Sustainable Urban Green Space Planning in Response to Rapid Urbanization: The case of Debre Berhan and Debre Markos, Ethiopia

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A dissertation submitted to the Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC), Addis Ababa University in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Urban and Regional Planning

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# APPROVAL SHEET

# EiABC, Addis Ababa University

This is to certify that the thesis is prepared by Alemaw Kefale Getnet entitled: "Sustainable urban green space planning in response to rapid urbanization: The case of Debre Berhan and Debre Markos, Ethiopia" submitted in fulfillment of the requirements for the degree of Doctor of Philosophy in Urban and Regional Planning complies with the regulations of the Addis Ababa University and meets the accepted standards concerning originality and quality.

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# Declaration

I undersigned, declare that, this thesis is my own and original and has not been presented for a degree in any other university and that all resources of materials used for the thesis have been duly acknowledged following the scientific guidelines of the University.

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## ABSTRACT

**Sustainable Urban Green Space Planning in Response to Rapid Urbanization: The case of Debre Berhan and Debre Markos, Ethiopia**

Alemaw Kefale Getnet

Addis Ababa University, 2025

Urban green spaces (UGS) play a vital role in enhancing the quality of life in cities, particularly in terms of resilience to climate change (Bressane et al., 2024). However, rapid urbanization has severely impacted these areas, especially during the densification of urban functions. Unplanned growth has led to significant losses in urban landscapes, vegetation, and ecosystems. In developing countries, including Ethiopia, the effectiveness of current practices in green space planning and development is being questioned, highlighting the need for improved quality and provision. This study evaluated the availability, accessibility, quality, user preferences, and constraints related to urban green spaces in the rapidly urbanizing cities of Debre Berhan and Debre Markos. A mixed–methods approach was employed, utilizing both qualitative and quantitative data. Sampling techniques included probability and purposive sampling, with data gathered from document reviews, satellite imagery, field surveys, and insights from city administration offices and key informants. Tools for data collection included interviews, questionnaires, and document analyses, with data processed using software such as SPSS and ArcGIS 10.8. The findings revealed a significant decline in vegetation cover in both cities from 2000 to 2020, with a marked transformation of green spaces and agricultural land into built environments. Many users stated that urban green spaces are neither accessible nor good quality. The planning of these spaces does not take into account users' preferences and perceptions. Users value green spaces for their recreational, aesthetic, and pollution-mitigating benefits. Notably, only quantitative standards were employed for green space planning, while alternative models remain unfamiliar in both cities.

These results underscore the need for enhanced knowledge and strategies to effectively integrate and manage urban green spaces in rapidly urbanizing areas.

**Keywords:** Urban green spaces, accessibility, quality, land use land cover (LULC), green space planning

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## Acronyms

**ANGSt:** Accessible Natural Green space Standards

**BWS:** Best Worst Scaling

**CSA:** Central Statistical Agency

**DB**: Debre Berhan

**DM:** Debre Markos

**EPA:** Environmental planning Authority

**EGSI**: Ethiopian Geospatial Institute

**GIS:** Geographic Information System

**LULC:** Land Use/ Land Cover

**Ha:** Hectare

**UN-Habitat:** United Nation Habitat

**MUDH:** Ministry of Urban Development and Housing

**SBPDA:** Sanitation, Beautification, and Park Development Agency

**NDVI:** Normalized Differentiation Vegetation Index

**OLI:** Operational Land Imager

**TM:** Thematic Mapper

**UN:** United Nation

**UTM**: Universal Transverse Mercator

**USGS:** United States Geological Survey

WHO: World Health Organization

**SGDS:** sustainable development goals

**SPSS**: Statistical Package for Social Science

## List of Appendices

# Chapter One. Introduction

Urban green spaces (UGS) are essential elements of the urban environment, contributing to quality of life and enhancing human well-being (Selanon & Chuangchai, 2023). Although the functions and benefits of urban green spaces are acknowledged, they do not get full attention in rapidly urbanizing cities in Ethiopia in general and in Debre Berhan and Debre Markos towns, in particular, and they are consequently under pressure with rapid urbanization. As an urban planner and environmentalist expert, I was engaged with projects in these cities. I got to observe the poor condition of green spaces in the areas I was questioning about the solutions for the degradation of green spaces and making urban green spaces sustainable. Thus, the author was motivated to assess better the existing situations of urban green spaces, planning practices, users' perceptions and preferences, challenges, and the solutions for the constraints. This chapter presents the study's background, problem statement, objectives, research questions, scope, and significance.

## 1.1 Back ground of the study

Urban areas are evolving rapidly worldwide; since the last three decades, the sizes of cities worldwide have altogether increased (Melchiorri et al., 2019). About 55% of the world's population lives in urban areas, this is expected to increase to 68% by 2050. Accordingly, there will be an increase in the world's population by at least 2.5 million people, most of which (90%) are expected to be in Asia and Africa (UN, 2018). The urban population of Africa is currently experiencing the highest urban growth rate in the world at 3.3% urbanization rate per annum, and it is expected to double from 294 million in 2000 to 742 million in 2050 (Abdelaziz, 2014). In sub-Saharan Africa, the geographic extent of secondary cities (with population numbers from 1000 to 500,000) has been increased by a factor of 2.5 (Maru & Worku, 2022). Ethiopia is a developing country located in sub-Saharan Africa, which is the second-most populous country in Africa next to Nigeria (MUDHo, 2015). Secondary cities in Ethiopia are expanding at high rates as a consequence of the government's priority for urbanization, assuming that it will accelerate the progress toward achieving middle-income status by 2025 (Caravaggio et al., 2021). Following this, many investment questions for huge factories and other developments are flattering excess in cities like Debre Berhan, Kombolcha, Bahirdar, Debre Markos, and other cities of Ethiopia, making the planning tough and fail to achieve the goals of a green city (Environmental Protection Authority, 2011).

Rapid urbanization has put immense pressure on urban green spaces, resulting in the loss of ecosystem services, vegetation, and landscapes due to unplanned urban growth (Gantiva et al., 2015). Urbanization with inefficient land uses creates long-term challenges for cities (Bagan et al., 2019; Wellmann et al., 2018). This rapid urbanization may negatively affect the quantity, accessibility, and quality of urban green spaces due to the unceasing expansion of built-up areas and the ever-growing urban population (Liu et al., 2021). It causes local environmental degradation, such as the intensification of the urban heat island, loss of urban green spaces, loss of biodiversity, and reduced ecosystem services (Girma, 2019; Zipperer et al., 1997) and busy urban life (Cetin, 2017). In the inner and dense parts of cities, green spaces have been degrading, resulting urban heat islands (Halder et al., 2021) and reduction of green spaces and ecosystem services (Kim & Kwon, 2021; Zewdie et al., 2021; Cilliers et al., 2013).

Evaluating, anticipating, and monitoring the urban dynamics of its extent, direction, intensity, impacts, and factors are paramount to sustainable urban development (Wang et al., 2020). Temporal and spatial detection and quantification of land use and land cover are also important for managing urban landscapes and developments (Subasinghe et al., 2016). Remote sensing and GIS applications are useful for analyzing and monitoring urban green spaces by providing accurate and reliable data for assessing the distribution, extent, quality, and changes in urban green space (Zhou et al., 2018). They were used for urban green space accessibility mapping, cover change detection, accessibility, and quality analysis (Yang et al., 2023; Siddique et al., 2022; Amir et al., 2018; Cetin, 2017; Xu & Cui, 2016). For example, Huang et al.(2018) assessed the urban green space of Lengshuijiang City using high-resolution remote sensing. Shahabi et al.(2012) used GIS to evaluate green space destruction and change detection in urban areas in the case of Boukan City.

Urban green spaces interplay between greening and reducing social vulnerability is crucial (Cheng, 2013). They have urban ecological, recreational, hydrological, and social benefits (Cetin, 2017; Daniels et al., 2017; Johari, 2012). They are significant for urban environmental indicators for the sustainable operation and development of a city (Mougiakou & Photis, 2014). They play a vital role in improving the quality of life in urban areas (Mensah et al., 2016), ecological functioning and integrity (Cetin, 2017; Wolch et al., 2014), maintaining a comfortable temperature, improving well-being, and aiding in physical and emotional recovery from stress (Kothencz et al., 2017; Jansson, 2014). They can improve urban living conditions by enhancing aesthetics, air quality, and raising property values (Saeed & Mullahwaish, 2020), public spaces and natural environments are provided and maintained to promote social equity (Zheng et al, 2019), and using less energy for cooling. Additionally, children's physical, social, and cognitive growth relies on play ( Suppakittpaisarn et al., 2017; Lee and Maheswaran, 2011). Johari (2012) summarized the benefits of green spaces to the environment, society, health and well-being, and the economy. These benefits include air quality improvement, pollution mitigation, microclimate modification, biodiversity protection, social interaction and integration, recreational opportunities, sense of safety, city image and identity, cultural value enhancement, physical and emotional health improvement, and economic attractiveness for businesses, added value, increased market value of properties, and tourism. However, when urban green spaces are not properly maintained, they can have ecosystem disservices (Gómez-Baggethun & Barton, 2013). Urban regions and their surroundings receive provisioning, regulating, recreational, and supporting ecosystem services from nature (Millennium Ecosystem Assessment, 2005).

Barrera et al (2016) and Green space scotland (2008) put the key measures of green space values are quality, quantity, and accessibility (how well-connected, accessible, and inclusive green space is to communities). Similarly, Barrera et al. (2016) put three ecological indicators of urban green spaces in two spatial scales: city-level and local-level (i) the total area of green space in relation to population and urban context, (ii) the quality of green space based on its size, shape, and vegetation cover, and (iii) the spatial distribution and accessibility of green space. The most used indicator to assess green spaces is their total area coverage with respect to the total city area. Green space Scotland (2008) stated that one of the key measures of green space value is the quantity (overall quantity of green space). Similarly, Mougiakou & Photis (2014) stressed on the size that an optimum landscape should have large patches of natural vegetation, supplemented with small patches scattered throughout the matrix.

Accessibility of green spaces is a measure of relative remoteness and proximity to residents (Texier et al.,2018). It should override the availability standard because there may be high levels of public green spaces in some areas and some not, which they arise the question of inequity of green space distribution (Jabbar et al., 2022). Proximity to an urban park or geographically defined green space, proportion of green space or greenness within a certain distance from residence, and perception-based measures of green space accessibility are indicators of green space accessibility (WHO Regional Office for Eruope, 2016). For example, in Birmingham, cities should have an accessible natural green space less than 300 meters (in a straight line) from home (Moughtin & Shirle,2005). In Ethiopia, every inhabitant shall live within 500m of a public green open space of a size of at least 0.3 ha (MUDHo,2015). However, Azagew & Worku (2020); Girma (2019); Gashu&Gebre-Egziabher (2019) indicated that urban green spaces have been decreasing through land use conversion and other factors in Ethiopia.

## 1.2 Rationale of the study

Urbanization is the movement of people from rural areas to cities, either for permanent residence or temporary business activities (Ojo, 2017). Population growth and migration to urban areas are the manifestations of rapid urbanization that challenge green spaces (Rana, 2011). Cities are under high pressure due to rapid urbanization increasing population density in cities, and the problem will potentially accelerate when the densification in the cities continues reducing the green spaces that, causes other social, environmental, and economic impacts to the residents (Lundh,2017). Therefore, it is important to have a convenient, sustainable, and optimum index of green spaces in a way that could give proper and expected ecosystem services. It means, it is essential to establish sufficient, accessible, and quality green spaces according to per capita standards. For example, compact cities with lower percentages of urban green spaces lack ecosystem services (Russo, 2018). According to Marando et al.(2022) and Balany et al. (2020), high-quality and sufficient greenery elements should be available in urban areas to mitigate the urban heat island and provide ecosystem services properly. However, the current measurement of green spaces is inadequate because it fails to differentiate between areas with numerous small urban green space (UGS) units and those with a single large UGS unit located at the edge, which may not be easily accessible to nearby residents, leading to fragmentation issues (Texier et al., 2018).

While research is conducted on several dimensions of urban green spaces, provision, and access inequalities have been overlooked. There is still no methodological consensus about conceptualizing and measuring its provision and access (Texier et al., 2018). Future research should focus on creating accessibility and sustainable quality standards for city green spaces (Barrera et al., 2016). Various characteristics and functions of urban green spaces have been extensively recognized and discussed. However, what constitutes a high-quality green space is still not adequately researched (Johari, 2012). In this regard, further research is needed to examine which properties and potentials of urban green spaces can provide urban ecosystem services in sustainable compact cities if well-managed (Jansson, 2014). Therefore, this study aims to examine the urban green space values/sustainability indicators in the study areas and recommend planning solutions for its sustainability.

### 1.3 Problem statement

Urban population growth harms basic urban infrastructure and services (Asoka et al., 2013) in accommodating the population growth and various socioeconomic demands. Some undesirable urban features would happen that include unrestricted outward development, leapfrog expansion of low-density areas, lack of coordinated planning, and large-scale conversion of open spaces and farmland for urban use (Rahimi, 2016). One urban strategy to cope with this is compact development with an infilling growth approach (Hampton, 2010 and Owusu, 2012). Infilling is important to increase urban density, however; it has been proved that densification processes like compacting, intensifying, consolidating, and expanding urban functions pose pressures and challenges to urban green spaces since intensifying of land conflicts with the preservation of ecosystems (Gantiva et al., 2015). This intervention revitalized older urban areas such as brownfields, underused areas, green spaces, open spaces, and vacant buildings (Elgendy et al., 2004). Compactness can enhance access to urban facilities, reduce the conversion of agricultural land to urban areas, and shorten commuting distances; however, it may also lead to a decrease in recreational spaces and an increase in urban heat island effects (Russo, 2018). The problem potentially accelerates when the densification in cities continues reducing the green spaces, causing other social, environmental, and economic impacts on the residents (Lundh, 2017). It increases the frequency and intensity of the natural hazards in cities, including flooding (Dodman et al., 2013) and climate change (Derkzen et al. 2017) due to green space degradation. On the other hand, edge/sprawl developments degrade urban green spaces on the cities' outskirts and change agricultural lands to paved surfaces in expansion areas (Hampton, 2010). Gashu and GebreEgziabher (2018), Getu et al. (2021), and Degefu et al. (2021) also mentioned that unplanned sprawl and expansion have resulted in the loss of working and urban landscape, vegetation, and ecosystem services in rapidly growing cities. In both ways, green spaces face challenges and lack attention for the sake of economic and social development over environmental sustainability. Despite the potential benefits of urban green space development in urban areas, many rapidly growing cities do not prioritize it (Odhengo et al., 2024). According to Cyrus (2021), this lack of attention can be attributed to a limited perception of the benefits of urban green spaces and constraints within the urban planning systems of many developing countries. For example, in Ethiopia, green spaces face challenges and lack attention because the stakeholders prioritize economic and social development over the cost of environmental sustainability (Yeshitela, 2020). Therefore, there is a need for more proactive efforts to address these issues and prioritize the development of urban green spaces.

As changes occur and new challenges arise in urban green space development, urban planning must emphasize to inner development (Elgendy et al., 2004). Reductions in green spaces in urban areas have social, environmental, and economic impacts on residents (Lundh, 2017). Zipperer et al. (1997) and Girma (2019) revealed that rapid urbanization leads to environmental degradation, including heat islands, loss of green spaces, and biodiversity. Many countries, including Ethiopia, have formulated greening policies and strategies to sustain urban green spaces and enhance the residents' quality of life. For example, urban greening strategy for mitigating the impacts of urbanization (Dutta et al., 2021) and provisioning and maintaining green space networks through different specialized development methods, techniques, and regulations (Girma, 2019). However, in Ethiopia, urban green space provisions are inadequate (Dubbale et al.,2010) and have poor quality. They do not meet the minimum standard of the World Health Organization, which is 9m2 of green space per capita, and the minimum standard of the Ministry of Urban Development and Housing (2015) which is 15$m^2$ public green spaces per capita within the city boundaries.

In Ethiopia, studies have been conducted focusing on urban green infrastructure development and planning (Girma, 2019; Gashu and Gebre-Egziabher, 2019), local communities' perceptions and use of urban green infrastructures (Gashu et al., 2020). Recent studies have been also conducted focusing on barriers to green infrastructure development and planning (Gashu & Gebre-Egziabher, 2019a), indicator development for assessing recreational ecosystem service capacity of urban green spaces (Nigussie et al., 2020), and urban green infrastructure planning in Ethiopia

(Girma et al., 2019). These studies mainly focus on policy, availability, and management challenges of green infrastructure development. This indicates that urban green spaces are the subject of numerous studies; however, most of these studies link the benefits of green spaces primarily to their availability while giving less consideration to their qualities. As also discussed in the study, Benti et al.(2021) discussed that more focus on physical planning is one of the causes of unsustainable natural and working landscapes in urban areas of Ethiopia.  It implies there is a knowledge gap on how green spaces are planned for its sustainability.

Recently, different studies indicated the importance of assessing the quality of green spaces, including the network, shape, and other aspects of the green space qualities (Zhang et al.,2017; Banzhaf and Barrera, 2017; Zhu et al, 2019; Johari, 2012; and Stessens et al., 2020).  However, Efforts only focus on the built environment in developing countries (Mersal, 2016; Daramola & Ibem, 2010; Kim & Pauleit, 2007). Due to this, cities are growing rapidly in developing countries but failing to achieve efficient and effective urban development (Farrell, 2017a), particularly in providing sustainable urban green spaces. Very limited research was done about the quality of green spaces in Ethiopia, particularly in the study areas. Therefore, the purpose of this study is to have a comprehensive examination and investigation of green space sustainability indicators in urban development. Urbanization is unavoidable (Cohen, 2009) and has recently become a pressing issue in third-world cities, while densification of urban development is happening as urban land becomes increasingly scarce (Wiesner et al., 2012). In this regard, it is essential to study how to plan green spaces and how their increased quality can offset the loss of green space quantity. Therefore, it is very important to study urban green space sustainability indicators and their optimal planning in rapidly urbanizing Ethiopian cities.

## 1.4 Research objectives

### 1.4.1 General objective

The main objective of this research is to analyze urban green spaces sustainability indicators in Debre Berhan and Debre Markos cities, Ethiopia.

### 1.4.2 Specific objectives

1) To examine the spatial coverage and transformation of urban green spaces
2) To assess the accessibility of urban green spaces
3) To assess the users' preferences and perceptions towards urban green spaces
4) To investigate the urban green space quality attributes

## 1.5 Research Questions

This study will answer the following research questions

1. To what extent are urban green spaces available and transformed?
2. To what extent are green spaces accessible?
3. What are the preferences and perceptions of users towards urban green spaces?
4. How the users perceive quality attributes of urban green spaces?

## 1.6 Scope of the Study

The spatial scope of the study was in two rapidly urbanizing cities in Ethiopia. Debre Berhan and Debre Markos are among many rapidly growing cities of Ethiopia selected for this study. The thematic scope of the study focuses on several key areas related to urban green spaces. First-ly, it was limited to assessing the vegetation health indices and land use land cover change analysis including land use change detection and conversion matrix. Secondly, it is focused on urban green space accessibility analysis using users' distance from the nearest park and the time taken to reach the nearest park on foot. Additionally, the study explores users' preferences and perceptions of the use and management of green spaces and their roles in urban green space development. Besides this, the study is focused on the urban green space quality analysis from the user's and experts point of view. Another important aspect of the study is the analysis of planning and management trends among experts in green space development, including the challenges they face in fostering sustainable urban green spaces. Overall, the thematic scope encompasses the assessment of urban green space coverage, accessibility, quality, and users' preferences for these spaces. The study is temporally limited to the period from 2000 to 2020 analyzed on a decadal basis.

## 1.7 Significance of the Study

This study can have management-related, socio-economic, ecological, and academic significance. It could be an input for the green infrastructure policies of Ethiopia and add knowledge on climate-resilient green economy strategies. It can assist public authorities and urban planners in designing and manage urban green spaces to meet user needs. Therefore, the study hoped to give awareness and exposure to green space planning strategies and models in rapidly urbanizing cities, specifically in the Ethiopian context, to bring a sustainable and livable environment. Besides, this study may provide baseline information for future research in this and other areas.

This study is also useful for decision-makers, urban planners, and other key stakeholders for successful quality urban green space planning and management aiming to satisfy the needs and demands of the residents in rapidly urbanizing cities of the global south by developing quality urban green spaces. The study also contributes to the emerging literature on the practicality and applicability of urban green space planning models in rapidly urbanized cities of developing countries.

## 1.8 Limitation of the study

The data collection of this study was conducted during the COVID-19 pandemic, which imposed difficulties in interviewing the key informants. Apart from a survey in Bahir Dar and Hawassa that investigated the perceptions and use of urban green infrastructure among local communities, there is a lack of adequate literature on the preferences and perceptions of users towards urban green spaces in Ethiopia (Gashu et al., 2020). Therefore, as such studies were not conducted in Ethiopia, it is less appropriate to compare the results of this study to the Ethiopian context. The Landsat images' medium spatial resolution/quality was the other limitation of the study, which took more work to identify and distinguish between land-use and land-cover types. However, to address this limitation, we used Google Earth, Landsat images, and other existing spatial plans of the Cities. The Landsat data were taken only on two months in a year of the driest seasons of Ethiopia; therefore, it may not represent the average annual green space covers.

## 1.9 Organization of the research

The research paper is divided into six chapters. The first chapter briefly introduces urban green spaces, the rationality of the study, the problem statement, the research objectives, the research questions, the study's scope, the study's significance, the study, the limitation of the study, and the organization of the thesis. The second chapter presents a literature review of pertinent aspects of the research. It provides definitions of terms and concepts on urban green spaces, sustainability indicators/values, urban planning theories on urban green spaces, urban green space planning approaches and models, green urbanism and the lessons of European cities, and integrating the urban environment in urban planning strategies. In Chapter 3, the study area and research methodology are presented. In chapter 4, the presentation of results is given according to the research objectives with the main findings of the research paper. Chapter 5 presents a discussion of the research paper. Finally, chapter 6 contains a conclusion and recommendations based on the study's findings and concludes with suggestions for future research direction. The appendices present data collection tools and a list of published articles.

# Chapter Two. Literature Review

This chapter thoroughly analyzes various aspects related to urban green spaces and urbanization. It reviews the key concepts, definitions, types, benefits, and green space planning and management strategies. The chapter also highlights the indicators of sustainable green space and the international and national standards. Moreover, it assesses Ethiopia's current trends and standards of urban green space planning.

## 2.1 Theoretical framework

This study is based on green urbanism and biophilic urbanism theory. These theories prioritize the sustainability of the environment through developing and managing urban green spaces and nature in urbanization processes.

Green urbanism theory encourages green behavior and infrastructures with a relatively small ecological impact (Kahan, 1996) and incorporates ecology and more ecologically responsible forms of living and settlement (Beatley, 2000). It includes public and private decisions and is analogous to nature. Beyond this, greening concerns low- and middle-income countries for social, economic, and environmental improvement (Dodman et al., 2004) and go together with densification (Lehmann, 2016). Green cities sustainably increase the quality of life in urban areas through green spaces, and they should be integrated into the development of cities in policy, process, planning, and management instruments (Nassar, 2013). The vision of green urbanism is to create cities that are more nature-based, ecologically friendly, participatory, effective, and efficient by restoring, replenishing, and nurturing urban ecology through creative planning approaches such as planting green rooftops, bringing forests and green spaces into the very heart of cities (Bradford, 2007).

Biophilic urbanism theory also emphasizes the natural elements of the urban areas that bring nature into the city by increasing parks and open spaces, green and blue corridors, and networks that link them (Beatley, 2017). Biophilic cities offer the opportunity to have frequent and intimate interactions with nature and nearby nature (Beatley & Newman, 2013). Biophilic design and planning promote a connection with nature and encourage pro-environmental and sustainable values and behaviors (Totaforti, 2020). Therefore, these two urbanism theories are selected because they are appropriate and fit under the dynamic of rapid urbanization for enhancing environmental sustainability against garden city theory and others (Figure 1).

## 2.2 Conceptual framework

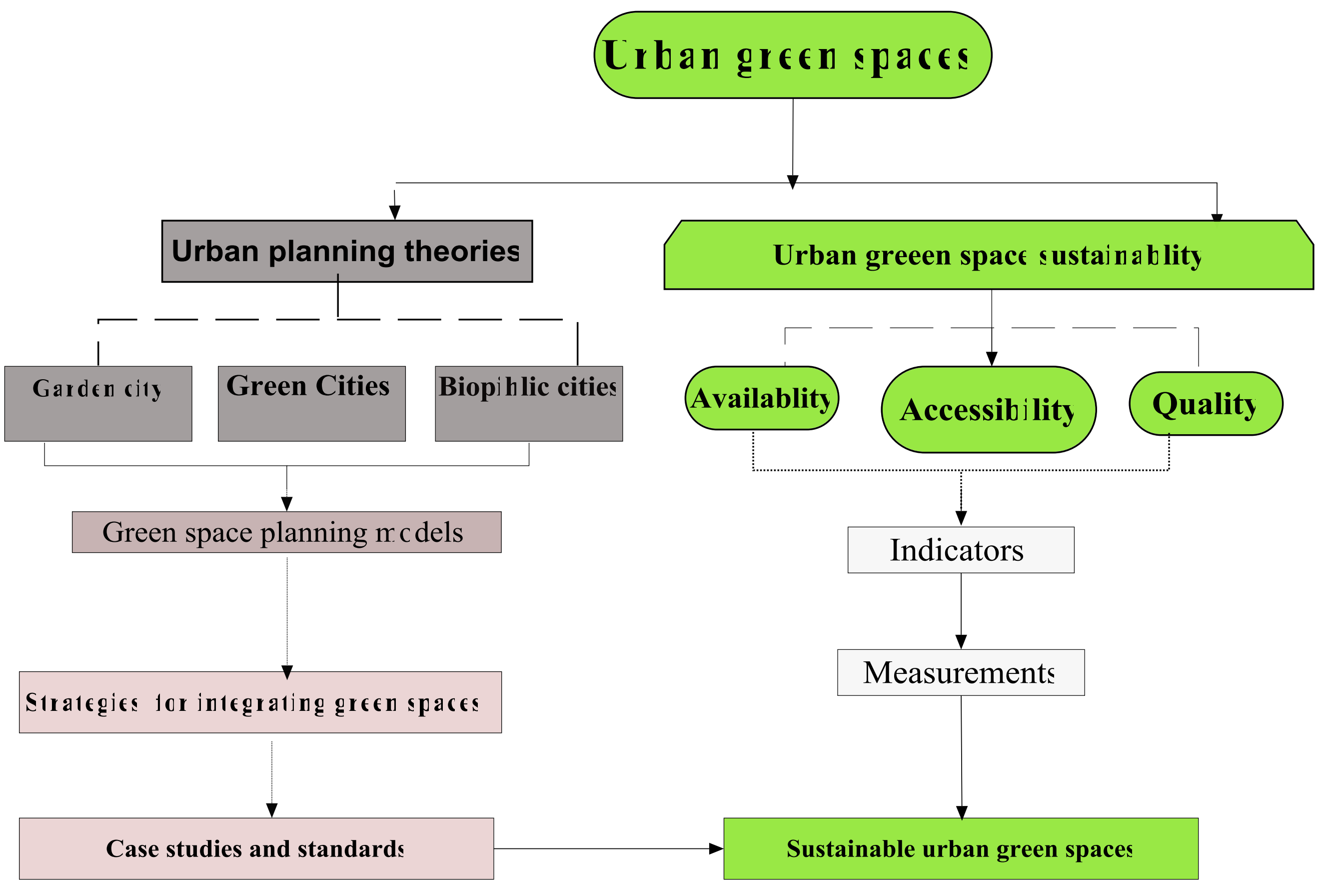



**Figure 1:** Conceptual framework

## 2.3 Urbanization

The current level of urbanization worldwide and the number and size of the world's largest cities are unprecedented (Asoka et al., 2013). At the start of the twentieth century, only 16 cities in the world, the majority of which were in advanced industrial countries, had a population of a million people or more (Cohen, 2006). Urbanization refers to people moving from rural areas to towns and cities (Vlahov & Galea, 2002). It is the process of population concentration in cities, leading to economic and social transformations (Li et al., 2019). This usually occurs when a country's economy shifts and new industries emerge. Rural residents are attracted by the superior public services, cultural facilities, convenient infrastructures, and increased opportunities in cities. Massive rural labor shifts out of agriculture and into urban areas enlarge the size of the urban population (Wang, 2019). In recent years, rapid urbanization has been observed in various Africa and Asia countries, and globally, the pace of urbanization is increasing.

Developing countries have undergone significant growth due to rural-to-urban migration, converting rural land to urban areas. In recent years, concerns regarding uncontrolled urbanization have become increasingly urgent (Busho et al., 2021). The urban population in Ethiopia is growing rapidly. In 2012, it was only 17.3%, lower than the Sub-Saharan Africa average of 37%. However, this is expected to change significantly. According to the Ethiopian Central Statistics Agency, the urban population is projected to almost triple from 15.2 million in 2012 to 42.3 million in 2037, growing at 3.8% annually. This report's analysis suggests that the urbanization rate will be even faster, at about 5.4% per year. This would mean a tripling of the urban population even earlier, by 2034, with 30% of the country’s population living in urban areas by 2028 (Bank & Alliance, 2015).

### 2.3.1 Causes of urbanization

Several factors, including migration, natural increase, industrialization, commercialization, social benefits and services, modernization, and rural-urban transformation, cause urbanization (Bairoch & Goertz, 1986). Rural residents are drawn to cities by superior public services, cultural facilities, convenient infrastructure, and increased opportunities. The shift of rural labor from agriculture to urban areas enlarges the urban population (Wang, 2019). Urbanization results from the continuous mass movement of people from villages or rural settlements to cities or urban areas. It can also result from natural population increase (the excess of births over deaths), especially in areas where advanced technology and developmental projects are present (Bodo, 2019). In Ethiopia, rural villages are upgraded to towns when they meet the following requirements: over half of the population is engaged in non-farming activities such as petty trading, service provision, and the like (Bank & Alliance, 2015). Additionally, most of the residents in the area benefit from urban-based facilities like electricity, piped water supply, telephones, schools, and health services. The total population living in that particular location must be 2,000 and above, and the area is believed to have the potential for economic growth and the attraction of migrants to engage in nonfarm activities.

### 2.3.2 Impacts of urbanization

Urbanization presents numerous opportunities for the growth of the economy, social infrastructure, and technology sectors. This provides society with improved living standards, better healthcare facilities, and increased employment opportunities. Nevertheless, urbanization also brings challenges, such as overcrowding and environmental degradation (Ramaiah & Avtar, 2019). For sustainable and eco-friendly urbanization, it is urgent to implement comprehensive land use planning for urban settlements. This should include creating and maintaining urban green spaces (UGS) like parks, gardens, and roadside vegetation. Rapid and unplanned urbanization in cities has been a major concern worldwide. Increased urbanization has significantly changed the land use patterns of many cities, thereby altering the physical characteristics of the land surface (Swain et al., 2017). According to Mensah (2014), urbanization is a significant factor that is consistently associated with the destruction of urban green spaces. Due to the rapid and continual expansion of metropolitan areas, cities are experiencing numerous issues, such as intense summer heat, heat island effects, depletion of green spaces, and strain on ecosystems (Sultana et al., 2024). The rapid urbanization has led to a reduction in green spaces and intensified urban heat and pollution in the city (Olfato-Parojinog et al., 2024). In the endeavor to create a greener and healthier urban environment, rooftop agriculture has surfaced as a promising solution, providing opportunities for environmental restoration and safe food production (Sultana, et al., 2024). It also results in the development of green areas, leading to a significant fragmentation of urban green spaces. This causes various socioeconomic and environmental issues. Hence, it is crucial to comprehend the connections between urbanization processes and the patterns of urban green spaces (Li et al., 2019). The accelerated rate of urbanization in all forms and the population growth in Morocco has been generating serious environmental problems and concern for both the government and interested stakeholders (Garouani et al., 2017).

In developing countries, the urbanization process plays a crucial role in modifying the local environment on a large scale. Rapid urbanization has significantly altered the quality of the environment, affecting built-up areas, green open spaces, as well as roadways and transit arteries, which are key elements of urban form and the physical texture of cities (Chaka et al., 2024). Due to ongoing urbanization in developing countries, access to urban green spaces (UGS) is decreasing, impacting the quality of life for urban residents (Olfato-Parojinog et al., 2024). Rapid urbanization hurts the environment and human well-being at various levels (Busho et al., 2021).

## 2.4 Land use land cover

Land Use/Land Cover (LULC) is the physical composition and characteristics (e.g., grass, forest, and impervious surfaces) or human-related activities (e.g., residential, commercial, and transportation) of land elements on the Earth's surface (Scheme, 2019). Land cover refers to the physical material that covers the land, including vegetation, buildings, roads, and water. It can impact an ecosystem's weather, soil, water chemistry, and energy flow. On the other hand, land use refers to the human activities that take place on the land, such as agriculture, commerce, residential use, or recreation. The same area of land can have multiple land uses. Accurate and timely information about land use and land cover (LULC) and its changes in urban areas is crucial for urban land management decision-making, ecosystem monitoring, and urban planning (Coskun et al., 2008). Land use/land cover (LULC) information is essential for various purposes such as thematic requirements, infrastructure planning, disaster management, and spatial planning (Hariyono et al., 2023). To obtain this information, available data sources are processed. Remote sensing data, including satellite imagery, aerial photographs, and lidar, is commonly used for extracting land use and land cover classes. This data is often more cost-effective than using terrestrial survey methods to obtain information on a large scale with wide area coverage.

### 2.4.1 Land use land cover change

The study of land use and land cover change (LULCC) asserts that human activities significantly alter the land's surface and have substantial impacts on the climate, weather, and the environment. According to Lambin et al (2001), changes in land cover (biophysical attributes of the earth's surface) and land use (human purpose or intent applied to these attributes) are extremely important. These changes are so widespread that, when considered on a global scale, they significantly impact on key aspects of Earth System functioning. The land use/land cover pattern of a region results from natural and socio-economic factors, as well as their utilization by humans in time and space (Zubair, 2006). Land use and land cover change have become central components in current strategies for managing natural resources and monitoring environmental changes.

Recently, geographical information systems (GIS) and remote sensing are widely used for land use and land cover (LULC) mapping and change detection worldwide (Abebe et al., 2022). Monitoring changes in land use and land cover (LULC) to understand landscape dynamics and evaluate environmental health over different time and space scales. Assessing LULC change is crucial for evaluating environmental and ecosystem management, conservation, land use planning, resource management, and overall sustainable environmental practices(Chamling & Bera, 2020).

### 2.4.2 Land use and land cover classification

The process of assigning land cover classes to pixels and categorizing them is known as Land Use and Land Cover (LULC) classification. Land cover classes include water, urban areas, woods, horticulture, buildings, forests, farmland, grasslands, mountains, and highlands. Image classification automatically organizes all pixels in an image into specific land cover categories based on their unique reflectance properties. In other words, different features exhibit a distinct blend of reflectance based on their natural characteristics (Alshari & Gawali, 2021). Image classification involves automatically categorizing all the pixels in an image. According to Gautam et al. (2018), the following steps are considered for image classifications: determination of a suitable classification system, selection of training samples, image pre-processing, feature extraction, selection of suitable classification approaches, post-classification processing, and accuracy assessment. Supervised image classification involves using samples with known identities to classify pixels with unknown identities. The process begins with the user selecting and naming areas corresponding to the classes of interest on the image. These classes represent information categories. The image classification algorithm then identifies similar regions based on the user's input. The classification process is dependent on the algorithm being used. In supervised classification, spectral signatures are derived from specific locations in the image, known as 'training sites,' defined by the user. Typically, a vector layer is digitized over the raster scene, consisting of polygons overlaying various land use types. Supervised classification techniques require the analyst to define training areas to determine the characteristics of each category. Each pixel in the image is then assigned to one of the categories based on the extracted discriminating information. For supervised classification, the image pixels representing the categories are gathered, and characteristic decision functions are calculated from these training samples (Ayhan & Kansu, 2012).

To detect land use and land cover (LULC) change from multi-band and multi-temporal raster imageries, image interpretation and classification process is computed (Chamling & Bera, 2020). The most popular classification methods and associated algorithms are grouped into supervised and unsupervised, parametric and nonparametric, hard and soft (fuzzy classification), or per-pixel, sub-pixel, per field categories. Supervised image classifications aim to automatically categorize the pixels of common reflectance range into specific LULC class (El Garouani et al., 2017). Image classification is a common method for change detection. One advantage of image classification is its ability to generate a series of land cover maps. While performing supervised classification, the maximum likelihood classifier (MLC), spectral mapping classification, K-Means, and ISODATA are the most preferred and commonly used image classification methods (Chamling & Bera, 2020).

The maximum likelihood algorithm is widely used for classifying satellite imagery. It calculates the likelihood that each pixel belongs to a specific class. The basic theory assumes that these likelihoods are equal for all classes and that input bands are uniformly distributed. However, the method requires significant amount of calculation time and assumes a normal distribution of the data in each band during the classification process. One drawback is that it tends to over-classify signatures with relatively large values in the covariance matrix (El Garouani et al., 2017). The maximum likelihood classifier (MLC) is a widely used supervised classification method due to its relatively fast computation time compared to other methods. This method assumes that all pixels belong to specific classes. However, MLC is most accurate when the spectral data follows a normal distribution. To address any errors that may arise from non-normal data, post-classification correction can be performed using ancillary data in five essential steps (Chamling & Bera, 2020).

Maximum likelihood classification (MLC) is a method used to determine the most likely class of distributions based on a given statistic. The origins of MLC can be traced back to electrical engineering. This method assumes that the training samples follow a normal distribution. The algorithm creates probability density functions for each category. During classification, any unclassified pixels are assigned to a category based on the likelihood (probability) of that pixel occurring within each category's probability density function (Hariyono et al., 2023).

## 2.5 Urban green spaces

As a process, approach, and concept, urban greenery is synonymous with urban green space, urban green infrastructure, urban natural vegetation, and organized open space. All of these are aimed at creating livable and sustainable human settlements. Urban greenery can be seen as a way to nurture and enhance natural green spaces or infrastructure within urban areas, which can be very important for people and the environment (Zakka et al., 2017). Green spaces are often confused with other terminologies in urban planning, especially open spaces, and public open spaces (Mensah, 2014b). In the context of urban studies, there are many definitions of 'urban open and green space,' such as green space, open space, public space, and public gardens (Rakhshandehroo et al., 2017). Specifically, the meaning of urban green spaces in urban planning practices defined by more different authors such as Urban Green spaces include any natural elements in towns and cities that provide an ecological or ecosystem service function (Romero, 2010). Larkham (1991) uses the term urban green spaces for all areas naturally or artificially covered with vegetation. Johari (2012b) defined urban green spaces as any area or land within a metropolitan area covered with vegetation or water.

