Green space Accessibility and Distribution: in the case of Gelan town

Kormu Teferi Dafersha

A thesis Submitted to

The department of Architecture

School of Civil Engineering and Architecture

Presented in partial Fulfillment of the Requirement for the Degree of Master's in Urban planning and Design

Office of Graduate Studies

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Adama, Ethiopia

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Advisor Doctor Yared Girma

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Declaration

I declare that this thesis entitled "Green space Accessibility and Distribution: in the case of Gelan Town" is my own work and has not been submitted to any university for similar purpose. The references used in this thesis are duly recognized by proper citations.

Kormu Teferi Dafersha ________________________ _____________________

Name of student Signature Date

Recommendation of Advisors/ Supervisors

I, the major advisor/supervisor of this thesis, hereby certify that I have closely advised/supervised the student while developing this thesis/dissertation entitled "Green space Accessibility and Distribution: in the case of Gelan Town," prepared under my guidance by Kormu Teferi Dafersha.

Therefore, I recommend the submission of revised version of the thesis to department following the applicable procedures.

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We, the advisors of the thesis entitled "Green space Accessibility and Distribution: in the case of Gelan Town," and developed by Kormu Teferi Dafersha hereby certify that the recommendation and suggestions made by the board of examiners are appropriate incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Reviewers of the thesis open defense by Kormu Teferi Dafersha have read and evaluated the thesis/dissertation entitled "Green space Accessibility and Distribution: In case of Gelan Town" and assessed the understanding of the candidate about the thesis research. This is, therefore, to certify that the thesis/dissertation is accepted for partial fulfillment of the requirement of the degree of Master of Science in Urban planning and Design.

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Table of Contents

List of tables

List of Figure **page**

LIST OF ACRONYM

AOSSA- Area Out Side Service Area

WHO-World Health Organization

GCI - Green Space Cool

GIS - Geographical Information System

GS- Green Space

OG -On Ground

PCI -Park Cool Island

PCGSSA - Percent of City Green Space Service Area

PGS-Percent of Green Space

SA-Service Area

SP-structural plan

TCA - Total City Area

TGSSA -Total Green Space Service Area

TP- Total population

UGS- urban green space

UN- United Nation

WGS - World Geodetic System

Abstract

Green spaces are essential components of urban environments, providing numerous benefits to residents. However, their accessibility and distribution are often unequal, leading to inequitable access to these benefits. Hence, the objective of the study is to assess the accessibility and distribution of green space in Gelan town. The study used ArcGis10.5 to analysis the accessibility and distribution of green space in Gelan Town from Town Structural Plan; and also used aerial image and site visit to see the current condition of the green space. Using these methods the accessibility problem and distribution problem is detected. In addition to accessibility and distribution problem, the existing green areas are so little and have low quality. As have seen by site visit some sites detected do not even been planted plant and it is difficult to say it is green space. There is no amenity; so there should enough green space and the existing green space should be clean, amenity should be included and should be developed to serve the residents. If it is not developed and clean, it will be harmful site than recreation area, it will cause health problem than health benefit. So the green Area should be fairly distributed within the city and residents should get quality green space within 500m as it is recommended by our urban green space standard manuals and guide lines.

Key words: *Green space, Gelan Town, accessibility, distribution, road network analysis, Hazard.*

Chapter One

1. Introduction

The unstoppable urbanization is growing at fast rate with opportunities and with its' negative impact on environment globally as well as our country. Reports show more than half of our world population live in urban currently. Predictions indicate that by 2050, two-thirds of the world's 9.8 billion people will live in urban areas (United Nations [UN] 2015b as cited in World Bank 2018). This fast growing urbanization plus industrialization degrades natural elements and replace with artificial and it causes hazard if not proactively planned and not managed correctly. High industrial activities endanger many components of the natural environment such as water, soil and air (Starczewski et al., 2023). Extreme heat is a growing threat to the health of urban ecosystems, particularly in densely populated and industrialized cities (Amberber et al., 2020 as cited in Degefu, et al., 2023). Urbanization induces high pressure on natural resources and threats to compromise the quality of life within urban centers (Mazza and Rydin.1997, Liu, 2008).

