents were analyzed, specifically identifying explicit references to various terms of green space planning principles and implicit references to related concepts like accessibility, ecological, social, and economic functions. This study reveals that the policies are only on paper; the formulation of regulations and standards required to implement the policies on the ground is missing. The organizational structure lacks some of the key actors required to implement green space plans.

5: CONCLUSION AND RECOMMENDATION

5.1. Conclusions

The urban areas in Adama City have expanded dramatically, while green areas have been declining. Those areas, which are close to built-up and urban centers, were subjected to significant loss of vegitation (greeneries) in the last two decades. The green spaces in the urban areas have been declining faster and faster so that a large section of the general public does not have access to such green spaces. As the green spaces are the significant components of the urban landscape and provide multiple benefits as composite functions that include environmental, socio-cultural and economic benefits.

The Analaysis demonistrate that multi-temporal Landsat images, this study quantitatively reveald the dynamic of green space in Adama city. Integrated data analysis using remotely sensed satellite imagery and GIS spatial data facilitated the analysis of the spatial distribution of green space changes involving land-use/land-cover classification changes from time to time. In this study, a cost- and time-effective framework for monitoring spatiotemporal changes of green spaces in relation to the NDVI was presented. We found that the green space in study area has increasingly decreased in the period of 2000-2020, which was mainly due to the so large-scale reduction of Agriculture land that the increase of Builtup area. Changes of green spaces were examined based on spectral vegetation indices (the NDVI) and supervised land cover classification.

The NDVI showed a fluctuating trend during the be study period. The lowest values were recorded in 2000 and 2010, while the highest values were observed in 2020, indicating vegetation recovery in the last decade. The central city was characterized by the lowest NDVI, throughout the whole study period, while the peripheral area represented the largest reservoir of greenness in Adama city. Land cover classification was performed for 2000, 2010 and 2020 and resulted in a very high overall accuracy (from 86.89 % to 96.69%% and a Kappa coefficient from 0.84 to 0.95).

Spectral vegetation indices were positively correlated with the amount of precipitation during the growing season. Vegetation recovery at the end of the last decade may have different driving mechanisms, including an increased amount of precipitation and the implementation of new regulations regarding the conservation of natural areas. The awareness of the population towards planting and using green areas for the intended values are very poor. They prefer using the areas intended for green areas for illegal activities like, for storing and selling construction materials, dumping for solid wastes,animal grazing, agricultural production and so on than getting intensive values of green areas. Under developments of green areas were a result of the absence of the required professionals with experience and sufficient budget. The municipal authority human resource had lack of urban planner and professional personnel for related fields for developing the sector. This implies no attention was given for the sector's development,but environmental degradation and raise of temperature from year to year was the main characteristics of the city.

There were various factors which contribute to the low level of awareness of the people about the benefits gained from the well developed and managed green areas. Low attention given to the sector by the population and officials on the city, the type of economic activities and the level of education and discipline studied by the officials affect their awareness towards green areas development and management. They believed that green areas were simply open spaces used for mainly for storing and selling construction materials, dumping of solid waste.

5.2. Recommendations

To achieve the goal of making City a clean, green and move green space planning and implementation in Adama city The following recommendation suggested base on the findings. The city administration must make Proper implementation of rules and regulations through ordinal scrutiny of the concerned officials and workers in fulfilling their responsibility those who have a direct and indirect responsible and involved organization of the city administration and other private consultants or individuals. Primarily, the study will demonstrate the efficiency of geospatial technology for analysis of assess the urban green space. Secondly, concerning urban planners and decision-makers may use this outputs as a base line for making a decision regarding green space area location in Adama city.

One of the results noticed in this study was the major LULC changes caused by rapid expansion of built-up areas, while green areas have been declining.

- Therefore, a proper planning should be implemented by considering urban green space development and the Town development plan should focus on a vertical built up expansions rather than horizontal expansions.
- The land cover proportion of each green infrastructure typologies should be described in the document clearly. The implementation strategy should clearly define each stake

holders responsibility, duty and the required budget and source of it for proper implementation of green infrastructures.

- The proposed green spaces should deliver clearly to concerned body, Continuous follow up and monitoring activities should be done, Awareness creation program should be given to the community, There must be coordination among plan preparation and implementer body and Enough budget should allocate to develop the green infrastructure spaces.
- Creating integration among different actors of those who are engaged in urban green areas development and management; including, Sanitation, Beautification, and Parks development Agency and Environmental Protection Authority and private sectors.
- Establishing good system of urban green areas management through the use of technology like Geographic Information Systems (GIS).

