ANALYZING THE SPATIOTEMPORAL DYNAMICS OF LAND USE/LAND COVER AND SUITABLE SITE SELECTION FOR DEVELOPMENT OF URBAN AMENITIES: A CASE OF URBAN GREEN SPACE IN AMBO TOWN, ETHIOPIA

By: Kayo Mulisa Dendena

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 of Science in Geo-informatics

Office of Graduate Studies

Adama Science and Technology University

September, 2022

Adama, Ethiopia

ANALYZING THE SPATIOTEMPORAL DYNAMICS OF LAND USE/LAND COVER AND SUITABLE SITE SELECTION FOR DEVELOPMENT OF URBAN AMENITIES: A CASE OF URBAN GREEN SPACE IN AMBO TOWN, ETHIOPIA

By: Kayo Mulisa Dendena

Advisor: Dejene Tesema Bulti (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 of Science in Geo-informatics

Office of Graduate Studies
Adama Science and Technology University

May, 2022
Adama, Ethiopia

DECLARATION

I hereby declare that this Master Thesis entitled "Analyzing the Spatiotemporal Dynamics of Land Use/Land Cover and Suitable Site Selection for Development of Urban Amenities: A Case of Urban Green Space in Ambo Town, 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.

Kayo Mulisa Dendena	______________	________________
Name of Author	Signature	Date

RECOMMENDATION

I, the advisor(s) of this thesis, hereby certify that I have read the revised version of the thesis entitled "Analyzing the Spatiotemporal Dynamics of Land Use/Land Cover and Suitable Site Selection for Development of Urban Amenities: A Case of Urban Green Space in Ambo Town, Ethiopia" prepared under my/our guidance by Kayo Mulisa submitted in partial fulfillment of the requirements for the degree of Master's of Science in Geo-informatics. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Dejene Tesema (PhD)	______________	______________
Advisor	Signature	Date

APPROVAL PAGE

I, the advisors of the thesis entitled "Analyzing the Spatiotemporal Dynamics of Land Use/Land Cover and Suitable Site Selection for Development of Urban Amenities: A Case of Urban Green Space in Ambo Town, Ethiopia" and developed by Kayo Mulisa, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Dejene Tesema (PhD)	______________	______________
Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Kayo Mulisa have read and evaluated the thesis entitled "Analyzing the Spatiotemporal Dynamics of Land Use/Land Cover and Suitable Site Selection for Development of Urban Amenities: A Case of Urban Green Space in Ambo Town, 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

Final 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

ACKNOWLEDGMENT

First and foremost, I would like to thank almighty God (Waqaa), who gives me strength and encourage in all of my work. Next, I would like to express my deepest gratitude and thanks to my advisor, Dr. Dejene Tesema for his professional guidance, supervision and constructive comments throughout the completion of this thesis work.

I am very grateful to Adama Sceince and Technology University (ASTU), School of Civil Engineering and Architecture and Geomatics Engineering Department for financial support and encouragement to done my thesis. As well as I am grateful to Geomatics Engineering, Departments staff members for gave me moral, support and encouragement to accomplish my thesis. And also, I would like to appreciate Ambo Town municipality for provide me structure plan and population data of the town. My thanks also goes to Geospatial information Institute (GII) for gave me the spot-7 data.

I would like to appreciate my elder sister Mergitu Mulisa for her support and encouragement in every situation of my life. I would also like to appreciate Mr. Nabiyu Iyasu for his support by asking and sharing useful information. This acknowledges also goes to all my classmates who gave moral supports to accomplish my thesis as well as both Mr. Gamada Dhaba and Mr. Gadisa Tarafe for gave me their expensive time in data collection.

Finally, I would like to express my sincerely gratitude to my family for their love, respect, morally, frank support and encouragement throughout of this long process of learning program.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

LIST OF ACRONYMS AND ABBREVIATIONS

AHP	Analytic Hierarchy Process
ASTER	Advanced Space Borne Thermal Emission and Reflection Radiometer
CSA	Central Statistics Authority
ERDAS	Earth Resource Data Analysis System
DEM	Digital Elevation Model
FAHP	Fuzzy Analytic Hierarchy Process
FAO	Food and Agriculture Organization
GII	Geospatial Information Institute
GIS	Geographical Information System
GPS	Global Positioning System
LULC	Land Use and Land Cover
MCA	Multi-Criteria Analysis
MCDM	Multi-Criteria Decision Making
MCE	Multi-Criteria Evaluation
MoUDC	Ministry of Urban Development and Construction
MoUDH	Ministry of Urban Development and Housing
MRS	Multi-Resolution Segmentation
NUGIS	National Urban Green Infrastructure Standards
OBIA	Object Based Image Analysis
RS	Remote Sensing
SDS	Spectral Difference Segmentation
TFN	Triangular Fuzzy Numbers
TIFF	Tagged Image File Format
UGI	Urban Green Infrastructure
UGS	Urban Green Spaces
UHI	Urban Heat Islands
USGS	United States Geological Survey
WHO	World Health Organization

ABSTRACT

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. LULC change in urban area is becoming the major factor in reducing green area extent. These necessitate the need for analyzing urban land use/land cover change. Urban green space (UGS) has emerged as a key component of the overall city planning due to its environmental benefits and human well-being. Despite its multiple benefits, UGS is under considerable pressure, particularly in rapidly growing cities in developing countries. Enhancing knowledge of UGS's spatiotemporal changes and efficient development planning are necessary to fully gain its benefits. However, investigations in this respect in Ethiopian urban centers are scant. This study aims to analyze the spatiotemporal changes in UGS in Ambo Town, Ethiopia, from 2006 to 2022 and scientifically select suitable sites for its development. Through object based image classification of time series spot_7 and Sentinel-2A images using the nearest neighboring algorithm, land use and land cover (LULC) maps of the study area for the years 2006, 2016, and 2022 were prepared, and then the spatiotemporal changes of LULC were investigated. Determinant physical, accessibility, environmental, and socio-economic factors for UGS development were identified through a literature review, focal group discussion, and expert interview. The factors were standardized based on suitability rankings. A Fuzzy Analytical Hierarchy Process (FAHP) was employed to determine the relative importance of each factor. Suitable sites were identified through weighted spatial overlay analysis in a GIS environment. The findings show that the built-up area has grown at a rate of about 10.8% per year over the last 16 years, indicating rapid urban growth. During the study period, UGS coverage in the study area decreased by 1.4%. Moreover, the results show that 325.4 ha are highly suitable and 3191.5 ha are suitable for UGS development, distributed over the study area. This study would aid in the formulation of appropriate UGS planning and management policies. It would also give planners and stakeholders vital information regarding appropriate sites for the growth of UGS in the future in Ambo Town.

Key words: FAHP, GIS, Geospatial Technology, LULC, MCDM, OBIA, UGS

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Urbanization is a worldwide phenomenon that emphasizes the process of both vertical and horizontal physical expansion of urban areas. It is mainly the process by which towns and cities are formed and become larger gradually as more people begin living and working in cities (Ibido, 2020). According to Satterthwaite et al. (2010) Urbanization is a global process which demonstrates itself through rapidly changing human population densities and land use and land cover. Urbanization is also used for the expansion of urban land uses and a shift in settlement patterns from dispersed to more dense settlement. Land Use/Land Cover (LULC) pattern change, industrialization and social transformation occur during the urbanization processes.

Natalie (2015) argued that a key element in the transition to more urbanized environments is related to the extent to which urban amenities have a role in resident perceptions of quality of urban life. It identify that "amenities are key to understanding quality of life because they are precisely what make some places attractive for living and working, especially relative to other places that do not have them and/or are burdened with their opposites, disamenities". According to Natalie (2015), urban amenities are the specific urban facilities that contribute to the urban living experience of residents; they are linked to the daily life needs of residents in a neighborhoods. Urban amenities means urban facilities such as parks, playgrounds, green spaces, parking facilities, public Wi-Fi facilities, public bus transport, bus shelters, taxi and rickshaw stands, libraries, affordable hospitals, cultural centres, recreation centres, stadium, sports complex and any other urban facility that the State Government may, on the recommendation of the Authority, specify to be an urban amenity, but does not include infrastructure development work.

The world has experienced tremendous urbanization and population growth. According to United Nations (2019) reported, the world's population is expected to increase by 2 billion persons in the next 30 years, from 7.7 billion currently to 9.7 billion in 2050. Ethiopia has one of the fastest growing urban populations in the world with the number of people living in cities are projected to contribute more than 50 million to the urban increment between 2014 and 2050 and will constitute together another 20 percent of the total increase in urban population (United Nations, 2015). it is the second most populous country in Africa with 107 million inhabitants (United Nations, 2017). Besides the population of Ambo town has been growing rapidly over the past years. The 1994 census reported the town had a total population of 27,636, as Central Statistic Authority (CSA) (2000) 76774, as CSA (2007) 48,171, as CSA (2017) 83,053 and as projected in 2021 by Ambo kebele, a total population was 1, 43212. This shows the population of the town is highly increasing from time to time mainly in case of rural to urban migration.

Urban green spaces (UGS) refer to soft landscape elements such as grass, shrubs and trees situated within city limits left by urban plans or by default (Girma et al., 2019). UGSs are urban areas which are covered in natural or semi-natural ecosystems converted to urban spaces by human influence (Bilgili and Ercan, 2012). Green spaces provide linkage between people (who live in the urban) and nature. So, these areas are very important for the urban people (Cemil et al., 2012).

Green spaces provide economic, environmental, social and cultural benefits. It's a vital role in the life of urban residents (Kmail and Onyango, 2020). The existence of urban green area in a contemporary urban environment is expected to improve air quality, reduce noise and air pollution and enhances aesthetic quality. Development of urban greenery is a key factor of the overall city planning, as its benefits have direct effects on the environment as well as on the quality of life of its residents (Assaye et al., 2017). Therefore, it is necessary that they are distributed equitably to all population groups in the city and town. These benefits can be maximized for all communities through adequate planning, design collaboration and evaluation (WHO, 2017).

Rapid Urbanization is an important global phenomenon and it becomes a great concern for many parts of the world. According to WHO (2017) a brief for action, Urban living limits access to nature and can increase exposure to certain environmental hazards, such as noise and air pollution. It has posed greater pressure on natural resources and the environment and the amount of land exploited for development of infrastructure and buildings has increased at the expense of urban green spaces. Although, rapid urbanization results in the conversion of several urban lands into built up structures and in excessive destruction of the natural ecosystem including green spaces (Areola and Ikporukpo, 2018). Due to rapid and unplanned urbanization in developing world, city administrators and urban planners are challenged with problems in delivering basic services like green space, sanitation, water supply, transportation, and primary health center, schools, public services providing offices with or nearby them at least need some more green space to maintain appropriate carrying capacity (Pokhrel, 2019).

Moreover, the Environmental Policy of Ethiopia has documented the importance of planning of green spaces within urban areas. This gives a room for various stakeholders to develop and manage urban forests, street trees etc. 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).

Geographic Information System (GIS) and Remote Sensing are now providing new tools for advanced ecosystem management. At present, GIS and RS has been recognized as a valuable technology for viewing, monitoring, analyzing, and mapping suitable site for urban growth and expansion. Moreover, remote sensing data are very useful because of their repetitive coverage, and real-time data acquisition. Satellite data, RS and GIS are the most relevant technologies for meeting these needs in the most effective manner (Al-bilbisi, 2019). Multi-criteria analysis approach that is integrated with the GIS has been increasingly used for suitable site selection and it is considered as one of the crucial tools for urban green spaces planning (Berkel et al., 2014; Ustaoglu and Aydınoglu, 2020).

Land suitability analysis is the process to determine whether the land resource is suitable/ appropriate for some specific uses and the suitability level by considering different factors such as LULC patterns, landscape, road infrastructure and soil (Javadian et al., 2011; Kumar and Biswas, 2013; Yousefi et al., 2016). Identifying appropriate suitability factors are the ultimate objective of suitability analysis (Abebe and Megento, 2017). Land suitability analysis for recreational use is vital in planning as it gives room for choosing the most suitable site from among various alternatives. It is helps in delineating suitable locations for various types of development and determining suitable locations or sites that met certain criteria (Sahabo and Mohammed, 2016).

Therefore, this study focuses on analysis spatiotemporal dynamics and site suitability for UGS development using remote sensing and GIS with the integration of Multi-criteria decision making (MCDM) approach in Ambo Town.

1.2. Statement of the Problem

UGSs are unable to provide urban residents with the desirable services due to rapid urbanization and unplanned urban growth, lack of proper site selection and planning and lack of attention to population thresholds (Ahmadi et al., 2017). Due to rapid urbanization, population growth and unplanned urban growth, lack of proper site selection, coherent management approach and spatial planning and lack of attention to population thresholds urban green spaces are unable to provide urban dwellers with the desirable services (Girma et al., 2019). Because of the unplanned urban expansion, no balance is seen between natural land patterns and human settlements, in a phrase of urban green spaces and open spaces urban expansion has been dominating natural networks that provide multifunction for both human and ecology (Abebe and Megento, 2017). The UGS coverage is not adequate to meet people's needs due to population pressure, expansion of industry, and construction in the process of urbanization (Cetin, 2015).

One of the major impacts of urbanization is a shrinking of UGSs, through the development of infrastructures and various development projects. Lack or degradation of urban green space can contribute to the burden of disease by worsening the effects of other adverse factors in the urban environment (Kruize et al., 2019). These include air pollution, noise pollution, heat waves and flooding problems. According to WHO (2016) loss and degradation of green space diminishes an important restorative resource for the individual and reduces opportunities to meet people and engage in physical activity in an attractive and relaxing environment.

Due to rapid urbanization and population growth, Ambo Town was putting pressure to join land for unplanned and uncontrolled development, LULC change due to horizontal expansion of urban area and increment of built-up areas, occupying unsuitable sites and declining basic services especially green spaces. Besides, there are many challenges that affect particularly the urban green space of the Town such as informal settlement, urban sprawl, lack of public awareness, low community participation, lack of expert manpower in this area, poor administration and poor cooperation among different organization. Also, the Town does not have up-to-date information that can give an impression about the physical changes in general and the amount of green space in particular.

The problem is expected to get worse in the coming years due to the huge construction of buildings, roads and less attention given to UGS. At this time planner's role becomes important to find out the extent of LULC change and analysis the potential site for UGS development in the town in sustainable way to reduce the problem raised by unplanned urban expansion using geospatial technology.

In Ethiopia, there were some studies conducted on the site suitability analysis of urban green space development using GIS and Remote sensing such as Abebe and Megento (2017), W/gebriel (2017), Hailemariam (2021) and Yirgalem (2021). These studies have focused on the LULC change analysis in the urban environment using traditional pixel-based techniques and also focused on the weight determination in the MCDM problem using AHP method. However, these studies did not give attention to the OBIA for LULC change analysis, high resolution imagery for high accuracy and FAHP method for weight determination. There is some limitation in considering a traditional pixel-based techniques and AHP method. Because pixel-based was used spectral information only from traditional Landsat imagery, it had low accuracy. Also, there are some limitations in AHP method because the selection of target option is subjective and impressive, so the traditional AHP cannot accurately determine the relative weight. Besides, there were no studies conducted in the study area related to site suitability analysis for urban green space development in the context of LULC change.

Generally, UGSs have a significant role in enhancing the quality of life of urban inhabitants and in supporting urban metabolism (Braubach et al., 2017). However, UGSs have experienced a physical and social decline, while its heterogeneousness and richness are often neglected and its contribution to the well-being of a community ignored within current urban planning instruments (Cetin, 2015).

Therefore, this study aimed to fill the existing research and knowledge gap by using the geospatial technology by applying OBIA techniques to analyze the change existed in the LULC patterns particularly green space from 2006 to 2022 year. it's necessary considering high resolution image in OBIA which has higher accuracy that was efficiently analyzed the impact of LULC change on UGS and applying GIS-based multi-criteria analysis method to select suitable sites for UGS development of Ambo Town using FAHP method for determining the weight of each factors.

1.3. Objectives of the Study

1.3.1. General Objective

The main objective of this study is to analyze the LULC dynamics and suitable sites selection for urban green space development of Ambo Town using remote sensing and GIS tool based on MCDM approach.

1.3.2. Specific Objectives

The specific objectives of this study are to:

- Determine the urban LULC change trend of Ambo Town particularly urban green spaces over the past 16 years (2006-2022);
- Identify the main determinant factors affecting the urban green space development of the study area;
- Find out the suitable sites for urban green space development of Ambo Town.

1.4. Research Questions

- How has the extent of urban LULC of Ambo Town been changed from 2006 to 2022?
- What are the underlying factors that affect the development of urban green space of the study area?
- Which sites are suitable for urban green space development of the study area?

1.5. Significance of the Study

Study of suitability analysis is important for urban and regional planners and decision makers to assess suitable site for urban green space development by considering various factors. The main significance of this study will provide invaluable data for local engineers, urban planners and policy makers on proper area for the development of urban green spaces, and will serve as an input for further studies. This research will also be useful especially to Ambo Town municipality and specifically infrastructure department as reference from the results obtained; they can locate which area is really suitable to be developed as green space in Ambo Town. Also, for the official, it is useful for their professional allocation for the development and management of green space by address a scientific approach to determine suitable land for urban green space in healthy urban development and help in revision of policy and preparation of development plans in the study area and for other cities as well.

1.6. Scope of the Study

This study was limited its scope to Ambo Town. It focused on site suitability analysis for urban green space development using integrating FAHP-GIS-MCDM approach based on the change trend exist on LULC pattern, particularly green space during study period (2006 to 2022) in study area and it conducted based on nine parameters/factors. Research on urban green space development potential site selection requires a wide scale of study in all cities and towns of the country. But, with the available time and resource in order to make the study more manageable and due to the difficulties of urban green space development site selection, the scope of this study will be delimited to Ambo town.

1.7. Limitation of the Study

There was some limitation during this study. One of the limitations was difficult to get recent high resolution satellite imageries for high accuracy classifying LULC of the study area. Also, it was impossible to get very high resolution satellite imageries such as QuickBird and IKONOS. Availability of data also another limitation such as land price or land value data this is also one of the factor affect the urban green space development. The other limitation was parameters of green space development were set by reviewing different literature and prior knowledge of the study area instead of common standards.

1.8. Organization of the Thesis

The study is organized into five chapters. Chapter one contains brief description of introduction such as background of the study, statement of the problem, research questions, objectives, significance, scope and limitation of the study. Chapter two reviews the relevant theoretical and empirical literature that was associated with the study. Chapter three gives description of the study area, the materials and methods, and details the methodology. Chapter four was concerned with results and discussion of the study. Chapter five covers the conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. Definition of Urban Green Space

There is a large body of literature on definitions of urban green space (UGS). According to Kmail and Onyango (2020) Green space can be defined as a space in an urban area covered by vegetation and it can be publicly or privately accessible and an area of greenery including public parks, playing fields, streets with plants and others in an urban area. As Mitchell and Popham (2008) and Jansson (2014) Green space as an "open, undeveloped land with natural vegetation", a definition that includes areas such as parks, forests, vegetation corridors, playing fields, wetlands, urban forests, cemeteries etc. According to Costa et al. (2008) urban green space is defined as a public open space in an urban area which is predominantly characterized by a high percentage of vegetation and non paved surfaces. According to Mathias (2016) citing different sources an UGS can be defined as formal and informal. Formal green areas include protected public parks, street gardens, playgrounds, sport fields, squares, private gardens, and vegetation cover in schools, hospitals, churches, mosques, embassies, cemeteries, parking lots, pedestrian lanes, etc. On the other hand, informal green areas include forest areas, river valleys, reserved expansion areas, agricultural lands, open leftover spaces, grazing lands, steeper degraded areas, shrub lands, etc. In the views of Manlun (2003) Green spaces are land uses that are covered with natural or man-made vegetation in the built-up areas and planning areas. According to Jim and Chen (2003) urban green spaces consist of outdoor places which have some amount of vegetation and can mainly be found in semi-natural areas. “UGSs are understood as public green spaces located in urban areas mainly covered by vegetations (as opposed to other open spaces) which are directly used for active or passive recreation or indirectly used virtue of their positive influence on the urban environment, accessible to citizens, serving the diverse needs of citizens and thus enhancing the quality of life in cities or urban regions” (Abebe, 2009).

2.2. Types of Urban Green Space

There are different ways to classify urban open space and green space, such as its size, how people use it, its intended function, its location etc. Types of green spaces that serve different uses over the city, green space systems can be created as a result of efficient organization (Bilgili and Ercan, 2012).

According to Vargas-Hernández et al. (2017) urban green spaces are classified in different categories by size, spatial characteristics, geographic locations, uses, functions service purposes, facilities, and property. It can be classified by the type of facilities and degree of naturalness. Urban green spaces can be urban parks, nature parks, pocket parks, district parks, community parks, neighborhood parks, sporting fields, urban forests. It can be cricket oval, Skateboard Park and bowling green. The agency managing the park can be national park, state park, City Park. The history of the park can be heritage rose garden. The condition of the park, the land use history of the area, street-corner neighborhood park, the types of users, landscaping and embellishments can be dog park, bike park or Chinese garden and the philosophy behind can be recreation reserve or civic square are the types of urban green spaces.

Components of urban green areas are vegetation, water, accessibility, services of shelters, toilets, seating, playgrounds and sport areas, events and activities, environmental quality conditions and resources such as lighting, safety, litter bins, friendly staff, artistic features and artifacts such as sculptures, etc (Vargas-Hernández et al., 2017). Natural play spaces are growing rapidly in popularity as they become recognized for their significant positive impacts on the health, wellbeing and growth of children. Natural play spaces use a blend of natural areas, water and local plants to interest children in learning about the wonders and secrets of the natural world. Community gardens have significant benefits to the community on social, economic and environmental aspects. Urban agriculture has a slightly different focus than community gardens and exerts an important impact on social movement around the community and food security. It is considered beneficial to both the ecological and food security movements (Samson, 2014).

2.3. Benefits of Urban Green Space

Urban green spaces have many functions and benefits. These functions and benefits are important to improving life quality in the urban areas. UGSs play a key role in improving the environmental quality, livability, and sustainability of our towns and cities. They provide a range of benefits at both the national and the local levels and offer many useful opportunities to people in different ways (Baycan-levent and Nijkamp, 2009). According to Mitchell and Popham (2008) people who live near green spaces are healthier than people who live farther from green spaces.

In 21 St Century, there is wide consensus about the importance and value of urban green spaces in cities towards planning and constructing sustainable eco-cities. Gradually growing traffic and urban heat, especially in the developing countries is not only damaging the environment, but also incur social and economic costs. Green spaces in the city should be easily accessible and adequately optimum in quality and quantity to meet social and psychological needs of citizens (Haq, 2011). The contribution of UGSs towards improving the urban environment, quality of life and sustainability of cities in urban planning and policies is as important as the other urban infrastructures, like water, electricity, sewage systems and transportation (Fariba, 2013).

