URBAN GREEN SPACE DEVELOPMENT SITE SUITABILITY ANALYSIS USING GEOSPATIAL TECHNOLOGY: A CASE OF MODJO TOWN, ETHIOPIA

Name of candidate: Balcha Tadesse Tefera

A thesis submitted

to

The Department of Geomatics Engineering

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Geo-informatics

Office of Graduate Studies

Adama Science and Technology University

Adama, Ethiopia

September, 2023

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APPROVAL OF BOARD OF EXAMINERS

I/we, the advisors of the thesis entitled "URBAN GREEN SPACE DEVELOPMENT SITE SUITABILITY ANALYSIS USING GEOSPATIAL TECHNOLOGY: A CASE OF MODJO TOWN, ETHIOPIA" and developed by Balcha Tadesse Tefera, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by Balcha Tadesse Tefera, have read and evaluated the thesis entitled "URBAN GREEN SPACE DEVELOPMENT SITE SUITABILITY ANALYSIS USING GEOSPATIAL TECHNOLOGY: A CASE OF MODJO 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 Engineering, the Graduate program of the department of Geomatics Engineering.

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CANDIDATE’S DECLARATION

I hereby declare that this Master Thesis entitled “URBAN GREEN SPACE DEVELOPMENT SITE SUITABILITY ANALYSIS USING GEOSPATIAL TECHNOLOGY: A CASE OF MODJO 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.

Balcha Tadesse Tefera	______________________	________________
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "URBAN GREEN SPACE DEVELOPMENT SITE SUITABILITY ANALYSIS USING GEOSPATIAL TECHNOLOGY: A CASE OF MODJO TOWN, ETHIOPIA" prepared under my guidance by Balcha Tadesse Tefera submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Geo-Informatics Engineering, the Graduate program of the department of Geomatics Engineering. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Dejene Tesema (PhD)	____________________	_______________
Major Advisor	Signature	Date

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LIST OF ACRONYMS

AHP	Analytic Hierarchy Processes
CAD	Computer Aided Design
CSA	Central Statistical Agency
CR	Consistence Ratio
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
ERDAS	Earth Resource Data Analysis System
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPS	Global Positioning System
LSA	Land Suitability Analysis
LULC	Land Use/Land Cover
MCA	Multiple-Criteria Analysis
MCDA	Multiple-Criteria Decision Analysis
NUGIS	National Urban Green Infrastructure Standards
TIFF	Tagged Image File Format
UGI	Urban Green Infrastructure
UGS	Urban Green Space
UN	United Nations
USGS	United States Geological Survey
WLC	Weighted Linear Combination

ABSTRACT

One of the critical issues in urban planning is the determination of appropriate locations for urban green space development in and around the town. This study demonstrates the use of Geospatial technology based Multi-Criteria Decision Analysis (MCDA) techniques for selection of suitable sites for urban green space development of Modjo Town. Nine factors (proximity to transportation, proximity to river, proximity to facility location, proximity to noise influence, land use land cover, slope, soil, population density and proximity to residential area) were identified for criteria evaluation. The thematic maps of these criteria were prepared and standardized using pair wise comparison matrix known as Analytical Hierarchy Process (AHP). A weight for each criterion was given by comparing them with each other according to their importance, the consistence of comparing matrix were checked by calculating the consistence ratio (CR). The consistency ratio of this study indicated that 0.04 which is less than 0.1. Thus, consistent matrix was formed which was acceptable in order to combine all the layers. Finally using these weights all maps layer were integrated and overlaid to generate final site suitability map for the urban green space development. The final site suitability map was reclassified to five suitability classes: highly suitable, moderately suitable, marginally suitable, currently not suitable and permanently not suitable. The findings of this study revealed that 5.47% area is highly suitable, 27.59%areais moderately suitable, 51.45% area marginally suitable, 11.70% area is currently not suitable and 3.79% area is permanently unsuitable for urban green space development. This result shows that most of the area selected as highly suitable for future urban development are Shrub and bushes, bare land and farm land.

Keywords: *Geospatial Technology; Site Suitability analysis; Multi-Criteria Decision Analysis; Urban green space development*

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

With more than 50% of the global population now living in urban areas, the world has experienced unprecedented urban growth in recent decades (Wu, 2014). In the last few decades, substantial growth of urban areas has occurred worldwide with population increase being one of the most obvious agents responsible for this growth (BARBARA, 2012). The world population has increased from 2.58 billion in 1950 to 7.8 billion people in 2020 and is projected to 9.7 billion by 2050 (UNDESA, 2020). According to the World Urbanization Prospects reported by the United Nations (UNDESA, 2020), the global population living in the urban area increased from 30% in 1950 to 56.2% in 2020 of the world's population and by 2050, 68% of the world's population is projected to be urban. Because of the ongoing urbanization and growth of the world's population, there will be about 2.2 billion or more people are expected to be added to the urban population by 2050, mainly in Africa and Asia. This rapid urbanization has posed greater pressure on natural resources and the environment (Rees and Wackernagel, 1996; Shi, 2002) and the amount of land exploited for infrastructure development and buildings has increased at the expense of urban green spaces (Sandstrom, 2002).

Ethiopia is the second most populous country in Africa with 120.8 million inhabitants (United Nations, 2022). According to the National Report on Housing & Sustainable Urban Development, Ethiopia is one of the least urbanized countries in Sub-Saharan Africa. Currently,20 percent of the total population lives in urban areas (MoUDC, 2014). 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 (MoUDC, 2014).

Green spaces are land uses that are covered with natural or man-made vegetation in the built-up areas and planning areas (Manlun, 2003). Urban green spaces (UGS) are of crucial importance, especially in an urbanized world, as they are the key providers of ecosystem services and improve the quality of life of urban dwellers. Urban Green Spaces provide various environmental, socio-cultural and economic benefits to cities and their population. According to the World Health Organization (2017), UGS are innovative, nature-based approaches that increase the quality of urban settings, enhance local resilience and promote sustainability in response to pressures of urbanization and climate change. According to Mitchell and Popham, (2007), people who live near green spaces are healthier than people who live farther from green spaces. Therefore, it is necessary that they are distributed equitably to all population groups in the city and town (WHO, 2017). As noted by WHO (2017), green space intervention scan improves environmental conditions (e.g., filtering pollutants and CO_2 from air), protect and improve biodiversity, promote outdoor activities and active lifestyles, increase social interactions and provide good physical and mental well-being. These benefits can be maximized for all communities through adequate planning, design collaboration and evaluation (WHO, 2017).

Despite the numerous above-mentioned benefits, urban green spaces are unable to provide urban dwellers with the desirable services due to increased urbanization and unplanned urban growth, lack of proper site selection and planning, lack of attention to population thresholds (Wright and Nebel, 2002; Ahmadi et al., 2016). The urban green spaces exposure is not enough to meet the increasing population pressure per unit area along with growing human pressure, expansion of building construction sites and industrialization in the process of urbanization (Cetin, 2015). According to Jim and Chen (2003), with the increasing populations require for municipal areas, some ecological and environmental roles move towards improving the eminence of life. 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). Therefore, by taking into consideration environmental, physical, accessibility and socio-economic factors, well planned and well-designed green spaces within the reach of the community are mandatory in order to maximize the value that green spaces bring to urban dwellers and their environment in a sustainable way (Giles-Corti et al., 2005).

Land suitability analysis (LSA) is the process to determine whether the land resource is appropriate for some specific uses and to determine the suitability level by considering different influencing factors such as land use and land cover type (LULC), landscape, soil type, road infrastructure and other basic factors (Manlun, 2003). LSA is vital in urban green spaces planning as it gives room for choosing the most suitable site from among various alternatives (Sahabo and Mohammed, 2016). The suitability analysis of urban green space development is considered as one of the most important and effective techniques for identifying the best urban green space development locations. This technique employs different types of criteria and weights (Alexander et al., 2012). For suitable site selection, the multicriteria analysis (MCA) approach that is integrated with the Geographical Information System (GIS) has been increasingly used (Uy and Nakagoshi, 2008; Van Berkel et al., 2014; Ustaoglu, and Aydınoglu, 2020; Achalu, 2021). In order to determine different land problems considering the alternatives, MCA focuses on various parameters such as biophysical, socio-economic and policy-related factors in decision-making processes (Pramanik, 2016).

Both in developed and developing countries, MCA methods integrated with GIS have been widely applied to select agricultural sites, industrial sites, residential areas, landfill sites, wind farms, disaster area, health centres, urban development site and education centres (Rikalovic et al., 2014; Rahmati et al., 2016; Marsh et al., 2016; Vasileiou et al., 2017). To choose a suitable location for the development of urban green spaces and in urban planning, the MCA technique has not been used very well in developing nations like Ethiopia as a tool for making decisions based on the structural plan and situation of the area at all. In order to determine the best location for the development of urban green space, this study used geospatial technology to quantify and evaluate the conventional techniques of existing and projected urban green space development in the town based on the town structural plan.

1.2 Statement of the Problem

Rapid Urbanization is an important global phenomenon and it becomes a great concern for many parts of the world. Today, more than half of the world's population resides in urban areas, and this is due to socio-economic reasons which lead people to move from rural areas to urban areas (UNDESA, 2018). Therefore, the trend towards urbanization is increasing, which results in the growth of the urban population and the extent of urban areas (UNDESA, 2018). In recent decades, due to concerns over clean air, water, climate and land-use change, sustainability has attracted attention, especially sustainable urban planning (Wheeler and Beatley, 2014). Since changes in urban population result in land-use change, effective land use planning is needed to evaluate the best sites for urban green space development.

One of the major impacts of urban expansion is a shrinking of urban green spaces, through the development of new 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, heatwaves 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.

Modjo is a Town in Ethiopia, where this study was conducted, has also an experience of greater challenges of urbanization and industrial construction which directly or indirectly affect both natural and man-made urban green space in the town. As reported by Modjo Town mayor office and municipality of the town during the last twenty years, urban area has increased due to construction huge industries and infrastructure development, while both natural Shrub and bushes and man-made green area has decreased which is unbalanced and very small compared with rapid urbanization and population growth of the town. The problem is expected to get worse in the coming years due to the huge construction of factories, expansion of residential area, construction of road and less attention given to UGS. At this time planner's role becomes important to find suitable site for UGS development in the town to reduce this problem using geospatial technology.

In Ethiopia, there were some studies conducted on green space using geospatial technology and these studies have focused on the impacts of urban growth on green space (Gashu and Gebreegziabher, 2018; Abo et al., 2018),the development of functional green infrastructure and ecosystem service (Woldegerima et al., 2017), planning aspect (Girma et al., 2018), green spaces depletion (Girma et al., 2019a),utilization pattern (Molla et al., 2017; Girma et al., 2019b), Designing Potential Greenways (Adinew, 2018). However, these studies did not give attention to the issue of site suitability analysis for green space development in the urban area and they did not used up-to-date data most of them used out-of-date data from municipality of respective town or city. Recently Few studies were conducted on the issue of site suitability analysis for UGS development such as yirgalem (2021), Eshetu (2021) and kayo (2022). Yirgalem and Eshetu have focused on the LULC change analysis in the urban environment using traditional pixel-based techniques and kayo have focused on the LULC change analysis in the urban environment using object-based image analysis. However, these studies did not give attention to the Sub-pixel classification for LULC change analysis and not give attention to examining the suitability of exist green space area sites. Additionally, no research was done in Modjo Town on the use of geospatial technology for site appropriateness analysis for green space development in relation to the structural design, stakeholder participation, or community need. This study therefore aimed to analyze the current structural plan, the needs of the community, and what is better from developed countries in order to fill the existing research and knowledge gap using geospatial technology. It did this by applying sub-pixel image classification techniques to map the LULC patterns and GIS-based Multicriteria analysis method to identify suitable sites for urban green space development in Modjo Town.

1.3. Objectives of the Study

1.3.1. General objective

The general objective of this study is to select suitable sites for urban green space development in Modjo Town using Geospatial technology.

1.3.2. Specific objectives

More specifically, the specific objectives of the study are:

- To identify the main determinant factors for urban green space development site selection;
- To examine the spatial suitability of existing urban green space area of Modjo Town;
- To prepare urban green space development suitability map of Modjo Town;

1.4. Research Questions

- What are the determinant factors for selection of site for urban green spaces development?
- What is the suitability level of existing urban green space in Modjo Town?
- Which sites are suitable for urban green space development in Modjo Town?

1.5. Significance of the Study

Study of site suitability analysis is an important for urban and regional planners and decisionmakers to assess the influences of urbanization on green spaces. Findings of the study will serve as a working document for Modjo Town management officials in the identification and selection of suitable sites for urban green space development in the Town. The main significance of this study will be to bring desirable changes in selecting suitable site for urban green space development. Hence, the findings and suggestions of this study will be used by urban planners and city administration to exercise right judgment on the provision of preferable location for urban green space development. Also, the techniques and procedures used in this study will be used as a reference material for organizations working on environmental issues and researchers as a baseline study for further studies.

1.6 Scope of the Study

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 spatial scope of this study was limited to Oromia Regional State, Modjo Town Administration. Whereas, the contextual scope was limited to suitability analysis for urban green space development using geospatial technology and examining the suitability of existing urban green space of the Town.

1.7 Limitation of the Study

No research, has complete and free from limitations. Some of the limitations faced me in this study were absence of kebele boundary of town and difficulty of getting Very high-resolution satellite images required to undertake this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concepts and Definition of Urban Green Space and Open Spaces

In built-up regions and planned areas, "green spaces" refers to those land uses that are covered with artificially or naturally created vegetation. The definition of a "green space system" has been debated for a very long time. From their own specialized perspectives, many disciplines have put forth various definitions, such as Horticultural Greenland System, Urban Greenland System, Ecological Greenland System, Urban Green Space, and Green Open Space. Along with city theory, which focuses primarily on horticultural, ecological, and spatial connotations, the definition of a green space system has also been evolving over time (Byomkesh, 2012). Urban green spaces, according to Jim and Chen (2003), are outdoor locations with some level of vegetation, typically located in semi-natural regions. This includes urban features like green parks, green walls, and green roofs that connect urban, peri-urban, and rural areas while hosting biodiversity and enabling ecosystems to function and provide their functions (Verd et al., 2020). Urban green spaces are all vegetated areas, including those with trees, shrubs, and grasses, according to Fam et al. (2008).

A formal and informal definition of an urban green area can be found in Alamrew's (2002) citation of many sources. Private gardens, playgrounds, sports fields, squares, protected public parks, churches, mosques, embassies, cemeteries, parking spaces, pedestrian lanes, and other vegetation cover are examples of formal green zones (Mainardi, 2019). For example, forest areas, river valleys, designated expansion areas, agricultural lands, open remaining spaces, grazing fields, steeper degraded areas, shrub lands, etc. are examples of informal green areas. Green areas in cities are utilized to link people to nature. In this sense, green spaces serve as an urban equivalent of the natural or nearly natural areas that surround cities (Sikorska et al., 2020).

Urban open spaces (UOS) are urban areas with a semi-natural environment that have been altered by human intervention and serve as a link between the urban and the natural worlds. Many phrases used to describe open spaces in this context refer to the nearby or surrounding natural areas of cities (Aronson et al., 2017).

Open spaces that are typically covered with natural or artificial vegetation make up "green" environments. Urban open and green spaces (UOGS) can take on a variety of shapes, forms, functions, and purposes; they may differ greatly from community to community; they can range from a straightforward playing field to a natural landscape or an environment that is meticulously maintained and are typically open to the public, even though they may be privately owned (Enger, 2005). The most well-known UOGS are amenity green spaces with excellent landscape design and upkeep, although no single open green space example best exemplifies what this phrase refers to. Each community will need to build a system of UOGS that combines and interrelates diverse types to suit a variety of community needs. It is crucial to recognize the many types of open green space (Panduro & Veie, 2013).