REFERENCES

Azagew S, Worku H.(2020); Accessibility of urban green infrastructure in Addis - Ababa city , Ethiopia : current status and future challenge. *Environ Syst Res*. Published *online. doi:10.1186/s40068-020-00187-0*

Alexander, D. (2007). Green Infrastructure, Linking Landscapes and Communities Green Infrastructure, Linking Landscapes and Communities. *Island Press.Washington, D.C. ISBN: 1-55963-5584. Natural Areas Journal, 27(3), 282–283.*

Assefa A, Mpyanga S. (2018) : Green Area Typologies And Mapping Of Green Structures *In Addis Ababa And Dar Es Salaam Report produced by : Kumelachew Yeshitela.*

Andrés J, Gantiva F. (2015), Methodological proposal for measuring and predicting Urban Green Space per capita in a Land-Use Cover Change model : Case Study in Bogota. Published online.

Alexander, D. (2007). Green Infrastructure, Linking Landscapes and Communities Mark

A.Manlun, Y. (2003). Suitability Analysis of Urban Green Space System based on GIS.

Faculty of Geo-Information Science and Earth Observation.

Berhanu, K. (2017). Cellular Automata Model Based Urban Sprawl Mapping: A Case of Mekelle City, *Ethiopia. Msc thesis submitted to Addis Ababa University.*

Benedict, Edward T. Mc-Mahon (2006).Green Infrastructure, Linking Landscapes and Communities.IslandPress.Washington, D.C. 299 paper.. ISBN: 1-55963-5584. Natural Areas Journal, 27(3), 282–283.

Błaszczyk M, Suchocka M, (2020); Wojnowska-heciak M, Muszyńska M. Quality of urban parks in the perception of city residents with mobility difficulties. Published online:1-25. doi:10.7717/peerj.10570

Bertram, (2015),The role of urban green space for human well-being FilipLefebre, Berhanu,K.2017 Lee &Maheswaran 2011; Lovell & Taylor 2013; Adinolfi et al. 2014).

Carter M. (2014)Beyond proximity : The importance of green space useability to self-reported health;11:322-332.

Eshetu SB, Yeshitela K, Sieber S. (2021); Urban Green Space Planning ,Policy Implementation and Challenges : The Case of Addis Ababa. Published online:1-14.

Girma Y, Terefe H, Pauleit S, Kindu M. (2018), Urban green infrastructure planning in Ethiopia : The case of emerging towns of Oromia special zone surrounding Finfinne ☆. *J Urban Manag*. 2019;8(1):75-88. doi:10.1016/j.jum.2018.09.004

Gao, B.C.,(1996), NDWI A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sens. Environ. 58, 257–266.*

Haq, S. M. A. (2011). Urban Green Spaces and an Integrative Approach to Sustainable Environment.*Journal of Environmental Protection, 02(05), 601–608.*

https://doi.org/10.4236/jep.2011.25069.

Holben, A.N.; Tucker, C.J.(2009), Analysis of the phenology of global vegetation using meteorological satellite data.
Int. J. Remote Sens. 1985, 6, 1271–1318.

Kelemu F, G. (2016). Causes,consequences and policy implications of squatter settlements in Gondar town in the case of kebele 18.
Innovare journal of social sciences, 4(2), 1-8.

Manlun, Y. (2003). Suitability Analysis of Urban Green Space System based on GIS. *Faculty of Geo-Information Science and Earth Observation.*

Opeyemi, A. and Trina, W. (2014) Potential Application of Change in Urban Green Space as an Indicator of Urban Environmental Quality Change. *Universal Journal of Geoscience, 2, 222-228.*

Haq, S., (2011). Urban green spaces and an integrative approach to sustainable environment. Journal of Environmental Protection.

Grahn, P. &Stigsdotter, U. (2003). Landscape planning and stress. Urban Forestry & Urban Greening.

Huang C, Yang J. (2017), Green Spaces as an Indicator of Urban Health : Evaluating Its Changes in 28 Mega-Cities. 2;(December). doi:10.3390/rs9121266

Hordofa H, Shaoxian K.(2021), Assessment of Urban Greenery Status in Major Cities of Oromia ;03(03):21-27.

Lundh J.2017, Indicators for ecosystem services in urban green space management. Published online.

Leeuwen ES Van.(2009), The multi-functional use of urban green space.

Madureira H. (2018); Preferences for Urban Green Space Characteristics : A Comparative Study in Three Portuguese Cities. *doi:10.3390/environments5020023*

Sis, Z. (2016) Evaluating Urban Expansion Using Integrated Remote Sensing and GIS technique: A Case Study in Greater Chengdu, China University of Saskatchewan, Saskatoon.