According to (Cemil et al., 2012), urban green spaces are important as functions and meanings of urban climate, noise moderation, air cleaning and handle of surface water. It important as an indicator of environmental changes and as a part of the circulation of nutritive substances, cultivation of energy plants, biodiversity to save valuable urban species, as refuges for species from rural biotopes and as spreading corridors. It's also important as social and cultural values for health, recovering and rehabilitation, to give beauty and comfort, to give room for passivity and activity, as a cultural heritage, as an arena for citizenship, for education. Gardening and allotments are important as history of urban landscapes, as a social function for life and beauty, providing a reserve and urban design to give the city an understandable structure, to connect different scales and parts of the urban landscape. The benefits of urban green areas are described below under the main headings

2.3.1. Environmental Benefits

Urban green spaces provide ecosystem services for maintenance of biodiversity and regulation of urban climate. Comparing with rural areas, differences in solar input, rainfall pattern and temperature are common in urban areas. Solar radiation, air temperature, wind speed and relative humidity vary significantly due to the built environment in cities. The urban heat island effect is caused by the large areas of heat absorbing surfaces, in a combination of high energy use in cities (Mohammad and Zhirayr, 2013).

Therefore, adequate forest, plantation and vegetation around urban dwellers and management of water bodies can help to mitigate the situation. Green spaces that feature good connectivity and act as “wildlife corridors” or function as “urban forests”, can maintain viable populations of species that would otherwise disappear from built environments (Haq, 2011). Regional green space is based on the protection and optimization of natural ecological system and continuous suburban green space of large size. It is not only improving the whole ecological environment of the city region and its neighbors but also provides important support for urban environmental improvement. Furthermore, introduction of sub-urban green space into the city also acts as the base of ecological balance (Wuqiang et al., 2012).

Figure 2.1: Green areas near the housing area Source: (Cemil et al., 2012)

2.3.2. Economic and Aesthetic Benefits

Urban green space can have long-term positive effects on the economy but can also generate more direct economic benefits and values through e.g. increased property value, willingness-to-pay for goods, urban agriculture and city branding (Jansson, 2014). Using vegetation can reduce the energy costs of cooling buildings. It has been increasingly recognized as a cost effective reason for increasing green space and tree planting in temperate climate cities. Plants improve air circulation, provide shade and they transpire.

This provides a cooling effect and contributes to lower air temperatures. Haq (2011) noted as a park of 1.2 km by 1.0 km can produce an air temperature between the park and the surrounding city that is detectable up to 4 km away and also a study in Chicago has shown that increasing tree cover in the city by 10% may reduce the total energy for heating and cooling by 5 to 10%. Areas of the city with enough greenery are aesthetically pleasing and attractive to both residents and investors. Still, indicators are very strong that green spaces and landscaping increase property values and financial re-turns for land developers, of between 5% and 15%, depending on the type of project (Mohammad and Zhirayr, 2013).

Figure 2.2: Green areas provides aesthetically well places (Cemil et al., 2012)

2.3.3. Social and Psychological Benefits

Urban green spaces provide a number of benefits for human health, including longevity, physical and mental well-being, brain power and child development, all important for social and economic sustainable development. Access to green spaces plays a major role for the child-friendliness of cities and children's physical and mental development. Among children in highly urbanized areas, the risk of overweight can be reduced by proximity to much vegetation. Green spaces can increase the attractiveness of urban areas for residents and visitors, providing possibilities for increased quality of life in terms of e.g. safety, participation, social interaction and attractive living and working environments (Jansson, 2014). Urban green spaces have a range of social and health benefits. Urban green spaces serve as a near resource for relaxation; provide emotional warmth People satisfy most of their recreational needs within the locality where they live.

Urban green spaces serve as a neat resource for relaxation. People who were exposed to the natural environment, their level of stress decreased rapidly as compared to people who were exposed to urban environment, whose stress level remained high. Certainly, improvements in air quality due to vegetation have a positive impact on physical health. The connection between people and nature is significant for everyday enjoyment, work productivity and general mental health (Haq, 2011).


a

b

Figure 2.3: a. Recreational activities on water surface b. People are sitting in a park for recreational activity (Cemil et al., 2012)

2.3.4. Biodiversity and Nature Conservation

Green spaces do function as protection center for reproduction of species and conservation of plants, soil and water quality. Green area can influence biodiversity by increasing habitat area, increasing inhabitants of some protected species and increasing species movement. The positive impacts that urban green space can have on air, soil and water quality provide benefits for biodiversity (Cemil et al., 2012; Samson, 2014). Urban green spaces provide the linkage of the urban and rural areas. They provide visual relief, seasonal change and link with natural world. A functional network of green spaces is important for the maintenance of ecological aspects of sustainable urban landscape, with greenways and use of plant species adapted to the local condition with low maintenance cost, self sufficient and sustainable(Mohammad and Zhirayr, 2013).

Figure 2.4: Green areas are important for biodiversity (Cemil et al., 2012)

2.4. Status of Urban Green Spaces in Ethiopia

The Urban Development Policy 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). 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 (Mathias, 2016).

As (Abebe and Megento, 2017) concluded that the rapid urbanization in Addis Abeba has given little room for the development of green areas. The green areas include open spaces and environmental sensitive areas (parks, urban agriculture, recreation, mineral resources). The development plan of Addis Ababa is being revised now, which is put into effect tree planting along the ring roads, and enforces one-plot-one tree requirements (Mathias, 2016). In Ethiopia, the cities of Addis Abeba, Adama, and Hawass green areas are being shifted to other land uses such as residential, industrial and commercial developments which leads to environmental deterioration (Senia, 2021).

2.5. Urbanization Effects on Urban Green Space Development

Urbanization remains a major factor that has been predominantly linked to causing of green space destructions (Mensah, 2014). Urbanization takes the form of either densification of urban core or spatial expansion of urban areas outwards (urban sprawl). Densification of 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, per-urban lands and former agricultural lands. 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 (Honu et al. , 2009).

According to (MoUDC, 2014) Housing and Sustainable Urban Development report, Ethiopia is one of the least urbanized countries in Sub-Saharan Africa. Currently, 20 percent of the total population lives in urban areas. However, the country has one of the highest rates of urbanization even by the standards of developing countries, which is estimated at 4.1 percent. According to the policy document, the main challenges facing urban areas in the country are poorly developed social and physical infrastructure; shortage and deterioration of housing; lack of recreation areas; inadequate municipal waste management; absence of well integrated urban-rural linkage; unbalanced urban growth and weakly developed national and regional urban systems. The Urban Development Policy 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 (Mathias, 2016).

Changes in land use, particularly the replacement of green space by buildings, roads and parking lots causes urban areas to become warmer than surrounding areas because these impermeable materials absorb heat and release it more slowly. Solar reflectance is influenced by the color of materials, with darker colors, like asphalt and tar roofs, reflecting less and absorbing more solar energy, which warms the air above them (EPA, 2008).

2.6. Land Use/ Land Cover Change

LULC change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world’s forest, grassland, and agricultural resources has become an important priority (Zubair, 2006).

LULC change occurs when humans alter the landscape, and this leads to increasing loss, fragmentation and spatial simplification of habitat. Many fields of study require monitoring of LULC change at a variety of scales. LULC change assessment is dependent upon high-quality input data, most often from remote sensing-derived products such as thematic maps (Robertson and King, 2011). Changes in LULC can 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, the magnitude of LULC change differs with the time period being examined, geographical location, slope gradient and elevation range (Mengistie et al., 2011).

LULC have increasingly become a global challenge. They are the most direct expression of the effects of human activity on the natural ecosystems. Land use changes and developments have resulted in population pressure. Both positive and negative health and welfare effects have arisen, as a result of random industrialization, economic development, modernization, and urban planning policies. It has been found that changes in land use have negative impacts on the climate, ecosystems, surface radioactivity (e.g., increased atmospheric greenhouse gasses, depletion of the ozone layer), agricultural activities, and biodiversity on both local and global scales (Hasan et al., 2019).

2.7. Application of Geographic Information System and Remote Sensing in Suitability Analysis

Remote sensing provides a useful source of data to extract accurate land cover information. high spatial resolution remote sensing is becoming increasingly available from airborne sources and this makes it possible to get a detailed land cover map from such data (Dehvari and Heck, 2019). GIS has been applied in many disciplines including geography, forestry, urban planning, natural hazard management, recreation and tourism management, industrial facility management and environmental studies. Particularly, in suitability analysis, GIS has a great role in multi criteria decision making process. The survey showed that the GIS-MCDA approaches were most often used for tackling land suitability problems (Malczewski, 2006).

Suitability analysis is built upon the concept of multi-criteria evaluation. MCDM or multi-attribute decision making (MADM) techniques involve the evaluation of several criteria or datasets to meet a specific objective. In MCDM process, criteria or datasets are examined for assigning relative ranks and individual feature weights based on the land use type for which suitability being examined. Weighted summation is sufficiently straightforward to use GIS data. It will be incorporated into the land-use suitability analysis (Eastman, 2009). The suitability analysis process requires the identification of the appropriate locations for a particular land use activity by considering physical resources (elevation, slope, aspect, climate), natural resources (soils, geology, hydrology, vegetation and wildlife habitat and environmentally sensitive areas), and existing land use and development of man-made facilities such as transportation systems, existing urban areas, and utility networks (Kuldeep, 2013).

2.8. Multi Criteria Decision Making

MCDM has been a very fast-growing field in recent years. MCDM includes a finite set of alternatives, so that a decision maker can rank them, and there is a finite set of criteria which are weighted by decision maker, with respect to the importance of criteria. So, MCDM is an advanced discipline which can be applied to complex decision making problems, by providing an effective solution for ranking of alternatives. The desired result can be achieved, adhering to the appropriate criteria of the related decision making problem (Rashad et al., 2020).

The techniques adopted in the various approaches of decision analysis are MCDM. Research on land evaluation requires a large amount of spatial and non-spatial data, which GIS are capable of easily and efficiently handling. Therefore, many researchers have used GIS for land evaluation, a process, which enables the integration of multiple attributes and different criteria that are involved in decision-making (Malczewski, 2007; Abdelrahman et al., 2017). Land evaluation can be seen as a multi-criteria decision analysis (MCDA) process, which is combined with GIS, can become a powerful approach for land evaluation (Joerin, et al, 2001; Malczewski, 2006; Aldababseh et al, 2018). GIS techniques play a crucial role in spatial analysis, whereas MCDA provides a rich collection of tools for structuring decision problems, as well as evaluating and prioritizing alternative decisions (Malczewski, 2006).

In recent years, the integration of MCDA techniques with GIS has considerably advanced to evaluation/selection the optimum alternative. GIS-MCDA is a process of decision making at which geographic data value judgments are brought together to obtain more information for the decision makers. To combine MCDA and GIS each of the criteria should be represented as a map in the GIS database. In GIS technology, usually the alternatives are a collection of point, line and area objects, attached to which are criteria values (criteria map). GIS can recognize, correlate and analyze the spatial relationship between mapped phenomena, thereby enabling policy makers to link disparate sources of information, perform sophisticated analysis, visualize trends, project outcomes and strategize long-term planning goals (Mehdi and Hajizade, 2014).

2.9. Fuzzy Analytic Hierarchy Process

FAHP was adopted to calculate the relative weights of various indicators, and the indicators were dynamically sorted according to their importance (Lin, 2020). The combine effect of fuzzy set theory and AHP gives FAHP as a more powerful methodology for MCDM. In order to model the uncertainty of human preference, the AHP method is combined with the pair comparison of fuzzy sets. The FAHP facilitates decision-making procedures with precise definitions. it is an early used the triangular membership function to represent pair fuzzy ratios to figure out the partial fuzzy priority through the method of least squares (geometric mean method) (Lin, 2020).

The traditional AHP method is problematic in that it uses an exact value to express the decision-makers opinion in a comparison of alternatives and AHP method is often criticized, due to its use of unbalanced scale of judgments and its inability to adequately handle the inherent uncertainty and imprecision in the pair-wise comparison process. To overcome all these shortcomings, FAHP was developed for solving the hierarchical problems. Decision-makers usually find that it is more accurate to give interval judgments than fixed value judgments. This is because usually he/she is unable to make his/her preference explicitly about the fuzzy nature of the comparison process. So, the first study of FAHP is which compared fuzzy ratios described by triangular fuzzy numbers (Moayeri et al., 2015). Merging the strength of Fuzzy methods with AHP is one approach for overcoming the limitations of the AHP. FAHP allows decision-makers to evaluate their preferences within a reasonable interval. These intervals result in a fuzzy judgment matrix, corresponding to the rigid value judgment matrix of classical AHP (Abimbola et al., 2020).

2.10. Application of Fuzzy Analytic Hierarchy Process

As many researchers argued (Wang and Chin, 2011; Iftikhar et al., 2017; Rashad et al., 2020) FAHP proves to be a very useful methodology for multiple criteria decision-making in fuzzy environments, which has found substantial applications in recent years. As a practical yet popular methodology for dealing with fuzziness and uncertainty in MCDM, FAHP has found huge applications in the near future. Hence, FAHP will find more applications than conventional AHP. AHP approaches are applied in the presence of certain and complete information. Unfortunately, such approaches are not always capable of providing an exact solution of complex problems, and are insufficient to work under many circumstances of real-life situations. Therefore, AHP is not considered as a convenient method for decision making under uncertainty (Rashad et al., 2020).

Likewise an AHP, FAHP provides a hierarchical structure, facilitates the decompositions and pair wise comparisons, reduces the inconsistency and generates the priority vectors. Also, a fuzzy AHP can solve and support spatial reasoning problems in a number of different contexts such as: locating convenience stores and other facilities, hospital site selection, screening potential landfill sites, supplier selection and local park planning. So, a more powerful methodology for MCDM (Iftikhar et al., 2017).

2.11. Object-Based Images Analysis

The OBIA technique encompasses the segmentation of image data into objects on scale levels. The segmentation of the images object primitive is handled by the factor of scale, shape and compactness. Multi-resolution Segmentation (MRS) is a powerful region-based segmentation algorithm. It is a bottom up region merging approach that groups the areas of neighboring pixels into meaningful segments or objects according to the homogeneity criteria (Sibaruddin et al., 2018).

According to Labib and Harris, (2018) both bottom up algorithms (i.e. Multi-resolution Segmentation (MRS)) and top down (i.e. Spectral Difference Segmentation (SDS)) were utilized to get acceptable segmentation results for OBIA method. For segmentation, the process eCognition Developer was utilized. This software and its developed algorithms are widely used in different OBIA studies. MRS algorithm follows sequential region merging, starts at the single pixel level and mutually similar neighboring pixels form smaller segments. The segments grow and pixels are grouped until a "heterogeneity threshold" is reached. The variance threshold is a function of image layer weight, scale parameter, shape (defines the weight of colour when segmentation) and compactness (defines the closeness of pixels in an object, compared to the circle). However, selection of weight, scale parameter and shape is matter of experimentation to achieve acceptable segmentation with clear differences among objects. In addition to the MRS algorithm, SDS algorithm was applied in the segmentation process. This is a widely used segmentation algorithm in case of extracting urban-vegetation-related information. This algorithm allowed image objects to be merged based on spectral mean values below a given threshold and help improve the segmentation accuracy (Labib and Harris, 2018).

Image segmentation is the first stage of the OBIA, where the image is segmented into homogeneous and discrete objects based on color, spectral characteristics, similar texture, and shape of objects. MRS is a bottom-up region merging procedure which is proved to be the most notable segmentation method with several iterative steps to create large objects from smaller ones, was chosen to segment the satellite image. The significant part of the object-based classification is the selection of the best parameter combination, specifically optimal scale parameter (SP) in MRS (Balcik et al., 2020).

The results showed that OBIA technique produced better image classification than those produced using pixel-based technique. This result was due to the consideration of the factors of spectral, shape, and texture in OBIA (Sibaruddin et al., 2018). Nowadays, object-based analysis of satellite data is well-established, and there is a common consensus that it is based on the concepts of segmentation, edge-detection, as well as object detection and classification, all of which have been present in the field of remote sensing already for decades (Usmerjena et al, 2011). OBIA has several advantages over the pixel based methods; such as, consideration of spatial auto-correlation, improved image class, contextual consideration, integration of ancillary data in the process (Labib and Harris, 2018).

2.12. Land Suitability Classification

The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses. According to FAO (2007) land suitability classification is divided into order, class, sub-class and unit. Land suitability orders indicate whether the land is assessed as suitable or not suitable for the use under consideration. There are two orders represented in maps, tables, etc. by the symbols S and N respectively. Order S suitable land on which sustained use of the kind under consideration is expected to benefits, without unacceptable risk of damage to land resources. Order N, not suitable land which has qualities that appear to preclude sustained use of the kind under consideration.

Land suitability classes reflect degrees of suitability and the classes are numbered consecutively, in sequence of decreasing degrees of suitability within the order. Within the order suitable the number of classes is not specified. There might, for example, be only two, S1 and S2. The number of classes recognized should be kept to the minimum necessary to meet interpretative aims. According to FAO (2007) land suitability classification within the order suitable, there are three Classes are recognized with the following names and definitions may be appropriate in a qualitative classification. Class S1 highly suitable land having no significant limitations to sustain application of a given use only minor limitations that will not significantly reduce productivity or benefits. Class S2 moderately suitable land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land. Class S3 marginally suitable land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, this expenditure will be only marginally justified.

Within the order not suitable, there are normally two Classes. Class N1 currently not suitable land having limitations which may be manageable in time, but which cannot be corrected with existing knowledge of current acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner. Class N2 permanently not suitable land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner (FAO, 2007).

The Subclasses are a more detailed division of classes based on land quality and characteristics (soil properties and other natural conditions). For example, Subclass S3rc is land that is marginally suitable due to rooting condition (rc) as the limiting factor (FAO, 2007).

Land suitability units are subdivisions of a subclass. All the units within a subclass have the same degree of suitability at the class level and similar kinds of limitations at the subclass level. The units differ from each other in their production characteristics or in minor aspects of their management requirement often defined as differences in detail of their limitations. Their recognition permits detailed interpretation at the farm planning level. Suitability units are distinguished by Arabic numbers following a hyphen, e.g. S2e-1, S2e-2. There is no limit to the number of units recognized within a subclass (FAO, 2007).

2.13. Criteria for Suitability Analysis of Green Space

Criteria are very significant in the site selection of the identified land use and used as key drivers in the selection of the geographic location. Different researchers mentioned different criteria and sub-criteria for urban green space development such as LULC, proximity to the residential areas, proximity to the urban facilities, proximity to the historical place, distance to the existing local parks, access to transportation proximity to educational areas, population density, slope, distance to noise influence, hydrology, (eg., Manlun, 2003; Heshmat et al., 2013; Kuldeep, 2013; Pantalone, 2010). The criteria which are mentioned by different researchers are categorized into three units: Environmental, Socio-economic and Geomorphological (Heshmat et al., 2013).

2.13.1. Accessibility Criteria

Accessibility to green space is one of the important factors that determine the usefulness and the likelihood of monitoring and maintenance their safekeeping for the public, which will be essential in addition to the Passersby's aesthetic and ecosystem services similarly easy access to green space during an emergency or crowed put additional benefit and utilization of green spaces. So for this study distance from the main and emergency road was considered as important accessibility criteria. An earlier study carried out by Yang et al. (2008); Kumar and Biswas (2013); Pokhrel (2019) considered accessibility as an important factor for suitability evaluation/analysis'.

2.13.2. Physical Criteria

As per the (FAO, 2006) classification slope has been divided into various classes the slope value 0 to 0.2% is considered as flat slope and 2 to 5%as a gentle slope. Where 5, 10 to 30% is considered as sloping and strongly sloping. Similarly, slope greater than 30% is considered as moderately to seep slope respectively. The most appropriate slope for building a green space is appropriate is 2 to 15%. However, in general, the limiting factors are not problematic as the slope can be properly used for soil conservation, design or improve beautification. However, a gradient from 0 to 2 is not much suitable due to drainage problem. Similarly, the aspect, direction of the slope also determines the quality of sunlight which has some influences in the growth and development of vegetation or greenery.

2.13.3. Socio-Economic Criteria

Various socio-economic factors are directly or indirectly associated with the green space suitability evaluation. Factors like facility location, land use, population density, house density, and zoning area have used for this study. For example distances from facility location to green space is important to ensure their closeness and high compatibility with each other for maintaining the healthy environment for hospital visitors, students, employees and consumers for revitalization at these services center. Similarly, places near the high population density with a greater number of a citizen with crowded places required access to the open green spaces (Schipperijn et al., 2010). This is similar to other factors.

2.13.4. Environmental Criteria

Environmental criteria are the most significant and important criteria for the evaluation of open green spaces in any locality. Factor like availability open space, river network, Water body, existing park and vegetation plays an important role. As (Kuldeep, 2013) state that land closer to river stream banks get more preferences and help to maintain the environmental health of the green open area. Similarly, green location near to water resources like reservoirs, ponds, lakes, rivers is the best suitable location for green space planning (Heshmat et al., 2013). In case of the existing park, it is recommended develop a park or green spaces with a certain degree of distances to make equal spatial distribution and this will help to secure development of green spaces or vegetation's to a new area (Pantalone, 2010).

2.14. Review of Empirical Studies

Different researchers were attempts to analysis UGS development on the characterization of LULC change phenomena on different period of time as internationally and national began decades ago. Most of Ethiopian researchers' emphasis UGS development based on LULC dynamics using unsupervised classification, supervised classification technique and AHP method. However, most recent techniques apply to analysis urban green space development like object based image analysis and FAHP are plays an important role in classification of LULC change and determining the weight of each factors respectively (Author).

Hailemariam (2021) studied about suitable site selection for UGS development using geographic information system and remote sensing based on multi criterion analysis. Urbanization remains a single predominant factor that is continuously linked to the destruction of urban green spaces. In Ethiopia, urban green areas have been consumed by industrial, commercial, residential and infrastructural developments, as well as by spontaneous and illegal settlements along mountain slopes, river valleys and other open spaces. Public green space are not uniformly distributed in the town in addition to this greening rate is relatively low in contrast to numerous population in the urban centre. That is more and more green areas are continuously replaced by other commercial land use every year. Supervised classification followed by reclassification were done to classify suitable land use land cover for urban green space and AHP method used to determine weight.