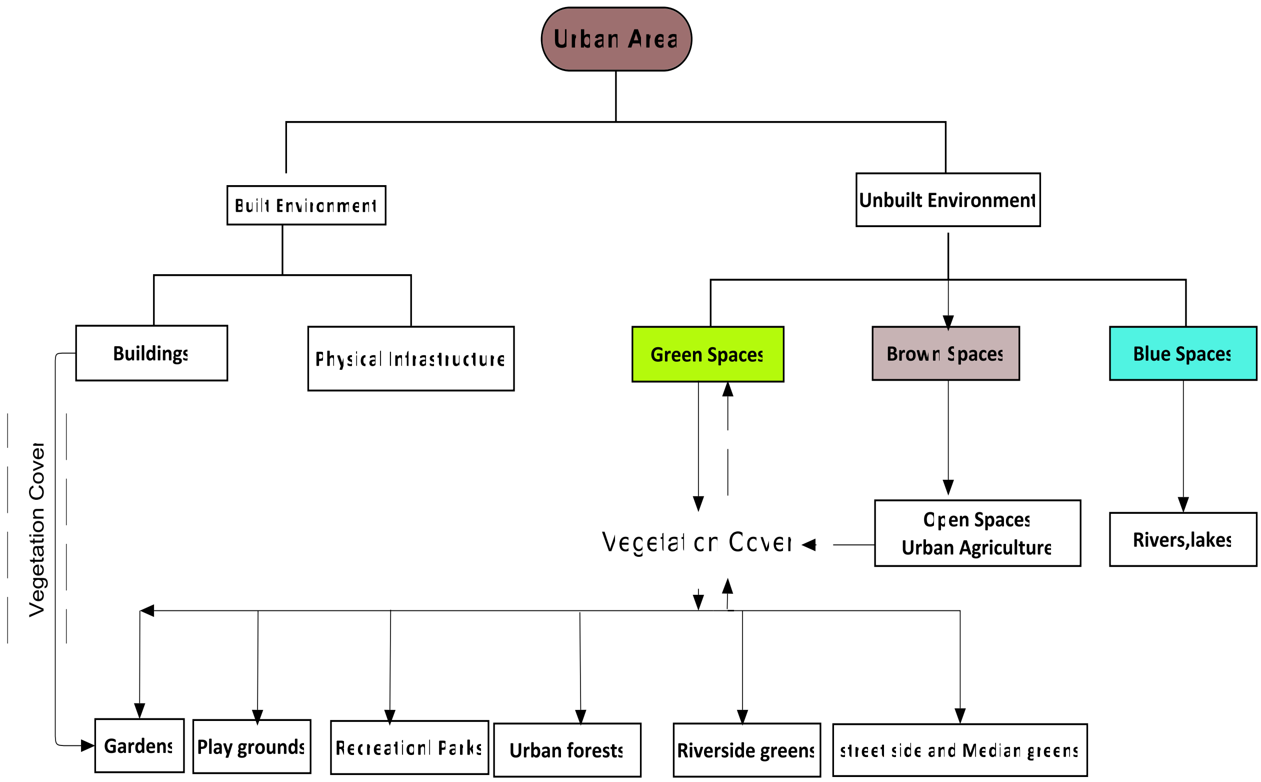



**Figure 2**: Conceptualization of green spaces in urban landscape
Source: own constructed

Lundh (2017) defined green spaces as areas that are characterized by the presence of various green structures. These include green corridors that follow transportation networks, parks and gardens, natural wild spaces, urban forests and community woodlands, cemeteries, allotments, playing fields, playgrounds, and derelict and vacant lands. While they may be less common, green spaces can also exist within built-up urban areas. Generally, as stated in Rakhshandehroo et al.(2017), green spaces are accessible public areas with open spaces or vegetated land or structure that constitute green elements, which include parkland, greenways, open space, natural heritage or environment lands, vacant lands, or conservation lands. From the above definitions of green spaces, all green spaces found in urban areas that give ecological and ecosystem services to the urban context are called urban green spaces.

### 2.5.1 Urban green spaces accessibility

Different authors categorized urban green space types in various ways. Urban green spaces are often classified based on size, function, nature, amenities, and ownership; however, in this paper, urban green spaces are classified regardless of the parameters or variables. It means it could be stated in different categories. Still, this study focuses on typologies practiced in urban planning to decrease the ambiguity of green space types. In the border way, some urban green spaces include recreational green space, incidental green space, private green space, productive green space, burial grounds, institutional grounds, wetlands, and woodlands. Under the 'Habitat Complexes' Romero (2010) categorizes urban green spaces as large parks (usually > 5ha), small city center non-domestic gardens (< 0.5ha), large non-domestic gardens (0.5 - 5 ha ), domestic gardens of cities and town centre (< 0.5ha with very mixed species rich flora and fauna), and domestic gardens of villages and urban peripheries.

In another context, Pauleit et al.(2015) categorized the green spaces into field crops, vegetable farms, public recreational parks, riparian vegetation, plantation forests, institutional forests (mixed forests), street plantations, and grassland. The common urban green spaces consist of street side and median greens, roof gardens, recreational parks, playing lots, urban forests, riverside greens, and other green covers in the urban area (Kabisch et al., 2016).

Areas with street trees on pedestrian roads, in road medians, and street side greens are part of cities' green infrastructure component (Amba et al., 2013). On the Other hand, recreation parks can be described as urban parks, nature parks, pocket parks, district parks, community parks, neighborhood parks, sporting fields, urban forests, and the like (Byrne & Sipe, 2010). Conversely, according to Cetin (2017), urban park green spaces can be divided into comprehensive parks, community parks, special parks, strip parks, and street green spaces.

### 2.5.2 Benefits of urban green spaces

Scholars put the green space benefits with different terms like function, attributes, values, importance, and services. Urban green space (UGS) is a key element of sustainable urban planning and can bring a variety of well-being to urban life and provide and maintain public spaces and a natural environment to promote social activities and equity (Zheng et al., 2019). Green spaces serve as important ecological and recreational areas in urban environments (Cetin, 2017). Forests provide crucial ecological services such as watershed protection, biodiversity conservation, carbon sequestration, and recreation opportunities. Furthermore, sustainable forest management can yield energy and raw materials. Dunes, coral reefs, and mangroves protect cities from storm surges, prevent erosion and siltation, and, in the case of the latter two, act as fishery nurseries. Parks and greenbelts act as sinks for carbon dioxide (CO2) and counteract the heat island effect of large built-up areas. (Johari, 2012a) has summarized the benefits of green spaces, which are environmental benefits such as improving air quality and mitigating pollution, modifying microclimate and protecting biodiversity, hydrological benefits like water conservation, social benefits such as promoting social interaction, recreational activities, creating a sense of safety, and enhancing the image and identity of the city. It also has health and well-being benefits, including, physical and emotional health psychology, and improving mood. Lastly, green spaces also offer economic benefits.

**Table 1: The main benefits of urban green spaces**

| | |
|---|---|
| **Environmental Benefits** | ✓ Pollution mitigation<br>✓ Micro-climate modification<br>✓ Biodiversity<br>✓ Hydrology |
| **Social Benefits** | ✓ Social cohesion<br>✓ Recreation and leisure<br>✓ Sense of safety<br>✓ City image and identity<br>✓ Improve cultural values |
| **Health and Wellbeing** | ✓ Physical and emotional health<br>✓ Psychology<br>✓ Feeling / Mood |
| **Economy** | ✓ Business attraction<br>✓ Increase the value of assets around it<br>✓ Increase property value<br>✓ Tourist attraction |

Source: (Johari, 2012a; Lee & Maheswaran, 2011)

### 2.5.3 Eco system services of urban green spaces

Urban green spaces in cities consist of various elements or patches that provide ecosystem services. Generally, the benefits of urban green spaces could also be summarized as the ecosystem services of green spaces: provisioning, regulating, recreational, and support services. Urban green spaces provide four ecosystem services: provisioning services (food, water, fiber, etc.), regulating services (climate and water regulation, pollination, etc.), cultural services (recreation, education, etc.), and supporting services (nutrient cycling, etc.)(Daniels et al., 2017; Kamble et al., 2012). Unless we plan, design, and manage urban green spaces properly, they have ecosystem disservices (Gómez-Baggethun & Barton, 2013). It includes air quality problems, allergies, infrastructure damage, fear, and stress, accidents, habitat competition with humans, etc.

**Table 2: Categorization of ecosystem services provided by urban green spaces**

| Provisioning Services | Regulating Services | Cultural Services |
|---|---|---|
| *Products obtained from ecosystems* | *Benefits obtained from regulation of ecosystem processes* | *Nonmaterial benefits obtained from ecosystems* |
| ■ Food | ■ Climate regulation | ■ Spiritual and religious |
| ■ Fresh water | ■ Disease regulation | ■ Recreation and ecotourism |
| ■ Fuelwood | ■ Water regulation | ■ Aesthetic |
| ■ Fiber | ■ Water purification | ■ Inspirational |
| ■ Biochemicals | ■ Pollination | ■ Educational |
| ■ Genetic resources | | ■ Sense of place |
| | | ■ Cultural heritage |

| Supporting Services | | |
|---|---|---|
| *Services necessary for the production of all other ecosystem services* | | |
| ■ Soil formation | ■ Nutrient cycling | ■ Primary production |

Source: (Lundh, 2017) modified from Millennium Ecosystem assessment, 2003

## 2.6 Urban green space sustainability indicators/values

The Earth's surface has undergone rapid urbanization in recent decades, leading to significant changes in Land Use/Land Cover (LULC). However, this fast and unplanned development has not been sustainable, posing a threat to the long-term survival of the Earth. It is also noted that in developing countries, unregulated LULC changes have resulted in severe environmental degradation, endangering the sustainability of development. Uncontrolled urbanization can lead to the loss of agricultural and forest land, and natural resources, and may even result in permanent changes to the land. As a result, there is a need for continuous monitoring of LULC.

The concept of sustainable development, as defined by the United Nations World Commission on Environment and Development (Brundtland Commission, 1987) refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. When planning sustainable urban green spaces, it's important to preserve, improve, and provide green spaces, consider using nature-based solutions, creating green buildings, and being mindful of carbon balance and people's perceptions and behaviours (Climate-ADAPT, 2023). The significant consequences of green developments are (Csete & Horváth, 2012):

- Keeping and increasing the green spaces;
- Care about the urban ecosystems and stop the biodiversity loss;
- Rule and ease the urban microclimate;
- Improve human health, the quality of living;
- Increasing adaptation;
- Blunt the effects of harmful meteorological events.

Mougiakou & Photis (2014) broadly put urban environmental indicators for a city's sustainable operation and development. These are green areas, proximity of green space, and accessibility - public access to green space, availability of public open areas, urban renewal areas, and protected areas as a percent of the total area. According to Green Space Scotland (2008), the key measures of green space value are

- Quality (how green space assets address the varied functions, needs, and aspirations of its users and other stakeholders),
- Quantity (overall quantity of green space), and
- Accessibility (how well-connected, accessible, and inclusive green space is to communities).

According to Barrera et al. (2016), ecological indicators of urban green spaces in two spatial scales, city-level and local level, “the total area of green space in relation to population and urban context, (ii) the quality of green space based on its size, shape and vegetation cover, and (iii) the spatial distribution and accessibility of green space.” Banzhaf and Barrera (2017) referred to green space quality as an effective assessment of green spaces, and its ecosystem service provision depends on the quantity, quality, and accessibility of green spaces. It implies that the amount of GS per inhabitant does not provide enough information for effective decision-making on whether the green spaces are sustainable.

The most used indicator to assess green spaces is their total area coverage for the total city area. Mougiakou & Photis (2014) stress size, an optimum landscape has large patches of natural vegetation supplemented with small patches scattered throughout the matrix. However, De La Barrera et al.(2016) discussed that the effective assessment of green spaces and their ecosystem service provision depends on the quantity, quality, and accessibility of green spaces. On the other hand, Texier et al.(2018) mentioned that the ecological and recreation services provided by UGS are not only on their location, scale, and shape but also on potential accessibility and local urban context.

#### 2.6.1 Availability of urban green spaces (spatial coverage)

The World Health Organization recommends at least nine $m^2$ of green space per person, with an ideal $50m^2$ per capita for urban green spaces. 10 $m^2$ per person is needed in a 300m radius (Moughtin & Shirley, 2005b). Commonly,' size' of green space matters as the larger the green space size, the greater the magnitude and the ecosystem services provided (Barrera et al., 2016). Texier et al.(2018) discussed that the size of urban green spaces (UGS) is a crucial factor that impacts not only the level of use and the type of activities performed in UGS but also the ecological qualities of UGS. A larger UGS will likely have a more diverse flora and fauna, making it more environmentally valuable. It is a quantitative attribute, but to strengthen the effectiveness and sustainability of green space benefits to the residents' the quality and accessibility of green spaces are important. Concerning this, the quantity of green spaces or availability is inadequate as it does not differentiate between areas with small UGS units accessible and one large UGS unit located at its corner that is not proximate to the residents, thus raising the fragmentation issue. It implies that the location and distribution of green spaces matter, and residents prefer close green spaces that maximize the use of green space for everyone rather than large greenways or belts that increase ecological benefits in corners.

**Measurement of green space availability:** An area's greenness can be determined using the Normalised Difference Vegetation Index (NDVI). It measures street trees and other streetscape greenery and the density or percentage of green space by area. The normalized difference vegetation index (NDVI) measures the live, green vegetation present (WHO Regional Office for Eruope, 2016). Similarly, Rousta et al.(2018) used NDVI and NDBI (Normalized difference built-up index) for Land use and cover change indicators.

#### 2.6.2 Quality of urban green spaces

The quality of urban green space significantly contributes to neighborhood satisfaction and well-being, independent of the mere amount of green space (Zhang et al., 2017). Green Space Scotland (2008) defines the quality of Green space as appropriate, accessible, safe, inclusive, welcoming, well-managed, and serves a purpose. Most of the time, the quality of green space has been measured with expert assessments, such as checklists, in situ observations, and geographical information system (GIS) analyses (Zhang et al.,2017). This approach does not consider the laypersons' consent and appraisals about their environment. Measuring people's perceptions has value for monitoring the quality of green spaces and supporting planning decisions. According to (Johari, 2012a), quality green spaces have multi-functional characteristics. High-quality green spaces are ecologically, socially, and economically sustainable.

**Indicators of green space quality:** Most indicators/assessments of green space quality usually used include accessibility, maintenance, perceived safety, presence of amenities, or absence of litter (Green Space Scotland, 2008; Johari, 2012; Zhang et al., 2017 ). Jansson (2014) mentioned five urban green space qualities consideration in planning, including proximity, sufficient size, variations in character and type to provide better functions, maintenance, and participation of people in green space development, which have shifted from the above assessment in size of green spaces and community participation. It is understood that there is no designed standard to measure perceived green space quality (Zhang et al., 2016; Mensah, 2015). Because of this, there may have been changes in the usage of some themes and their associated indicators. Based on numerous studies, Figure 3 highlights themes and indicators crucial for improving the quality of green spaces (Mensah, 2015). The quality of green spaces is a function of size, vegetation cover, shape, and the elements inside the green spaces (Banzhaf & Barrera, 2017). Therefore, the context of the green spaces, size, shape, and vegetation cover should be included in the quality assessment since they highly determine the quality of the green spaces with other non-spatial themes.

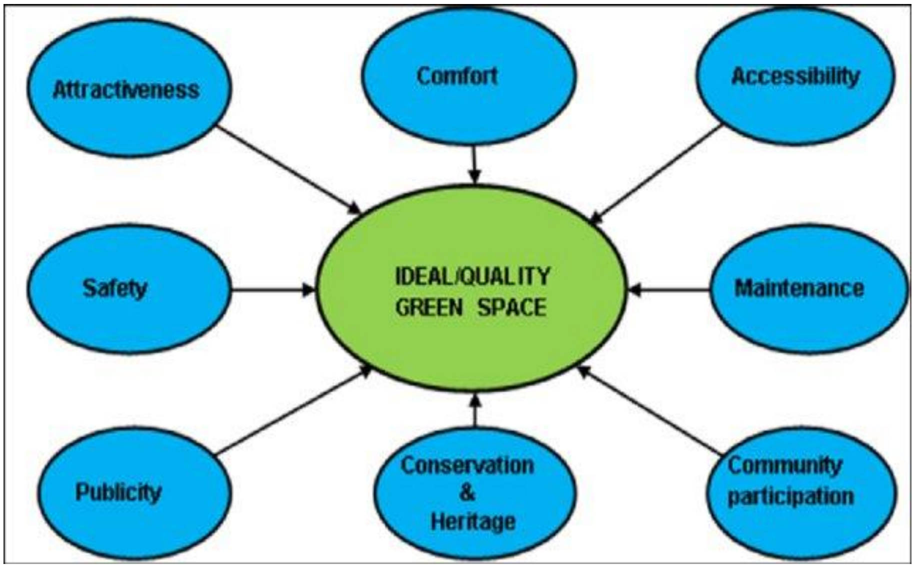



**Figure** 3: Themes for assessing the quality of green spaces
Source: (Mensah, 2015)

**2.6.3 Accessibility of urban green spaces**

Accessibility of green spaces is a measure of relative remoteness and proximity to residents (Texier et al., 2018). Five urban green space qualities considered in planning are: Proximity to where people live, work, commute, and spend time is a determinant for, e.g., use and health, sufficient size, variations in character and type provide better functions—maintenance, and participation of people in green space development (Jansson, 2014b). Accessibility should override the availability standard because there may be a high level of public green spaces in some areas and some not.

**Indicators of green space accessibility**: When assessing green space accessibility, it is important to consider the proximity of individuals, households, or communities to these areas. Living close to an urban park or a green area, the proportion of green space or greenness within a certain distance from residence, and perception-based measures of green space accessibility are indicators of green space accessibility (WHO Regional Office for Eruope, 2016). For example, in

Birmingham, cities should have an accessible natural green space less than 300 meters (in a straight line) from home (Moughtin & Shirle,2005). In Ethiopia, every inhabitant shall live with-in 500 m of a public green open space of a size of at least 0.3 ha (MUDHo,2015).

## 2.6 Urban planning theories on urban green spaces

### 2.6.1 Green cities

The concept of a green city aims to enhance the sustainability of urban areas by incorporating green infrastructure and ecosystem services into urban planning (Bhargava et al., 2020). Essentially, this concept encompasses the principles of integrating urban and natural elements, restoring urban ecosystem values, minimizing resource and energy consumption, and leveraging the ecosystem services provided by natural components (Manea & Iuliana, 2014). Jansson (2014) stated that green city elements contribute to a safer society with less negative social behavior and higher perceived personal safety. Green cities are those that have clean air and water, pleasant streets and parks, have the capacity of resiliency in natural disasters and shocks, and encourage green behavior and public transit and which have relatively small ecological impact(Kahan, 1996). Similarly, Beatley (2000) defined green cities as cities that incorporate ecology and more ecologically responsible forms of living and settlement.

Sustainable development, sustainable communities, and sustainable cities are important now, so there is a need for new urbanism (ecological) endorsed by American architects and planners Andrés Duany and Elizabeth Plater-Zyberk define green cities as cities that strive to live within their ecological limits, reduce their ecological footprints, accept the decisions of the public and private about transportation, energy, water, and food supply for their populations, facilitate more sustainable healthful lifestyles, emphasize high quality of life (Beatley, 2000). Beyond this, green cities are designed for and function analogous to nature or sustainability. According to the ecological Australian architect Glenn Murcutt, cities should be developed sustainably by considering nature, including sun orientation, wind direction, and water flow, and by using simple materials and touching the earth lightly (Williams, 2007). Dodman et al.(2004) stated that greening cities could increase social equity and the quality of life in several ways as more recent studies of low- and middle-income countries identified greening' of urban areas address concerns of economic development, poverty, and environmental improvement (at both local and global scales). Similarly, to keep cities cool, integrating urban greenery and green roofs must go hand-in-hand with densification (Lehmann, 2016).

### 2.6.2 Garden City

The Garden City was originally designed to address overcrowded cities' problems and the need for more green spaces (Coskun, 2024). The Garden City movement aimed to create self-contained communities surrounded by green belts, where residents could live harmoniously with nature and access all the necessary amenities (Moerman, 2020). According to Vernet & Coste (2017) the principles of the Garden City movement have evolved and been adapted to create sustainable urban green spaces that meet the needs of modern society while protecting the environment.

Roles, spatial arrangement, design, and planning of urban green spaces in cities and towns in the 20th century in the UK emerged with the concepts of Garden cities, first forwarded by Ebenezer Howard in 1898 under the title "To-morrow" (Yusof, 2012). Howard believed these new settlements would improve the quality of life, including better housing, working, and leisure conditions. The garden city model is considered one of the most significant urban utopian concepts, alongside other models such as Charles Fourier's "phalansteries," Ernest Callebach's novel "Ecotopia," and Le Corbusier's vision of "La ville verte" (the green city). It emphasizes preserving the natural environment (Mensah, 2015).

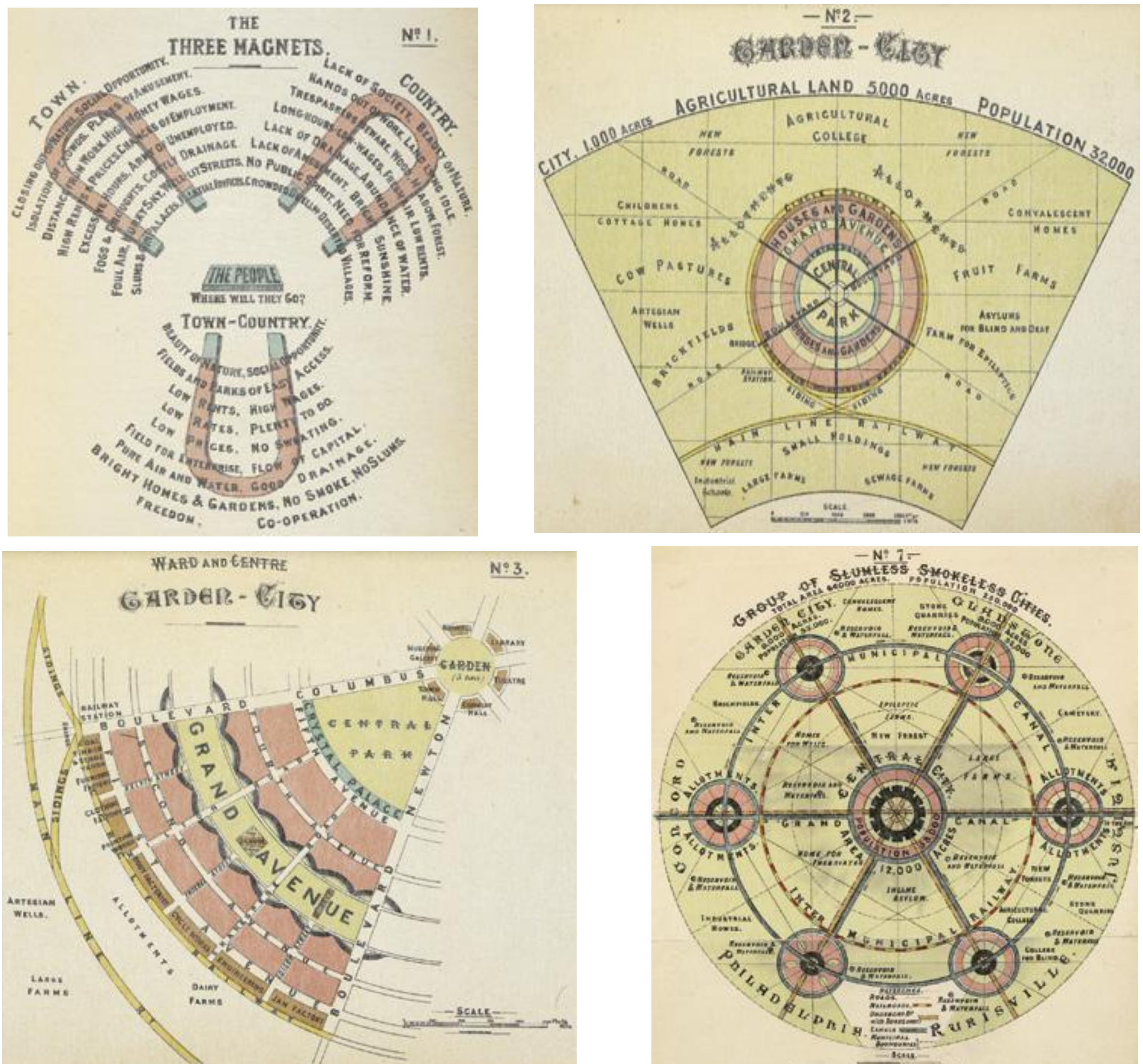


Figure 4: Garden cities of Tomorrow
Source: Peter hall, cities of tomorrow: an intellectual history of urban planning and design since 1880, 4th edition, 2014

The garden city is a self-contained community, which is surrounded by "greenbelts," containing proportionate areas of residences, industry, and agriculture; it was initiated in 1898 by

Ebenezer Howard in the United Kingdom for the reduction of challenges and problems in a countryside environment and a town (Hall, 2014). During his lifetime, Letchworth and Welwyn Garden City were built near London according to Howard's concept, and many other garden cities were developed based on his ideologies.

Figure 4 shows the different layouts of Howard's Garden City. The fourth shows his vision of the polycentric social city, the third (is a radial city incorporating a central park and green belt), and the second (a radial city with a green heart at the center and surrounded by green belts like agricultural and pastoral products). The first picture shows how he compromises the countryside and the town with the concept of three magnets. The idea of three magnets is to enhance workers' quality of life by providing comfortable working zones and transportation. According to (Amati, 2008a), the drawbacks of the garden city were not clearly known, and ambiguity was created as more and more people moved out, the garden city would reach its planned limit; then, another would be started a short distance away and vast planned agglomeration, extending almost without limit. While garden cities were praised for being an alternative to overcrowded and industrial cities, along with greater sustainability, it was often criticized for damaging the economy, being destructive of the beauty of nature, and being inconvenient. More than half of the city's landmass is occupied by accessible green spaces that allow city dwellers to enjoy the natural environment (Mensah, 2015).

**2.6.3 Biopihlic cities**

Biophilic cities bring nature into the city by increasing parks and open spaces, green and blue corridors, and network links (Beatley, 2017). Biophilia refers to habitats that support other species, sustainable food production, and urban agriculture (Bruno, 2019). According to Beatley &

Newman (2013), Biophilic cities encourage daily contact with nature and promote environmental awareness. They are sustainable and resilient cities and its design element starts from building scales to blocks, streets, neighborhoods, communities, and regions (Panlasigui et al., 2021).

Biophilic design is focused on creating strong connections between nature and manmade environments which can have benefits for health and wellbeing (Stephen R. Kellert, 2015). He has mentioned six elements for biophilic design which are:

- Environmental features
- Natural shapes and forms
- Natural patterns and processes
- Light and space
- Place-based relationships
- Evolved human-nature relationships

A biophilic city is at its heart a bio-diverse city, a city full of nature, a place where, in the normal course of work and play and life, residents feel, see, and experience rich nature-plants, tree, and animals (Panlasigui et al., 2021). According to Beatley (2011), there are some indicators of a biophilic city, which includes a percentage of population within 100 meters of a park or green space, the existence of a connected, integrate ecological network, green urbanism from rooftop to region, percentage of city land area in wild and semi-wild nature, percentage of forest cover in the city, extent and number of green urban features (e.g., green roof tops, green walls, trees, etc), number of community gardens and garden plots. According to the above author, biophilic cities are places of easily accessible and abundant nature; rich, textures, and multisensory environments; inspired by mimic nature; and celebrate and exhibit the shapes and forms of nature.

Today, the consequences of increased urbanization and sprawl are becoming more and more evident. Many cities are grappling with social and environmental issues that have significantly impacted the health of their citizens and led to various urban problems (Zaĭtsev, 1976). In modern cities, integrating greenery systems and creating urban green spaces play a crucial role in enhancing the aesthetic and environmental quality of life for residents. Specifically, greening the built environment provides ecosystem services and goods (Pranjale-Bokankar et al., 2019). Biophilic urbanism is to address the modern urban separation from nature by integrating the natural world experience into everyday city life. It is becoming a popular planning and design approach for enhancing urban spaces by focusing on the physical environment, urban design, lifestyle, attitudes, and experiences (Russo & Cirella, 2017).

## 2.7 Urban green space planning approaches and models

### 2.7.1 Urban green space planning approaches

**The demand approach** focuses on responding to human demands for recreation, amenities, and environmental quality, which supports parks and gardens within or close to urban and metropolitan areas and is more related to planners and landscape designers (Maruani & Amit-cohen, 2007; Antrop, 2004).

**The supply approach** focuses on open space conservation to keep the existing landscape and natural values, typically associated with ecologists and conservationists (Maruani & Amit-cohen, 2007). According to the demand approach, open spaces fulfill the population's needs. Therefore, they should relate mainly to attributes of the target population size and demographic variables, values and preferences, residential distribution, and density (although certain characteristics of the natural surroundings can also be deemed attributes, such as topography that affects accessibility). On the other hand, a supply approach, which aims at conserving high-quality natural and landscape values, relies on the existing natural environment's visual, ecological, and spatial attributes.

### 2.7.2 Urban green space planning models

Until the 18th century, open spaces were easily accessible to most city dwellers; however, urban population growth and urbanization incorporating green spaces into urban planning emerged following the garden city model (Hall, 2014). These are seven major green space-planning models (Table 3), agreed with many scholars which enhanced the ideology or legacy of garden city theory (Amati, 2008; Maruani & Amit-cohen, 2007; Kühn, 2003).

**Table 3:** Seven types of green space planning models

| NO | Models | Descriptions |
|---|---|---|
| 1 | **Opportunistic** | It is a pattern where open and green spaces result from opportunities other than/rather than systematic planning processes. Such a model does not ensure the users' preferences and natural protection (Hall, 2014). |
| 2 | **Space standards—a quantitative** | It is based on quantitative matching between open space and the respective user population, claiming that adequate response to needs requires a certain minimal area size of open space for a given population. It is usually expressed in terms of land units per person, which is easy to plan and implement since it does not encounter complex ecological system thinking (Anteneh, 2014). It is based on users' needs and open space types, such as service range, minimal size, spatial distribution, residential densities, and types of activities. |
| 3 | **Park system** | It is a set of functionally interrelated green or open spaces– sometimes interconnected physically in a given geographical area, mostly in urban areas (Walmsley, |

| | | |
|---|---|---|
| | | 1995; Ndubisi et al., 1995; Turner, 1992). It is based on the readily available hierarchal distribution of recreational parks in size and structure. This model is easy to practice in newly developing areas but less so in densely developed areas (Maruani & Amit-cohen, 2007). |
| **4** | **Garden city – a comprehensive planning** | It favors open space as part of the development with its spatial structure to the lay of the developed areas and to preserve the natural environment (Mensah, 2015; Yusof, 2012). Initially, garden cities were designed as self-contained communities with "greenbelts" surrounding proportionate residences, industry, and agriculture areas. Green spaces and open spaces are the core values of sustainability in this model. |
| **5** | **Shape related** | It relates to the shape and spatial arrangement of the development. The best-known of these are "greenbelt," "green heart," "green fingers," and "greenways." These models were Greenbelt (Amati, 2008; Kühn, 2003), green heart (Beatley, 2000), green finger (Mensah, 2015), greenway/wedge, and green roof (Banting et al., 2005). |
| **6** | **Landscape related** | Preserving highly valued landscapes, especially mountain escapes and views of streams and waterways near city centers, is the main conceptual approach of the landscape-planning model (Anteneh, 2014). Its focus on scenic landscapes, streams, and waterways outside of highly populated areas limits the application of the model (Maruani & Amit-cohen, 2007). This model is important in rapid urbanization since green spaces and natural ecosystems are destroyed. |
| **7** | **Ecological determinism** | The planning of any development is determined by the land's natural characteristics through data collecting and analyzing the natural areas in the planned area (Maruani & Amit-cohen, 2007). This model opposes the opportunistic one since green and open spaces are allocated first before built-up spaces. |

## 2.8 Green urbanism and the lessons of European cities

### 2.8.1 Role of cities in global sustainability

The world is the focus of a disturbing period of growing consumption, population, and environmental degradation. Cities are affected by their location, climate, and natural features (Alliance, 2007). From global warming to biodiversity loss to patterns of sprawling land consumption, the environmental trends are increasingly terrible. Cities have sizeable ecological footprints. Beatley (2000) mentioned that the amount of land consumed by urban growth and development in American cities and metropolitan areas far exceeds the population growth rate, resulting in the loss of sensitive habitat, destruction of productive farmland and forestlands, and high economic and infrastructural costs. The low-density auto-dependent American landscape makes more sustainable living difficult.

Beatley (2000) discoursed that Cities need "cleverer technologies and humbler aspirations." Clever technologies are related to public transit, green building, and design, whereas humbler aspirations are related to people's lifestyles, like walking, bicycling, and other ways of consumption. Smart, innovative, and green cities will play a major role in any effective agenda for confronting global climate change, biodiversity loss, and other environmental challenges. As many of the problems and solutions are rooted in local activities, the participation of local authorities and cooperation of local authorities is a determining factor for the fulfillment of local sustainability because it contributes to global sustainability. For example, developed and developing countries have different environmental performances, and even cities in developed countries have variations in their ecological footprint due to differences in their spatial organization, management practices, and the development of their economic bases (Cracolici et al., 2010). There are clear and immediate differences between American and European cities' basic land use patterns and spatial forms. Therefore, it must have proper spatial organization and management of urban elements to make cities green and sustainable.

European cities are important practical and policy guidance sources for American cities and other regions struggling with urban sprawl (Kubina et al., 2021). Although there is a healthy debate about density and compactness as desirable planning goals (Jenks et al., 1996), there is considerable consensus among planners and policymakers that this is the appropriate direction for European cities. European cities are more compact and walkable, have good public transit, and are less reliant on automobiles. They have been experiencing decentralization pressures; they remain substantially more compact and dense than American cities by emphasizing the redevelopment and reuse of land within existing urbanized areas (Beatley, 2000). On the contrary, Jansson (2014b) argued that densification or compacting could be important for saving land and creating functional cities but risks resulting in a lack of green space qualities. Beatley examines a range of European cities that emphasize sustainable urban design and green infrastructure, including many influenced by the Garden City movement. He argues that these cities demonstrate the potential for green urbanism to create livable, healthy, and sustainable urban environments that incorporate nature into the built environment.

### 2.8.2 The vision of green urbanism

Urban environmental concerns often belong to the 'brown' or the 'green' agendas (Véron, 2010). The 'brown' agenda prioritizes local issues related to inadequate water and sanitation, urban air quality, and solid waste management, whereas the 'green' agenda focuses on future generations' natural resources utilization and environmental burdens (Dodman et al., 2004). Europeans came to the new approaches of Green Urbanism endorsed by American architects and planners Andrés Duany and Elizabeth Plater-Zyberk (Beatley, 2000). Since old views of cities, towns, and communities are incomplete, they incorporate ecology and more ecologically responsible forms of living and settlement. The vision of Green urbanism is beyond the Brown agenda since it highly works on the environmental sustainability of the future. The vision of green urbanism is to create cities that are more nature-based, ecologically friendly, participatory, effective, and efficient by restoring, replenishing, and nurturing urban ecology through creative planning approaches such as planting green rooftops and bringing forests and green spaces into the very heart of cities (Bhargava et al., 2020); Véron, 2010). In order to achieve these, Beatley (2000), referring to the European Commission (1996), identifies four important principles of sustainable development. They are the principle of urban management, the principle of policy integration, the principle of ecosystem thinking, and the principle of cooperation and partnerships. Different professionals use different perspectives as ecologists emphasize the importance of tracking the size of a city's ecological footprint and economists the economic aspects of the environment (Yigitcanlar & Dizdaroglu, 2015). Romero (2010) recommended integrated spatial planning, especially in land use planning, as guiding principles and strategies are important for protecting habitat loss and fragmentation and minimizing risks to sensitive sites.

Generally, the vision of green urbanism is to create sustainable and eco-friendly cities that prioritize the well-being of both humans and the environment (Cheshmehzangi & Griffiths, 2014 ; Nassar, 2013; Kasioumi, 2011). It may involve designing cities that are energy efficient, utilize renewable resources, and minimize waste. Green urbanism also emphasizes the importance of green spaces and natural habitats within cities, promoting healthy and active lifestyles for residents. Ultimately, the goal of green urbanism is to create urban environments that foster a balance between urban development and social, economic, and environmental sustainability (Adem et al., 2022).

## 2.9 Integrating the urban environment in urban planning strategies

In urban planning, the urban environment should be integrated with strategic approaches like

Eco-City Planning, local environmental management, and Ecological construction and living policies (Alliance, 2007). Urban activities have positive and negative environmental impacts at the local, regional, and global levels. So, as Cities are important sites for engaging with environmental issues, various strategies can integrate the environment into urban planning based on fundamental principles (Dodman et al., 2004). Integrated strategies for sectors including:

- Reducing energy consumption,
- Controlling air pollution in urban areas,
- Reducing industrial and traffic emissions,
- Improving water quality,
- Reducing the amount of solid waste generated,
- Or developing overall strategies for traffic and transport which avoid negative impacts on the environment.

Green cities sustainably increase the quality of life in urban areas (Efe et al., 2014). Dodman et al. (2004) concluded that clean and green cities are more attractive: integrating the environment in urban planning and management contributes to global environmental goals and generates substantial economic and social co-benefits. According to Alliance (2007) there are four types of instruments used to integrate the environment into urban planning and management; which includes policy, process, planning, and management instruments. Policy instruments: provide guiding principles for urban decision-makers. Process instruments: provide ways of doing something, steps that can be taken to reach a desired goal. Example, Stakeholder participation on visioning baseline studies, in planning and implementation process. Planning instruments provide various methods for developing and implementing urban development plans. These methods include creating an environmental profile through rapid urban environmental assessments, SWOT analyses, rapid ecological footprint assessments, land use/land cover change analyses, and Strategic Environmental Assessments (SEA).Management instruments: provide tools to direct and administer urban planning decisions. Like environmental budgets and audits.

#### 2.9.1 Strategies for greening the urban environment

In many European cities, the percentage of open land area that serves as green space is quite high; for example, in Vienna, some 50 percent of the city's land area is in green space, with 18 percent in forests. As mentioned in (Dodman et al., 2004), low-income cities are concerned with 'Brown Issues,' middle-income cities with 'Greening,' and high-income cities are more global and inter-generational perspectives. However, without considering the income level of cities, there are different strategies used so far in European cities.

**large blocks of open space or green wedges:** Many European cities have followed a strategy of urban planning that incorporates large green spaces close to residential neighborhoods (Beatley, 2000). For example, the following European cities use different strategies listed as follows: in Helsinki, large tentacles of green space penetrate the very center of the city, providing ecological corridors and connections with the surrounding countryside (Kong, 2012), for example, Keskuspuisto Central Park—an 11-kilometer-long unbroken green wedge. In Copenhagen, high-density development is clustered along transit lines (like "pearls along a neckless"), with large wedges of green space between them. Amsterdam uses similarly green wedges like Randstad's Green Heart, a large area of farms and open space in the middle of this urban agglomeration. In Britain, the designation of extensive greenbelts around cities has been a major growth containment strategy (Kong, 2012). London's greenbelt is large, some 1.2 million acres (70km).

Although urban encroachments and conversions have occurred, it has been mostly successful at preventing sprawl and preventing towns from merging, and they serve to promote urban regeneration (Cheshire, 2019). In many cities like Berlin, infill development, intensification, and the more efficient use of abandoned or underutilized land within the urban core. Berlin's visitors enjoy the picture-book green heart area, with its spic-and-span stewardship of every corner, with grazing cows and meticulous canals (Beatley, 2000).

**Ecological networks: national and urban:** Many European cities are trying to incorporate nature into the city center and establish physical and ecological links between urban areas and the surrounding green spaces. Moreover, there is a growing trend of developing and reinforcing ecological connections within and between city centers.

**Reimagining the built environment:** Organic, Living, Buildings and Urban Landscapes

The tangible forms that greenness strategies for naturalizing cities take are varied and diverse. Urban tree planting: at all places through campaign in residential, roads, transit lines. Green roofs: Creating Meadows in the Sky ability to extend the life of a roof, the ability to cool the urban environment (addressing the urban heat island effect), carbon dioxide sequestration, the control of storm water runoff, and the provision of significant habitat, especially for plants, invertebrates, and birds. City farms and ecology parks: The city of Göteburg, for example, owns sixty farms, encompassing some 2,700 hectares of land. Different urban green spaces have different planning strategies (Zheng et al., 2019). Urban type, existing and planned outdoor use, land use in the surrounding areas, and the domain of green areas are the determining factors in urban green system planning (Cetin, 2017).

