EVALUATION OF URBAN GREEN SPACE DEVELOPMENT USING GEOSPATIAL TECHNIQUES: A CASE OF ADAMA TOWN

By

Senia Nasir Mohammed

A Thesis Submitted to the Department of Geomatics Engineering, School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirments for the Degree of Master's in Geo-Informatics

Office of Graduate Studies

Adama Science and Technology University

Adama, Ethiopia

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CANDIDATE’S DECLARATION

I, Sania Nasir hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university and all sources of material used for this thesis have been properly acknowledged.

Candidate Name: Sania Nasir Mohammed

Signature: ________________

This MSc Thesis has been submitted for examination with our approval as thesis advisor/co-advisor.

ADVISOR’S APPROVAL

Name: ________________________________

Signature: _____________________________

Date of submission: _____________________

ADVISOR’S APPROVAL SHEET

To: Geomatics Engineering Department

Subject: thesis submission

This is to certify that the thesis entitled: Evaluation of Urban Green Space Development Using Geospatial Techniques: A case of Adama Town submitted for partial fulfillment of the requirements for the degree of masters in Geoinformatics. The graduate program of the Department of Geometics Engineering and has been carried out by Senia Nasir Mohammed ID NO. PGR/18454/11 under my advising. Therefore, we recommended that the student has fulfilled the requirements and hence hereby she can submit the thesis to the department.

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Co-Advisor Approval

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BOARD OF EXAMINERS APPROVAL SHEET

We, the undersigned, members of the Board of Examiners of the final open defense Senia Nasir Mohamed have read and evaluated her thesis entitled: Evaluation of Urban Green Space Development Using Geospatial Techniques: A case of Adama Town and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master of Science in Geoinformatics.

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AHP	Analytic Hierarchy Process
CMP	City Master Plan
DEM	Digital Elevation Model
FAO	Food and Agricultural Organization
GI	Green Infrastructure
GIS	Geographic Information System
GPS	Global Positioning System
LULC	Land Use/ Land Cover
MCDM	Multi-Criteria Decision Making Method
MCE	Multi-Criteria Evaluation
UGI	Urban Green Infrastructure
UGS	Urban Green Space
WLC	Weighted Linear Combination

ABSTRACT

Urban green space is one of the essential components of the urban environment. It has various environmental, social, and economic benefits to city dweller urbanization posed significant challenges to green space development of Adama town. In Ethiopia it is hard to meet the standards of green infrastructure correspondingly Adama lacks standardized greenery of the street tree and city parks thus, This study aims to evaluate the urban green infrastructure development .specifically the objective of this study is to: evaluate existing urban green infrastructure with the master plan, generate factors for suitability site selection for urban green infrastructure (UGI), drive suitability map for urban green infrastructure, evaluate existing UGI with the proposed suitability map. This study evaluation of the implementation of CMP 2004 for UGI was performed by taking into account the locational aspect of the UGI. The result indicates 181.*32 ha (23.86 %) areas of the proposed UGI of CMP* 2004 *were changed into a settlement, cropland and bare land due to the increment of population, for firewood and grazing purposes*.*The study was used sentinel2A, master plan, DEM and point data to evaluate UGI in the study area. The methodology adopted in this research includes the generation of road, stream, slope, land use land cover, soil, population maps using GIS techniques. The pairwise comparisons method was used to estimate the weight for factors by creating a ratio matrix. A suitability map of the study area was generated using a spatial analysis tool which is used to select the potential site for the UGI of the study area. Moreover, based on GIS-based multi-criteria analysis results of the analysis were* the *highly suitable area 105.39 ha (0.83 %), suitable area 2151.2 ha (16.94%), moderately suitable area 7748.28 ha (61.02 %), and less suitable area 2672.37 ha (21.05%) and the unsuitable area was 20.57 ha (0.16%). To conclude, GIS technologies can play a crucial role in urban research which strongly helps the site selection process to establish urban green spaces. Besides, it has outstanding spatial problem-solving capabilities and performs a more systematic suitability analysis, which has been used to help spatial decision-making, and AHP is a versatile and practical tool for selecting urban green areas in the study area.*

Keywords: Urban Green Space, Land Use / Land Cover, *Dominant factor, Geographic Information System, CityMaster Plan*

CHAPTER ONE

INTRODUCTION

1. 1 Background

Land evaluation is the method by which land output is measured when used for a specific purpose(Van den Bossche et al., 2018). The urban green space suitability evaluation approach is a critical tool for selecting suitable locations for UGS planning and construction. farther it is used for quantitative analysis that traditional planning has found hard to achieve it is also a more practical planning scheme than the traditional approach(Li et al., 2018)

One of the essential components of the urban environment is green spaces. Green space reference to those land uses in the built-up and planning areas which contain natural or man-made vegetation in it (Manlun, 2003). Green infrastructure varies in scale, habitat density, species resources, environmental quality, public transport proximity, facilities, and services(Fuller & Gaston, 2009). Urban green infrastructure(UGI) includes parks and forests, sports fields, green lakes, streams and river banks, greenways and walks, community gardens, street trees, and nature conservation areas, as well as less traditional areas such as green walls, green streets, and cemeteries(Planning & Resources, 2017).

Urban areas account for almost 80 percent of total global emissions of carbon dioxide, methane, and nitrogen oxide. The environmental impact of such statistics is that urban areas are a major contributor to climate change, particularly when the impacts of air pollution are added to the loss of forest and vegetation cover associated with urban expansion(Series, 1996).

In the United States and other nations, it is a new solution to urban greening that has obsolete integrated sewage networks that are prone to flooding during heavy rain(Kondo et al., 2015). (Manlun, 2003) stated that in china the benefits of urban green infrastructure are identified in ecological, social and economic ways. Providing clean air, observing toxic gas, balancing carbon and oxygen trapping dust, and eliminating noise are some ecologically beneficial and save energy which benefits economically.

UGS offers in central Nairobi town benefits that reduce adverse effects, for instance, a city lack of quality and quantity UGS vulnerability to calamities vices, low suitability for human livings(De Ridder et al., 2004). Besides, it is an advancing concept in support of sustainability for abiotic, biotic, and cultural functions(Ahern, 2007). Green infrastructure has therefore become an important international policy project in many cities and has been used to tackle a wide range of environmental and social issues(Barnhill & Smardon, 2012).

A study in Chicago showed that an average of 85% of air pollution can be filtered in a green area(Elgizawy, 2014).In the UK, Europe, and North America, the implementation of green infrastructure has varied across scope (Mell, 2010). By the ideas of Garden Cities and the protected designations of green spaces, the UK has seen green infrastructure develop(Howard, n.d.).In Europe, green infrastructure development has been linked to urban greening agenda development and the need to effectively develop integrated green space in high-density landscapes(Beatley, 2000).

Green infrastructure improves aesthetic value to one city which is shown to decrease stress, whereas, inadequate planning and lack of attention Rapid population growth and high reduction of green infrastructure resources are Africa's current major environmental issues(M. B. Molla, 2015).

In Ethiopia, the concern of urban greens in urban planning, social and economic development effort is crucial for sustainable development. Even with this effort, urban greens facilities in Ethiopia's capital city hardly meet the standards that other competitive African cities have set(Aynachew, 2014). Despite this, the study area lacks standardized greenery of a street tree and city parks which results in the sun's extreme heat and unbearable dust that indicate poor development both in terms of adequacy and management of urban green spaces (MOHAMMEDNUR, 2017). Hence this study aimed to evaluate the urban green space of the town.

1.2 Statement of the problem

Urban green space(UGS) is a major provider of ecosystem services, and improves the quality of life of urban residents a such as parks, woods, street trees, green roofs, gardens, and cemeteries are particularly important in an urbanized world(Breuste et al., 2015). The establishment and management of urban green space across the urban centers have not been uniform and there is a great deal of variation among the urban centers.

In Ethiopia, the establishment and management of green space across the urban centers have not been standardized and well-developed green infrastructure. (Manual for Recreational ParksDevelopment and Management, 2015). According to (bizuayehu, 2018) Adama town is facing tremendous environmental, social, and economic problems associated with a lack of appropriate green infrastructure development, management, and protection.

In addition to this, the study area's urban green spaces are located without consideration of the standards such as(MUDHo, 2015) states that A Woreda Park should be about 3 ha, can accommodate up to 40,000 people in a radius of 1,000 to 1,500 m, with a carrying capacity of 0.075 ha/1,000 pop., should be situated on local or collector streets, not arterial streets, and should be well-accessible by public transport.

Adama town still holds a strategic position in terms of the trade, tourism, and transport interactions, and proximate to Addis Ababa, the city has huge potential for urban growth and expected to play different roles at local and national levels. These factors demand up to standard green space, housing, infrastructure, and utilities, social services, and facilities (Girma, 2018).

Beyond this general declaration, the status and overall challenges faced by the urban green space in the study area are not determined. Besides, The previous study conducted in the study area based on examining the major challenges and opportunities of the urban green infrastructure of the town and an Inventory of major management problems with street trees has also been undertaken. Therefore, the current study carried out to assess the status of existing urban green space and Identify suitable sites for urban green space development in the GIS environment using Multi-criteria evaluation in the study area.

1.3 Objective

1.3.1 General Objective

The general objective of the study is to evaluate urban green space development using geospatial techniques in Adama town.

1.3.2 Specific Objectives

- To identify factors for suitability site selection for urban green infrastructure in the study area
- To generate a suitability map for UGS in the study
- To evaluate CMP 2004 and CMP 2017 Vs. proposed suitability map
- To evaluate the existing UGS Vs. proposed suitability map

1.4 Research questions

- What are the factors that used to generate a suitability map of urban green space in the study area?
- Which sites are suitable for urban green space development in the study area?

- How to evaluate the CMP of 2004 and 2017 Vs the proposed suitability map?

- How to evaluate existing green space with the proposed suitability map of the study area?

1.5 Scopes

Since the selection of UGS sites is a broad subject matter, it is difficult to address all issues in this study. Therefore, this study is restricted in place and issue of concern. Geographically, it is delimited to Adama Town administration boundary, Oromia National Regional State of Ethiopia. As far as the problem is broad, the selection of UGS sites by using GIS techniques is limited in the study area.

1.6 Significant of the study

Urban planners will adopt and assess appropriate locations for urban green spaces to maximize the advantages of urban green spaces within the built-up region(Tan, 2006) moreover the outcome of the study will provide the following significances: help urban planners plan more challenging land use and then reschedule the suitability analysis process,

identify locations best suited for specific purposes, Local government officials to build an effective green space network in urban settings, to serve as a guide for further studies by providing valuable data on the development of urban green areas which is to improve the image of the town. Planners to assist in the establishment of an appropriate urban green space system. Besides, the result may help the municipality to fill the indicated managerial, professional, and economic gaps to promote the city's existing green development status. Ultimately, the study result can serve as a source of information for urban green planners and practitioners engaged in work on urban green infrastructure.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This aspect of the study reviews the various literature related to the topic under consideration to cover critical facts and findings which have already been identified by previous researchers and numerous studies in and around UGS.

2.2 Concept of Urban Green Infrastructure and Urban Green Space

Green infrastructure is defined in different ways by different authors such as Green infrastructure was a common platform for intelligent design and sustainability planning (Chang et al., 2012), Green infrastructures are natural areas offering many vital services that support and enhance the quality of life besides it accommodate a network of open spaces, air sheds, watersheds, wetlands, wildlife habitats, parks, and others. (Planning & Resources, 2017).

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

The economic benefits of GI are Through enhancing the physical environment, GI improves efficiency and employment opportunities through improving working conditions and design and construction processes(Kim & Song, 2019).from the socio-cultural point of view, GI encourages leisure activities and generates beauty in cultures, as well as providing benefits in terms of the educational role of nature and the protection of historical natural resources, Green zones extended by using GI and regenerating communities increase the quality of public services, protect through crime prevention and natural disasters, enhance the physical environment of communities and raise social, mental and physical health(Glascoe, 1998).

The creation of public and/or private urban green areas should be directly linked to international standards(Lamma, 2016). The global standard for access to green areas for the World Health Organization (WHO) is 7 m2 per capita distributions of green areas. As reported by the United Nations (UN), the per capita distribution of green areas is 30 m2(Lamma, 2016).

There is no single universally accepted definition for the term urban green Spaces. Many scholars tried to define the term from their respective research area point of view. According to (Mensah, 2014) 'Green space' is a phrase used to describe a large area of land that Some academics use words like "open space" and "public open spaces" interchangeably when referring to green spaces. He clarifies that "green spaces in urban areas cover all areas that to some degree have some vegetation, either natural or artificial. It isn't only confined to city parks and gardens. It refers to land that is primarily made up of unsealed, permeable ‘soft' surfaces such as dirt, grass, shrubs, and trees, and is accessible or maintained privately or publicly.

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

The physical components of urban green space include urban forests, parks, riverine, and street trees. Natural playfields, community parks, urban agriculture, and rooftop gardens are just some of the prospects for green space. Community gardens provide important social, economic, and environmental benefits to the community. Urban agriculture has a somewhat different emphasis than community gardens, but it has a significant effect on social movement and food security in the community. It is viewed as advantageous to both the

environmental and food security movements(Abebe & Megento, 2017a).

Figure 2.1: An overview of Stuttgart and its green space system

Source :(Nilsson et al., 2011)

(Haq, 2011) also stipulated the definition of urban green spaces which is agreed on by ecologists, economists, social scientists, and planners as Public and private open spaces in urban areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users. The following are some examples of various forms of urban green space:-

Parks: (Sadeghian & Vardanyan, 2015) in their study of urban park history, classification, and functions broadly defined and discussed Park as an area of natural, semi-natural, or planted space set aside for human enjoyment and recreation or the protection of wildlife or natural habitats.

Figure 2.2. Parkland(Van den Berg et al., 2014)

Besides, parks are areas gears towards fulfilling the leisure, recreational and educational needs of the young and old, male and female, rich and poor, and people of varying abilities.

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

Figure 2.3: street trees

Source : (Urban, 1994)

Rooftop gardens

They cover hundreds of acres of undeveloped land, leading to issues such as the "heat island effect" and increased storm-water run-off. Green roofs with wildflowers, trees, shrubs, or vegetables could be easily installed on schools, apartments, homes, and workplaces in the area, transforming rooftops into valuable green spaces. Green roofs are categorized into two groups. It can provide many benefits, including Increased access to safe outdoor green space;A venue for urban food production; Promotion of individual, community, and cultural diversity; Areas for study and horticultural therapy; improved air quality and absorption of carbon dioxide; Minimization of stormwater run-off, and support for a rainwater collection system Increased habitat for birds, butterflies and insects; and

Reduced heating and cooling costs by providing a layer of insulation on buildings(Kuhn, 2001).

Figure 2.4 : Illustrative green roofs in Dhaka

Source : (Hossain et al., 2019)

Urban forests

In the last few decades, the term "forest" has taken on a new meaning. Before the 1960s, it was primarily thought of as a productive land use that provided timber, wood, and food. FAO recently defines forests as ‘Land extending to more than 0.5 ha, with trees higher than 5 m and a canopy cover of more than 10%’(Nilsson et al., 2011).

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. Green spaces provide linkage between people (who live in the urban) and nature (Manlun, 2003). green spaces do have environmental, social, and economical benefits, which we call ecological service.(Gebremeskel, 2014) states urban green space provides environmental benefits, by buffering Urban Heat Island Effect, Water Pollution Purification by slowing the overland flow (runoff) and allowing contaminants to percolate through the soil pores and Flood Management.