Yirgalem (2021) studied about the suitability analysis of UGS development using geospatial technology in Adama town; the urban areas in Adama town have expanded dramatically, while green areas have been declining. UGS plays a vital role in the mitigation of negative impacts of urbanization; however, it is often affected by the process of land use and land cover (LULC) changes in an urban area based on supervised classification and AHP method.

W/gebriel (2017) analyzed about GIS and RS applications for potential UGS development site selection in Abiy Addi town central Tigray; LULC and green cover changes monitoring is required showing a need for green space development sites identification. The main motivation to this was the existence of low and even unplanned leftover greens in the study area. LULC changes in this study based on CORINE classification system, supervised/unsupervised classification and AHP method.

Abebe and Megento (2017) studied about UGS development using GIS based multi-criteria analysis in Addis Ababa metropolis. The urban/built-up areas in Addis Ababa have expanded dramatically, while green areas declined. According to the new City Development Plan (2001–2010), the city has currently consumed more than 75% of its areas for development, leaving little space for green areas. The classification achieved in this study indicates that large area is less suitable for park development in the existing situation (49.76% of the area). The LULC of the study area was analyzed using 15 m resolution of Landsat image based on supervised classification and AHP method.

2.14.1. Research and Knowledge Gaps

All of the researchers focused that LULC change have impact on UGS and considering a pixel based technique and AHP method. Though, there are a gap in considering pixel based technique and AHP method. In case of pixel based, the remote sensing image used has low resolution or low accuracy, so there are a large number of mixed pixels affecting the classification, resulting pepper phenomenon, poor visual effect, unreasonable classification results and shows poor assessment results. Therefore, it’s necessary considering object based image analysis technique using high resolution or higher accuracy image for efficiently analyze the impact of LULC change on urban green space, largely avoids misclassification caused by the similar spectral features and similar shape features between different land types and effectively improve the classification accuracy.

In case of AHP, uses hierarchical structures to represent a problem and then develop priorities for alternatives based on the judgment of the user. This may not fully reflect a style of human thinking because the decision makers usually feel more confident to give interval judgments rather than expressing their judgments in the form of single numeric values. So, FAHP method is capable of capturing a human's appraisal of ambiguity when complex multi-attribute decision making problems are considered by transformed crisp judgments into fuzzy judgments that should be able to tolerate vagueness or ambiguity for determining the weight of each factor.

Additionally, there was not conducted any study in Ambo Town related to urban green space and the results of other studies in different urban centers in the country could not provide the whole picture of the problem of study area due to some limitations such as difference in spatial planning, level of urbanizations, difference in level of management, etc.

2.15. Conceptual Framework

Theory comes from one of the different fields that deal with the interaction of humans with their environment (e.g., economy, sociology, political, ecology, and social psychology). Theory, observation, and models are crucial components of land use research. There are three main traditions of theorizing land use such as urban and regional economics and regional science, sociology and political economy and nature-society theories (Hersperger et al., 2010). Urban and regional economics and regional science are important for sustainable land management and urban planning. The sociological and political economy approach is used for land use research in combination with the economic approach. Nature-society theories refer to a holistic view of the human cause of environmental change and concerned of the interaction between environment, economy, society, technology and culture.

Urban green spaces are an important part of urban ecosystems, play a vital role in environmental, economic and social aspects in urban areas (Mensah, 2014). Moreover, green spaces sequester CO2 and produce O2; 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. Applying the ecological factor threshold method will help quantify how much green area is necessary to maintain an ecological balance in urban areas (Pham and Nobukazu, 2008).

There are three main components which determine LULC change such as driving forces, actors and land itself (Hersperger et al., 2010). The driving forces are forces which interact with actors to shape the land change like climate change, human activities, urbanization and population growth, etc. Government policy influences the actors through making decisions (e.g., land use policy, urban utilities planning, resettlement, etc.). Actors may be individuals or groups who own the land such as land owner and policy maker affect it directly. Land characteristics by itself can influence the land cover change (e.g. landforms) (Figure 2.5).

In general, there are many factors that affect LULC like land owner's activities, external driving forces, land characteristics and government policy. Conducting a study on land use requires developing urban green space by considering different determinant factors (main factors and sub factors) that affect urban green space development. Main factors are accessibility, physical, environmental and socio-economic. Sub-factors include road, slope, soil type, river, park, LULC, population density, industry and historical and cultural area etc. The conceptual framework illustrated in Figure 2.5 below demonstrates the main components which determine LULC change urban green spaces suitable site selection parameters and benefit of urban green spaces for urban ecosystems.

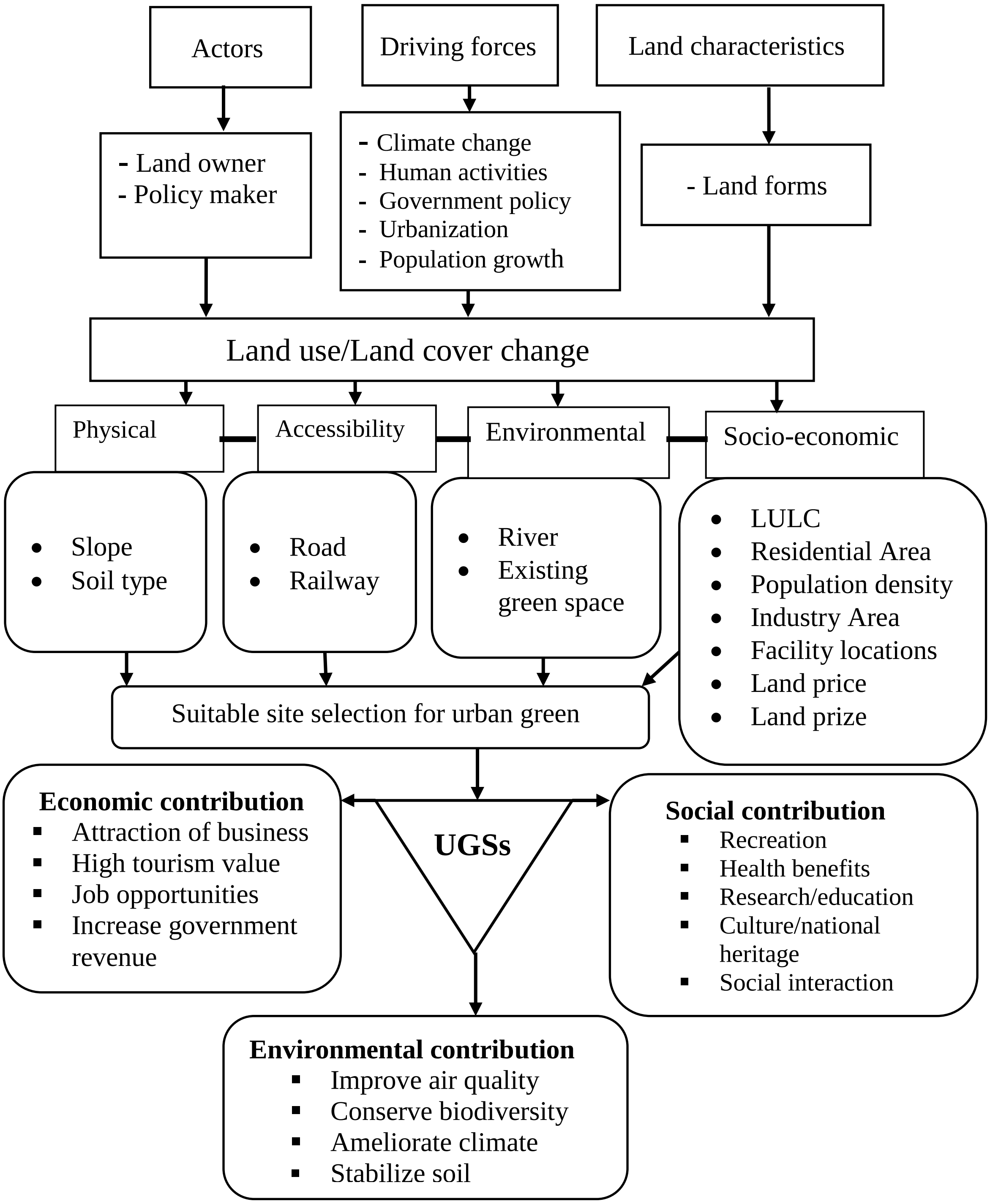


Figure 2.5: Conceptual framework of LULC change and suitability analysis

Source:(Manlun, 2003; Hersperger et al., 2010; Mensah, 2014) and modified by the author.

CHAPTER THREE: MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Geographical Location

The study conducted in Ambo Town which is established in 1889. Ambo Town is located in West Showa zone, Oromia Region in central Ethiopia, which was located to the west of Addis Ababa, the capital city of Ethiopia and on the road to Nekemte. It is the capital town of West Shewa Zone. Relatively Ambo Town is located 114km faraway West of Addis Ababa, 60 km North West of Waliso Town and 12km east of Guder town (UN-HABITAT, 2008; Shanmugham and Tekle, 2011;Ogato, 2013; Ogato et al., 2017). Ambo Town is among a few privileged towns of its time to have its own municipal administration since 1931 and a master plan since 1983. The Town divided into six administrative Kebele. The Town covers the total area of 8557.2 hectare. Ambo is known for its mineral water, which is bottled outside of Town; it is reportedly the most popular brand in Ethiopia. Residents of the Town are usually considered as being "proud Oromo Nationalists" and Pro-OLF. The geographical location of Ambo Town is approximately between 08^0 56'30''N – 08^0 59'30''N latitude and 37^0 47'30''E – 37^0 55'15''E longitude and an average elevation of 2101m above sea level.

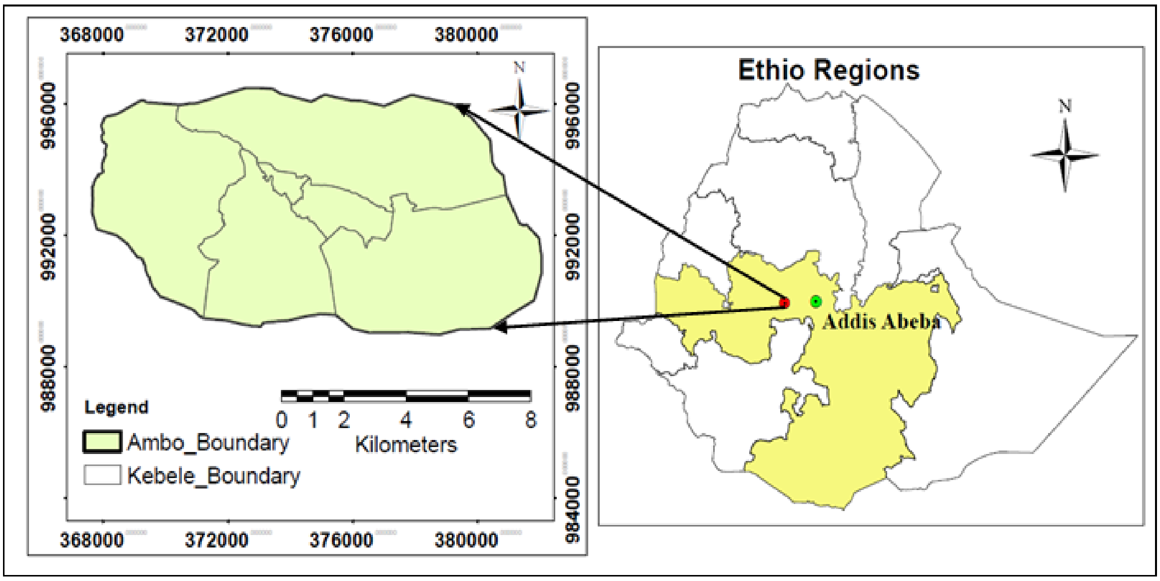


Figure 3.1: Location map of study Area Source: (Author, 2022)

3.1.2. Topography

The topography of Ambo Town is largely dominated by terrain with flat to undulating and steep slopes. In other words, the land surface terrain of the majority part of the surface of the town has slope gradient less than 20 percent. Most of the existing built up areas of the town is with gentle slope and undulating topography while some hilly slope and mountains are also seen in some parts of the Town. Along the course of rivers and streams, steep slope and gullies are also observed. The altitude ranges from 1861m to 2357m above sea level (m.a.s) (Figure 3.2). Slopes with 21-60% cover small area in the Town whereas slopes with 2-20% cover the majority areas of the Town (Ogato, 2013).

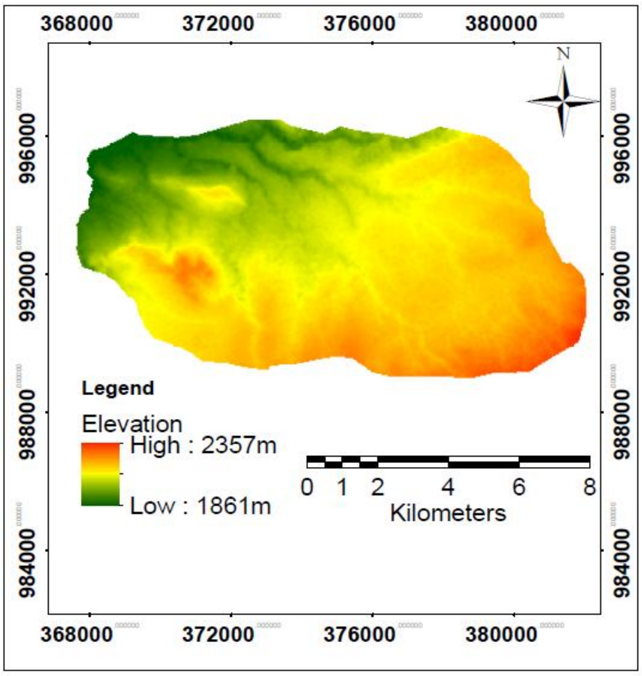


Figure 3.2: Topography map of the study area   Source: (Author, 2022)

3.1.3. Climatic Conditions

The mean annual temperature of the Town over 30 years (1981-2010) is 18.64 ^{0}C while the mean annual rainfall of the town over 30 years (1981-2010) is 968.7 mm. The highest rainfall concentration occurs from June to September. The mean monthly relative humidity winds of Autumn (locally Meher or Birra), Winter (locally Bega or Bona), Spring (locally Belg or Arfasaa) seasons are easterly and south easterly winds while that of Summer (locally Kremt or Ganna) seasons is westerly and south westerly winds. Generally the most dominant prevailing wind of Ambo Town is easterly wind (Ogato, 2013). The max, min and average temperature of Ambo Town over 10 years (2010 – 2021) is shown by below graph in ^{0}C.

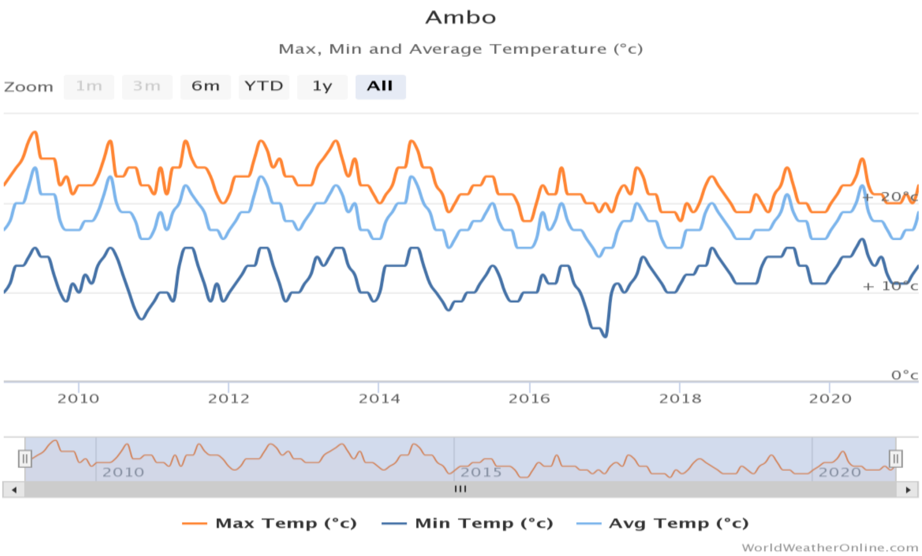


Figure 3.3: Max, min and average temperature of Ambo Town from 2010 – 2021
Source: (Achalu, 2021)

3.1.4. Demography

The population of Ambo Town has been growing rapidly over the past few years. The CSA (1994) reported this Town had a total population of 27,636 of whom 13,380 were males and 14,256 were females. The CSA (2000) reported this Town had a total population of 76774, of whom 39155 are guys and 37619 are females. The national CSA (2007) reported, a total population of Ambo Town 48,171, of whom 24,634 were men and 23,537 were women. According the national CSA (2017), the total population of the town for 2018 was 83,053; Men constitute 41,692 (50.2%) and Women constitute 41,361 (49.8%). As projected in 2021 by Ambo kebele, a total population of Ambo Town 1, 43212, of whom 70,616 were men and 72,596 were women (Ambo Kebele profile, 2021). When compare the five reports the population of the town is highly increasing from time to time.

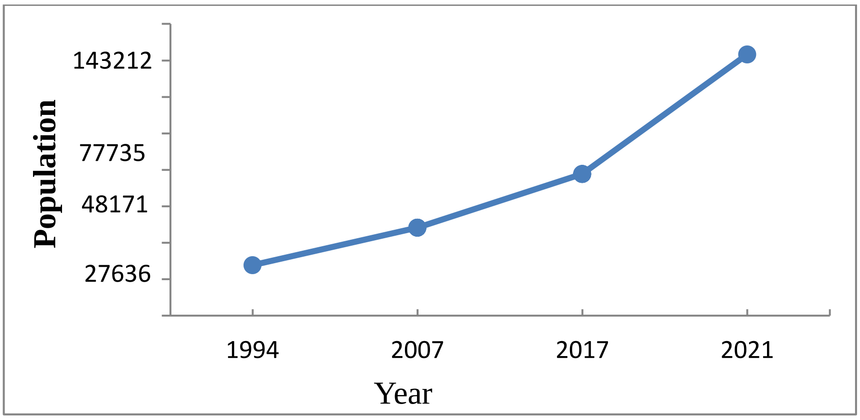


Figure 3.4: Population of Ambo Town from 1994 to 2021 Source: (Author, 2022)

According to projected population by kebele in 2021, the distributions of population in the Town are uneven. As a result, the density of population varies from one kebele to another kebele. The central parts of the Town have high population density such as Torban Kutaye and Yaa'i Gadaa whereas the eastern, southern and western part of the town has the least population density such as Awaro Qora, Sanqale Farisi and Kisose Oddo Liban. Hora Ayetu has the moderate population density as showed below (Figure 3.5). Population density was calculated as the total population in each kebele per the total area given for each kebele. It is calculated as:

$$\text{Population Density} = \left(\frac{\text{Total population of each kebele}}{\text{Total area of each kebele}}\right) \quad (1)$$

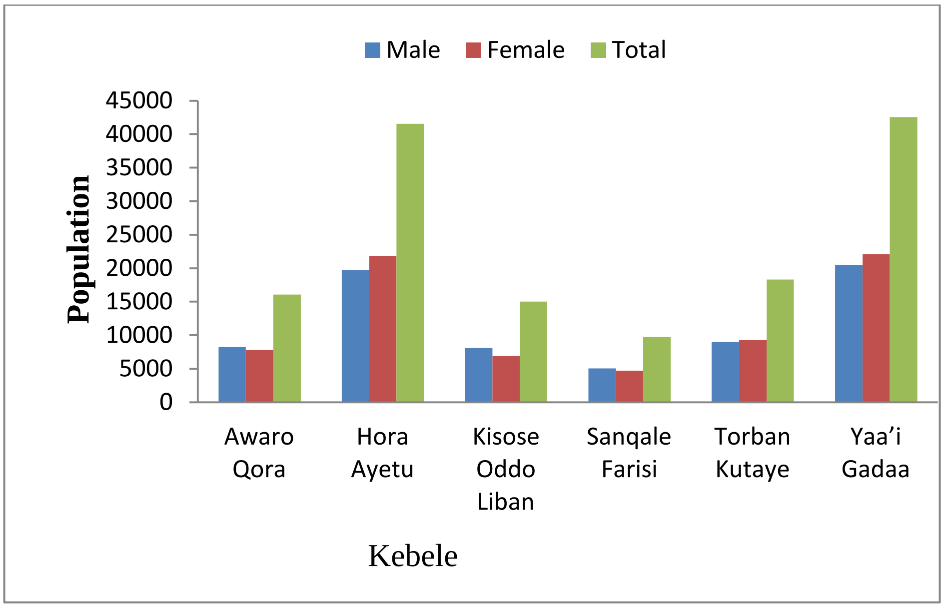


Figure 3.5: Population of Ambo town in 2021 at kebele level Source: (Author, 2022)

3.2. Materials and Software Used

The study used some materials to collect and analysis the data and software to interpret the data. To achieved the objective of this study different types of software used. The following table describes types of software's and the material used in the study with version of software's and their purposes.

Table 3.1: Instrument and Software Used

No	Materials/ software's name	Purpose
1	Hand held GPS	To collect coordinates of Facility center & Factor
2	ArcGIS 10.7	Data presentation, analysis, Weighted overlay analysis and map creation
3	ERDAS Imagine 2015	For processing and analyzing satellite images
4	Ecognition 8.9	For classification of LULC
5	Microsoft word 2007	For compiling the overall Report
6	Microsoft Excel 2007	For writing the non-spatial data which going to integrate with attribute table

Source: (Author, 2022)

3.3. Data Analysis Methods

In generally, to conduct the specific objectives or research question of this study the following three methods were used: OBIA method, Selection method and Weight overlay Analysis method.

3.3.1. Object Based Images Analysis Method

Presently, the OBIA technique is quite significant with the environment of image classifications. The OBIA technique takes the forms, textures and spectral information into consideration. The initial phase of classification starts with grouping the neighboring pixels into meaningful areas. OBIA technique gives a better classification result than pixel-based technique for high and very high resolutions (Sibaruddin et al., 2018). As a result, OBIA attempts to identify patterns in an image and use contextual information to group pixels into clusters that represent the same object. By grouping pixels into meaningful objects, spectral variability within a segment is minimized and differences between segments are maximized. An object-based approach also reduces the effects of spatial autocorrelation.

In general, high-resolution imagery is classified more accurately when using object based classifications than pixel-based classifications (Czarnecki, 2012). Therefore, this study was determined the change of urban LULC in Ambo town using object-based image analysis technique.

3.3.2. Selection Method

There is a variety of research on identifying and applying factors for urban green space development. The selection of criteria and their sub-criteria is a crucial stage as selection of criteria influences the judgment by segregating one criterion from other and at the same time, by giving more importance to one criterion over other. For urban green space planning, there were no universally agreed criteria and factors (Ullah, 2014). Therefore, the study selected nine main factors affecting urban green space development of study area.