2.2 Historical Development of Urban Green Spaces

The creation of a special "Park Deputation" and the appointment of a city public gardens director were both approved by the Berlin City Council in June 1870. Gustav Meyer (1816–1877), a royal court gardener, began serving in such capacity on July 1st, 1870. The administration of the Berlin public gardens officially began with this. Hermann Mächtig (1837–1909), a friend of Gustav Meyers, took over running the City Public Gardens Department in 1877. He was another representative of the Lenné-Meyer school's legacy and landscape gardening aesthetic. In 1909, Hermann Mächtig perished. As the director of the city's public gardens, Albert Brodersen (1857–1930) was chosen to succeed him in 1910 (Scott, 1969).

Historically, in order to implement a green comprehensive plan in the urban planning regions, create and protect urban parks, green spaces, and public lands, Japan has been operating under the Establishment of Green Comprehensive Planning from April 1977. Every five years, this planning was updated. Additionally, an integrated system of urban green spaces was created with the aid of those subsidiary laws, such as the Natural Parks Law, Metropolitan Parks Law, Children Parks Law, etc (Yokohari and Amati, 2005). These cultural imperatives have historically been presented in terms of the potential of urban parks and other green areas to address problems including the loss of nature (Schuyler, 1986), residential overpopulation (Cranz, 1982), and postindustrial deterioration (Greenberg and Lewis, 2000). Although the driving issues change over time, urban park history is mostly a narrative of planners' attempts to spatially mediate societal issues.

Looking back at this past can help us understand how urban green space is developed today, especially as new landscape ideas are developed as a result of the fight against global warming. Researchers can look at key points in the development of green spaces and gain knowledge from how earlier generations of planners and city boosters suggested using green space interventions to address societal issues. I demonstrate how early park developers attempted to resolve a number of issues, including the perceived disappearance of nature, the acculturation or exclusion of ethnoracial others, and the buttressing of land values, by using the case study of Chicago's Olmsted-designed South Park (current-day Washington and Jackson Parks). In the industrial cities of the nineteenth century, park developers aimed to construct areas that would foster passive recreation, create simulacra of nature within the larger urban environment, provide safe spaces for white women and children in the midst of ethnoracial admixture, deter undesirable activities through surveillance methods, and help structure future land values by offering a civic amenity. Although the case for this study is in the USA, the lessons from Chicago can help researchers comprehend park development in other countries. Given comparable historical trajectories in urbanization, there are obvious connections between Chicago and cities in North America and Europe; nevertheless, a critical examination of how green spaces have been included into urban development plans - and whose social issues they attempt to address - has implications for cities all around the world (Loughran, 2020).

2.3 Benefits of Urban Green Spaces

Nowadays, urban green space is increasingly gaining attention as a source of multiple benefits (Jorgensen and Gobster, 2010; Byrne et al., 2015). Different authors (Ahern, 2013; Roe and Mell, 2013) defined multi-functionality of green space as composite functions that include environmental, socio-cultural, and economic benefits. It supports many of the components of ecosystem services as defined by the Millennium Ecosystem Assessment. Ecosystem services include: Supporting services (habitat provision, nutrient cycling, soil formation, primary production), Provisioning services (fresh water, wood), Regulating services (climate, flood, disease) and Cultural services (aesthetic, educational, recreational). These are intrinsic to biodiversity, and provide for people’s well-being security, basic materials for good life, health, and good social relations (Diaz et.al., 2006). As most of our communities exist within the urban environment, the provision of green space is essential for the well-being of society (Diaz et.al., 2006).

2.3.1 Environmental benefits of urban green space

The environmental benefits of green space include local temperature moderation during hot weather cooling of the air temperature through shade provision and mitigation of urban heat island effects (Bowler et al., 2010; Mullaney, 2015; Nowak et.al, 2006). The roles of green space in reducing noise pollution, in mitigating flood in enriching biodiversity and improving ecosystem are also taken as environmental benefits (Bolund and Hunhammar,1999). The urban heat island outcome is caused by the large areas of heat absorbing surfaces, in a combination of high energy use in cities. Consequently, adequate forest, plantation and vegetation around urban dwellers and management of water bodies can help to mitigate the situation. Urban green spaces are not only improving the whole ecological environment of the city region and its neighbors but also provides important support for urban environmental improvement. Additionally, introduction of sub-urban green space into the city also acts as the base of ecological balance (Sadeghian and Vardanyan, 2013).

2.3.2 Socio-cultural benefits of urban green space

Socio-cultural benefits are the non-material benefits people obtain from green space (Mullaney et al., 2015). These include educational values, aesthetic values, social relations, sense of place, cultural heritage values, recreation, ecotourism and psychological well-being (O'Brien et al., 2017). Socio-cultural benefits of green space for urban residents include mental and physical health improvements such as stress reduction and relaxation (Hansmann R.et al., 2007; Konijnendijk et al., 2013). Further, green space directly increases the quality of life through active and passive recreational social benefits (Kabisch and Haase, 2014). Physical activities such as sports, playing with children etc. signify active benefits while the passive ones include relaxations, meeting with friends, or experiencing nature and the like (Byrne and Wolch, 2009). In addition, green space acts as meeting place for local residents and facilitates social interaction (Wolch et al., 2014).

2.3.3 Economic benefit of urban green space

Economic benefits of green infrastructure come from the increased values of properties near green spaces and the increased sales of properties along green commercial corridors (Heckert and Mennis, 2012; Mullaney et al., 2015). In this line, studies in China (Jim and Chen, 2010) and Adelaide in Australia (Mahmoudi et al., 2013) indicated that higher housing prices and property values are evident for sites situated in the vicinity of accessible green space. In addition to this, the economic benefits of green space include its contributions to tourism and its link with urban food (Heckert and Mennis, 2012). Pitman and Ely (2013), explained that green space and urban food are intimately related through the perceived needs to retain productive agricultural land on the urban fringe and to integrate food production into urban areas.

2.4. Factors Affecting Green Space Planning and Development

Urbanization continues to be a significant factor that has been primarily associated with the degradation of green space. Urban sprawl is the geographical outward growth of an urban area rather than the densification of the urban core. High population density and an increase in the built environment (building structures) in comparison to open areas are considered to be signs of densification of an urban centre (Mensah, 2014). On the other hand, urban sprawl refers to the outward spread of metropolitan regions, which frequently occurs in peri-urban lands, former agricultural lands, and urban fringes. The excessive loss of the natural ecosystem, including green spaces, and the conversion of many urban lands into built-up structures are the results of rapid urbanization (Honu et al., 2009).

Urbanization alters the structure of urban regions in addition to the size and number of cities. The natural environment, both inside and outside the city, is one of these changes' dimensions. Green spaces started to disappear on a large scale during the systemic shifts as Poland transitioned from the command-and-quota economy and shifted towards empowerment, and were replaced with new developments and increasingly dispersed settlement structures. Since then, this practice has continued. According to Hrehorowicz-Gaber (2015), during this time, almost 30% of open spaces that were used for a variety of purposes have disappeared (became part of new developments). According to Abebe and Megento (2016), urbanization has a detrimental effect on the environment by putting pressure on and reducing the amount of green space in numerous cities throughout Europe, North America, South America, Asia, and Africa. The situation in Africa is particularly dire. According to Gairola and Noresah (2010), the rate of urban growth, which is frequently influenced by prevailing socioeconomic variables, affects the loss of urban green areas. This phenomenon has been documented in both emerging and developed nations.

Contrary to popular belief, natural resources such as woods and water bodies are currently destroyed or reclaimed within towns and between rural areas and cities in order to make room for structures and a road network. Due to a lack of open places for recreation, many millennium cities and towns still do not have enough of them (Banerjee, 2001). Different uses of land resources are allocated by statutory land-use planning. Local governments might, however, prioritize financial gain and economic growth, which could have detrimental effects on the environment, such as a lack of publicly accessible urban green space (UGS). Institutional frameworks are related to the allocation of land resources in planning (Wang and Chan, 2019).

According to current trends in the built environment, there is a global worry about the need for greater space to accommodate urban populations, however this demand is particularly prominent in third-world nations (UN, 2005). An increase in residential space can also result in less spaces remaining for green space in the city. This is so because land is a fixed asset, whose usage can only be altered and not increased. Even where reclamation is done, it is done with great difficulty, takes a lot of time, and costs a lot of money. Because of this pressure on residential land use, among other land uses, more residential areas have been developed for economic reasons with little to no regard for the laws and regulations governing open space, setbacks, and green space within community centres, open areas, and residential plots within neighborhoods. The majority of recent changes in the status and flow of the biosphere, among other diverse challenges impacting the environment today, are caused by human activity rather than natural processes. This suggests that the unexpected rise in urban population has prompted physical development to spread and, inevitably, encroach on or reduce areas designated for green spaces (Oluwafemi, 2010).

Urban areas become warmer than the surrounding areas as a result of changes in land use, particularly the removal of green space in favor of buildings, roads, and parking lots since these impermeable materials store heat and release it more slowly (Wendel, 2011).

2.5 Status of Urban Green Spaces in Ethiopia

Ministry of urban development, housing and construction is trying to address the green space problem by producing National Urban Green Infrastructure Standards (NUGIS) which create the framework for municipalities to provide effective and sustainable urban green infrastructure (UGI) for their residents to protect public health and environmental quality (MoUDC, 2014). MoUDC has concerns with incorporating the issue of green areas, considerations of the compatibility of various land use activities, incorporation of generalized environmental objectives and identification of hazardous areas. It has also recognized cities as entities that try to work towards minimizing serious urban environmental causes.

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

2.6 Urban Land Suitability

Urban land suitability can be defined as the fitness of a given use of urban land for a defined purpose based upon a scientific study and defined parameters (Teklit, 2015). According to Teklit (2015), land may be considered in its present situation or after some arrangements are made on it. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for the defined purpose to be used" (FAO, 1976). In general, the urban land area can be classified as "Suitable" or "Not Suitable" for specific use: Suitable areas can be divided into three classes, which reflect the degree of suitability, one from the other. The number of classes can vary but it should be kept to the minimum necessary and should never exceed the number of classes from five (Teklit, 2015). FAO (1976), recommends three suitability classes and two not suitable classes.

Class S1 Highly Suitable: Land having no significant limitations to the sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.

Class S2 Moderately Suitable: Land having limitations which in the aggregate are moderately severe for sustained application of a given user; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use.

Class S3 Marginally Suitable: Land having limitations which in the aggregate are severe for sustained application of a given user and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.

Class N1 Currently Not Suitable: Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently 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. There can be many reasons why an area is classified as suitable and not suitable, for example, technical considerations like slope, soil, groundwater potential, urban infrastructure, road network and other (Teklit, 2015).

2.7 Land Use Suitability Analysis

One of the most useful applications of geospatial technology for planning and management is the land-use suitability analysis and mapping (McHarg, 1969; Hopkins, 1977). Broadly defined, land-use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specific requirements, or predictors of some activity (Hopkins, 1977). The geospatial technology-based land-use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability for animal and plant species (Pereira and Duckstein, 2001), geological favorability (Bonham, 1994), selecting the best site for future urban development (Achalu, 2021; Mesfin, 2019), and selecting the best site for urban green space development (Yirgalem, 2021; kayo, 2022; Eshetu, 2021).

2.8 Criteria for Suitability Analysis of Green Space

The chosen land use's site selection and the choice of the geographic location are both heavily influenced by criteria. For example, Heshmat et al. (2013); Manlun (2003); Kuldeep (2013); Pantalone (2010); Yousef et al. (2014) 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, and more. According to Heshmat et al. (2013), the parameters cited by various scholars are divided into three groups: environmental, socioeconomic, and geomorphological.

2.9 Principles of Urban Green Space Planning

The following are the most crucial principles for the formation and development of open green spaces planning: - adherence to natural features and conditions; - fundamental relationship with the landscape; - quantitative correspondence of the occupied space not only with functional requirements, but also with environmental ones; - continuity; - multi-level, relative uniformity of distribution; - availability; - functional diversity that satisfies population needs; the capacity to expand alongside the city.

2.10 Basic Concepts of Geographic Information System as a Tool

GIS is defined as a computerized system designed to store, retrieve, manipulate, analyze, and map geographical data. The central element of a GIS is the use of a location referencing system so that data about a specific location can be analyzed in its relationship to other locations. This makes it possible to take data stored in one form and combine it with data entered and stored in some other form. Such powerful facilities of the GIS have been used to perform spatial analysis for different purposes like suitability analysis (Malczewski, 2004). Nishanth et al. (2010), also emphasize the capability of GIS to combine spatial data (maps, aerial photographs, satellite images) with the other quantitative, qualitative, and descriptive information databases facilitating suitability analysis like site selection.

Moreover, the surface and overlay analysis capabilities in GIS can effectively facilitate handling the vast amount of spatial information. It is estimated that 80% of data used by managers and decision-makers is related to spatial data. Most of The Information is used by the decision-maker are derived from data (Malczewski, 1999). Accordingly, geographical information can be defined as geo-referenced data that has been processed into a form that is meaningful to the decision-makers and it is of real or perceived value in the decision-making process. Traditionally, spatial data has been acquired and rendered in pictorial form to accomplish a variety of activities related to land suitability analysis. But this traditional system is not efficient and cost-effective for handling land resources and perform land suitability analysis. To solve this problem database systems for spatial data, commonly named Geographic Information Systems were designed and developed enabling the acquisition, compilations, analyzing, and display of topographical interrelations. And to analyze different spatial features using different methods or approaches to GIS techniques (Dembski et al., 2019).

2.11 Basic Concepts of Remote Sensing as a Science

Remote sensing can be defined as a science and art of acquiring information spectral, spatial, and temporal information about material objects, or phenomenon above and below the earth's surface, without coming into physical contact with the objects or phenomenon under investigation (Lillesand and Kiefer, 2004). Without direct contact means the information is obtained or transferred through the interpolation of image and electromagnetic radiation pattern. In remote sensing, information transfer is accomplished by the use of electromagnetic radiation (Lillesand and Kiefer, 2004). The advancement of remote sensing technology to provide multi-spectral, multi-temporal, and multi-spatial images is very helpful to increase the speed and frequency with which one can analyze a landscape (Idowu and Ukoje, 2009). Nishanth et al. (2010), also states remote sensing as one of the excellent tools for inventory and analysis of environment and its resources, owing to its unique ability of providing the synoptic view of a large area of the earth's surface and its capacity of repetitive coverage.

Furthermore, remote sensing contributes to the development of objective and comprehensive assessments over larger geographic extents and inaccessible areas than is possible with fieldwork alone (Steininger and Horning, 2007). Moreover, the use of remotely-sensed data in natural resources mapping and as the source of input data for environmental analysis has been popular in recent years. The availability of remotely sensed data from different sensors of various platforms with a wide range of spatiotemporal, radiometric, and spectral resolutions has made remote sensing one of the best sources of data for large scale applications and study (Assefa et al., 2007).

2.12 Integration of GIS and Remote Sensing for Urban Green Space Site Selection

Since the 1990s, GIS and remote sensing have offered a sophisticated system of generating, storing and analyzing geometric and semantic information about spatial elements. GIS and remote sensing methods have been used in various scientific disciplines like in Environmental Science (Akar, 2009). For example, geospatial technology (GIS and Remote sensing) is an essential component of the Environmental Impact Assessment (EIA) process, as environmental resources are directly affected by changes in the shape and extent of the proposed disturbance (Satapathy et al., 2008). This is because, with the use of spatial techniques, EIA has enhanced substantial viewing, movement, query and even map-making capabilities (Satapathy et al., 2008).