## 2.10 Urban greening programs, a case study: London

Developing urban greening programs is crucial for fighting climate change and creating sustainable cities (Bulkeley & Betsill, 2005). Analyzing and monitoring green spaces' physical, functional, ecological, and economic aspects of green spaces is essential for enhancing their positive impact. According to Csete & Horváth (2012) London was among the pioneering cities to establish an urban greening program as a crucial part of its adaptation strategy. Developing urban greening programs is one of the most effective solutions in combating climate change and driving the practical implementation of more sustainable and resilient cities. Urban greening substantially improves air, water, and land resources by absorbing air pollutants, increasing water catchment and floodplain surfaces, and stabilizing soils (Adem et al., 2022). Urban forests serve as vital temperature buffers, providing essential shade in the summer and acting as windbreaks in the winter while also reducing noise pollution and $CO_2$ levels and providing a habitat for wildlife. The overall benefits to society, particularly to low-income residents, are profound, encompassing the positive impact of trees and vegetation on the mental and physical health of the populace, as well as the provision of recreational opportunities and an outdoor classroom for environmental education. Additionally, they offer aesthetic enhancements to an environment otherwise dominated by asphalt and concrete.

## 2.11 Urban green space planning in Ethiopia

The rapid urbanization trend and the urban growth rate in third-world countries of sub-Saharan Africa pose a significant challenge to achieving urban environmental sustainability (Farrell, 2017b). The weak legal and regulatory framework in Sub-Saharan Africa is easily noticeable, resulting in insufficient development and management of green spaces in urban areas

(Zakka et al., 2017). For example in Ethiopia, one of the most rapidly urbanizing countries in sub-Saharan Africa, urbanization mainly occurs through unplanned urban growth, which worsens environmental problems. The potential of green infrastructure to tackle these challenges is not yet well understood. For instance, despite proposals in planning documents for the city of Addis Ababa to develop green infrastructure based on principles such as integration and multi-functionality, these proposals are rarely implemented (Girma et al., 2019).

In Ethiopia, green space planning has been impacted by various factors, including urban expansion, lack of implementation, lack of coordination, lack of regulations, lack of reserved areas, and weak urban policy (Yirga Ayele et al., 2022). As the population grows and cities expand, green spaces are lost to residential, manufacturing, and storage land uses. Lack of implementation: The National Urban Green Infrastructure standard proposes that every resident should live within 500 meters of a public green space, but this standard has not been implemented. Lack of coordination: There is a lack of coordination between institutions and limited awareness in the community about the benefits of green spaces. Lack of regulations: There is a lack of regulations and standards to implement green space policies. Lack of reserved areas: There is a shortage for green spaces. Weak urban policy: There is a weak urban policy in place.

Literature on green infrastructure planning in Ethiopia is scarce. Existing literature focuses on climate change adaptation and the role of green infrastructure in creating water-resilient cities (Girma et al., 2019). In Ethiopia, the government is prioritizing the development of green spaces for recreation by creating new public parks and implementing riverside greening projects, particularly in the capital city, Addis Ababa (Nigussie et al., 2021).

### 2.11.1 General standards

According to MUDH (2015), Urban green infrastructure (UGI) shall be managed and administered in the interests of the local community and shall address its needs. It briefly notes on the location, accessibility, and capacity of the green and gray components of UGI.

**Location, capacity and accessibility**

According to MUDH (2015), urban Planning should allocate land strategically, designating 30% of roads and infrastructure, 30% for green spaces and public areas, and 40% for building developments. Accessibility must take precedence over quantity; if a neighborhood has ample public green space but certain homes lack easy access, this issue needs to be rectified. Public green spaces should be uniformly distributed to connect to form an expansive UGI network, and link with natural areas in the urban fringe and beyond. Planning should utilize existing natural features to guide the network’s development. Economic considerations are also important; while authorities may implement entry fees for public green spaces, they must recognize that many residents rely on these areas as their only access to green environments, particularly those without private gardens, vehicles, or the means to pay fees.

#### 2.11.1.2 The green components

Preserving existing vegetation, particularly trees, is vital wherever feasible. When establishing new green infrastructure, the use of native plant species is encouraged, while invasive species should be avoided. A diverse selection of plants should be incorporated to enhance these spaces' social, economic, and environmental value unless specific UGI standards dictate otherwise. Sufficient space must be allocated for plants to thrive. The choice of plant species, especially trees, should be based on the available space; narrower areas should feature slimmer trees, while wider areas can accommodate large specimens. Plant placement should ensure their mature size does not interfere with structures or services. Root deflection barriers should be utilized when necessary, and plant arrangement should not obstruct visibility or access, even as they mature.

#### 2.11.1.3 The gray components

Pavements: Pavements in green spaces should ideally consist of permeable materials, such as cobblestones, to enhance storm water management and ground water replenishment. Only access roads may utilize impermeable surfaces. These pathways should provide long-lasting durability while ensuring user comfort and convenience. Authorities must contain clear, unobstructed pathways with a minimum width of 1.3 meters.

Fences and walls: Living fences and walls are preferred for green spaces. Constructed from durable and locally sourced materials, these structures should avoid sharp edges and pointed finials to ensure safety. Facilities: Playground facilities must always be safe and well-maintained, with a minimum of five different types of play equipment. Protective surfacing should be provided on playground pavements, and seating areas for parents should be incorporated nearby. Tree pruning: Proper tree pruning enhances public safety and tree health. Branches should be trimmed to maintain appropriate clearances from structures, pathways, lights, and utility lines: Buildings: Approximately 1 m clearance. Street: 4 meters clearance over the center and 3 meters at the edge. Sidewalk / path: Minimum 2 m clearance. Lights: Minimum 15 centimeters. Overhead power lines: Minimum 1.5 m clearance.

### 2.11.2 Urban green infrastructure elements standards

#### 2.11.2.1 Recreational Parks

According to MUDH (2015), Recreation parks serve as vital components of urban green infrastructure. Authorities' should establish a hierarchy of parks, including Neighborhood Park, Woreda Park, Sub-city Park, and City Parks.

### Location, capacity and accessibility

Parks must be strategically situated within the city to ensure that all residents can reach a Woreda Park within 1,000 to 1,500 meters and a Sub-city Park within 4,000 meters. A Woreda park should span approximately 3 hectares, serving up to 40,000 people, while a Sub-city park should cover about 8 hectares, accommodating up to 160,000 residents. All parks should provide safe and accessible pedestrian routes, with at least 30% of the area designed for individuals with disabilities. Authorities may implement entrance fees but must ensure that low-income residents are not excluded. Green spaces should constitute at least 75% of all parks, with a significant portion comprising fruit trees to bolster food security. A variety of plant species is essential to support biodiversity. For Woreda Parks, facilities should include children's playgrounds, small sport areas, along with basic amenities like seating, litter bins, and lighting. These parks should integrate storm water management practices and include areas for urban agriculture, providing a comprehensive recreational experience.

# Chapter Three: Materials and Methods

This chapter presents a description of the study areas and the research methodology. It discusses the general processes and methods used to conduct the study and justify the appropriateness of these methods accordingly. The chapter describes the study areas, research type, methodological framework, research design, data types, data sources, data collection tools, sampling techniques, data analysis methods, and ethical considerations.

## 3.1 Description of the study areas

This research was conducted in Debre Berhan and Debre Markos, two rapidly urbanizing cities in Ethiopia. Debre Markos is located northwest of the country, about 300 km from Addis Ababa and 265 km from Bahir Dar. It serves as the capital of the East Gojjam Administrative Zone and comprises ten Kebeles. According to the Central Statistical Agency (CSA) of Ethiopia's population projection of towns as of July 2021, the city's population was estimated to be 133,810. Its elevation varies from 2350 to 2500 meters above sea level, while the average annual temperature is 15.9 °C. The city receives an average yearly rainfall of 1321 mm (climate-data.org). The city boundary comprises 20% swampy areas (slope of 0 - 2.5%), 75% working landscapes (with a slope of 2.6 - 20%), and 20% gullies, ridges, and escarpments (Andarge, 2017).

Debre Berhan is the capital of the Semien Shewa Administrative Zone of the Amhara National Regional State. It is about 120 kilometers northeast of Addis Ababa and has nine kebeles. [1]Kebeles are the lowest administrative units in Ethiopia. The town has an elevation of 2800 me-

[1] *Kebeles: are the lowest administrative units in Ethiopia.*

ters above sea level. As per the latest population projection by the CSA of Ethiopia as of July 2021, the town has a total population of 139,724. It is one of the coolest cities in the subtropical zone of Ethiopia, with an average annual temperature of 14.4°C and a precipitation rate of 964 mm (according to climate-data.org). The areas of DB and DM in 2020 were 146 $km^2$ and 73.5 $km^2$ respectively.

Spatial urban demand varies across Ethiopia due to the specificity of the different drivers and constraints; some have high urban demand, and some have low urban demand. Debre Berhan and Debre Markos Cities have high urban demand and are located in flood and drought risk zone (Institute & Institute, 2015). Debre Berhan has physically and demographically doubled in the past few years (Adgeh & Taffse, 2021). Debre Berhan has an industrial background, which has led to fast urbanization, and now it is dealing with the challenge of urban sprawl (Soni et al., 2018). Debre Markos has been urbanizing recently by incorporating agrarian lands and faced problems, including converting agricultural land and urban forests to other urban uses due to uncontrolled rapid urbanization (Mekuriaw & Gokcekus, 2019 ; Lingereh, 2017). There has been little or no research on the users' preferences and perceptions of urban green spaces, green space planning, and other aspects of urban green spaces in Debre Berhan and Debre Markos Cities. Because of rapid urbanization and urban growth in such cities and many cities and towns with similar administrative levels in Ethiopia, a study about green space is important for sustainable urban development and quality of life. These facts pushed for selecting these cities as the study areas since they provide interesting case studies of rapidly growing cities and zonal administration cities.

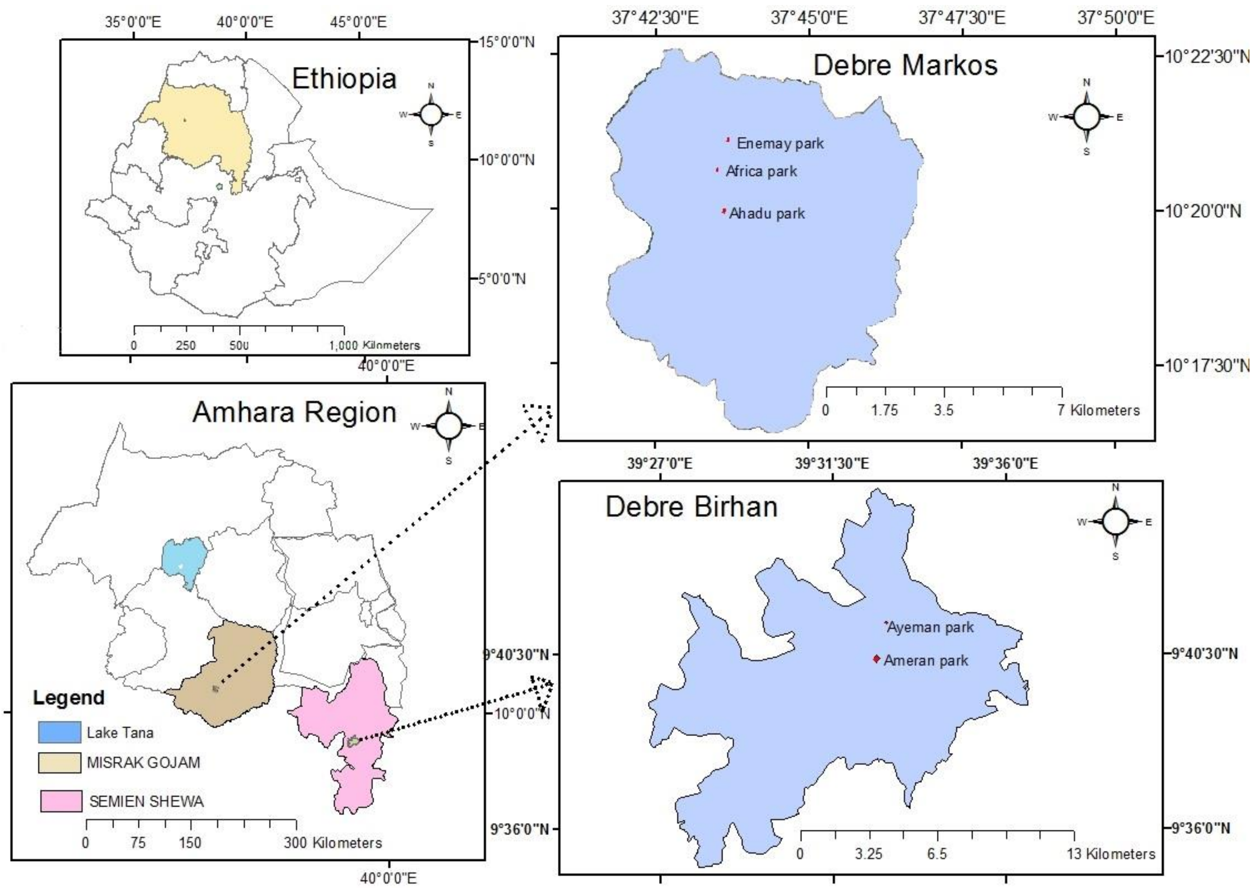



**Figure** 5**.** Location map of the study areas

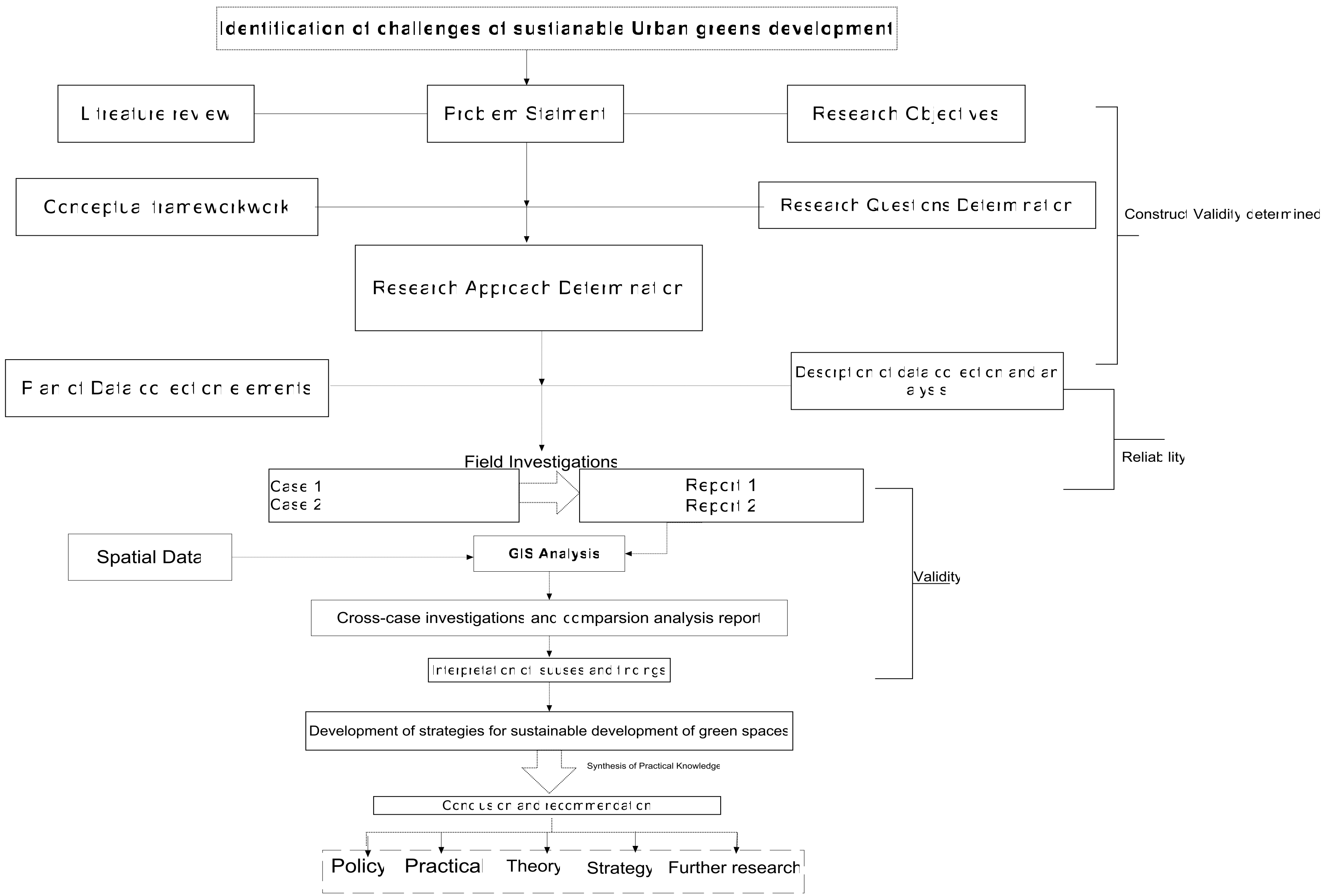
## 3.2 Methodological framework

In the epistemological view of empiricism and rationalism, given inductive logic, premises should be based on real experience or scientific experiments rather than on theory (Rojek, 2016), hence the premise of the study is constructed from observed phenomena. The premises of this study were urban green spaces based on inductive logic. The premises were inadequate, inaccessible, less quality, and green spaces planning were not based on users' preferences.

The research is descriptive, based on both quantitative and qualitative approaches, with a case study method. The quantitative approach emphasizes the quantifiable observations of the research, i.e., the numbers involved, and it is mainly objective (Zegeye et al., 2009). The case study method emphasized the full analysis of a limited number of cases using multiple data collection and generation methods (Rojek, 2016). It is the full analysis of a limited number of cases and is studied using multiple data collection and generation methods. Despite its many benefits, like getting firsthand information and a detailed understanding of the topic, some drawbacks of the case study are bias and doubt in generalization for broad issues from a single case (Zainal, 2007). So the survey method was used to eliminate some doubts and topics that need a full survey about the study, like the spatial coverage of green spaces. The nature of research questions, which requires different data sources, makes the mixed method approach a good choice (Zainal, 2007). A mixed methods approach was used mainly for completeness and triangulation (Hanson et al., 2005). Zainal (2007) mentioned a case study as a holistic and more comprehensive explanation of a phenomenon by including quantitative and qualitative data to help explain the process and outcome of a phenomenon through comprehensive observation, reconstruction, and analysis of the cases under investigation.

The qualitative study integrates varied human thoughts and experiences in in-depth discussions to better understand the variables of the topic under research and consider the non-random character of cases (Lynch, 2014). Cook & Crang (2008) and Atanga (2016) discussed qualitative research as useful and capable of helping to acquire such knowledge from individuals about their activities and experiences of the phenomenon under investigation. Hence, the accessibility and users' preferences, green space planning trends and approaches, and some variables of quality of green spaces were discussed in detail qualitatively.

### 3.3 Research Design



## 3.4 Sampling and sampling techniques

### 3.4.1 Selected urban parks

The researcher selected five recreational parks from two cities - Debre Berhan and Debre Markos. The chosen parks were Ameran Park and Ayeman Park from Debre Berhan City, Africa Park, Ahadu Park, and Enemay Park from Debre Markos City. These parks were selected based on their level of development, legal compliance, location, hierarchy, and service status. These factors indicate the functionality of the park. The location of the parks was considered in terms of their proximity to the inner, intermediate, and periphery parts of the respective cities. The study also considered the hierarchy of the parks, which included Neighborhood Park, Woreda Park, sub-city Park, and City Park. The hierarchy was determined based on the distance they serve (MUDHo, 2015a). According to this hierarchy, city parks are parks that cater to the needs of city residents and cover an area of approximately 8 hectares. These parks can serve up to 160,000 people within a 4,000-meter radius (sub-city) or 300,000 people within a 6,000-meter radius (city). Therefore, all the selected parks are city-level which meets the requirements.

**Table 4.** Description of the selected urban parks

| No | Name | City | Kebele* | Area in ha | Location | Hierarchy |
|---|---|---|---|---|---|---|
| **1** | Ameran park | *DB | 08 | 0.50 | Periphery | City Level |
| **2** | Ayeman park | DB | 04 | 0.16 | Periphery | City Level |
| **3** | Africa park | *DM | 04 | 0.74 | Intermediate | City Level |
| **4** | Ahadu park | DM | 02 | 0.4 | Inner | City Level |
| **5** | Enemay Park | DM | 08 | 0.76 | Periphery | City Level |

***DB –** *Debre Berhan*; ***DM** - *Debre Markos*

***Kebele*:*** *is the lowest administrative unit in the Ethiopian context*
***Hierarchy:*** *Neighborhood Park, Woreda Park, Sub-city Park, and City Park*
***Location:*** *Inner, Intermediate, and Periphery*


Figure 6: Selected urban parks a) Africa park, b) Ahadu Park, c) Ameran Park, d) Ayeman Park, and e) Enemay Park

To ensure that the questionnaire was completed properly, we planned to select one Neighborhood Park, Woreda Park, and City Park, each as a case from different parts of the city based on specific criteria. However, we found that some parks do not meet user data collection requirements. Therefore, we chose five parks that met the criteria. All selected parks are at the city level, with three located on the outskirts, one in the inner part, and one in an intermediate area (Table 4). All of them offer full services to users. Three parks require an entry fee, and purchasing fodder is mandatory to stay in the park. These are Ameran Park, Ayeman Park from Debre Berhan City, and Enemay Park from Debre Markos City.

### 3.4.2 Sampling of park users

The representative parks were purposely chosen, and the expected number of visitors per week on weekdays and weekends was estimated based on a one-week reconnaissance survey conducted with the help of park managers. Due to poor data recording in parks, weekly pilot testing and estimation of park users on weekdays and weekends have been conducted. After obtaining the estimated number of visitors per week from the rough estimation and the data provided by the park managers, sample respondents were selected using the Taro Yamane formula (Uakarn et al., 2021) in each park, as shown in (Table 5).

$$n = N / (1 + Ne^2)$$

*Where n= no of samples; N=total population; and E=error margin/margin error*

According to the formula, 350 park users were randomly selected from two cities, Debre Berhan and Debre Markos, with a 95% confidence level and a 5% margin error. These park users were selected from a population of 3840 estimated to have visited the parks during two consecutive weeks. Of the total respondents, 148 were from Debre Berhan City, and 202 were from Debre Markos City.

**Table 5.** Estimated number of park users on weekdays and weekends in each park and selected samples

| No | Park Name | City | No. of users in weekdays | No. of users on the week-end | Sub-total per week | Selected samples |
|---|---|---|---|---|---|---|
| **1** | Ameran park | DB* | 200 | 140 | 340 | 94 |
| **2** | Ayeman park | DB | 100 | 120 | 220 | 54 |
| **3** | Africa park | DM* | 200 | 140 | 280 | 48 |
| **4** | Ahadu park | DM | 400 | 300 | 700 | 108 |
| **5** | Enemay park | DM | 150 | 170 | 320 | 46 |
| | | **Total** | 1050 | 870 | **1920** | **350** |

***DB – Debre Berhan; *DM - Debre Markos***

## 3.4 Methods and procedures of data collection

### 3.4.1 Types and sources of Data

Both primary and secondary data were utilized. Primary data was collected from key informants, questionnaires completed by park users, and satellite images. Secondary data was collected by reviewing international, national, and local literature, including strategies, policies, regulations, theories, proclamations, and guidelines for urban green space accessibility, quantity, and quality. The secondary data sources were from the city administration, municipal office, sanitation beautification and parks development Agency, and federal and regional environmental protection agency. Secondary data include:

- Structure plan and other plans of the cities
- Polices and other legal frameworks (federal and regional)
- Satellite images of the cities
- Manuals and standards of (urban planning and environment)

Users' preferences and perceptions of urban green spaces and urban green space qualities and constraints were assessed using the Likert scale. According to Creswel (2012) scales improved through the development of the Likert scale (e.g., Strongly agree to disagree strongly), and a structured questionnaire method was used to collect information related to public preferences. The focus of the questions was related to the perceptions and preferences of the respondents (park users) to green space availability, quality, and accessibility. Questionnaires were also employed to collect data about park users' perceived quality of green spaces. The questionnaires were prepared based on the respondents' characteristics such as age, gender, education level, income status, and place of residence to determine respondents' perceptions of the aspirations of their city's public green spaces and their perception of the quality of existing public green spaces, particularly the recreational parks and other regulating ecosystem services.

### 3.4.2 Data collection tools

Qualitative and quantitative data were gathered using questionnaires and key informants interviews (KII).

#### 3.4.2.1 Questionnaire

Public authorities and urban planners can effectively design and manage urban green spaces by assessing users' preferences (Madureira et al.,2018). The study first identified the important attributes of urban green spaces through a literature review. Then, park users were asked to rate these attributes and their preferences using a questionnaire that employed the Best-Worst Scaling (BWS) method. The questionnaire had both open and closed-ended questions. It aimed to gather information about the users' perceptions and preferences for urban green spaces. The first part of the questionnaire had four questions about the respondents' characteristics, such as age, gender, occupation, and educational profile, as they influenced their preferences and perceptions. The second part comprised ten questions about the users' distance from home to the nearest park, frequency of visits, reasons for visiting, factors that encourage or discourage relaxing in the park, disturbances in the park, necessary facilities for improvement, perceptions of the benefits of urban green spaces, roles of users in the development of green spaces, and recommendations for the sustainable development of urban green spaces.

The quality of urban green spaces was evaluated by conducting a field survey of park users. The questionnaire consisted of two parts. The first part included four questions to gather information about the users' socioeconomic characteristics, such as age, gender, occupation, and education level. This information was used to analyze their perceptions of urban green spaces' quality and socioeconomic background. The second part of the questionnaire focused on the quality attributes of the green spaces, which are the basic determinants of their quality, and the users' satisfaction level with the services offered by urban green spaces. Users' perceptions of the quality of the green spaces and their satisfaction level were recorded using a five-point Likert Scale ranging from "1" for "very poor" to "5" for "very good."

The questionnaire was designed to collect park users' perceptions and preferences using a four-point Likert Scale (Madureira et al., 2018). The questionnaire was developed in English and then translated into Amharic to make it easier for park users to understand and fill out. In September 2021, the researcher conducted a pilot study with 30 park users in Ahadu and Enemay Parks to estimate the time it would take to complete one questionnaire and to adjust the data collection techniques accordingly. After making some modifications, the main survey was conducted in October 2021. Five data collectors were employed to collect data from five different parks between October 2021 and February 2022. The data collectors were selected from both cities. Before distributing the questionnaires to respondents, the data collectors were trained about the aim and procedures of the study. Data was collected from 2 pm to 6 pm on weekdays and from 10 am to 6 pm on weekends when the number of visitors was high. On average, each park user took between 20 and 25 minutes to complete the questionnaire, while a few questionnaires took between 30 and 35 minutes when the data collectors had to read the questions to the park users. More than 400 questionnaires were distributed with an estimated response rate of 90%. The response rate was higher than expected in Ameran and Ayeman Parks, while the response rate was lower in other parks. Out of the respondents, 50 questionnaires were invalid due to unclear answers and incomplete replies.

#### 3.4.2.2 Key informants interviews

25 experts, 13 from DB city and 12 from DM city, were interviewed. From DB city, two from Debere Berhan University, two from the city land development and management office, three from the city's urban plan preparation and documentation office, two from the city greenery and park development office, two from the city infrastructure planning and provision office, and two from the city cadaster preparation and registration bureau. From DM city, two from Debre Markos University, two from the city land development and management office, two from the city's urban plan preparation and documentation office, two from the city greenery and park development office, two from the city infrastructure planning and provision office, two from the city cadaster preparation and registration office, and two from the city infrastructure planning and provision office. The key informants were selected based on their green space planning and management roles. The main instrument used to interview the key informants was a structured interview. The main issues were the organization's collaboration in green space planning, perfor-

mances on the maintenance of recreational parks, ownership disputes, performances on follow-up and monitoring of green spaces, their opinion about existing green space values, the constraints for the development of quality green spaces, level of the organization's focus on the sustainable development of green spaces, and awareness and experiences on green space planning.

The interview was held in January 2022. Seventeen experts (Nine from DB and eight from DM) were interviewed in person; each took 30 – 40 minutes. Eight experts (Five from DB and three from DM) could not conduct interviews in person because of COVID-19 fear of meeting people in person, so the researcher gave them a printout of the structured interview guide. Their written responses were collected after two weeks. The researcher's previous experience with both cities' spatial plan preparation department section helped facilitate this interview; as Morse et al.(2002) used the researcher's experience in the interviewees' offices as a quality assurance aspect in collecting subjective qualitative data.

**3.4.2.3 Remote sensing data**

To assess the quality, distribution, and quantity of the urban green spaces earth observation system with satellite image, which has become an indispensable tool for researching and managing land use status, was used (Van et al., 2017). To that end, three sets of data (2000, 2010, & 2020) were used in this study. Medium-resolution satellite images from the United States Geological Survey (USGS) covering the city of the study areas were collected from the Global Visualization Viewer (GLOVIS) data portal. This includes Landsat 5 Thematic Mapper (TM) for 2000 and 2010, as well as Landsat 8 Operational Land Imager (OLI) for 2020 (Table 6).

**Table 6**: Images taken and their attributes

| Satellite | Sensor | Path/Row | | Spatial resolution | Date of acquisition | | Source |
|---|---|---|---|---|---|---|---|
| | | DB | DM | | DB | DM | |
| Landsat 5 | TM | 168/053 | 169/053 | 30m | 12-01-2000 | 19-01-2000 | USGS |
| Landsat 5 | TM | 168/053 | 169/053 | 30m | 23-01-2010 | 14-01-2010 | USGS |
| Landsat 8 | OLI | 168/053 | 169/053 | 30m | 04-02-2020 | 11-02-2020 | USGS |
| **Ancillary Data** | | | | | | | |
| **Data type** | | | | | **Data source** | | |
| Orthophoto 2017 (DB) | | | | | Ethiopian Geo-Spatial Institute | | |
| Orthophoto 2017 (DM) | | | | | Ethiopian Geo-Spatial Institute | | |
| Google earth images | | | | | Google earth pro | | |

#### 3.4.2.4 Document review

Different documents were reviewed to identify suitable green space planning models for the city. The documents were currently in use and related to urban green space planning. Google Earth was applied for those classes that were difficult to identify with Landsat images and other spatial plans. Specifically, the following documents were used, which include the structure plan of the cities of Debre Berhan and Debre Markos in 2014 and 2020, respectively. Ethiopian Environmental Policy 1997, Ethiopian National Urban Green Infrastructure Standards 2015, Urban Greenery and Beautification Strategy 2015, and Green Infrastructure-based Landscape Design 2011 manuals were used. The basis for selecting these documents is the importance of comparing/triangulating the existing spatial coverage of urban green spaces with the standards.

## 3.5. Data Analysis

Both qualitative and quantitative data analysis methods were applied. Hanson et al.(2005) stated that data analysis and integration can be done by analyzing the data separately, transforming them, or connecting the analysis in mixed methods studies. Since the study involves quantitative and qualitative analysis, description, classification, and data analysis can be initiated even before the complete data set. Different software tools like SPSS (Statistical Package for Social Science) and ArcGIS 10.8 were utilized for analyzing the data in the form of maps, percentages, graphical charts, and tabular analysis. Hollweck (2018) has recommended that data requiring interviews be analyzed under key themes using the theoretical proposition strategy. Thus, the data obtained from key informants' interviews were analyzed based on this strategy, which means the responses from the key informants were categorized under themes. Then, it was triangulated with document analysis and questionnaire results. For further analysis and discussion, the data obtained from key informants' was triangulated to be conclusive (Creswel, 2012) with document review and questionnaires.

### 3.5.1 Calculating vegetation health indices, spatial coverage, and distribution

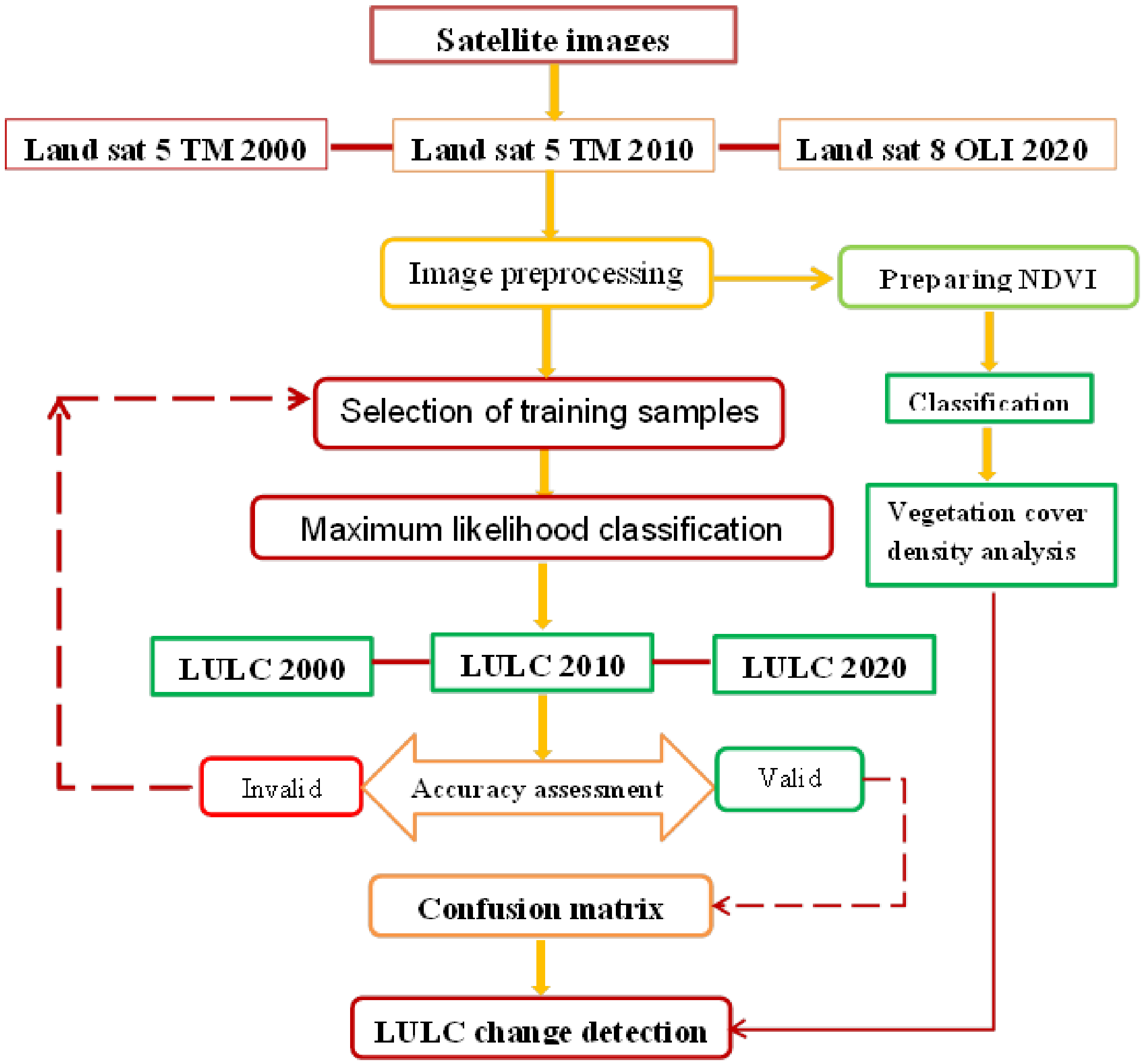



**Figure. 7:** The flow chart of the overall methodology used

As shown in Figure 7, different procedures were used in this study to analyze the Landsat images. Key steps in the process were (i) data acquisition and preparation, ( ii) NDVI derivation, (iii) classification of images and accuracy assessment, and (iv) detection of green space changes by conversion of classified images to vector files to analyze the land cover classes' attributes.

#### 3.5.1.1 Data acquisition and preparation

First of all, remote sensing data and other data sets were collected. Then, these satellite images were imported to GIS software for satellite image processing of NDVI and supervised classification of Landsat images to produce LULC class types. The raw images of the Landsat are annexed.

#### 3.5.1.2 Calculating vegetation health indices

To analyze the vegetation health indices and coverage of green spaces, unsupervised and supervised classification of the satellite image of study areas was done. Vegetation indices were measured using NDVI, which is a ratio between reflected red and Near Infra-Red (NIR) defined as:

$$\mathrm{NDVI} = \frac{\mathrm{NIR-red}}{\mathrm{NIR+red}} = \frac{\mathrm{Band\ 4-Band\ 3}}{\mathrm{Band\ 4+Band\ 3}} for\ Landst\ 7\ and\ 5\ and\ \frac{\mathrm{Band\ 5-Band\ 4}}{\mathrm{Band\ 5+Band\ 4}}\ for\ Landsat\ 8$$

The value ranges from - 1 to +1where the value is closer to -1, indicating barren and water bodies, whereas when it is close to 1, indicating sparse or dense vegetation.

#### 3.5.1.3 Image classification

The main aim of the classification process is to convert the original spectral data, which can be complex and have correlations across multiple picture bands, into a simple themed map, usually a land cover map, that end users can understand. Picture classification is an important stage in a remote sensing project because it extracts the most important and meaningful data from a multidimensional data set that would otherwise be difficult to analyze. There are two types of classification in GIS: supervised and unsupervised classification. While both aim for the same result, their conceptual strategies differ. In supervised classification, a human analyst (image interpreter) identifies training sites (or signatures) that describe each class in the proposed classification scheme. The sum of these signatures defines each class's statistical profile. Analytical techniques are then used to compare each pixel in the image to these statistical profiles, and the best matching class is assigned to the pixel. On the other hand, unsupervised classification requires minimal input from an analyst. An iterative automated process allocates pixels in a picture to certain clusters, which indicate natural groupings of pixels that are spectrally identical across image bands. The analyst then determines which class each cluster belongs to in the chosen classification scheme after this clustering process (Eastman, 2001).

To get the LULC map, a supervised classification with a maximum likelihood algorithm was used. Four land-use classes (Water bodies, built-up, barren and cropland, and urban green spaces) were defined (Table 7). Croplands were added with barren land since the cities' new structural plan or boundaries encircled many agricultural areas.