3.3.3. Weight Overlay Analysis Method

Weighted Linear Combination is a type of MCDA method in GIS environment used to evaluate the suitability of a region for urban development. The approach allows the decision maker to assign weights according to the relative importance of each suitability map and combines the reclassified maps to obtain an overall suitability score (Malczewski, 2004). Once the criteria maps and weights have been developed and established, a decision rule of multi-criteria analysis was used. As pointed by (Manlun, 2003; Eastman, 2009; Gelan, 2021), there are three common decision rule in multi-criteria analysis namely weighted linear overlay, Boolean overlay and ordered averaging.

In this study, to aggregate the standard layers could apply the weight linear combination technique. In this case, the factors or parameters (x_i) are multiplied with the weight of the suitability parameters (W_i) to get the composited weights and then summed. This can be done by using the following formula to derive the intended map i.e. urban green space suitability map for Ambo town.

$$S = \sum_{i=0}^{n}(WiXi) \qquad (2)$$

Where S is the composite suitability score, w_i is weights assigned to each factor, x_i is factor scores (normalized cell values) and n is total number of suitability criteria layer

3.4. Data Processing

The study analyzed the LULC change and site suitability for urban green space using geospatial technology of Ambo town. The GIS- based land suitability analysis using FAHP approach as the MCDA was used in this study. Land suitability analysis in a GIS environment is formulated as a MCDM problem. Under this situation, GIS-based multi-criteria land suitability analysis is becoming critical in determining the land resource that is suitable for UGSs (Cetin, 2015).

3.4.1. Image Pre-Processing

In this study, the necessary data were collected from different source. Before any operations can be carried out the required data need to be corrected and created. After data were collected the study started the process of manipulating, store, sorting etc in ArcGIS and the entire image (map) data was prepared using WGS 1984 and UTM Zone 37N. Also layer stake, radiometric correction, subset, mosaic, image enhancement using panchromatic band (pan sharpened) were carried out. These images are to be modified to give the best possible result. Further, the pre-processing of satellite image of study area of 2006, 2026 and 2022 were processed using ArcGIS and ERDAS IMEGINE 2015 software. LULC change was analyzed by using different satellite image such as spot-7 of 2006 and 2016, sentinel -2A of 2022.

3.4.2. Image Classification

Object-based classification attempts to identify patterns in an image and use contextual information to group pixels into clusters that represent the same object. By grouping pixels into meaningful objects, spectral variability within a segment is minimized and differences between segments are maximized. An object-based approach also reduces the effects of spatial autocorrelation. In general, high-resolution imagery is classified more accurately when using object-based classifications than pixel-based classifications (Czarnecki, 2012).

Object-based image classification is an effective alternative to a pixel-based approach. A substantial difference between traditional pixel-based image classification and object-based classification is that pixel-based classification does not use any spatial; classification is based on the spectral signature of a single pixel without consideration of other pixels around it (Czarnecki, 2012). However, increases in spatial resolution increases the probability that pixels surrounding the pixel of interest are the same. As a result, the signal a pixel radiates as a representative of a particular class becomes contaminated by the signals of the pixels around it. With an increase in spatial resolution comes a loss in statistical reparability within the spectral data space, thereby reducing the accuracy of pixel-based classifications. Higher spatial resolution increases the spectral variability within the trees or wetland, and therefore can decrease the statistical separation between each pixel. These increases in spectral variability makes separability using pixel-based classification methods more difficult (Czarnecki, 2012).

In this study, object-based image classifications were utilized to determine the LULC change of Ambo town. When classifying an image, different land covers were clarified with colors. The first step of classification was segmentation. To classify the image this study used both of multi-resolution segmentation and spectral difference segmentation. After created the multi-resolution segmentation and spectral difference segmentation using class hierarchy to created the classes for LULC. The classification was done using nearest neighboring algorithm. Nearest neighboring is carried out based on the quality and quantity of samples taken to produce good quality classification. Once an image is divided into segment, a classification can be performed. According to the classification, the images were classified into five major LULC classes such as bare land, shrub and bushes, forest land, farm land and built-up area.

3.4.3. Accuracy Assessment

Once an image is classified into a thematic map, its accuracy should be determined before the map is used. There have been many studies that investigate accuracy assessment and recommend the best approach to estimating error, but the reality is that methods for assessing accuracy and error vary between studies. Several factors can influence the accuracy of image classification. They include the MMU, sampling scheme, positional accuracy, and thematic accuracy. MMU refers to the areal point, pixel(s), or polygon used to define reference data. The sampling scheme refers to the method used to collect reference data. These reference data are used as training parameters in classification as well as in accuracy assessment, also referred to as the evaluation protocol and labeling protocol respectively (Czarnecki, 2012).

Producer's accuracy: is the probability that a selected area on the ground is classified correctly on the map; it resides in the matrix columns. Its measures the percentage of correctly classified pixels from a sample data or indirectly indicates errors of omission for a particular class. Producer's accuracy 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). It is calculated as:

$$\text{Producer's accuracy} = \left(\frac{Ci}{Ct}\right) * 100 \qquad (3)$$

Where, C_i is correctly classified sample locations of the reference data or column and C_t is total number of sample locations of the column.

User's Accuracy: is the probability that a classified sample on the map is the same as what is on the ground; it resides in the matrix rows. 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:

$$\text{User's accuracy} = \left(\frac{Ri}{Rt}\right) * 100 \quad (4)$$

Where, R_i is correctly classified samples in the row and R_t = total number of samples in the row.

Overall accuracy: Samples that are correctly classified reside in the error matrix on the major diagonal and overall accuracy can be determined by dividing the sum of the major diagonal by the total number of samples. It is calculated as:

$$\text{Overall accuracy} = \left(\frac{Sd}{n}\right) * 100 \quad (5)$$

Where, Sd is sum of values along diagonal and, n is total number of samples.

Kappa Coefficient: Kappa statistic (KHAT statistic) which measures the chance agreement vs. actual agreement of classes within an error matrix. KHAT values will range from 0 to 1, with 'zero' being completely chance agreement of classes, and 'one' indicating total statistical agreement of classes. A KHAT value greater than 0.8 represents strong agreement; a value between 0.4-0.8 represents moderate agreement; a value less than 0.4 represents poor agreement (Czarnecki, 2012). It is calculated as:

$$K^{\wedge} = \frac{Po - Pc}{1 - Pc} \quad (6)$$

Where, $K^{\wedge}$ is statistical significance of an error matrix, P_o is the actual agreement between classes and P_c is the chance agreement between classes.

3.4.4. Land Use/ Land Cover Change Detection

In this method three classified images were used to detect if change have occurred or not. Where the value is zero there has been no change, where the value is other than zero a change has occurred. This gives the opportunity to see what kinds of change there has been. In this study a changes has been created, since it was to be compared to the differential images. LULC was compared by using independently produced thematic maps of 2006, 2016 and 2022. The classified LULC maps to show the changes occurred between 2006 – 2016, 2006 – 2022 and 2016 – 2022 of study area. Also it was possible to calculate the amount of increase and decrease of each category of LULC. The values of LULC change were presented in terms of hectare and percentages. The LULC changes in hectares were calculated using the following equation:

$$\text{LULC change} = \text{Area}_{\text{final year}} - \text{Area}_{\text{initial year}} \quad (7)$$

The percentage of LULC changes were calculated using the following equation:

$$\text{Percentage of LULC changes} = \left(\frac{\text{Area of final year} - \text{Area of initial year}}{\text{Area of initial year}}\right) * 100 \quad (8)$$

Where, area is extent of each LULC type. Zero values indicate no change. The positive values indicate an increase of extent of area whereas negative values in shows a decrease of extent.

3.5. Site Selection Process in Multi-Criteria Analysis Method

Site selection process for UGS involves various social, technological, environmental and economic aspects. GIS-MCDA is a process that transforms and combines geographical data and value judgments (the decision-makers preferences) to obtain information for decision making (Malczewski, 2006). Under this circumstance, GIS-based multi-criteria land suitability analysis is becoming critical in determining the land resource that is suitable for UGSs (Cetin, 2015). In this study GIS used for real time database development, digitization and rasterization of vector data, buffering/distance calculation, reclassify, weight overlay and thematic map preparation etc. Therefore, this study using GIS-based multi-criteria suitability analysis with FAHP to support the decision making process on selecting an appropriate site for UGS development.

In this study, to select a suitable site for urban green spaces using GIS-based multi-criteria analysis the following six main steps were carried out:

- Spatial and non-spatial data collection
- Determination of criteria and sub-criteria
- Criteria standardization and factor map generation
- Determination of weighting for each factors
- Weighted overlay analysis and
- Validation /verification of result

3.5.1. Data Collection

Collecting accurate and reliable data is the most determinant factor for any research as it determines the quality of the research. In this particular research, the first steps was to identify the social, physical and economic factors to be considered for UGS followed by setting criterion based on the method followed and collecting relevant data. Second in LULC classification in order to employ the class, selection of training sites was conducted in 2006, 2016 and 2022 by selecting 2460, 2267 and 3424 samples respectively as well as to perform accuracy assessment, reference data/ sample points (create random points) was conducted in 2006, 2016 and 2022 by creating 330, 312 and 334 sample points respectively in this study.

Based on their source data are classified into two kinds:

Primary data: is a type of data which collected by direct measurements from study area.

Secondary data: is data which has been collected by individuals or agencies for purposes other than those of this particular research study. It is a data which collect from different data sources. The all data used in this study was secondary data accept Facility center and Factor data (Table3.2).

Table 3.2: Data Type and Source

No	Data Required	Data Source	Purpose	Resolution	Data Format
1	Sentinel-2A	USGS	For LULC extraction	10m	TIFF
2	Spot_7	GII	For LULC extraction	5m &1.5m	TIFF
3	DEM	Free ASTER	for extraction of Slope	30m	TIFF
4	Ambo structural plan	Ambo Municipality	For boundary delineation	1m	Shape file
5	Road and River	Google Earth pro	For road and river extraction	1m	Shape file
6	Population	Ambo kebele	For classification of Population by kebele	-	Float
7	Soil type	FAO	For soil classification	-	Shape file
8	Facility center & Factor	GPS field survey	For Facility center & Factor classification	-	Point

Source: (Author, 2022)

3.5.2. Determination of Criteria and Sub-Criteria

There were many factors affecting the development of urban green space. The study identified four main factors and nine factors/criteria as being relevant to the site suitability of urban green space development for study area by synthesized different literature review, personal experience, expert opinion, available data and based on previous related studies researched by different researchers (Manlun, 2003; Uy and Nobukazu, 2008; Pantalone, 2010; Kuldeep, 2013; Heshmat et al., 2013; Kumar and Shaikh, 2013 Yousefi et al., 2016; Abebe and Megento, 2017; Li et al., 2018; Pokhrel, 2019; Ustaoglu and Aydınoglu, 2020; Gelan, 2021) were all considered different parameters/factors for selection of suitable site for development of urban green spaces. Those main criteria were: physical, Accessibility, environmental and Socio-economic whereas criteria were: LULC, residential, distance from road, distance from river, distance from facility location (educational center and healthy center), slope, soil type, distance from factory and population density. However, existing green space/park, historical and cultural sites, and land price/value are the other factors affect to site suitability of urban green space; but not included in this study. As a result of non existence of green area, park and historical and cultural sites as well as no data about land price.

3.5.3. Criteria Standardization and Factors Map Generation

After identified appropriate criteria and sub-criteria to select a suitable site for urban green spaces the rating/scores has been assigned for each factor. Assigned rating (score) for each criterion and sub-criteria by review of previous scientific experimental research findings and literature on parameters were carried out. Then, assigned rating through consultations and discussion with experienced experts.

In GIS-based MCDM analysis, it’s essential to standardize the data in order to integrate the data measured in different units and mapped in different scale of measurement such as ordinal, interval, nominal and ratio scales (Gelan, 2021). Even though there are different methods that can be used to standardize criterion maps, linear scale transformation is the most frequently used technique (Malczewski, 2004). According to (FAO, 2006) rating of factors has usually made in terms of five classes: highly suitable, suitable, moderately suitable, less suitable, and not suitable.

For criteria standardization in this study, all the vector maps of the criteria were converted to raster maps data formats. After that using the Spatial Analyst tool in ArcMap the raster maps were reclassified into five classes with the values that range from 1 to 5, where the value of 5 was taken as highly suitable while that of 1 was very less suitable for all factors considered. This approach was enabled all measurements to have an equivalent value before any weights were applied. However, it was important to note that there were some variables that did not fulfill the whole range of the criteria. Once all the criteria maps were standardized, a weight of each criteria map was calculated using FAHP.

3.5.4. Determine Weight of Factors Using Fuzzy Analytical Hierarchy Process

GIS-Based MCDM were solving the spatial problem. One of the functions of GIS-Based MCDM analysis is assigning criteria weights for each factor maps. The purpose of weighing in this process is to express the importance or preference of each factor relative to another factor effect on urban green spaces. In this study, the FAHP using fuzzy pair-wise comparison matrixes were used to calculate weights for the criteria maps.

FAHP is frequently used in the solution of complex decision making problems, as it takes into account both qualitative and quantitative factors. Fuzzy preferences are actually based on fuzzy logic and fuzzy sets. In MCDM, fuzzy or uncertain preferences can be written as fuzzy utilities or weighted sums. These fuzzy utilities and fuzzy weighted sums are fuzzy numbers. In addition, consistency checking is an important factor in the FAHP method. Consistency checking proves that the constructed fuzzy pair wise matrices are acceptable and consistent (Rashad et al., 2020). In this study Triangular fuzzy numbers are adopted in the FAHP methods. TFN can be defined as a triplet (l, m, and u). The parameters l, m, and u., indicate the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event respectively.

In this study, in FAHP method the following four steps carried out to determine weight of factors:

1. Establish Fuzzy Pair wise Comparison Matrices of Criteria

The weights of the nine-level fundamental scales of judgments (9-degree preferences scale) are expressed via Triangular Fuzzy Numbers (TFN) due to its simplicity and effectiveness. In this case, all pair wise comparison judgments are represented as fuzzy triangular numbers. The linguistic scale, fundamental to TFN that is used to measure the relative importance of fuzzy weights is given in Table 3.3 as summarized by (Abimbola et al., 2020)

Table 3.3: Saaty's Scale versus Fuzzy AHP

Linguistic Variables	Saaty's scale (Crisp AHP Scale)	Fuzzy AHP Scale	
		TFS	**Reciprocal TFS**
Equally Important	1	(1, 1, 1)	(1, 1, 1)
Equally to Moderately Important	2	(1, 2, 3)	(1/3, 1/2, 1)
Moderately Important	3	(2, 3, 4)	(1/4, 1/3, 1/2)
Moderately to Strongly Important	4	(3, 4, 5)	(1/5, 1/4, 1/3)
Strongly Important	5	(4, 5, 6)	(1/6, 1/5, 1/4)
Strongly to Very Strongly Important	6	(5, 6, 7)	(1/7, 1/6, 1/5)
Very Strongly Important	7	(6, 7, 8)	(1/8, 1/7, 1/6)
Very Strongly to Extremely Important	8	(7, 8, 9)	(1/9, 1/8, 1/7)
Extremely important	9	(8, 9, 9)	(1/9, 1/9, 1/8)

Source: (Abimbola et al., 2020)

2. Determine Fuzzy Weights of Criteria

In this study, the fuzzy geometric mean was used to calculate the fuzzy weights. The fuzzy weights of each criteria were calculated by three sub-steps:

a. Find the vector product of each fuzzy number ($\tilde{r}_i$)

The formula of fuzzy numbers multiplication was according to Eq. 9.

$$\tilde{r}_i = \bar{A}_1 \otimes \bar{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \otimes l_2, m_1 \otimes m_2, u_1 \otimes u_2) \quad (9)$$

Where $\bar{A}$ is Fuzzy number and l, m, u is lower, middle and upper value of fuzzy number respectively.

b. Calculate Fuzzy geometric mean (r_i)

Fuzzy geometric mean was calculated by taken the n^{th} root of the product fuzzy number.

$$r_i = (\tilde{r}_i)^{1/n} = (\bar{A}_{i1} \otimes \bar{A}_{i2} \otimes \ldots \otimes A_{in})^{1/n} \quad (10)$$

c. Find the (-1) power of the summation of fuzzy geometric mean.

Replace the TFN, and rearrange it in increasing order. The formula of fuzzy numbers summation was according to Eq. 11.

$$\bar{A}_1 \oplus \bar{A}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 \oplus l_2, m_1 \oplus m_2, u_1 \oplus u_2) \quad (11)$$

The inverse formula of one fuzzy numbers was:

$$\bar{A}^{-1} = (l, m, u)^{-1} = \frac{1}{u}, \frac{1}{m}, \frac{1}{l} \quad (12)$$

$$(\sum_{i=1}^{n} ri)^{-1} = (r_{i1} \oplus r_{i2} \oplus \ldots \oplus r_{in})^{-1} \quad (13)$$

Fuzzy Weight ($\bar{w}$) was calculated according to Eq.14.

$$\bar{w} = r_i \otimes (r_{i1} \oplus r_{i2} \oplus \ldots \oplus r_{in})^{-1} \quad (14)$$

3. Defuzzify or De_fuzzification and Normalize the Relative Fuzzy Weights of Criteria

Since fuzzy weight is still TFNs, defuzzify fuzzy weight using the center area method. The formula of center of area was:

$$\text{Center of area (COA)} = \frac{l + m + u}{3} \quad (15)$$

Weights of Criteria are calculated using this COA formula:

$$W_i = \frac{l\bar{\omega}i + m\bar{\omega}i + u\bar{\omega}i}{3} \quad (16)$$

Where W_i is the relative non-fuzzy weight of each criterion

To normalize W_i, matrix W_i is transformed into matrix F = [f] the elements of matrix F are calculated according to Eq. 17.

$$f_i = \frac{Wi}{\sum_{i=0}^{n} Wi} \quad (17)$$

Where f_i is the normalized non-fuzzy weights

4. Computing the consistency ratio

Since the numeric values was derived from alternative (interval) preference, to calculate consistency ratio first convert the fuzzy pair wise comparison matrix into crisp pair wise comparison matrix of subjective preference of individuals by defuzzified matrix (taking ratio). Consistency Ratio is a comparison between Consistency Index and Random Index.

$$CR = \frac{C.I}{R.I} \quad (10)$$

Where C.I is the consistency Index and R.I is the Random Consistency Index.

Judgments that have a consistency ratio lower than 0.1 are acceptable and higher than 0.1 are not acceptable (i.e. are not consistent) (Abimbola et al., 2020) and RI is the random index and depends on the number of parameters being compared and detailed in Table 3.4 below:

Table 3.4: Random Index

Order Matrix	1	2	3	4	5	6	7	8	9	10
RI	0.0	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Abimbola et al., 2020)

Consistency Index is calculated using equation 18.

$$C.I = \frac{ƛ\max - n}{n-1} \quad (18)$$

Where n is the number of rows in the decision matrix and $ƛ_{max}$ is the largest eigenvalue of the comparison matrix.

In this study, $ƛ_{max}$ was calculated from weight sum value or weight vector and ƛ.

$$\text{Weight sum value} = Aw_i \quad (19)$$

$$ƛ = \frac{Awi}{wi} \quad (20)$$

$$ƛ_{max} = \frac{\sum_{i=0}^{n} ƛ}{n} = \frac{Awi}{nwi} \quad (21)$$

3.5.5. Weight Overlay Analysis

In this step to aggregate the criteria using weighted linear combination and applied it in the ArcGIS raster calculator.

3.5.6. Validation/Verification of Result

In this study verification was the last work. Validating or verifying the final result was help to evaluate the obtained result reliable or not. This performed by ground truth verification. Ground truth verification was done by conducted field surveys (Abebe and Megento, 2017).

The overall process performed to select the suitability site for urban green space development in Ambo Town as illustrated below Figure 3.6.