According to (O’Connor et al., 2013) the Social Benefits are Socialization and Cognitive Development Health Benefits Heritages of Culture Educational Benefits Socialization and Cognitive Development with the Children's cognitive abilities, mental resilience, and socialization are all improved as they spend time in green spaces. Health Benefits Heritages of Culture green spaces allow people of diverse cultures to know each other.

(O’Connor et al., 2013) also stated that Educational Benefits Green spaces may be used as open-door labs for students to learn about the social, economic, and environmental services that they provide. Researchers may use green spaces as a research topic. Economically Benefits Land and Immovable property values Elevation (Gebremeskel, 2014)states the housing and land values are higher by 8% to 20%, yet people show a willingness to pay for the presence of park, school, and a police station.

2.4 Status of Urban Green Infrastructure in World Wide

In the 1870s, concepts for green urban structures began with ideas of urban farming and garden allocation. In the UK, Europe, and North America the implementation of green infrastructure is based on the major planning concern or their concentration(Aynachew, 2014). In Europe, green infrastructure growth has been related to the development of the urban greening program and efficiently establish sustainable green space in high-density landscapes(Benedict & McMahon, 2002)on the other hand United States was based on landscape conservation In mid-1990s (Alexander, 2007).

Because of how the current green infrastructure is handled, the traditional method of evaluating green infrastructure in Poland has in most cases been limited to the determination of recreational resources known as green spaces within the city or its communities in terms of administration(Burawoy, 2013). 80% of the United Kingdom's population lives in urban areas and has a growing population. It is often at the detriment of green space, which is associated with the greatest threats to human health in deprived areas. This report discusses the facts of how green infrastructure can help address these issues and explores the issues raised by the implementation of green infrastructure(Wentworth & Wilebore, 2013).

Traffic accidents are also minimized by roadside trees. This is because the view and heat mitigation of the trees is going to calm down drivers. Individual driving speeds in the suburban settings were significantly reduced Faster drivers and slower drivers both drove slower when trees were present(Dixon & Wolf, 2007). Fuelwood, fruit, food, pasture for animals, wood and poles, spices, yarn, medicines, and other non-timber goods are the most obvious economic benefits of urban forests(FAO, 2016).

As a possible emerging tool, the US Environmental Protection Agency has adopted urban tree cover to help meet air quality standards(U.S. Environmental Protection Agency (EPA), 2012).Pollution removal essentially O3, PM10, NO2, SO2, CO varied among cities with total annual air pollution removal estimated at 711,000 metric tons by U.S. urban trees ($3.8 billion value). (Nowak et al., 2006).

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

2.5 Status of Urban Green Infrastructure in Africa

Green infrastructure is a likely solution to sustainable spatial planning. In terms of green infrastructure development over the past few years, the concept of green infrastructure has remained limited and underestimated in the context of broader spatial planning approaches in Africa, particularly in South Africa(Cilliers, 2019).

Currently, the rapid depletion of green spaces in Africa has resulted in green spaces occupying a very small percentage of many urban areas ' total land space. For instance, many cities in the Republic of South Africa have less than 10% of their total land occupied by green spaces(Matthew McConnachie et al., 2008). The situation in the city of Lagos (Nigeria) is more frightening, and green spaces now occupy less than 3% of the landmass of the city(Oduwaye, 2013).

Recent trends have shown that Africa's urbanization rate is twice as fast as Latin America and Asia(Europe & America, 2007). Similarly, this urbanization trend appears not to have translated to proportionate economic growth and better welfare for the citizens(Kjellstrom & Mercado, 2008). Studies have shown that the general attitude of green space planning in many African nations is often articulated with a direct intervention to a visible problem without any long-term plan which is Only the short-term effects that are set against limited time frames are based. However, the development of urban green space infrastructures such as Nigeria, South Africa, Egypt, and Ethiopia has received little attention from a few African states(M. Molla, 2015).

City leaders and urban planners are faced with challenges in providing basic services such as green space, sanitation, water supply, transportation, and primary health center due to rapid urbanization and population growth in the developing world(Abebe & Megento, 2017a). However, many urban people in Africa have very limited experience in building green infrastructure and are deficient in land-use decisions so they don't grasp its significance or the promise it can offer to their towns and cities(Youngquist & Clapp, 2009).

2.6 Status of Urban Green Infrastructure in Ethiopia

According to the report by Addis Ababa City Beautification, Parks and Cemetery Development and Administration Agency Addis Ababa’s accessible public parks are 19 and cover an area of 931, 086 m2. Consequently, the green area distribution per household is less than 0.3 m2, The area of 237,192.16 m2 is underdeveloped for public green parks, and this increases to 0.35 m2, which is still below the standards set by the WHO. To meet the minimum requirement of 7 m2, 2700 hectares of land should be used for urban green development.

The study(Abebe & Megento, 2017b) concluded that the rapid urbanization in Addis Abeba has given little room for the development of green areas. shows that, in the current situation, large areas are less suitable for park development 49.76 percent of the area.

According to the report by Adama specific urban infrastructure standard states” The Municipality shall ensure a minimum of 15 m^2 public green open space per capita within the city boundaries. Every inhabitant of Adama city shall live within 500 m from a public green open space of a size of at least 0.3 ha, an area big enough such as playing football and for other informal play.

2.7 Dominant Factors for Selection of Potential UGS Sites

Factors/criteria are important for green space development. The factors used for site selection process for a green space were selected based on different kinds of literature and prior knowledge of that particular area. According to (Chandio et al., 2011; Manlun, 2003; Pantalone, 2010; Pareta, 2013; Piran et al., 2013) studies conducted on green space development LULC, population density, soil type, slope, distance to road, and distance to stream were selected as factors that are important for the green space development for the study area.

2.7.1 LULC

Land use and Land cover is the main parameter for UGS site selection studies. Studies have shown that existing land use must be addressed when identifying appropriate sites for the provision of urban green spaces(Malmir et al., 2016) (Dağıstanlı et al., 2018) (Zhang et al., 2013)(Abebe & Megento, 2017a). According to different authors such as

(Abebe & Megento, 2017b)(Chandio et al., 2011)(Pokhrel, 2019)(Abebe, 2016)(Manlun, 2003) LULC classification standard for UGS practices, it can be classified into five LULC classes that represented in table 2.1.

Table 2.1: LULC classification (Abebe & Megento, 2017b)(Chandio et al., 2011)(Pokhrel, 2019)(Abebe, 2016)(Manlun, 2003)

LULC type	Level of suitability	value
Bare land and Grassland	Highly suitable	5
Vegetation	Suitable	4
Water body	Moderately suitable	3
Crop land	Less suitable	2
Built up	Un suitable	1

2.7.1.1 Accuracy Assessment of the Classification

Accuracy assessment was employed for determining whether the output map meets or does not meet the level of acceptance. Error matrices are a common method of expressing classification accuracy and were created to compare category by category basis, the reference data (ground truth), and the corresponding results of classification (Lillesand et al., 2008). The study assessed the accuracy of the classification results for each classified image. After creating the error matrix for each classification, user accuracy, producer accuracy, overall accuracy, and Kappa coefficient were computed. According to Lillesand et al.(2008) user 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). The producer's accuracies result 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). The Kappa coefficient of the agreement was used for multivariate statistical measure that can be used to test LULC classification accuracy. Computing Khat is the ability to use this value as a basis for determining the statistical significance of any given matrix or the differences among matrices.

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

Where r = number of rows in the error matrix; Xii = number of observations in row i and columni (on the major diagonal); Xi+ = total of observations in row i (shown as marginal total to right of the matrix); X•+i = total of observations in column i (shown as marginal total at bottom of thematrix) and N = total number of observations included in matrix.

2.7.2 Population Density

Population density is one of the key components for the evaluation of green space. (Chandio et al., 2011; Dağıstanlı et al., 2018; Pantalone, 2010; Piran et al., 2013; Tahmasebi et al., 2014) recommend that populated areas are highly appropriate for green space development. (Metropolitan, 2019) also stated that places near the high population density with a greater number of a citizen with crowded places required access to the open green spaces.

Table 2.2: Population density classification (Metropolitan, 2019)

Population density (pop/ha)	Level of suitability	value
>80	Highly suitable	5
50 – 80	Suitable	4
20 – 50	Moderately suitable	3
5-20	Less suitable	2
<5	Un suitable	1

2.7.3 Road

The proximity of roads also plays a crucial role in providing local people with easy and viable routes to access local green areas in their surroundings. (Chandio et al., 2011; Tahmasebi et al., 2014) recommended that the green space site is preferable when it is located at a suitable distance from roads in order to access transportation. The classification standard is illustrated in table 2.3 below.

Table 2.3: Distance from road classification (Chandio et al., 2011; Tahmasebi et al., 2014)

Distance from road(m)	Level of suitability	Value
< 400	Highly suitable	5
400 – 800	Suitable	4
800 – 1000	Moderately suitable	3
1000-1500	Less suitable	2

>1500	Un suitable	1

2.7.4 Soil

Based on (Mathias, 2016) eutric cambisols are considered as suitable soil as it is deep soil and contain 45% clay or more clay which is high natural fertility moreover the black or dark colors of soils as indicators of good soils (fertile soils) are reflections of the high amounts of organic matter contents in the soils, mollic andisols are black than haplic phaezems is dark gray which is limited agricultural value when they are shallow stony(FAO, 1984). Eutric fluvisols consider unsuitable compared to other type have the least content of clay (Mathias, 2016).

Table 2.4: Soil type classification ((Mathias, 2016; FAO, 1984)

Soil type	Level of suitability	Value
Eutric cambisols	Highly suitable	5
Mollic andosols	Suitable	4
Haplic phaeozems	Moderately suitable	3
Eutric fluvisols	Less suitable	2

2.7.5 Slope

According to (Abebe & Megento, 2017c; Dağıstanlı et al., 2018; Piran et al., 2013; Pramanik, 2016) have shown that low-slope(gentle slope) areas are highly suitable than the steep slope ground for the development of urban green spaces. According to (FAO, 2006) slope classification standard for UGI practices, it can be classified in to five slope classes that represented in table 2.5

Table 2.5: Slope classification (FAO, 2006)

Slope (%)	Level of suitability	Value
< 5	Highly suitable	5
5 – 10	Suitable	4
10 – 15	Moderately suitable	3
15 – 30	Less suitable	2
>30	Un suitable	1

2.7.6 Stream

Water plays a significant role in the growth and development of a living organism .besides, Water body like a stream, rivers, lakes, ponds, reservoirs are suitable for the development of green space(Abebe & Megento, 2017b; Manlun, 2003; Pareta, 2013; Piran et al., 2013).similarly (Pareta, 2013) noted that streams used to maintain good environmental health and are highly suitable from the ecosystem perspective too and the closer lands to the stream banks got more preferences are highly suitable for green space development. Accordingly, the classification standard showed in table 2.6

Table 2.6: Distance from stream classification (Pareta, 2013)

Distance from stream (m)	Level of suitability	Value
< 250	Highly suitable	5
250 – 500	Suitable	4
500 – 750	Moderately suitable	3
750	Less suitable	2
>1000	Un suitable	1

2.8 Suitability Analysis for Urban Green Space

Analysis of land suitability is important in deciding the land asset that is suitable for certain specific uses (Abebe & Megento, 2017a). The GIS-based suitability analysis can systematically integrate mathematical calculations with map processing, it greatly improves assessment efficiency, Easy to operate, and quick (Manlun, 2003). ITSAM(improved traditional suitability analysis model)which takes advantage of the certainty factor, can greatly simplify the GIS operation and has a more powerful application than the membership degree in the Fuzzy Set Theory in which it is difficult to integrate the membership degree with GIS(Janssen & Herwijnen, 1998). GIS-based suitability analysis methods can be classified into three classes:- direct overlay, weighted score, and ecological factors combination.

2.8.1 Direct Overlay

The direct overlay approach involves map overlay and a summation of equal weight which is traced back to the early 20th century (IAN L McHARG, 1992). This approach can be applied successfully to the suitability of land use, allowing effective and systematic urban planning to both social and environmental factors (Manlun, 2003). The drawback of the direct overlay technique is that it is an additive system of equal weight. Furthermore, the slight deviation from the gradual colors in the composite map is difficult to distinguish. Many factors have mutual relationships and mutual influences with each other. Since the method of direct overlay or the method of weighted score requires that each factor should be independent (Manlun, 2003).

2.8.2 Weighted Score

If the effects of all kinds of environment variables on the particular land use are very clear, the composite suitability cannot be obtained by having a direct overlay. It has to use the weighted score approach. The relative importance (weight) of each factor in the weighted score intends to be established (Manlun, 2003).

2.8.3 Ecological Factors Combination

Recognizes that different combinations of dependent factors determine the appropriateness of particular land use. It is useful to apply the hierarchical combination with a great number of variables in the analysis likewise it is suitable with a few criteria for the analysis. First, some complicated and interconnected dependent factors and evaluation criteria need to be developed by experts (Manlun, 2003).

2.9 Analytic Hierarchy Process (AHP) Weighting Method

Weighted suitability is more complicated since we compare suitability scales for all aspects and assign them a weighting factor that should represent their relative value rather than only finding the binary suitable/unsuitable for each aspect. Saaty (1977 and 1994) developed the Analytic Hierarchy Process (AHP), which is a multi-criteria decision-making approach. The AHP has stirred the interest of many researchers, owing to the method's appealing mathematical properties and the ease with which the requisite input data can be obtained (Manlun, 2003). The AHP is decision-making that can be used to overcome difficult decisions. The weights of the value of the decision criterion were determined using these comparisons(Seri, 2014).

In today's multicriteria weighting scheme, the nine-degree hierarchic analysis approach is commonly used In several ways, the nine-degree hierarchic analysis approach can be useful for calculating factor weights. Nevertheless, since the number of pairwise comparisons is increasingly growing, it is not feasible to use the nine-degree hierarchic analysis approach for a large number of variables. In other words, determining the numerical value from the nine-degree scale is difficult because there are too many variables to consider.

The popularity of this approach can be attributed to its strong mathematics. It facilitates the elicitation of complex judgments from various experts on a single stage.in addition it

Intensity of relative importance	Definition	Explanation

guarantees precision because it has a built-in tool for detecting inconsistencies in judgments. (R. W. Saaty, 1987)has indicated that a Consistency ratio of 0.1 or less is acceptable to continue the AHP analysis. accordingly, since the inconsistency of the factor weights' pair-wise comparison matrix can be calculated and controlled by the Consistency Ratio (CR). studies for instance (Dong et al., 2008; Tudes and Yigiter, 2010; Kumar and Shaikh, 2012; Bagheri et al., 2013; Romano et al., 2015; Abebe and Megento, 2017; Ustaoglu and Aydinoglu,2020) approved that AHP is a highly effective method for assessing the weight of variables.

1	Equal Importance	Two activities combine equally to the objective.
3	Moderate importance of one over another	Experienceandjudgment slightlyfavourone activity over another
5	Essential or strong importance	Experience and judgment strongly favour one activity over another.
7	Demonstrated importance	AnActivityisstrongly favoured anditsdominanceisdemonstrated in practice.
9	Extreme Importance	The evidence favouring one activity over another is of the highest possible order of affirmation. 2
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed.
Reciprocals of above non-zero numbers.	If an activity has one of the above numbers (e.g. 3) compared with a second activity, then the second activity has the reciprocal value (i.e.1/3) when compared to the first.	