**Table 7:** Description of land use and land cover classes used, adapted from (Akbar et al 2019 ; Alex et al. (2017)

| Land cover class | Description |
|---|---|
| **Water bodies** | Lakes, rivers, ponds, wetlands, and all kinds of water bodies |
| **Built-up** | All paved surfaces of urban features including road transportation, residential, commercial, service and administration buildings, and others |
| **Croplands** | Those cultivated and non-cultivated areas |
| **Barren land** | Areas with less than 10% vegetation cover throughout the year with no or very little vegetation. It includes exposed soils, quarries, landfill sites, and open spaces. |
| **Green spaces** | Urban areas with greater than 10 % vegetation cover throughout the year including riverside greens, parks, street medians and side greens, urban forests, cemeteries, and others |

#### 3.5.1.4 Accuracy assessment

This study used 20 training samples of 40 pixels for each land cover class, as Lillesand et al.(2015) noted that each category of land use classes needs 20 training samples of 40 pixels. After 80 training samples were selected, the Landsat images were classified based on maximum likelihood by inserting a supervised training sample. The accuracy assessment was done for the six classified maps using simple random sampling techniques using the Kappa statistic metric since it is the common metric to model users', producers', and overall accuracies (Kindu et al. 2020; Hua 2017). From each land use class, 20 samples were selected to triangulate with the exact land-use class that was referred from Google Earth, asset management plans of the cities, other existing spatial plans, and the available satellite images of the study areas. The formula were adapted from (Banko 1998 ; González et al. 2015).

$$\text{User Accuracy} = \frac{\text{Number of Correctly classified Pixels in each category}}{\text{Total number of classified Pixels in that category (the row total)}} \times 100$$

$$\text{Producer Accuracy} = \frac{\text{Number of Correctly classified Pixels in each category}}{\text{Total number of reference Pixels in that category (the column total)}} \times 100$$

$$\text{Overall Accuracy} = \frac{\text{Total Number of Correctly Classified Pixels (Diagonal)}}{\text{Total Number of Reference Pixels}} \times 100$$

$$\textbf{Kappa Coefficient } (\mathbf{K}) = \frac{\boldsymbol{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} (x_i + Xx_{+1})}}{\boldsymbol{N^2 - \sum_{i=1}^{r} (x_i + Xx_{+1})}}$$

Where; r = number of rows and columns in error matrix, N = total number of observations (pixels), $X_{ii}$ = observation in row i and column i, Xi+ = marginal total of row i, and X+i = marginal total of column i

#### 3.5.1.5 Change detection

After the accuracy assessment, images were reclassified to analyze the land cover classes' attributes in tabular form and percentages. The areas of the land use classes were calculated in km2 and its' percentages in 2000, 2010, and 2020 for both cities on a separate basis. The classes were compared in the same year and different years. The calculated land use and land cover of 2000 were used as a basis for 2010 and 2020 LULC for detecting the differences in the changes. Then, changes in urban green spaces were calculated using the formula adapted from(Kindu et al., 2020).

$$\text{Green space cover change (in \%)} = \frac{\text{Area}_{\text{final year}} - \text{Area}_{\text{initial year}}}{Area_{initial\ area}} \times 100$$

Table 8: Different green space availability standard

| NO | Organization | Standard |
|---|---|---|
| **1** | WHO | $9m^2$ of green space per individual with an ideal UGS value of 50 m2 per capita |
| **2** | (MUDHo, 2015b) | minimum of 15-m² public green space per capita within the city boundaries |
| **3** | Urban Planning preparation and Implementation Strategy of Ethiopia, (2014) | 30% of the land for roads and infrastructure, 30% for green areas and 40% for building construction in their urban land management plan. |

Source: Tabulated by the researcher

### 3.5.2 Accessibility analysis

An accessibility analysis can be done according to the Accessible Natural Green Space Standard (ANGst) performed using the non-linear distance (Siljeg et al., 2018). Service area and serviced population analysis and per capita park areas can be conducted using the "ANGSt model and buffering" technique in Khan & Shafqat (2014). Since, these findings are important to forward a set of recommendations that can help the planners appropriately allocate more parks in the city and accordingly for its beautification, policy change, and sustainability. However, the green space accessibility analysis was analyzed from the questionnaire results from the perspective of time taken to reach the nearest park on foot; the transportation modalities used, and the nearest park from their home. The accessibility of major international and national standards is shown in Table 9.

Table 9: International and national standard

| No | Organization | Standard |
|---|---|---|
| **1** | WHO | 1 accessible green space with in 300m |
| **2** | (Birmingham City Council, 1997) Birmingham Nature Conservation Strategy | ANGS<300, 20-ha site within 2 km; 100-ha within 5 km, 500-ha within 10 km of home. |
| **3** | (MUDHo, 2015) | 500 m from a public green open space of a size of at least 0.3 ha. |

*Source: Tabulated by the researcher*

### 3.5.3 Users' perceptions and preferences in the use of urban green spaces

To analyze the data collected, a descriptive statistical analysis was performed. The software used for this purpose was Statistical Package for Social Science version 20.0 (IBM SPSS Statistics 20). The software was used to calculate the reliability of the data and obtain means, percentages, frequencies, and crosstabs for each question. Charts, graphs, and tables were used to present the data. Furthermore, the Chi-Square distribution was used to test the independence between the socioeconomic profile of the respondents and their responses to the questionnaires. The qualitative data provided by the respondents were analyzed using qualitative analysis techniques under a key theme titled "solutions recommended for sustainable urban green spaces by park users." To ensure the accuracy and reliability of the results, the qualitative data was triangulated with the document analysis.

To ensure the reliability of the survey questions related to urban parks and green spaces, Cronbach's alpha coefficient was calculated on each detailed question item. The alpha value was measured as greater than 0.7 on each question item, which indicates that all questions can be considered reliable. According to Gliem & Gliem (2003), an alpha value of over 0.7 is acceptable. Therefore, after confirming the reliability, we proceeded with the descriptive analysis of each questionnaire theme to draw the analysis results.

### 3.5.4 Investigation of green space qualities

Four spatial and eight non-spatial attributes of urban green space qualities were drawn from the literature review (Zhang et al. 2017; Barrera et al. 2016; Mensah 2015; Johari 2012).1) social and cultural context, 2) conservation and heritage,3) community participation in the development of urban green spaces, 4) attractiveness, 5) comfort,6) safety,7) inclusiveness, 8) maintenance of green spaces are non-spatial attributes; and 9) accessibility,10) size,11) shape, and 12) vegetation cover density are spatial attributes which were drawn from the literature review. Then, a descriptive statistical analysis was applied. Statistical Package for Social Science version 20.0 (IBM SPSS statistics 20) was used as a reliability analysis tool to compute means, percentages, frequencies, and crosstabs for each question using graphs, charts, and tabular analysis. Scores of respondents were tested for independence among age, gender, occupation, and education level respondents using Pearson's Chi-square test of independence. The appropriate test selected was the Chi-square test that was applied to a contingency table of r (rows) x c (columns) with (r-1) (c-1) degrees of freedom, where columns represent the dependent variables (perceived spatial and non-spatial qualities of urban green spaces and users' satisfaction on services of urban green spaces) and rows represent the independent variables (age, sex, level of education, and occupation). A confidence level of 95% was considered.

The qualitative data provided by the respondents were analyzed using qualitative analysis techniques and triangulated with document analysis. Spatial qualities, including the density of vegetation cover, accessibility, shape, and size of the green cover, have been investigated and triangulated with the experts' view. Spatial attributes such as the density of vegetation cover, accessibility, shape, and size of green spaces have been studied through document analysis and expert opinion. The reliability of the research was determined by calculating the Cronbach's alpha coefficient on each survey question related to urban parks and green spaces. An alpha value greater than 0.7 was measured for each survey question, indicating that all question items were reliable. According to Gliem and Gliem (2003), an alpha value of over 0.7 is acceptable. After checking the reliability, descriptive analysis was used to draw results for each questionnaire theme.

Table 10: Summary of data collection and analysis

| No. | Objectives | Data used | Data collection tools | Data source | data analysis | Interpretation and presentation |
|---|---|---|---|---|---|---|
| 1 | To examine the density and spatial coverage GSs | • Landsat image<br>• proclamations and standards | • Remote sensing | • USGS<br>• DB and DM municipality,<br>• EGSI,<br>• EPA,<br>• MUDHo | Mapping and narration | percentages, text and detailed descriptions |
| 2 | Accessibility | Survey result | Questionnaires | • EGSI, DB and DM municipality | Descriptive analysis | text and detailed descriptions Frequencies and percentages |
| 3 | Users preferences | • Survey result | • Questionnaires | • Park users of the cities | Descriptive statistical analysis | Frequencies, percentages, cross tabulation |
| 4 | Investigating UGSs qualities | • Survey result<br>• Documents<br>• Landsat imagery | • Questionnaires<br>• and KII | • Park users of the cities and experts | Descriptive statistical analysis | Frequencies, percentages, cross tabulation |

### 3.6 Knowledge transition and ethical considerations

Ethical approval is necessary for quantitative research to gain the trust of respondents. The cornerstone of ethical research is 'informed consent' (Fleming & Zegwaard, 2018). Therefore, the willingness of respondents was considered. The authors and data collectors explained the objective of the survey to the respondents. The authors also assured respondents that their data would only be used for academic purposes. All concerned organizations, offices, agencies, and the respondents' information will always be confidential. Only a generalized analysis of the information obtained from the filled-out questionnaires was utilized in the research process. Accordingly, informed consent was obtained from all respondents who participated in the study.

# Chapter four: Results

This chapter presents the results/findings of the study in text, figures, maps, and tables.

## 4.1 Vegetation health indices

The lowest and highest NDVI values recorded in Debre Berahn were in 2010 and 2000, with -0.44 and 0.66, respectively (Figure 8). The orders of high vegetation index (NDVI values) in Debre Berahn were 0.66, 0.58, and 0.43 in 2000, 2010, and 2020 respectively. On the other hand, the orders in minimum values were recorded as - 0.44, -0.42, and - 0.19 in 2010, 2000, and 2020 respectively. The lowest order of values in Debre Markos was recorded as -0.1,-0.1, and -0.04 for 2000, 2010, and 2020 respectively (Figure 9). For Debre Markos City, the lowest NDVI values were the same in the 2000 and 2010 study periods. The highest NDVI values recorded in both cities were in the first study period, with a value of 0.66 and 0.7 in Debre Berhan and Debre Markos, respectively. The second and third high-order values of NDVI were in 2010 and 2020 in both cities. It was noticed that there was a decreasing trend of NDVI values throughout 2000 – 2020. In both cities, there was no NDVI value recorded close to 1. Generally, the NDVI values have been decreasing in the inner and intermediate zones, indicating that the green spaces have been converted to settlements intensively occasionally.

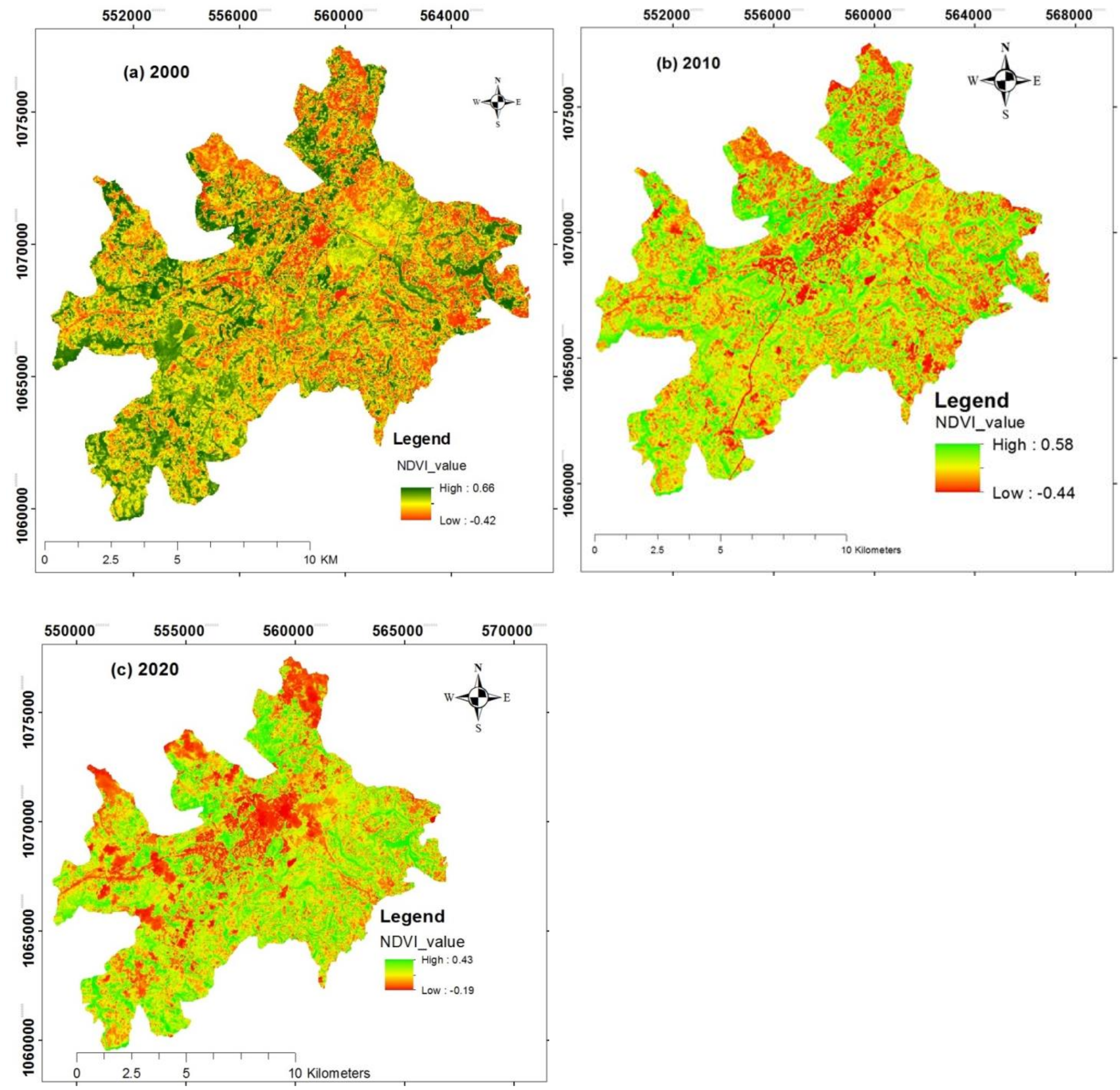



**Fig. 8:** NDVI of Debre Berhan City in (a) 2000, (b) 2010, (c) 2020

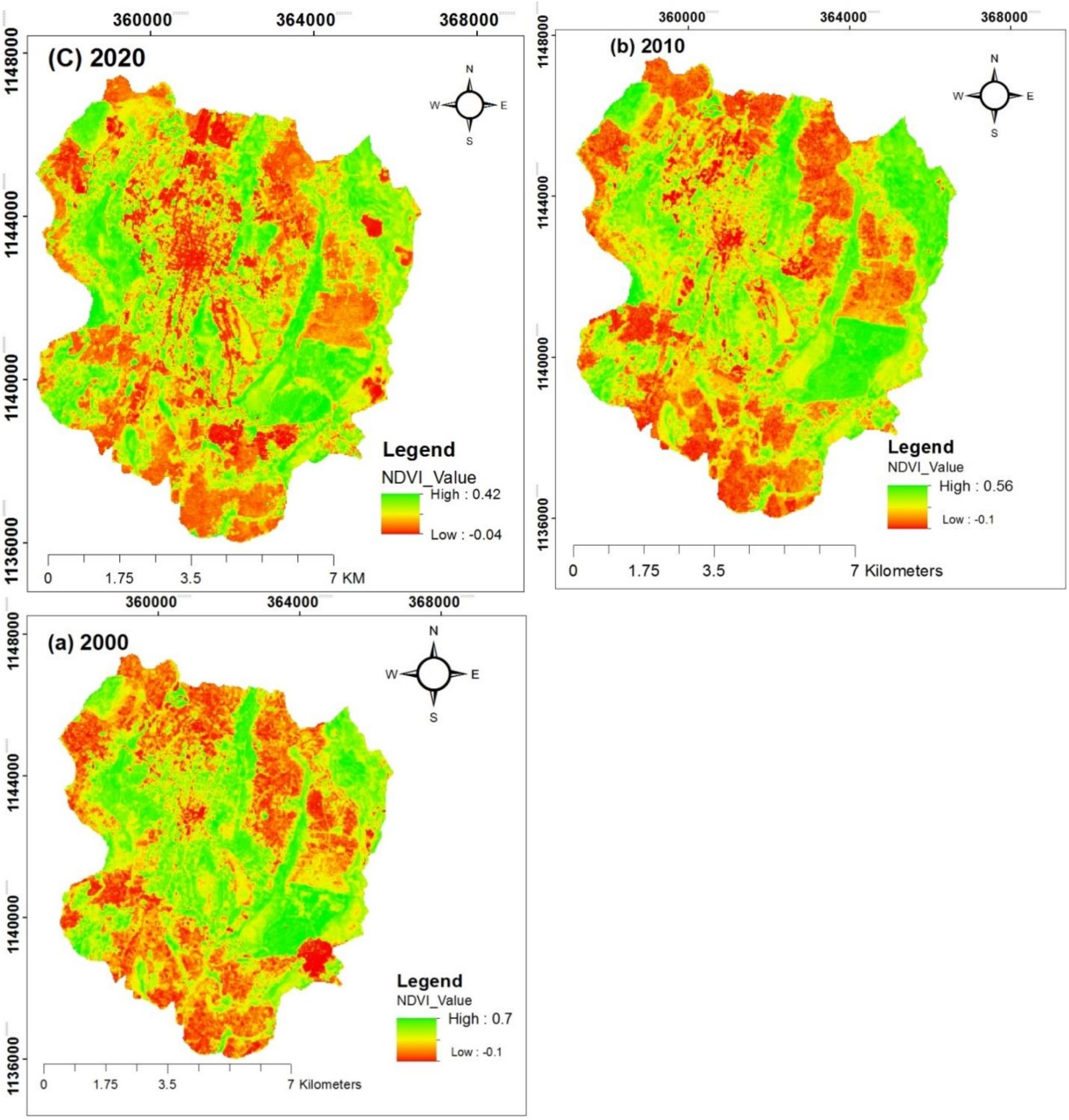



**Fig. 9:** NDVI of Debre Markos City in (a) 2000, (b) 2010, (c) 2020

### 4.1.1 Classification of NDVI values

The classification of NDVI values has been triangulated with the area's land use and cover. The red, orange, light green, and green shown in (Fig. 10) and (Fig. 11) were water bodies and built-up areas, barren croplands, sparse vegetation, and dense vegetation, respectively. The spatial coverage of these NDVI-based LULC classes was tabulated with its ranges, area in (km2), and percentages shared in (Table 11) and (Table 12) for Debre Berhan and Debre

Markos Cities, respectively. Figure 10 shows that Debre Berhan city in 2000 and 2010 was majorly covered by barren and croplands, followed by built-up and water bodies in second place in all study periods, as shown in (Table 11).

**Table 11:** NDVI ranges, areas & its percentages of Debre Berhan City in 2000, 2010, and 2020

| Land use classes | 2000 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | ranges | area in $km^2$ (%) | ranges | area in $km^2$ (%) | ranges | area in $km^2$ (%) |
| Water bodies & built-up | - 0.42 - 0.12 | 51.5 (35.2) | -0.44 - - 0.08 | 57.7 (39.4) | -0.19 – 0.11 | 17 (11.6) |
| Barren and croplands | 0.12 - 0.18 | 60.2 (41.2) | 0.08 – 0.15 | 58.4 (40) | 0.11 – 0.16 | 67.2 (45.8) |
| Sparse vegetation | 0.18 – 0.27 | 28.2 (19.2) | 0.15 – 0.26 | 22.4 (15.3) | 0.16 – 0.22 | 47.5 (32.5) |
| Dense vegetation | 0.27 – 0.66 | 6.3 (4.3) | 0.26 – 0.58 | 7.8 (5.4) | 0.22 – 0.43 | 14.6 (10) |
| **Total** | | **146.0 (100%)** | | **146.0 (100%)** | | **146.0 (100%)** |

The spatial coverage of sparse and dense vegetation was high in 2000 and decreased in 2010, again increasing by 2020. Even if the NDVI values decreased over the study period, the green coverage (Table 11) showed that sparse and dense vegetation increased from 23.5% in 2000 to 20.8% in 2010 and 42.5% in 2020. Despite the NDVI value being the lowest in 2020, more green space cover (especially sparse vegetation) was observed on the map, unlike in 2000 and 2010.

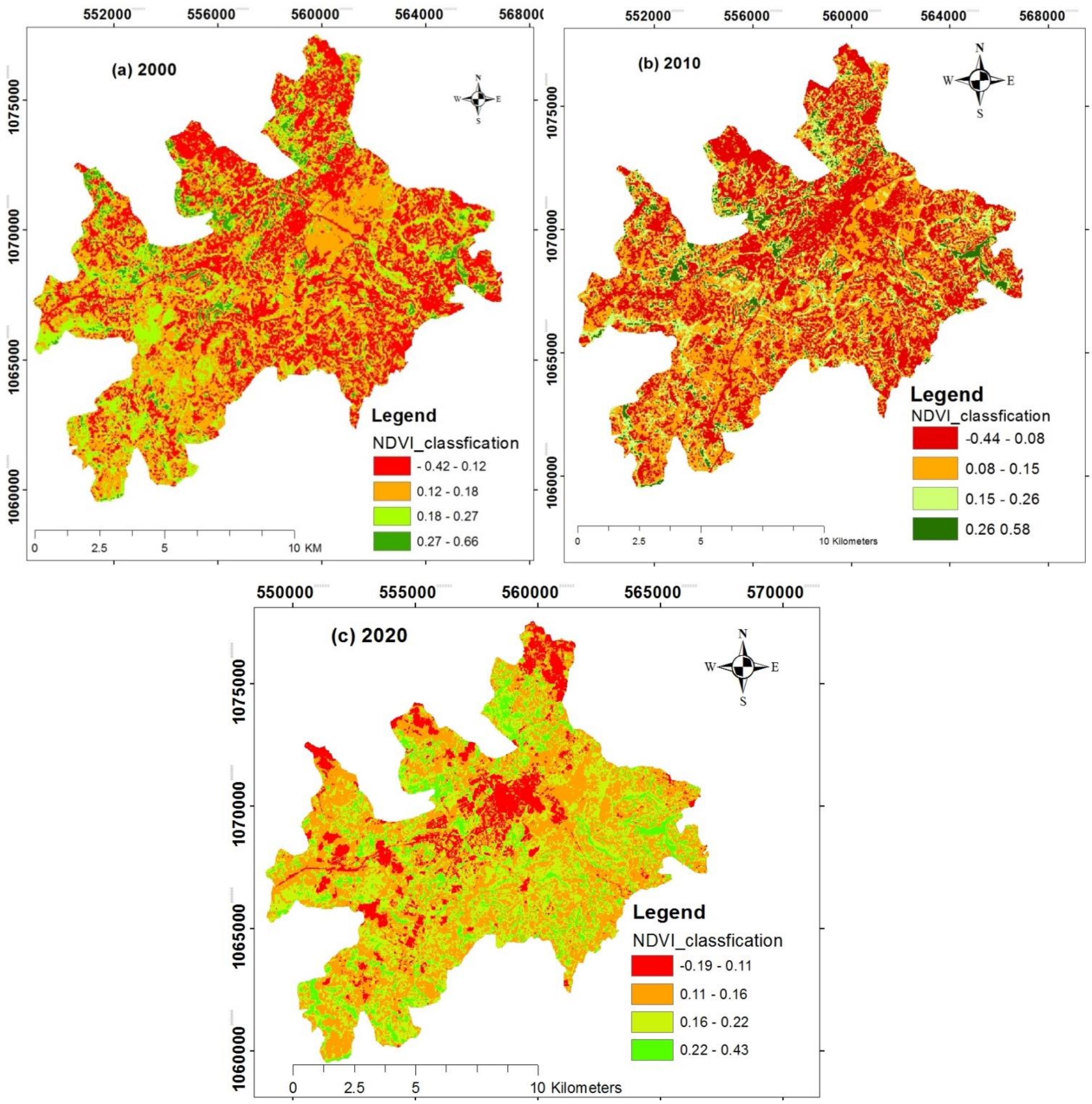



**Fig. 10:** NDVI classification of Debre Berhan City in (a) 2000, (b) 2010, (c) 2020

**Table 12:** NDVI ranges, areas & its percentages in Debre Markos City in 2000, 2010, and 2020

| **Land use classes** | **DM 2000** | | **DM 2010** | | **DM 2020** | |
|---|---|---|---|---|---|---|
| | ranges | area in km$^2$ (%) | ranges | area in km$^2$ (%) | ranges | area in km$^2$ (%) |
| Water bodies and built-up | -0.1 - 0.15 | 29.0 (39.4%) | -0.1 - 0.15 | 27.2 (37.0%) | - 0.04- 0.08 | 14.4 (19.6) |
| Barren and croplands | 0.15 - 0.24 | 18.5 (25.1%) | 0.15 - 0.24 | 19.4 (26.4%) | 0.13 - 0.18 | 24.6 (33.4) |
| Sparse vegetation | 0.24 - 0.33 | 16.2 (22.0%) | 0.24 - 0.33 | 15.3 (20.8%) | 0.18 - 0.25 | 22.4 (30.4) |
| Dense vegetation | 0.33 - 0.56 | 10.0 (13.5%) | 0.33 - 0.7 | 11.7 (15.8%) | 0.25 - 0.42 | 12.2 (16.6) |
| **Total** | | 73.5 (100%) | | 73.5 (100%) | | 73.5 (100%) |

As shown in Table 12, the spatial coverage of both sparse and dense vegetation was increased in the study period (2000 – 2020 though the sparse vegetation was decreased from 2000 - 2010. Water bodies and built-up were high in 2000 and 2010, while barren and croplands were highest in 2020. Unlike the city of Debre Berhan, the green spaces in Debre Markos city were concentrated in a certain area, particularly around the city periphery and encircling the built-up area like the urban green belt, as shown in Figure 11. Very significant green spaces were located in the southeast part of the city, where more green space stability was observed. The overall change of NDVI values decreased for both Cities from 2000 to 2020.

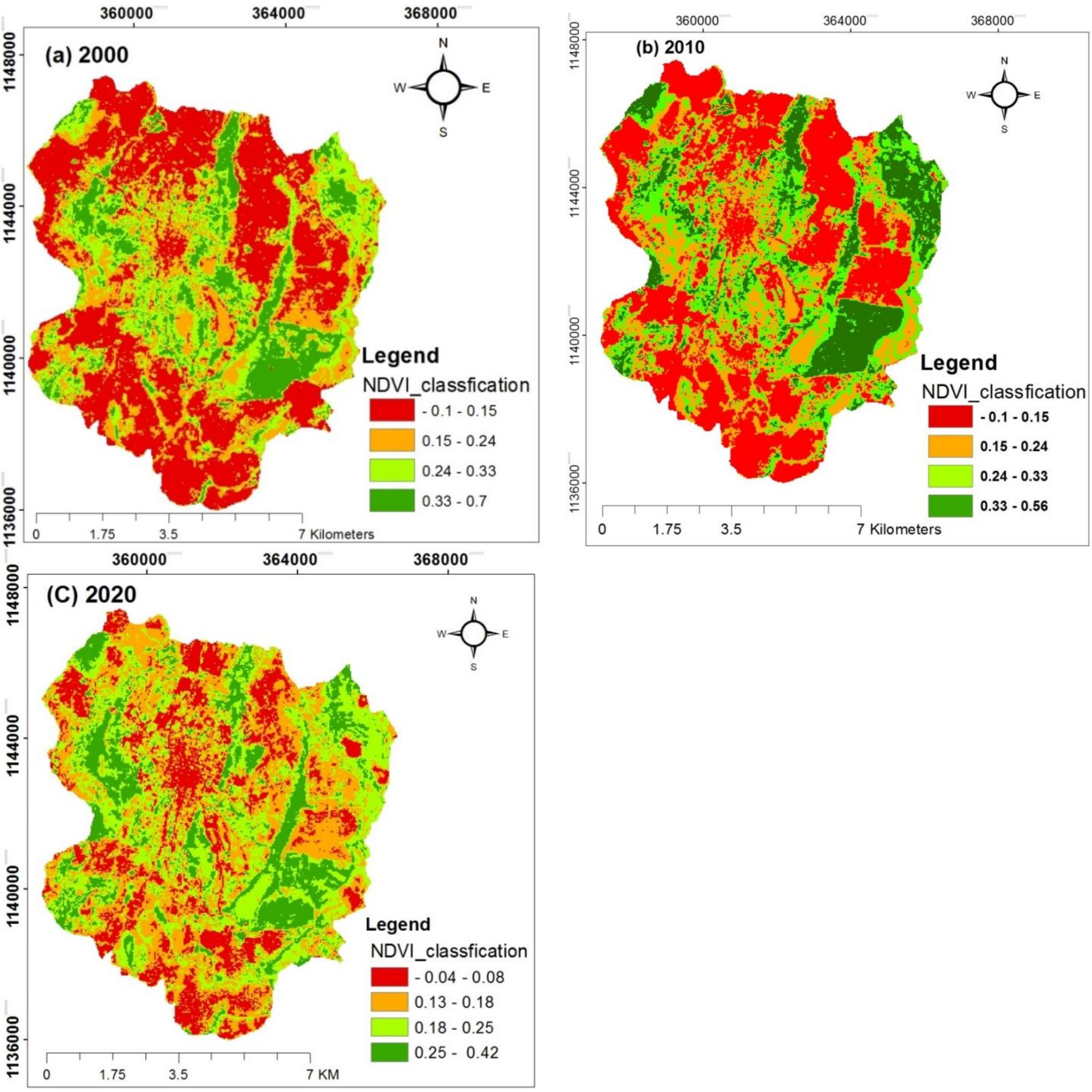



**Fig. 11:** NDVI classification of Debre Markos City in 2000, 2010, 2020 respectively

## 4.2 Land use and land cover analysis

### 4.2.1 Accuracy assessment

Table 13 shows that the overall accuracy of Debre Berhan City in 2000, 2010, and 2020 was 90%, 90%, and 90%, respectively. The overall accuracy of Debre Markos in 2000 and 2010 was 90% and 91.4% in 2020 (Table 14). The user accuracy ranges from 80% to 95%. The producer accuracy ranges from 75% to 100% for Debre Berhan, the user accuracy ranges from 80% to 95%, and the producer accuracy ranges from 80% to 100% for Debre Markos. The Kappa coefficients 0.86, 0.86, and 0.85 in Debre Berhan and 0.86, 0.86, and 0.88 in Debre Markos indicated a strong agreement with the six classified images. A value of kappa coefficient greater than 0.80 represents strong agreement, 0.60-0.80 is substantial, a value between 0.41-0.60 moderate agreement, and a value below 0.40 represents poor agreement (Kindu et al. 2020 and Wang et al. 2020).

**Table 13:** Summary of the classification accuracy assessment of Debre Berhan City

| Land class name | DB 2000 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | UA (%) | PA (%) | UA (%) | PA (%) | UA (%) | PA (%) |
| Water bodies | 90. 0 | 75. 0 | 80. 0 | 80. 0 | 80. 0 | 80. 0 |
| Built-up | 90. 0 | 100. 0 | 95. 0 | 95. 0 | 95. 0 | 95. 0 |
| Barren and cropland | 90. 0 | 85.7 | 90. 0 | 85.7 | 90. 0 | 85.7 |
| Green spaces | 90. 0 | 94.7 | 90. 0 | 94.7 | 90. 0 | 94.7 |
| Over all accuracy | **90** | | **90** | | **90** | |
| Kappa Statistic | **0.86** | | **0.86** | | **0.85** | |

*UA= User's accuracy, PA= producer's accuracy*

**Table 14:** Summary of the classification accuracy assessment of Debre Markos City

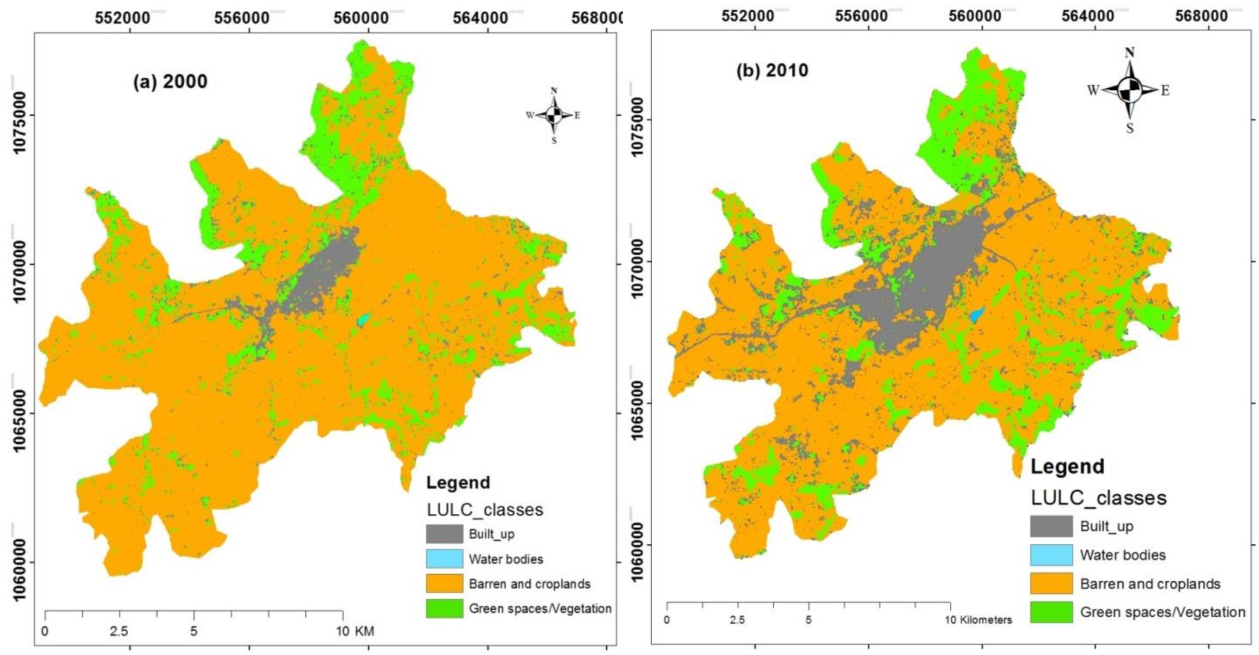
| Land class name | 2000 | | 2010 | | 2020 | |
|---|---|---|---|---|---|---|
| | UA (%) | PA (%) | UA (%) | PA (%) | UA (%) | PA (%) |
| Water bodies | 80. 0 | 88.9 | 80. 0 | 80. 0 | 80. 0 | 81.8 |
| Built-up | 95. 0 | 100. 0 | 90. 0 | 100. 0 | 90. 0 | 100. 0 |
| Barren and cropland | 90. 0 | 90. 0 | 90. 0 | 90. 0 | 90. 0 | 90. 0 |
| Green spaces | 90. 0 | 81.8 | 95. 0 | 86.4 | 95. 0 | 90. 0 |
| Over all accuracy | **90** | | **90** | | **91.4** | |
| Kappa Statistic | **0.86** | | **0.86** | | **0.88** | |

*UA= User's accuracy, PA= producer's accuracy*

### 4.2.2 Land use and land cover

The area of interest was classified into four land use and land cover classes: water bodies, built-up, barren and cropland, and green spaces. (Fig.12a) and (Fig.13a) show barren and croplands with a landscape area of 117.4 $km^2$ (80%) in Debre Berhan and with an area of 38.5

km$^2$ (52.3%) in Debre Markos in the year 2000. In the same period green spaces with an area of 20.3 km$^2$ (13.9 %) and built-up with 8.6 km$^2$ (5.9 %) cover the second and third place in Debre Berhan. Similarly, in Debre Markos, green spaces and built-up areas were the second and third largest land class types, with 28.5 km2 (38.7%) and 6.2 km2 (8.42%), respectively. In the city of Debre Berhan in 2010, barren and croplands were the dominant land use type, with an area of 97.5 km2 (66.75%). Green spaces with 25.7 Km2 (17.6 %) and built-up areas of 22.71 km2 (15.55 %) hold the second and third place respectively. On the other hand, in the same year (2010), as shown in (Table 8), green spaces were the dominant land use class with an area of 34.4 km2 (46.74%), mainly with the cover of sparse vegetation and less dense vegetation as it was also shown in (Table 4) in the city of Debre Markos. Barren and Croplands and Built-up were the second and third largest class types, with an area of 28.6 km2 (38.86%) and 10.3 km2 (14%), respectively.



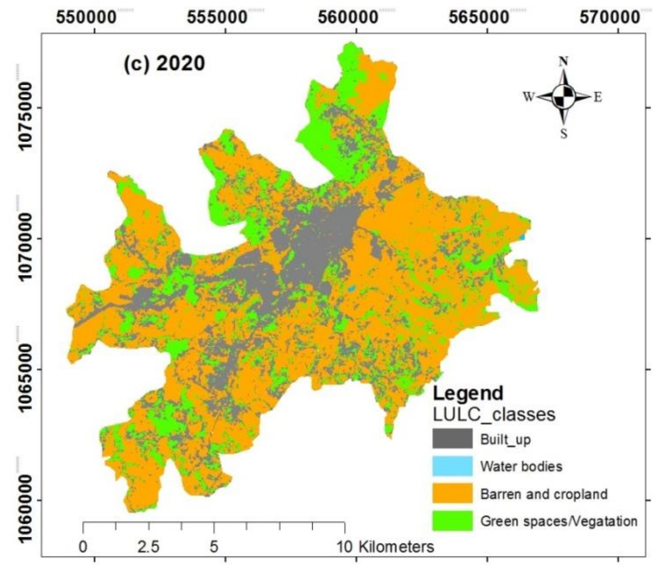



**Fig. 12**: land use and land cover map of Debre Berhan in (2000, 2010, and 2020)

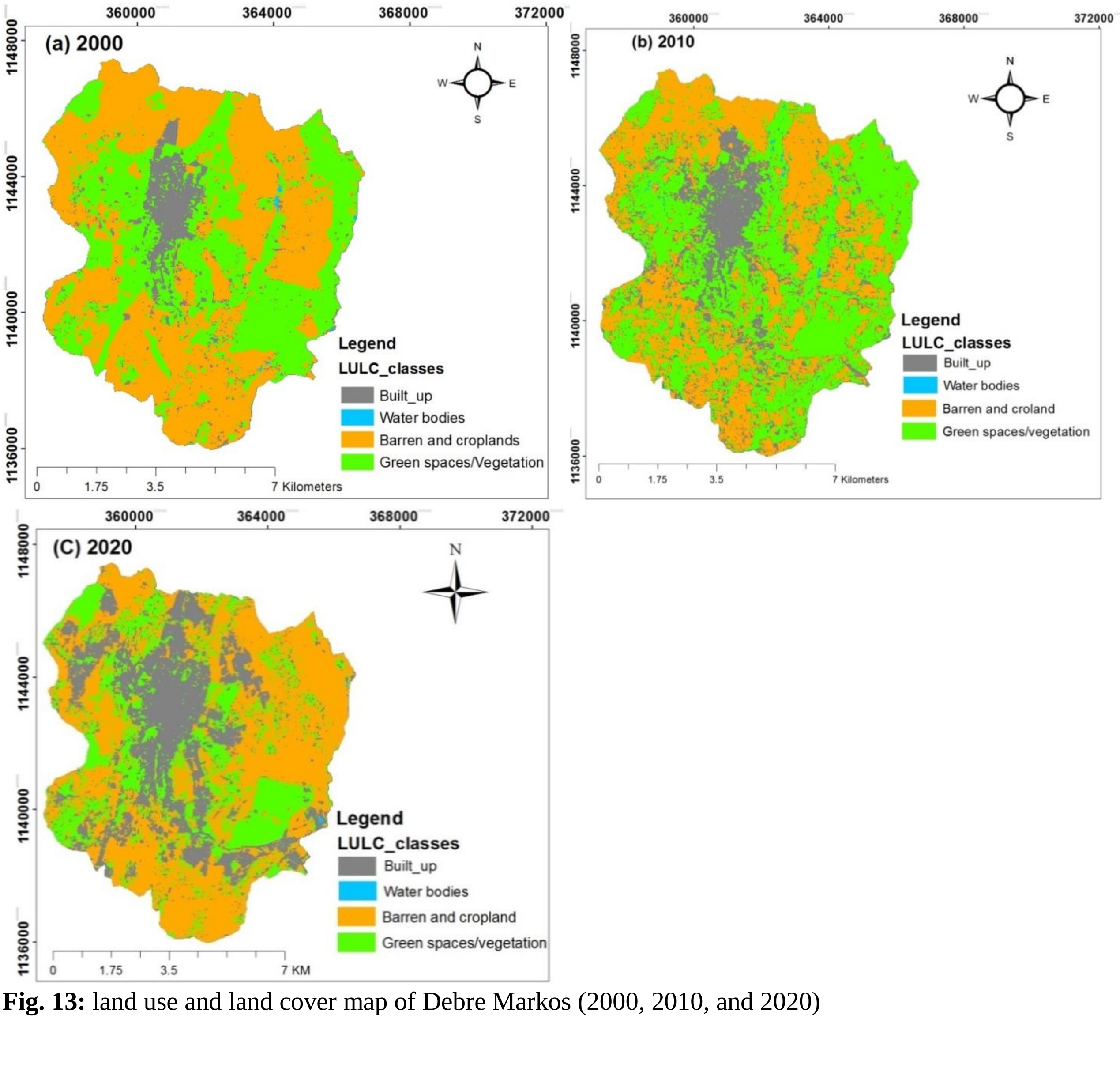



**Fig. 13:** land use and land cover map of Debre Markos (2000, 2010, and 2020)

Compared with the results of LULC 2010, there was a significant land-use change in green spaces followed by built-up areas. In 2020, in Debre Berhan city, barren and croplands with an area of 78.7 km2 (54%) and built-up with an area of 39.4 km2 (26.95%) lay in first and third place—the third largest land-use type comprised green spaces with 27.9 km2 (19.1%). Barren and croplands were also the dominant land class type, with an area of 36.3 km2 (49.3%) in Debre Markos, while green spaces and barren and croplands take second and third places, respectively.