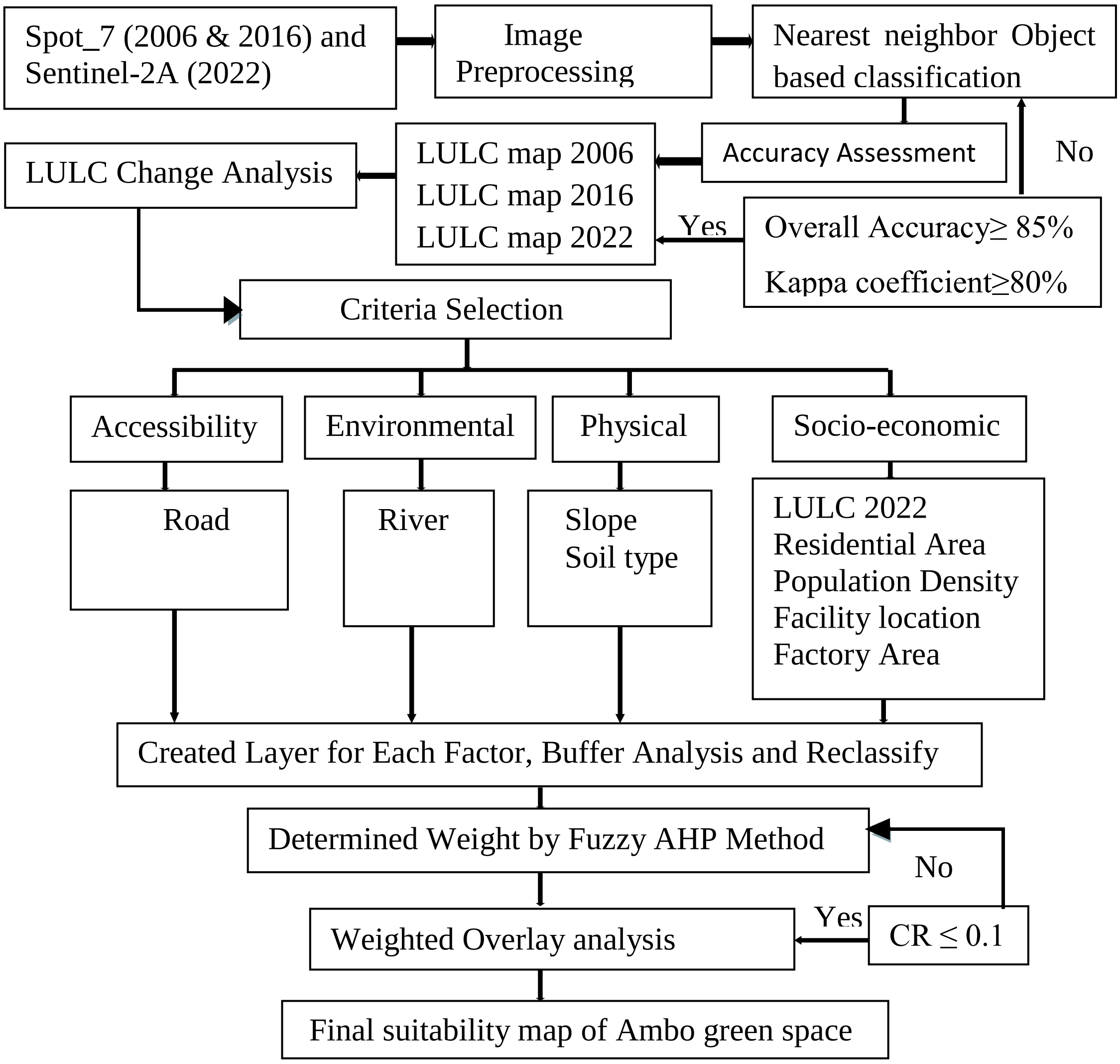


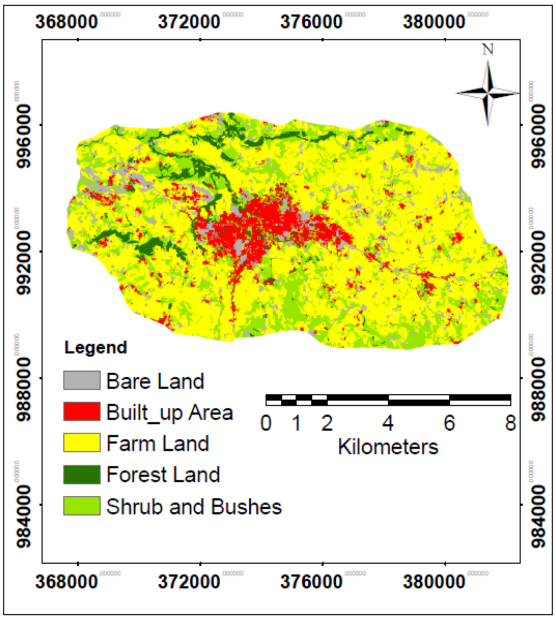
Figure 3.6: General work flow of the study Source: (Author, 2022)

CHAPTER FOUR: RESULTS AND DISCUTIONS

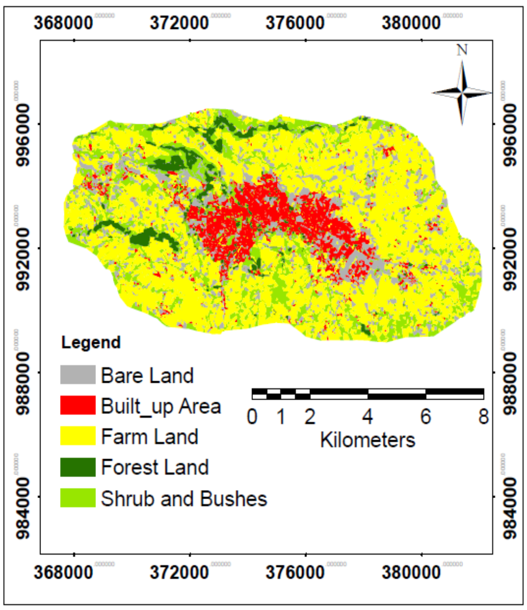
This chapter discusses based on synthesized the literature reviews, expert opinions, and available data to achieve the objectives of this study. In this study, different data sets were used to produce LULC classification map, LULC change trend analysis, site suitability analysis and a wide variety of criteria (factors and constraints) have been selected for UGS development. The result of FAHP shows that the derived factors have a different degree of influence on UGS development. Based on the result of this study, FAHP is highly efficient instrument for determining factor weights and is more beneficial than alternative approaches and AHP method since the inconsistency of the factor weights ‘pair-wise comparison matrix can be calculated from average of fuzzy numbers (defuzzified matrix) and controlled by the consistency Ratio(CR). Therefore, suitable urban green space development sites were determined for Ambo Town by using GIS tool and weighting sum of FAHP method.

4.1. Land Use/ Land Cover Classification

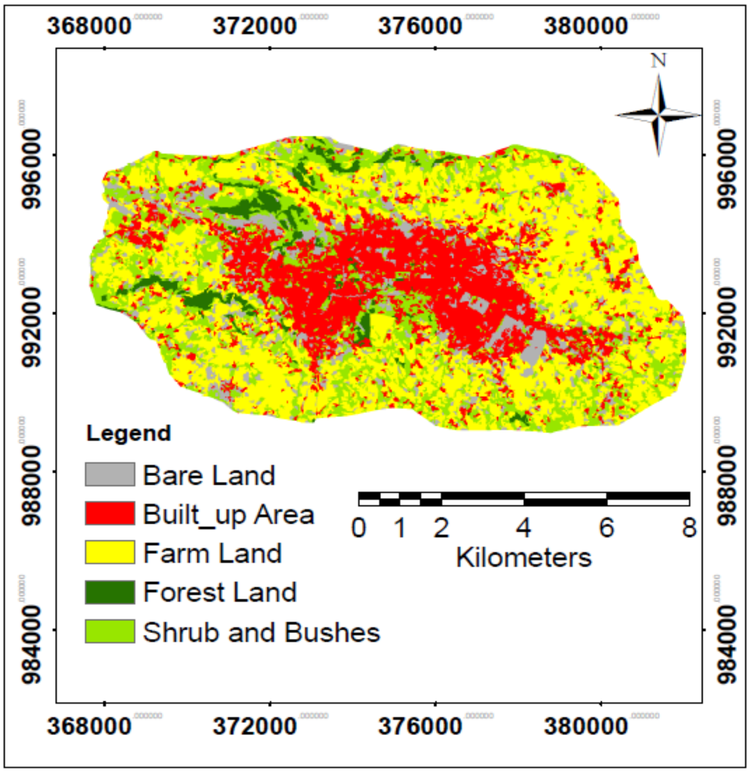
To fulfill the overall objectives of the study, in this study, three LULC classification maps were produced (Figure 4.1 a, b and c) for LULC dynamics analysis of study area were classified spot_7 image of 2006 and 2016, and sentinel 2A image of 2022. Those images were classified into five major LULC classes. There are: bare land, shrub and bushes land, forest land, farm land and built-up area. Based on the LULC classification result showed, the major part of area was cover by farm land over three years (Figure 4.1).



a.



b.



c.

Figure 4.1: LULC classification map of (a) 2006, (b) 2016 and (c) 2022 Source:(Author, 2022)

4.2. Accuracy Assessment of the Classification

Sample points are selected by referring to the pan-sharpening Sentinel_2A image and spot_7 images in ArcGIS to validate the accuracy of object-based classification methods, and then, converted this sample points to a raster format, which is considered as the ground truth samples. The accuracy assessment results include two parts, namely the confusion matrix and error matrix. The confusion matrix is the accuracy assessment matrix generated by using ground truth samples, which is a two-dimensional matrix formed by the actual categories and the classification categories. The error matrix is the accuracy assessment matrix generated based on samples.

Therefore, in this study accuracy assessment of the three years analyzed based on confusion matrix. The overall accuracy value were 98.5%, 98.7% and 98.5% recorded whereas the kappa coefficient value were 97.8%, 98.3% and 98.1% calculated for 2006, 2016 and 2022 respectively.

The Kappa statistics value between 0.81 and 1.00 represents almost perfect, a value between 0.61 and 0.80 represents a substantial agreement and a value between 0.41 and 0.60 represents moderate (Landis and Koch, 2020). So, all of the classification were in acceptable range over the three study period. The accuracy assessment results of confusion matrix of 2006, 2016 and 2022 are shown in Table 4.1, 4.2 and 4.3 respectively.

Table 4.1: Confusion matrix of LULC classification for 2006

	Reference Map							
Classified Map	Classified Data	Built-up Area	Shrub and Bushes	Bare Land	Farm Land	Forest Land	sum	User Accuracy (%)
	Built-up Area	60	0	1	1	0	62	96.8
	Shrub and Bushes	0	82	0	3	0	85	96.5
	Bare Land	0	0	19	0	0	19	100
	Farm Land	0	0	0	142	0	142	100
	Forest Land	0	0	0	0	22	22	100
	sum	60	82	20	146	22	330	
	Producer Accuracy (%)	100	100	95	97.3	100		
	Overall Accuracy	98.5						
	Kappa Statistic	97.8						

Table 4.2: Confusion matrix of LULC classification for 2016

	Reference Map							
Classified Map	Classified Data	Shrub & Bushes	Built-up Area	Farm Land	Bare Land	Forest Land	sum	User Accuracy
	Shrub and Bushes	68	0	1	0	0	69	98.6
	Built-up Area	0	73	0	1	0	74	98.7
	Farm Land	0	0	94	0	0	94	100
	Bare Land	0	0	1	48	0	49	98.0
	Forest Land	1	0	0	0	25	26	96.2
	sum	69	73	96	49	25	312	
	Producer Accuracy	98.6	100	97.9	98.0	100		
	overall Accuracy	98.7						
	Kappa Statistic	98.3						

Source:(Author, 2022)

Table 4.3: Confusion matrix of LULC classification for 2022

	Reference Map							
	Classified Data	Farm Land	Built-up Area	Shrub and Bushes	Bare Land	Forest Land	sum	User Accurac y (%)
Classified Map	Farm Land	82	1	1	0	0	84	97.6
	Built-up Area	0	98	0	0	0	98	100
	Shrub and Bushes	1	1	75	0	0	77	97.4
	Bare Land	1	0	0	44	0	45	97.8
	Forest Land	0	0	0	0	30	30	100
	sum	84	100	76	44	30	334	
	Producer Accuracy (%)	97.6	98	98.7	100	100		
	Overall Accuracy	98.5						
	Kappa Statistic	98.1						

Source:(Author, 2022)

4.3. Land Use/ Land Cover Dynamics Analysis

In this study, based on three LULC classification maps were produced (Figure 4.1 a, b and c) and statistical spatiotemporal of LULC classification to compute the LULC dynamics (Table 4.4). As the results of LULC classification, over the three reference years, the dominant area was covered by farm land and the lower area was covered by forest land. LULC in study area such as built-up area and bare land were continuously increased, whereas farm land and forest land were continuously decreased and the shrub and bushes land were shows a varying pattern over the three reference year (Table 4.4).

In 2006 the major part study area was covered by farm land 56.4% of the total area. Shrub and bushes, built-up area, bare land and forest land were covered 23.1%, 8.8%, 7.3% and 4.4% the area respectively. In 2016, farm land, shrub and bushes, and built-up area were covered 50.2%, 24.2% and 12.4% of the total area respectively. The remaining parts of the area were covered with bare land and forest land 9.2% and 4.0% of the area respectively. In 2022, built-up area was increased by double to 24.1% and the remaining (75.9%) was the share of other LULC classes (Table 4.4 and Figure 4.1 a, b and c).

Table 4.4: LULC classification coverage for 2006, 2016 and 2022

LULC Types	**2006**		**2016**		**2022**	
	Area(ha)	Area (%)	Area(ha)	Area (%)	Area(ha)	Area (%)
Farm Land	4825.0	56.4	4294.4	50.2	3363.3	39.3
Shrub and Bushes	1978.9	23.1	2070.7	24.2	1870.8	21.9
Built-up Area	754.7	8.8	1063.6	12.4	2059.1	24.1
Bare Land	624.3	7.3	786.1	9.2	954.1	11.1
Forest Land	374.2	4.4	342.4	4.0	309.9	3.6
Total	8557.2	100	8557.2	100	8557.2	100

Source:(Author, 2022)

The farm land and forest land from LULC classes were decreased throughout the study period whereas built-up area and bare land were increment during the study period in the study area. Also, Shrub and bushes land was showed decreasing during trend of 2006 to 2022 and 2016 to 2022 in the study area. Generally, the change trend occurred in these three study periods as illustrated as below (Table 4.5 and Figure 4.2).

Table 4.5: LULC change trend during 2006 - 2022

LULC Types	**2006 -2016**		**2016 - 2022**		**2006 - 2022**	
	Change(Δ/ha)	(%)	Change(Δ/ha)	(%)	Change(Δ/ha)	(%)
Farm Land	-530.6	-11.0	-931.1	-21.7	-1461.7	-30.3
Built-up Area	308.9	40.9	995.5	93.6	1304.4	172.8
Bare Land	161.8	25.9	168.0	21.4	329.8	52.8
Shrub & Bushes	91.8	4.6	-199.9	-9.7	-108.1	-5.5
Forest Land	-31.8	-8.5	-32.5	-9.5	-64.3	-17.2

Source:(Author, 2022)

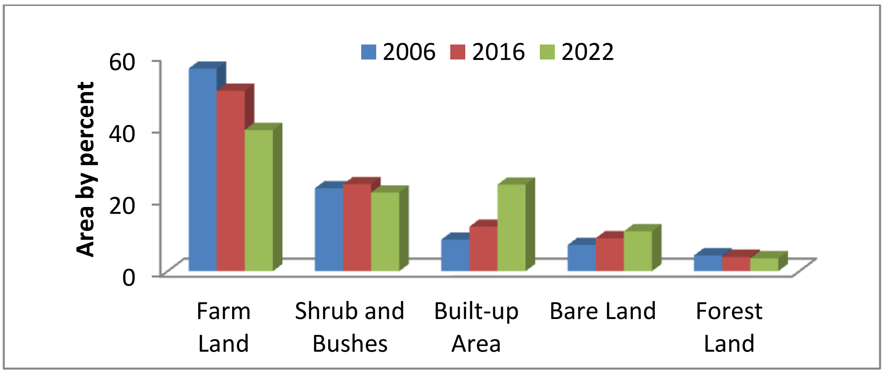


Figure 4.2: LULC Change trends from 2006-2022 Source:(Author, 2022)

Abebe and Megento (2017) reported that, a rapid and unplanned expansion and commercial development, along with population pressure, has negative impact on the green space. As the result of LULC change analysis showed the built-up area were continuously increased throughout the study period, while shrub and bushes land and forest land become decreased in the study area. This reduction of shrub and bushes (greeneries) and forest has indicated that the Town administration has a problem of proper planning and implementation to keep the Town green with the exception of intervening in some areas such as the establishment of a few parks and roadside plantation in the Town. Hence, based on the problem stated in section 1.2 and the results of LULC change trend analysis the site suitability analysis for urban green space development within the town are necessary in order to keep the quality and quantity of urban green space that bring positive impact on human health, recreational site, people relax more, reducing CO_2 and weather condition. As well as give value to urban dwellers and their environment in a sustainable way.

4.4. The Dominant Factors for Urban Green Space Development in the Study Area

The factors are important for urban green space development. In this study, the factors used for site selection process for urban green space development were selected based on different literature reviews and the prior knowledge of that particular area. Based on the existing situation and availability of data obtained; there was carried out nine factors to selected the suitable site for UGS development for study area. There are: LULC, distance from residential area, distance from road, distance from rivers, distance from facility locations, slope, soil type, distance from factory and population density.

4.5. Suitability Analysis for Urban Green Space Development

4.5.1. Suitability of Land Use/ Land Cover

The LULC of the study area was analyzed from Sentinel 2A with spatial resolution 10m through object based image classification technique by Ecognition software application. LULC was classified from false-color composite raster band combinations in Red-Green-Blue color order using multi-resolution segmentation and spectral difference segmentation algorithm. The class hierarchy was used to create signatures for each class. Nearest neighbor algorithm was used to classify LULC using layer value, the mean, standard deviation, brightness and maximum differences from the signature.

Different literatures analyzed the LULC by identify the suitable land based on their use type for green space development (Abebe and Megento, 2017; Pokhrel, 2019; Senia, 2021;Yirgalem, 2021). The suitability level of LULC were ranked from high value to lower value as highly suitable, suitable, moderately suitable, less suitable and unsuitable. Based on knowledge obtained from literature reviews were selected bare land and shrub and bushes land as highly suitable and suitable for urban green space development respectively. Also, in this study forest land, farm land and built-up area were considered as moderately suitable, less suitable and very less suitable for green space development respectively (Table 4.6 and Figure 4.3).

Table 4.6: Reclassified LULC and area of suitability level

LULC type	Value	Level of suitability	Area	
			Ha.	%
Bare Land	5	Highly suitable	954.1	11.1
Shrub and Bushes	4	Suitable	1870.8	21.9
Forest Land	3	Moderately suitable	309.9	3.6
Farm Land	2	Less suitable	3363.3	39.3
Built-up Area	1	Very less suitable	2059.1	24.1

Source:(Author, 2022)

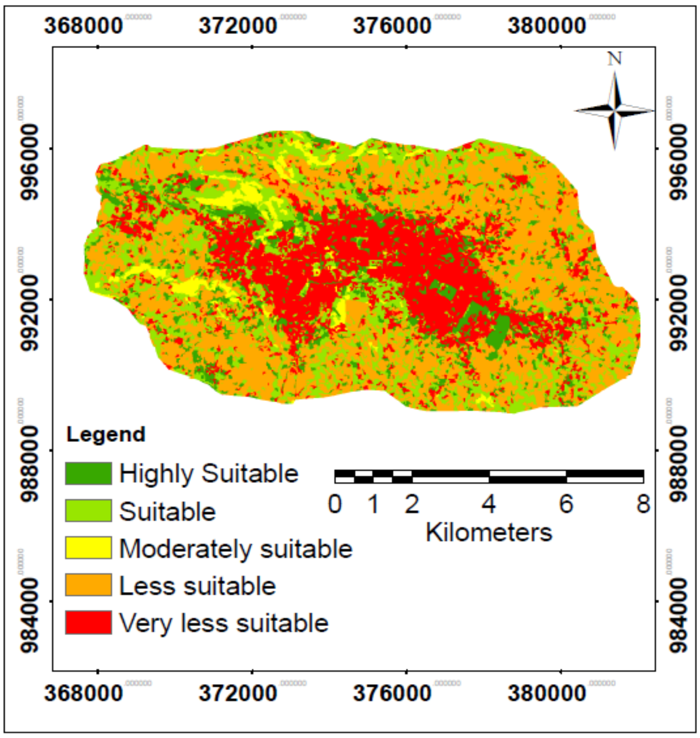


Figure 4.3: Reclassified LULC Map of 2022 Source:(Author, 2022)

4.5.2. Suitability of Distance from Residential Area

In any site suitability analysis, the proximity is always significant. As different literature analyzed residential land use account for the most important urban land use on which living facilities are required to be based, and parks should be established close to them for relaxation and recreation (Yousefi et al., 2016). Distance between settlement areas and green spaces had an adverse impact on users and reported that green spaces such as parks, playground and sport field closest to settlement areas are most popular. Thus, the proximity of green spaces to the settlement area in terms of distance is important to consider benefits (Ustaoglu and Aydınoglu, 2020; Gelan, 2021; Yirgalem, 2021). Based on this, by making buffer analysis, the areas that have been identified within 500m, 500m to 1000m, 1000m to 1500m, 1500m to 2000m and greater than 2000m from residence area was considered as highly suitable, suitable, moderately suitable, less suitable and very less suitable respectively for green space development (Table 4.7 and Figure 4.4).

Table 4.7: Reclassified distance from residential area and area of suitability level

Distance from residential area (m)	Value	Level of suitability	Area	
			Ha.	%
<500	5	Highly suitable	4278.1	50.0
500-1000	4	Suitable	1741.8	20.4
1000-1500	3	Moderately suitable	1526.5	17.8
1500-2000	2	Less suitable	679.2	7.9
>2000	1	Very less suitable	331.6	3.9

Source:(Author, 2022)

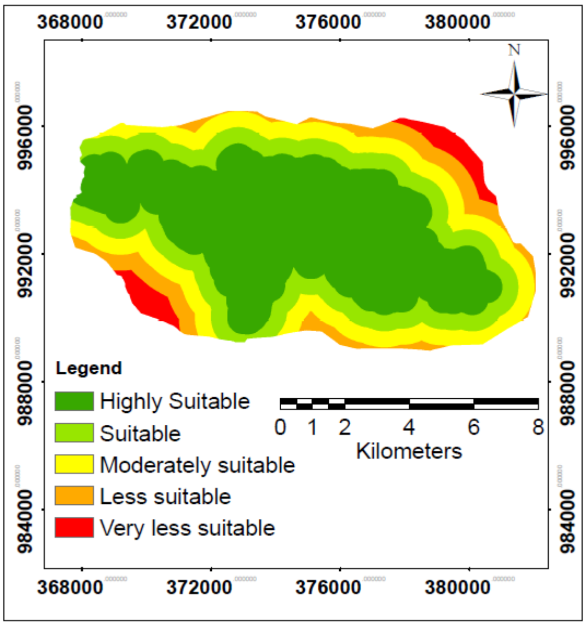


Figure 4.4: Reclassified distance from residential area map Source:(Author, 2022)

4.5.3. Suitability of Distance from Road

English Nature believes that local authorities should consider the provision of natural areas as part of a balanced policy to ensure that local communities have access to an appropriate mix of green spaces providing for a range of recreational needs. English Nature recommends that provision should be made of at least 2ha of accessible natural green space per 1000 population (Hailemariam, 2021). Green space accessibility can be defined as the ability to reach and access green spaces. Access to good quality green space plays a key role in achieving sustainability and livability.

So, it could be determined by the distribution of green spaces and easiness of their access (Kmail A. B. and Onyango, 2020). Based on these claims the lands which are closer to the road network are more suitable than farther land. accordingly, by making buffer analysis, the areas within 500m, 500m to 1000m, 1000m to 1500m, 1500m to 2000m and greater than 2000m radius from the road network have been considered as highly suitable, suitable, moderately suitable, less suitable and very less suitable respectively for green space development (Table 4.8 and Figure 4.5).