Moreover, they have the capacity to provide valuable and timely information about natural resources, urban change and the extent of environmental change being experienced in earth as an important basis for sustainable planning for land management and decision making (Twumasi et al., 2016). Therefore, geospatial information technologies are the key to planning, management and administration of land. Remote sensing and GIS can contribute substantially in a more supplementary fashion to some of the interactive operations that should become an asset for assessing, understandings, mapping utility and solving complex urban environmental issues like urban green space development suitable site selection (Eshetu, 2021; Yirgalem, 2021). Generally, combination of the GIS and Remote Sensing systems provide multi-spectral, multi-temporal and multi-scales (spatial resolution), which can be adopted according to the degree of details needed. This technique plays an important role in selecting suitable site for urban green space development.

2.13 Multi-Criteria Decision Analysis for Urban Development Site Selection

Multi-criteria Decision analysis (MCDA) is a set of mathematical tools and methods allowing the comparison of different alternatives according to many criteria, often conflicting, to guide the decision-maker towards a sensible choice (Chakhar and Mousseau, 2008). MCDA consists of a series of techniques that permit a range of criteria relating to a particular issue to be scored, weighted, and then ranked by, for example, experts, interest groups or stakeholders according to their degree of suitability or importance for locating a particular facility or service (Malczewski, 2004) like an urban development site.

The integration of MCDA techniques with GIS has considerably advanced the conventional map overlay approaches to the land-use suitability analysis (Eastman, 1997; Malczewski, 1999; Thill, 1999). The MCDA procedures define a relationship between the input maps and the output map. The procedures involve the utilization of geographical data, the decision maker’s preferences, and the manipulation of the data and preferences according to specified decision rules. Accordingly, two considerations are of critical importance for spatial MCDA: (i) the GIS capabilities of data acquisition, storage, retrieval, manipulation, and analysis, and (ii) the MCDA capabilities for combining the geographical data and the decision maker's preferences into unidimensional values of alternative decisions. Several multicriteria decision rules have been implemented in the GIS environment for tackling land-use suitability problems. Analytic Hierarchy Process (AHP) is one of the most commonly used MCDA tools.

This tool is applied in site selection processes as it assists the decision-making process by allowing decision-makers to organize the criteria and alternative solutions of a decision problem in a hierarchical decision model (Eldrandaly et al., 2005). Furthermore, Multi-criteria approaches have the potential to reduce the costs and time involved in siting facilities by narrowing down the potential choices based on predefined criteria and weights while also permitting sensitivity analysis of the results from these procedures (Higgs, 2006).

Therefore, the role of MCDA in urban green space development site selection can be completed by integrating it with GIS. Eldrandaly et al. (2005), emphasize, integrating GIS and MCDA can solve the challenges of site selection which involves highly complex spatial decision-making processes.

2.13.1 Analytic hierarchy process

Analytic hierarchy process (AHP), which was developed by Saaty (1980), is currently one of the important techniques for analyzing land suitability. AHP is categorized under the multi-criteria decision analysis approach and is an effective technique that helps planners and decision-makers to analyze all data before arriving at a final decision for future land-use changes (Achalu, 2021; Bagheri et al., 2013; Yirgalem, 2021). AHP has been integrated with GIS tools to identify the importance of the criteria used and to calculate weights by using a scale of importance and the opinion of experts (Achalu, 2021; Mohammad et al., 2013). AHP has the ability to allow a hierarchical structure of the criteria, when allocating the weights, it gives users a better focus on specific criteria and sub-criteria.

AHP is commonly applied to identify the weights of influencing factors on urban green space site selection based on the analysis functions of GIS. AHP is also a structured approach that can be used for complex cases of making decisions that include competing criteria (Javadian et al., 2011). The weights of factors in AHP can commonly be identified by using driven knowledge and driven data. The weights of factors can also be calculated by using a questionnaire given to specialists who have considerable experience in the field of urban growth and can then be determined by using pairwise comparison method to measure their relative importance regarding one another (Bagheri et al., 2013; Mohammad et al., 2013; Javadian et al., 2011)

The main challenge in applying the AHP model is that AHP needs the right experts with the widest knowledge and experience in the fields of suitability analysis and application to judge the factors in terms of their importance and weights (Maher et al., 2016; Mohammad et al., 2013). Identifying the relative weights of the factors used in land suitability analysis is generally difficult (Maher et al., 2016). Thus, the use of a technique that has a powerful capability to identify the weights is important to minimize the difficulties of weighting factors. AHP is one of the significant techniques used in analyzing issues related to spatial nature (Javadian et al., 2011).

2.13.2 Weighted linear combination

Weighted linear combination (WLC) is the most prevalently used multi-criteria evaluation analysis method in GIS (Siefi et al., 2017; Malczewski, 2000). Land-use suitability analysis using weighted overlay method leads to more rational urban planning decision-making. Weighted overlay analysis includes different data layers with various aspects. In this method, manipulation of the overlay process is allowed by assigning different weights for each input layers, so the factors that play a more critical role will have a more significant impact on shaping the outcome of the overlay analysis. This is the advantage of weighted overlay over other methods such as fuzzy overlay, binary overlay, or ranking overlay (Malczewski, 2006). However, this method is highly dependent on the determination of factor weights, where highly favored factors will result in higher values in the final output raster. This issue is critical, so expert’s opinion is crucial in the defining scales applied to input layers and weights given to factors in the AHP process.

2.14 Empirical Literature Review

In line with urban expansion occurred in our today world; assessing the impacts of urbanization on urban green space, suitable site selection for urban green space development and analyzing accessibility of urban green space have become the subjects of recent research. This section presents a review of empirical studies conducted in different parts of the world. The review mainly focused on those studies made the impacts of urbanization on urban green space, site selection for urban green space development and analyzing accessibility of urban green space.

2.14.1 Global perspectives

Among some studies done focusing on urban green space planning and development, Sharma et al. (2022) was done on urban green space planning and development in Noida city using geospatial technology. The main objective of this study was examining the spatial variability of availability of adequate sites for the development of urban green amenities in Noida city. Multi-criteria assessment of potential locations has been accomplished using Analytical Hierarchical Process coupled with geospatial technology. According to their results of this study A total of 46.47 % of the land was found to be in the category of highly and moderately suitable for greening the city, highlighting the potential of developing different forms of green spaces in the area.

Another study done by Yang (2003) focused on suitability analysis of urban green space system based on GIS. The main purpose of this study was to develop an approach of GIS based suitability analysis to identify suitable site for urban green space system development. This approach identifies seven major steps involved in suitability analysis, these includes selecting suitability factors, scoring, weighting suitability factors, generating suitability scenarios using GIS, ranking suitability scenarios, making sensitive analysis and output evaluation. The result of this study confirmed that suitability analysis is a powerful tool for green space system planning and development. Continued development and refinement of suitability analysis, particularly with GIS technology can enable urban planners to help local government officials and local residents to create suitable green space system.

Reviewing the global factors influencing UGS access inequality in different cities across multiple continents and nations may offer significant insights in this area of study. According to the global distribution map, investigations have mainly been conducted in large cities (blue circles on the figure) with populations more than 1,000,000 (Martinez-Vazquez et al., 2008). Many times, the administrative geographic units for the demographic data changed, and the spatialization of population data to lessen the spatial mismatch between the availability of urban parks and patterns of population distribution has not been adequately examined. Recently, the units from which demographic data was derived were prognostic areas (sub-district level) in Berlin (Kabisch & Haase, 2014), US Census data by block group boundaries in Boston (Cradock et al., 2005), and neighborhoods in Denver (Rigolon, & Flohr, 2014). These studies missed the extraordinarily high heterogeneity of population distribution found in urban settings because they made the assumption that the population is dispersed evenly within the statistical unit. Due to diverse demands for recreation and relaxation, the quality of urban woods may have an impact on inhabitants' propensity to visit them in large cities (Jim & Chen, 2006). In Hangzhou, China, a groundbreaking analysis into park access patterns was conducted (Wei, 2017). The research in Hangzhou did not reveal any statistically significant disparities among socioeconomic categories in terms of park access variations, but this study highlighted the primary impact of park investment on local sub-districts to increase general accessibility. The lack of place-based socioeconomic data and multi-temporal park distribution data are the key obstacles to the development of the research of the dynamics of access inequality (Collins et al., 2020).

Local urbanization trends and the strong demand for UGS for public health may be the causes of the majority of empirical studies on UGS equity being conducted in western Europe, China, Australia, and the US (Wei, 2017). One of the urgent study areas is the comparison of park accessibility and the variations in accessibility among socioeconomic categories because the US and China have contributed the most to the publications in this subject and have amassed spatially explicit studies for specific cities. Additionally, the urban land structure may have a big impact on how UGS is provided. As a result, considering the various spatiotemporal patterns of urbanization in China and the US could enhance studies on the disparities in access to UGS that are related to time and space (Boulton et al., 2018).

2.14.2 Lessons learnt from international experiences

In the development of UGS, certain cities might give more weight to industrial expansion and economic growth than urban planning. Real estate investing may potentially jeopardize the access equity issue. Since UGS access is not merely a matter of green infrastructure, the necessary modification of a city's non-biotic or grey buildings, particularly the transport system, should be properly taken into account when developing UGS. Large cities (those with a population of more than 1,000,000) are disproportionately affected, while the severity of UGS access inequality varies between nations. Different groups showed differences in UGS, and access inequality was examined in various geographical contexts. There are few analyses of mitigating strategies in the literature we reviewed. We identified the key trends, knowledge gaps, and clusters of this study area by taking into account their approach, and we emphasized the importance of incorporating the UGS access inequity factor into urban planning and management to prevent heightened demands on the sustainable development of cities.

Researchers must focus on the process through which theoretical concepts become practical. Nevertheless, despite extensive research, it appears that "only a few have attempted to connect the theory with the practices."

Therefore, in a global context, most nations didn't incorporate what they had in mind for their city's "structural plan" for a variety of reasons. Some of them include the population growth brought on by rural-to-urban migration, spatially explicit urban environment data with socioeconomic conditions, and the personal and social implications of unequal access to quantity, quality, and proximity to UGS.

2.14.3 Local perspective

In the context of Ethiopia, the impacts of urbanization driven LULC changes on urban green space, planning aspect, green spaces depletion, utilization pattern, Designing Potential Greenways and site suitability analysis for urban green space development have been assessed by several studies in different parts of the country, such as Bahir Dar and Hawassa (Gashu and Gebreegziabher, 2018); Addis Ababa (Abo et al., 2018; Woldegerima et al., 2017); Sebeta Town (Girma et al., 2019a; Girma et al., 2019b); Southern Ethiopia (Molla et al., 2017); Hawassa (Adinew, 2018); Adama (Yirgalem, 2021); Sululta town (Eshetu, 2021) and Ambo town (kayo, 2022).

Among the few studies focusing on the impacts of urbanization driven LULC changes on urban green space Gashu and Gebre (2018) investigated the Spatiotemporal trends of urban land use/land cover change on green infrastructure in two Ethiopian cities Bahir Dar and Hawassa. According to their results, vegetation decreased by 30 and 14% in Bahir Dar and Hawassa respectively for the period 1973–2015, while built-up areas expanded by 10 and 24% respectively in the two cities. These land use changes have significant impacts on spatiotemporal trends of green infrastructure in urban areas. Abo et al. (2018) analyzed the use of urban spatial scenario design model as a strategic planning tool for Addis Ababa city. The results of these study indicated that Addis Ababa's settlement area has been expanding into the city's peripheral area at the expense of losing green infrastructure of farmland and vegetated areas.

Woldegerima et al. (2017) investigated the Ecosystem services assessment of the urban forests of Addis Ababa city. The aim of this study was to assess selected ecosystem services such as carbon storage potential, habitat support and soil erosion protection provided by different categories of urban forest of Addis Ababa. The result showed that carbon density in the study area varied with forest categories viz. 293tons/ha,142tons/ha and 132tons/ha in the dense, medium and open forest types respectively. Girma et al. (2019a) analyzed the Urban green spaces supply in rapidly urbanizing countries case study of Sebeta Town. In this study, they analyzed urban green space changes and their drivers in Sebeta town of Ethiopia from 2003–2016 by using three time series Landsat images of 2003, 2010 and 2016, land inventory, interview, focus group discussion, and field observation for data collection and a combination of techniques, including pixel-based image classification, qualitative descriptive and GIS-based processing for data analyses. The findings of their study show that area of green space has decreased by 51.8% at the rate of 3.9% annual loss between the year 2003–2016 while the built-up area increased by 562.1% at the rate of 43.2% annual growth.

Another study on Socio-economic characteristics and utilization of urban green infrastructure in southern Ethiopia was made by Molla et al. (2017). This paper investigates the effect of socioeconomic characteristics of people on a monthly visit of green infrastructure in Southern Ethiopia. Data were collected using structured questionnaires and key informant interview, a total of 400 urban communities were interviewed in the entire study area. The collected data were analyzed using descriptive statistics, multiple regression models and chi-square test. The study confirmed that people's socio-economic characteristics have significant relation and/or effect on the monthly visit and utilization of green infrastructure in the study area.

Adinew (2018) studied the Identifying and Designing Potential Greenways in Hawassa city using GIS. His objectives were assessment of potential areas, assessment of suitable landscape and delineation of potential greenway network and detail design on a specific site was conducted to ease integration and implementation at local scale. Finally, greenway networks were produced, in the potential routes in the city of Hawassa, the generated city scale corridor need to be designed on the actual ground as realized on the next part of the study. Overall, all greenway corridor identification and local area design were effective in addressing sustainability, socio-cultural transportation and ecological components for Hawassa.

Yirgalem (2021) study aimed at identifying suitable sites for urban green space development in Adama town using geospatial technology. He has used pixel-based image classification techniques to analyze LULC change patterns. The result of his study indicated that the urban areas in Adama Town have expanded dramatically, while green areas have been declining and those areas, which are close to built-up and urban centers, were subjected to significant loss of shrub and bushes (greeneries) in the last three decades. Kayo (2022) analyzed the spatiotemporal dynamics and suitable site selection for development of urban amenities in ambo town. This study aims to analyze the spatiotemporal changes in urban green space in Ambo Town from 2006 to 2022 and scientifically select suitable sites for urban green space development. He has used object-based image classification techniques to map LULC of the study area for the years 2006, 2016, and 2022. The findings this study 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, urban green space coverage in the study area decreased by 1.4%.

2.15 Research and Knowledge Gaps

Most of the researchers raised above under empirical literature review shows the impacts of LULC change have on urban green space. Many of them used pixel-based image classification technique and one researcher used object-based image classification to map LULC of the study area. Though, there are a gap in considering pixel-based and object-based image classification technique. Pixel based image classification assume that only one land use land cover type exists in each image pixel and Object-based approaches are considered more appropriate for very high-resolution remote sensing images since they assume that multiple image pixels form a geographic object. However, such an assumption is often invalid if we apply pixel-based classification for medium and coarse resolution remote sensing imagery and object-based image classification for image that haven't very high resolution. 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 sub-pixel-based image classification (fuzzy classification) technique which consider heterogeneity of landscapes when compared to the spatial resolution of a remote sensing image.

Additionally, all the researchers reviewed above don’t give attention to examining the suitability of existing urban green space, analyzing the accessibility of the identified site, did not used up-to-date data most of them used out-of-date data from municipality of respective town or city or town and some missed some basic influencing factors which can change the result. Besides, there were no studies conducted in Modjo Town related to analyze site suitability and accessibility of Urban green space development using geospatial technology. Therefore, this study aimed to fill the existing research and knowledge gap using geospatial technology by applying sub-pixel image classification techniques to analyze the change existed in the LULC patterns and GIS-based Multicriteria analysis method to analyze site suitability and accessibility of Urban green space development.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of Study Area

3.1.1 Geographic location

This research was conducted in Modjo Town which is Established in 1925. Modjo Town is among a few privileged towns of its time to have its own municipal administration and a master plan. The town covers the total area of 5284hectareswithelevation between 1788 and 1825 meters above sea level. Modjo Town is located in east Shewa Zone of the Oromia national Regional State in central Ethiopia. Relatively Modjo Town is located 64km faraway east of Addis Ababa the capital city of Ethiopia and 12km west of Adama Town. The geographical location of Modjo Town is approximately between a latitude and longitude of 8°39′N39°5′E (Minalu, 2016).