Source:Saaty(1985)

Table 2.7: AHP Scale of Relative Importance

2.10 Multicriteria Evaluation Methods for Ranking

An evaluation method supports the ranking of alternatives any procedure that using one or more decision rules(Janssen & Herwijnen, 1998). The objective of the MCE is to examine selected possibilities based on multiple criteria and objectives(Carver, 1991). Together with the Geographic Information System (GIS), the MCE technique can assist in categorizing, analyzing and arranging usable knowledge regarding spatial planning choices appropriately(Pujadas et al., 2017)

The multi-criteria evaluation function of the suitability assessment provides arithmetic and logical operators for attribute combination(Jiang & Eastman, 2000). There are two basic classes of multicriteria assessment methods in GIS: Boolean overlay operations (no compensatory combination rules) and weighted linear operations Combination methods

(WLC) (compensatory combination rules) (Mokarram & Aminzadeh, 1996). the different approaches that are used for multicriteria evaluation clarified as follows.

GIS overlay functions are common and often required tools to integrate various factors and generate useful information for decision-makers. The overlay methods are used to combine different model factors. For example, combining various parameters like slope, climatic factors, vegetation cover, etc. When dealing with indistinct phenomena, data integration using fuzzy overlay functions may improve the reliability of the decisions it is also a common approach to the uncertainty of model locations in GIS (MesgariI et al., 2008).To determine the composite map layer (output map), the overlay techniques allow the map layers (input maps) of the attributes to be aggregated.

2.10.1. Weighted Linear Combination

The weighted linear combination (WLC) model is one of the most widely used decision rules based on GIS(Hopkins, 1977). The key reason for its acceptance is that the approach is very simple to implement using map algebra operations and cartographic modeling within the GIS framework. The effectiveness of the WLC approach derived from its simple implementation by the use of basic GIS operations such as raster reclassification, multiplication, and overlay(Jamal-uddeen, 2014).

One advantage of the WLC approach is the ability to assign specific relative weights by the aggregation to each of the factors, can be formalized through multi-attribute decision-making (MADM), and can also be easily understood and appealed to decision-makers intuitively. The sum of the set of factor weights for evaluation must be one, the resulting suitability map will have the same range of values as the standardized factor maps that were used. It is an average strategy that softens the Boolean approach's hard decisions and avoiding extremes (Drobne & Lisec, 2009).

Boolean logic and weighted linear combination (WLC) are the most common techniques or decision rules in GIS (Abudeif et al., 2015). Ordered Weighted Averaging is A multi-criteria procedure structure for aggregation within the GIS environment(Wanderer & Herle, 2015).The decision-maker could make a decision based on the various spatial decision conditions Experience difficulties in getting accurate parametric numbers of OWA(Jacek Malczewski, 2006b).

2.11 Evaluation of Existing Urban Green Space

Ecological suitability evaluation was initially introduced by McHarg in the 1960s. the emergence of the Geographic Information System (GIS), the evaluation of ecological suitability has been extended to a wide range of disciplines, including urban land development(Z. Li et al., 2018a), regional agricultural planning(Ngowi & Stocking, 1989) and green road planning(Giordano & Riedel, 2008). The evaluation process is the basis for scientific decision-making about land resources as it is the potential of land development (Shearer & Xiang, 2009). This is to ensure the sustainable use of land an important quantitative analytical method (Q. Li et al., 2017).

Site suitability evaluation involves creating maps of suitability that identify areas that are most suitable for a particular activity(Hopkins, 1977). to evaluate the implementation of the Adama City master plan in preserving planned green space lands No experimental research is conducted(Tesema, 2018) and he explained that "proposed ground protection area is well preserved while farmland, informal green, and formal green areas are meet more difficulties to follow the plan. " Evaluation of implementing green space highly indicates the control of urban sprawl(Omer, 2015).

2.12 Conceptual Framework

In Ethiopia, the cities of Addis Abeba, Adama, and Hawass green areas are being shifted to other land uses(Arsiso et al., 2018) such as residential, industrial and commercial developments which leads to environmental deterioration(Terfa et al., 2019). moreover, The earlier research on urban green spaces focused primarily on highlighting and addressing the challenges and opportunities for urban green spaces development and management of the study area. Despite this study focused on onGIS based multicriteria analysis provides a rich range of techniques and procedures to organize decision problems and to plan, analyze, and prioritize alternative decisions.

Since AHP uses a hierarchical structure; it enables decision-makers to identify high-level strategic priorities and clear indicators for better strategic alignment evaluation. This can be implemented in any organization of any maturity level as inputs are structured using either empirical data or subjective assessments where measurements are not available and sensitivity analysis is carried out in the process(T. L. Saaty, 1984).

The direct overlay was used by McHarg and his colleagues to examine the suitability of land use for natural resources, passive recreation, active recreation, residential development, trade development, and industrial development, etc. However, this approach is that it is a kind of equal-weight additive method. Each factor's function is different and sometimes the same factor may be considered repeatedly. Moreover, it is difficult to identify the little difference from the gradual colors in the composite map.

A weighted score is capable of girding, classifying, and quantifying the map which is suitable for computer applications. This is why this approach has been implemented so extensively in recent years. However, the theory of mathematics demands that any factor is independent. Many factors have relationships with each other and mutual influences. A modern method of 'combining ecological factors' created to address this disadvantage.There are four main groups of techniques for the development of weight such as ranking method, rating method, pairwise comparison method, and trade-off analysis method. From these, in this study, A pair comparison approach which is known as the Analytical Hierarchy Process (AHP) will be applied with the added benefits of having a structured framework for group discussions and helping the decision-making community concentrate on areas of consensus and disagreement when determining criterion weights(Drobne & Lisec, 2009)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study area, Adama town, is positioned at crossroads in the southeast of Addis Ababa at 99 km and 84.7 kilometers distance via old and express road respectively along the allweather road which connects the city with Addis Ababa and the seaport of Djibouti. Geographically, the study area lies between 8’ 27’’ 00’’ to 8’ 37’’ 00 North latitude and 39^0 12’ 00’’ to $39^0$27’ 00’’ East longitude. It covers an area of about 13,211.15ha (Kedir, 2018).

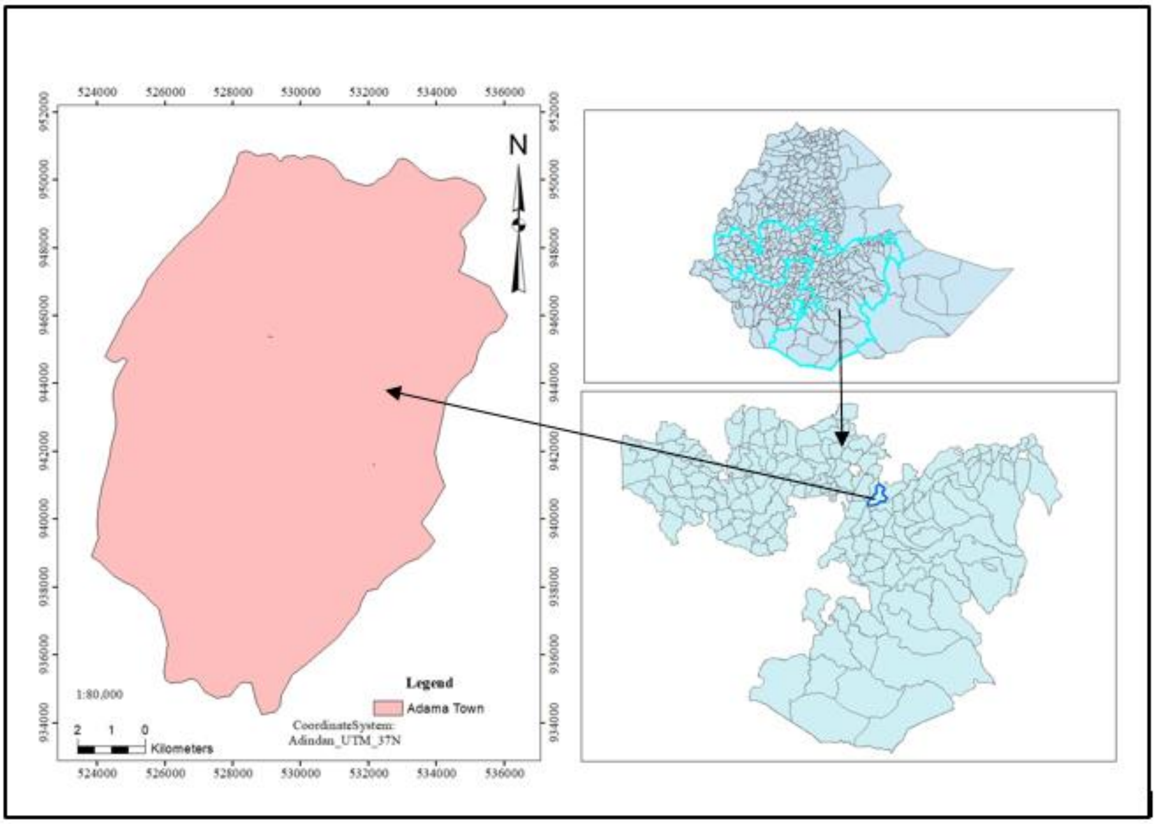

Figure 3.1: Location Map of the study area

3.2 Climate

Adama city has a hot and dry climate with sparse rainfall in the winter and milder conditions in the summer. There are two distinct seasons of the wet season and dry season. the healthful climate condition of Adama city is mainly characterized by light and relatively low summer precipitations. According to information gathered from Adama city metrological observation station, in the last 13 consecutive years 2005-2017 E.C the average maximum and minimum annual temperature of the city is 32.8 co and 11.6oc respectively .adama city was experienced an average annual temperature and rainfall of 21.9oc 847.14 mm respectively in the last eleven years. Similarly, the average maximum and minimum annual rainfall for years 1997-2007 E.C was 1106.2mm and 492.5mm respectively (Kedir, 2018).

3.3 Population Density

The distribution of the population in the city is uneven as elsewhere in the country. The overall population density of the city is 2810 per square kilometer. The central parts of the city have a high population in comparison with the urban expansion areas. The urban Genda/kebele with the biggest population is 09, whereas, the urban Genda/Kebele with the least population is 06(Kedir, 2018).

Table 3.1: Population size of Adama twon with *Kebele*

AdamaTwon Kebele Name	Population	Area(ha.)	Population Dencity (population /ha)
Kebele 01	30,109	1571.3	19.16
Kebele 02	21,508	338.30	63.58
Kebele 03	31,421	334.77	93.86
Kebele 04	32,045	256.02	125.17
Kebele 05	30,252	351.11	86.16
Kebele 06	11,147	30.94	360.27
Kebele 07	18,389	49.42	372.06
Kebele 08	17,363	54.92	316.17
Kebele 09	34,854	482.01	72.3
Kebele 10	28,215	192.87	146.29
Kebele 11	29,646	161.89	183.12
Kebele 12	16,954	85.14	199.12
Kebele 13	17,226	127.32	135.3
Kebele 14	33,209	1016.39	32.67
Deka Adil	2,538	1683.45	1.51
Dabe Soloke	7,083	1098.39	6.45
Melka Adama	2,637	1910.5	1.38
Boku Shenen	6,845	3466.68	1.97

Source: CSA (2017and 2020 projected)

3.4. Soil Characteristics

The characteristics of soil is a result of topography, climate, and type of parent material and environment, the type of soil existing in Adama city area are predominantly sandy and loamy in texture which is identified with permeability and susceptibility to natural forces of wind sweep and water erosion due to deforestation. To large existent, the upper layer of the soil is very thin. Adama city's soft soil is good for making adobe and mud block that the poor households are indebted to its abundance in the locality (Kedir, 2018).

3.5. Topography

When it comes to Adama city, the city is located in a spectacular landscape of great scenic beauty. Topographically, the city is divided into the low lying centre and hill slopes with their unique landscape sceneries .adama city was established in a flat and undulating fertile land that ranges from a completely low lying centre of the city to hilly ridges overlooking the city. Aadma is bounded by kechema ridge in the west,Kufagutu peaks on the north ,dibibisa and migira ridge in the west and boku ridge in the south. The city is topographically situated at the 1500-1900 meters above mean sea level, according to the present master plan of the city.

3.6 Data types and Data Sources

Different types of spatial and non-spatial datasets were obtained from different organizations and processed using multiple GIS tools and remote sensing techniques for mapping and analysis purposes. Input datasets included Advanced Space born Thermal Emission and Reflection Radiometer (ASTER) global DEM which is acquired from Geospatial Information institute Addis Ababa with a resolution of 20m, Sentinel2A multispectral imagery was downloaded freely with different resolution bands accessed from Copernicus Open Access Hub data were used to produce LULC map and analyze the suitability of urban green space of the study area. These Sources of data are described in Table 3.1.

Table 3.2: Data Types and Data Sources of the study

Types Of Data	Scale	Source	Format	Purpose/Description

Sentinel 2A Image	10m	Copernicus Open Access Hub	Image	For Classification
Soil	1:50,000	Ministry Of Agriculture, Addis Ababa,2020	Shape File (Polygon)	Suitability Analysis
Population	-	Central Statically Agency Of Addis Ababa,2020	Shape File (Point)	Suitability Analysis
Road Network	1:50,000	Adama Municipality,2020	Shape File (Line)	Suitability Analysis
Digital Elevation Model (Dem)Aster	20m	Geospatial Information institute Addis Ababa,2020	TIFF	To Drive Slope And Stream
Point Data	-	Field Observation	Excel	Accuracy Evaluation
City Master Plan 2004&2017	1:50,000	Adama city administration urban land sectors office,2020	Shapefile format	Evaiuation
Study Area Boundary Map	1:50,000	Adama Municipality,2020	Shape File (Polygon)	Delineation

3.7 Softwares Used

Different software and materials were used to analyze the research. Each software and material elaborated in detail in table 3.2 in terms of purpose and version used for the research.

Table 3.3: Softwares and Materials Used

No.	Material	Version	Purpose

1	ArcGIS	10.7	Factor development weighting and weighted overlay analysis
2	ERDAS IMAGIN	2015	To generate a LULC map
3	Microsoft Excel	2016	Database file creation for event layer generation process for evaluation input
4	Handy GPS	-	For point data collection for accuracy assessment and existing urban green areas
5	Google earth pro		For checking the green area

3.8 Methods

The techniques used to analyze and organize the collected data for the current study are briefly explained as follows. Qualitative and quantitative data were prepared for the analysis by following the metadata and analysis specification: coordinate system and datum (i.e. UTM-37N, Adindan), extent (Easting range 523818.657500 m to 536068.560100 m and Northing range 934241.571800 m to 950845.008800 m). According to (Malczewski, 2006) stated that GIS-MCDA is a method that transforms and combines geographical data and value judgments (the expectations of the decision-maker) to obtain decision-making knowledge.

After the data is collected from various sources, the data were analyzed by using different software such as Arc GIS 10.7 and ERDAS Imagine 2015. To meet the specific objectives of the suitability analysis for the selection of urban green infrastructure sites in the study area. Suitability analysis is more than a GIS-based procedure while database and spatial information are the core of the process.

GIS provides spatial overlay capabilities and methods for grid-cell processing that allow us to analyze spatial factors.GIS can process tremendous data and have efficient map display and output functions, the main trend is to use GIS in the suitability analysis. The analysis will be performed by using several data such as satellite imagery (Sentinel 2A) with a spatial resolution (10m*10m) which was used for performing classification(LULC), Aster digital elevation model (DEM) was used to drive slope and stream maps and by developing factors i.e. slope, soil type, stream, population density, and land use land cover in ArcGIS and Erdas imagine environment.