Table 4.8: Reclassified distance from road and area of suitability level

Distance from Road (m)	**Value**	**Level of suitability**	**Area**	
			Ha.	%
< 500	5	Highly suitable	2879.0	33.6
500-1000	4	Suitable	1815.7	21.2
1000-1500	3	Moderately suitable	1615.5	18.9
1500-2000	2	Less suitable	1245.5	14.6
>2000	1	Very less suitable	1001.5	11.7

Source:(Author, 2022)

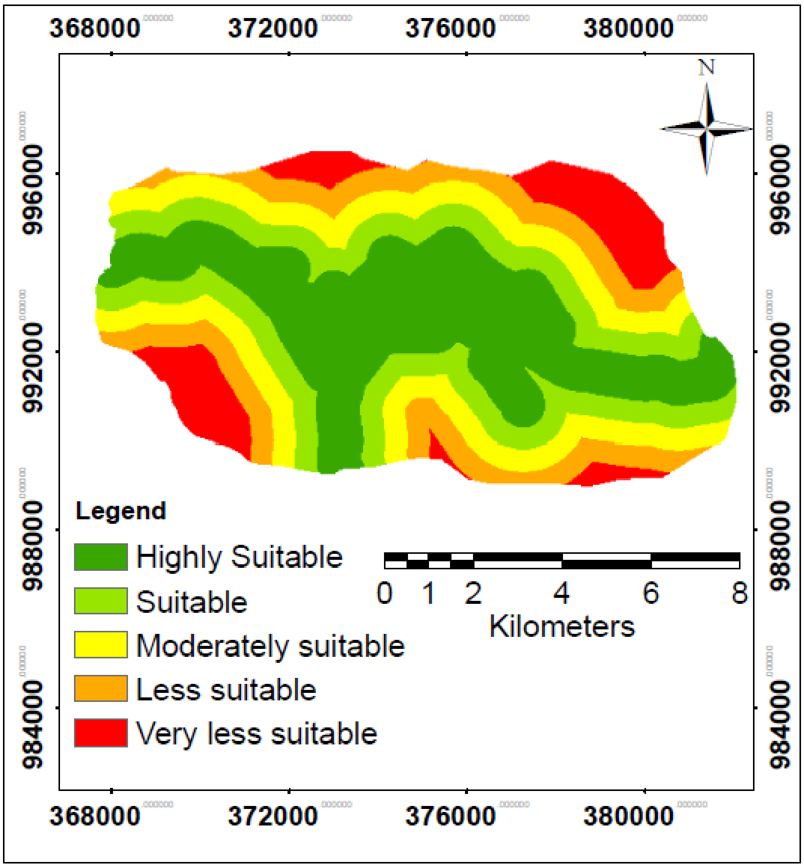


Figure 4.5: Reclassified distance from road map Source:(Author, 2022)

4.5.4. Suitability of Distance from the River

Water plays a significant role in the growth and development of a living organism. As (Pokhrel, 2019) state that land closer to river stream banks get more preferences and help to maintain the environmental health of the green open area. (Manlun, 2003; Kuldeep, 2013; Abebe and Megento, 2017; Gelan, 2021; Hailemariam, 2021) have noted that for the development of green space, lands closest to rivers, lakes and reservoirs are highly suitable. As a result, the distance less than 250m from the river was considered as highly suitable and between 250m and 500m was considered as suitable for urban green space development in this study. Additionally, the distance 500m to 1000m, 1000m to 1500m from it was considered as moderately suitable and less suitable for green space development respectively. Whereas distance greater than 1500m from it was relatively considered as very less suitable for green space development (Table 4.9 and Figure 4.6).

Table 4.9: Reclassified distance from river and area of suitability level

Distance from River (m)	Value	Level of suitability	Area	
			Ha.	%
< 250	5	Highly suitable	2022.3	23.6
250-500	4	Suitable	1599.8	18.7
500-1000	3	Moderately suitable	2107.1	24.6
1000-1500	2	Less suitable	1069.8	12.5
>1500	1	Very less suitable	1758.2	20.6

Source:(Author, 2022)

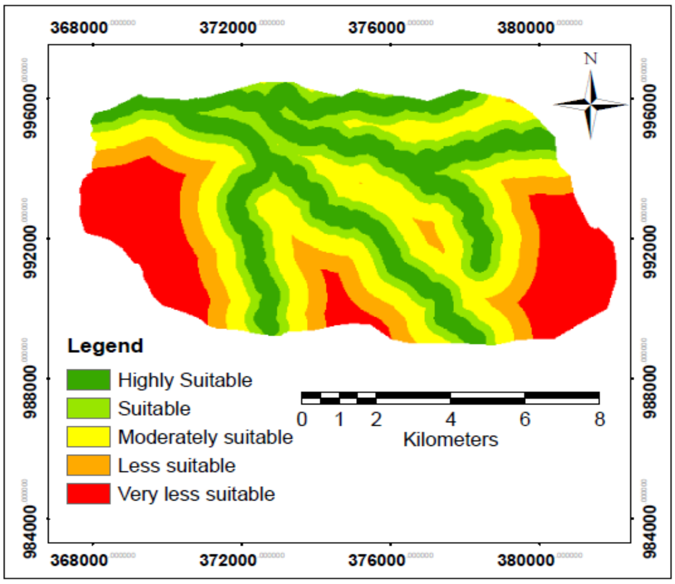


Figure 4.6: Reclassified distance from river map   Source:(Author, 2022)

4.5.5. Suitability of Distance from Facility Locations

The facilities location covers the schools, college, hospitals, and major health facilities, police stations; fire brigade locations that are crucial and important to get all services and meantime need some open spaces nearby such locations. While developing green space closer to these locations could maintain the ecological benefits and provide environmental services to all service takers as well as provides shelters at any emergency(Pokhrel, 2019). The main objective is to ensure their proximity and high compatibility with each other, while creating a healthy environment for students and employees and for visitor revitalization at these centers(Yousefi et al., 2016). Therefore, taking this statement into account and expert opinion the areas within the buffer of 250m, 250m to 500m, 500m to 1000m, 1000m to 1500m and greater than 1500m from educational center and health center was considered as highly suitable, suitable, moderately suitable, less suitable and very less suitable for green space development respectively (Table 4.10 and Figure 4.7).

Table 4.10: Reclassified distance from facility locations and area of suitability level

Distance from facilities location (m)	Value	Level of suitability	Area	
			Ha.	%
< 250	5	Highly suitable	794.1	9.3
250-500	4	Suitable	745.6	8.7
500-1000	3	Moderately suitable	1351.4	15.8
1000-1500	2	Less suitable	1486.9	17.4
>1500	1	Very less suitable	4179.2	48.8

Source:(Author, 2022)

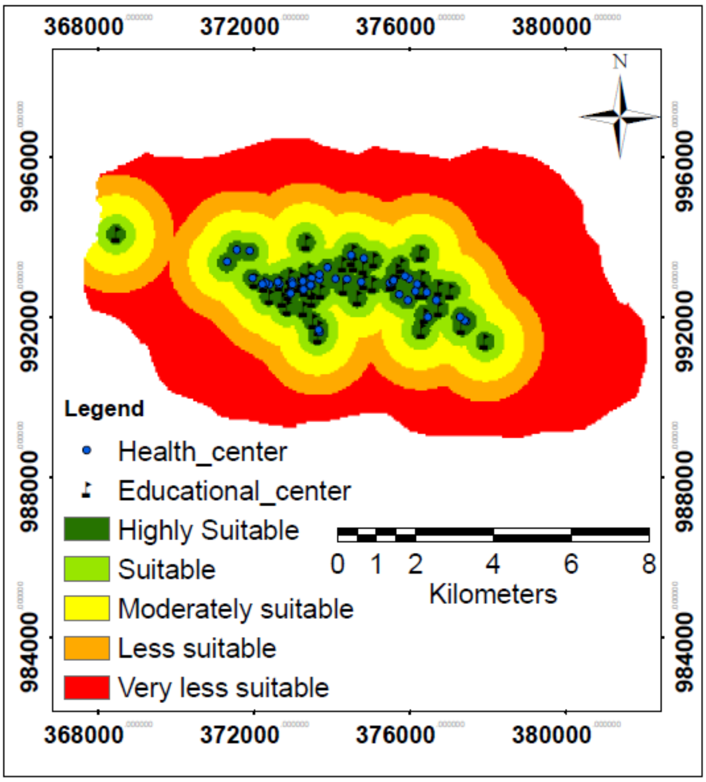


Figure 4.7: Reclassified distance from facility locations map Source:(Author, 2022)

4.5.6. Suitability of Slope

Various researchers consider the areas covered by low slope was highly suitable for the development of urban green spaces (Heshmat et al., 2013; Hailemariam, 2021) and the aim of building a green space is to create a common space for use by all sectors of society such as children, the elderly and the disabled; so taking the necessary measures in this respect is essential (Abebe and Megento, 2017; Pokhrel, 2019; Gelan, 2021).

According to (FAO, 2006) the slope value 0-0.2 % is considered as flat and up to 5 gently slope. 5-10 % and 10-15 % is called sloping and strongly sloping respectively. As (Youssef et al., 2011) the standardized potential scores of slope greater than 20% , 15-20%, 10-15%, 5-10% and less than 5% was categorized as very low, low, moderate, good and very good respectively. Therefore, this study considered the flat and gently slope more highly suitable than the land with steep slope. The areas covered by slope 0-5%, 5-10%, 10-15%, and 15-20% was considered as highly suitable, suitable, moderately suitable and less suitable for site urban green space development. Areas within the slope greater than 20% were considered as very less suitable for green space development in these studies (Table 4.11 and Figure 4.8).

Table 4.11: Reclassified slope and area of suitability level

Slope (%)	Value	Level of suitability	Area	
			Ha.	%
< 5	5	Highly suitable	2726.5	31.9
5-10	4	Suitable	2977.9	34.8
10 -15	3	Moderately suitable	1871.0	21.9
15-20	2	Less suitable	746.0	8.7
>20	1	Very less suitable	235.8	2.8

Source:(Author, 2022)

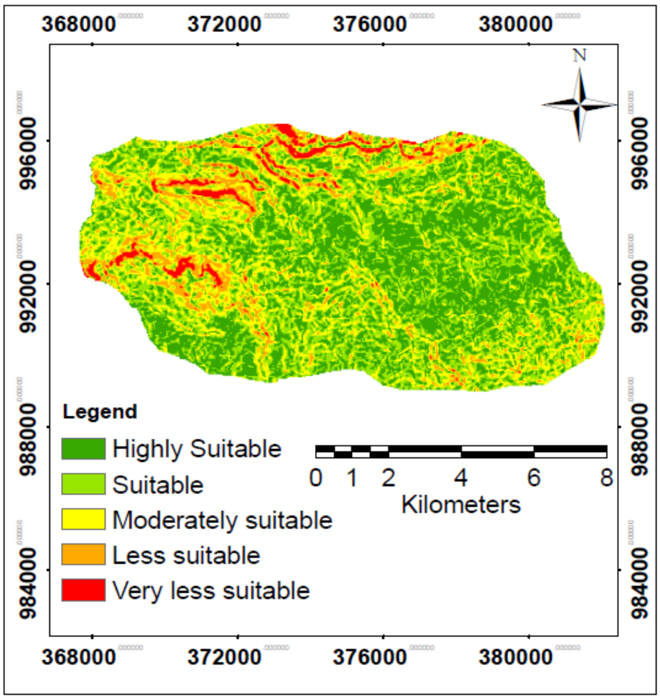


Figure 4.8: Reclassified slope map Source:(Author, 2022)

4.5.7. Suitability of Soil Types

The soils of the study area are classified into two categories based on data obtained from FAO data base namely, Pellic Vertisols and Eutric Nitosols. Vertisols are characterized by a clay-size-particle content of 30 percent or more by mass in all horizons (layers) of the upper half-metre of the soil profile, by cracks at least 1cm (0.4 inch) wide extending downward from the land surface, and by evidence of strong vertical mixing of soil particles over many periods of wetting and drying. They contain high levels of plant nutrients, but, owing to their high clay content, they are not well suited to cultivation without painstaking management. They are dark-coloured soils (though they have only moderately humus content) that may also be characterized by salinity and well-defined layers of calcium carbonate or gypsum (Encyclopedia , 2016).

Nitisols are technically defined by a significant accumulation of clay (30 percent or more by mass and extending as much as 150cm [5 feet] below the surface) and by a blocky aggregate structure. They are perhaps the most inherently fertile of the tropical soils because of their high nutrient content and deep, permeable structure. Nitisols are also strongly influenced by biological activity, resulting in a homogenization of the upper portion of the soil profile (Encyclopedia, 2016). Based on this argument, the Pellic Vertisols soil was considered more highly suitable than Eutric Nitosols soil for green space development Whereas, Eutric Nitosols soil was considered as suitable for green space development (Table 4.12 and Figure 4.9).

Table 4.12: Soil type and area of suitability level

Soil type	**Value**	**Level of suitability**	**Area**	
			Ha.	%
Pellic Vertisols	5	Highly suitable	4186.3	48.9
Eutric Nitosols	4	Suitable	4370.9	51.1

Source:(Author, 2022)

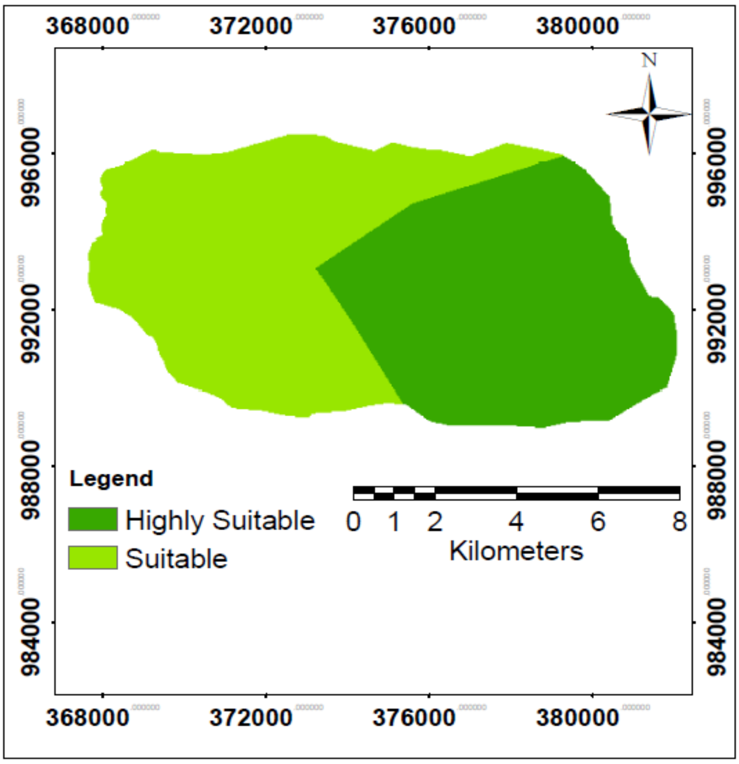


Figure 4.9: Reclassified soil type map Source:(Author, 2022)

4.5.8. Suitability of Distance from Factory

Noisy areas are not suitable for green space like the factory area because of high sound pollution and smokes. Therefore, the farther lands from the factory get more preferences for developing green space(Manlun, 2003; Jabir and Arun, 2014**;** Abebe and Megento, 2017). On the basis of this claim, in this study the areas buffer greater than 1000m was considered as highly suitable, suitable from 750m to 1000m, moderately suitable from 500m to 750m, less suitable from 250m to 500m and very less suitable if less than 250m for green space development (Table 4.13 and Figure 4.10).

Table 4.13: Reclassified distance from factory and area of suitability level

Distance from factory (m)	**Value**	**Level of suitability**	**Area**	
			Ha.	%
>1000	5	Highly suitable	7243.9	84.7
750-1000	4	Suitable	536.2	6.3
500-750	3	Moderately suitable	415.3	4.8
250-500	2	Less suitable	258.6	3.0
< 250	1	Very less suitable	103.2	1.2

Source:(Author, 2022)

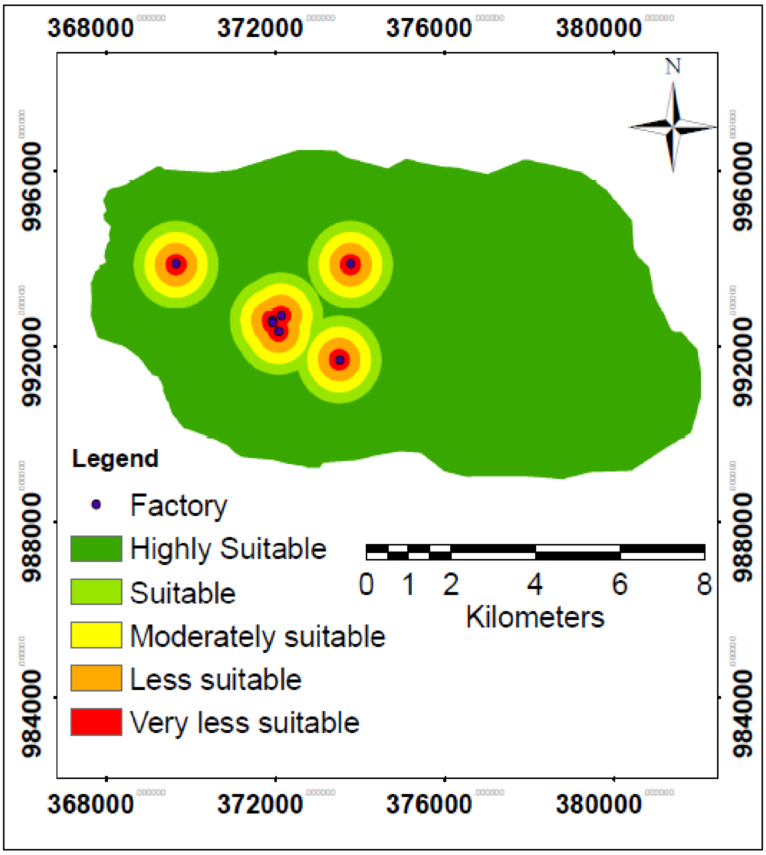


Figure 4.10: Reclassified distance from factory map Source:(Author, 2022)

4.5.9. Population Density

For the evaluation of green space, population density is one of the important criteria. When there is more population density in a particular residential region it is recommended to develop more green space close to those areas (Pokhrel, 2019). Urban green space suitability assessment is directly or indirectly correlated with different socio-economic factors. Population density is known to be one of the socio-economic factors influencing the appropriate selection of green space in urban areas. Places with a higher number of people with crowded places near the high population density required access to the open green spaces (Gelan, 2021). Access to this sort of land use by a greater number of citizens and focus on the crowded places can be considered as a measure (Yousefi et al., 2016). Some researchers (Pantalone, 2010; Heshmat et al., 2013; Abebe and Megento, 2017) also recommend that populated areas are highly suitable for developing green space.

Based on projected population data in 2021 (Table 4.14), the study area is highly populated in the central parts of the Town that was considered as highly suitable area and the southern part of the Town is medium populated which is considered as moderately suitable area for green space development. The eastern and northern part of the Town is low populated that was considered as less suitable area for green space development. The western part of the town is very low populated that was believed to be insufficient to suited UGS development (Table 4.15 and Figure 4.11).

Table 4.14: Projected kebele population in 2021 with sex and population density

Kebele	**Male**	**Female**	**Total Population**	**Area (ha)**	**Population Density**
Awaro Qora	8250	7796	16046	2272.1	7
Hora Ayetu	19724	21817	41541	1451.9	29
Kisose Oddo Liban	8100	6900	15000	2436.8	6
Sanqale Farisi	5062	4713	9775	1948.5	5
Torban Kutaye	9000	9300	18300	91.1	201
Yaa'i Gadaa	20480	22070	42550	356.8	119
Total	70616	72596	143212	8557.2	

Source:(Author, 2022)

Table 4.15: Reclassified population density and area of suitability level

Population density (pop/ha)	**Value**	**Level of suitability**	**Area**	
			Ha.	%
>100	5	Highly suitable	447.9	5.2
20-100	3	Moderately suitable	1451.9	17.0
6-20	2	Less suitable	4708.9	55.0
< 6	1	Very less suitable	1948.5	22.8

Source:(Author, 2022)

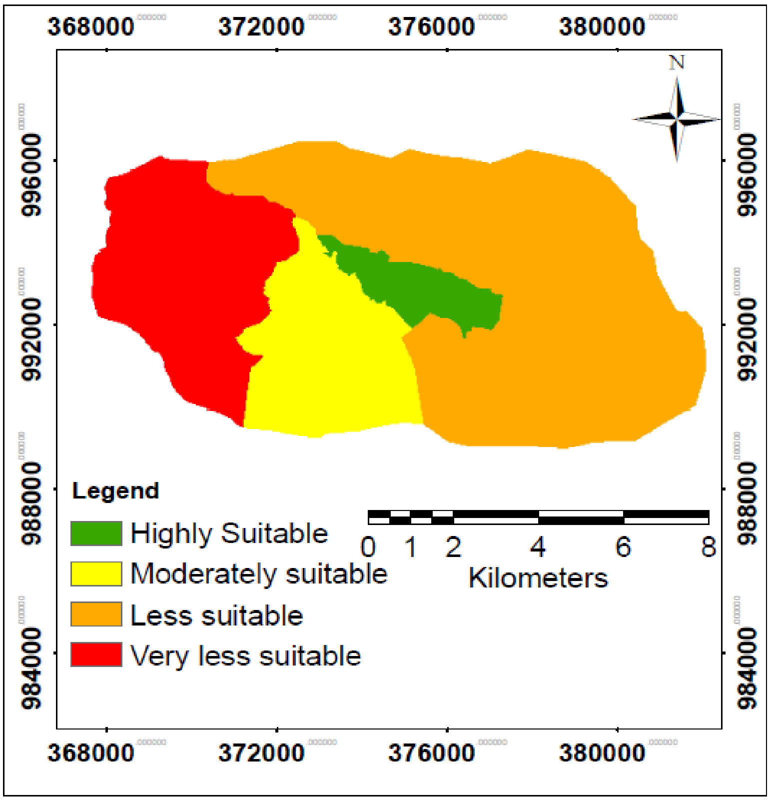


Figure 4.11: Reclassified population density map Source:(Author, 2022)

4.6. Fuzzy Analytical Hierarchy process for Weight Derivation

4.6.1. Establish Fuzzy Pair-Wise Comparison Matrices of Criteria

The triangular fuzzy number AHP method adopted in this study can effectively improve the calculation of fuzzy vectors or criteria weight in the interval by established a fuzzy pair-wise comparison matrix. Weights of criteria were calculated for each factor by using the average of value of TFNs within scale of value 1 to 9. The accuracy of the proposed FAHP performance was assessed by consistency ratio. According to importance or preferences, the averaged pair wise comparison of the criteria was represented by following Table 4.16.