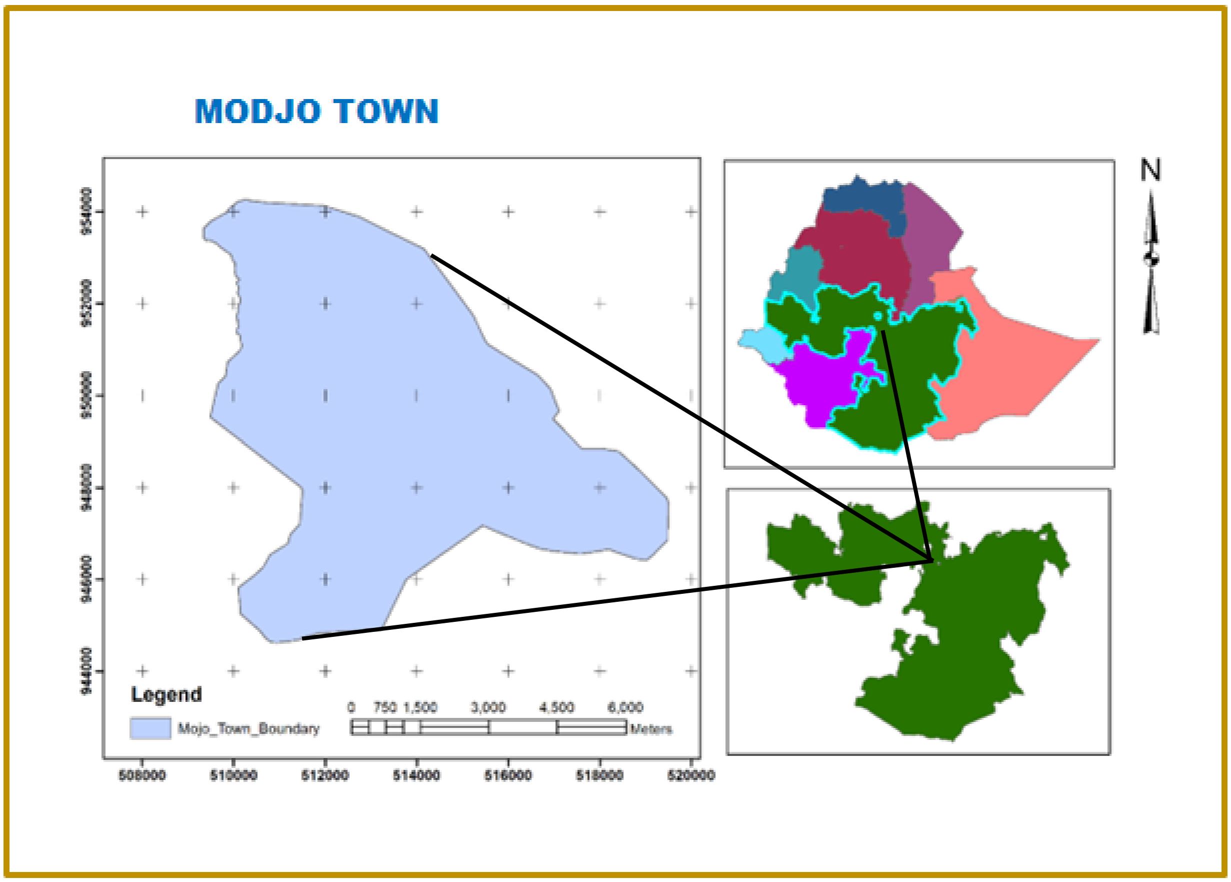

Figure 3.1 Location of study Area

3.1.2 Population

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), Modjo town has a total population of 39,316, of whom 19,278 were males and 20,038 were females. However, it is believed that this number was inaccurate when recorded and underestimated the town's population. Recently the town faces a robust annual growth and the people of town growing to 60,380 (Modjo town municipality report, 2023). The 1994 census reported this town had a total population of 21,997 of whom 10,455 were males and 11,542 were females. When compare the three reports the population of the town are highly increasing from time to time (Kiflu, 2010).

3.1.3 Land use

In Modjo Town and the surrounding area major land use categories residential, commercial, mixed-use, grasslands, open space, forest and others. In Modjo, the built-up area is the major land use category. Likewise, surrounding area encompasses mixed land cover types which are built up, forest, agriculture, shrublands, open space and grasslands (Gessesse et al., 2015).

3.1.4 Climatic conditions

In Modjo, the wet season is mostly cloudy, the dry season is partly cloudy, and it is warm year-round. Over the course of the year, the temperature typically varies from *56°F* to *82°F* and is rarely below *51°F* or above *87°F*.

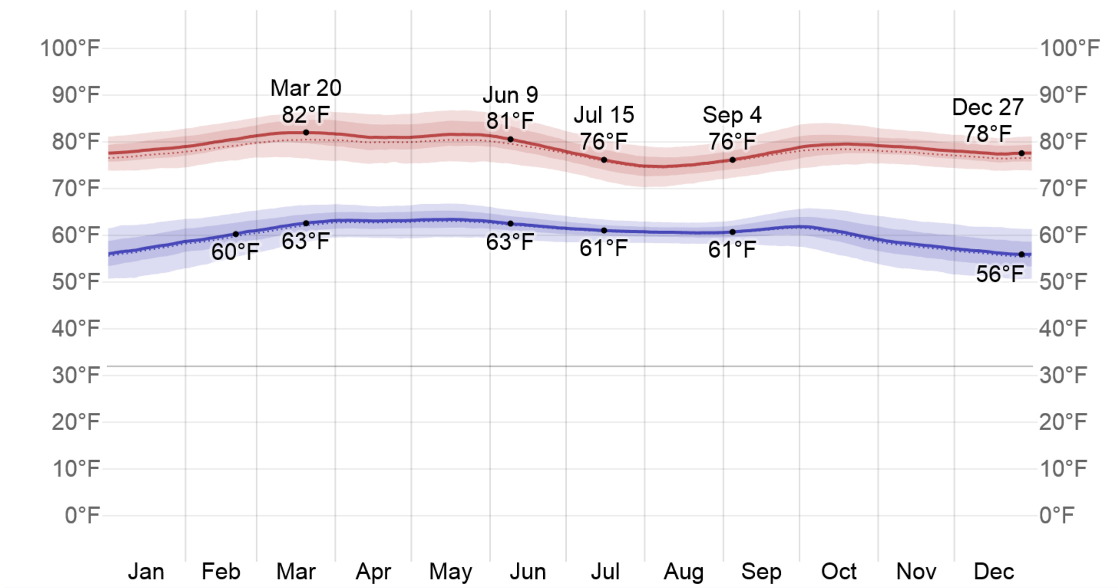

Figure 3.2 Average High and Low Temperature in Modjo (Source: Ethiopian Meteorological Authority, 2022)

3.2 Data Source

This part includes gathering both spatial and non-spatial data from primary and secondary sources. The table below shows types of data used in my study, formats of the data and sources from where the data have been gathered.

Table 3.1 Data and their sources

NO	Data	Data Source	**Type**	Format	Resolution
1	Sentinel-2A of 2022	USGS	Secondary	TIFF	10m
2	Transportation network	Google earth pro	Secondary	Vector	-
5	ASTER Digital Elevation Model (DEM)	Geospatial information institute (GII)	Secondary	Raster	20m
6	River (stream)	Google earth pro	Secondary	Vector	-
7	Soil data	FAO	Secondary	Vector	-
8	Population	Modjo Municipality	Secondary		-
9	Health facility	GPS field survey	Primary data	Vector	-
10	Factory				
11	School				
12	Modjo Masterplan	Modjo municipality	Secondary	CAD	-

3.3 Software Used

Software is program used for collecting, organizing, analysis, interpretation, and presentation of data. In order to meet the objective of this study I have used the software listed in below table.

Table 3.2 Software used and their purpose

S.NO	Name of software	Purpose
1	ArcGIS 10.8 and QGIS 3.28	Data processing and thematic map preparation
2	ERDAS Imagine 2015	For processing and analyzing satellite Image
3	Google Earth Pro	Use as a base map in visual image interpretation.
4	Microsoft Word and Excel	Integrating attribute data and writing final thesis report
5	IDRISI Selva 17	for weight module determination

3.4 Data Collection Method

The data collection method is centered on a different app developed on the open-source platform. The app allows the observer to record geolocated information on observed activities for a complete list of options, time-related information and user characteristics (number of users). It also identifies and characterizes recreational equipment in each UGS (e.g., benches, water fountains, waste bins, and different sports and cultural equipment types). All this was implemented in a single app, allowing for the centralization and pre-treatment of the information, reducing posterior data preparation time. All data recorded in the app was geolocated over high-resolution aerial imagery to ensure spatial accuracy. The open-source system was created to guarantee accuracy and effectiveness in data collection. To safeguard any missing data, records were recorded in a geodatabase. Whether a user was an individual or a member of a group affected how many users were counted. Based on the user's motion state, the data collecting technologies were able to limit the list of potential activities, ensuring that only pertinent actions were recorded.

Collecting accurate and reliable data is the most determinant factor for any research as it determines the quality of the research. In order to conduct this study, a step-by-step method was followed from data collection to analysis. First of all, preliminary studies of literatures were done and parameter affecting the urban green space development suitability analysis has been identified. Based on the reviewed literatures the following nine parameters were selected and considered for urban green space development site suitability and accessibility analysis. These parameters (LULC of 2023, soil type, population, slope, road network, river or stream, residential area, facility location and noise influence or factory) were collected from their respective source as described in table 3.1. Based on their sources these parameters were classified in to secondary data and primary data.

Primary data is a type of data which collected by direct measurements from study area by the researcher for the purpose of his or her current study and Secondary data is data which has been collected by individuals or agencies for other purposes. The data that is be used in this study were collected from both sources. For example, satellite image of 2022, soil type, population, DEM, road network and river were obtained from secondary sources. On other hand facility location of school, health center and noise influence or factory were obtained from primary sources.

3.5 Data Preparation Methods

Once the data were collected from their respective sources the next step is preparation of collected data for further analysis. Data preparation methods used in this study are georeferencing, mosaicking, clipping, digitization, image classification and accuracy assessment.

3.5.1 Georeferencing

Georeferencing is the process of assigning locations to geographical objects within a geographic frame of reference. It is fundamental to geospatial technologies in general and geographic information system (GIS) in particular. The main purpose of georeferencing is to relate internal coordinate system of a digital map, aerial photo, satellite image and scanned map to a ground reality of geographic coordinates. All data used in this study were georeferenced in ArcMap 10.8using GCP to relate data layer to ground reality and facilitate the spatial analysis.

3.5.2 Clipping

Clip is the process of cut the features in area of interest from image, scanned map, digital map and any GIS layers. To clip features in study area overlay a boundary of study area on target features to be clipped and perform GIS operation. In this study most of data collected were clipped in Arc Map 10.8 by using Modjo Town boundary. Accordingly, satellite image, soil map, road network, river network, highway, railway and DEM used in this study were clipped.

3.5.3 Digitization

Digitization simply defined as the process of converting analog data in to digital data. Road network, highway, railway and river network used in this study were digitized from Google earth pro in kml format and were converted to shape file in Arc Map 10.8.

3.6 Data Analysis Methods

Urban green space site selection requires effective criteria assessment according to the governmental legislations, policy, existing relevant literatures and practices to reduce social, economic, and environmental and health effects (Siddiqui, 1996). In this study, by taking into account these criteria the overlaying method of influencing parameters was used to analyze suitable urban green space development sites. After all data were collected from their sources and prepared for analysis, the analysis was performed using different software like ArcMap 10.8, IDIRS selva 17 and ERDAS Imagine 2015. Once data were prepared, before starting final urban green space development site suitability analysis, the data prepared for analysis was buffered by specified distance, data in vector format was rasterized and all parameters were reclassified for further analysis.

3.6.1 Image classification

Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. It plays an important role in remote sensing images and is used for various applications such as environmental change, agriculture, land use/land planning, urban planning, geographic mapping, disaster control, object detection and suitability analysis. The general methods of remote sensing image classification are pixel-wise, sub-pixel-wise and object-based image classification methods (Li et al., 2014). Pixel-wise image classification methods assume each pixel is pure and typically labeled as a single land use land cover type (Fisher, 1997; Xu et al., 2005). However, such an assumption is often invalid for medium and coarse resolution imagery, majorly due to the heterogeneity of landscapes when compared to the spatial resolution of a remote sensing image (Lu and Weng, 2007). As a result, the applications of pixel-wise classifications decrease the classification accuracy of land use land cover maps (Pu et al., 2003; Shanmugam et al., 2006). As a better alternative, sub-pixel image classification techniques are considered more appropriate as the areal proportion of each land use land cover type can be accurately estimated (Zhang and Foody, 1998; Woodcock and Gopal, 2000). Compared to traditional per-pixel and sub-pixel classification methods, object-based models provide a new paradigm to classify remote sensing imagery (Blaschke, 2010; Myint et al., 2011). With object-based models, geographical objects, instead of individual pixels, are considered the basic unit for analysis. But Object-based approaches are considered more appropriate for very high-resolution remote sensing images since they assume that multiple image pixels form a geographic object (Li et al., 2014). If we apply this method to medium and high-resolution images the result will not accurate. Thus, a sub pixel-based image classification method was used in this study to map LULC of 2023 of Modjo Town.

3.6.2 Accuracy assessment

Accuracy assessment is employed for determining whether the output LULC map meets or does not meet 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). In this study the accuracy of the classification results for was calculated from Error matrices.

Table 3.3 Accuracy of classified LULC (Source: Lillesand et al., 2008)

LULC	Shrub & Bushes	Bare Land	Water Body	Built-up	Farm Land	Raw Total
Shrub & Bushes	210	0	4	0	0	214
Bare Land	0	189	0	3	0	192
Water Body	6	0	115	7	4	132
Built-up	0	1	0	268	1	270
Farm Land	0	1	1	4	321	327
Column Total	216	191	120	282	326	1135

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'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). 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 overall accuracy results from dividing total of diagonal by sum of row or column total. To check the accuracy of LULC used in this study, overall accuracy was computed from error matrix.

Overall accuracy = (1135 /1144) *100% = **99.21%**

The Kappa coefficient of agreement was used for multi-variate 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.

$$K\hat{} = \frac{n\sum_{i=0}^{r} xii - \sum_{i=0}^{r}(xii+ .\ x+i)}{N^2 - \sum_{i=0}^{r}(xii+ .\ x+1\ )} \text{---3.1}$$

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

3.6.3 Buffering

Buffering is a spatial analysis also called proximity analysis. It is used to generate areas of a given distance around the specified criteria that has been used for urban green space development site selection. In this study buffer zones were created around roads, river, residential areas, railways, highways, facility location and noise influence based on the specified distance for each parameter.

3.6.4 Rasterization

Rasterization can be defined as the process of converting information in vector format to raster format. As mentioned under data preparation section most of data used in this study weredigitized from secondary sources. Those data in vector format (roads, river, residential areas, soil types, population density, highways, railways, facility location and noise influence) were converted to raster format in ArcMap 10.8 for further analysis.

3.6.5 Reclassification

Is the process of classifying something (map) again and again. In this regard the parameters considered in this study are LULC of 2023, soil type, population, slope, road network, river or stream, residential area, highways, railways, facility location and noise influence or factory. Finally Based on FAO (1976) classification, all these parameters were internally classified in to five classes (Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), Currently Not Suitable (N1) and Permanently Not Suitable (N2)) with values ranging from 5 to 1, where 5 denotes the highly suitable and 1 denotes the Not Suitable for all factors and constraints considered.