#### 4.2.3 Land use and land cover change detection

The consistent changes in built-up land cover took place from 2000 to 2020, resulting in increased built-up areas at the expense of barren and croplands and green spaces in Debre Berhan and Debre Markos, respectively, as shown in the land cover conversion matrix. Barren and croplands had decreased by 32.96% from the initial year at Debre Berhan, whereas green spaces had decreased by 41% at Debre Markos. All land use classes have shown significant variations throughout the study period. However, the built-up land cover class was highly dynamic in both cities. It has increased by 357.9% and 224.2% over the study period of 2000 – 2020 in Debre Berhan and Debre Markos, respectively. According to the results of the LULC analysis, the green space coverage of the Debre Berhan was 13.9%, 17.6%, and 19.06 % in 2000, 2010, and 2020 respectively. Accordingly, the green space coverage in Debre Markos was 38.7 %, 46.74%, and 22.8% in 2000, 2010, and 2020. This result shows that green space cover change increased in Debre Berhan and decreased in Debre Markos over the study period. In 2000, Barren and croplands were the dominant land cover type, with an area of 117.4 km2 (80%) and 38.5 km2 (52.3%) of the total Debre Berhan and Debre Markos area, respectively. Green spaces were the second largest LULC classes in both cities; however, the green spaces and croplands, including barren, have been changed messily over the study period, as shown in (Table 15) & (Table 16). This was a signal for environmental degradation triggered by unsustainable development of land resources. These land cover classes, including the built-up areas, had undergone drastic changes.

Table 15: **LULC statistics and its overall changes in Debre Berhan City in 2000, 2010, and 2020**

| **Land cover type** | **2000** | | **2010** | | **2020** | | **Overall change** | |
|---|---|---|---|---|---|---|---|---|
| | Area ($km^2$) | %age | Area ($km^2$) | %age | Area ($km^2$) | %age | Area ($km^2$) | %age |
| Water bodies | 0.10 | 0.05 | 0.15 | 0.10 | 0.10 | 0.05 | 0. 00 | 0. 00 |
| Built-up | 8.50 | 5.90 | 22.70 | 15.55 | 39.37 | 26.99 | 30.78 | 357.90 |
| Barren and Croplands | 117.30 | 80. 15 | 97.45 | 66.75 | 78.63 | 53.90 | -38.70 | -32.96 |
| Green spaces | 20.10 | 13.90 | 25.70 | 17.60 | 27.90 | 19.06 | 7.60 | 37.40 |
| **Total** | **146.0**0 | **100.00** | **146.0**0 | **100.** 00 | **146.0**0 | **100.** 00 | | |

NB. LULC statistics is area in $km^2$ and its percentage out of the total area

**Table 16**: LULC statistics and its overall changes in Debre Markos City in 2000, 2010, and 2020

| **Land cover type** | **2000** | | **2010** | | **2020** | | **Overall change** | |
|---|---|---|---|---|---|---|---|---|
| | Area ($km^2$) | % age | Area ($km^2$) | % age | Area (km2) | % age | Area (km2) | % age |
| Water bodies | 0.1 | 0.14 | 0.1 | 0.14 | 0.1 | 0.14 | 0.0 | 0.00 |
| Built-up | 6.4 | 8.70 | 10.4 | 14.14 | 20.3 | 27.61 | 13.9 | 224.2 |
| Barren and Croplands | 38.5 | 52.39 | 28.6 | 38.91 | 36.3 | 49.39 | -2.2 | -5.71 |
| Green spaces | 28.5 | 38.77 | 34.4 | 46.80 | 16.8 | 22.86 | -11.7 | -41.00 |
| **Total** | **73.5** | **100.00** | **73.5** | **100.00** | **73.5** | **100.00** | | |

NB. LULC statistics is area in $km^2$ and its percentage out of the total area

Some trends have been observed in all land use classes throughout the study period. However water bodies had no significant cover change in both Cities. In Debre Berhan city, water bodies were 0.05%, 0.1%, and 0.05% (2000, 2010, and 2020) respectively, showing no over change from the initial year. Similarly the water bodies in Debre Markos City also showed no cover change; it was 0.1Km$^2$ (0.14%) in all three periods. The built-up land cover increased drastically with a change of 164.1%, 73.4%, and 357.9% in the period of 2000 – 2010, 2010 – 2020, and 2000 – 2020 respectively. The built-up areas have been increased triple times of the area of initial year which was a huge increase. The barren and croplands were rapidly reduced with 16.92%, 16.3%, and 32.96% in the period of 2000 – 2010, 2010 – 2020, and 2000 – 2020 respectively. It was the only land-use class that has been reduced. As shown in (Table 7) built-up, green spaces, and barren and croplands were in the order of high change with (357.9%, 37.4%, and -32.96 %) overall changes respectively. It has been noticed that a reduction in barren and croplands by 32.96% was due to its conversion to built-up areas and green spaces as shown in the Land use/land cover conversion matrix. Green spaces had been in a smooth change with 26.6% from 2000 – 2010 and with 8.6% from 2010 - 2020. The overall change from 2000 – 2020 was 37.4% which indicated that the change rate was gradual in the first period (2000 – 2010) and dramatic in the next period (2010 – 2020).

In Debre Markos, the Built-up area was increased by 66.12 %in 2000 - 2010 and 95.14% in 2010 – 2020. However, the overall change (2000 – 2020) of built-up areas was drastically increased by 224.2%, which doubled from the initial year's total area. Barren and croplands decreased in the initial period (2000 – 2010) from 52.3% (38.5km2) to 38.86% (28.6km2) with 25.7%. Then, it increased by 26.9% and decreased by 5.71% throughout 2010 – 2020 and 2000 – 2020, respectively. As shown in (Table 8), the order of intensive LULC change recorded was built-up, green spaces, and barren and croplands with an overall change of 224.2%, -41%, and -5.71%, respectively. The total area of green space in Debre Markos in 2000 was 28.5 km2 (38.7 %). 2010, it increased by 20.7% and became 34.4 km2 (46.74 %). Then, in 2020, it decreased to 16.8 km2 (22.6%), with 51.2% and 41% throughout (2010 – 2020 and 2000 – 2020) respectively. The green spaces decreased by more than half from the initial year, and it was noticed that 10.7 km2 and 7.3 km2 areas of green space covers had been changed to barren and croplands and built-up areas, respectively. Generally, the results show that in Debre Berhan city, all land classes have increased except the barren and croplands, which decreased by 33% from the initial year. Conversely, in Debre Markos city, the result in (Table 8) showed that green spaces and croplands decreased while built-up areas were tripled and water bodies remained unchanged.4.2.4 Land use and land cover conversion matrix

**Table 17:** Land use and land cover conversion matrix for Debre Berhan from 2000 – 2010**.**

| LULC classes | Barren and cropland | Built-up areas | Green spaces | Water bodies | Total_2010 |
|---|---|---|---|---|---|
| Barren and cropland | **92.6** | 1.4 | 3.4 | 0.0 | **97.3** |
| Built-up areas | 13.9 | **5.6** | 3.2 | 0.0 | **22.8** |
| Green spaces | 10.6 | 1.5 | **13.6** | 0.0 | **25.7** |
| Water bodies | 0.0 | 0.0 | 0.0 | **0.1** | **0.1** |
| **Total_2000** | **117.2** | **8.5** | **20.2** | **0.1** | **146.0** |

*NB.The row total sums the amount of land for each LULC type in the first study year, and the column total sums the amount of land in the final study year. The bold diagonal values represent the un-changed area of each class, whereas the other values represent the change in area..*

**Table 18:** Land use and land cover conversion matrix for Debre Berhan from 2010 – 2020

| LULC classes | Barren and cropland | Built-up areas | Green spaces | Water bodies | Total_2020 |
|---|---|---|---|---|---|
| Barren and cropland | **65.8** | 5.0 | 7.9 | 0.1 | **78.7** |
| Built-up areas | 19.6 | **13.7** | 6.0 | 0.0 | **39.3** |
| Green spaces | 11.9 | 4.1 | **11.9** | 0.0 | **27.9** |
| Water bodies | 0.0 | 0.0 | 0.0 | **0.1** | **0.1** |
| **Total_2010** | **97.3** | **22.8** | **25.7** | **0.2** | **146.0** |

**Table 19:** Land use and land cover conversion matrix for Debre Berhan from 2000 – 2020

| LULC classes | Barren and cropland | Built-up areas | Green spaces | Water bodies | Total_2020 |
|---|---|---|---|---|---|
| Barren and cropland | **72.8** | 1.5 | 4.3 | 0.0 | **78.7** |
| Built-up areas | 28.7 | **5.4** | 5.2 | 0.0 | **39.3** |
| Green spaces | 15.5 | 1.7 | **10.7** | 0.0 | **27.9** |
| Water bodies | 0.0 | 0.0 | 0.0 | **0.1** | **0.1** |

| Total_2000 | 117.2 | 8.5 | 20.2 | 0.1 | 146.0 |
|---|---|---|---|---|---|

The highlighted numbers in the diagonal indicate that the land cover is unchanged and to its original extent. The total area of barren and cropland was 117.2 km2 (Table 17). Between 2000 and 2010, out of the total 117.2 km2 of barren and cropland, 92.6 km2 remained unchanged, whereas 24.6km2 barren and cropland was converted into built-up (13.9 km2) and green spaces (10.6km2) (Table 18). In 2010, the barren cropland became 97.4 km2. Between 2010 and 2020, 65.8 km2 was remained unchanged. The remaining 31.5 km2 was changed into built-up areas (19.6 km2) and green spaces (11.9 km2). From the total area of barren and cropland, 117.2 km2 in 2000, 72.8 km2 remained unchanged in the study period from 2000 to 2020. The remaining 44.4 Km2 was changed to built-up areas and green spaces with an area of 28.7 Km2 and 15.5Km2 respectively (Table 19).

The total area of the green spaces was 20.2 km2 in 2000. Between 2000 and 2010, 13.6 km2 was remained unchanged. The rest 6.6km2 was changed into barren and cropland and built-up areas with an area of 3.4km2 and 3.2 km2. The green spaces had been increased to 25.7 km2 in 2010. 17.3 km2 area of green space remained unchanged over the study period of 2010 to 2020. 7.9 km2 and 6 km2 green space areas were changed to barren, cropland, and built-up areas. The green space changes between 2000 and 2020: 5.2km2 and 4.3km2 were changed to built-up areas and barren and cropland, respectively, while 10.7km2 remained unchanged. Generally, the conversion rate was high in all classes except the water bodies remained unchanged throughout the study period.

**Table 20:** Land use and land cover conversion matrix for Debre Markos from 2000 - 2010

| LULC classes | Barren and cropland | Built-up areas | Green spaces | Water bodies | Total _2010 |
|---|---|---|---|---|---|
| Barren and cropland | **23.0** | 0.9 | 4.8 | 0.0 | 28.6 |
| Built-up areas | 3.4 | **4.0** | 2.9 | 0.0 | 10.3 |

| | | | | | |
|---|---|---|---|---|---|
| Green spaces | 12.1 | 1.5 | **20.9** | 0.0 | 34.5 |
| Water bodies | 0.0 | 0.0 | 0.0 | **0.1** | 0.1 |
| **Total_2000** | **38.5** | **6.4** | **28.5** | **0.1** | **73.5** |

**Table 21:** Land use and land cover conversion matrix for Debre Markos from 2010 - 2020

| LULC classes | Barren and cropland | Built-up areas | Green spaces | Water bodies | Total _2020 |
|---|---|---|---|---|---|
| Barren and cropland | **17.3** | 2.3 | 16.7 | 0.0 | 36.3 |
| Built-up areas | 6.5 | **6.6** | 7.2 | 0.0 | 20.3 |
| Green spaces | 4.8 | 1.6 | **10.4** | 0.0 | 16.8 |
| Water bodies | 0.0 | 0.0 | 0.0 | **0.1** | 0.1 |
| **Total_2010** | **28.6** | **10.5** | **34.3** | **0.1** | **73.5** |

**Table 22:** Land use and land cover conversion matrix for Debre Markos from 2000 – 2020

| LULC classes | Barren and cropland | Built-up areas | Green spaces | water bodies | Total_2020 |
|---|---|---|---|---|---|
| Barren and cropland | **24.6** | 1.0 | 10.7 | 0.0 | 36.3 |
| Built-up areas | 8.4 | **4.5** | 7.3 | 0.0 | 20.3 |
| Green spaces | 5.4 | 0.8 | **10.6** | 0.0 | 16.8 |
| water bodies | 0.0 | 0.0 | 0.0 | **0.1** | 0.1 |
| **Total_2000** | 38.5 | 6.3 | 28.6 | 0.1 | 73.5 |

The total area of barren and cropland in Debre Markos was 38.5 km2 in 2000 (Table 20). Between 2000 and 2010, out of the total 38.5 km2 barren and cropland, 23 km2 remained unchanged, whereas 12.1 km2 of barren and cropland was converted into green spaces and 3.4 km2 into built-up areas. In 2010, the total area of barren and cropland became 28.6 km2. In 2010 - 2020, 17.3 km2 area of barren and cropland remained unchanged. The rest, 6.5 km2 was changed to built-up areas and 4.8 km2 to green spaces (Table 21). Then, from the total area of barren and cropland, which was 38.5 km2 in 2000, 24.6 km2 remained unchanged in the study period from 2000 to 2020. The remaining 7.4 km2 is barren, and cropland was changed to built-up areas and green spaces with an area of 8.4 km2 and 5.5 km2, respectively (Table 22).

The total area of the green spaces was 28.5 km2 in 2000. 4.8 km2 and 2.9 km2 green spaces were changed into barren and cropland and built-up areas, while 20.9 km2 remained unchanged from 2000 - 2010. In 2010, the green spaces had been increased to 34.4 km2. Between 2010 and 2020, only 10.4 km2 of green space remained unchanged. However, 16.7 km2 and 7.2 km2 green spaces were changed to barren and cropland and built-up areas, respectively. Out of the total 28.6 km2 area of green spaces, the overall change of the green space between 2000 and 2020 was 10.7 km2, and 7.3 km2 was changed into barren and cropland and built-up areas, respectively, while only 10.6 km2 remained unchanged. Like the case of Debre Berhan City, the land cover conversion rate was high in all classes between 2010 and 2020 at Debre Markos City, except the water bodies remained unchanged throughout the study period.

The LULCC brings environmental problems as urban green spaces, agricultural areas, bare lands, and water bodies are degraded. Urban expansion and industrial development in the study areas consume fertile agrarian lands, reducing the availability of land for crop production. It also leads to erosion due to changes in flood regulation, often increasing vulnerability to extreme weather events, as happened in the Debre Markos City in the WESTA River recently. It also causes the fragmentation of landscapes, disrupting migration routes and life cycles of species, which affects ecological processes.

## 4.3 Green space accessibility and connectivity

### 4.3.1 General profile of the respondents

Most survey participants were male (62.1%), while 37.9% were female. Almost half of the respondents (49.6%) were between 20 and 30 years of age.

**Table 23.** Profile of respondents

| Profiles | | Number (%) |
|---|---|---|
| Gender | Male | 217 (62.1%) |
| | Female | 133 (37.9%) |
| Age | 15-20 | 76 (21.6%) |
| | 21-30 | 173 (49.6%) |
| | 31-50 | 76 (21.6%) |
| | 51- 60 | 22 (6.3) |
| | >60 | 3 (0.9%) |
| Education level | No education | 2(0.6% |
| | Primary (1-8) | 25(7.1%) |
| | Secondary (9-10) | 72(20.6%) |
| | Preparatory (11-12) | 57(16.3%) |
| | *TVET or Diploma | 83(23.7%) |
| | Degree | 89(25.4%) |
| | MA(MSC)&above | 22(6.3%) |
| Occupation | Student | 99 (28.3%) |
| | Self-employed | 121 (34.6%) |
| | Employed | 71 (20.3%) |
| | Retired | 4 (1.1%) |
| | Unemployed | 53 (15.1%) |
| Total | | **350 (100%)** |

***TVET-Technical and Vocational Education Training***

In Table 23, it is shown that out of 350 respondents, the majority were self-employed, students, or employed, with 34.6%, 28.3%, and 20.3%, respectively. Almost all the respondents (99.4%) were literate, ranging from primary to high school, with 23.7% and 25.4% having a "TVET/Diploma" and "Degree," respectively. Only 6.3% of the respondents had an MA (MSC) or higher.

Of the 350 users, most were self-employed, students, or employed, with 34.6%, 28.3%, and 20.3%, respectively. Almost all of the respondents were literate, with education ranging from primary to high school, and notably, 23.7% and 25.4% of the respondents had a "TVET/Diploma and Degree," respectively. Only 6.3% of the respondents had an "MA (MSC)" and above.


**Fig. 14**: Profile of Experts in percentage

Out of the total of 25 experts, nearly 96% of them were degree holders and above. More than 76% have more than six years of work experience in different professions. 5(20%), 13 (52%), 3(12%), and 4(16%) of the experts had planning and designing, monitoring and follow-up of the implementation, evaluation of the performances, and funding and capacity building roles in general respectively (Fig. 14).

### 4.3.2 Users' distance from the nearest park

Out of the total number of respondents, 31% lived within 1-1.5 km from the nearest park to their home, and 31% lived within 1.5 - 4 km. About 18% of the respondents had the nearest park within 500m, while 16% lived within the 4 - 6 km distance range. Only 4% of the respondents lived more than 6km from urban parks (Figure 15).

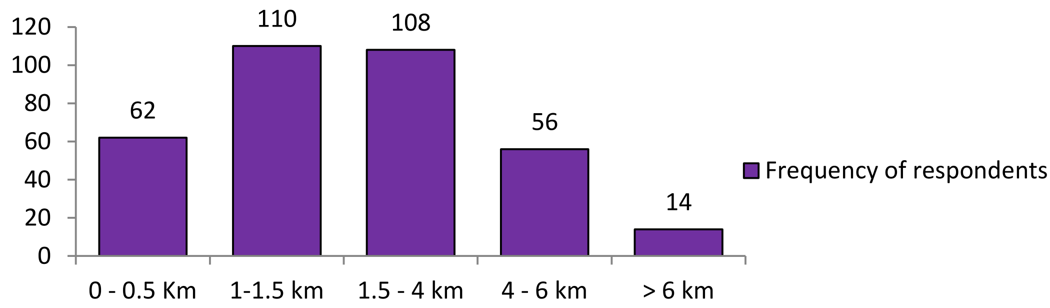



**Figure 15.** Users' distance from the nearest park

#### 4.3.3 Transportation modalities to come to parks

The mean score results show that park users sometimes come to parks by walk and taxi. 80% and 57% of the respondents never used a cycle or automobile to visit parks. Most respondents visited parks "often" with their feet (Table 24). The mean value of the frequency of park visits was (1.57) and a standard deviation of 0.939.

**Table 24:** Frequency of users' Transportation modalities

| Transportation modalities | Never | Sometimes | Often | Very Often | Mean | Standard Deviation |
|---|---|---|---|---|---|---|
| By walk | 22.9% | 41.7% | 18.9% | 16.6% | 2.29 | 0.999 |
| By Cycle | 80.8% | 16.0% | 2.0% | 1.1% | 1.23 | 0.538 |
| By taxi | 22.3% | 48.0% | 22.0% | 7.7% | 2.15 | 0.855 |
| Automobile | 53.7% | 38.9% | 4.3% | 3.1% | 1.57 | 0.722 |
| Others | 69.8% | 22.2% | 5.3% | 2.7% | 1.41 | 0.714 |

Interpretation of mean score: <1.80 = Never, 1.81–2.60 = Sometimes, 2.61–3.40 = Often, <3.41- 4.20 = Very often

#### 4.3.4 Time taken to reach the nearest park on foot

According to the findings (fig.16), almost half, or 49%, of the people who visit the park must walk for more than 20 minutes to reach the closest park or green area on foot. A quarter of them, or 24%, typically takes 15 to 20 minutes, while just 27% reach their destination in less than 15 minutes. About 73% of the participants take more than 15 minutes to get to the nearest green space.

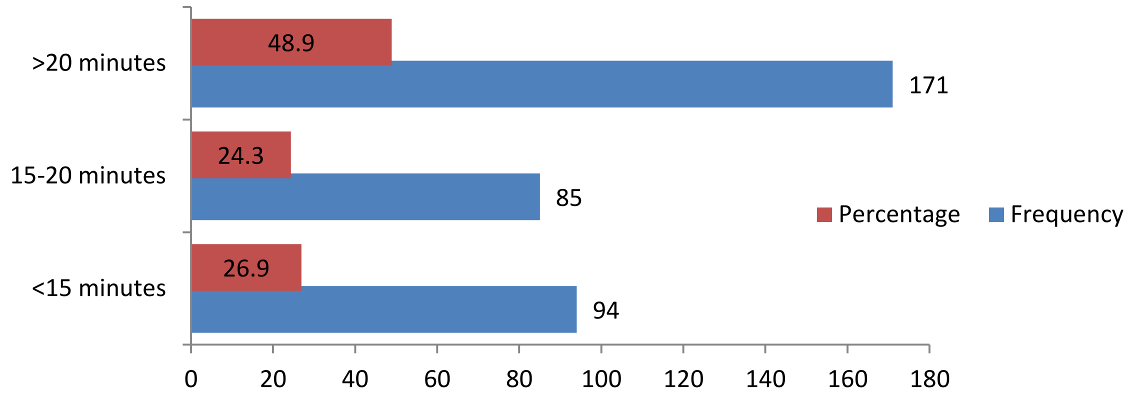



**Figure 16:** Frequency of users' responses to the time taken to reach to the nearest green spaces on foot

**4.3.5 Association of users' age and gender with users' took to reach the nearest park on foot**

We used Chi-square tests of independence to analyze whether socio-demographic characteristics such as gender and age impact the time it takes users to reach the nearest park on foot. Our findings reveal no significant association ($p > 0.05$) between the age and gender of users and the time taken to reach the nearest park, as shown in Table 25.

**Table 25:** Chi-square tests of the respondents' age and gender with users' took to reach the nearest park on foot

| | **Non-spatial attributes** | | |
|---|---|---|---|
| | **$X^2$** | **df** | ***P* value** |
| Gender | 1.24 | 2 | 0.545 |
| Age | 12.493 | 8 | 0.131 |

**4.3.6 Urban green space connectivity and distribution**

Urban green connectivity refers to a network of green spaces and natural areas that are connected through pathways or corridors within an urban environment. These green spaces may include parks, gardens, green roofs, and other natural areas, which offer several benefits, like improving air quality, reducing heat island effects, and promoting biodiversity. In this context, distribution refers to these green spaces' fair access and distribution throughout the urban environment. It is essential to ensure that all residents have equal opportunities to access the benefits of green spaces, regardless of their location within the city. In this study, as shown in (figure 18), there was a fragmentation and degradation of green spaces

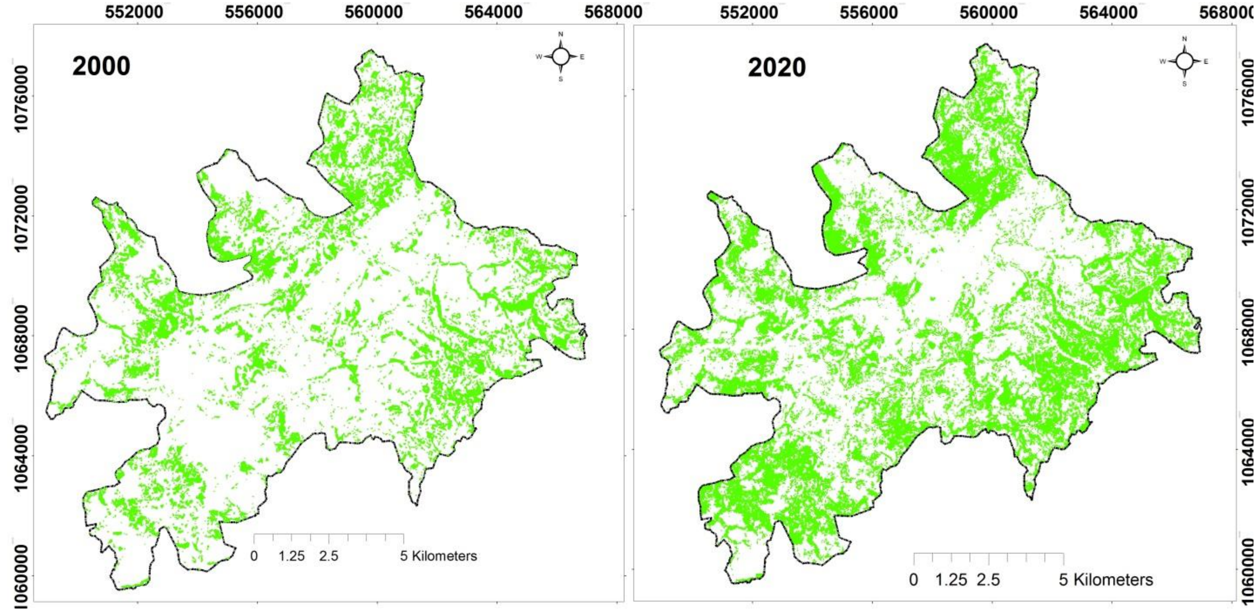


**Figure 17:** Urban green space connectivity comparison between 2000 and 2020 in DB

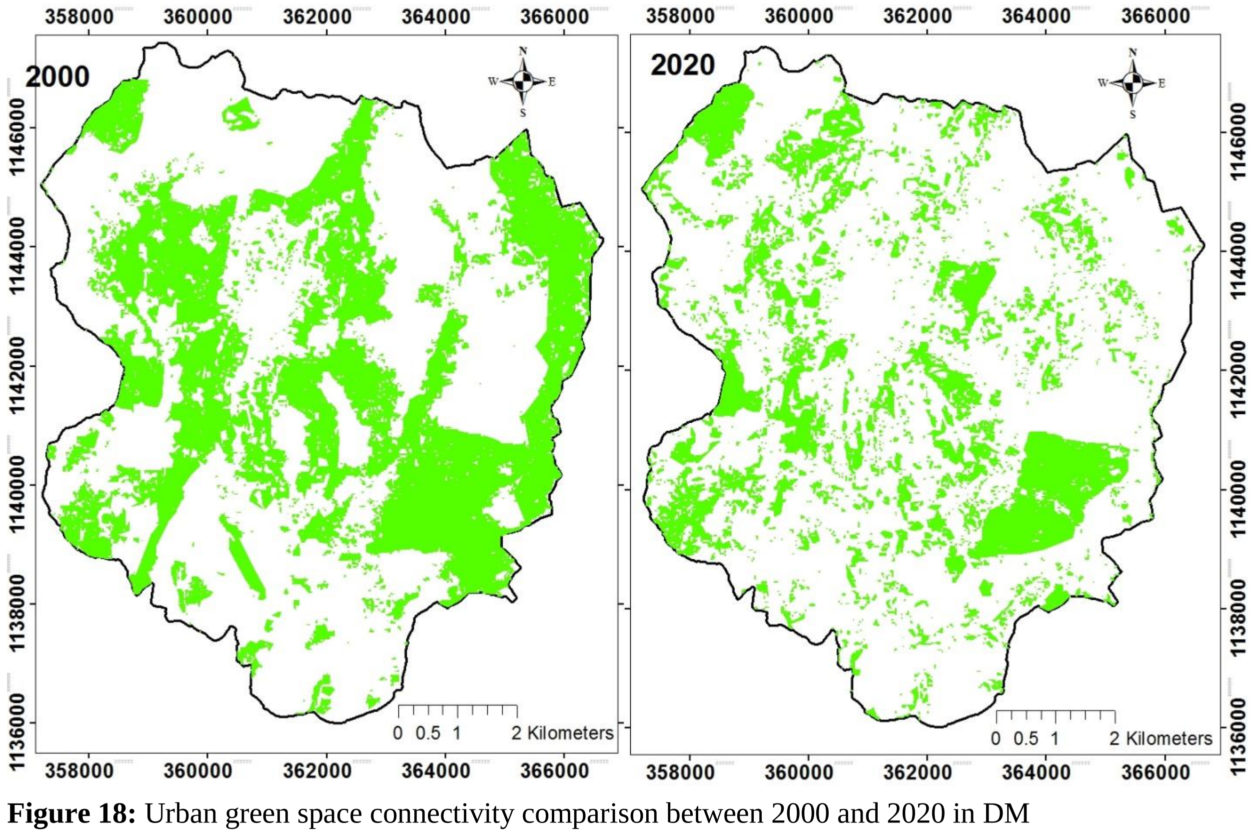


**Figure 18:** Urban green space connectivity comparison between 2000 and 2020 in DM

## 4.4 Users' preferences and perceptions on the use and management of green spaces

### 4.4.1 Users' frequency of park visit

According to the survey, most park users rarely visit parks, with only 7.1% of respondents visiting parks more than eight times a month and 10.1% coming four to eight times a month. Figure 19 show s that 67.7% of respondents visit parks only once or twice a month. The mean value of park visits was 1.57, with a standard deviation of 0.939.

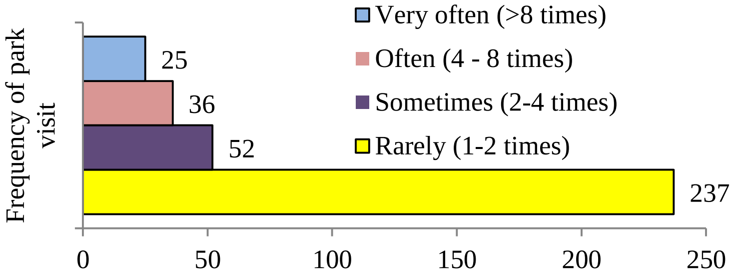



Figure 19: Frequency of park users' visit

The frequency of park visits by citizens is determined by socio-economic factors such as age, occupation, gender, and education level. The results of the relationship analysis are presented in Figure 20. Figure 20a shows that the proportion of users visiting the parks "very often" decreases continuously as users' age. After age 51, the proportion of users who visited the parks "very often" became 0%.

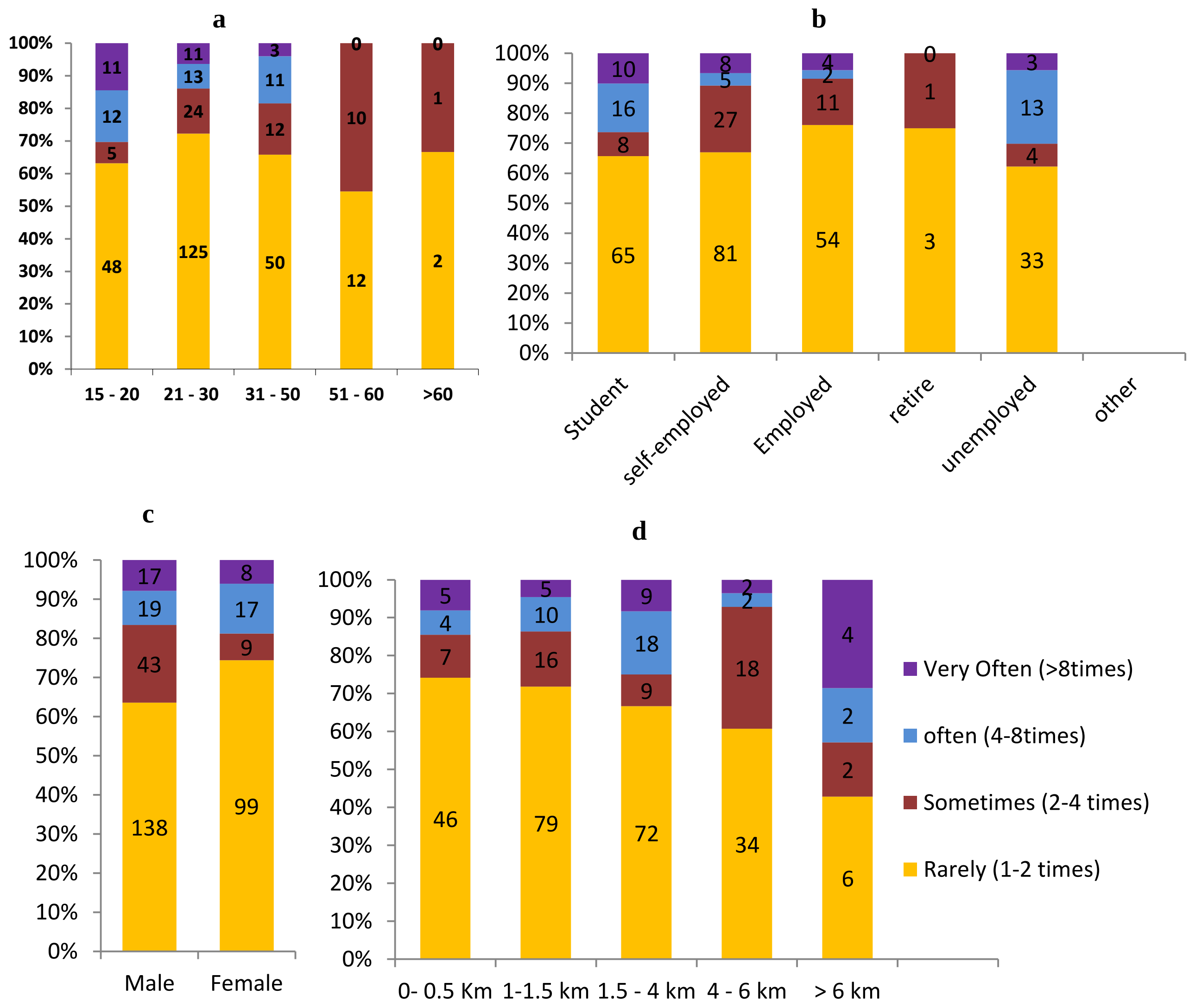



**Figure 20**. The relationship between the frequency of park visits and (a) age, (b) occupation), (c) gender (d) distance from the nearest park

According to Fig. 20d, only 1.43% of the respondents visited parks "very often" when the distance between their home and the nearest park was less than 0.5 km. The percentage of visitors remained the same (1.43%) even when the nearest park was between 1 km and 1.5 km away. However, the number of frequent park visitors increased to 2.6% when the distance between the park and the home was 1.5 km - 4 km. The visitation frequency decreased to 0.6% when the distance was between 4 km and 6 km and then increased to 1.14% when the nearest park was more than 6 km away. Fig. 5c shows that 12.3% of males and 8.1% of females visited parks "very often." Among the visitors who visited parks "very often," 2.9% were students, and 2.3% were self-employed, as shown in Fig. 20b.

### 4.4.2 Purpose of green spaces visits

The survey respondents used a Likert scale to label their reasons for visiting urban green spaces. According to the labeling, "1" meant "Never," "2" meant "Sometimes," "3" meant "Often," and "4" meant "Always". The table shows the mean of the respondents' rank order. "To chill with friends" was the most popular reason for park users visiting green spaces, as indicated in Table 26.

**Table 26.** Order of respondents' responses on the purpose of their visits to green spaces

| Purposes | Average Likert score |
|---|---|
| To chill with friends | 2.85 |
| To enjoy nature and meditate | 2.38 |
| for enjoying the cultural and historical facilities | 2.35 |
| for sheltering purpose | 2.27 |
| For others | 2.27 |
| To walk | 1.94 |
| For events like wedding | 1.78 |
| To have physical exercise | 1.75 |
| For reading | 1.72 |
| To make social life such as Idir and Ikub | 1.53 |

***Idir and Ikub: are the Ethiopian social-cultural activities practiced for supporting each other in economic development and other social beliefs, especially in death***

A chi-square test of independence on the reasons for meeting "to chill with friends" showed that the opinions of respondents were dependent on their age ($\chi2$ (12, N= 350) = 58.257, $p < 0.05$), gender ($\chi2$ (3, N= 350) = 35.093, $p < 0.05$), and occupation ($\chi2$ (15, N =350) = 48.369, $p < 0.05$). However, the views on this issue were not related to the level of education of the respondents ($\chi2$ (18, N= 350) = 30.975, $p > 0.05$). This means that people with similar levels of education did not necessarily have similar views on the subject.

It was found that 26.1% of respondents visit green spaces "always," and 37.1% visit "often" to hang out with their friends. The second most common reason for visiting green spaces was to "enjoy nature and meditation," with 13.8% of respondents visiting "always" and 25.2% visiting "often" for this purpose (Figure 6). The views of respondents varied based on their age ($\chi 2$ (12, N= 350) = 31.93, $p < 0.05$), gender ($\chi 2$ (3, N= 350) = 36.588, $p < 0.05$), and education level ($\chi 2$ (18, N= 350) = 41.82, $p < 0.05$), but not on occupation. Additionally, 13.7% and 28.9% of respondents visit green spaces "always" and "often", respectively, to "enjoy the cultural & historical facilities." The views of respondents regarding this purpose also varied based on their age ($\chi 2$ (12, N= 350) = 23.784, $p < 0.05$), gender ($\chi 2$ (3, N= 350) = 16.104, $p < 0.05$), and education level ($\chi 2$ (18, N= 350) = 67.066, $p < 0.05$), but not on occupation.