Table 4.16: Fuzzy Pair-Wise Comparison Matrix of Criteria

Criteria	LULC			RES			RO			RI			FL			SL			ST			FA			PD			Weight
LULC	1	1	1	1	2	3	1	2	3	2	3	4	3	4	5	5	6	7	7	8	9	7	8	9	9	9	9	25
RES				1	1	1	1	2	3	2	3	4	2	3	4	4	5	6	6	7	8	7	8	9	9	9	9	22
RO							1	1	1	1	2	3	2	3	4	3	4	5	4	5	6	5	6	7	7	8	9	17
RI										1	1	1	1	2	3	2	3	4	3	4	5	3	4	5	5	6	7	12
FL													1	1	1	1	2	3	2	3	4	2	3	4	3	4	5	8
SL																1	1	1	1	2	3	1	2	3	2	3	4	6
ST																			1	1	1	1	2	3	1	2	3	4
FA																						1	1	1	1	2	3	3
PD																									1	1	1	3

Source:(Author, 2022)

Note: LULC = Land use/Land covers   RES = Residential   RO = Road   RI = River
FL = Facility Location SL = Slope ST = Soil Type F = Factory   PD = Population Density

In order to determine the criteria weight for site suitability UGS, the nine factors were tested on the proposed FAHP method using dataset in Table 4.16 and the results of weight was displayed in Table 4.16. According to the result generated by proposed FAHP in Table 4.16, the disputed factors have different degree of influence on urban green space. As a result, shows that LULC was the highest priority by obtained weight value of 25. As well as, residential area, road, river, facility location, slope, soil type, factory and population density was obtained the weight value of 22, 17, 12, 8, 6, 4, 3 and 3 respectively. Besides, the consistency ratio of the proposed FAHP methods has obtained 0.04, which is smaller than 0.1, this indicates that the proposed FAHP method acceptable. So, the weight assigned to each factors emphasis the importance of each factor has in site suitability of UGS.

4.7. Weight Overlay Analysis

After all parameters were prepared in reclassified raster format and criteria weights were calculated for each factor the overlay analysis was performed using weight overlay tool in ArcGIS spatial analysis extension by considering weight of criteria. The reclassified input datasets were assigned a weight value to express the importance of each criteria to the other criteria for suitable site selection of UGSs. In order to select the suitable sites for urban green space development all the reclassified dataset were overlaid (Figure 4.12).

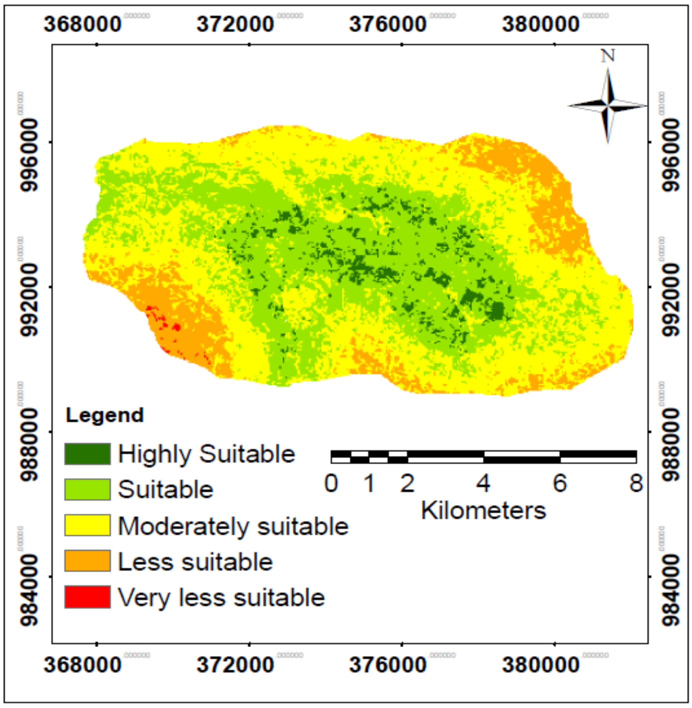


Figure 4.12: Final suitability map of urban green space Source:(Author, 2022)

Finally, based on the suitability reclassified standard the GIS-based MCA was obtained the overall suitability map. According to the findings of this study, shows that 325.4 hectare and 3191.5 hectares were highly suitable and suitable for UGS development respectively. The large area was moderately suitable for green space development in the existing situation which covers 3939.8 hectare of the area where as the remaining area 1087.5 hectare and 13.0 hectare was less suitable and very less suitable for green space development respectively (Table 4.17). These results call attention to the need for proper and sustainable urban green space development in order to save Ambo population healthy and ecosystem in the long term by using the highly suitable area as primary for urban green space development in Ambo Town.

Table 4.17: Final suitability Area

Level of suitability	**Area**	
	Hectare	Percent
Highly suitable	325.4	3.8
Suitable	3191.5	37.3
Moderately suitable	3939.8	46.0
Less suitable	1087.5	12.7
Very less suitable	13.0	0.2

Source:(Author, 2022)

4.8. Field Verification

The field survey aim is to verification of input data classification and accuracy assessment. Field verification was made by visiting the location and comparing the results to your observation. After that, field verification was made to assess the ground truth of the suitable area using GIS-MCDM process with reference to around Ambo university hachalu hundessa campus (Awaro), Ambo polytechnic College No1 and No2, one of the best suitable sites, and also, around Ambo main university and Ambo university referral hospital is a suitable site for UGS development. The LULC of the selected areas are mostly bare land and some part of shrubs and bushes are selected as suitable for UGS development. Based on distance from residential, road, river, facility location, slope, soil, factor and population, the selected areas are identified as suitable site for UGS development (Figure 4.13).

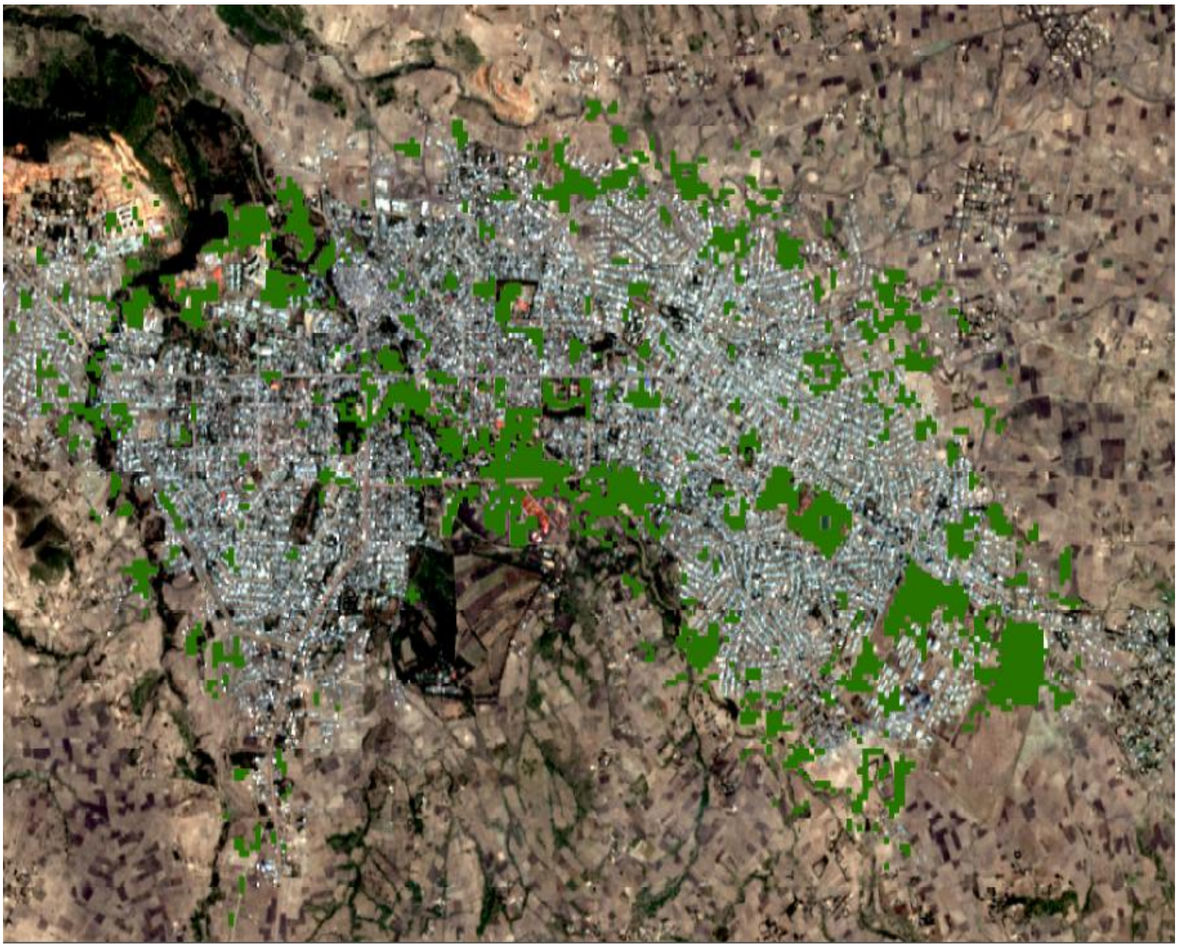


Figure 4.13: Selected areas for green space development Source:(Author, 2022)

4.9. Discussions

The increasing urbanization and human population growth during recent decades have resulted in significant loss of habitats in the urban landscape, accompanied by many environmental problems, such as a reduction of green spaces and ecosystem deterioration. In many cities around the world, random urban growth leads to the change of land use and land cover. As Addo-fordwuor (2014) state that a major problem of rapid urban growth is changing land use patterns. According to them, the general characteristics of rapid urbanization experienced by most sub-Saharan African countries are rampant changes in land and building uses.

Green spaces constitute a major environmental resource of urban landscape. Mensah (2014) state that urbanization remains a single prime factor that is always associated with the destruction of UGSs. He also states that, in Africa, statistics show that urban green spaces are depleting at an alarming rate with green spaces now occupying small fraction of the landmass of several urban areas.

The study indicated that over 16 years built-up area shown continuous increment where as shrub and bushes (greeneries) shown decline. The study agrees with the present studies that have shown LULC change has negative impact on the green space. For example, Mensah (2014) argued that urbanization has a negative impact on the natural environment by encroaching green spaces in many cities. Similarly, Abebe and Megento (2017) reported that, rapid and unplanned expansion and commercial development, along with population pressure, has exerted tremendous negative impacts on green space in the City of Addis Ababa. So, the LULC change analysis is important for providing the necessary data on changes concerning to extent, trend, location and how the change was distributed spatially. For that reason, the study analyzed the LULC change trend existed during study period in Ambo Town and indicated the trends of LULC change particularly green space concerning to analyzed the site suitability for UGS. As a result shows the study area practiced descending trends in most of LULC classes during the study period such as shrub and bushes land, forest land and farm land, whereas bare land and built-up area was showed increment along the study period.

There is different result of object based and pixel based classification when using different remote sensing images. Classified LULC maps from remote sensing imageries may contain some errors. Therefore, accuracy assessment was employed to find out those errors so as to ensure reliability of the produced LULC maps. For example, Abebe and Megento (2017) result indicated that the error matrix of overall accuracy and kappa statistics have less than 90 % value and Yirgalem (2021) result showed that the error matrix of overall accuracy of 1991, 2006 and 2021 was 93.87%, 96.56% and 94% with the kappa statistics of 0.87, 0.95 and 0.92 respectively. Therefore, the study demonstrated that the error matrix of overall accuracy of 2006, 2016 and 2022 was 99.2%, 99.9% and 99.8% with the kappa statistics 98.8%, 99.4% and 99.6% respectively. So, the effectively classification can be seen from object based classification because it give better accuracy assessment by using high spatial resolution images.

As a result shown that the different LULC classes in Ambo Town were spatial decline and converted to other classes due to horizontal expansion of urban area and increment of built-up areas within study area respectively. The LULC maps of 2006, 2016 and 2022 were indicated that the study area was undergone continuous change during study period. When, built-up area was increased from 754.7 hectare in 2006 to 2059.1 hectare in 2022, the shrub and bushes land was decreased from1978.9 hectare in 2006 to 1870.8 hectare in 2022; the forest land was decreased from 374.2 hectare in 2006 to 309.9 hectare in 2022; also the farm land was decreased from 4825.0 hectare in 2006 to 3363.3 hectare in 2022. The conversion of LULC classes that the marked increment of built-up area was greatly the result of diminished shrub and bushes, forest land and farm land. Hence, the reduction of green space and absence of Public Park has indicated that the Ambo town municipality specifically infrastructure department has a problem of proper planning and implementation to keep the town greenery with the exception of the plantation of a few roadside trees and Public Park in the Town. Therefore, suitability analysis for UGS development within the Town are necessary in order to maximize both quality and quantity of UGS that bring that value to urban dwellers and their environment in a sustainable way.

As review different literature, there are many factors affect UGS development. These factors has classified into main factor such as physical, accessibility, environmental and socio-economic factors and sub-factors. Therefore, this study used nine site selection criteria (LULC, distance from residential area, distance from road network, distance from river, distance from facility location, slope, soil type, distance from factory and population density) to select the potential site for UGS development. As Yirgalem (2021) final result shown 6.39%, 25.41%, and 36.42% of the study area has been identified as highly suitable, moderately suitable and less suitable for UGS development respectively. Therefore, in this study the final suitability map has shown that five suitability classes namely, highly suitable (3.8%), suitable (37.3%), moderately suitable (46.0%), less suitable (12.7%) and very less suitable (0.2%) was identified from the all surface of study area.

Accordingly to Abebe and Megento (2017) and Yirgalem (2021), analysis the changes in the LULC patterns and identifying suitable sites for UGS development using remote sensing and GIS based MCDM using AHP can play a crucial role in urban research and help to get up-to-date information about the urban LULC dynamics with frequent coverage and low cost. According to the information of main urban objects (farm, shrub and bushes, built-up area, bare and forest land), the decision making scheme of information extraction based on the difficulty extraction sequence is proposed, which largely avoids misclassification caused by the similar spectral features and similar shape features between different land types and effectively improve the classification accuracy. Besides, one comprehensively utilized MCDM strategy is the AHP. AHP, in spite of its simplicity in idea, it can’t consider imprecise input. The weights derived by AHP method do not represent the relative importance of decision criteria or alternatives. So, in this study the FAHP has demonstrated its effectiveness as a MCDM technique which includes a few preferences inside uncertain, imprecise and obscure settings than AHP method. Therefore, understanding the change of LULC patterns, requires high resolution remote sensing images that have high accuracy in order to detect the change exist in study area and to identify a suitable sites for UGS development, it requires integration of geospatial technology and GIS based MCDM using FAHP in order to select the suitable site for UGS and assist an effective planning of green area in sustainable way.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

In this study, the application of remote sensing in detecting LULC dynamics, Ecognition application in OBIA or image classification, GIS application in site suitability analysis and MCDM approach in spatial problems was conducted to find the potential suitable areas for UGS development of Ambo Town. FAHP method has been applied extensively for weight derivation or decision making problems involving multiple criteria evaluation/selection of alternatives. Consequently, the FAHP-GIS-MCDM method is used to synthesize the decision group. The subjectivity and vagueness of the alternative selection process is handled with the use of fuzzy numbers for linguistic terms. Since FAHP provided accurately and effectively the optimal weight in selection of suitable sites for UGS.

OBIA was performed on satellite images with different spatial resolutions such as spot-7 has 1.5m and 5m spatial resolution whereas sentinel 2A has 10m spatial resolution. As the results of LULC analysis revealed, in 2006 the major part study area was covered by farm land 56.4% of the total area. Shrub and bushes, built-up area, bare land and forest land were covered 23.1%, 8.8%, 7.3% and 4.4% of the area respectively. In 2016, farm land, shrub and bushes, and built-up area were covered 50.2%, 24.2% and 12.4% of the total area respectively. The remaining parts of the area were covered with bare land and forest land 9.2% and 4.0% of the area respectively. In 2022, built-up area was increased by double to 24.1% and the remaining (75.9%) was the share of other LULC classes. As a result, the urban areas of Ambo Town have expanded dramatically, while green areas have been declining over 16 year. The areas which are close to urban centers were subjected to significant loss of shrub and bushes (greeneries) and forest in the past 16 years.

Site suitability analysis for UGS development is a complex procedure which involves physical, accessibility, environmental and socio-economic factors. Therefore, in this study, nine criteria were considered in order of importance were LULC (25%), distance from residential (22%), distance from road (17%), distance from river (12%), distance from facility location (8%), slope (6%), soil type (4%), distance from factory (3%) and population density (3%) for proper selection of site suitability of UGS development in Ambo Town. Determining suitable areas for UGS development the site suitability analysis was performed involves multi-criteria analysis steps.

The result of this analysis revealed that out of total area 8557.2 hectare found in study area, 325.4 hectare is highly suitable and 3191.5 hectare is suitable for UGS development. Whereas 3939.8 hectare, 1087.5 hectare and 13.0 hectare is moderately suitable, less suitable and very less suitable for UGS development respectively. Therefore; the Town has great potential to develop adequate UGSs.

In generally, the result verified that integrated geospatial technology and MCDM with FAHP are very applicable and effective in selection of suitable sites for UGS development by saving the time and resource needed. Also, OBIA is a high-quality technique to help in LULC dynamics detect and mapping by giving up-to date information.

5.2. Recommendations

Based on the findings of this study the following recommendations are drawn:

- ❖ As the result of this study noticed, the LULC was changed due to increment of built-up areas whereas green spaces have been diminishing. Therefore, Town development plan should be focus on proper planning to implement particularly UGS development and vertical built-up expansion rather than horizontal expansion. Also, it should be encourage the community and stakeholders so as to develop and maintain a community garden in line with structural plan of Town. It should be continuously studied and implemented the change of green space with appropriate and effective measure for enhancing and improving both quality and quantity of UGS at national level.
- ❖ UGS such as parks, playgrounds, residential greenery may promote both mental and physical healthy. Besides, they contribute to ecosystem services such as reducing heat island effect and carbon storage, aiding water regulation etc. Therefore, the town administration, municipality and beatification should be need to respect the national standard of green space coverage of the Town outline in the master plan, find up-to date information about LULC using geospatial technology and formulate policy to develop and manage UGS in context of GIS-based MCDM processes.
- ❖ In this study, spot_7 and sentinel 2A imageries were used for LULC classification. Spot_7 and sentinel 2A imageries have 1.5m, 5m and 10m resolution which are not very high resolution. So, some result of LULC type was generalized by other LULC types and some errors were also incurred in image classification. Therefore, future studies should be considering very high resolution images such as QuickBird and IKONOS so as to overcome that problem.

REFERENCE

AbdelRahman M. A. E, Shalaby A. and Belal A. A. (2017). A GIS based model for land evaluation mapping: a case study North Delta Egypt. Egypt. J. Soil Sci., 57–3, 339–351. doi: 10.21608/ejss.2017.255.1043.

Abebe, A.S. (2009). Analysis of the development and management of green areas in Fenote-Selam City, Amhara Region, Unpublished" MSc. Thesis submitted to the Urban Management Masters Program, Ethiopian Civil Service College, p. 77.

Abebe, M. T. and Megento, T. L. (2017). Urban Green Space development using GIS-based multi-criteria analysis in Addis Ababa metropolis. Applied Geomatics 9, p. 87. https://doi: 10.1007/s12518-017-0198-7.

Abimbola H. A, Bolanle A. O, and Adebayo O. A. (2020). Performance Analysis of Fuzzy Analytic Hierarchy Process Multi-Criteria Decision support models for Contractor selection, Scientific African, 1–23. doi: 10.1016/j.sciaf.2020.e00471.

Achalu, K. (2021). Remote Sensing and GIS Based Site Suitability Analysis for Future Urban Development: A Case of Ambo Town and Surrounding Area, Unpublished" MSc. Thesis Submitted to The Department of Geomatics Engineering School of Civil Engineering and Architecture, 1–88.

Addo-fordwuor, D. (2014). Green Space Depletion in Ghana's Urban Settlements : A Case of Kumasi, Unpublished" MSc. Thesis Submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology, p. 142.

Al-bilbisi, H. (2019). Spatial Monitoring of Urban Expansion Using Satellite Remote Sensing Images : A Case Study of Amman City , Jordan. doi: 10.3390/su11082260.

Aldababseh, A. Temimi M, Maghelal P, Branch O. and Wulfmeyer V. (2018). Multi-Criteria Evaluation of Irrigated Agriculture suitability to achieve Food Security in an Arid Environment. Sustainability, 10, 803. doi: 10.3390/su10030803.

Ahmadi N, Golestani M. A. and Bayzidan M. (2017). The current status of urban parks and green spaces in Tehran, Iran. Acta Hortic, 1189 155–160. doi: 10.17660/ActaHortic.2017.1189.31.

Ambo Town kebele profile report (2021).

Areola, AA and Ikporukpo, C. (2018). Social Ecology and Urban Green Spaces in Ibadan, Nigeria. Appl. Sci. Environ. Manage., Vol. 22 (7) 1111–1120. doi: https://dx.doi.org/10.4314/jasem.v22i7.19.

Assaye R, Suryabhagavan K. V., Balakrishnan M. and Hameed S. (2017). Geo-Spatial approach for urban green space and environmental quality assessment : A case study in Addis Ababa City. Journal of Geographic Information System, 9, 191–206. doi: 10.4236/jgis.2017.92012.

Balcik F. B., Senel G. and Cigdem Goksel C. (2020). Object-Based Classification of Greenhouses using Sentinel-2 MSI and SPOT-7 Images: A case study from Anamur (Mersin), Turkey, Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13, 2769–2777.

Baycan-levent, T. and Nijkamp, P. (2009). Planning and Management of Urban Green Spaces in Europe : Comparative Analysis. Urban Plann., 1–12. doi: 10.1061/(ASCE)0733 -9488(2009)135:1(1).

Bilgili, C.B. and Ercan, G. (2012). Urban Green Space System Planning, Landscape Planning, ISBN: 978-953-51-0654-8, In Tech, Available from: http://www.intechopen.com/books/landscape-planning/urban-green-space-system-planning, pp. 1–18.

Braubach M, Egorov A, Mudu P, Wolf T, Thompson C. W, and Martuzzi M. (2017). Effects of Urban Green Space on Environmental Health, Equity and Resilience. 187–205. doi: 10.1007/978-3-319-56091-5.

Cetin, M. (2015). Using GIS analysis to assess urban green space in terms of accessibility : case study in Kutahya, International Journal of Sustainable Development & World Ecology, 22:5, 420–424, doi: 10.1080/13504509.2015.1061066.

Costa, C. S., Erjavec I. S. and Mathey J. (2008). Green spaces – a key resources for urban sustainability. The GreenKeys approach for developing green spaces, 199–212. doi: 10.5379/urbani-izziv-en-2008-19-02-012.

Central Statistical Authority (1994). Population and housing census of Ethiopia Results at country level Vollume II Analytical Report, pp. 1–392.

Central Statistical Authority [Ethiopia] and ORC Macro. 2001. Ethiopia Demographic and Health Survey 2000. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Authority and ORC Macro, pp. 1–299.

Central Statistical Authority (2007). Central Statistical Agency of Ethiopia: The population and housing census of Ethiopia. Addis Abeba.

Central Statistical Authority (2017). Ethiopian Population and Housing Census. Data Capturing and Processing Implementation Strategy, pp. 1–33.