3.6.6 GIS based multi criteria decision analysis

GIS-based MCDA involves the utilization of geographical data, the decision makers preferences and the combination of the data and preferences according to specified decision rules (Malczewski, 2006). MCDA have the potential to reduce the costs and time involved in urban green space development site analysis by narrowing down the potential choices based on predefined criteria and weights. AHP and WLC are the two most widely used MCDA methods that was used for this study.

3.6.7 Analytic hierarchy processes

The Analytic Hierarchy Process (AHP) is a decision-making method for prioritizing alternatives when multiple criteria must be considered. It offers a methodology to rank alternative courses of actions based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each of the alternatives. AHP was be used in this study to derive weights for each parameter.

3.6.8 Estimation of the consistency ratio

The aim of estimating consistency ratio is to determine whether comparisons matrixes are consistent or not to use for overlay analysis. According to Lawal et al. (2011), if the consistency ratio is less than or equal to 0.1, it is significantly acceptable reciprocal matrix. Thus, to check the consistence of comparisons matrixes used in this study consistence ratio was calculated. To calculate the consistency ratio: First Determine the weighted sum vector, next Determine the consistency vector, next Compute lambda max (λmax) using 3.2 formula and finally, calculate consistency ratio (CR) by using 3.3 formula.

$$CI = \frac{\lambda \max - n}{\mathrm{n-1}} \text{---} 3.2$$

$$CR = \frac{\mathrm{CI}}{\mathrm{RI}} \text{--} 3.3$$

Where, CI is consistence index, n is number of parameters, CR is consistence ratio.

3.6.9 Weighted linear combination

Weighted Linear Combination (WLC) is a type of MCDA Method in GIS environment used to evaluate the suitability of a region for urban green space 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). In this study, GIS based MCDA was employed.

$$\mathrm{S} = \sum_{i=0}^{n} wi\ xi * \Pi\ cj \text{--} 3.4$$

Where **S** is the composite suitability score, w_i is weights assigned to each factor, x_i is factor scores (normalized cell values), c_j is constraints (built-up and protected area), and Π is the product of constraints.

The overall process performed to find suitable site for urban green space development in Modjo Town is illustrated by the below general work flow. This work flow shows source of data, generated input data, operation performed to urban green space development site suitability and accessibility analysis.

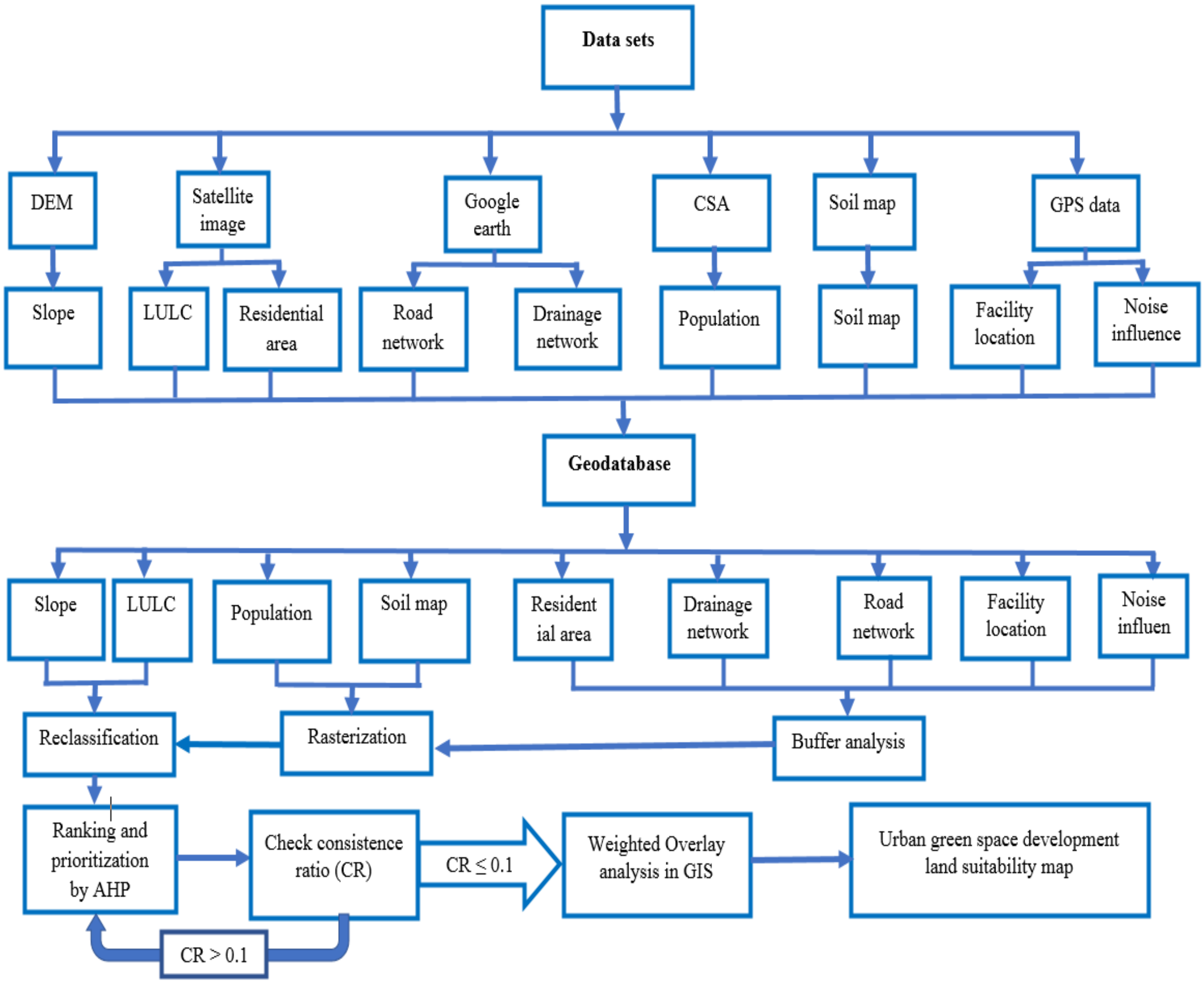

Figure 3:3 General work flow

CHAPTER FOUR

RESULT AND DISCUSSION

In this chapter, the Land suitability analysis for urban green space development in Modjo Town is discussed, and various data sets were utilized. The data was analyzed, and a LULC map for the current year (2023) was developed, which is presented in figure 4.1 and table 4.1. Statistical analysis of LULC for the study area is also provided. Furthermore, suitability analysis maps were created for each criterion, and a composite map was produced by overlaying the individual maps with weights assigned to each factor. Tables were used to summarize the reclassified criterion, standardization score, area coverage of suitability levels, and weights of each factor.

4.1. **The Main Determinant Factors for UGS Development in the Study Area**

For the Land suitability analysis of urban green space development in Modjo Town, several factors were chosen based on literature and prior knowledge of the area. Nine factors were considered, including LULC, distance from transportation, population density, soil type, slope, distance from noise sources, distance from residential areas, distance from facilities, and distance from streams. The availability of data for Modjo Town was taken into account when selecting these factors. The suitability analysis was performed using these factors to identify suitable locations for UGS development. Tables were used to summarize the results, including the reclassified criteria, standardization score, area coverage of suitability levels, and weights of each factor. A composite map was produced by overlaying individual maps with assigned weights for each factor.

4.2. Suitability Analysis for Urban Green Space Development

4.2.1 Suitability of land use/land cover

Previous studies have shown that current LULC must be considered when choosing suitable sites for the development of urban green spaces and have identified the suitability of different LULC based on their use type (Heshmat et al., 2013; Abebe and Megento, 2017; Dagistanli et al., 2018; Pokhrel, 2019; Ustaoglu and Aydinoglu, 2020). Modjo Town’s land use/land cover data were categorized into five main classes: built-up area, farm Land, water bodies, shrub and bushes and bare land (Figure. 4.1). Based on knowledge obtained from the analysis of literature, bare land and Shrub and bushes were considered to be highly suitable for urban green spaces development.

Additionally, in this study farm land was considered as moderately suitable, water body and Built-up area were considered as less suitable conditions for green space development (Table 4.1; Figure 4.1).

Table 4.1: Reclassified LULC and area coverage of suitability levels

LULC type	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
Bare land	5	S1	57.994	1.10
Shrub and bushes	5	S1	136.232	2.58
Farm Land	4	S2	2822.516	53.42
Water body	3	S3	67.199	1.27
Built-up area	3	S3	2199.768	41.63

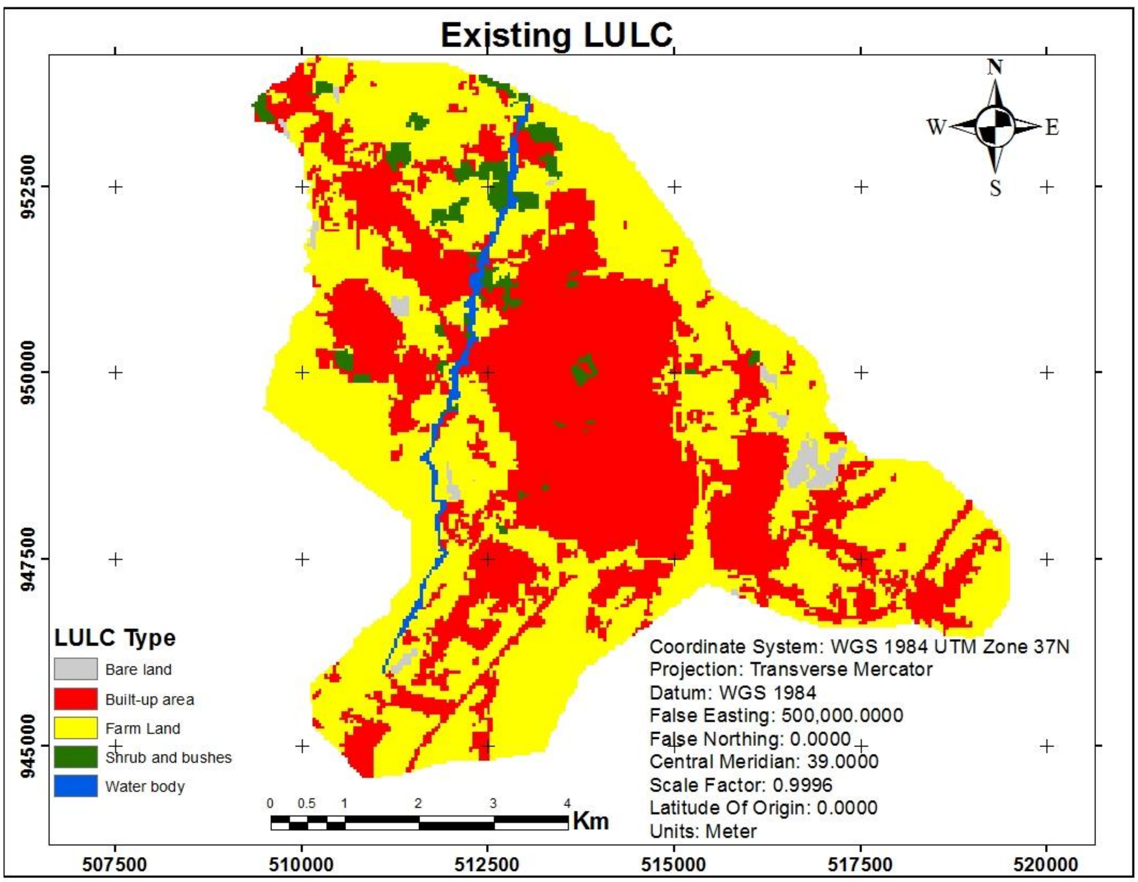

Figure 4.1: Existing land use and land cover map

4.2.2. Suitability of slope

The slope of Modjo Town was derived from DEM data obtained from USGS/SRTM. As the slope is very steep, greening the land is difficult because it needs some landscape modifications such as reshaping, and vice versa (Lo and Jim 2010). On the other hand, earlier studies have shown that low-slope areas are highly suitable for the development of urban green spaces (Yousef and Mohammad, 2014; Abebe and Megento, 2017; Dagistanli et al., 2018; Pareta, 2019) 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 (Yousef and Mohammad, 2014). Based on the (FAO, 2006), the slope value 0 to 0.2 % is considered as flat and up to 5% gently slope and these slopes are considered as highly suitable in this study. Slope value 5 to 10 % and 10 to 15 % is called sloping (moderately suitable) and strongly sloping (less suitable) respectively (Table 4.2; Figure 4.2).

Table 4.2: Reclassified slope and area coverage of suitability levels

Slope (%)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
<5	5	Highly suitable	4395.547	83.19
5–10	4	Moderately suitable	724.678	13.72
10–15	3	Less suitable	103.793	1.96
15–30	2	Not suitable	39.444	0.75
>30	1	Permanently unsuitable	20.247	0.38

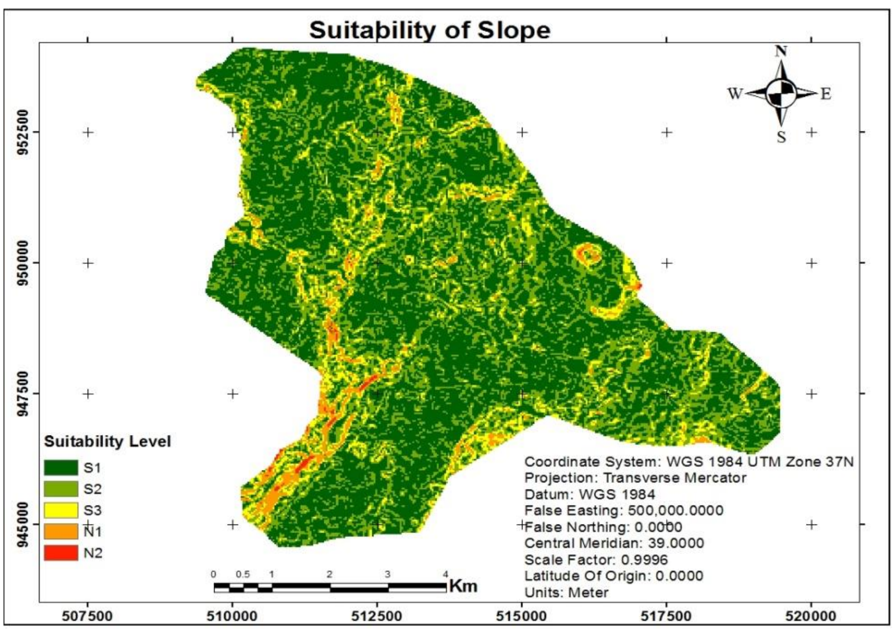

Figure 4.2: Reclassified slope map

4.2.3. Proximity to the stream

Water plays an important role in the growth and development of a living organism. Water bodies/streams is one of the key factors that regulate and make UGS development works easily because it is the heart of the growth and development of green plants. Due to, the above fact any UGS should be sited near water source areas. According to some earlier studies carried out by various researchers like (Heshmat et al., 2013) stated that land closer to water bodies like rivers, lakes, reservoirs and ponds are suitable for the development of green space. As they preserve good environmental health and are highly suitable from the ecosystem perspective too. Distance from the stream less than 200m; between 200 and 500m and in between 500 and 1000m are highly suitable; moderately suitable and less suitable respectively (Table 4.3; Figure 4.3).