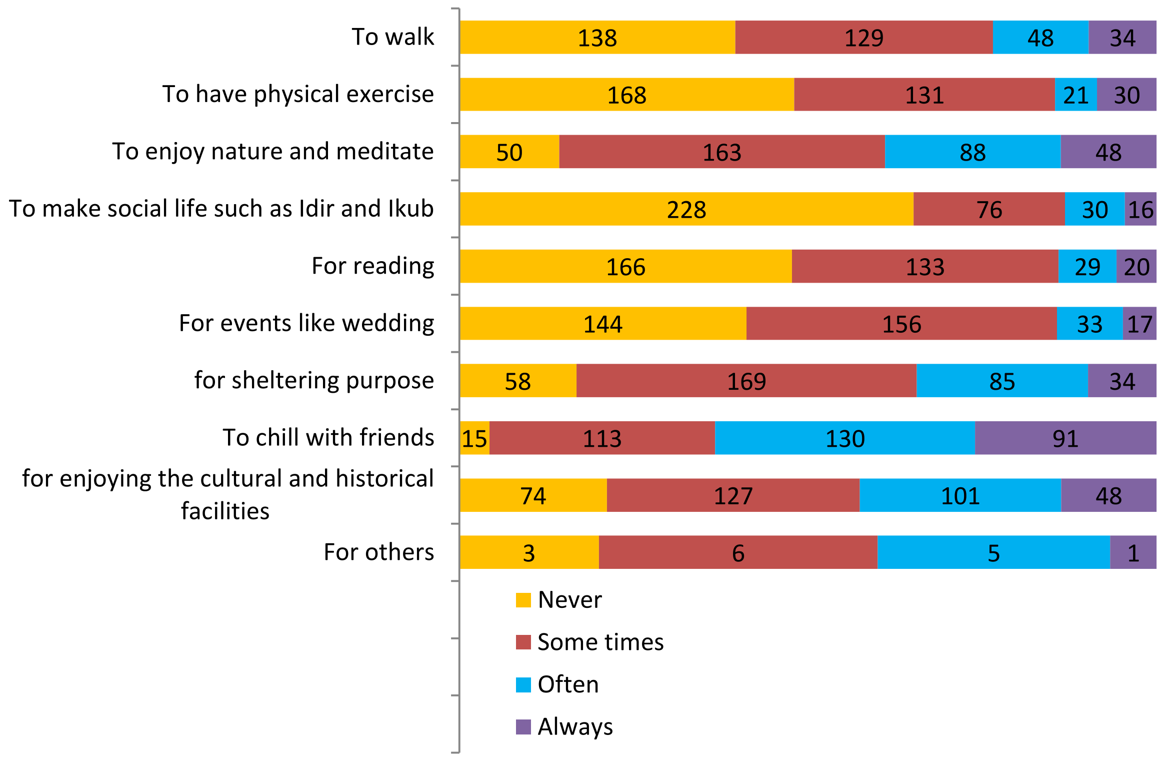



**Figure 21**. Frequency of respondents' responses on the purpose of visits to green spaces

In Debre Berhan and Debre Markos cities, people visit green spaces primarily to relax with friends, enjoy nature and meditation, and explore cultural and historical facilities. However, according to Table 5, most respondents (65.1%, 48%, and 47.7%) never visit green spaces for social activities such as Idir and Ikub, physical exercise, or reading purposes (Figure 21).

#### 4.4.3 Factors and facilities encouraging users to relax

Based on the data in Figure 22, it can be seen that most respondents were strongly encouraged to use green spaces in parks due to factors such as safety and security, fences, sufficient facilities, and spacious areas. The percentage of respondents encouraged by each factor was 25.4%, 24.9%, 19.1%, and 18.0%, respectively. A chi-square test of independence was conducted to determine if the respondents' views on the factors that encourage them to relax in green spaces varied based on their demographic characteristics. It was found that age and gender significantly impacted on the respondents' views. For example, the respondents' views on safety and security were dependent on their age ($\chi 2$ (12, N= 350) = 28.552, $p < 0.05$) and gender ($\chi 2$ (3, N= 350) = 10.956, $p < 0.05$). Similarly, the respondents' views on sufficient facilities were dependent on their age ($\chi 2$ (12, N= 350) = 25.689, $p < 0.05$) and gender ($\chi 2$ (12, N= 350) = 16.18, $p < 0.05$). In contrast, their views on the existence of spacious areas were dependent on their age ($\chi 2$ (12, N= 350) = 23.724, $p < 0.05$) and gender ($\chi 2$ (3, N= 350) = 12.888, $p < 0.05$). However, the respondents' level of education and occupation did not have a significant impact on their views. It was also found that the respondents' views on cultural and historical facilities as an encouraging factor were dependent on their gender ($\chi 2$ (3, N= 350) = 15.283, $p < 0.05$), age ($\chi 2$ (12, N= 350) = 25.938, $p < 0.05$), occupation ($\chi 2$ (15, N= 350) = 27.08, $p < 0.05$), and level of education ($\chi 2$ (18, N= 350) = 45.541, $p < 0.05$).

**Table 27.** Order of factors and facilities encouraging users to relax

| Factors and facilities | Average Likert scale |
|---|---|
| Existence of fences | 3.04 |
| Safety and Security | 3.01 |
| Existence of spacious areas | 2.72 |
| Clean facilities | 2.69 |
| The good natural environment and dense vegetation | 2.67 |
| Sufficient facilities | 2.52 |
| Cultural and historical facilities | 2.46 |
| Others | 1.71 |

Based on the survey results, visitors to the park relax the most when they have access to certain facilities and factors. These include the presence of fences (60.6%), safety and security (58.0%), clean facilities (49.4%), and spacious areas (49.4%). Interestingly, the respondents' views on the importance of fences as a relaxing factor appeared to be independent of age, gender, occupation, and level of education, as shown by a chi-square test of independence. On the other hand, a significant percentage of respondents (ranging from 22.6% to 34.9%) disagreed with the idea that a good natural environment and dense vegetation, sufficient facilities, clean facilities, and spacious areas were present in the parks. Moreover, 20.3% and 18.0% of the total respondents were not encouraged by sufficient facilities and cultural and historical facilities in the parks, respectively.

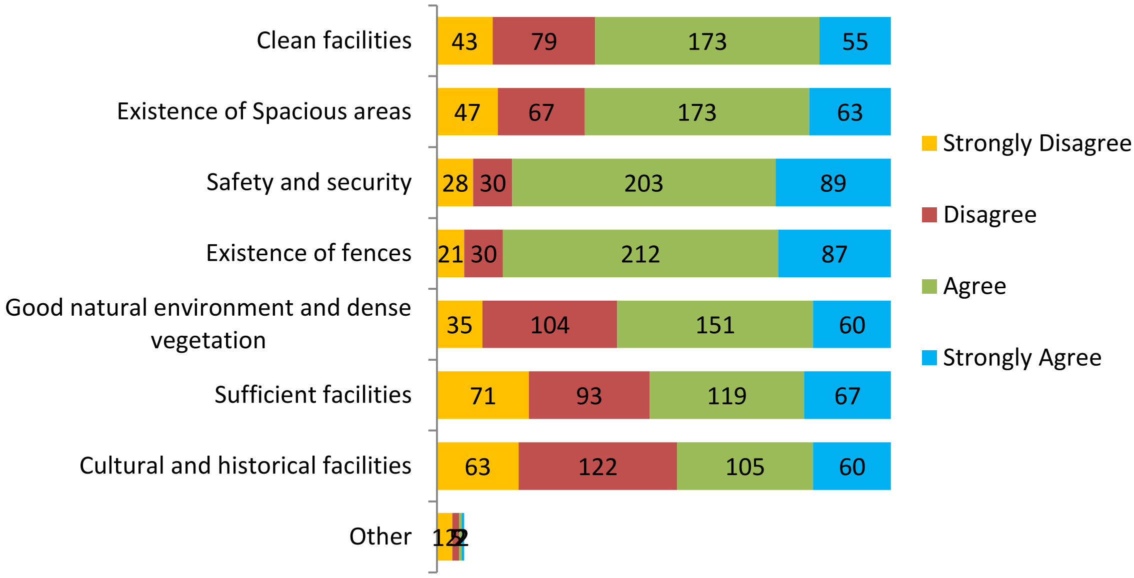



**Figure 22.** Respondents' frequency to the factors and facilities encouraging users to relax

### 4.4.4 Factors discouraging users to visit green spaces

According to a survey, out of 350 respondents, only 16 mentioned factors that discourage them from visiting green spaces. These factors include illegal activities in the park, chewing Khat (a stimulant leafy green plant mostly used in Northeast Africa), improper waste disposal, lack of promotion, and inaccessibility of green spaces, absence of water areas such as fountains and swimming pools, and absence of calm areas in the parks. These factors highly discourage people from visiting urban parks. Out of the 16 respondents who selected the "others (specify and rate it)" option, 37.5% of them mentioned alcoholic drinks, chewing Khat, and bedroom services (which promote prostitution) as highly discouraging factors to visit urban parks. These factors were ranked as the top discouraging factors in Table 28.

**Table 28.** Respondents' responses based on the order of factors discouraging users to visit

| Factors | Average Likert scale |
|---|---|
| 1. Others | 3.13 |
| 2. Lack of comfortable sitting areas | 3.09 |
| 3. Absence of safety and security | 3.07 |
| 4. Improper park management | 3.07 |
| 5. Absence of enough facilities for children | 3.00 |

| | |
|---|---|
| 6. Lack of green and dense vegetation | 2.98 |
| 7. Far from home | 2.97 |
| 8. Absence of historical and cultural facilities | 2.96 |
| 9. Inaccessible for transportation | 2.75 |
| 10. Absence of parking area | 2.69 |
| 11. Absence of large gathering spaces for families and other | 2.64 |
| 12. social activities like Idir, Ikub | |
| 13. Unaffordability of entrance fees | 2.49 |

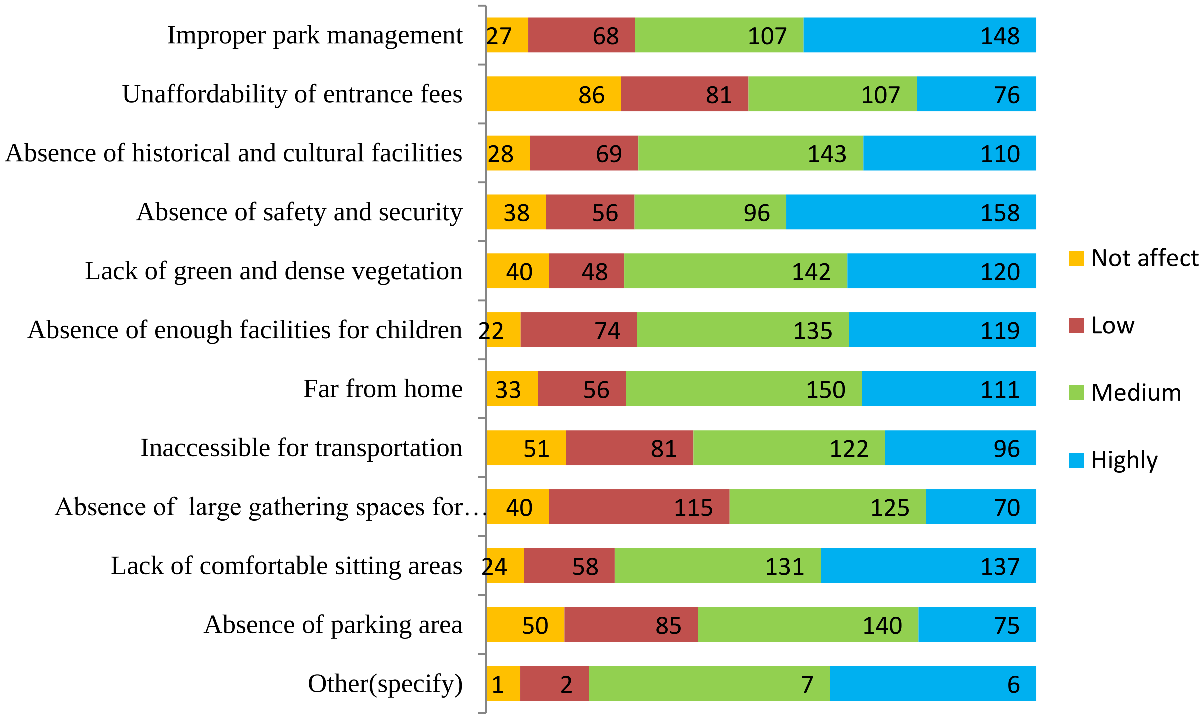



**Figure 23.** Respondents' frequency to the factors discouraging users to visit green spaces

According to Fig. 23, nearly half of the respondents, specifically 45.4%, 42.3%, and 39.1%, discouraged highly visiting parks due to the absence of safety and security measures, improper park management, and lack of comfortable seating areas, respectively. On the other hand, 42.9%, 40.9%, 40.6%, and 40.0% of the respondents were discouraged in a medium level from visiting parks far from home, absence of historical and cultural facilities, lack of green and dense vegetation, and absence of parking areas, respectively.

#### 4.4.5 Users' view on the intensity of disturbances in urban parks

Urban green spaces are popular places where people go to unwind with their friends, relax amidst nature, and meditate to alleviate their stress by escaping the hustle and bustle of the city. Thus, it is crucial to consider the users' perspectives on the types and levels of disturbances they experience. According to the survey results, the overall intensity of the disturbances caused by noise pollution from people and traffic, dust, bad smells, illegal activities, and others was rated as "Mild," with an average Likert score of "2.965." The respondents used a Likert scale to rate the intensity level, with "1" being the most intense (Severe), "2" being moderate, "3" being mild, and "4" being none. Based on this scale, the order of intensity levels as reported by the respondents were illegal activities (3.22), bad smell due to poor waste management (3.06), dust pollution (2.87), and noise pollution from people and traffic (2.73), as shown in Table 29.

**Table 29.** Respondents' responses to the intensity of disturbances in parks

| Disturbances | Average Likert Scale |
|---|---|
| 1. Illegal activities | 3.22 |
| 2. Bad smell due to poor waste management | 3.06 |
| 3. Dust pollution | 2.87 |
| 4. Noise pollution from people and traffic | 2.73 |
| 5. others | 2.50 |

#### 4.4.6 Users' preferences on the need for improvement and provision of facilities in the park

Based on the results of a questionnaire about the need for improvement and provision of facilities, respondents indicated that the most important facilities to be improved and provided were restrooms (71.1%), followed by fences and lighting (58.9%), and water and river access (51.4%). Cultural and historical facilities, play equipment, water, and river access were considered "important" by 43.4%, 37.0%, and 33.7% of respondents, respectively (as shown in Fig. 24). A chi-square test of independence was conducted to examine the relationship between age and views on the improvement and provision of facilities in the park. The test showed that respondents' views were dependent on their age, including "play equipment" ($\chi2$ (12, N= 350) = 25.177, p = 0.01), "restrooms" ($\chi2$ (12, N= 350) = 29.717, p = 0.01), "green spaces and plants" ($\chi2$ (12, N= 350) = 29.717, p < 0.01), "children's playground" ($\chi2$ (15, N =350) = 44.997, p =0.05), "parking" ($\chi2$ (12, N= 350) = 49.311, p < 0.01), and "picnic facilities" ($\chi2$ (12, N= 350) = 23.741, p=0.02). The respondents of all genders rated the need for improvement and provision of facilities as "very important" for "restrooms" and "fences and lighting" provisions in the urban parks ($\chi2$ = 41.417; df= 3; p < 0.01).

**Table 30.** Users' view on the need for improvement and provision of facilities in the park

| List of Facilities | Average Likert scores |
|---|---|
| Restrooms | 3.55 |
| Fences and lighting | 3.44 |
| Water and river access | 3.38 |
| Children playground | 3.35 |
| Green spaces and plants | 3.31 |
| Picnic Facilities | 3.29 |
| Play equipment | 3.28 |
| Cultural and historical structures | 3.27 |
| Trails and walkways | 3.25 |
| Parking area | 3.06 |
| Others | 2.98 |

The respondents were asked to rate the importance of various facilities on a scale of 1 to 4, with 1 being not important and 4 being very important. Based on their responses, the facilities were ranked using the Likert scale. Table 8 displays the mean scores for each facility in descending order. The facilities that received the lowest scores and thus require improvement are restrooms, fences and lighting, water and river access, and children's playgrounds. These facilities received an average Likert value of 3.55, 3.44, 3.38, and 3.35, respectively.

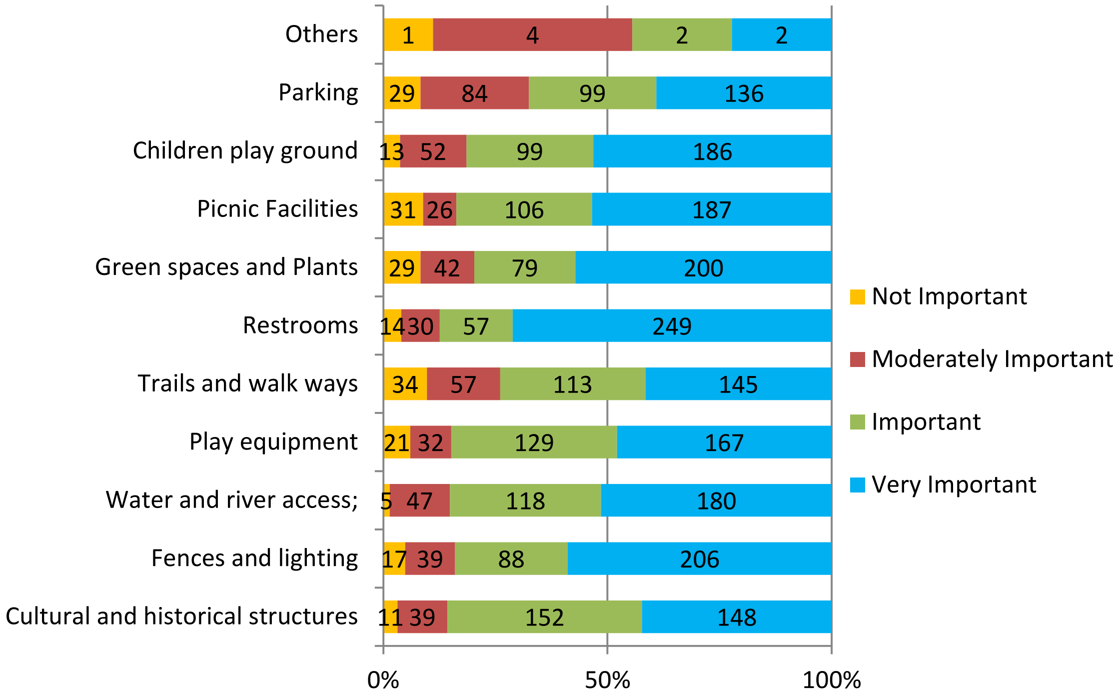



**Figure 24**. Frequency of users' views on the need for improvement and provision of facilities in the park

**4.4.7 Perceptions' of users to the benefits of urban green spaces**

According to the results, the majority of park users perceived three aspects of green spaces to be of "high" importance, namely recreational services (74.6%), aesthetics (70.3%), and protection against dust and other pollutants (62.3%). Meeting social activities like Idir and Ikub, cooling and sheltering, and protection against dust and other pollutants were considered "medium" benefits by 29.5%, 27.1%, and 24.6% of respondents, respectively. On the other hand, 24.5% and 24.1% of respondents perceived green spaces to have low benefits for provisioning services such as timber, fruits, and leaves and for meeting the purpose of social activities, respectively. Provisioning services, meeting the purpose of social activities like Idir and Ikub, and sources of medicine were recognized as "low" benefits of green spaces by 12.9%, 16.9%, and 13.0% of the respondents, respectively (Figure 25).

**Table 31. P**erceptions of users to the benefits of urban green spaces based on the order of rank

| Benefits | Average Likert scores |
|---|---|
| 1. Recreational services | 3.68 |
| 2. For aesthetics purposes | 3.57 |
| 3. Protection of dust and other pollutants from the households and manufacturing sectors | 3.49 |
| 4. For cooling purposes and sheltering | 3.44 |
| 5. Sources of medicine | 3.12 |
| 6. Provisioning services like timber, fruits, and leafs | 2.96 |
| 7. Meeting purpose for Idir, Ikub, and other social activities | 2.72 |

A statistical analysis was conducted to determine if there was any association between users' responses regarding the benefits of urban green spaces and their occupation, age, gender, and level of education. The results showed that respondents' views were significantly dependent on their occupation ($\chi2$ (95, N= 350) = 158.908, $p < 0.001$), age ($\chi2$ (76, N= 350) = 175.135, $p < 0.001$), gender ($\chi2$ (19, N =350) = 68.226, $p < 0.001$), and level of education ($\chi2$ (114, N= 350) = 240.798, $p < 0.001$). This means that respondents' views were influenced by their characteristics, but they had similar views across the board.

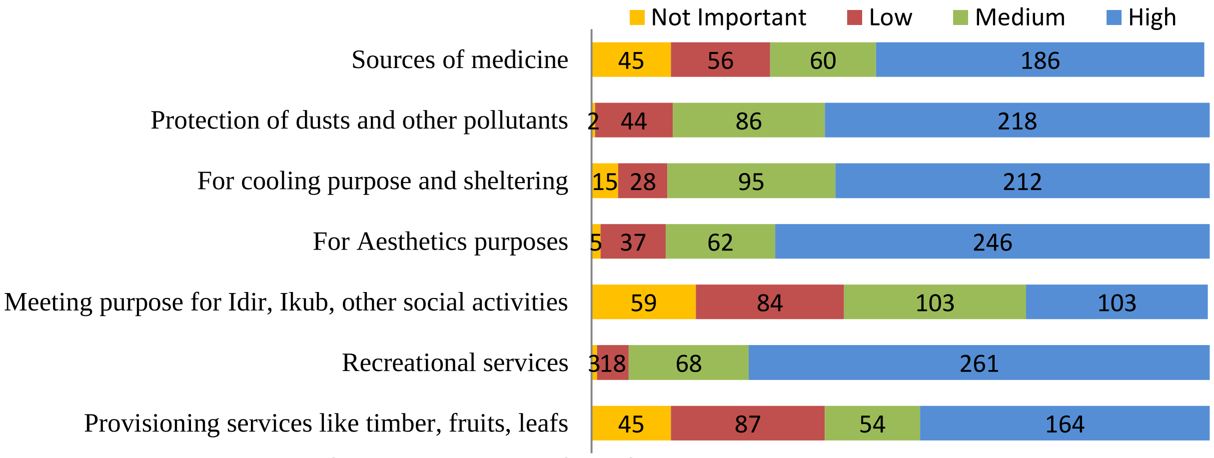



**Figure 25.** Perceptions of users to the benefits of urban green spaces

The findings suggest that residents view green spaces as providing various benefits, from recreational opportunities (with a mean score of 3.68) to provisioning services such as sources of medicine (with a mean score of 3.12). However, residents have a moderate perception of the provisioning of ecosystem services, such as timber, fruits, and leaves, as well as their ability to meet the needs of Idir, Ikub, and other social activities, with mean scores of 2.96 and 2.72, respectively (as shown in Table 31)

### 4.4.8 Roles of users in urban green spaces development

Urban residents can participate in various stages of green space development, from planning to post-implementation. According to Table 32, 8.6%, 8.6%, and 7.4% of the respondents always work as manpower during implementation, maintenance, rehabilitation, and selecting suitable sites. Out of all the respondents, 12.6%, 11.7%, and 7.4% often participate in maintenance and rehabilitation as working manpower during the implementation phase and in public hearings and meetings of the projects. A chi-square test of independence for the responses on the roles of users in green space development indicates that the views of respondents are dependent on their gender ($\chi2$ (6, N= 350) = 14.400, p = 0.02) and education level ($\chi2$ (24, N = 350) = 405, p = 0.02). However, respondents do not share similar views across their age level and occupations, as the p-value is greater than 0.05.

**Table 32**. Roles of users in green space development

| **Roles** | **Mean** |
|---|---|
| Others | 1.94 |
| Working man powers during the implementation phase | 1.77 |
| In maintenance and rehabilitation | 1.77 |
| Public hearings and meeting | 1.63 |
| Selection of the suitable sites | 1.56 |
| Financing of projects and maintenance | 1.55 |

The respondents' results showed that residents participated "sometimes" in all roles, with 5.4% mentioning participation in "other roles" (mean value of "1.94").

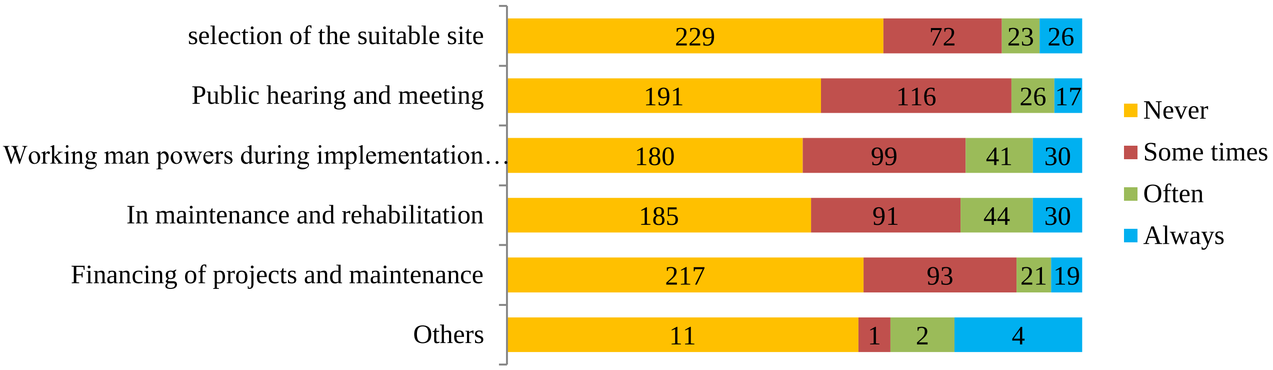



**Figure 26.** Roles of users in green spaces development and the frequency of participation

## 4.5 Urban green spaces quality from the perspective of users and experts

### 4.5.1 Urban park users' perception of urban green spaces quality

In general, green space users perceived the qualities of urban green spaces in both cities as "medium," with a mean value of each above "2.65" and an average value of "3.08" (Table 33). According to the responses of park users, the spatial quality attributes were rated "medium," ranging from the mean score of 3.19 to 3.41, and the non-spatial qualities were also rated "medium" ranging from the mean score of 2.65 (consideration of social and cultural issues of the residents to 3.31(attractiveness of the green spaces). On the other hand, dense vegetation, with a mean score of 3.41, ranked first with the label "good." On average, 8.43% and 27.3% of respondents rated the urban green space quality attributes as very poor and poor, respectively. Overall, 38.9%, 30.3%, and 30.1% of users rated inclusiveness, availability, and conservation of historical heritage and consideration of social and culture of the society of the green spaces poor with the mean score of 2.74, 2.88, and 2.83, respectively. Community participation, availability of conserved historical heritage, and consideration of social and cultural issues of the society were rated "very poor" by 20.1%, 11.1%, and 10.9% of respondents, with the mean score of 2.65, 2.88, and 2.83, respectively (Table 33).

**Table 33:** users' perception on the urban green space qualities (n=350)

| | Quality attributes | Very poor | Poor | Medium | Good | Very good | Mean | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| 1 | It has a dense vegetation cover | 4.3% | 18.6% | 31.5% | 23.2% | 22.3% | 3.41 | 1.15 |
| 2 | It is comfortable | 4.3% | 11.2% | 50.4% | 16.6% | 17.5% | 3.32 | 1.03 |
| 3 | It is attractive | 4.3% | 14.6% | 46.1% | 15.8% | 19.2% | 3.31 | 1.07 |
| 4 | It has inviting and functional shape | 6.0% | 13.1% | 43.7% | 19.1% | 18.0% | 3.3 | 1.09 |
| 5 | It is safe | 8.3% | 12.9% | 36.3% | 26.9% | 15.7% | 3.29 | 1.13 |
| 6 | It is easily accessible | 7.7% | 18.6% | 36.6% | 21.7% | 15.4% | 3.19 | 1.14 |
| 7 | It is maintained regularly | 7.0% | 24.6% | 37.1% | 17.7% | 13.6% | 3.06 | 1.12 |
| 8 | It is a convenient size | 8.9% | 22.9% | 42.9% | 12.6% | 12.9% | 2.98 | 1.11 |
| 9 | Presence and conservation of historical heritage | 11.1% | 30.3% | 31.7% | 13.4% | 13.4% | 2.88 | 1.19 |
| 10 | Consideration of social and cultural issues of the residents | 10.9% | 30.1% | 35.2% | 12.6% | 11.2% | 2.83 | 1.13 |
| 11 | It is inclusive for all | 8.3% | 38.9% | 30.3% | 15.7% | 6.9% | 2.74 | 1.04 |
| 12 | There is community participation in the development | 20.1% | 24.9% | 34.1% | 12.0% | 8.9% | 2.65 | 1.19 |
| | average | 8.43% | 27.3% | 38.5% | 17.27% | 14.58% | 3.08 | 1.12 |

*** Interpretation of mean score:** <1.80 = very poor, 1.81–2.60 = poor, 2.61–3.40 = medium, <3.41- 4.20 = good, 4.21 – 5.00 = very good.

The three highest "very good" rated green space quality attributes were dense vegetation cover, comfort ability, and attractiveness, with a mean score of 3.41, 3.32, and 3.31(scored by 22.3%, 17.5%, and 19.2% of respondents, respectively). Generally, all attributes were rated “medium” with an average mean score of 3.08. However, based on the experts' interview analysis results, the existing quality of urban green spaces was perceived as "poor (below standards) by the majority of the experts."

#### 4.5.2 Users' view on major determinants of sustainable urban green spaces

42.7% and 16.35% of the users scored "disagree" and "strongly disagree "on the status of determinants of sustainable urban green spaces, with a mean score value of 2.36 and a mean standard deviation of 0.883. In line with this, the quality, accessibility, fair and even distribution, and adequacy of urban green spaces were in the order of disagreement based on the mean score value from 2.49 to 2.26 (Table 6). Half the users and 15.4% scored “disagree” and “strongly disagree” on the equity of urban green spaces, respectively. 41.1% and 22.6% of users rated “disagree” and “strongly disagree” on the adequacy of urban green spaces and recreational areas.

**Table 34:** Users' view on major determinants of sustainable urban green spaces (n=350)

| **Determinants of sustainable UGSs** | **Strongly Disagree** | **Disagree** | **Agree** | **Strongly Agree** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|
| The quality of urban green spaces is good | 14.0% | 39.1% | 30.6% | 16.3% | 2.49 | .926 |
| Urban green spaces are accessible | 13.4% | 40.9% | 37.1% | 8.6% | 2.41 | .827 |
| UGSs are distributed fairly and evenly | 15.4% | 49.7% | 26.0% | 8.9% | 2.28 | .831 |
| UGS and recreational areas are | 22.6% | 41.1% | 23.7% | 12.6% | 2.26 | .948 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| adequate | | | | | | | |
| | **average** | 16.35% | 42.7% | 29.35 % | 11.6% | 2.36 | 0.883 |

*** Interpretation of mean score:** <1.80 = Strongly Disagree, 1.81–2.60 = Disagree, 2.61–3.40 = Agree, <3.41- 5.00 = Strongly Agree

### 4.5.3 Users' satisfaction with the urban green space quality

49.1% and 12.6% of the respondents were "slightly satisfied" and "not satisfied," with the quality of urban green spaces in both cities (Fig. 27). Only 15.4% of the respondents were very satisfied, and 22.9% were satisfied. The mean score of respondents was "2.41" with Std. Deviation of 0.897 that lay in the rate of slightly satisfied considering the interpretation of mean score: <1.80 = not at all satisfied, 1.81–2.60 = slightly satisfied, 2.61–3.40 = Satisfied, <3.41- 5.00 = very satisfied.

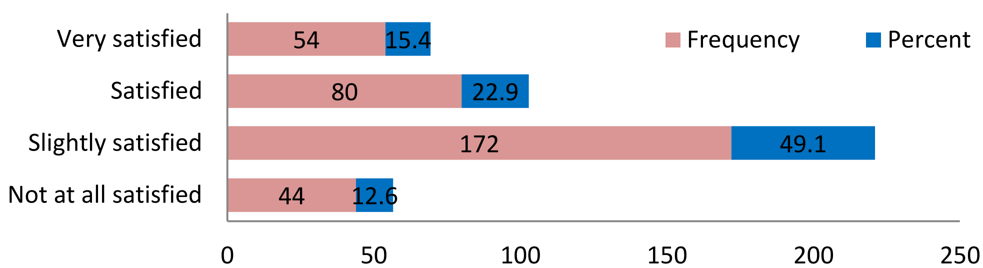



**Fig. 27:** frequency on respondents satisfaction on the urban green space quality

### 4.5.4 Association of users' characteristics with the perceived qualities and satisfaction

The association of the socio-demographic characteristics (gender, age, level of education, and occupation) with the perceived quality of spatial and non-spatial attributes and the users' satisfaction were assessed accordingly. To this end, the Chi-square tests of independence results are presented in Table 35. The results show no statistically significant association ($p > 0.05$) between respondents' education level and perceived spatial qualities of urban green spaces. In contrast, gender, age, and occupation statistically correlate significantly with spatial attributes ($P < 0.01$). Similarly, a statistically significant association ($p = 0.002$) exists between respondents' gender and perceived non-spatial qualities. On the other hand, age, level of education, and occupation of respondents have no statistically significant association with non-spatial quality attributes ($P > 0.05$), i.e., the quality of non-spatial attributes are not equally perceived or have no similar views across all age groups, all education level, and all occupation categories.

**Table 35:** Chi-square tests of the respondents' characteristics and the perceived quality attributes of green spaces and users' satisfaction

| | **Spatial attributes** | | **Non-spatial attributes** | | **All attributes** | | **Satisfaction level** | |
|---|---|---|---|---|---|---|---|---|
| | $X^2$ | *P* value | $X^2$ | *P* value | $X^2$ | *P* value | $X^2$ | *P* value |
| Gender | 17.702 | 0.001 | 16.982 | 0.002 | 68.433 | 0.000 | 4.037 | 0.257 |
| Age | 24.416 | 0.048 | 12.129 | 0.735 | 212.812 | 0.000 | 33.054 | 0.001 |
| Education | 33.169 | 0.101 | 24.865 | 0.413 | 293.396 | 0.000 | 46.526 | 0.000 |
| Occupation | 51.066 | 0.000 | 22.169 | 0.331 | 224.463 | 0.001 | 15.435 | 0.421 |

A significant statistical association ($P < 0.01$) exists between respondents' age and education level and users' satisfaction with the quality of urban green spaces. It means there is a difference in views of satisfaction across the age and education level of respondents. On the other hand, the gender and occupation of the respondents have no significant statistical association ($P > 0.05$). It implies that the views of respondents to satisfaction with the quality of urban green spaces are similar across all occupation categories and in both genders. Generally, there is a statistically significant association ($p < 0.01$) between the respondents' age, gender, education level, and occupation and the total perceived quality of urban green spaces attributes.

## 4.6 Experts view on applicability and practicality of green space planning models

### 4.6.1 Experts' view on existing situations of urban green spaces values

Experts rated the existing situations of urban green spaces in Debre Berhan and Debre Markos cities based on the major determinants of the sustainability of green spaces in urban areas. Based on the analysis, all determinants, quality, quantity, and accessibility of green spaces were rated below standards with a mean value of 1.72, 1.92, and 2.04, respectively (Table 8). 88% of the experts confirmed that the quality of green spaces was "below standards."

**Table 36:** Experts' view on existing situations of urban green spaces values

| | far below standards | below standards | meets standards | above standards | no idea | Mean | Std. Deviation |
|---|---|---|---|---|---|---|---|
| Accessibility | 32.0% | 40.0% | 24.0% | 0.0% | 4.0% | 2.04 | .978 |
| Quantity | 36.0% | 36.0% | 28.0% | 0.0% | 0.0% | 1.92 | .812 |
| Quality | 40.0% | 48.0% | 12.0% | 0.0% | 0.0% | 1.72 | .678 |
| Average | 36% | 41.33% | 21.33% | 0.0% | 0.13% | 1.89 | .822 |

*** Interpretation of mean score:** <1.80 = far below standards, 1.81–2.60 = below standards, 2.61–3.40 = meets standards, <3.41- 5.00 = above standards

### 4.6.2 Challenges perceived by experts for the development of quality urban green spaces

**Table 37:** Percentage of experts' responses to the challenges for development of quality urban green spaces

| | **None** | **Low** | **Medium** | **High** | **Very high** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|
| Financial problem | 4.0% | 16.0% | 16.0% | 28.0% | 36.0% | 3.76 | 1.234 |
| Land-use change | 8.0% | 20.0% | 40.0% | 8.0% | 24.0% | 3.20 | 1.258 |
| Lack of maintenance and monitoring | 4.0% | 24.0% | 36.0% | 24.0% | 12.0% | 3.16 | 1.068 |
| Lack of coordination | 12.0% | 20.0% | 32.0% | 20.0% | 16.0% | 3.08 | 1.256 |
| Poor green space planning | 16.0% | 16.0% | 44.0% | 12.0% | 12.0% | 2.88 | 1.201 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Poor implementation strategies | 16.0% | 32.0% | 20.0% | 20.0% | 12.0% | 2.80 | 1.291 |
| Others(specify) and rate- | 0.0% | 4.0% | 4.0% | 0.0% | 0.0% | 2.50 | .707 |
| Average | 8.6% | 18.9% | 27.4% | 16.0% | 16.0% | 3.05 | 1.14 |

*** Interpretation of mean score:** <1.80 = none, 1.81–2.60 = low, 2.61–3.40 = medium, <3.41- 4.20 = high, 4.21 – 5.00 = very high.

All experts mentioned that ownership disputes of urban green spaces were critical in the development process, especially between the urban land development office, the urban plan preparation office, and the city's sanitation, beautification, and park development office. This was due to weak collaboration and integration of offices, as stated by the experts. Even though organizations have participatory and collaborative planning approaches, most (60%) of the experts scored as there was 'weak collaboration' in the development process of urban green spaces. The financial problem, land use change, lack of maintenance and monitoring, and lack of coordination were rated as the challenges and constraints for sustainable quality urban green space development with the mean score of 3.76, 3.20, 3.16, and 3.08 (Table 37).

**Table 38:** Experts' view on the management performances and related issues of urban green spaces

| **Performances** | **far below standards** | **below standards** | **meets standards** | **above standards** | **not our responsibility** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|
| **Timely maintenance** | 12.0% | 52.0% | 16.0% | 0.0% | 20.0% | 2.64 | 1.319 |
| **Follow-up and monitoring** | 20.0% | 24.0% | 32.0% | 8.0% | 16.0% | 2.76 | 1.332 |
| **Average** | 16.0% | 38% | 24% | 4.0% | 18% | 2.7 | 1.32 |
| | never | rarely | sometimes | often | always | | |
| **Ownership dis-** | 20.0% | 20.0% | 32.0% | 16.0% | 12.0% | 2.80 | 1.291 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **putes** | | | | | | | |
| **Collaboration** | 4.0% | 24.0% | 32.0% | 32.0% | 8.0% | 3.16 | 1.028 |

Experts mentioned lack of maintenance and monitoring as a high challenge for the development of quality green spaces; the performances of their organization on maintenance, monitoring, and follow-up were below standards, as it was reported by the majority (54%) of the experts. 80% of the interviewed experts confirmed that ownership of urban green spaces was an issue and occurred ranging from 'rarely' to 'always' observed by 20% and 12% of the experts, respectively (Table 38). Lack of coordination and collaboration was also mentioned as a challenge for the sustainable development of quality urban green spaces; only 8% of the experts mentioned that collaboration was 'always' between different organizations and stakeholders.4.6.3 Experts' awareness of green space planning approaches and models

For extensive analysis, five key experts working in the spatial plan preparation department were interviewed intensively about their focus on green space values and their awareness and experience with green space planning approaches and models listed in Table 1. They stated that they focus more on the quantity and accessibility of green space by using a demand green space planning approach. They were also asked about their awareness of different green space planning models; only one expert was slightly aware or familiar with each green space planning model, and four experts were unaware at all (Fig. 28). According to the majority of the expert's Space standards - a quantitative model was commonly practiced in planning and designing of urban green spaces, while park system model, garden city-a comprehensive planning model, shape-related models, and ecological determinism were never practiced in both cities (Fig.29). Space standards - a quantitative model were the most familiar than others. The park system model, ecological determinism, shape-related models, and garden city –comprehensive planning were not familiar to most of the experts.