The techniques were used to analyze and organize the collected data for the study are briefly explained as follows:- The first step was to set the goal or define the problem. this study aims to produce a map showing suitable sites for green space in the study area. The second step was determining factors/ criteria that are important for green space development. The factors used for the site selection process for a green space were selected based on different kinds of literature and prior knowledge of that particular area. According to (Chandio et al., 2011; Manlun, 2003; Pantalone, 2010; Pareta, 2013; Piran et al., 2013) studies conducted on green space development LULC, population density, soil type, slope, distance to road, and distance to stream were selected as factors that are important for the green space development for the study area.

The third step was standardizing each factor/ criterion score. It is important to set the suitability values of the factors to a common scale to make comparisons possible. Therefore, all input datasets were changed into a raster at 10-meter resolution and to a common measurement scale using a conversion tool. Based on the FAO land suitability classification, by using rescaling option (i.e. 1 to 5 by 1 where 1, 2, 3, 4, and 5 refers to unsuitable, less suitable, moderately suitable, suitable, and highly suitable) and developing factors (i.e. land use land cover, road, stream, slope, soil type, and population density) for green space development in ArcGIS environment.

The fourth step was defining weights for each criterion based on its importance for the green space development using AHP tool in arc map . The relative importance (i.e. weight) of the developed factors was computed using a pairwise comparison technique. A weight value was allocated to the reclassified input datasets to express the significance of each criterion to the other criteria for adequate site selection for green space. The matrix of AHP pairwise comparison was generated and criteria weights were determined by comparing factors for each criterion using a scale with values from 9 to 1.AHP and the Geographic Information System (GIS) are an integrated technique used to assess suitable land use for UGS in Adama town.

The weighted overlay analysis was conducted based on the weight of the developed factors to generate a layer of UGS sites in the study area using the ArcGIS weighted overlay tool.The implementation of urban green space of the 2004 CMP was evaluated with the ground truth data which is collected using GPS and then connected using ARC GIS software to represent existing urban green areas. Based on the field observations, UGS was selected for the evaluation purpose. The evaluation of the selected UGS was conducted based on the spatial information (i.e. location of UGS in the suitability map of UGS in the study area.The overall workflow of the current study is illustrated in Figure 3.2, to accomplish the above-mentioned set of activities in the study.

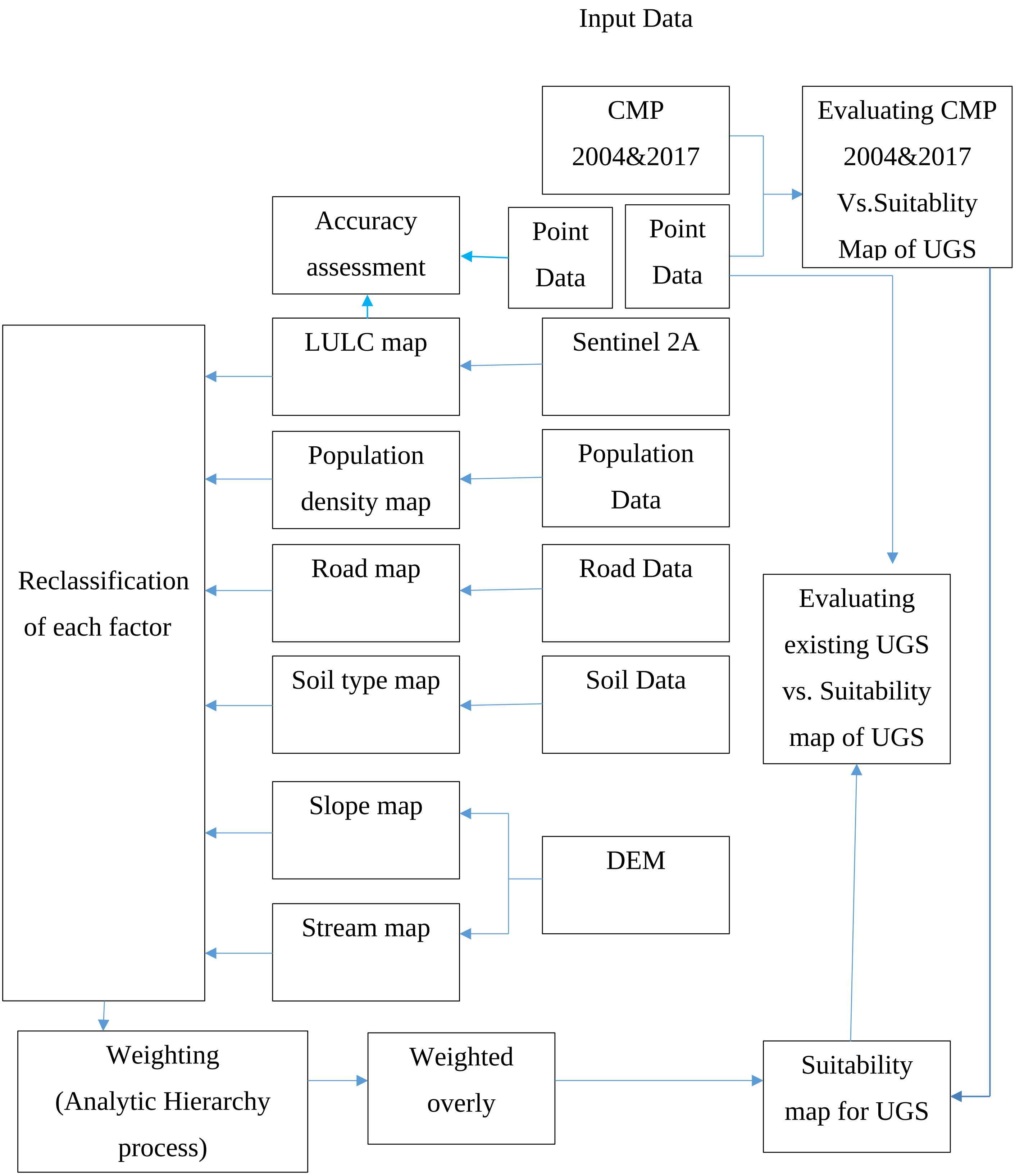

Figure 3.2: Schematic for the general workflow of the study

CHAPTER FOUR

ANALYSIS, RESULT AND DISCUSSION

4.1 Analysis, Results, and Discussion

To meet the specific objectives of the study, the analysis was performed by setting specified spatial resolution (10m*10m) and spatial extent was the boundary of the study area in a GIS environment. The outcomes obtained from the analysis of the study were represented in the forms of maps and tables.

4.2 Land Use and Land Cover map

The Land use/Land cover (LULC) map of the study area was generated from Sentinel 2A with a spatial resolution of 10m through a supervised classification technique in ERDAS IMAGINE 2015 software. Combination of Various false-color composite raster band combinations in Red-Green-Blue order and from the previous knowledge of the area and field observation was used to define training sites. The training site characterization was used to create signatures for each information class. The maximum likelihood algorithm was used to classify LULC using the mean, variances, and covariance data from the signature. Six types of LULC were found in the study area: built-up, cropland, vegetation, grassland, bare land, water body. The LULC map was reclassified based on the importance to select potential areas of UGI. Therefore, the highest value was given for bare land and Grassland due to its accessibility for creating green spaces used for recreational purposes for UGS potential sites. The suitability levels of LULC were ranked as very highly suitable, suitable, moderately suitable, less suitable, and unsuitable.

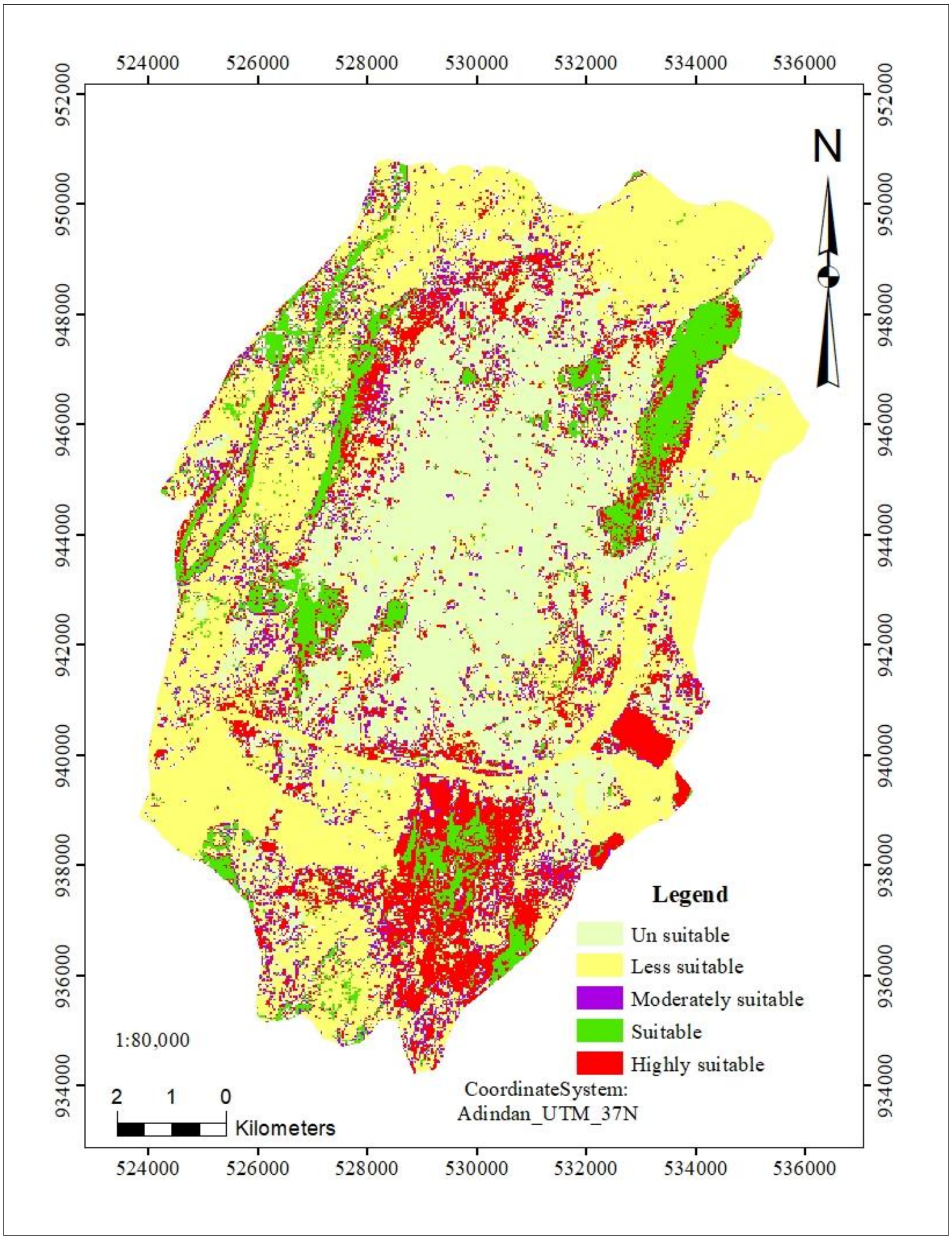

Figure 4.1: Reclassified LULC map for UGS in the study area

The reclassified map of LULC in figure 4.1 demonstrated: the highly suitable area was 1825.34 ha (13.82 %) in Northwest and Southeast parts, the suitable area was 1234.2 ha(9.34 %) in Northeast, Southeast and West parts, moderately suitable area was 771.4ha (5.84 %) where found in Northwest, Southeast, East, and South parts, less suitable area was 5411.25 ha (40.96 %) in most peripheral parts and the unsuitable area was 3968.96 ha (30.04%) in the Central parts of the study area. The majority of the study area (71 %) was occupied by unsuitable and less suitable levels of LULC to select potential sites of UGS.

__4.2.1__ Accuracy Assessment of the Classification

Accuracy assessment was employed to find out those errors so as ensure the reliability of the produced LULC map. The classified map was assessed and compared with a referenced data and ground truth using an error matrix. The overall accuracy was 87.69%with the Kappa statistics 0.84976 (Table 4.1). The Kappa statistics value greater than 0.80 (i.e., 80%) represents a strong agreement and a value between 0.60 and 0.80 represents a substantial agreement (Landis and Koch, 1977). According to (Anderson *et al*., 1976) the map met the accuracy requirements, and there is a positive correlation between the remotely sensed classified samples and the reference data. Results of user's accuracy in this study showed that the maximum class accuracy was for vegetation (96.30%) and the minimum was for bare lands (83.33%).

Table 4.1: Error matrix of LULC classification

CLASSIFICATION ACCURACY ASSESSMENT REPORT								
Classified Data	crop land	settlement	Water body	Grass land	vegetation	Bare lands	Producer Accuracies	Users Accuracy
crop land	28	0	0	1	0	1	96.55%	93.33%
Settlement	0	29	0	0	1	0	100%	96.67%
Water body	0	0	9	0	1	0	100%	90%
Grass land	1	0	0	18	3	3	90%	72%
Vegetation	0	0	0	1	15	4	75%	75%
Bare lands	0	0	0	0	0	15	78.95%	100%
Overall Classification Accuracy = 87.7 %								
Overall Kappa Statistics = 0.84976								

As mentioned in section 2.7.1.1 accuracy assessment was done to determine whether the output map meets the level of acceptance which compares the classified image to other data sources such as ground truth data. despite this, the above table 4.1 shows the LULC classification accuracy assessment report, the LULC classes shown in column and row of the table. the numbers indicated in the table represent how many training samples were found in each LULC class. According to the area coverage of each class, the number of sample data was used, if we take cropland as an example total of 30 sample data were used from these samples the correctly classified samples are 28 which means from the total data samples 28 data which indicates the user value and producer's value (ground truth) falls under the same LULC whereas the remaining 2 samples fall under grassland and bare land

.for water body which also the same as the least area coverage, 10 sample data were used from those 1 sample data is not correctly classified. The same procedure was followed for all the remaining LULC classes.

4.3 Population Density Map

Population density map was generated from the input population data by computing population density using a field calculator in Arc GIS environment. Then it was converted into raster and reclassified into five suitability classes based on the stated in section 2.7.2.