Table 4.3: Proximity to the stream and area coverage of suitability levels

Distance from stream (m)	Standardization score/value	Level of suitability	Area (ha.)	Area cover in (%)
<200	5	S1	1069.581	20.24
200–500	4	S2	884.099	16.73
500–1000	3	S3	790.803	14.97
1000–1500	2	N1	732.243	13.86
>1500	1	N2	1806.984	34.20

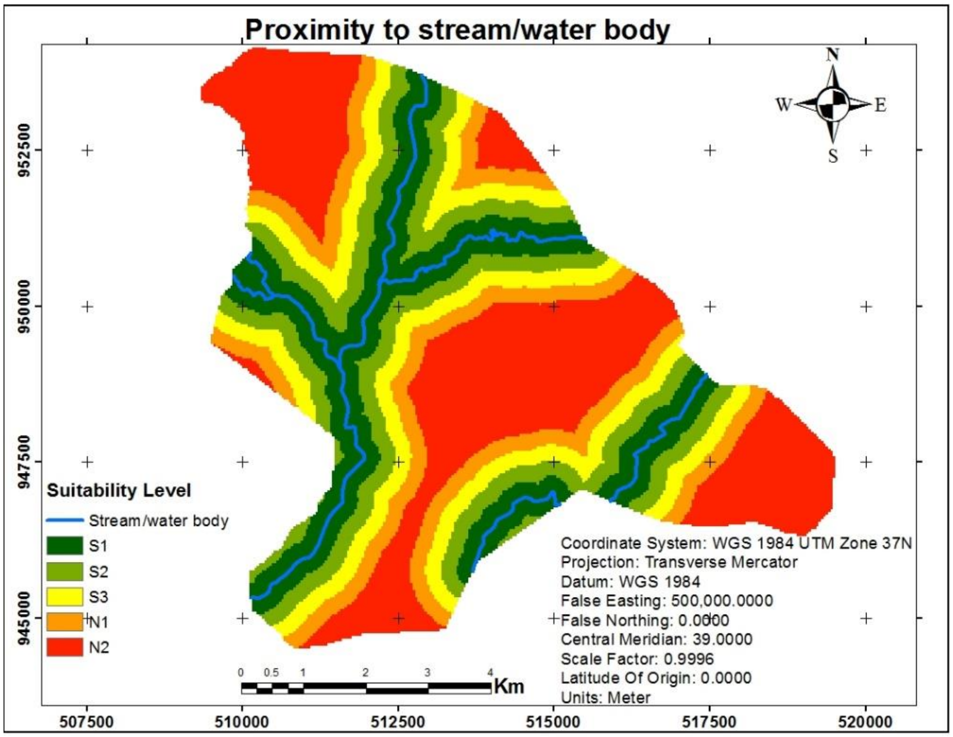

Figure 4.3: Proximity to stream map

4.2.4. Proximity to facility locations

The facilities location covers the schools, college, major health facilities and hospital's locations that are crucial and important to get all services and meantime need some green spaces nearby such locations. Based on those views the lands which are closer to those facilities are more suitable than farther land (Pokhrel, 2019). Therefore, if distance from the facilities location is less than 400 m, it was considered as highly suitable; 400m – 800m, moderately suitable; 800m-1200m, less suitable; 1200m–1600m, not suitable and >1600m, permanently not suitable for developing green space (Table 4.4; Figure 4.4).

Table 4.4: Proximity to facility locations and area coverage of suitability levels

Distance from facilities location (m)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
<400	5	S1	557.194	10.55
400–800	4	S2	949.329	17.95
800–1200	3	S3	755.303	14.30
1200–1600	2	N1	666.964	12.63
>1600	1	N2	2354.920	44.57

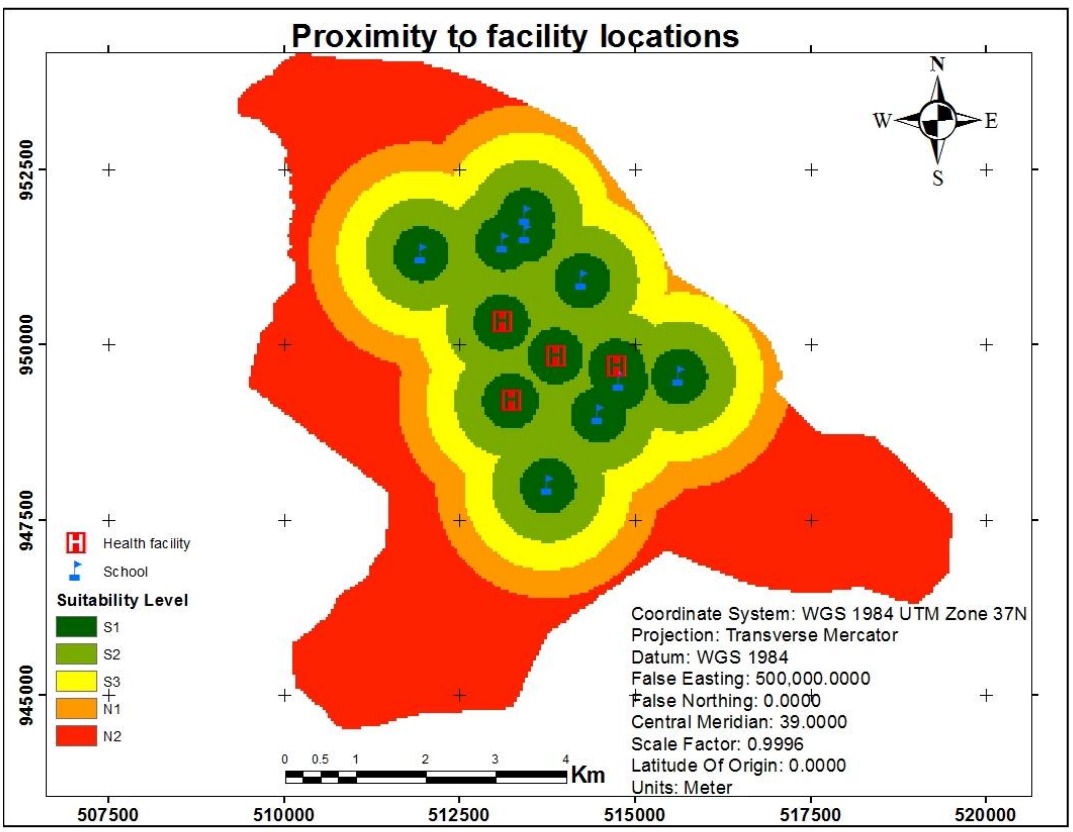

Figure 4.4: Proximity to facility locations map

4.5.5. Proximity to noise influence

Noisy areas are not suitable for green space like the factory area because of high sound pollution and smoke (Manlun, 2003; Pareta, 2019). Therefore, the farther lands from the factory get more preferences for green space development. In this study, by making buffer analysis, as totally unsuitable if less than 500m, not suitable between 500m and 1000m, less suitable from 1000m to 1500m, moderately suitable from 1500 to 2000m and highly suitable greater than 2000m for green space development (Table 4.5; Figure 4.5).

Table 4.5: Proximity to factories and area coverage of suitability levels

Distance from factory (m)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
>2000	5	S1	716.102	13.55
1500–2000	4	S2	623.485	11.80
1000–1500	3	S3	1110.955	21.03
500–1000	2	N1	1587.492	30.05
<500	1	N2	1245.677	23.58

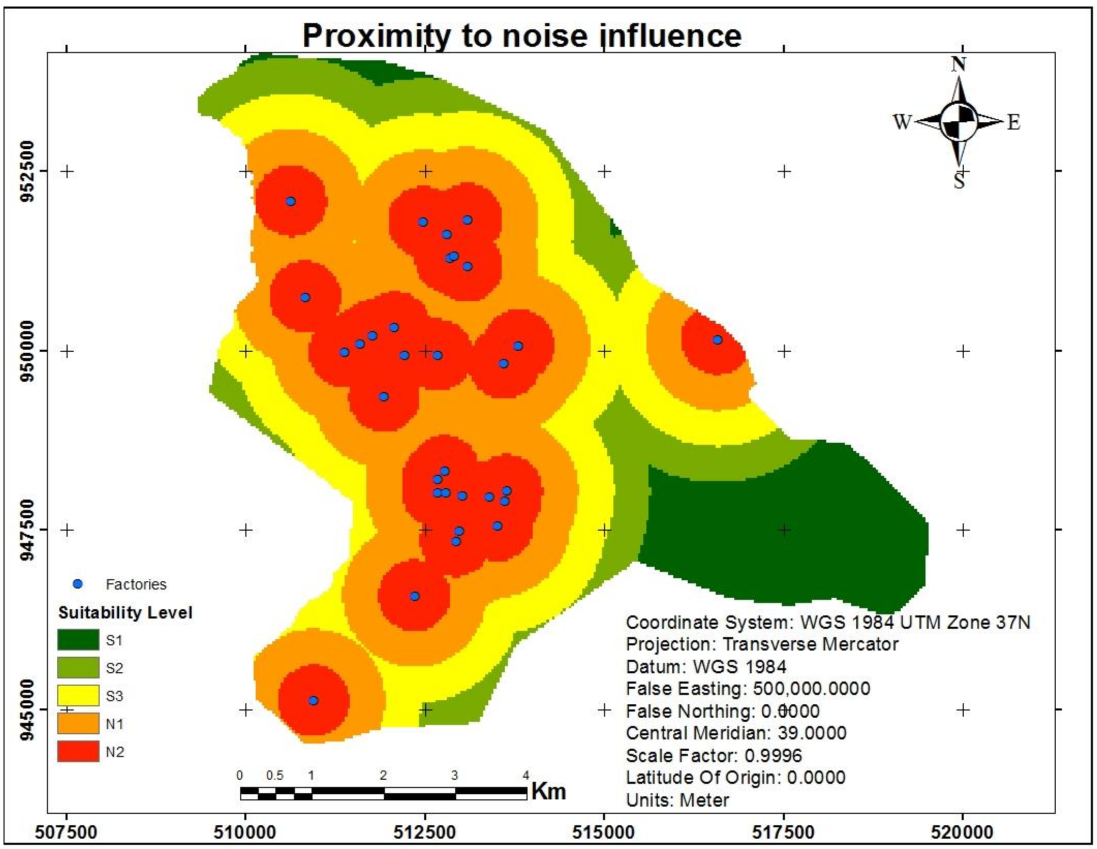

Figure 4.5: Proximity to factory map

4.5.6. Proximity to residential/settlement areas

Agreed their numerous ecological, social, and economic advantages, green spaces must be accessible to settlement areas in urban areas (Zhang et al., 2013; Malmir et al., 2016; Ustaoglu and Aydınoglu, 2020). 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. For this study, areas within 200m, 200m to 500m and 500 m to 1000 m, distances from the settlement area have been considered as highly suitable, moderately suitable and less suitable respectively (Table 4.6; Figure 4.6).

Table 4.6: Proximity to settlement/residential area and area coverage of suitability levels

Distance from residential area (m)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
<200	5	S1	3529.965	66.81
200–500	4	S2	939.020	17.77
500–1000	3	S3	714.170	13.52
1000–1500	2	N1	98.628	1.87
>1500	1	N2	1.927	0.04

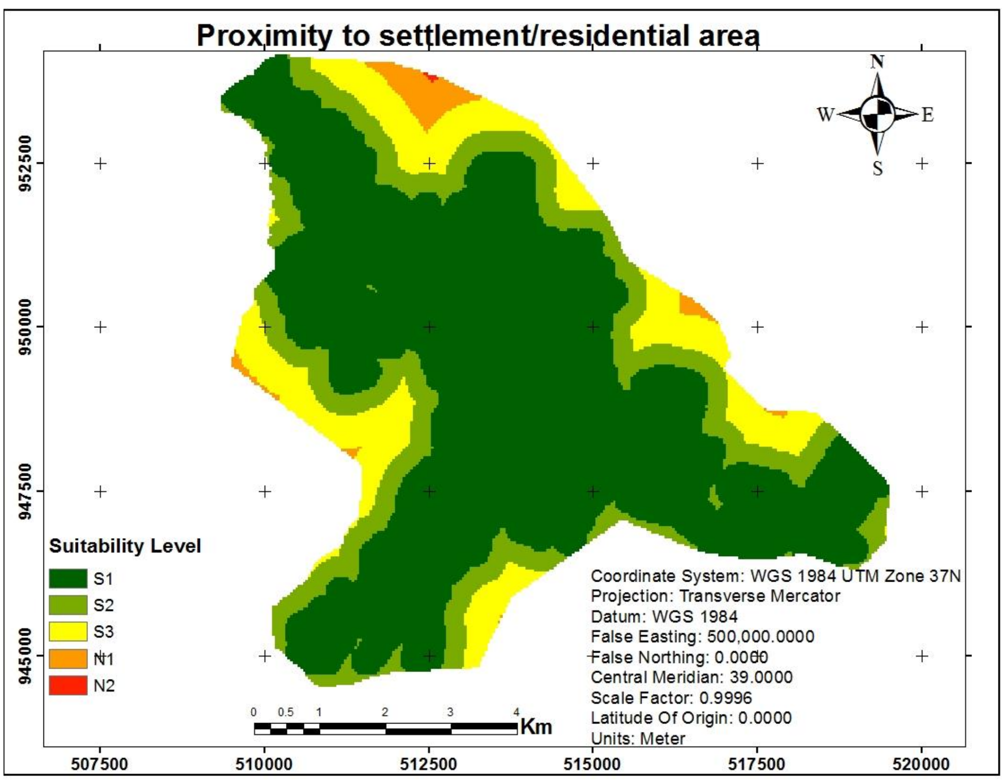

Figure 4.6: Proximity to settlement/residential area

4.2.7. Suitability of soil type

Soils of Modjo Town is classified into one principal type that is Eutric Cambisols. Eutric Cambisols have relatively good structure and chemical properties and are not therefore greatly affected by degradation processes until these become large. Eutric Cambisols are considered as highly suitable soil because of increasing clay with depth, they tend not to be greatly impacted by degradation (FAO-UNESCO, 1974).

Table 4.7: Soil type and area coverage of suitability levels

Soil type	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
EutricCambisols	5	S1	5283.709	100

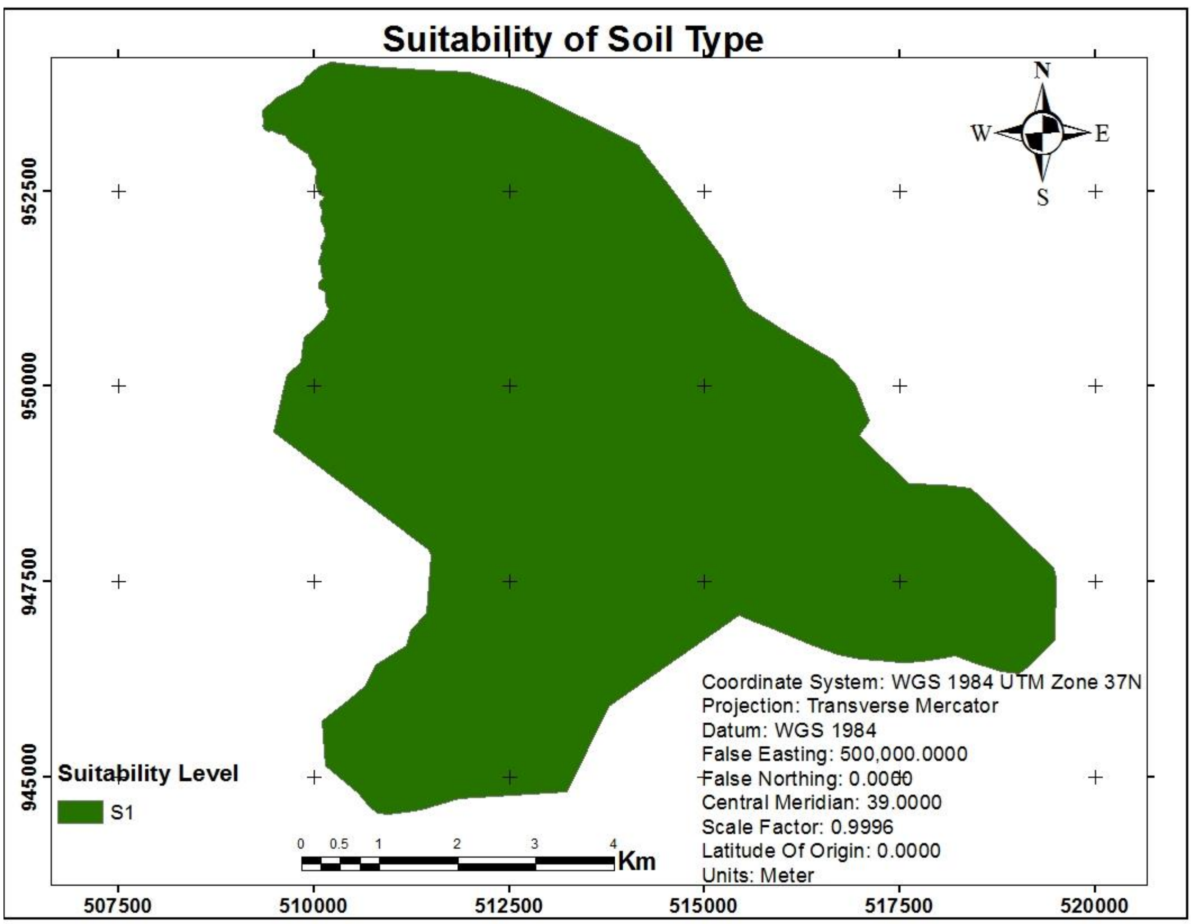

Figure4.7: Reclassified soil map (Source: FAO)

4.2.8. Population density

Population density is one of the socio-economic factors influencing the appropriate selection of green space in urban areas. Some researchers (Ahmed et al., 2011; Heshmat et al., 2013; Elahe et al., 2014; Dagistanli et al., 2018; Pokhrel, 2019) recommend that areas that have high population density are highly suitable for developing green space. On the basis of this claim, the study area is densely populated in the west/central parts of the Town and it is considered as highly suitable for the development of urban green space. The south and east portion of the Town is sparsely populated and believed to be insufficiently suited to UGSs development (Table 4.8; Figure 4.8).