Czarnecki, C. (2012). Object based Image analysis for Forest-type mapping in New Hampshire, unpublished" MSc. Thesis and Capstones Submitted to the University of New Hampshire, 741, pp. 1–100.

Dehvari A. and Heck, R.J. (2019). Comparison of Object-based and Pixel based infrared Airborne Image classification methods using DEM thematic layer, African Journal of Geography and Regional Planning, 6(2), pp. 1–11.

Eastman, J. R. (2009). IDRISI Taiga and Guide to GIS and Image Processing, Clark University, Worcester, MA 01610-1477 USA, pp. 1–342.

Encyclopedia, Britannica (2016). Nitisol, https://www.britannica .com/science/Nitisol.

EDP (U.S. Environmental Protection Agency). 2008. "Urban Heat Island Basics." In: Reducing Urban Heat Islands: Compendium of Strategies. Draft. https://www.epa.gov/heat-islands/ heat-island-compendium.

FAO. (2006). Guidelines for Soil Description. Food and Agriculture Organization of the United Nations, Rome.

FAO. (2007). Land Evaluation. Towards a Revised Framework; FAO: Rome, Italy.

Fariba, S. (2013). A Spatial and Social Analysis of Green Space Access : a mixed-methods approach for analysing variations in access perceptions, Unpublished" MSc. Thesis submitted for the degree of Doctor of Philosophy at the University of Leicester, 1–187.

Gelan, E. (2021). GIS -Based Multi - Criteria Analysis for Sustainable Urban Green Spaces Planning in Emerging Towns of Ethiopia : The case of Sululta Town. https://doi: 10.21203/rs.3.rs-125112/v1.

Girma Y, Terefe H. and Pauleit S. (2019). Urban Green Spaces Use and Management in Rapidly Urbanizing Countries:The case of emerging Towns of Oromia Special Zone Surrounding Finfinne, Ethiopia, Urban Forestry and amp; Urban Greening, https://doi: 10.1016/j.ufug.2019.05.019.

Hailemariam B. A. (2021). Suitable site selection for Urban Green Space development using GIS and Remote Sensing based on multi criterion analysis, IJHCUM, 6(1), pp. 97–110. doi: 10.22034/IJHCUM.2021.01.08.

Haq, S. A. (2011). Urban green spaces and an integrative approach to sustainable environment, J. Environmental Protection, 601–608. doi: 10.4236/jep.2011.25069.

Hasan S, Shi W, Zhu X. and Abbas S. (2019). Monitoring of Land Use / Land Cover and Socioeconomic changes in South China over the last three decades using Landsat and Nighttime Light Data. Remote Sens., 11:1658, doi: 10.3390/rs11141658.

Hersperger, A. M., Gennaio, M. P., Verburg, P.H., & Burgi, M. (2010). Linking Land change with Driving Forces and Actors : Four Conceptual Models: Ecology and Society, 15(4:1), 1–17.

Heshmat P, Rahim M, Hassan A, Javad S. and Omid K. (2013). Site selection for local forest park using Analytic Hierarchy Process and Geographic Information System (Case Study : Badreh County), Intl. Res. J. Appl. Basic. Sci., 6(7), 930–935.

Ibido, Mesfin. N (2020). Pollution Control 2020- Urban expansion and its impact on peri-urban household: The case of Gelan and Dukem Towns, Ethiopia. J. Nuklear Energy and Power Generation Technologies 4(2).

Iftikhar, Ahmad M. and Siddiqui A. S. (2017). A study on Fuzzy AHP method and its applications in a tie -breaking procedure, Global Journal of pure and applied Mathematics, 13(6), 1619–1630. Jabir.K and Arun, Das.S (2014). Evaluation of Recreational site selection and the prospects of recreational establishments in MysoreCity. Int. J. Environmental Sciences, 3(1), pp. 17–21.

Jansson, M. (2014). Green space in compact cities : the benefits and values of urban ecosystem services in planning, Nordic Journal of Architectural Research 2, 139-160, pp. 1–20.

Javadian M, Shamskooshki H. and Momeni M. (2011). Application of sustainable urban development in environmental suitability analysis of educational land use by using AHP and GIS in Tehran. Procedia Engineering, 21, 72–80. doi: 10.1016/j.proeng.2011.11.1989.

Jim, C.Y. and Chen, S. S. (2003) Comprehensive Greenspace Planning based on Landscape Ecology Principles in Compact Nanjing City, China, 65, pp. 95–116, doi: 10.1016/S0169-2046(02)00244-X.

Joerin, F. Thériault, M. and Musy, A. (2001). Using GIS and outranking multicriteria analysis for land-use suitability assessment. Int. J. Geogr. Inf. Syst., 15, 153–174. http://dx.doi.org/10.1080/13658810051030487

Kmail, A. B. and Onyango, V. (2020). A GIS-based assessment of green space accessibility: case study of Dundee. Applied Geomatics, 12(4), 491-499. doi: https://10.1007/s12518-020-00314-7.

Kruize H, van der Vliet N, Staatsen B, Bell R, Chiabai A, Muiños G, Higgins S, Quiroga S, Martinez-Juarez P, Aberg Yngwe M, Tsichlas F, Karnaki P, Lima ML, García de Jalón S, Khan M, Morris G. and Stegeman I. (2019). Urban Green Space : Creating a Triple Win for Environmental Sustainability, Health, and Health Equity through Behavior Change. Int. J. Environ. Res. Public Health, 16:4403 doi: 10.3390/ijerph16224403.

Kuldeep, P. (2013). Remote sensing and GIS based site suitability analysis for tourism development. International Journal of Advanced Research in Engineering and Applied Sciences, 2(5), 43–58.

Kumar, M. and Biswas, V. (2013). Identification of potential sites for Urban development using GIS based multi criteria evaluation technique . A Case study of Shimla Municipal Area , Shimla District ,Himachal Pradesh, India', J. Settlements and Spatial Planning, 4(1), pp. 45–51.

Kumar, M. and Shaikh, V. R. (2013). Site suitability analysis for Urban development using GIS based multicriteria evaluation technique:A case study of Mussoorie Municipal Area, Dehradun District, Uttarakhand, India, 41(2), 417–424. doi: 10.1007/s12524-012-0221-8.

Labib S. M. and Harris A. (2018). The potentials of Sentinel-2 and LandSat-8 data in green infrastructure extraction , using object based image analysis (OBIA) method, European Journal of Remote Sensing, 51(1), 231–240. doi: 10.1080/22797254.2017.1419441.

Landis, J. R. and Koch, G. G. (2020). The Measurement of Observer Agreement for Categorical Data published by : Int. Biometric Society Stable URL : https://www.jstor.org/stable/2529310, 33(1), pp. 159–174.

Li, Z. Fan, Z. and Shen, S. (2018). Urban green space suitability evaluation based on the AHP-CV combined weight method : A case study of Fuping County, China. Sustainability, 10(2656). doi: 10.3390/su10082656.

Lin, Chun-Nan (2020). A Fuzzy Analytic Hierarchy Process-based analysis of the dynamic sustainable management Index in Leisure Agriculture, pp. 1–17, 12, 5395; doi:10.3390/su12135395.

Malczewski, J. (2004). GIS-based land-use suitability analysis : A critical overview. Progress in Planning, 62, 3–65. doi: 10.1016/j.progress.2003.09.002.

Malczewski, J. (2006). GIS - based multicriteria decision analysis : a survey of the literature, Int. J. Geographical Information Science, 20(7), 703–726.

Manlun, Y. (2003). Suitability analysis of Urban Green Space System Based on GIS', Unpublished" MSc. Thesis submitted to the Int institute for geo-information science and earth observation, Enschede, Netherlands, pp. 1–101.

Mathias, T. A. (2016). Remote Sensing and Geographic Information System Based suitability analysis of Urban Green Space development in Addis Ababa : A case study of Bole Sub-City, Unpublished" MSc. Thesis Submitted to the Department of Geography and Environmental Studies, p. 94.

Mehdi, Z. and Hajizade, F. (2014). Fuzzy Analytical Hierarchy Process (FAHP): A GIS-based multicriteria evaluation/selection analysis, pp. 1–7 doi: 10.1109/GeoInformatics.2011.5980971.

Mengistie K, Thomas S, Demel T, & Thomas K. (2013). Land Use/Land Cover Change Analysis Using Object-Based Classification Approach in Munessa Shashemene Landscape of the Ethiopian Highlands. Remote Sensing, 5, 2411-2435.

Mensah, C. A. (2014). Urban Green Spaces in Africa. Nature and Challenges. International journal of Ecosystem 4(1), 1–11. doi: 10.5923/j.ije.20140401.01.

Mensah, C. A. (2014). Destruction of Urban Green Spaces: A Problem Beyond Urbanization in Kumasi City (Ghana), 3(1), 1–9. doi: 10.11648/j.ajep.20140301.11.

Mitchell, R. and Popham, F. (2008). Effect of Exposure to Natural Environment on Health Inequalities : an Observational Population Study, 372, 1655–1660.

Moayeri M, Shahvarani, A and Behzadi H. M. (2015). Comparison of Fuzzy AHP and Fuzzy TOPSIS methods for Math Teachers selection, Indian. Journal of Science and Technology, 8(13). doi: 10.17485/ijst/2015/v8i13/54100.

Mohammad, S. M. and Zhirayr, V. (2013). The Benefits of Urban Parks , a Review of Urban Research, Journal of Novel Applied Sciences, 2(8), 231–237.

MoUDC (Ministry of Urban Development and Construction). 2014. National Report on Housing & Sustainable Urban Development. Addis Ababa, Ethiopia.

MoUDH (Ministry of Urban Development and Housing). 2015. Ethiopia National Urban Green Infrastructure Standard. Addis Ababa, Ethiopia.

Natalie. A (2015). Understanding the Importance of Urban Amenities: A Case Study from Auckland. Buildings, 85-99; doi: 10.3390/buildings5010085.

Ogato, G. S, Abebe, K, Bantider A., and Geneletti D. (2017). The quest for mainstreaming climate change adaptation into urban development platting of Ambo Town, Ethiopia. America Journal of Human Ecology, 2(3), 103-119. doi: 10.1007/978-3-319-49520-0-5.

Ogato, G. S. (2013). The Quest for Mainstreaming Climate change adaptation into Urban Development planning of Ambo Town, Ethiopia, 2(3), 103–119. doi: 10.11634/216796221302478.

Pantalone, S. (2010). Creating the Urban Forest : Suitability Analysis for Green Space in the City of Boston, USGS Land Cover Institute, Tufts University.

Pham, D. U. and Nobukazu, N. (2008). Application of Land Suitability Analysis and Landscape Ecology to Urban Green space planning in Hanoi, Vietnam, 7, 25–40. doi: 10.1016/j.ufug.2007.09.002.

Pokhrel, S. (2019). Green space suitability evaluation for urban resilience: an analysis of Kathmandu Metropolitan city, Nepal, Environ. Res. Commun. 10(26). doi: 10.1088/2515-7620/ab4565.

Rashad A, Temizkan H. and Rafig A. (2020). Fuzzy Analytic Hierarchy Process-Based Multi-Criteria Decision Making for Universities Ranking, Symmetry, 12, pp. 1–15. doi: 10.3390/sym12081351.

Robertson, D. L. and King, Douglas J. (2011). Comparison of pixel- and object-based classification in land cover change mapping. International Journal of Remote Sensing, 32:6, 1505–1529. doi: 10.1080/01431160903571791.

Sahabo, A. A. and Mohammed, A. B. (2016). GIS Based Multi-Criteria Analysis for siting recreational parks in Yola-North Local Government. Int J Appl Sci Eng Res 5(1), 20–29.

Samson, A. (2014). Assessment of Urban Green Infrastructure in Addis Ababa: The case of Bole Sub City, Unpublished" MSc. Thesis Submitted to the School of Graduate Studies of Addis Ababa University, 1–83.

Satterthwaiter D, McGranahan G, and Tacoli C. (2010). Urbanization and Its Implications for Food and Farming. Phil. Trans. R. Soc. B, 365, 2809-2820. doi: 10.1098/rstb.2010.0136.

Schipperijna J, Ekholmb O, Ulrika K. Stigsdottera, Toftager M, Bentsena P, Kamper-Jørgensen F. and Thomas B. R (2010). Landscape and Urban Planning Factors Influencing the Use of Green Space : Results from a Danish National Representative Survey, 95, 130–137. doi: 10.1016/j.landurbplan.2009.12.010.

Senia, N. M. (2021). Evaluation of Urban Green Space development using Geospatial Techniques : A Case of Adama Town, Unpublished" MSc. Thesis Submitted to the Department of Geomatics Engineering, School of Civil Engineering and Architecture, 77 pp.

Shanmugham, S. and Tekle, S. B. (2011). An Assessment of the Status of Water Supply and Sanitation in Ethiopia: Acase of Ambo town. Journal of Sustainable Development in Africa. 13(1), 23–43.

Sibaruddin H. I, Shafri H Z M, Pradhan B. and Haron N. A. (2018). Comparison of pixel-based and object-based image classification techniques in extracting information from UAV imagery data. Earth and Environmental Science, 169. doi: 10.1088/1755-1315/169/1/012098.

Ullah, K. M. (2014). Urban Land-Use Planning using Geographical Information System and Analytical Hierarchy Process: Case study Dhaka City, Unpublished" MSc. Thesis Submitted to the Department of Physical Geography and Ecosystem Science Centre for Geographical Information Systems, 83 pp.

UN-HABITAT (2008). United Nations Human settlements programme regional and technical cooperation division Ethiopia: Ambo Urban Profile.

United_Nations (2015). United Nations, Department of Economic and Social Affairs, Population Division (2015). World Urbanization Prospects: The 2014 Revision, (ST/ESA/SER.A/366), 1–517.

United_Nations (2019). Department of Economic and Social Affairs, Population Division. World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).

United Nations (2017). Economic Report on Africa 2017: Urbanization and Industrialization for Africa's Transformation.

Ustaoglu E. and Aydınoglu A. C. (2020). Land Use Policy Suitability Evaluation of Urban Construction Land in Pendik District of Istanbul , Turkey, 99. doi: 10.1016/j.landusepol.2020.104783.

Van Berkel D. B., Munroe D. K. and Gallemora C. (2014). Spatial analysis of land suitability, hot-tub cabins and forest tourism in Appalachian Ohio, Applied Geography, 54, 139–148. doi: 10.1016/j.apgeog.2014.07.012.

Vargas-Hernandez, J. G, Pallagst K. and Zdunek-Wielgłaska, J. (2017). Urban green spaces as a component of an ecosystem. Functions, services, users, community involvement, initiatives and actions. Revista de Urbanismo, 37, 1-26. https://doi.org/10.5354/0717-5051.2017.47057.

Veljanovski T, Kanjir U. and Oštir K. (2011). Object-Based Image Analysis of Remote Sensing Data. Geodetski vestnik, 55(4), 665–688.

W/gebriel Mebrahtu (2017). GIS and Remote Sensing applications for potential Urban Green Space development site selection: The case of Abiy Addi Town (Central Tigray, Ethiopia).

Wang, Y. M. and Chin, K. S (2011). Fuzzy analytic hierarchy process : A logarithmic fuzzy preference programming methodology, International Journal of Approximate Reasoning, 52(4), 541–553. doi: 10.1016/j.ijar.2010.12.004.

WHO (2016). Urban green spaces and health:A review of evidence. World Health Organization Regional Office for Europe, Copenhagen, Denmark, 1–91.

WHO (2017). Urban green spaces : a brief for action. World Health Organization Regional Office for Europe, 1–24.

Wuqiang L, Song S, and Wei L. (2012). Urban spatial patterns based on the urban green space system: A strategic plan for Wuhan City, P. R. China Shi Song.

Yang F, Zeng G, Du C, Tang L, Zhou J. and Zhongwu Li Z. (2008). Spatial Analyzing System for Urban Land-Use Management based on GIS and Multi-Criteria Assessment Modeling. Progress in Natural Science, 18, 1279–1284. doi: 10.1016/j.pnsc.2008.05.007.

Yirgalem, G. (2021). Suitability Analysis for Urban Green Space development using Geospatial Technology: A case of Adama Town, Ethiopia, Unpublished" MSc. Thesis Submitted to The Department of Geomatics Engineering School of Civil Engineering and Architecture, 1–100.

Yohanes A. K, Chandy H. S. and David J. G. (2009). Occurrence of Non-Native Species Deep in Natural Areas of the Shawnee National Forest, Southern Illinois, U.S.A., 29(2), 177–187. doi: 10.3375/043.029.0210.

Yousefi E, Salehib E, Zahiric S. H. and Yavarid A. (2016). Green space suitability analysis using Evolutionary Algorithm and Weighted Linear Combination (WLC) method, Space Ontology International Journal, 5(4), 51–60.

Youssef A. M, Pradhan B. and Tarabees E. (2011). Integrated Evaluation of Urban Development Suitability Based on Remote Sensing and GIS Techniques: Contribution from the Analytic Hierarchy Process, 4, 463–473. doi: 10.1007/s12517-009-0118-1.

Zubair, A. O. (2006). Change Detection in Land Use and Land Cover using Remote Sensing Data and GIS: A case study of Ilorin and Its Environs in Kwara State. Unpublished" MSc. Thesis Submitted to the Department of Geography, University of Ibadan, 1–54.

APPENDICES

Appendix 1: Coordinates of Educational Centers

No	Name of schools	Easting	Northing
1	Global College Ambo Campus	373442	992959
2	Ambo Micro Business College	373427	992888
3	Ambo Meserete Hiwot Kidane Meheret Kinder Garten School	373479	992645
4	Future Generation Hope Primary School No.2	373480	992425
5	Future Generation Hope Kinder Garten	373276	992188
6	Ambo Addis Katama Primary School	372858	992246
7	Ambo Bright Primary School No.1	372729	992449
8	Ambo Secondary School	372401	992512
9	Biftu Bari Academy	372257	992812
10	Kush Land College	372013	992916
11	Gadaa International College	372654	992831
12	Rift Valley University Ambo Campus No.1	372900	992824
13	Ambo Bright Primary School No.2	372878	992609
14	Ambo University	372923	992998
15	Ifa Kinder Garten (KG) Ambo Kalehiwot church	373142	992823
16	Senayas College Ambo Campus	373211	992904
17	Rift Valley University Ambo Campus No.2	373296	992713
18	Letu Academy Kinder Garten	373524	991881
19	Ambo Polytechnic College	373639	991529
20	Hunde Gudina Primary School	373664	991738
21	Global College Ambo Campus No. 2	373714	992656
22	Odo Liban Primary School	373342	993872
23	Walif Academy Ambo Branch	374277	993325
24	Liban Mecha Secondary School	374567	993330
25	Ambo Full Gospel Belivers Church Kinder Garten	374512	993456
26	Liben Mecha primary School	374537	993632
27	Ambo primary School	374804	993264
28	Hayota Bori Academy	375076	993425
29	Bakalcha Bari primary and Secondary School	373408	993139

30	Ambo Town Senkele primary School	368462	994077
31	Awaro Secondary School	376278	993590
32	Ambo Polytechnic College	375660	993163
33	Ambo Adventist School	375784	993303
34	Abdi Kenya Academy and Primary School	376316	992965
35	Future Generation Hope Primary School No.1	376367	992630
36	New Millennium Academy Kinder Garten	376748	992726
37	Global Academy School	377034	992644
38	Ambo University Hachalu Hundessa Campus	377918	991375
39	Awaro Primary School	376740	992194
40	Future Generation Hope Sec. and Prep. School	376376	992044
41	Abdi Borif KG School	377321	991744
42	Burka Bektota Kinder Garten and Elementary(1-8) School	376294	991667
43	Bekan Academy and Primary School	376244	992656
44	Ambo preparatory School	375044	992801
45	Betakinati primary School	374301	992749
46	Mekne iyasus Academy	374668	992464
47	Ambo Adventist Kinder Garten and primary School	374816	992888
48	Horn of Africa Business College Ambo Campus	375506	992836
49	Harbar College	375574	992868

Appendix 2: Coordinates of Health Centers

No	Name of health facilities	Easting	Northing
1	Ambo General Hospital	373487	992962
2	Urji Medium Clinic	373460	992775
3	Dambal Clinic	373460	992767
4	Ambo Town Health Center	372400	992806
5	Heran medium Clinic	372305	992846
6	Bilise Dental Clinic	372215	992815
7	Agape Medium Clinic	371967	992962
8	Ambo University Referal Hospital	371893	993642
9	Land Mark Medium Clinic	371560	993672

10	Kenya Medium Clinic	371316	993372
11	Oda Medium Clinic	372654	992819
12	Elyon Medium Clinic	372614	992868
13	Mo’a Medium Clinic	372943	992582
14	Walin Medium Clinic	372984	992884
15	Jibat Medium Clinic	372990	992815
16	Dr. Milki Darara Kafani Medium Clinic	373262	992888
17	Ambo Medium Clinic	373278	992684
18	Q/phawlos Medium Clinic	373686	991628
19	Gosu Health Center	373664	991674
20	Oromia Cli+nic	373444	992805
21	Dr. Gabisa Medium teeth Clinic	373457	992784
22	Dr. Bedasa Medium Clinic	373677	992924
23	hawelan Clinic	373682	993054
24	Abeyna Medium Clinic	373892	993238
25	Gibe primary Clinic	374093	992944
26	Wedu primary Clinic	374387	992933
27	Bonsa Medium Clinic	374495	993541
28	Hawinet Medium Clinic	374821	993460
29	Awash Medium Clinic	376190	992813
30	Hawetan Medium Clinic	376434	992614
31	Bonsa Medium Clinic	377465	991883
32	Latan Lower Clinic	377401	991905
33	Lati Medium Clinic	376464	991992
34	Africa Medium Clinic	376683	992418
35	Dibora Medium Clinic	375950	992419
36	Awaro Health Center	377298	991996
37	Yafet Medium Clinic	376144	992637
38	Amen Physiotherapy Speciality Clinic	375988	992945
39	Yerosen Medium Clinic	375875	993012
40	Elshaday Medium Teeth Clinic	374756	992870
41	Dr. Robsan Dental Clinic	375486	992841

42	Mandela Medium Teeth Clinic	375568	992869
43	Furtu Medium Clinic	375727	992552
44	Hawi Medium Clinic	375584	992905

Appendix 3: Coordinates of Factory locations

No	Name of Factories	Easting	Northing
1	Ambo Mineral Water Factory	369653	993873
2	Edic Genso Factory	373517	991683
3	Genso Factory	373785	993873
4	Ambo IGM Powder and bread factory	372137	992695
5	Investor powder and bread factory	371925	992581
6	Powder and bread factory	371938	992532
7	Ambo farmer corporation animals food factory	372078	992336