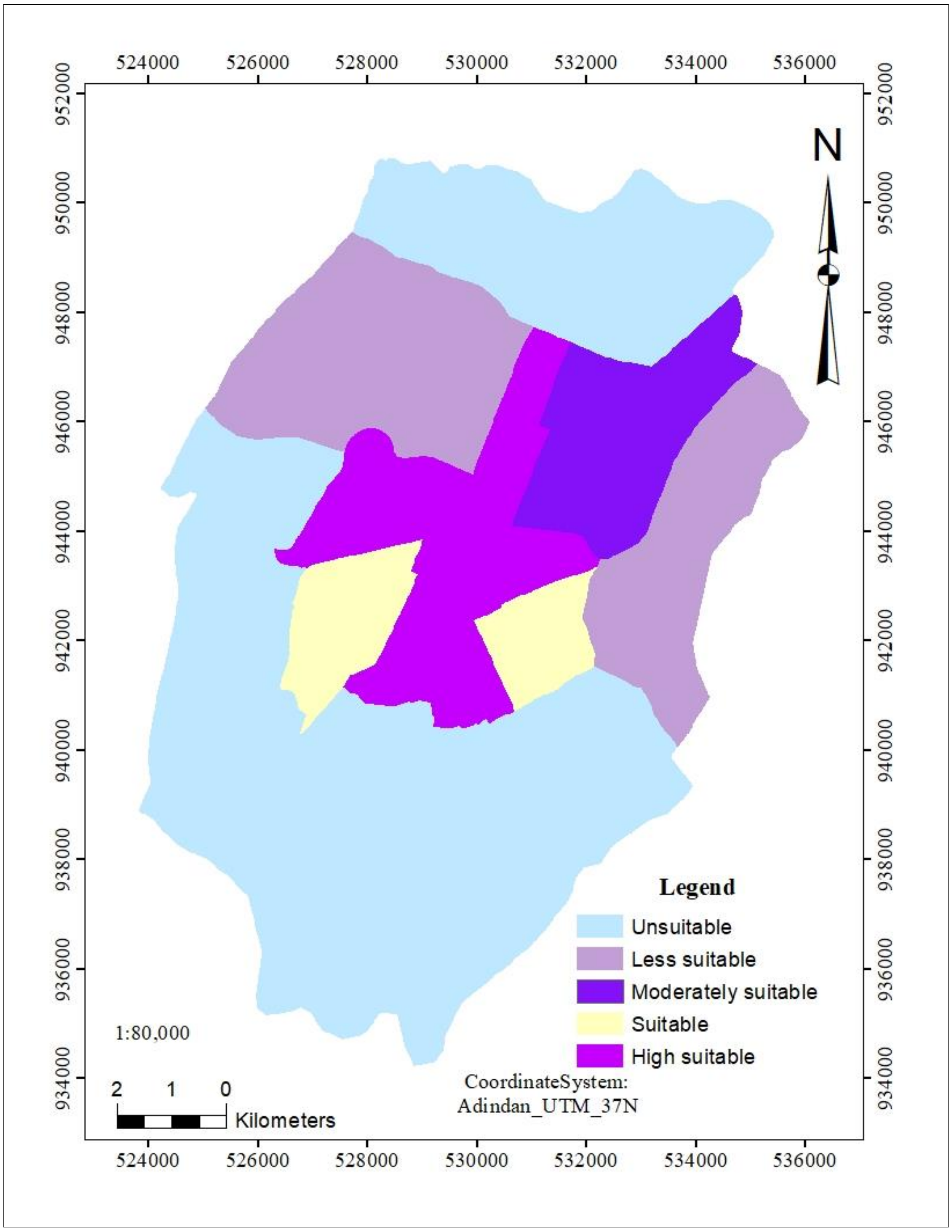

Figure 4.2: Reclassified population density map for UGS in the study area

The output map of the reclassified population density map illustrated in figure 4.2 The highly suitable area was 1644.58 ha (12.45%) in the Central part, the suitable area was 820.31ha (6.21%) in Central East and Central west parts, the moderately suitable area was 1016.47 ha(7.69%) in Northeast part, the less suitable area was 2669.32 ha (20.21%) in Eastern and Western parts and the unsuitable area was 7060.47 ha (53.44%) located in the Northern, Southern and Southwest parts of the study area.

4.4 Road Map

In this study, the road map was created using a proximity analyst tool from input road network shapefile data in the ArcGIS environment. The raster road map was reclassified into five classes. In the analysis, the cell size was 10m by 10m within the extent of the study area in ArcGIS software version 10.7. The suitability ranks for each reclassified road distances were assigned based on the proximity to UGS to access transportation as described in section 2.7.3

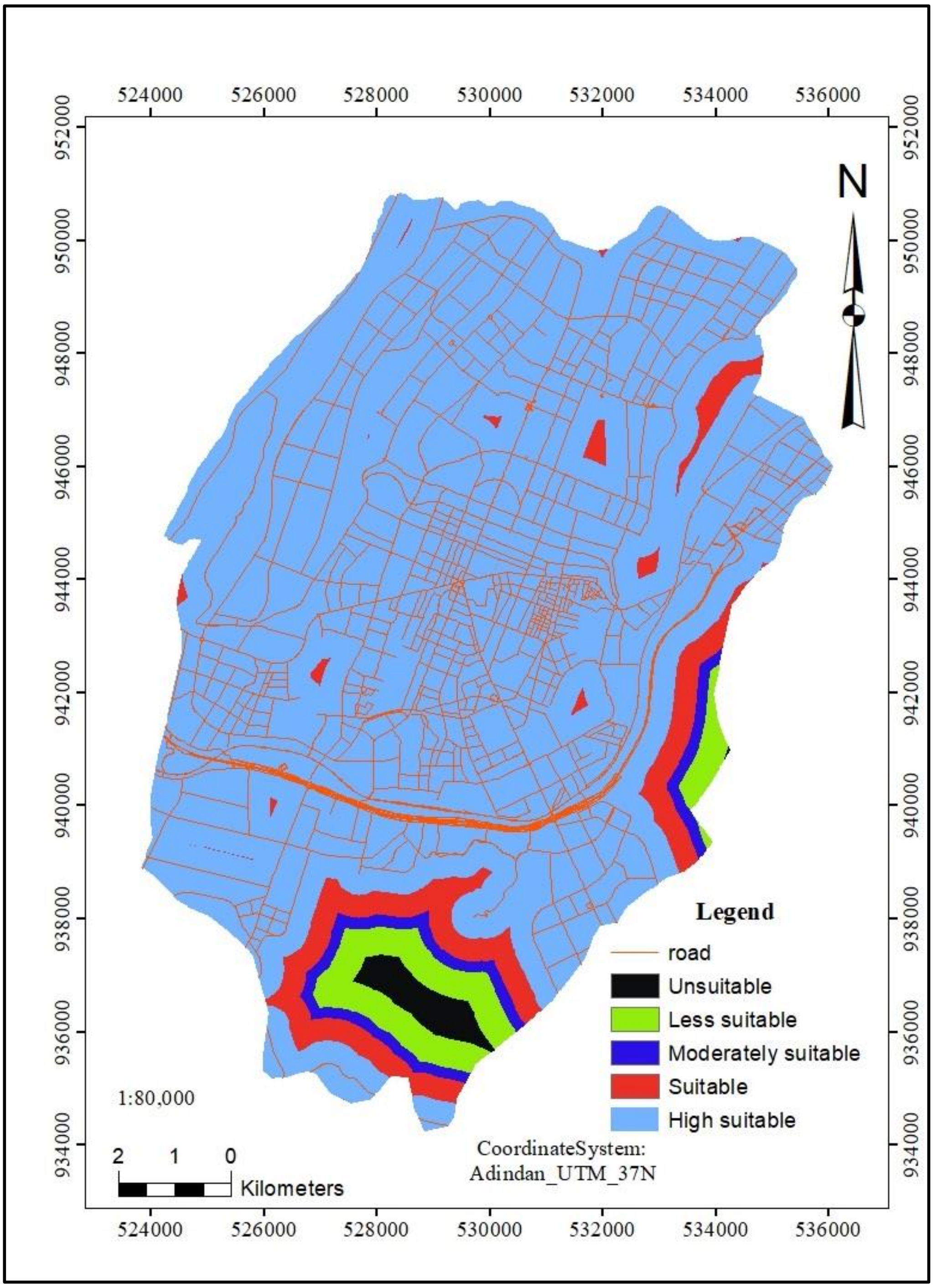

Figure 4.3: A reclassified road map for UGS in the study area

Figure 4.3 shows reclassified road map for UGS in the study area which was divided into a very highly suitable area of 11525.35ha (87.25 %) with the spatial location of the majority parts of the study area, suitable area of 804.58 ha (6.09 %), moderately suitable area of 264.35ha (2.00 %), less suitable area of 462.88ha (3.50 %) and unsuitable area152.99ha (1.16%) were located in Eastern and Southern parts of the study area. Generally, 95.34 % of the road distances in the study area were categorized from very highly suitable to moderately suitable areas to select UGS potential sites.

4.5 Soil Map

In this study, a soil map was created by dissolving similar soil type classes from input soil shapefile data using a dissolving tool in the ArcGIS environment. The raster soil type map was reclassified into four types of existing soil type classes namely haplic phaeozems, Mollic andosols, Eutric cambisols, Eutric fluvisols after conversion of its vector format map into a raster format. In the analysis, the cell size was 10m by 10m within the extent of the study area in ArcGIS software version 10.7. The suitability ranks for each reclassified soil type class were assigned based on section 2.7.4.

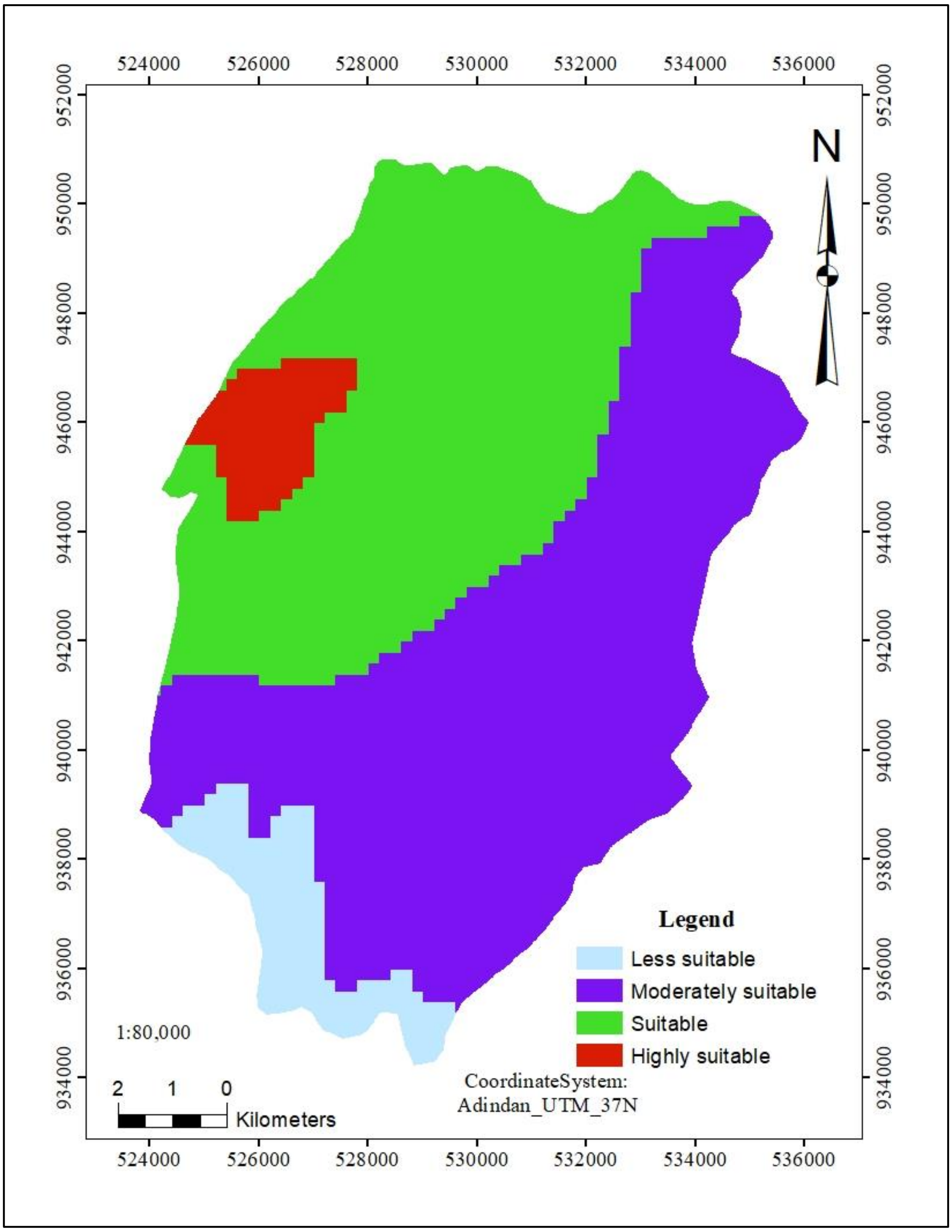

Figure 4.4: Reclassified soil map for UGS in study area

The reclassified map of soil reported that highly suitable area was covered by 546.56ha (4.14%) located in the Western part, the suitable area was 5250.23 ha (39.74 %) found in Northern and Northwest, the moderately suitable area was 6578.53 ha (49.79%) located in the Eastern, Northeast, Southeast and Southwest parts while the less suitable area was 835.83ha (6.33%) found in the Southern parts of the study area. This indicated that 93.67 % of the study area was from highly suitable to a moderately suitable level in terms of soil type classes of the study area.

4.6 Slope Map

The slope map was generated from Digital Elevation Model (DEM) data with a spatial resolution of 20 meters first DEM 20m resampled to 10m resolution using resample tool in ArcGIS 10.7 then slope map generated using spatial analysis tools by masking within the study area. The generated slope map was reclassified into 5 slope classes based on the FAO 2006 slope classification standard described in table 2.5. The suitability ranks were given for each class regarding the importance of the selection of UGS potential sites, gentle slope class was given the highest rank value to develop green space.

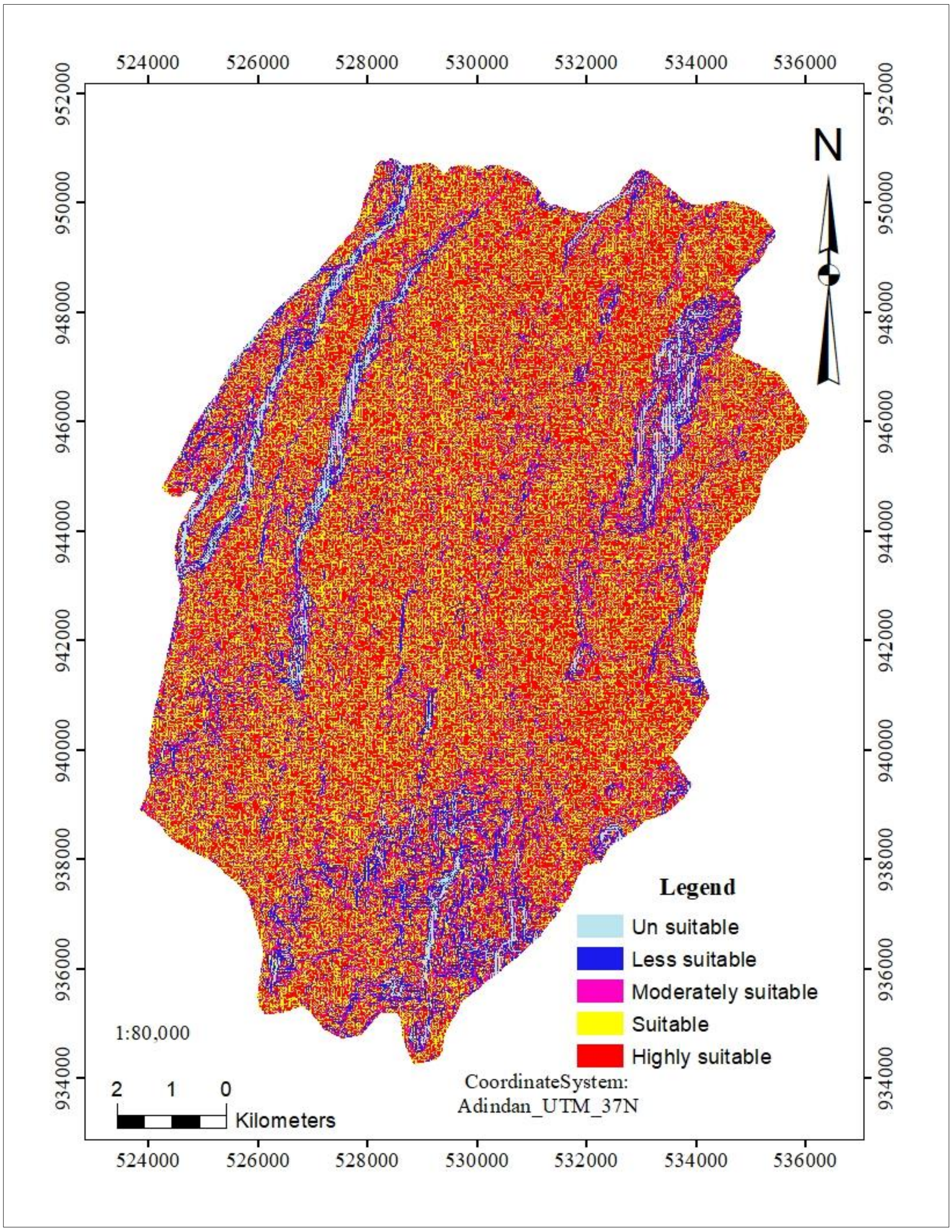

Figure 4.5: Reclassified slope map for UGS in the study area

The output map of the reclassified slope for UGS is demonstrated in figure 4.6. The highly suitable area of 5219.39 ha (39.60 %), suitable area of 3976.48 ha (30.2%), and moderately suitable area of 2140.06 ha (16.30 %) were scattered within the study area, less suitable areas of 1480.38ha (11.20%) and unsuitable area 349.26ha (2.70%) were located in the western, northeast and southeast parts of the study area scattered in most parts.