Table 4.8: Reclassified population density and area coverage of suitability levels

Population density (pop/ha)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
14.438	5	S1	1610.304	30.48
12.214	4	S2	1195.070	22.62
9.268	3	S3	1992.617	37.71
8.369	2	N1	485.718	9.19

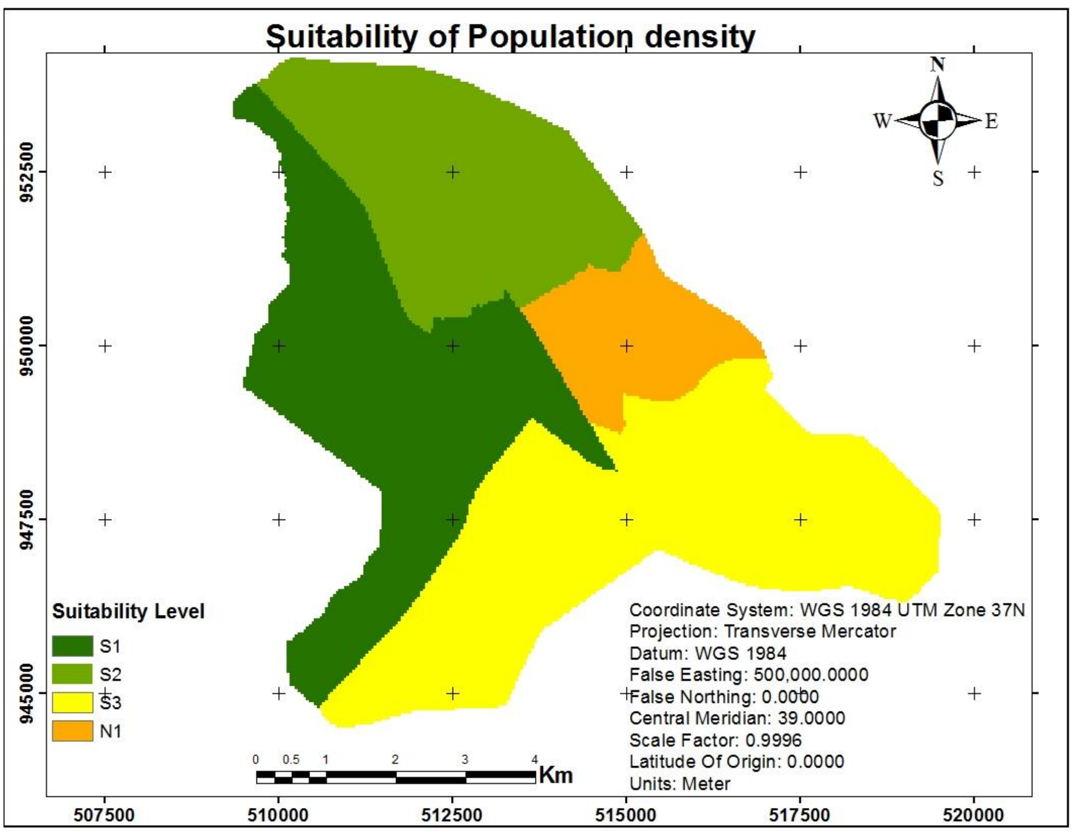

Figure 4.8: Reclassified population density map

4.2.9. Proximity to transportations

One of the fundamental elements that makes urban green space more convenient for users is the availability of road infrastructure, which is important in supplying feasible routes to the local population to access urban green areas in their surroundings (Bunruamkaew and Murayama, 2011; Kienast et al., 2012; Morckel, 2017). The green space site is also preferred if it is located reasonably far from roads so that access to transportation is possible (Chandio et al., 2011; Tahmasebi et al., 2014). In this study, by making buffer analysis, areas within the 300m, 300m-600m and 600m-900m radius of the road network have been considered as highly suitable, moderately suitable and less suitable respectively (Table 4.9; Figure 4.9).

Table 1.9: Proximity to transportations and area coverage of suitability levels

Distance from Road (m)	Standardization Score/Value	Level of suitability	Area (ha.)	Area cover in (%)
<300	5	S1	3163.152	59.87
300–600	4	S2	1165.864	22.07
600–900	3	S3	497.149	9.41
900–1200	2	N1	152.334	2.88
>1200	1	N2	305.210	5.78

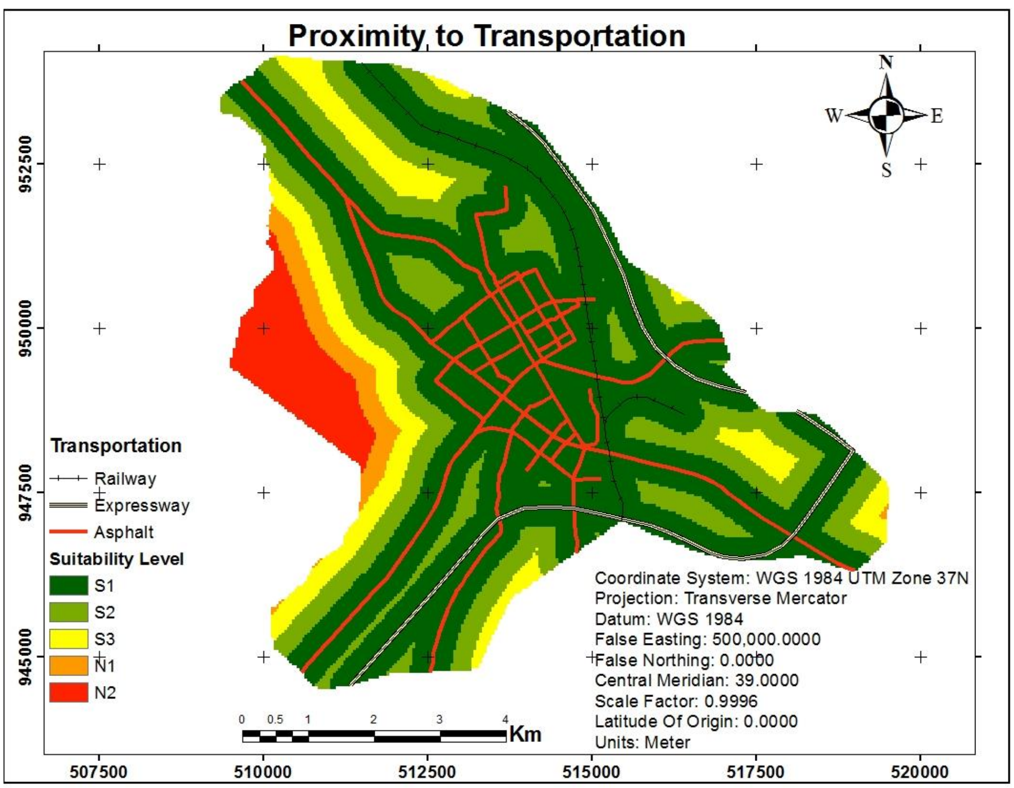

Figure 4.9: Proximity to transportations map

4.3. AHP Weight Derivation

The Analytical Hierarchy Process (AHP) approach ranks several options according to priority using many quantitative and qualitative characteristics discovered through GIS research. The systematic hierarchical decision tree that is utilized to identify possible UGS sites is shown in Figure 3.3. The fundamental goal, which is the identification and mapping of prospective areas for UGS development in the town, is outlined in the first level of the decision tree under the dataset. The second level lists the many quantitative and qualitative elements taken into consideration throughout the site selection process and gathered from secondary sources and remotely sensed data. The second-lowest level of the database describes the various options or alternatives for choosing the primary goal.

A large collection of reasonable decision alternatives is given rank by the AHP after being converted from several criteria to a relative scale of evaluation. Ratio scales are created by paired comparisons of the various variables and the individuals within each factor. By comparing factors on a scale from one to nine for which the comparisons are done, an AHP pairwise comparison matrix was generated, and criteria weights were determined for each factor. Where 9 denotes the extreme orientation to the alternative, 7 indicates a very strong orientation, 5 indicates a strong orientation, and so on down to 1, as illustrated in Figure 4.10. And the midpoint between the two adjacent judgements is represented by the numbers 2,4,6,8, when compromised is needed

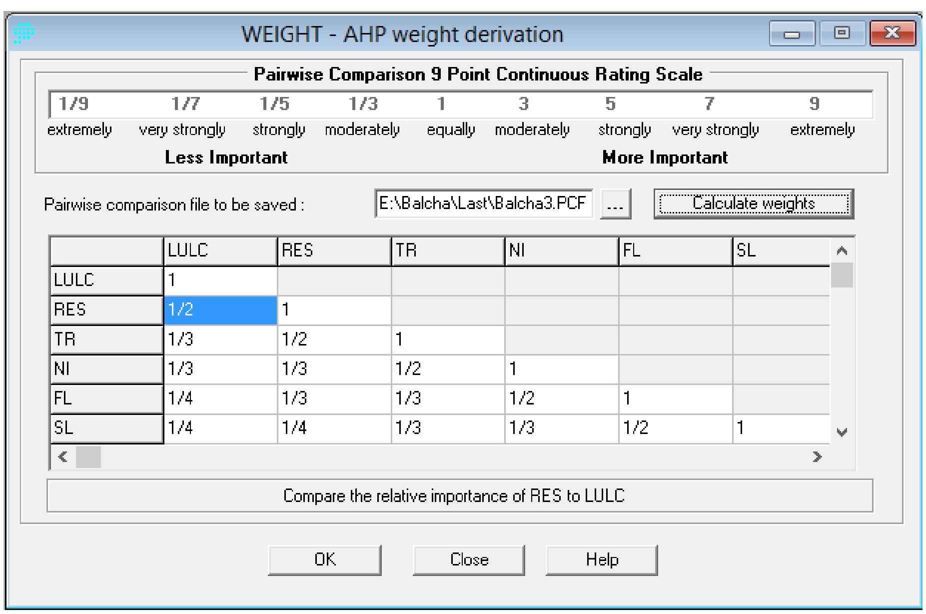

Figure 4.10: Pairwise comparison matrix

The decision-making process is made simpler by assigning individual scores to each of the factors on the basis of pairwise comparison matrix. As indicated in Table 4.10, the pair-wise comparisons of various criteria are typically organized into a square matrix with diagonal components equal to 1.

If a given activity "a" is compared to another activity "b" and "b" has one of the above values assigned to it, then "b" has the opposite value to "a." The inverse comparison results are thus shown by the reciprocals of these numbers, which range between 1/3 and 1/9.

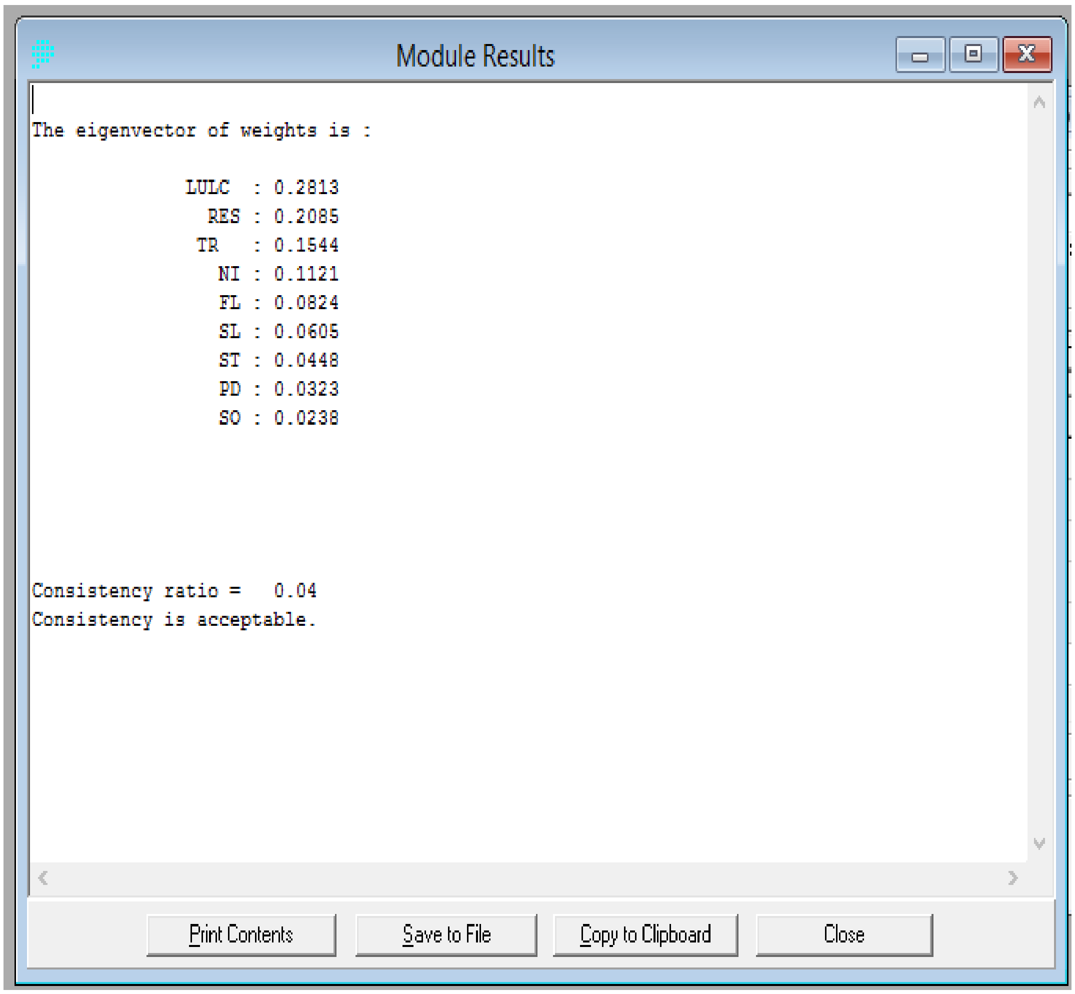

Figure4.11: Eigenvector of the pair wise comparison matrix

Table 4.10: Pairwise comparison matrix

Criteria	LULC	RES	TR	NI	FL	SL	ST	PD	SO	Weight
LULC	1	2	3	3	4	4	6	6	7	28
RES	1/2	1	2	3	3	4	4	5	6	21
TR	1/3	1/2	1	2	3	3	4	4	5	16
NI	1/3	1/3	1/2	1	2	3	3	4	4	11
FL	1/4	1/3	1/3	1/2	1	2	3	3	4	8
SL	1/4	1/4	1/3	1/3	1/2	1	2	3	3	6
ST	1/5	1/4	1/4	1/3	1/3	1/2	1	2	3	5
PD	1/6	1/5	1/4	1/4	1/3	1/3	1/2	1	2	3
SO	1/7	1/6	1/6	1/4	1/4	1/3	1/3	1/2	1	2