Stanley CH, Hecht R, Cakir S, Brzoska P.(2021) Approach to user group-specific assessment of urban green spaces for a more equitable supply exemplified by the elderly population. Published online. doi:10.3897/oneeco.7.e83325

Szeremeta, B.; Zannin, P.H.T.(2009), Analysis and evaluation of soundscapes in public parks through interviews and measurement of noise.Total Environ, 407, 6143– 6149.

Sis, Z. (2016) Evaluating Urban Expansion Using Integrated Remote Sensing and GIS technique: A Case Study in Greater Chengdu, China University of Saskatchewan, Saskatoon.

Sewunet, Sh(2017).Urban *Sprawl Mapping and Land use Change Detection Using Spatial Metrics Method: A Case Study of Addis Ababa City and Its Surrounding Areas, Ethiopia*. *MSc thesis submitted to Addis Ababa University.*

Scott S. (2006), Urban Green Space : The Incorporation Of Environmental Values In A Decision Support System. 11(May):177-196.

Tudorie CM. 2019, Urban Green Indicators : A Tool To Estimate The Sustainability Of Our Cities.;*14(1):19-29. doi:10.2495/DNE-V14-N1-19-29*

Taylor L, Hochuli DF. (2016), Landscape and Urban Planning Defining greenspace : Multiple uses across multiple disciplines. *Landsc Urban Plan*. 2017;158:25-38. *doi:10.1016/j.landurbplan..09.024*

Tulu, T. (2017). Spatiotemporal land use/land cover change, driving forces and consequences in ameya woreda, central, Ethiopia.MA thesis submitted to Addis Ababa University

Tongliga, B., Xueming, L., Jing, Z., Yingjia, Z. and Shenzhen, T. (2016) Assessing the Distribution of Urban Green Spaces and Its Anisotropic Cooling Distance on Urban Heat Island Pattern in Baotou.
China. International Journal of Geo-Information, 5, 12.

WHO Regional Office for Europe (2017). Urban green space interventions and health: a review of impacts and electiveness. Copenhagen: WHO Regional Office for Europe.

Woldesemayat EM, Genovese PV,(2021). Functional Land Use Areas in Addis Ababa , Ethiopia , and Their Relationship with Urban Form. Published online .

Wei, X., & Cai, J. (2018). Analysis and optimization design of green space landscape pattern of Nanchang City Park in GIS. Journal of Applied Ecology, 29(09), 2852–2860. doi:10.13287/j.1001-9332.201809.007.

Wang, Z., Wang, Z., & Bao, Y. (2011). Landscape pattern analysis on the urban green space system of Tongren City based on GIS. Journal of Gansu Agricultural University, 46(01), 110-114+126.

Wolch J, Byrne JA, (2014). Urban green space , public health , and environmental justice : The challenge of making cities ` just green enough '.. doi:10.1016/j.landurbplan.2014.01.017

Worku H. (2019). Status and Challenges of Urban Green Infrastructure Access in Rapidly

Zhao H, Zhu T, Wang S, Lindley S.(2021); Study on the Changes of Urban Green Space with Remote Sensing Data : a Comparison of Nanjing and Greater Manchester.;31(1):461-474. doi:10.15244/pjoes/138208

Zabelskyte G, Kabisch N.(2021), Patterns of Urban Green Space Use Applying Social Media Data : A Systematic Literature Review. Published online:1-21.

Zhu, C.H., Ya-bing, (2018) Landscape pattern evolution along terrain gradient in Fuzhou City, Fujian Province, China. *Journal of Applied Ecology, 29,1–13.*

APPENDIXS

This Appendix show the details of the collected point of intersected data contained different layers 148 point of interesting. each POI has four items of information: name, category, coordinate, and classification (discussed in data preparation parts). this points were closely related to the actual utilization status of UGS services. (Sources Adama city structure plan, 2019 and own site visiting/collection)

APPENDIX 1: Point of Interesting Related to UGS center location.