4.7 Stream Map

The stream map of the study area generated from Digital Elevation Model (DEM) with 20m resolution first DEM 20m resampled to 10m resolution using resample tool in ArcGIS 10.7 then using Arc GIS Hydrology Spatial analysis tools within the study area spatial extent. All sinks were removed or filled from DEM to keep continuity flow, flow direction was assigned to identify the flow direction of each cell's, then flow accumulation was estimated from flow direction which indicates how many upstream cells flow to each cell and converted into a vector layer or stream to feature, and then the maximum distance was calculated with the extent of the study area as well as it was converted into raster data in order to reclassified into five classes according to section 2.6.5. The closer lands to the stream banks got more preferences and highly suitable for green space development.

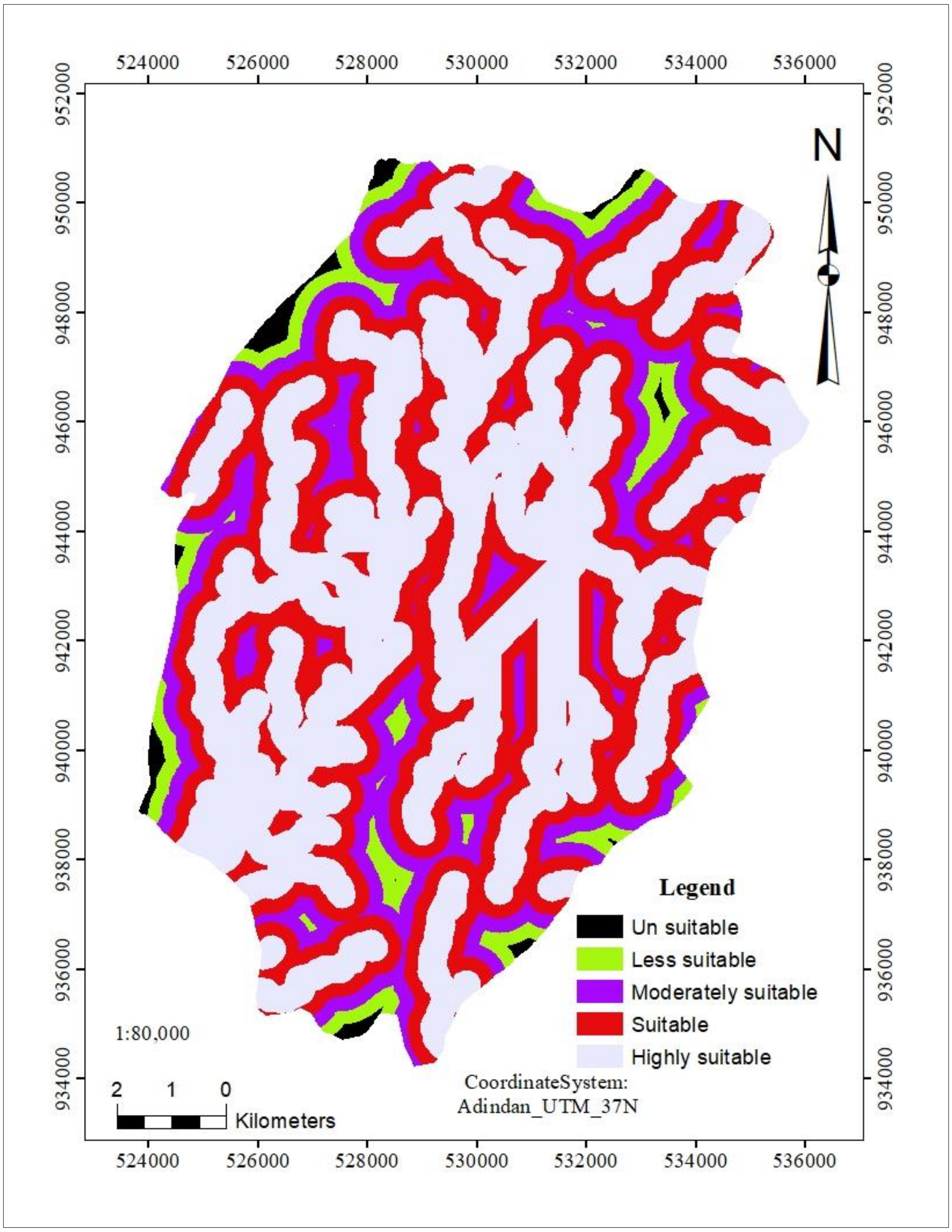

Figure 4.6: Reclassified stream map for UGS in study area

Figure 4.6 shows reclassified stream map for UGS in the study area which was divided into a highly suitable area of 6489.28 ha (49.12%) and a suitable area of 4130 ha (31.26%) where located in most parts of the study area, moderately suitable area of 1803.78 ha (13.65%), less suitable area of 627.81 ha (4.75%), as well as unsuitable area160.28ha (1.22%), were located in peripheral parts of the study area for UGS. The majority of the study area (80.38 %) was occupied by highly suitable and suitable levels of stream to select potential sites of UGS.

4.8 Weight Derivation

To identify suitable areas for UGS in the study area, a multi- criteria decisionmaking (MCDM) technique was used. The criteria which were taken into account for MCDM are LULC, road, stream, slope, soil, and population density. The Pairwise comparison method was developed based on an analytic hierarchy process (AHP) (Saaty, 1980) to estimate the weight for each criterion by creating a ratio matrix using the AHP tool in the Arc GIS software. As input, it takes the pair-wise comparison of the parameters and produces their relative weights as output. If the consistency ratio is less than or equal to 0.1, it shows an acceptable reciprocal matrix (Lawl et al., 2011). Hence, the consistency ratio weight calculation for this study is accepted with 0.049.

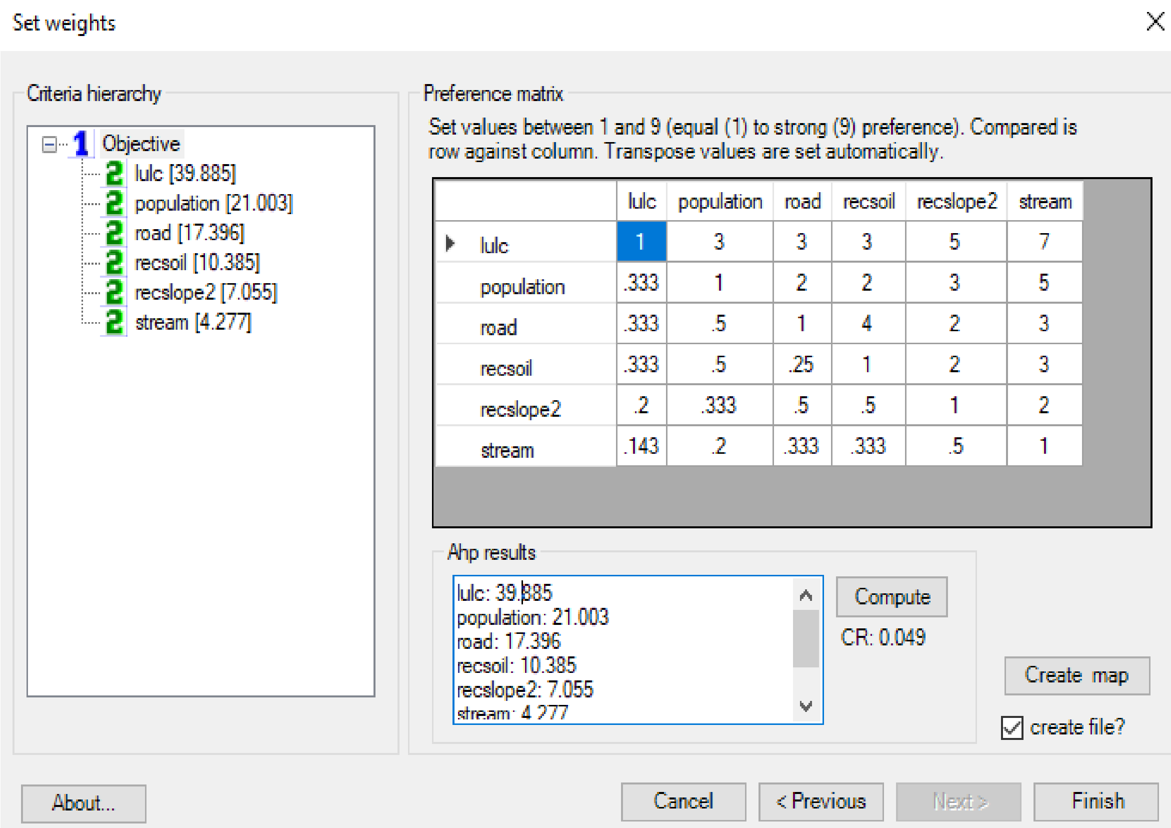

Figure 4.7: AHP Weight Derivation for UGS

4.9 Site Suitability Map for UGS

Weighted overlay analysis was done by combing each reclassified raster map for UGS with their corresponding weights which were developed in the Arc GIS software for each parameter of UGS using weighted overlay spatial analysis tools in the ArcGIS environment. The resultant polygon of homogeneous areas or the site suitability maps for UGS was produced.

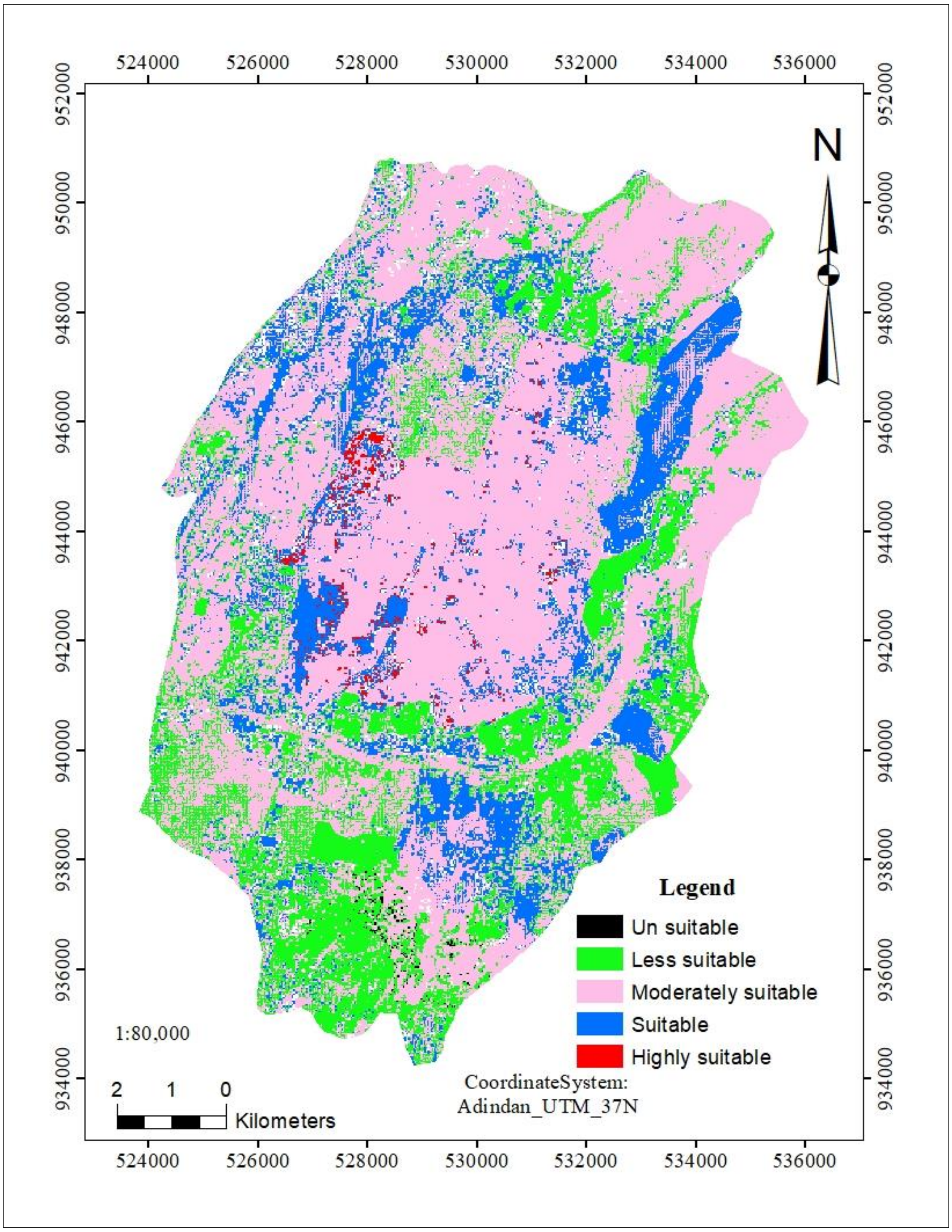

Figure 4.8: Suitability map for UGS in the study area

The output site suitability map of the UGS was displayed in figure 4.8. The map depicted the suitability status with the corresponding area coverage and their direction as followed: the highly suitable area was 105.39 ha (0.80 %) located in the Central West and South parts of the study area, the suitable area was 2151.2 ha (16.28%) found in Northeast, Southeast, Northwest and Southwest parts, moderately suitable area was 8261.62 ha (62.54 %) located in central and peripheral parts, and the less suitable area was 2672.37 ha (20.22%) found in Northern, Southern and Southeast parts while the unsuitable area was 20.57 ha (0.16%) spatially located in the Southern parts of the study area.

4.10 Evaluation of the City Master Plan (CMP)

4.10.1 Evaluation of the Existing UGS vs. CMP

In this study, Evaluation of the implementation of CMP 2004 for UGI was performed by taking into account from locational aspect of the UGI. The geographical locations of existing urban green infrastructures were collected with hand held Global Positioning System (GPS) instrument during field observation and also using Google earth. Hence, the collected data in the study area were evaluated by overlaying the collected point data on the CMP 2004 of the study area in ArcGIS environment.