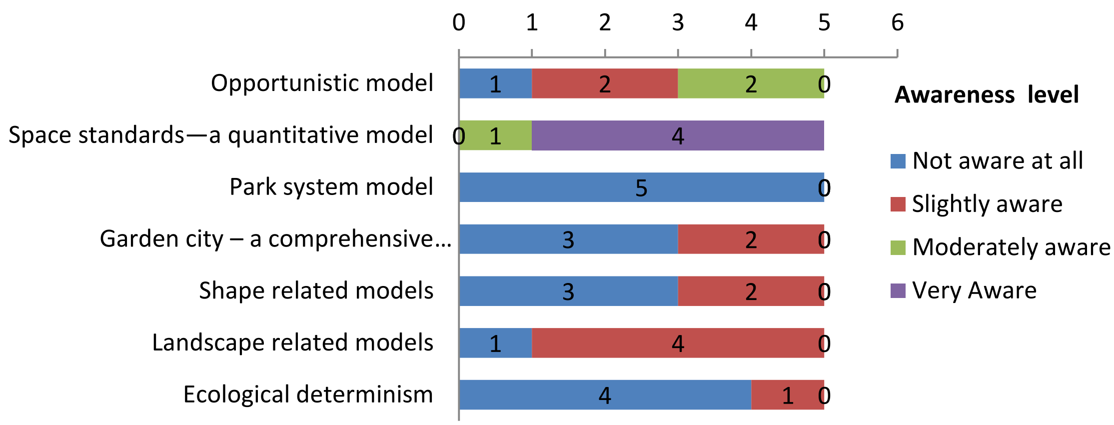



**Fig. 28:** Frequency of experts to the familiarity of urban green space planning models

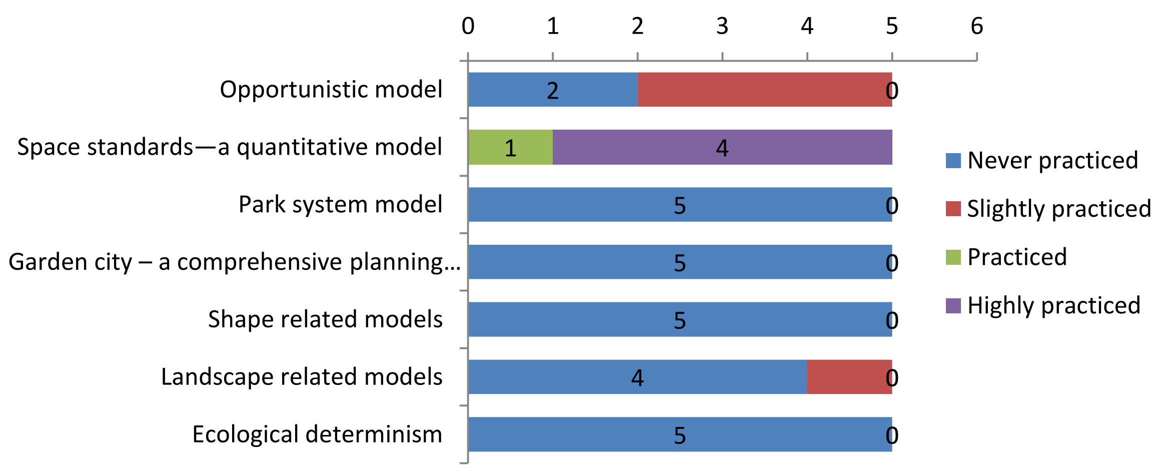



**Fig. 29:** Experts' experience to the application of urban green space planning models

# Chapter five: Discussion

This chapter is focused on interpreting the research findings and results. It compares and contrasts the results with previous studies in the literature review chapter. This chapter aims to discuss the outcomes and findings of the research. The candidate summarizes and interprets the main findings as a key component of the discussion section, maintaining the analytical and contextual coherence and integration of the key findings. They also substantiate the key findings with the literature review, identify the specific contribution of the dissertation to the existing empirical and theoretical knowledge base within the domain of the research topic, discuss the implications of the research to education, research, policy, and practice, indicate the limitations of the study, including suggestions for future research, and provide conclusions and recommendations based on the results/findings.

## 5.1 Spatial coverage of urban green spaces in DB and DM Cities

A report published in 2018 by the World Health Organization provides specific recommendations on the provision of urban green spaces, including a minimum of nine square meters of green space per person in urban areas and ensuring that green space is distributed equitably across the metropolitan area, with a focus on areas with limited access to green space. Maintaining and improving the quality of existing green spaces through routine maintenance and enhanced management practices and encouraging citizen engagement in the design and management of green spaces to meet local needs is also important.

Monitoring and managing natural resources, including the LULC change, is important for sustainable urban development (Mahmoodzadeh, 2001). In this regard, NDVI offers a critical input for the cover change analysis, especially for green spaces/vegetation, by differentiating the shrubs, dense vegetation, urban forests mixed, and grasslands (Wang et al., 2020; Singh et al., 2016). Seboka (2016) confirmed no significant negative correlation between NDVI and rainfall in Ethiopia. Kourouma et al. (2021) put drought classification schemes using drought indices of NDVI extreme drought (<0.1), severe drought (<0.2), moderate drought (<0.3), mild drought (<0.4), and no drought (>0.4). The big order NDVI values of Debre Berhan were 0.66, 0.58, and 0.43 in 2000, 2010, and 2020 respectively. All high NDVI values were greater than 0.4, with this scheme showing that the city has not been in a drought. 0.7, 0.56, and 0.42 were the highest NDVI values recorded at Debre Markos in 2000, 2010, and 2020 respectively. Debre Markos had shown the highest value in 2000 even if most of the study area had low values. This highest record occurred due to the Yeraba urban forest (highly dense) located in the southeastern part of the city before encroachment. It has also been observed that 0.66 and 0.58 were the highest NDVI values recorded in 2000 and 2010 in Debre Berhan City, with less spatial coverage, while most of the area was covered with low NDVI values. This dense vegetation with less spatial coverage was urban forests in mountainous areas along the Debre Berhan-Addis Ababa road. The overall change over the study period from 2000 - 2020 showed a declining trend for both Cities, the changing condition was very similar. This implies that there was rapid urbanization and degradation of green spaces as the construction space (urbanization and expansion) and the green space are mutually complementary, as Zhao et al.(2022) discussed.

NDVI values have been classified into four classes. In vegetation cover analysis, Akbar et al. (2019) used the NDVI-based classification method for its simplicity which incorporates water bodies (-0.28-0.015), built-up areas (0.015-0.14), barren (0.14-0.18), shrub and grassland (0.18-0.27), sparse vegetation (0.27-0.36), and dense vegetation (0.36-0.74). The results of this study

‘NDVI classification’ of both cities were fitted with (Akbar et al., 2019) classification. For example, as shown in Tables 3 and 4, barren and cropland lay in NDVI ranges of 0.12 – 0.18 and 0.15 – 0.24 in Debre Berhan and Debre Markos Cities, respectively. In the same way, sparse vegetation was in ranges of 0.18 – 0.27 and 0.24 – 0.33 in Debre Berhan and Debre Markos respectively. On the other way, Alex et al. (2017) used three classifications ranging from ‘-1 to 0’ (non-vegetation), ‘0-0.2’ (less vegetation), and > 0.2 (high vegetation). In this regard, approximately 64.7%, 60.7%, and 88.3% of Debre Berhan city in 2000, 2010, and 2020 accounted for NDVI values greater than zero, indicating the sparse and dense vegetation, including the shrubs and grasslands. In Debre Markos city, 60.6%, 63%, and 80.4% of NDVI values in 2000, 2010, and 2020 respectively, were greater than zero, indicating the presence of sparse and dense vegetation, including shrubs and grasslands. The results of this study indicated that green spaces, encompassing both sparse and dense vegetation, represented 23.5%, 20.7%, and 42.5% of the area in Debre Berhan for the years 2000, 2010, and 2020, respectively. In comparison, green spaces accounted for 35.5%, 36.6%, and 47% in Debre Markos during the same years. It is more aligned with the Akbar et al.(2019) classification than Alex et al. (2017) since other studies including Al-doski (2013) confirmed that vegetated areas have stronger near-infrared reflectance with NDVI values ranging between 0.2 and 1.

On the other hand, Taufik et al.(2016) also classified Landsat 8 satellite image ‘NDVI values’ into three classes’ ‘water’ less than 0.1(very low), ‘non-vegetation’ from 0.2 to 0.5 (moderate), and ‘vegetation’ from 0.6 to 0.9. However the results of NDVI values of Landsat 8 classifications of Debre Berhan and Debre Markos in 2020 have shown sparse and dense vegetation in NDVI ranges of 0.16 – 0.43 and 0.18 – 0.42, respectively. According to Taufik et al. (2016) classification, 0.16 -.43 and 0.18 – 0.42 would be laid in the ‘non-vegetation’ category; however, the results of this study were crosschecked with existing land use, Google Earth, and existing spatial-related plans for being they were vegetated. Ethiopia is located in the tropical Sahel and semiarid grassland with an annual NDVI of 0.29 (Zhang, 2016), which might be the factor of disagreement with the classification of others. This shows that the implications of any classification of NDVI values to the land use cover are determined by climate variability, Landsat image resolution, the theme of study and area, and the city's grain.

## 5.2 Green space covers change

Several studies related to Land use and land cover change in Ethiopia at different spatial scales ranging from regional to district scale confirmed the rapid urbanization impacts on the natural environment (Tewabe & Fentahun, 2020; Woldesemayat & Genovese, 2021a; Woldesemayat & Genovese, 2021b; Gebreyesus et al., 2022). For instance, Wondyfraw et al.(2019) and Assefa et al.(2021)noted that the urban expansion of Bahir Dar City had brought ecological, socioeconomic, and environmental impacts. For this, Kindu et al.(2020)suggested investigating detailed drivers, consequences of changes, and future options for integrated planning and management of urban green spaces to address the challenges of rapid urbanization. The rate of urbanization was high after 2010 outwards from the urban core in Debre Markos and scattered linearly in Debre Berhan due to rapid urbanization at the time. The factors of such rapid changes were the economic development of both cities with major industrial power plants that need wide areas, for example the industrial park of Debre Berhan, which took 1100 ha of land. Beyond this, rural-to-urban migration, natural population increase, and urban planning policies like compact development approach (Russo, 2018) are also the main drivers. The other driver is the housing provision policy of Ethiopia which gives a small plot of land individually (72 $m^2$, 94m$^2$, 105 m$^2$, 150m$^2$, etc.) engulfs agricultural lands and green spaces haphazardly. Those houses could be constructed with a small area of land using a vertical development approach instead of giving them individually; therefore, Ethiopia's horizontal urban development approach and the small parcel housing provision policy aggravate the green space degradations in urban areas. The green spaces had increased by 37.4% in 2020 from the initial study year and spatial coverage of green spaces became 19.1% in Debre Berhan. While it had decreased in Debre Markos by 41 % in 2020 from the initial study year and, the spatial coverage became 22.8 %. Still, the spatial share of green spaces in both cities has not satisfactorily the urban planning preparation and implementation strategy of Ethiopia (2014) allocated 30% of the land for roads and infrastructure, 30% for green areas, and 40% for shared public use. The development trends showed a signal for its reduction (Figure 30).

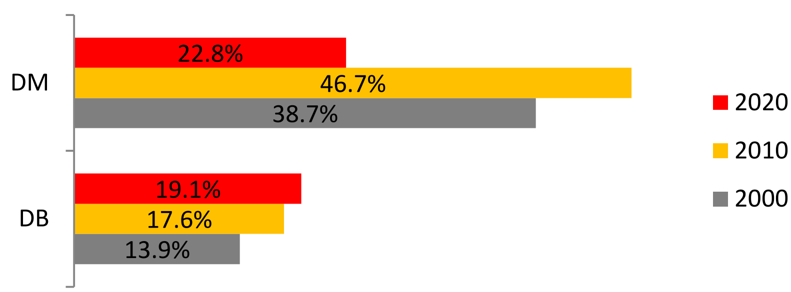



**Figure. 30:** Green spaces cover change over a period of 2000 to 2020

Significant LULC changes occurred between 2000 to 2020 in those areas bounded by red color (Fig. 31). Both cities converted a large area of green space covers to built-up areas. Barren and croplands converted drastically to built-up after 2010 following the industrialization and the establishment of Debre Berhan University in 2007. The letter ‘A’ shown in the map is Debre Berhan University, which is one of the 2$^{nd}$ generation universities in Ethiopia. Land ‘B’ and ‘C’ were the urban green spaces and croplands, respectively, in 2000 and have now changed to condominium housing and villa houses. Those areas indicated in ‘D’ and ‘E’ are manufacturing zones established after 2010, which engulfed large areas of croplands.

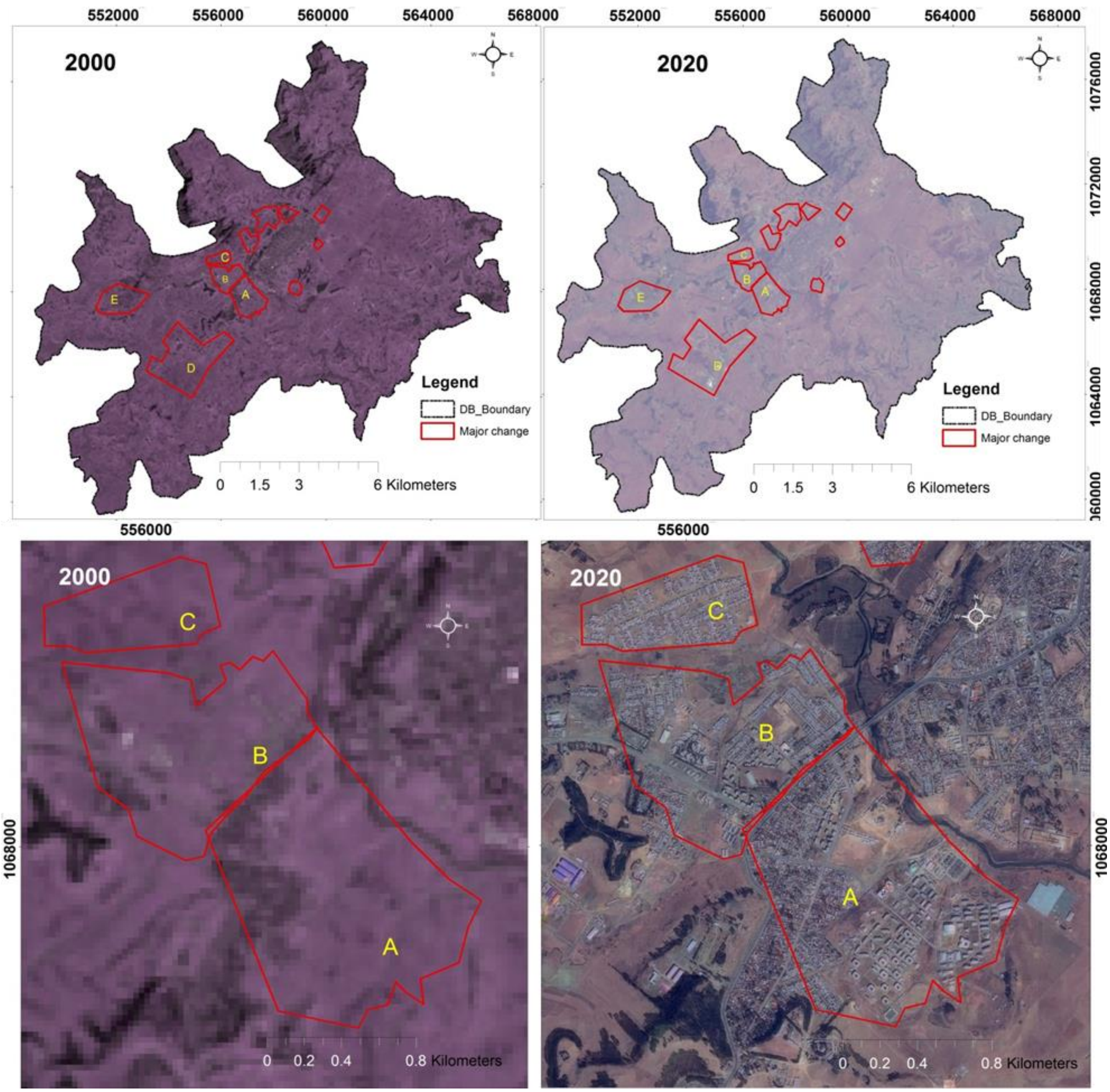



**Fig.31:** Location of significant LULC changes occurred in Debre Berhan City from 2000 to 2020

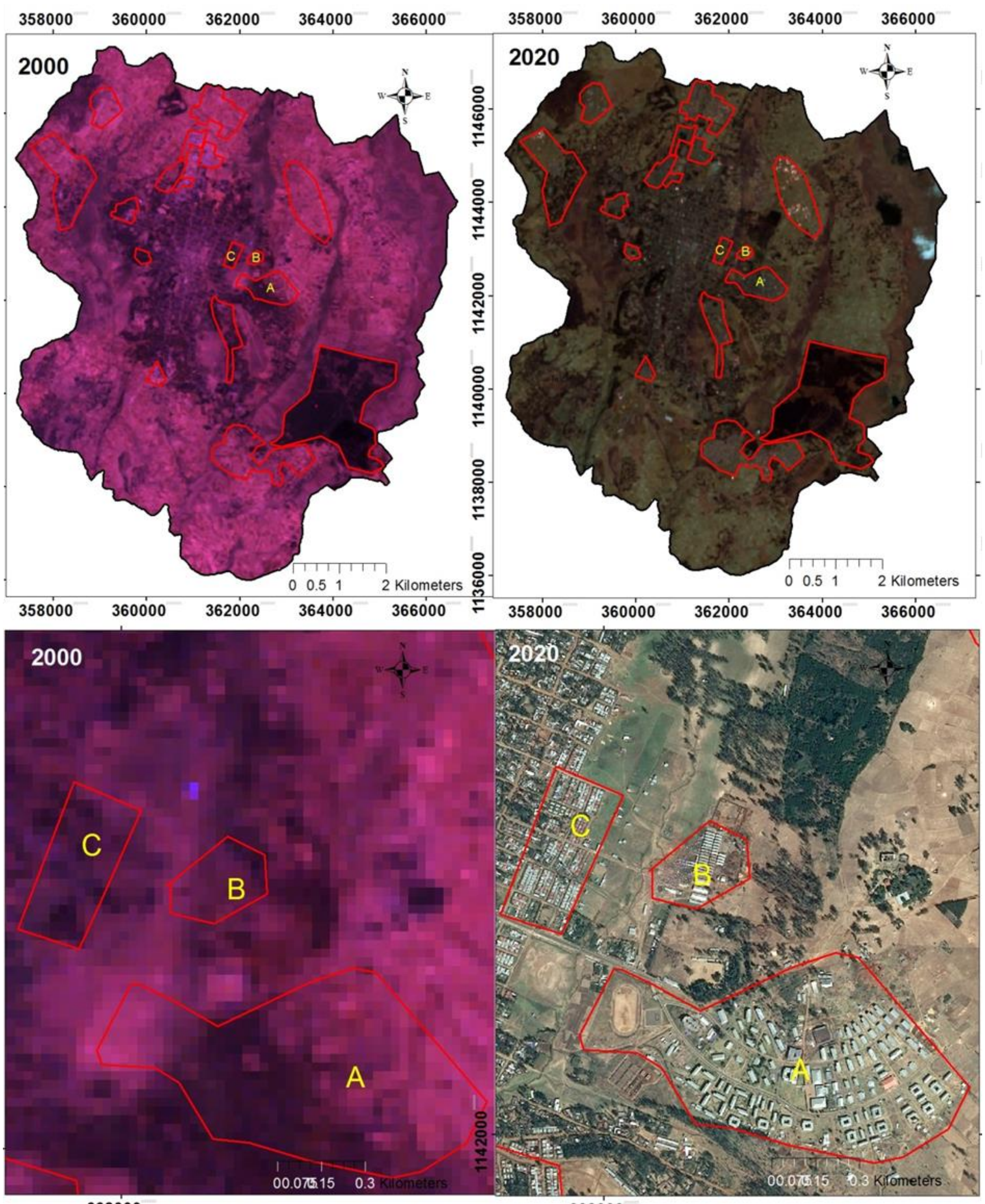



**Figure. 32:** Significant LULC changes in Debre Markos City from 2000 to 2020

Similarly, in Debre Markos City, croplands were converted to built-up areas rapidly in 2010 following the establishment of Debre Markos University (DMU) in 2005 indicated in the letter

‘A’ in the map (Fig. 32). The LULC of DMU was originally croplands. Those areas indicated in ‘B’ and ‘C’ are city-level market and villa houses, respectively, originally urban green spaces used as public spaces and cultural ceremonies like Christmas and Epiphany.

### 5.2.1 LULCC and spatial structure of Cities

The results show that green spaces have been degraded in Debre Markos while increasing at Debre Berhan between 2000 to 2020. Such trends of green space degradation were also reported by some other previous studies, such as Mikias et al.(2018) for Wolitya Sodo Town; Mohamed & Worku (2019) for Addis Ababa; and Kindu et al.(2020) for Bahir Dar and Hawassa city. It was also reported for other cities of the world as Aguayo et al.(2007) for Chile, Subasinghe et al.(2016) in Srilanka, and Alex et al. (2017) for Banglore had reported a reduction in urban green space cover. LULC change studies in Ethiopia revealed that rapid urbanization and uncontrolled urban expansion are the main causes of land use and land cover change (Mohamed & Worku, 2020; Mohamed & Worku, 2019; Fetene et al., 2016; Mikias et al., 2018). Thus, urbanization and population growth were discussed as the factors of this green space cover change; however, the structure of the city and its planning also contribute. For example, Nor et al.(2017) have modeled and predicted urban expansion in three cities in Jakarta, Kuala Lumpur, and Metro Manila to identify the main drivers resulting in spatial patterns, including spatial planning. They discussed previous master planning mistakes and uncontrolled planning policies' influence on rapid urban expansion and green space degradation in their study about the impact of rapid urban expansion on green space structure. The areas of barren land and croplands have decreased, while built-up areas have increased, leading to a reduction in green spaces. Similar to the findings of the land use and land cover change of Debre Markos, Aguayo et al.(2007) found that mostly barren and croplands decreased when built-up increased in Hawasa. Similar results were observed in

Debre Berhan, where built-up areas increased, barren land and croplands decreased, and green space cover expanded. In Debre Berhan in 2000, the built-up cover was less and scattered with major route lines. Barren and Croplands were mostly around the city edge, whereas substantial green spaces have been away from the city's core as shown in the NDVI classification map and LULC map. Its location has allowed the green spaces not to been encroached even if less development also happened away from the urban core.

In 2020, barren and croplands and green spaces were converted into built-up. In a similar study, Ermias (2017) found that only built-up areas increased while others, including vegetation cover, decreased from 1995 to 2015. However, this study shows that green spaces increased from 2000 to 2020 in Debre Berhan. In Debre Markos city, most green spaces were located between the built-up and croplands and/or barren, as shown in the NDVI classification map and LULC map in which it was exposed for instantaneous encroachment. According to Debre Markos structural plan report 2018, the municipality has practiced urban expansion planning intensively from the city's core to the outskirts of the city through infilling and compacting approaches, which imposed pressures on the surrounding green spaces and croplands. In contrast, Temesgen (2019) discussed that the fragmented and dispersed development pattern of Debre Markos City was the cause of the green space degradation. However, the high green space cover degradation that occurred in Debre Mrkos City were due to the city's compact structure that aggravated engulfing of green spaces concentrated in the near distance. It has not been developed by flinging those landscapes that must be jumped for sustainable development. Khanal et al.(2019) reported similar problems in rapidly urbanized cities and suggested sustainable management of cities through ecosystem-based adaptation systems. Such intensive degradation of green spaces in a particular area brings urban heat island effects and climate change unless this rapid urbanization is tackled with proper planning.

## 5.2 Urban green space accessibility and connectivity

### 5.3.1 Users' distance from the nearest park

According to regulations in Ethiopia, every person should have access to a public green space that is at least 0.3 hectares in size and located within 500 meters of their home (MUDHo,2015). However, a survey found that only 18% of respondents had a park within that distance. Similarly, in Birmingham, it is recommended that cities have natural green spaces within 300 meters (in a straight line) of homes, but many people do not meet this standard (Moughtin & Shirley, 2005b). World Health Organization also suggests one accessible green space within 300m. Despite the nearest distance of the park is outside the recommended distance, the study found that users often come to parks on their feet. It shows that people in the study area have a culture of walking. This can have a positive impact on the environment and encourage physical activity.

### 5.3.2 Users' time taken to reach the nearest park on foot

Only 27% reach their destination in less than 15 minutes, while most take more than 15 minutes to reach the nearest green space. The time it takes for a user to reach the nearest park on foot can have different implications depending on the situation. If it takes a long time, users might be less likely to engage in physical activities such as walking or jogging, which can negatively affect their health, as discussed in Xingyou Zhang et al.(2011). If there is a significant distance to the nearest park, users may have less access to these activities, which could negatively impact their mental health and overall happiness. However, green space accessibility is low in the study areas as it has also been studied by Azagew & Worku (2020b) in Addis Ababa. Having easier access to parks can encourage people to walk or bike, positively impacting the environment. Promoting walking or biking instead of driving can also help reduce carbon emissions and promote sustainability. The study revealed no significant association ($p > 0.05$) between the age and gender of users and the time taken to reach the nearest park.

### 5.3.3 Urban green space connectivity and distribution

Landscape connectivity refers to the ability of species to move and thrive within a landscape and the extent to which landscape elements inhibit their movement (Liu et al., 2022). Urban green connectivity refers to the network of green spaces and natural areas within an urban environment connected through corridors or pathways. These green spaces can include parks, gardens, green roofs, and other natural areas, providing numerous benefits, such as improving air quality, reducing heat island effects, and promoting biodiversity. Urban green spaces in the central metropolitan area are an important storage resource, but their connectivity is relatively poor and does not transition well with other urban spaces in China (Zhou et al., 2023). Similarly, in the study areas, the green spaces are fragmented and less connected over the study periods. Woldesemayat & Genovese (2021b) confirmed this in their research about urban green space composition and configuration in Addis Ababa. There was an uneven distribution and inequity of green spaces throughout the urban environment, as found in a study by Anteneh et al. (2023), who researched the Geospatial assessment of urban green space in Debre Markos City. This is important to ensure that all residents have equal access to the benefits of green spaces, regardless of where they live within the city.

## 5.4 users' preferences and perceptions towards urban green spaces

### 5.4.1 Frequency of park visits

Based on the data analysis, only 7.2% of park users were over 50 years old, which is significantly low for the older population in Ethiopia. Additionally, the percentage of users who visit parks "very often" decreases as the users' age increases. Ethiopia is a rapidly growing country, and the number of senior citizens will increase by 2032, with a rise in life expectancy from 59.5 years in 2012 to 67.9 years in 2032 (Bekele & Lakew, 2019). Only 37.2% of park visitors were female, lower than the expected sex ratio of 50% for Ethiopia, 51% for Debre Berhan City (Amdetsion, 2017), and 52% in Debre Markos City (Mullu, 2015). It has been observed that older people and females visit parks less often in rapidly urbanized cities, particularly in the study areas. This highlights the need to reconsider the design and facilities of green spaces, focusing on including various programs and amenities that encourage elders and females to visit urban parks and green spaces.

Less respondents visited parks more than eight times per month, which is less frequent than Hangzhou, China , where park visits occurred 1-3 times per month (Zhan et al., 2021) and in Kuala Lumpur, Malaysia which was in a weekly basis (Sreetheran, 2017). According to Gashu et al.(2020), only 1.4% of residents in Bahir Dar and Hawassa cities, Ethiopia, used urban green infrastructure monthly. Similarly, in Debre Berhan and Debre Markos Cities, most respondents reported that they were not frequent park visitors. The study found that only 1.43% of respondents visited parks very often, despite 18% living within walking distance of fewer than 500 meters. However, when the nearest park distance was between 1.5 and 4 kilometers, 2.6% of respondents visited parks very often. This result contradicts a study conducted in Hangzhou, China, which revealed that most visitors habitually revisit parks within 1 kilometer of their residences (Zhan et al., 2021). The study conducted in Odense, Denmark, by Schipperijn et al.(2010) found a distance decay in using urban green spaces. As the estimated distance to the nearest urban green space exceeds 100 meters, the number of users visiting these areas declines. This challenges the assumption that the only factor influencing the visitation frequency of parks in Debre Berhan and Debre Markos Cities, Ethiopia, is their accessibility within walking distance. Rather, the quality of parks, including comfort and safety, and transportation modalities and modes also play a role. The low frequency of park users in the study areas may be due to the absence of the habit of walking and visiting parks.

### 5.4.2 Purpose of park visits

According to the study, the most common reasons for visiting green spaces were to "chill with friends" and to "enjoy nature and meditate.” This finding indicates that attitudes towards urban parks and green spaces in Ethiopia are similar to those in other developing countries, such as China, Malaysia, Turkey, Korea, and India. For instance, the most popular reason for visiting a park in Hong Kong, China, was "to enjoy the freedom and time of being alone"(Mak & Jim, 2019). Most visitors to parks in Kuala Lumpur, Malaysia, come for fresh air and relaxation, which is also true for Asian countries (Sreetheran, 2017). According to a study by Yilmaz et al.(2014), most people in Turkey prefer parks for relaxation and refreshment. However, the use of parks for active purposes such as walking, jogging, dog walking and sports activities is relatively low. In contrast, countries like Denmark, Hungary, and the USA utilize parks and green spaces for various activities, including walking, jogging, sports, and dog walking. (Nagy, 2002). In Coimbra, Leipzig, and Vilnius, parks were mainly used for physical activities such as walking and biking (Priess et al., 2021). Debre Berhan and Debre Markos city inhabitants enjoy visiting urban parks and green spaces for passive outdoor activities such as relaxation, socializing with friends, and meditation. However, they have expressed their desire for more active recreational facilities such as sports, jogging, and dog walking to be added to the parks. This suggests that the purpose of visiting parks is influenced by climate, religion, culture, and social values specific to the community and country.

#### 5.4.3 Factors encouraging and discouraging park visits

In Ethiopia, particularly in rapidly urbanizing cities with a growing population, people visit parks more frequently if they feel safe and secure. The existence of fences is one of the factors that encourage park visitors, as it provides a sense of security. This is due to the high crime rates reported in rapidly urbanizing cities, as in other countries. For example, a study by Lis et al.(2019) found a strong correlation between the frequency of park visits and the perception of safety in the park. According to the survey, respondents discouraged visiting parks 'highly' due to the following reasons: absence of safety and security, improper park management, and lack of comfortable seating areas. Previous studies have shown that the absence of safety and security is a significant factor that affects people's willingness to visit urban green spaces (Maruthaveeran & Van den Bosh, 2015; Bahriny & Bell, 2020). According to a study by Barbosa et al. (2007), females tend to visit urban parks less frequently than males, mainly due to safety concerns. This trend was also observed in Debre Berhan and Debre Markos. However, the study found that gender did not play a significant role in determining users' responses to safety and security concerns ($\chi 2$ (3, N= 350) = 6.590, $p > 0.05$). In other words, respondents of different genders had varying opinions on the issue. Therefore, the absence of safety and security measures does not uniquely discourage females from visiting parks in the study areas. The study also revealed that the presence of alcoholic drinks, the consumption of Khat, and the availability of bedroom services were highly discouraging factors for park visitors. Therefore, park authorities should prioritize the physical accessibility, safety, and security of parks, and ensure the visibility of the surroundings.

#### 5.4.4 Users' views of the intensity of disturbances

Park users visit green spaces at various times and frequencies depending on their environmental preferences. Some may seek a quiet place, while others may require noise to relax. However, the study results indicate that respondents were highly impacted by illegal activities, including drinking alcohol and chewing Khat in the parks, bad smells due to poor waste management, and dust pollution. Disturbances from noise pollution caused by people and traffic were relatively low. These results indicate poor integration of park stakeholders in maintaining a clean and safe park environment. The respondents reported that user-generated disturbances, such as drinking and chewing Khat in the parks, were more prevalent in parks where university students come to relax. Concerns were growing about persistent practices, such as chewing Khat, among Ethiopian university students (Gebrehanna et al., 2014). The impact of alcoholic drinks and chewing Khat on individuals has intensified since the outbreak of COVID-19, which has limited social gatherings in bars and groceries. These conditions have led to psychological stress, making it difficult for people to enjoy parks and contributing to an unhealthy and unproductive society. These conditions must be improved to promote mental and physical well-being among individuals.

### 5.4.5 Perceptions of users to the benefits of urban green spaces

Based on the result, users of parks have a good understanding of the recreational, ecological, and provisional benefits of urban green spaces. The benefits perceived by the respondents were similar to those found in other countries. For instance, in Latin America, people appreciate green spaces' relaxation, socialization, fresh air, and shading benefits, as studied by Wright et al.( 2012). According to the study, the participants perceived that green spaces have high benefits for recreational activities, aesthetics, and protection from dust and pollutants, respectively. The study also found that the medicinal benefits, provisioning services such as timber, fruits, and leaves, and socialization opportunities like Idir, Ikub, and other social activities were perceived as "medium" benefits of green spaces. Similarly, the study reported that urban green spaces in Addis Ababa were considered important for providing fruits and medicines in private gardens but not in larger urban green spaces like neighborhood parks (Yeshitela, 2020).

### 5.4.6 Users' preferences to facilities improvement and provision

Developing standard parks that meet the needs of all residents can take time due to financial constraints. However, it is crucial to properly monitor and manage existing parks and green spaces while also incorporating user preferences. According to a survey, respondents identified restrooms, fences and lighting, water and river access, and children's playgrounds as the top four necessary improvements. Fences and lighting facilities are often added and improved as part of management strategies to reduce the fear of crime in urban parks (Maruthaveeran & Van den

Bosh, 2015). MUDHo (2015) has established guidelines for the components of hardscape (gray) and softscape (blue and green) that should be incorporated in every park. A survey showed that all facilities were rated as "important" for improvement, such as parking areas and restrooms. This indicates a high demand for improving and providing all city facilities. In 2018, the Ethiopian government initiated the Green City Development Plan in Ethiopia and launched various projects in the capital city, Addis Ababa, including Entoto Park, Sheger Park, and Unity Park. We hope this initiative will be implemented in other regional cities and towns, leading to adequate facilities and improved urban parks and green spaces in rapidly urbanizing areas. Debre Berhan City plans to develop a large city park with components and facilities specified by the Ethiopian National Urban Green Infrastructure Standard (2015) and the Minister of Urban Development and Housing of Ethiopia (2015).

#### 5.4.7 Park users' roles and frequency of participation

If urban residents have positively perceive urban parks, they are more likely to contribute to their development (Yeshitela, 2020). The users of urban parks in Debre Berhan and Debre Markos cities have a positive perception of the benefits of urban green spaces, regardless of their age, gender, level of education, or occupation. However, 50% of the respondents have never participated in developing and managing parks. Similar findings have been reported in other studies concerning the lack of participation in green space development projects, such as in Ethiopia (Girma et al., 2019) in African countries, including Ghana (Asibey et al., 2019; Mensah, 2015) and Nigeria (Daramola & Ibem, 2010). People's participation in urban park development is necessary for green space improvement (Hanif et al., 2020).

## 5.5 Urban green space qualities from the perspective of users and experts

### 5.5.1 Users' perception of the urban green space quality attributes and their satisfaction

The findings revealed that most respondents were not satisfied with the quality of urban green spaces in both cities. The findings agree with other studies, e.g., Gwedla & Shackleton (2019), who showed that most respondents were dissatisfied with the general appearance of urban trees in the Eastern Cape, South Africa. In line with this in the study of users' perception of urban Parks in Ibeju-Lekki, Lagos State, Okunlola et al.(2022) showed park users were not satisfied since the design strategies do not meet their needs in many aspects, including social inclusivity, maintenance, and green-grey integration. The perceived spatial and non-spatial green space qualities in Debre Berhan and Debre Markos cities were "medium." Generally, all green space quality attributes were rated "medium," with an average mean score of 3.08. However, based on the experts' interview analysis results, most experts perceived the existing quality of urban green spaces as poor (below standards). There was a difference on the perception of users and experts to the quality of urban green spaces.

Most (59.5%) of the respondents scored "disagree" on the status of the major determinants of sustainable urban green spaces. It implies that urban green spaces in the study areas were not quality, accessible, fairly distributed, and adequate (Table 5). Almost half of the respondents and 15.4% scored "disagree" and "strongly disagree" on the equity of urban green spaces. In line with this in a rapidly urbanizing Chinese city, the equity of green spaces in the quality and proximity of green space is poor (Zhang, 2023).

### 5.5.2 Association of socio-economic characteristics to the perception of green space quality

Most of the park users were males. Female park visitors appeared low, accounting, for only 37.2% of the respondents, comparing the female population is 51% in Debre Berhan City (Amdetsion , 2017), 52% in Debre Markos City (Mullu, 2015), and 50% sex ratio in the population of Ethiopia. Basu & Nagendra (2021), in their study of perceptions of park visitors on access to urban parks and benefits of green spaces in Hyderabad, India, showed that more male than female users come to urban green spaces. Similarly, Shan (2014) also reported that in the large Chinese city of Guangzhou, China, more male than female users come to urban green spaces. However, Pleson et al.(2014) stated that more female than male users come to urban green spaces in Taipei, Taiwan. Ives et al. (2017 also reported that more female than male users come to urban green spaces in Lower Hunter Valley, New South Wales, Australia.

Half of the respondents were in the age range of $\geq 20 - 30$, and only 0.9% of respondents were above 60. The elderly park users were low compared to Ethiopia's aged population expected in 2032, with an increase in Life expectancy from 59.5 in 2012 to 67.9 in 2032 (Bekele & Lakew, 2019). 31.7% of the respondents were above BSc (BA) degree/MSc (MA) degree, and 99.4% were literate; therefore the respondents had a relatively high level of education. 15.1% of the respondents were unemployed. This finding shows a high unemployment rate and dependence in the study areas. This study is in line with the research result of Kassa (2012), which reported that the unemployment rate in urban areas of Ethiopia was 20.5% in 2009.

The findings from this study show that some socio-demographic characteristics (age, education level, and occupation) had no significant association with users' perception of the quality of urban green spaces. However, a statistically significant association ($p < 0.01$) existed between the respondents' gender and the total perceived quality attributes. Similarly, age and level of education had a significant association with the users' satisfaction level of green space quality attributes, while gender and occupation did not. However, in the study of Bahir Dar and Hawassa, Gashu et al.(2020) argued that demographic, socio-economic, institutional, and physical factors contribute to different perceptions of green infrastructure. It implies that socio-economic characteristics' association with the perceived urban green space quality attributes depends on the geography (Qureshi et al., 2013), culture (Shan, 2014), climate, and religious practices of the study areas.

## 5.6 Experts' view on green space planning models applicability and practicality

### 5.6.1 Challenges perceived by experts to develop quality urban green spaces

88% of the experts rated the existing situations of the quality, quantity, and accessibility of urban green spaces in Debre Berhan and Debre Markos cities as "below standards." A well-organized space, termed "good management," is something users value most in an urban green space development (Mutiara & Isami, 2012). The most important challenge most of the interviewees mentioned is the financial constraint. In another study about barriers to green infrastructure development in Bahirdar and Hawssa, Gashu & Gebre-Egziabher (2019a) also showed financial challenges under capacity barriers. Zewdie & Tegegne (2019) have mentioned financial constraints as a major factor affecting green area development and management negatively in Debre Berhan City, Ethiopia. Since providing green spaces in urban areas is often costly, it is difficult for cities in developing countries like Ethiopia to develop quality green areas. Global funders, including the World Bank have supported urban greening initiatives in African cities. A green development path posed particularly acute challenges for the donors since the damage that had occurred before was irreversible or prohibitively costly to fix (Roland et al., 2017). However, it is possible to develop; for example, in October 2019, the government of Ethiopia started city beautification and park development projects in Addis Ababa, Ethiopia, estimated to take one billion dollars with a fund granted from fundraisers. Therefore it is clear that one significant challenge facing developing quality urban green space development in rapidly urbanized cities in Ethiopia is limited financial resources. 70% of the interviewees mentioned that land use change was the second most significant challenge/constraint for developing quality green spaces. In support of this, Yeshitela (2020) discussed that since urban land ownership is for the government in Ethiopia and as the urban population continues to increase, demand for land also rises, resulting in competing interests in urban green spaces.