s/n	Easting	Northing	Detail_sub types of (POI)	POI Categiries
1	528902	940829	Sn. George Church	Worship
2	530892	939953	Boku Michael Church	
3	528348	947967	Markos Church	
4	525760	942447	Kidenameret Church	
5	525257	941417	Adama Meseret Kristos Church	
6	528789	941634	Church	
7	527366	948953	Kechema church	
8	530012	943612	Najash Mosque	
9	531012	946734	Kale Hiwot Church	
10	530639	946810	protrstant Church	
11	530588	946532	Medihanealem Church	
12	532470	943924	orth.church/cemetery	
13	533669	948729	Mariam Church	
14	525792	938486	Melka Adama Johanis Church	
15	528384	938649	St.Arsema Orthodox Church	
16	523204	942347	Balewold Orthodox Church	
17	521184	944520	St.George Church	
18	524082	939823	Maserat Kiristos Church	
19	526696	936283	St>Goergi Chirch	
20	530607	937092	st. merry orthodox church	
21	526492	935600	Meseret Kristos Church	
22	527962	943042	Ganda Sport Field	Sport and recreation
23	529783	943805	Ababa Bikila Stadium	
24	530536	942385	Gibe Recreation Center	
25	533498	940823	Industrial Park	Industry and manufacturing
26	529945	945404	Private Hospital	Health
27	528610	944623	Oda Health Center	
28	529518	944175	Akilseia Hospital	
29	529851	947645	Health Center	
30	529630	944057	Rift valley Hospital	
31	531411	943132	Health Center	
32	530277	947194	Dispora Park	Green areas

s/n	Easting	Northing	Detail_sub types of (POI)	POI Categiries
33	529757	946788	Muslim Cemetry	
34	529819	938120	Boku steam	
35	526187	942851	Galma Abba Gada Center	Govnt institution
36	526578	943197		
37	531698	946957	Oromia Television	
38	522858	943802	Jojo Gudedo Police station	
39	528430	944569	Adama No_3 School	**Education**
40	528878	944667	Kidus Kuran Primary School	
41	528569	945721	Goro High School	
42	528291	943571	Holy Angels School	
43	528909	943680	Nafyad KG_1	
44	528215	943932	Endalus School	
45	528221	943953		
46	528723	944004	Adventist school	
47	528506	946002	Vera School	
48	528832	946100	New Lief School	
49	528826	946680	Star Acedamy	
50	527255	943330	English Alive acadamey	
51	527226	943555	Neroo School	
52	527427	943782	Unity Universty College	
53	527729	943201	Dambaala Highschool	
54	527586	943257	Colonel Dajane sime Primary School	
55	526991	943517	Model Acedamy	
56	527461	942198	Wonderland school	
57	527502	942286		
58	530051	945834	Adama No 6 primary School	
59	530740	947255	Abune Gorgorios School	
60	530663	947613	Excel Acadamy KG-6	
61	530868	947662	Oda School 1-8	
62	528172	943086	chilalo academy	
63	528969	943471	Nafyad Primary & Secondary School	
64	529019	943637	Rift Vally Universty	
65	529450	943553	Ethiopian Catholic Church School	
66	528992	945869	Mako bill school	
67	529227	946437	Adama youth academy	
68	523863	943444	Jogo gudedo Primary School	
69	528335	941325	Biruktawit School KG- 8	
70	528547	941531	lugo High school	
71	528617	941505	lugo primary school	
72	529544	941085	Goyas School	

s/n	Easting	Northing	Detail_sub types of (POI)	POI Categiries
73	530653	940408	yomad Kg	
74	529641	946029	Abinezer kindergarten	
75	529050	946144	Abdi Boru School	
76	529862	944459	ROYAL UNIVERSTYCOLLEG	
77	530645	943756	Adama No-4 primary school	
78	530956	944447	kemara school	
79	530908	944420	Kegna academy	
80	531673	944872	abuna Georges school	
81	531341	945146	Kindergartan	
82	530957	945214	Awash Secondary School	
83	530926	945373	Awash Elemetary School	
84	531674	945531	kdn mirhet catholic school	
85	530280	942207	Bethel Model Acedamy	
86	530671	942898	Adama High School	
87	530329	942895	Unique Primary School	
88	530072	943089	R V University Center for Distance Edu	
89	530543	943175	Excel Primary School	
90	530069	942800	Unique High School	**Education**
91	530092	942859	Unique Elementry School	
92	531273	947957	Guda Miju School	
93	531191	946708	Nafyad School	
94	530976	945746	Engiles School	
95	531098	945791	Meserete Kirstos primary School	
96	531923	946328	ASTU	
97	530739	946743	Wisdem AcadamyKG to 8	
98	532173	948482	Bole Preparatory School	
99	532470	946225	Kemara School	
100	533712	943840	Dabe Soloke Primary School	
101	531518	939384	Hawas Preparatory School	
102	532035	943240	akber school	
103	532313	943006	kena school	
104	530783	942954	premary School	
105	521451	944539	School	
106	532486	948608	Daka Adi Primary School	
107	530265	939962	Burka High School	
108	528326	944174	Youth Center	Community and cultural
109	529163	946308	Youth center	
110	531318	945528	Youth center	
111	527871	943541	Kuriftuu Hotel	**Commerce and Business**
112	529415	944048	karamara Hotel	