Table 4.2 : status of CMP 2004 for UGS of the study area

	The proposed CMP 2004 for UGI	The implementation status of CMP 2004 for UGI based on LULC type			
		UGI	Bare land	Settlement	Crop land
Total coverage area(ha)	759.88 ha	578.56ha	25.92ha	86.24 ha	69.16 ha

According to table 4.2 from the total coverage area of CMP 2004 for UGI merely 578.56 ha of the UGI area was implemented. The rest areas were occupied by settlement 86.24 ha (11.35 %), bare land 25.92 ha (3.41%) and crop land 69.16 ha (9.1%). Based on the report of Adama city administration urban land sectors office the changes of UGI areas to settlement due to the increment of population year to year. Some investors request the UGI areas for different investments like manufacturing and Commercial Buildings, Municipality Permits for investors to encourage the investment.

Some proposed UGS areas of CMP 2004 exist in the ground as bare land because they are not developed or planted as UGS by the community or and city administration office till now. Some of the UGS areas was changed to bare land due to disforestation by the community for firewood and grazing for the domestic animal special at peripheral areas of the study area while some of UGS areas were changed to cropland due to increment of population and lack of cultivation land for farmers lived around peripheral areas of the town.

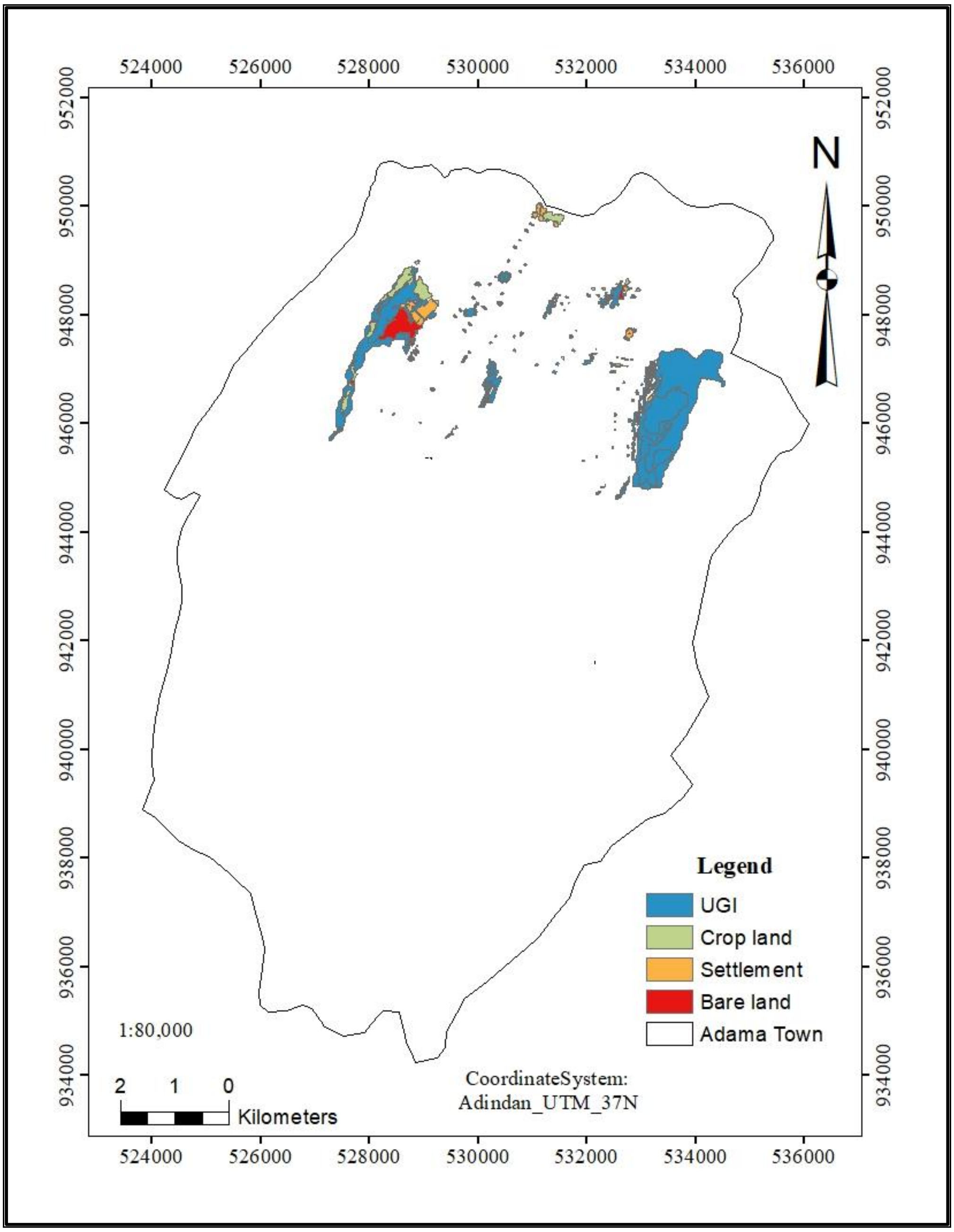

Figure 4.9: CMP 2004 for UGS in the study area

4.10.2 Evaluation Of CMP 2004 Vs. UGS Proposed Suitability Map

In this study, the Evaluation of CMP 2004 in the study area was conducted by taking into account the locational aspects of the UGS in the suitability map. The extracted UGS 2004 was overlayed on the developed suitability map of UGS in the ArcGIS environment. From the result, the 336.536 ha (54.14 %) of urban green space are located in a suitable area and the 262.61 ha (42.25 %) of UGS located in a moderately suitable area and the 22.43ha (3.61%) area are less suitable. From the result of the analysis of the evaluation of CMP 2017 versus UGS suitability map, the majority of UGS were in the suitable and moderately suitable domain in the study area.

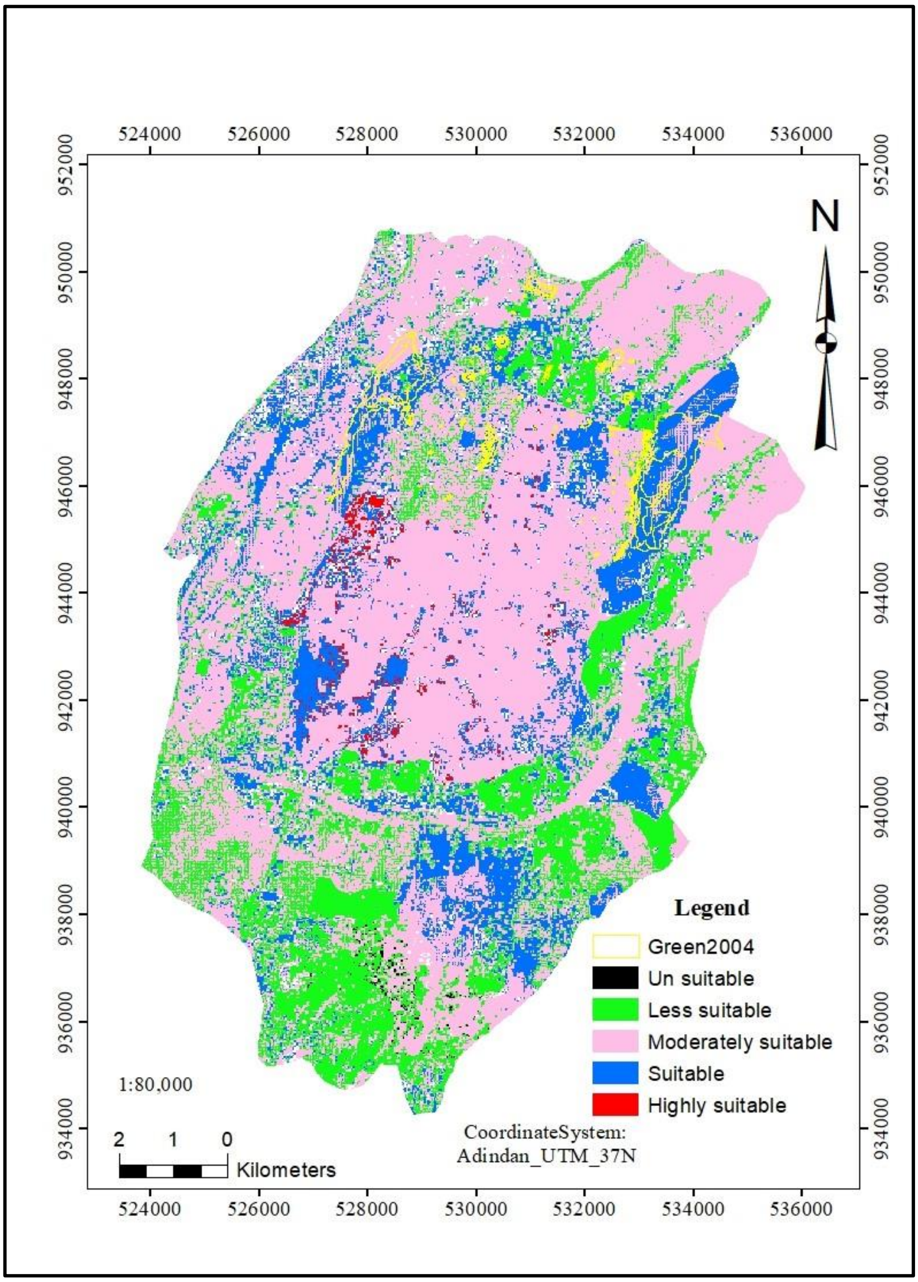

Figure 4.10 : Green Space of CMP 2004 with suitability map

4.10.3 Evaluation Of CMP 2017 Vs. Proposed UGS Suitability Map

Evaluation of CMP 2017 in the study area was conducted by considering the locational aspects of the UGS in the suitability map. The extracted UGS 2017 was overlayed on the developed suitability map of UGI in the ArcGIS environment. From the result, the 423.73 ha (73.24 %) of urban green structures are located in a suitable areas and the 310.14 ha (57.86 %) of UGS located in a suitable area and the 216.32ha (40.36%) area are moderately suitable. The rest 9.55ha(1.78%) located in a less suitable area in the proposed suitability map. From the result of the analysis of the evaluation of CMP 2017 versus UGS suitability map, the majority of UGS were in the suitable and moderately suitable domain in the study area.

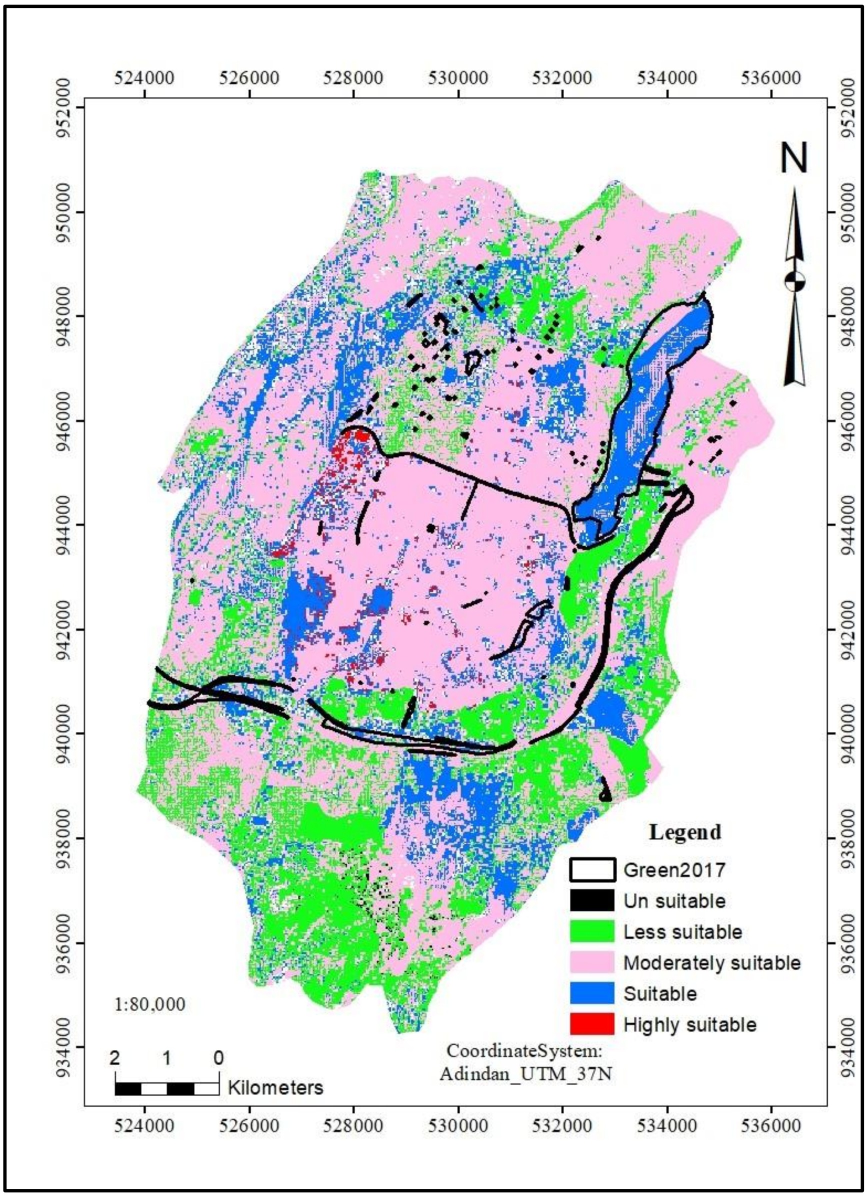

Figure 4.11: Green Space of CMP 2017 with suitability map

4.11 Evaluation of the existing UGS vs. Proposed UGS Suitability Map

Evaluation of existing UGI in the study area was conducted by considering the locational aspects of the UGI. Geographical locations of urban green structures were collected with the hand-held Global Positioning System (GPS) instrument during field observation. Accordingly, the collected locational information of the existing urban green structures in the study area was evaluated by overlaying the collected waypoints on the developed suitability map of UGS in the ArcGIS environment. From the output, the 423.73 ha (73.24

%) of urban green structures are located in a suitable areas and 149.80 ha (25.89 %) of found in a moderately suitable areas and the rest 6ha (0.86%) covered less suitable. From the result of the analysis of the evaluation of the existing UGI versus the suitability map, the majority of existing UGI locations of UGI was in the suitable and moderately suitable domain in the study area.