Note: LULC = Land use/ land cover, RES = Residential area, TR = Transportations, NI = Noise Influence, FL = Facility locations, SL = Slope, ST = Stream, PD = population density, SO = Soil type

The above AHP result shows that the derived factors have a different degree of influence on urban green spaces. As it is evident from (Table 4.10; figure 4.11), the weight assigned to the factors reveals the relative importance of each parameter in exposing an area to urban green spaces evaluation. As a result, shows land use/land cover with the weight of 28 has the highest priority, 21, 16, 11, 8, 6, 5, 3 and 2 was obtained as a weight value for the distance from residential area, distance from roads/transportation, distance from factory/noise influence, distance from facility locations, suitability of soil type, distance from the stream, population density and suitability of slope respectively with 0.04 of consistency ratio (Figure 4.11). Consistency ratio of 0.1 or less is acceptable to continue the AHP analysis (Saaty, 2008). In this study, consistency ratio (CR) of conducted AHP comparisons has obtained 0.04, which is smaller than 0.1 therefore the comparisons can be acceptable. Based on the result of this study, AHP is a highly effective instrument for determining factor weights and is more helpful than alternative approaches since the inconsistency of the factor weight's pair-wise comparison matrix can be calculated and controlled by the Consistency Ratio (CR). In various studies (Kumar and Shaikh, 2012; Bagheri et al., 2013; Romano et al., 2015; Abebe and Megento, 2017; Pokhrel, 2019; Ustaoglu and Aydinoglu, 2020), this has been confirmed.

4.4. **Weighted Overlay Analysis**

After weighting the parameter, as regards the relative importance of each parameter as well as suitability index, all the reclassified parameters were overlaid in order to select suitable sites for green space development using the weighted overlay tool or a raster calculator in ArcGIS and final urban green spaces suitability map was prepared (Figure 4.12).

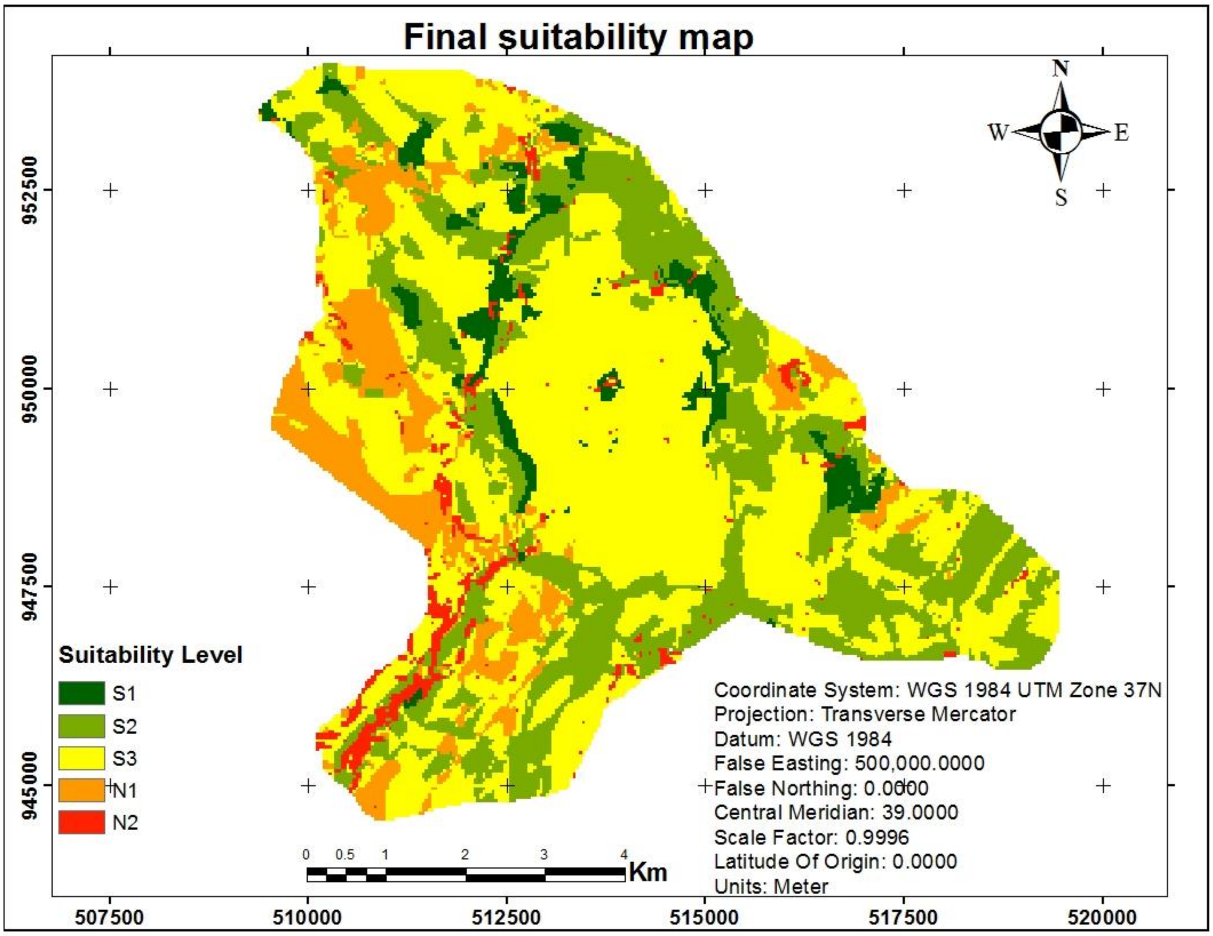

Figure 4.12: Final suitability map

According to GIS-based multi-criteria analysis, the result obtained from the overall suitability map shows 289.158 and 1457.841 hectares are highly suitable and moderately suitable for green space development. The large area is less suitable for green space development in the existing situation which covers 51.45% (2718.206 ha) of the area. The remaining 11.70% and 3.79% are not suitable and permanently unsuitable for green space development respectively (Table 4.11). In the land use plan, the selected areas are mostly categorized as Shrub and bushes, bare land and farm land.

Table 4.11: Final suitability area and percent of total area coverage

Level of Suitability	Area (ha.)	Percent of total area (%)
S1	289.158	5.47
S2	1457.841	27.59
S3	2718.206	51.45
N1	618.225	11.70
N2	200.279	3.79

4.5. Comparison of Suitability Area for UGS Vs. Proposed Structural Plan Green Area

After suitability area for UGS was identified it is possible to compare it with the proposed structural plan of the Town. Comparison of proposed structural plan in the study area was conducted by considering the locational aspects of the UGS in the suitability map. Figure 4.13 shows the comparison between the suitability area for UGS and the proposed structure plan of Modjo Town. The extracted proposed structural plan green area was overlayed on the suitability area for UGS map of the town in the ArcGIS environment. From the comparison of suitability area for UGS map Vs. proposed structural plan green area, the all of proposed structural plan green area were in the less suitable domain of the study area.

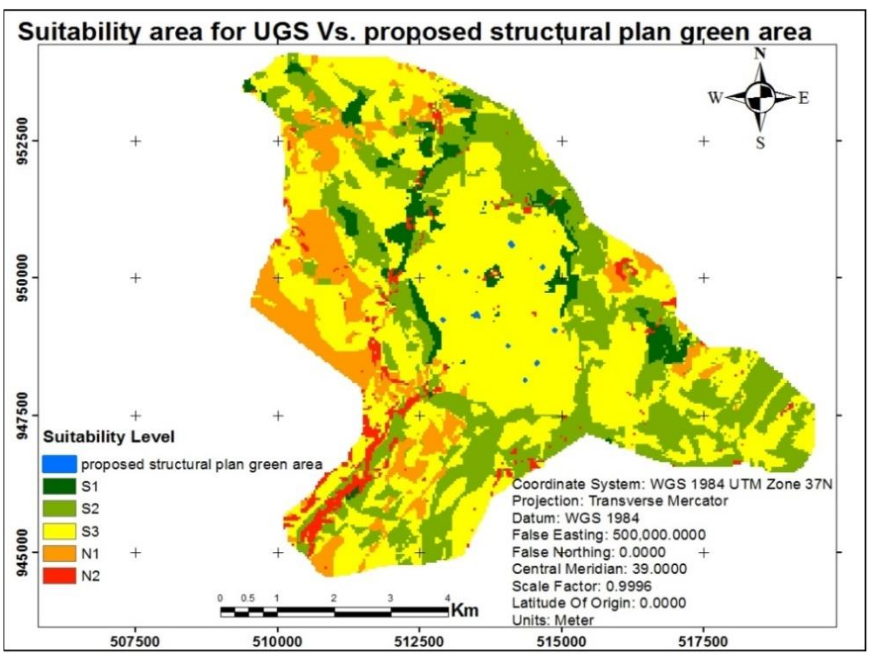

Figure 4.13: Comparison between suitability area for UGS and proposed structure plan

4.6. Summary

The world has experienced tremendous urbanization and population growth. Land use and land cover (LULC) pattern change, industrialization and social transformation occur during the urbanization processes. One of the major impacts of urbanization is a shrinking of urban green spaces, through the development of infrastructures and various development projects. Urban green space (UGS) plays a vital role in the mitigation of negative impacts of urbanization, but it is often abominably affected by the process of land use land cover (LULC) changes in an urban area (Dinda et al., 2021).

There are many determinant factors (main factors and sub factors) that affect urban green space development. Main factors are accessibility, physical, environmental and socio-economic factors. Therefore, the current study used nine site selection criterion including environmental criteria (stream/river), accessibility criteria (Transportations), physical criteria (slope and soil types) and the Socio-economic criteria like LULC, noise influence, distance from residential area, population density, and distance from facility locations are the main determinant criterion used to select suitable site for urban green space development. The final map has shown that, 5.47%, 27.59%, and 51.45% of the study area has been identified as highly suitable, moderately suitable, and less suitable for green space development respectively.

Accordingly, understanding LULC patterns and identifying suitable sites for urban green space development, requires accurate use of geospatial technology in order to assist an effective planning process of green areas in a sustainable way.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter presents the inferences and suggestions derived from the research conducted. The conclusion reflects the overall outcomes of the study in relation to its objectives, providing a comprehensive summary of the research findings. On the other hand, the recommendations focus on addressing the identified gaps in the study and offer suggestions for further exploration in the researched areas.

Furthermore, this chapter includes recommendations aimed at enhancing the suitability analysis for the development of urban green spaces in Modjo Town. These suggestions are intended to guide future research endeavors and initiatives that seek to improve the effectiveness and efficiency of the Town infrastructure analysis.

5.1. Conclusion

In conclusion, geospatial technology is essential for doing site suitability analyses for the creation of urban green spaces. Planners and decision-makers can evaluate and rank suitable locations for the creation of green space in urban settings by integrating different geospatial data sources and analytical techniques. Geospatial technology is used to gather and analyze pertinent data, including LULC, topography, distance from existing green spaces, population density, and accessibility to services. Geospatial tools can be used to aggregate and analyze these data layers to create suitability maps, which show regions most ideal for creating green spaces based on predetermined standards and goals. Instead, then depending entirely on subjective judgements, geospatial technology empowers planners to make well-informed decisions based on objective data and analysis.

The decision-making process becomes more transparent and credible thanks to this strategy. Multiple spatial datasets can be combined using geospatial technology, giving a comprehensive view of the research area. This thorough research makes sure that all pertinent elements are taken into account and helps identify potential obstacles and opportunities for green space development. Planners can visualize the study area and the anticipated green space developments thanks to geospatial technology's strong visualization capabilities. This provides a better understanding of the possible impact of green space projects and assists in presenting the analysis results to stakeholders. Numerous components of the analysis process are automated using geospatial technology, which boosts productivity and scalability. It helps planners analyze vast areas and weigh numerous scenarios quickly, saving them time and resources.

The process of evaluating a piece of land's appropriateness is essential for determining where to build green spaces. An extensive multi-criteria analysis approach is needed to identify potential locations for green space development. The rapid growth of Modjo Town has benefited greatly from this study, and it is crucial to take into account a number of elements when evaluating urban green space to maintain safety. Assessing recreational places, like the urban green space in Modjo Town, can be done faster and for less money if geospatial technology is used. Using geospatial technology, a multi-criteria analysis showed that 33.060% of the land area in Modjo Town is appropriate for creating urban green spaces, with 5.47% being extremely suitable and 27.59% being moderately suitable. It should be emphasized that some other locations might be ideal for the construction of green space, but doing so would require a sizable investment and specialized planning.

The study emphasizes the value of geospatial technology in developing urban green spaces by giving up-to-date data on land use. In the research region of Modjo Town, the application of AHP-based MCA approaches was found to be a useful and flexible strategy for identifying suitable locations for urban green spaces.

It's crucial to remember that geospatial technology is a tool that must be used in conjunction with subject-matter expertise and regional context. Even if the analysis offers useful insights, the final choice regarding the creation of new green spaces should take community involvement, social equality, and long-term sustainability into account. Overall, the planning process is improved, evidence-based decision-making is encouraged, and healthier and more sustainable urban environments are created as a result of the use of geospatial technologies for urban green space development site suitability study.

In summary, the suitability results can help with understanding the interplay of the elements and how they relate to the urban environment in the research area. It can be used to assist people in making wiser decisions and so improve the community's and the environment's overall quality of life. Suitability analysis is a potent technique for developing and refining green space systems, aiding local government representatives and residents in developing a viable green space system in the urban environment.

5.2. Recommendation

Considering the findings of this study, the researcher has the following specific recommendations to successfully carry out the developing of urban green space in Modjo Town:

- The Town municipality/administration and beautification office update land use and land cover data using the findings from this research and adhere to national requirements for the coverage of green space. As can be seen from the analysis's findings, Modjo Town has fewer green places.
- Validate the analysis's findings by comparing them with the Town structural plan and local knowledge. Engage stakeholders, such as the neighborhood community, to get their feedback and improve the green space suitability analysis. Include input to make sure the analysis is in line with regional requirements, tastes, and sustainability objectives.
- Present the results of the appropriateness analysis to the appropriate decision-makers, authorities, and community members by comparing them to the present Modjo Town structural plan. Assist in the facilitation of a participatory planning process that includes discussions, workshops, and consultations to choose the final locations for the creation of green space. When making decisions, take into account variables including financial restrictions, land ownership, and potential environmental effects.
- Create a monitoring and evaluation system based on the findings of the research analysis to evaluate the success and impact of the green space development projects. To ensure the long-term viability and success of the town's greenery, continuously check the state of the green spaces, collect user feedback, and carry out periodic evaluations.
- Urban planners and decision-makers can effectively apply the outputs obtained from study area for green space development by heeding these tips.
- The Town municipality and other researchers will use the geospatial technology and GIS-based MCA by utilized as valuable tools in conducting suitability analysis for the development of other urban site suitability selection various socio-economic data.

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