s/n	Easting	Northing	Detail_sub types of (POI)	POI Categiries
113	529238	945264	Old Musilim Cemetery	**Cemetery**
114	526861	941682	Cemetry	
115	530383	946680	Orthodox Cemetry	
116	529961	946784	Protestant Cemetry	
117	532058	951418	Cemetry	
118	523107	942368	Cemetry	
119	524058	939504	Protestant cemetery	
120	517850	937465	Orthodox Cemetry	
121	526688	936731	Protestant Cemetry	
122	532977	935892	Orthodox Cemetry	
123	518075	936811	Protestant Cemetry	
124	527521	941395	Protestant church	
125	527488	941856	ODA School	
126	527540	941330	Health center	
127	530037	946676	Catholic Cemetry	
128	530095	947735	Hawi Acadamy	
129	530223	947499	AlJamal Mosque	
130	529421	942376	Catholic Kindergarten	
131	529330	942379	Catholic Health Center	
132	529534	942781	Adama Boset Primary and Sec School	
133	529454	943152	Catholic Acadamy	
134	529236	943219	Catholic Kindergarten	
135	528775	942770	Bilal Mosque	
136	528226	942553	Danbala Mosque	
137	530775	946128	Gada Resort	
138	529829	943029	Makko Billi Kindergarten	
139	532281	944436	Geda Resort	
140	530809	943698	Youth center	
141	530399	943702	Anole health center	
142	530296	943741	Kulafa Mosque	
143	532097	944965	Day Star Accademy	
144	530869	945256	Amanuel Church	
145	531030	946129	Adama General Hospital and College	
146	534122	936932	Adula Elementery School	
147	533772	948670	orthodox Cemetery	
148	530512	946259	Dinku pp school	

APPENDIX 2: QUESTIONNARIE AND INTERVIEWS

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF CIVIL ENGINEERING AND ARCHITECTURE

MSC In GEO-INFORMATICS PROGRAM

Date ______/_______/________

Dear Participant, this information will only be used for our research. We thank you very much for your help and cooperation.

As part of my M.Sc. Thesis in Geoinformatics at Adama Science and Technology University, I am conducting a survey that investigates the perceptions of experts about The Spatial Distribution of Green Space in Adama City.

Please respond to the following questions that provide inputs for my research. Hence give your idea on space provided.

Part I: Demographic information of Respondent

Answer the following questions according to the given instruction.

- Gender: Male ☐ Female ☐
- **Age:** ☐ less than 25 ☐ [26 –35] ☐ [36 – 45] ☐ 60 and above
- **Place of birth**___________________________
- **Place of living: Sub City**__________________/**kebele**______________________
- **Education level**: ☐ Illiterate ☐ Primary school ☐ Secondary School

  ☐ Diploma ☐ degree/ BSC ☐ Masters/MSc ☐ above

Part II: Questionnaires for Experts and individual persons

1. Do you consider that your job involves the planning, provision or maintenance of green space? ☐ Yes ☐no ☐ may be

2. Do you think that factor affect Urban green area facing any problem to give satisfactory provision for community? Select factors listed in below table.

Factors that affect Urban Green area development and management.

	Factors	Tick Circle for Select
A	Low level of community participation	○
B	Lack of awareness	○
C	Lack of financial/budget	○
D	Lack of professionals	○
E	Existing structural plan	○
F	Lack of coordination between community and municipality.	○
G	Lack of controlling and monitoring the private developers	○

3. In your sub city is lack of financial/budget has effect for developing urban green space? Yes? ☐ No? ☐ if YES what are causes of financial constraints in your office?

	Cause of Financial	Tick Circle for Select
A	Real lack of budget	○
B	Less attention had given	○
C	Non-inclusion green areas in budget allocations	○

Part III: INTERVIEWS

1. What is your current position in the urban planning office/Green space development?

---

2. What is Distance from your home to nearest urban park/greenery__________(m)

---

3. Are there any others benefits that you think can be provided by green area?
4. Are you satisfied with current spatial distribution of urban green space in city. Yes/no? If your answer is 'yes' how do you think it equally distributed and enogh?
5. What are the major factors that affect urban green space in your kebele/sub City?
6. In your sub city/ kebeles for what purpose use green areas?

	Purpose to Use Green Area	Tick Circle for Select
A	For holyday ceremony, Burial and meeting	○
B	Damping solid waste	○
C	Storing and sealing for construction materials	○
D	Animal grazing	○
E	Agricultural production	○

THANK YOU FOR YOUR COOPERATIVE!