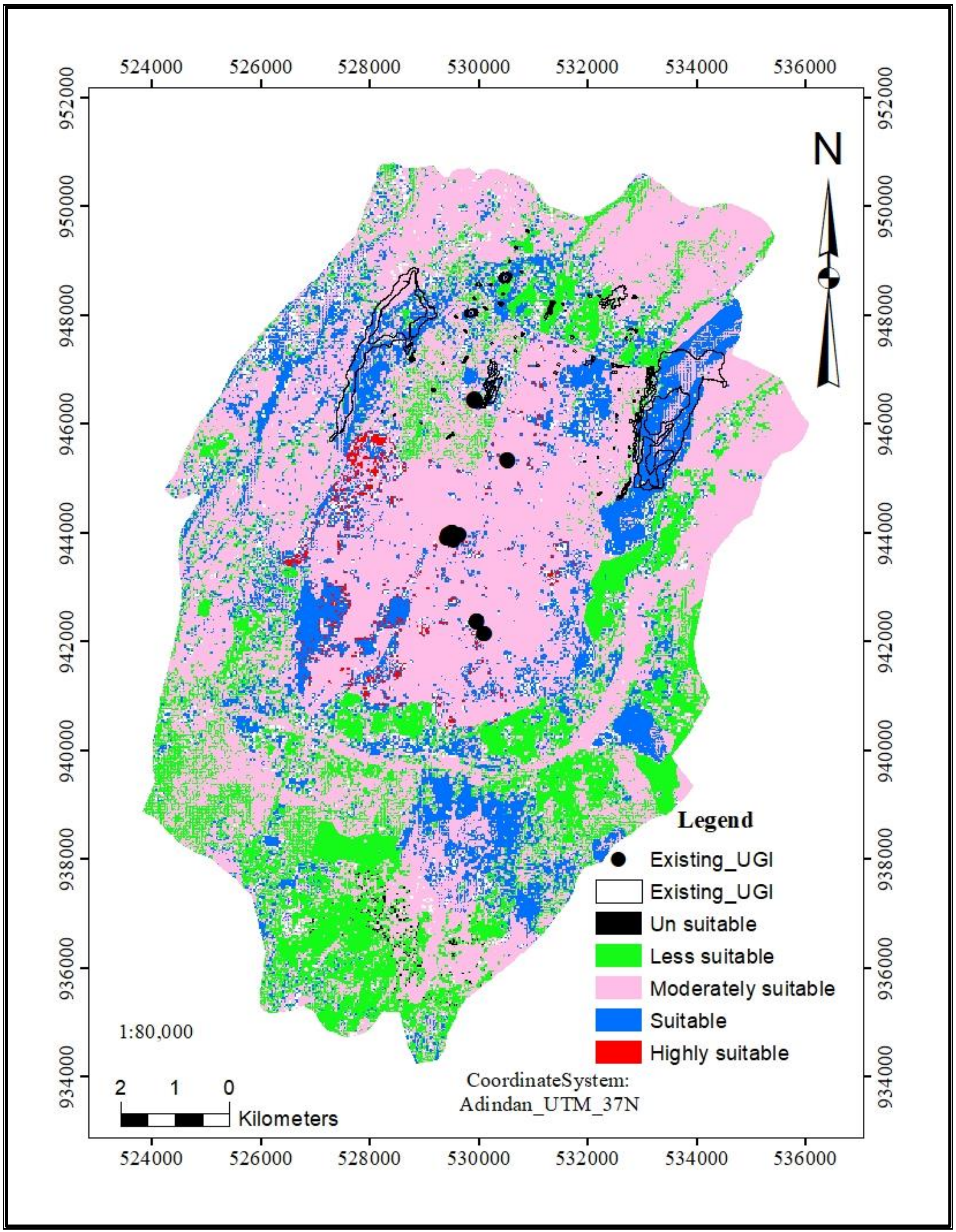

Figure 4.12: Existing UGS in the study area.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The 181.32 ha (23.86 %) areas of proposed UGI of CMP 2004 were changed into settlement, crop land and bare land due to the increment of population, for firewood and grazing purposes.Since green spaces are essential components of the urban environment and provide several advantages by serving as a city lung, improving the center for physical, psychological stress relief, and improving social cohesion through social interaction and recreation. Further, lack of public awareness, low level of community participation, poor implementation of government policies, lack of cooperation among different stakeholders have contributed to the attenuation of green spaces in the town.

Since the analysis of urban green spaces is important by the use of appropriate analytical methods to identify their potential and to better choose the most appropriate land use to enhance their integrity and preserve the benefits obtained from them, Land suitability analysis is a critical element in determining areas suitable for some specific purposes such as green space development. From the study, we can see that little space has been given for the development of green areas. The classification achieved in this study indicates that a large area is moderately suitable for green space development in the existing situation (62.54 % of the area). The town, therefore, has great potential to develop adequate urban green spaces.

The evaluation result achieved from two master plans which are CMP 2004 the UGS in the suitability map the 336.536 ha (54.14 %) of urban green space is located in a suitable area which is the largest area and the 262.61 ha (42.25 %) of UGS located in a moderately suitable area and the 22.43ha (3.61%) area are less suitable. Also from the Evaluation of CMP 2017 the result obtained 423.73 ha (73.24 %) of urban green structures are located in a suitable areas and the 310.14 ha (57.86 %) of UGS located in a suitable area and the 216.32ha (40.36%) area are in moderately suitable. The rest 9.55ha(1.78%) located in a less suitable area in the proposed suitability map.

As demonstrated in this study GIS technologies can play a crucial role in urban research which strongly helps the site selection process to establish urban green spaces. Besides it has outstanding spatial problem-solving capabilities, as seen in this report, it has been used to help spatial decision-making, and AHP is a versatile and practical tool for selecting urban green areas in the study area. This research, therefore, provide a structure for the planning process using GIS and AHP for the planning of the Ethiopian County and the findings can be useful in urban green space planning and future land use planning in the study area.

5.2 Recommendations

The following suggestions are forwarded based on the review of the research results to facilitate the creation of green spaces. Legal structures should be developed and implemented. To ensure sustainable green areas for the long term, an adequate management system is necessary. The current system of management of green spaces, particularly the city's street trees, is weak. As the results of the study revealed, the health of street trees was found to be fair, showing poor/lack of management practices.

GIS technologies are critical for multi-criteria decision-making processes, as seen from several past findings, including this one. Therefore, the city administration and beautification, park and sustainable development administration agency need to respect the national standard of green space coverage of the town as outlined in the master plan Using GIS technologies to update the green space coverage and to reconcile various criteria such as physical, socio-economic, environmental criteria that have seen from this study, formulate guidelines to develop and manage the urban green space in the context of GIS-MCA process. Moreover, the town administration, particularly beautification, park and sustainable development administration should encourage the community and stakeholders so to develop and maintain a community garden in line with the master plan and LDP (local development plan).

Finally, future research should concentrate on determining the suitable site selection for urban green spaces portion such as park, roadside green, green area, and the like, separately.

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APPENDIX

Appendix: Ground Truth Data

NO	X	Y
0	532947.9249	949522.8205
1	534633.9157	949680.4486
2	533391.5654	950133.9547
3	529592.9631	950299.4042
4	528759.0984	949466.5677
5	529188.9174	949497.6948
6	525158.6431	940128.3732
7	525741.6791	939860.4606
8	525972.6224	939282.3619
9	525128.7472	942102.8178
10	527006.3534	945084.9443
11	524727.4361	938807.644
12	525382.5178	944634.8999
13	528741.652	948814.3046
14	526154.2477	946882.0137
15	527413.8401	938438.4565
16	528584.3579	939275.1702
17	526798.8862	939072.7459
18	527426.8175	936892.5157
19	527364.3902	935261.2131
20	528315.4888	936031.6789
21	532437.6371	938788.657
22	532947.12	939885.4404
23	533111.2886	939074.8831
24	532374.9581	940847.5423
25	532110.3791	940479.2147
26	532610.3008	941204.9462
27	532996.4998	942378.3403
28	533873.2175	942730.7945
29	534014.2306	943271.4661
30	533178.7302	943133.0039
31	534121.1246	944052.5411

32	534316.8816	944459.7914
33	534637.7843	944391.6532
34	534629.7025	945086.143
35	534986.1034	944865.9501
36	534195.2979	945566.3685
37	535478.2133	945653.6083
38	535598.154	946459.7062
39	534736.9587	947098.1182
40	534436.163	946837.7095
41	535716.675	945965.4919
42	532229.7637	949667.388
43	532842.8507	948505.7074
44	530319.9062	949329.8001
45	531622.4428	941647.9094
46	531401.6778	941998.5482
47	528305.6879	942108.6437
48	527925.0022	941651.6175
49	528313.6738	941777.0846
50	529009.3109	944982.6602
51	528566.1551	944103.1399
52	530387.1159	943458.6671
53	527970.3881	942738.8177
54	529219.4592	941896.0242
55	530421.625	943074.0982
56	531628.1056	944528.2393
57	531588.459	945357.4022
58	532262.5193	944960.7369
59	532543.7968	945587.601
60	531815.9565	944260.6972
61	530832.2902	944339.1914
62	532324.3558	943665.6804
63	529741.5334	945645.3266
64	529726.3505	945885.4546
65	528816.3341	946234.2834
66	528939.4418	946838.4035
67	529644.3356	947098.8182
68	531000.5047	946616.7375
69	531484.1804	947265.687
70	529574.6495	945067.1485
71	530664.854	945340.4932
72	529221.9903	947544.1864
73	530567.9961	947822.9474
74	529065.1315	942862.2213
75	528750.1673	942064.8573

76	530565.1737	942477.1524
77	530958.1192	942793.2399
78	531161.1333	942316.6174
79	530359.8273	941960.8609
80	529012.3917	941166.4336
81	528692.258	941302.9389
82	529694.4193	941885.7431
83	530158.7271	940872.3981
84	529794.4403	940707.0945
85	528772.4363	940538.8707
86	527217.337	941615.2594
87	527483.1149	941788.676
88	531485.1983	948235.0042
89	531713.3764	948694.3569
90	532187.048	948034.6147
91	533176.2756	947322.6146
92	532645.7841	946455.0541
93	533554.1019	943982.8987
94	532913.322	943629.9333
95	533145.5089	943843.3023
96	533612.2257	944672.4207
97	530373.1588	940325.3685
98	531854.4044	939663.1679
99	531635.1254	939264.143
100	533077.1419	945818.8979
101	533078.9479	945732.598
102	533055.7871	945664.5743
103	533036.5708	945579.6553
104	533009.4972	945463.2964
105	533691.2412	948857.7971
106	533686.5826	948762.1305
107	533748.6279	948947.3614
108	533725.2156	948913.7993
109	534129.129	948252.0146
110	534073.4487	948223.956
111	532727.0742	950241.86
112	532882.545	950359.3553
113	532423.4629	950004.6481
114	532337.758	949974.4318
115	531977.2064	949528.7409
116	531926.888	949473.7692
117	533598.6781	948553.8681
118	533503.4	948382.8209
119	533760.9636	947899.03

120	527670.4624	943347.5765
121	527656.76	943008.9866
122	527095.0324	943021.9583
123	526891.0925	943305.0246
124	526800.3078	943084.427
125	526770.0475	942966.0004
126	526666.8507	942826.615
127	525862.0241	942631.425
128	525801.0123	942767.8494
129	525748.2494	942589.7951
130	526991.6154	943655.0476
131	527929.4918	944380.0274
132	528013.9178	944530.2224
133	528098.4917	944285.8477
134	528327.3153	945208.2857
135	529254.9041	943703.6095
136	529260.1945	943974.9837
137	529792.5057	943489.2059
138	529827.701	944021.0121
139	531284.2248	945552.2785
140	531373.2844	945759.118
141	531245.4593	945491.511
142	526389.1866	936919.6888
143	526504.9348	937428.2127
144	527041.8921	937446.1904
145	527105.041	937955.5242
146	525955.9021	937310.4617
147	525617.6119	937889.1657
148	530826.1573	940994.4584
149	531237.9532	940815.4997
150	532836.6558	940780.6432
151	533318.6905	940315.483
152	533072.1428	940522.3062
153	530636.3479	938667.9489
154	532283.1946	938200.4911
155	528935.6976	937299.1941
156	529796.1512	936193.7251
157	529416.2938	939381.3164
158	528631.6515	937807.633
159	528436.3705	937429.2515
160	531162.5509	949131.5093
161	530526.9257	948356.3306
162	531522.1582	949165.3175
163	529913.2574	948728.9497

164	528928.1698	947813.2428
165	528229.7259	947058.7342
166	528079.1827	946769.1127
167	527670.0917	945844.3342
168	525362.426	945142.5671
169	525685.516	945614.961
170	525129.0951	944858.1671
171	524607.4497	943800.9284
172	526279.6786	942220.1824
173	526426.5752	942277.0794
174	526242.7479	942382.5352
175	526611.4926	941228.5705
176	526873.9323	942116.2222
177	526978.1778	941968.6053
178	525722.9179	940678.1543
179	526849.9192	939559.7551
180	530033.5378	937774.0159
181	530877.3217	937478.1659
182	530967.6104	937151.2644
183	530461.7143	938454.5481
184	529370.6533	938920.1599
185	529882.1426	939247.586
186	530455.4296	938896.734
187	528726.1273	938496.1536
188	528509.9452	936855.498
189	528907.6142	937053.1906
190	532587.7631	938570.8605
191	533060.914	944068.9277
192	533104.8838	944862.5706
193	533836.7336	945571.8052
194	533958.6195	945964.4278
195	533378.5099	946546.8947
196	529303.1748	948483.5562
197	529515.2788	948421.0445
198	529076.2478	948104.3922
199	529838.0123	948116.1181
200	528615.765	950595.618
201	528633.5372	950052.812
202	528027.8414	949384.9883
203	527829.948	949138.202
204	527597.4756	948783.4498
205	527419.1029	948523.2011
206	527214.6229	948066.0738
207	526392.6796	947658.0801

208	526322.1843	947356.6745
209	527714.8252	946354.3443
210	527520.3443	945694.5095
211	527942.1101	947092.5749
212	526006.2862	945776.0671
213	526946.378	946183.4668
214	525550.1764	944318.5524
215	525838.1832	944819.118
216	524851.3004	944293.9565
217	525105.0962	944625.3906
218	526944.5195	942660.6039
219	526953.0358	942363.2253
220	527307.6004	942662.8334
221	526468.7044	942852.1597
222	526073.359	942805.7153
223	526622.3126	943254.8622
224	525385.0844	938093.9405
225	525618.3353	938036.3946
226	525894.9359	938652.9082
227	525208.7025	938665.9841
228	529325.1353	938245.2746
229	530776.4976	936709.0241
230	530714.6943	936540.326
231	529639.9103	938733.3477
232	530169.3999	938780.3619
233	528640.4349	942741.844
234	528469.4679	942608.7802
235	528489.1126	942856.2601
236	533761.9079	946638.8365
237	533542.7129	946247.7372
238	532657.3327	944468.5554
239	534380.2324	947499.6544
240	534306.3063	948153.0987
241	533851.1339	947308.0528
242	531825.0556	946941.4923
243	532106.3952	946933.1395
244	532354.0673	946429.7063
245	531801.0977	946142.4568
246	531341.1227	946149.7223
247	531087.2021	946195.7819
248	529913.3224	947098.1791
249	529934.5201	946940.0248
250	526276.0743	938463.5241
251	526400.1309	939040.3108

252	526213.8217	938531.2126
253	525962.4709	937556.6677
254	526525.5309	936999.2115
255	526543.3915	937133.0903
256	526698.176	937698.878
257	526932.1943	937012.6365
258	530151.7618	937622.2889
259	529412.9747	937819.1908
260	532326.928	940288.8342
261	532471.1523	940428.6242
262	531643.9551	940959.6612
263	531214.615	941332.0838
264	530985.907	941341.9583
265	530844.7	941396.2378
266	532181.3533	941855.707
267	532006.4749	941605.9257
268	531389.8037	943365.7568
269	531594.6666	943446.2029
270	531688.4761	943894.5184
271	531551.9336	943842.9925
272	529043.8876	942342.6319
273	529501.4879	942502.5276
274	529595.9782	942880.0919
275	529862.4026	942454.5512
276	529274.269	940898.1908
277	529313.6272	940790.2583
278	528915.2064	940165.9291
279	529512.1434	940151.3838
280	525943.6001	940521.2357
281	526102.8638	940950.1643
282	526435.2074	940329.4511
283	526681.428	939583.8196
284	524371.348	940819.9512
285	524827.4182	940964.1119
286	524323.7835	940722.0438
287	525510.5748	941542.0645
288	524345.5982	940221.8898
289	524248.1549	940088.5867
290	524231.3006	939231.9123
291	524178.7342	939455.2785
292	530348.3543	950175.8573
293	531164.4337	949794.7849
294	530538.61	949518.5676
295	529900.3196	949495.7138

296	529301.269	948831.0828
297	529178.4944	948760.6737
298	530180.7247	948715.3524
299	532270.5778	948560.2834