Land use change in the name of urban densification for accommodating other infrastructures is a challenge for urban green development (Mofrad et al., 2022). Lack of maintenance, monitoring, and coordination were the third and fourth-order challenges mentioned, respectively. The interviewees mentioned that lack of coordination challenges to green space quality development in Ethiopia, particularly in the Debre Berhan and Debre Markos Cities. Ownership disputes of urban green spaces were also a very critical challenge. Similarly, in other studies in Ethiopia, Benti et al.(2022) reported that unclear boundary settings are challenges for sustaining natural urban landscapes. In line with this, Mofrad et al. (2022) stated that the complexity of dual governance and the governance gap at the district level is a challenge for urban green development in Canberra, Australia.

### 5.6.2 Experts' awareness and experience of green space planning approaches and models

Among urban green space planning models, space standards - a quantitative model was known and practiced. In contrast, others were not familiar to the majority of the experts and never practiced in both cities. The experts focused on the quantity of urban green spaces than the accessibility and quality in urban green space planning. They focused only making 30% of the city green with the consideration of the structural plan preparation manual of Ethiopia, 2011. Benti et al.(2021) also concluded that focus on physical planning causes for the unsustainable natural and working landscapes in the urban areas in Ethiopia. Only one expert was "slightly aware" or "familiar" with each green space planning model, and four were unaware. In line with this study, Gashu & Gebre-Egziabher (2019a) have mentioned the lack of knowledge about urban green infrastructure planning as a technical barrier in Ethiopia for the development of urban green. Similarly, Girma (2019) also mentioned that lack of awareness, poor involvement, and low practices were barriers to adopting green infrastructure planning principles.

### 5.6.3 Impacts of LULCC on Ecosystem Services

In this study, a decline in barren lands, agricultural lands, and green spaces, and an increase in built-up areas were observed between 2000 and 2020. Land-use and land-cover change (LULCC) impacts provisioning, regulating, supporting, and cultural ecosystem services (Chen et al., 2024; Hailu et al., 2024). Barren and croplands have been degraded by 32.96% and 5.71% in Debre Berhan and Debre Markos, respectively. This change impacted the cities' provisioning, regulating, and supporting ecosystem services, as confirmed by Belay et al.(2022). Rapid urbanization consumes fertile agricultural lands in the inner city and outskirts of the cities. For example, the expansion around the Egzerab church area in Debre Berhan and the Bole area in Debre

Markos were fertile land used for the ‘Teff’ production of local livelihoods and economies dependent on agriculture. This finding is consistent with a study by Erasu & Lika (2022), who researched the conversion of farmland to non-agricultural land uses in peri-urban areas of Addis Ababa. So, converting arable land to built-up areas reduces food production capacity, threatening the local and the city's food security/provisioning ecosystem services in the area of studies as it is also studied in (Satterthwaite et al., 2025). In addition, the transformation of barren lands and croplands affects the regulating services that help maintain the balance of ecological processes and ensure a stable environment. As urban areas replace these lands, there is a decrease in carbon sequestration capacity and an increase in greenhouse gas emissions, contributing to urban heat islands. This change also impacts supporting services by causing habitat and biodiversity loss and disrupting nutrient cycling.

The decline in ecosystem services value due to deforestation has been highlighted in various studies (Chen et al., 2014; Thi et al., 2020) Similarly, the green space cover in Debre Markos has decreased by 41%, impacting the ecosystem services in various ways. It affects the recreational, regulating, and supporting ecosystem services. Due to the degradation of green spaces, decline in air quality regulation, increased urban heat island effect, increased flooding, and erosion are some of the impacts, aligned with González-Garcíaa et al.(2020), who highlight the impacts of land use change on regulating services. For example, there was flooding and erosion in the WESTA River recently. The LULCC in Debre Markos City impacts the recreational ecosystem services access to natural areas for recreation, ecotourism, and outdoor activities, affecting mental and physical well-being. Some open spaces used for public festivals and events and playgrounds are changed to built-up areas. However, it increases the recreational and regulating ecosystem services in Debre Berhan City as the cover of green spaces increases.

# Chapter six: Conclusion and Recommendations

## 6.1 Conclusions

The main objective of the study was to analyze the spatial coverage of urban green spaces, changes in urban green space coverage and its density, users' preferences and perceptions towards urban green spaces, and the quality of urban green spaces over the past 20 years (2000 – 2020) in two rapidly urbanizing cities, Debre Berhan and Debre Markos, in Ethiopia. The study used both qualitative and quantitative research approaches with case study method. Primary and secondary data were employed including remote sensing data. The data collection tools were questionnaires and key informants' interviews. Both qualitative and quantitative data analysis methods were applied.

Quantitative evidence of LULC changes in this study indicates that Debre Berhan and Debre Markos have undergone substantial changes after 2010, driven primarily by industrialization and economic development. Built-up and green spaces land cover land use classes were increased in Debre Berhan city while a reduction of the barren and croplands and water bodies remained unchanged. These changes highlight the urgent need for sustainable urban planning and conservation strategies to balance development with ecological preservation. The City's spatial structure and the far location of substantial green spaces from the urban core were the factors for increasing in green spaces. Green spaces were reduced overwhelmingly in Debre Markos City which needs urgent ecological-based planning approaches and solutions. The observed spatial structure and growth patterns of Debre Markos City indicate that infilling development has played a key role in the degradation of green spaces. It is also true that other rapidly urbanized cities have similar growth patterns that have intensified land conversion,  like Bahirdar (Kindu et al., 2020) and other world cities (Chihambakwe & Moyo, 2024). These trends underscore the importance of integrating sustainable urban planning approaches prioritizing green space conservation while accommodating urban growth. Therefore, urban planners should include green space planning models in their spatial plans and policy documents.

The study's findings indicate that age, gender, and occupation significantly influence the reasons for visiting urban green spaces. Additionally, the preferences and perceptions of urban residents regarding park improvements and the amenities provided are influenced by their age and gender. Furthermore, the benefits of urban green spaces are perceived differently based on the gender, age, and education level of the residents.

The availability of urban green spaces for urban residents within walking distance of 500 m is inadequate, and they travel more than 15 minutes to get to the green space, limiting accessibility and reducing the benefits of urban greenery. This gap underscores the need for strategic urban planning that prioritizes integrating easily accessible green spaces within city layouts. Users' frequency and purpose of park visits are shaped by socioeconomic factors such as age, occupation, gender, and education. Most visitors use these spaces once or twice a month, with social interactions, primarily spending time with friends, as the main purpose of their visits. Students aged 15 to 30 make up the majority of frequent park users. The presence of fences is the main factor that encourages park visits. In contrast, illegal activities such as chewing khat and drinking alcohol in the park are the main factors that discourage infrequent park visits. Restrooms, fences, lighting, and access to water and rivers are the most desired facilities to be improved and provided. Users perceive urban green spaces primarily as recreational environments, highlighting the need for enhanced infrastructure, security measures, and inclusive urban planning to improve accessibility and user satisfaction. Urban residents have very limited involvement in the development of green spaces, with only 8.6% participating as laborers during the implementation phase. This low level of public engagement emphasizes the need for inclusive planning approaches that promote community participation from the design stage to post-implementation. Urban planners, policymakers, and community organizers are crucial in fostering this engagement.

Ethiopia has established standards, policies, and strategies to develop and protect urban green spaces. These include the Ethiopian National Urban Green Infrastructure Standard of 2015, the Climate Resilient Green Economy of 2011, the Green Infrastructure-Based Landscape Design of 2011, and the Urban Greenery and Beautification Strategy of 2015. However, it is necessary to implement these standards better or assess their practicality in the areas studied. Therefore, comparative analyses among different levels of cities and regions in Ethiopia should be conducted to achieve sustainability in developing urban green spaces and devise policies that represent and balance citizens' attitudes toward urban parks and green spaces. Urban green spaces, particularly urban parks, depend on their suitability, adaptability, and sustainability for effective and efficient use. Therefore, knowledge of green space planning, management, development, and local expertise from urban residents, including their preferences and perception of urban parks, is essential for the sustainable development of urban green spaces and the workability of rapidly urbanizing cities. The results indicate that male park users were more numerous than females, and adults aged 20-30 were the dominant users of the urban green spaces. The number of elderly park users was low. The results also indicate that the users perceived green spaces' spatial and non-spatial quality as "poor" and "very good," respectively. The perceived spatial quality of green spaces was dependent on the users' age and gender, while the non-spatial quality of green spaces was dependent only on the users' gender. The users were not satisfied with the urban green space qualities; their perceptions of all green space quality attributes had a significant statistical association with the socio-demographic characteristics of users (age, gender, education level, and occupation).

Most experts perceived the quality of urban green spaces as "below standards." Many challenges hindered the overall urban green space development in the study areas. The experts mentioned that lack of finance was one of the major constraints for developing quality green spaces. Additionally, ownership disputes among responsible organizations hinder effective implementation, emphasizing the need for stronger collaboration and coordination. They also failed to do regular follow-up and monitoring of the maintenance and management of urban green spaces. Experts lack knowledge of green space planning models and approaches. The spatial plan preparation experts practiced only Space standards - a quantitative model focused merely on meeting 30% of the city's green. However, depending on the city structure, based on the preliminary suitability analysis and users' preferences', other green space planning models could be practiced for developing quality green spaces, for instance, green heart and green belt models in Debre Berhan and Debre Markos city, respectively.To solve these challenges, it is important to enhance financial investment, strengthen institutional cooperation, improve monitoring and maintenance practices, and provide training on diverse green space planning models. A comprehensive and multi-dimensional planning approach that exceeds space standards will ensure sustainable, accessible, and well-managed green spaces, ultimately improving urban livability and environmental resilience.

Rapidly urbanizing cities, especially those in developing countries, could learn from this study about contextualizing green space quality attributes and applying green space planning models in city planning. Thus, integrating urban green space planning strategies and management is foremost to increase the quality of urban green spaces in rapidly urbanizing cities. However, more research is needed to understand better the trends, practices, and challenges of urban green space planning, development, and management in rapidly urbanizing cities and the means of enhancing the capacity of experts. Therefore, further study is needed to develop a theoretical framework for incorporating green space planning models and approaches in urban planning and development to ensure adequate and quality green spaces. Thus, the methodology followed in this research could be adapted in similar studies at different urban centers of Ethiopia and other developing countries.

## 6.2 Recommendations

### 6.2.1 Availability of green spaces

Ethiopia has rapid urbanization, including in Debre Berhan and Debre Markos. As cities grow, more open spaces for inhabitants to enjoy are often needed. Since adequate urban green spaces positively impact public health, mental well-being, and the environment. This study confirmed that the specific requirements for providing sufficient urban green spaces are known but failed to propose as the land ownership is to the government and prioritizes economic and social development over environmental sustainability. An Integrated Urban Development Plan (IUDP) is recommended to embed sectoral objectives to ensure equal economic, social, and ecological development opportunities in a city in a comprehensive development strategy. The central idea of the Integrated Urban Development Plan (IUDP) is to minimize friction and conflicts among various stakeholders. Therefore, rapidly urbanizing cities must prioritize green spaces as part of their planning strategies. Several approaches can be taken to achieve sustainable development of green spaces (increase the spatial coverage of urban green spaces), including incorporating green roofs and walls in buildings to maximize the use of vertical spaces. It is also recommended to introduce community gardens on underutilized land, and they also have benefits to promote local food production and increase access to fresh produce that supports Ethiopia's climate-resilient green economy strategies. Therefore, it is recommended to employ further research on ways of bringing (maximizing) multifaceted benefits of urban green spaces in rapidly urbanized cities to accommodate the demand of the added population. The waterways in the study areas should be more utilized and proposed for suitable land use on the structural plan prepared; hence, developing linear parks along waterways or transportation corridors such as roads and railways enhances urban green space provisions. Creating pocket parks in small vacant lots within the urban fabric of the cities also recommenced to improve the availability of urban green spaces.

The issues with green space provisions stem from land scarcity in dense cities. However, green space inadequacies result from poor planning in the study area. Urban green spaces are proposed opportunistically in the study areas without understanding the cities' spatial structures, which is important to characterize the urban landscape. The five key attributes of urban spatial structure, including urban land cover, density, centrality, fragmentation, and compactness, must be measured and analyzed to propose green spaces accordingly. Urban planners in the study areas prepare existing land use/or land use land cover during the structural plan or local development plan preparation for the suitability analysis and estimation of the land budget allocation for different urban land uses. Private gardens and small pocket spaces are counted as urban green spaces in the existing situation analysis, which increases the existing share of urban green spaces.

Therefore, it is better to incorporate them as residential land use to improve the net density of urban green spaces in the proposal. The current share of urban green spaces in DB and DM is 19% and 22.8%, respectively. The proposed land use land cover share of rapidly urbanizing cities should consist of 30% green, 30% road infrastructures, and 40% other urban functions by studying the land suitability such as the topography analysis. All hilly 15-20 percent slopes should be restricted from construction activities and covered by appropriate vegetation. Pursuing leapfrogging development instead of infilling and sprawl-type development is recommended, as this approach has been shown to increase green space cover in Debre Berhan. Generally, further detailed study of local climate zones of the study areas would strengthen the land use and land cover change analysis of this study.

### 6.2.2 Green space accessibility and landscape fragmentation

In the study areas, recreational parks are primarily located on the outskirts of the cities rather than in the central business district (CBD). This raises concerns about centrality and spatial injustice regarding urban green spaces. Centrality refers to the percentage of the urban population living near these green spaces. To address this issue, urban planners should focus on decentralizing employment from the CBD and promoting the development of polycentric cities. This approach would create multiple employment centers throughout the metropolitan area, making recreational parks available to most people and increasing the availability of open spaces in inner cities. The study shows that urban green spaces are not within walkable distance; a walkable neighborhood emphasizes that areas should be compact, pedestrian-friendly, and mixed-use, ensuring that many daily activities are within a five-minute walk. Therefore, accessibility should be checked at the neighborhood level before the implementation of the structural plan or local development plan.

Fragmentation, or scattered development, is usually assessed by the relative amount and spatial organization of open spaces or green spaces disrupted by the noncontiguous expansion of cities into the surrounding countryside. Urban planners in rapidly urbanizing cities should develop a policy about incorporating large blocks of open space or green wedges during structural plan preparation for providing ecological corridors and connections with the surrounding countryside. The city developers could take lessons from developed countries, from Helsinki, as large tentacles of green space penetrate the very center of the city, for example, Keskuspuisto Central Park—an 11-kilometer-long unbroken green wedge. In Copenhagen, high-density development is clustered along transit lines (like "pearls along a neckless"), with large wedges of green space between them. In Amsterdam, green wedges like Randstad's Green Heart, a large area of farms and open space in the middle of this urban agglomeration. In Britain, the designation of extensive greenbelts around cities has been a major growth containment strategy. London's greenbelt is large—some 1.2 million acres (70km). Although urban encroachments and conversions have occurred, it has been mostly successful at preventing sprawl and preventing towns from merging, and they serve to promote urban regeneration.

The city administrations should ensure that green space is distributed equitably across the urban area, focusing on areas with limited access to green spaces. Repurposing brownfield sites is an eco-friendly way to increase biodiversity. However, it's important to be mindful of unintended negative consequences and conduct ecological assessments before developing these sites. Focusing on smaller sites or areas with a high concentration of brownfield sites is recommended to minimize biodiversity loss. GIS network analysis and green-oriented development are also better for making network analyses to incorporate green spaces during city planning.

### 6.2.3 Users' preferences and perceptions

The findings of this study show that there was no participation of citizens in urban green space planning and management and the green spaces are not based on users' preferences and perceptions. It shows the disconnection between urban planning and the needs of the community. Integrating users' preferences into planning models, enhancing expert knowledge through capacity-building initiatives, and promoting inclusive, context-specific green space development is essential. Encouraging community involvement in designing and managing green spaces is crucial to ensure they meet local needs and enhance the users' sense of stewardship. The landscape planners and environmentalists who participate in the decision of urban green spaces should check whether the planned green spaces are based on the citizens' preferences. Understanding the demographics of people who use urban green space and their preferences can help researchers develop interventions and programs to promote equitable access to green space. Park users require more cultural and historical sculptures. Consequently, city administrations should engage in participatory urban planning and decision-making throughout the entire planning process. Additionally, studying how different communities' value urban green space can provide insight into how to design and manage green spaces that meet the needs of diverse urban population.

### 6.2.4 Urban green space qualities

Maintaining and improving the quality of existing green spaces through routine maintenance and enhanced management practices is important for sustainable urban green space development. Urban green space and LULC change are significant challenges facing Ethiopian cities, which require attention from planners, policymakers, and the public to promote sustainable urban development and preserve ecological values. A green space is considered high quality if it meets most of the 12 attributes rated by park users. The development of Debere Berhan and Debre Markos cities follows the Homer Hoyt sector model, which suggests that cities develop in sectors. However, this model is not ideal for ensuring accessibility and equity in land use. Planners should prioritize a mixed-use development approach that integrates green spaces within residential, commercial, manufacturing, and service areas to provide quality green spaces for everyone.

The city administration should control land use change of green spaces to small-scale enterprises. There should be integration and collaboration of offices for sustainable development. Ownership problems, lack of budget, and land use change were mentioned as challenges of green space development, especially in the inner city. Urban green spaces are taken as a creation of jobs like animal husbandry and cafeterias, which is one of the big challenges of sustainable development of urban green areas. Therefore, awareness should be created through community awareness programs, involvement in restoring green areas, and establishing green space advocacy groups. It is recommended to study strategies and means to give the intended purposes of green spaces with limited/small amounts of green spaces to the maximum satisfaction of users that are equivalent to the services provided by the minimum required urban green spaces.

#### 6.2.5 Applicability and practicality of green space planning models

The city administrations should enhance experts' knowledge about green space planning models and monitor the implementation phase. All stakeholders should also be advised to stress the urban green spaces during the plan preparation and implementation phase. Green spaces should be a top priority on the urban development agenda for planning authorities and related institutions. While there is growing attention toward advocacy for urban green space planning in Ethiopia, several factors undermine its proper implementation, including issues surrounding policy, funding, maintenance, and institutional capacity. Further research is needed to identify sustainable solutions to address these challenges and measure the impacts of these interventions over time.

This study has implications for Ecological Research, Environmental policy and management, Climate change adaptation and mitigation, and Public health and well-being. Ecological research: Urban green spaces can serve as important habitats and corridors for wildlife in urban areas. Monitoring changes in these spaces can provide valuable information on how urbanization impacts biodiversity and ecology in cities. Environmental policy and management: Urban green space cover change analysis can help policymakers and land managers identify areas where green space is declining, and new green spaces are being created. By tracking these changes over time, policymakers and managers can make informed decisions on allocating resources to protect and enhance green spaces. Climate change adaptation and mitigation: Trees and other vegetation in urban areas help reduce the urban heat island effect and absorb carbon dioxide. Studying changes in urban green space coverage can provide insights into the evolution of this vital ecosystem service and aid in developing strategies for adapting to and mitigating climate change in urban areas. Public health and well-being: Green spaces have positively impacted mental and physical well-being. Research into urban green space cover change can help identify areas where residents may be losing access to green space and where interventions are needed to help promote healthy outdoor activities.

**Generally the following are some future research suggestions**

- Since the study reveals the need for communities' participation in the development of urban green spaces, it is important to study the role of public-private partnerships and community involvement in the development of urban green spaces as it helps in the management of sustainable urban green space development.

- Due to the rapid urbanization in the inner part of the city, and urban expansion and urban sprawl at the edge of the cities, sometimes it isn't easy to gain urban green spaces as much as we want within the delineated urban area administration. Therefore, assessing vertical green space development as an option for sustainable urban green space development in rapidly urbanizing cities can be a future research area.
- Different green space planning models are reviewed and assessed with the experts' opinions regarding the applicability and planning trends in the study areas. However, a good research topic is a study about suitable green space planning models for different urban structures in rapidly urbanizing cities of developing countries.
- It is better to focus on the edge development for provisions and the quality of green spaces in the inner part of the city for optimal planning for quality of life in green spaces of limited size. Some characteristics of UGS can provide sustainable urban ecosystem services and quality of life in green spaces of limited size. Therefore, as it fills the research gap and literature review, it is better to study some qualities or characteristics of urban green spaces that provide sustainable urban ecosystem services in rapidly urbanizing cities of Ethiopia and other cities in developing countries.

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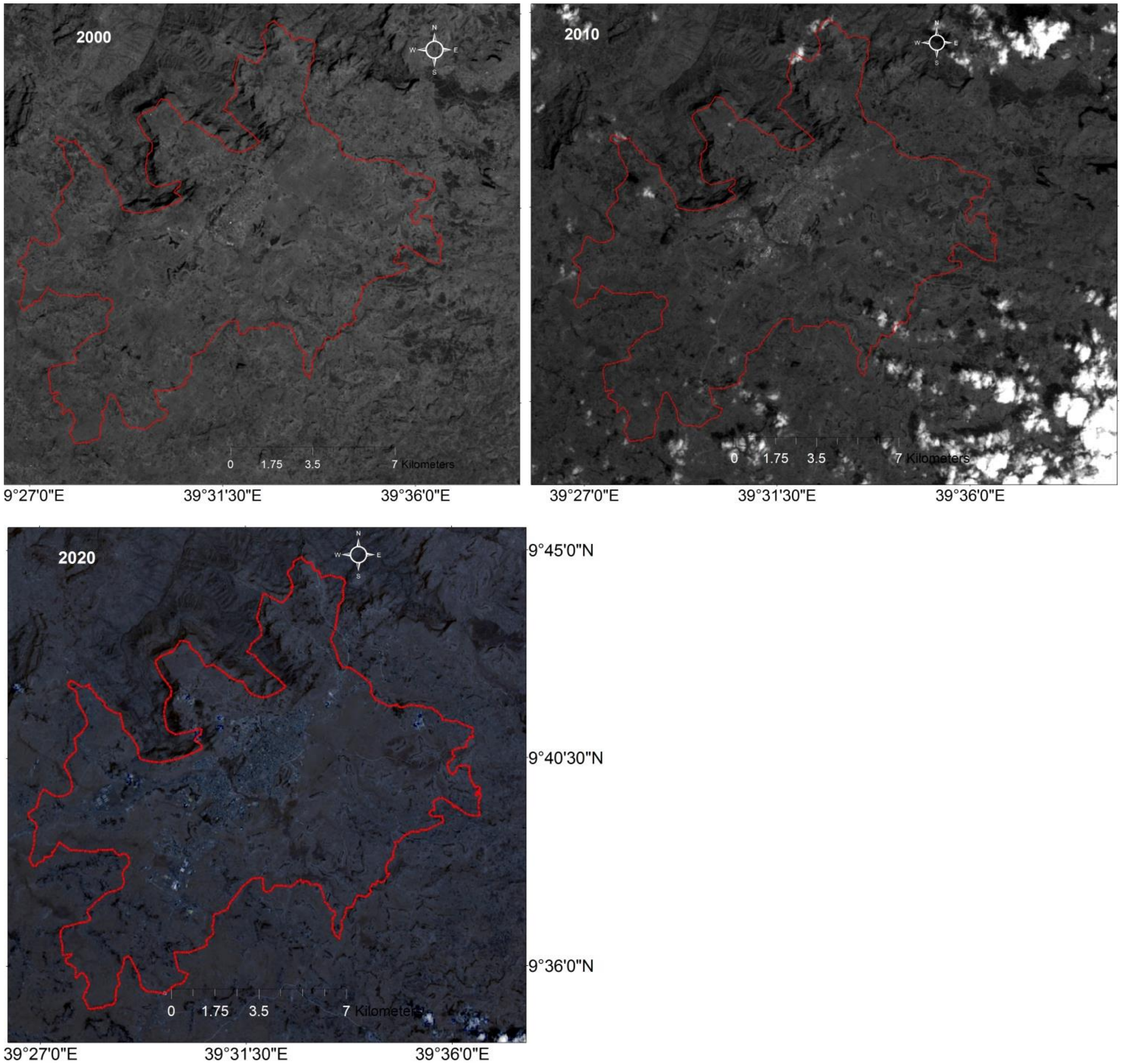
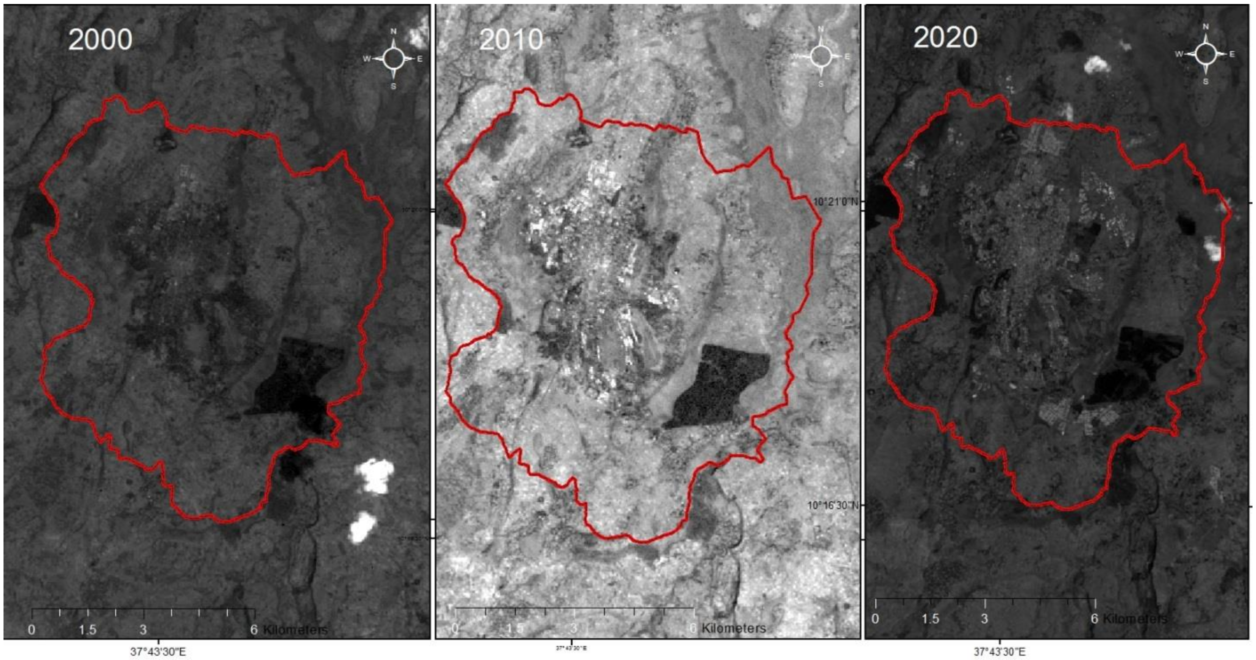
**Appendix I:** Raw images of the entire LandSat




Raw image of the entire Landsat data for Debre Berhan City in2000, 2010, and 2020 respectively



Raw image of the entire Landsat data for Debre Markos at 2000, 2010, and 2020 respectively

## **APPENDIX II**: Questionnaire for green space users

Dear respondents, this questionnaire aims to collect data for the specified academic research titled: Users' Preferences and Perceptions towards Urban Green Spaces in Rapidly Urbanized Cities: The Case of Debre Berhan and Debre Markos, Ethiopia. This questionnaire is prepared to gather users' perceptions and preferences towards urban green spaces, particularly recreational parks and playgrounds. The data collected and the information to be answered in this questionnaire will be used for academic research purposes only. The respondents' information will be kept confidential at all times. Only a generalized analysis of the information in this completed questionnaire will be utilized in the research process. Last but not least, your response in this regard is highly valuable & contributes to the outcome of this study.

We sincerely thank you for your invaluable time and cooperation in advance.

**Instructions**

The questionnaire has two (2) parts:

Part I: It contains profile of the respondents.

Part II: It contains green space preferences', perceptions, and related issues

**Please answer, rate, and tick (✓) the questionnaire by selecting the appropriate choices**

## PART I: Profile of the respondents

Park name (Green space name) -------------------------------------------------------

1. **Gender** 1) Male ☐ 2) Female ☐
2. **Age** 1) 15-20 ☐ 2) 20-30 ☐ 3) 30-50 ☐ 4) 50- 60 ☐ 5)>60 ☐

3. **Occupation** 1) Student ☐ 2) self-employed ☐ 3) Employed ☐ 4)retire ☐ 5) unemployed ☐ 6) other ☐

4. **Education level** 1) No education ☐ Primary (1-8) ☐ 3) Secondary (9-10) ☐ 4) Preparation (11-12) ☐ 5)TVET or Diploma ☐ **6)** Degree ☐ 7) MA(MSC)&above ☐

## PART II: Green space users' perception, preferences, and related issues

1. How far is it from your home to the nearest park?

   1) 0- 0.5 Km ☐ 2) 0.5-1.5 km ☐ 3) 1.5 - 4 km ☐ 4) 4 - 6 km ☐ 5) > 6 km ☐

2. How often do you come to this place in a month?

1) Rarely (1-2 times) ☐ 2) Sometimes (2-4 times) ☐ 3) often (4-8times) ☐ 4) Very often (>8times) ☐

3. For what purpose do you come to the green spaces?

| **Purposes** | 1)Never | 3)Sometimes | 3) often | 4) Always |
|---|---|---|---|---|
| 3.1 for walk | | | | |
| 3.2 To have physical exercise | | | | |
| 3.3 To enjoy nature and meditate | | | | |
| 3.4 To make social life such as Idir and Ikub | | | | |
| 3.5 For reading | | | | |
| 3.6 For events like wedding | | | | |
| 3.7 for sheltering purpose | | | | |
| 3.8 To chill with friends | | | | |
| 3.9for enjoying the cultural and historical facilities | | | | |
| 3.10 if other's(specify) and measure it----- -- ----------------------------------------------------- | | | | |

4. How much do you agree on the following factors and facilities encouraging you to relax in this park?

| Factors | 1) Strongly Disagree | 2)Disagree | 3) Agree | 4)Strongly Agree |
|---|---|---|---|---|
| 4.1 Clean facilities | | | | |
| 4.2 Existence of Spacious areas | | | | |
| 4.3 Safety and security | | | | |
| 4.4 Existence of fences | | | | |
| 4.5 Good natural environment and dense vegetation | | | | |
| 4.6 Sufficient facilities | | | | |
| 4.7 Cultural and historical facilities | | | | |
| 4.8 Other (specify) and rate it------------------- -------------------------------------------------- | | | | |

5. How much the following reasons discourage you to use and recreate in the parks?

| Factors that discourage to use parks | 1.Not affect | 2. Low | 3. Medium | 4.Highly |
|---|---|---|---|---|
| 5.1 Improper park management | | | | |
| 5.2 Unaffordability of entrance fees | | | | |
| 5.3 Absence of historical and cultural facilities | | | | |
| 5.4 Absence of safety and security | | | | |
| 5.5 Lack of green and dense vegetation | | | | |
| 5.6 Absence of enough facilities for children | | | | |
| 5.7 Far from home | | | | |
| 5.8 Inaccessible for transportation | | | | |
| 5.9 Absence of large gathering spaces for families and other social activities like Idir | | | | |
| 5.10 Lack of comfortable sitting areas | | | | |
| 5.11 Absence of parking area | | | | |
| 5.12 Other(specify) and rate--------------------------- -------------------------------------------------- | | | | |

6. Which disturb you while you are relaxing? Please tick based on the intensity of disturbances?

| Factors | 1) Severe | 2) Moderate | 3) Mild | 4) None |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 6.1 Noise pollution from people and traffic | | | | |
| 6.2 Dust pollution | | | | |
| 6.3 Bad Smell from poor waste management inside and outside | | | | |
| 6.4 Illegal activities in the park | | | | |
| 6.5 Other's please specify and rate------------------------------------------------------------------------ ---- | | | | |

7. Which of the following aspects of the existing City Park are most in need of improvement or attention?

| **Activities** | 1) Not Important | 2)Moderately Important | 3) Im-portant | 4) Very Important |
|---|---|---|---|---|
| 7.1 Cultural and historical structures | | | | |
| 7.2 Fences and lighting | | | | |
| 7.3 Water and river access; fountains | | | | |
| 7.4 Play equipment | | | | |
| 7.5 Trails and walk ways | | | | |
| 7.6 Restrooms | | | | |
| 7.7 Green spaces and Plants | | | | |
| 7.8 Picnic Facilities | | | | |
| 7.9 Children play ground | | | | |
| 7.10 Parking | | | | |
| 7.11others(Specify)------------------------- ----------------------------------------------- | | | | |

8. What do you think about the use of green spaces in cities?

| **Uses** | 1.Not important | 2)Low | 3)Medium | 4)High |
|---|---|---|---|---|
| 8.1 Provisioning services like timber, fruits, leafs | | | | |
| 8.2 Recreational services | | | | |
| 8.3 Meeting purpose for Idir, Ikub, and other | | | | |

| | | | | |
|---|---|---|---|---|
| social activities | | | | |
| 8.4 For aesthetics purposes | | | | |
| 8.5 For cooling purpose and sheltering | | | | |
| 8.6 protection of dusts and other pollutants from the households and manufacturing sectors | | | | |
| 8.7 sources of medicine | | | | |
| 8.8 others……… | | | | |

9. Please tick your roles of green spaces development based on the frequency you have participated.

| **Roles** | 1)Never | 3)Sometimes | 3. often | 4) Always |
|---|---|---|---|---|
| 9.1 In green space planning and design including selection of the suitable site | | | | |
| 9.2 Public hearing and meeting about the green spaces development | | | | |
| 9.3 Working man powers during implementation phase | | | | |
| 9.4 In maintenance and rehabilitation of green spaces | | | | |
| 9.5 Financing of projects and maintenance | | | | |
| 9.6 Others (specify) and rate it ----------------------------------- | | | | |

10. How do you evaluate the quality of parks in terms of the following parameters?

| **Parameters** | very low | low | medium | high | very high |
|---|---|---|---|---|---|
| 10.1 Consideration of social and cultural issues of the residents | | | | | |
| 10.2 Presence and conservation of historical heritage | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10.3 There is community participation in the development | | | | | | |
| 10.4 It is attractive | | | | | | |
| 10.5 It is comfortable | | | | | | |
| 10.6 It is safe | | | | | | |
| 10.7 It is inclusive for all people | 10.7.1 Income | | | | | |
| | 10.7.2 Age | | | | | |
| 10.8 It is maintained regularly | | | | | | |
| 10.9 It is easily accessible | | | | | | |
| 10.10 It is a convenient size | | | | | | |
| 10.11 It has inviting and functional shape | | | | | | |
| 10.12 It has dense vegetation cover | | | | | | |

11. How much do you agree on the status of the basic indicators that determine the sustainability of green spaces?

| **Rates** | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| 11.1 There is adequate green spaces and recreational areas | | | | |
| 11.2 Green spaces are distributed fairly and evenly | | | | |
| 11.3 Green spaces are accessible | | | | |
| 11.4 Quality of green spaces are good | | | | |

12. Generally how much have you been satisfied with the services you get from the recreational areas and green spaces? ---------------------------------------------------------------------------

1) Not at all satisfied 2) slightly satisfied 3) satisfied 4) very satisfied 5) completely satisfied

13. What kind of solutions do you recommend for the sustainable development of green spaces?

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## APPENDIX: III Structured interview for professionals

Dear interviewees, this questionnaire aims to collect data for the specified academic research titled Urban Green Space Quality Attributes and Constraints from users' and experts' perspectives in two Ethiopian cities: Debre Berhan and Debre Markos. These questions are prepared for data gathering regarding planning and management practices of urban green spaces to bring sustainable development of green spaces. The data collected and the information to be answered in this questionnaire will be used for academic research purposes only. Only a generalized analysis of the information in this completed questionnaire will be utilized in the research process. All concerned companies and agencies and the interviewee's data will always be confidential.

**Part I: General Information about Interviewees**

**Name of the organization**-------------------------------------------------------

1. **Educational Level**

   1. TVET ☐ 2. Diploma ☐ 3.Degree ☐ 4.Masters and above☐ 5. Other ☐

2. **Work Experience**

   1) 0 - 5 years ☐ 2) 6 - 10 years ☐ 3) 11 - 15 years ☐ 4) above 15 years ☐

3. **Profession**

   4.1 Urban planner ☐ 4.2 Landscape designer ☐ 4.3 Economist ☐
   4.4 Sociologist ☐ 4.5 Engineer ☐ 4.6 Architecture ☐
   4.7 Environmentalists ☐ 4.8 Ecologist and horticulture ☐
   4.9 Demographer and geographer 4.10 Psychologist ☐ 4.11 others ☐

5. How often do you collaborate and integrate with other offices to manage the green spaces

   1) None ☐ 2) Very weak ☐ 3) Weak ☐ 4) Strong ☐ 5) Very strong ☐

6. How often does your organization disagree on ownership of green spaces?

1) Never ☐ 2) Rarely ☐ 3) Sometimes ☐ 4) Always ☐ 5) Very Often ☐

7. Please rate your organization performances of timely maintenance of recreational parks?

1) Far below standards ☐ 2) below standards ☐ 3) meets standards ☐ 4) above standards ☐ 5) It is not our responsibility ☐

8. Rate your organization's performance on follow-up and monitoring to take measures against illegal activities in recreational parks, street medians, playgrounds, and others.

1) Far below standards ☐ 2) below standards ☐ 3) meets standards ☐ 4) above standards ☐ 5) It is not our responsibility ☐

9. Please rate your opinion on the quantity, accessibility ,and quality of green spaces in your city

| **Rates** | 1) Far below standards | 2) below standards | 3) meets standards | 4) above standards | 5 )I have no Idea |
|---|---|---|---|---|---|
| 8.1 Quality of green spaces | | | | | |
| 8.2 Accessibility of green spaces | | | | | |
| 8.3 Quantity of green spaces | | | | | |

10. How much the following constraints contribute for less quality green spaces in rapidly urbanized cities like Debre Berhan and Debere Markos?

| **Factors** | 1. none | 2. low | 3. medium | 4.high | 5. very high |
|---|---|---|---|---|---|
| 9.1 Poor green space planning | | | | | |
| 9.2 Financial problem | | | | | |
| 9.3 Lack of coordination between stakeholders | | | | | |
| 9.4 Absence of proper Implementation strategies | | | | | |
| 9.5 Land-use change | | | | | |
| 9.6 Lack of maintenance and proper monitoring | | | | | |
| 9.7 Others(specify) and rate-------------- | | | | | |

11. To what extent your organization's focus on sustainable development and growth in green spaces?

| **Rates** | Low | Medium | High | Very high |
|---|---|---|---|---|
| 12.1 Quality of green spaces | | | | |
| 12.2 Accessibility of green spaces | | | | |
| 12.3 Quantity of green spaces | | | | |

12. please rate your awareness and experience about green space planning models

| Models | Not at all aware | Slightly aware | Moderately Aware | Very Aware |
|---|---|---|---|---|
| 10.1 Opportunistic model | | | | |
| 10.2 Space standards—a quantitative model | | | | |
| 10.3 Park system model | | | | |
| 10.4 Garden city – a comprehensive planning model | | | | |
| 10.5 Shape related models | | | | |
| 10.6 Landscape related models | | | | |
| 10.7 Ecological determinism | | | | |

13. Please rate your experience on these green space planning models

| Models | Never practiced | Slightly practiced | Practiced | Highly practiced |
|---|---|---|---|---|
| 10.1 Opportunistic model | | | | |
| 10.2 Space standards—a quantitative model | | | | |
| 10.3 Park system model | | | | |
| 10.4 Garden city – a comprehensive planning model | | | | |
| 10.5 Shape related models | | | | |
| 10.6 Landscape related models | | | | |
| 10.7 Ecological determinism | | | | |