Gelan city is a fast growing city and is industry hub. This urbanization and industrialization will cause different pollution in addition to destruction of green space as have indicated by many researches. This in turn will cause natural changes, environmental pollution and different hazards.

So finding solution is our mandate and to combat this, many studies recommend green space is the most important things in urban. Urban green infrastructure is identified as an alternative nature-based and cost-effective remedy to some of these negative consequences (pakzad and Osmond, 2016).

Therefore, this research analysis and assess the accessibility and distribution of green space in Gelan City and compere with standards to proactively put solution for the problem.

1.1 Background of the Study:

Many literatures indicate that, urban population is more than half of world population. For the first time in human history, over half of world's population is now living in urban centers (United Nations, 2014). Net population growth is now occurring almost entirely within urban areas and by 2050, urban environment will need to accommodate an additional 2.6 billion people, including 86% of the developed world and 64% of the developing world (Potter 2013 as cited in Girma 2019).

Gelan town is experiencing a rapid population growth. With this rapid population growth, there is an increase in density of built up area, expansion of housing, infrastructure development, and restructuring of industrial areas in the city. This causes the depletion of green space and threats the sustainability of the City.

Urban Green Space is very important for cities of our world. About green is about life on earth at all. But urbanization degrades green and constructs the gray. Urbanization causes high pressure on natural resources and threats to compromise the quality of life within our world urban areas (Mazza and Rydin.1997, Liu, 2008). Nowadays, cities share only 2.7% of the Earth's surface (UNESA 2014 as cited in Azagaw & Warku 2020), but use 75% of total energy, release 80% of greenhouse gas and have generically had a harmful effect on natural resources (Gret-Regamey et al. 2013). These results show that we should think of urban green area when we design and construct our cities. It is more important than gray, it is the matter of life, not only of aesthetics.

Nowadays our world countries and cities put different share of urban green space in their cities to combat these problems proactively. As standard 30% of our city should be green space, but Ethiopian written manual by Ministry of Urban Development, Housing and Construction says; In Ethiopia, the establishment and management of UGIs across the urban centers have not been uniform and there is a great deal of variation among the urban centers.

Green spaces and other nature-based solutions offer innovative approaches to increase the quality of urban settings; enhance local resilience and promote sustainable lifestyles, improving both the health and the well-being of urban residents (World Health Organization (WHO 2017). Again WHO (2017) says Parks, playgrounds, Gardens, Wetlands, outdoor sports facilities, amenity green spaces, Cemeteries, river sides, cycle tracks or vegetation in public and private places are a central component of these approaches. It is therefore necessary to ensure that public green spaces are easily accessible for all population groups and distributed equitably within the city (WHO 2017).

Accessible and safe green spaces may be important to people's sense of well-being and mental health and a positive influence on levels of physical activity. WHO (2017) says Parks, playgrounds or vegetation in public and private places are a central component of these approaches and can help to ensure that: urban residents have adequate opportunities for exposure to nature, urban biodiversity is maintained and protected, environmental hazards such as air pollution or noise are reduced, the impacts of extreme weather events (heat waves, extreme rainfall or flooding) are mitigated, the quality of urban living is enhanced and the health and well-being of residents is improved.

Different studies use different methods to analysis and assess conditions of urban green spaces; ArcGIS is good, accurate and simple method to analysis the accessibility and distribution of urban green space. There are two common methodologies to study green space accessibility using GIS. They are buffering and network analysis. By comparing the two approaches, the network analysis approach is more accurate and suitable for analysis of urban green space accessibility. Why network analysis approach is preferred is that, it has an advantage over the covering approach as it reflects the actual travel and avoids all the barriers that make routes inaccessible by pedestrians (Moseleya et al. 2013). So this Thesis used network analysis approach to analysis the accessibility and distribution green space in Gelan City.

The other important approach researchers uses for urban green space study is urban green space (UGS) per capita. The most used quantitative indicator to assess urban green infrastructure is urban green space (UGS) per capita. Even though different countries recommend different per capita, The National Urban Green Infrastructure Standard of Ethiopia propose $15m^2$ per capita public green open space with in 500m from a public green open space that is at least 0.3 hectares in size

1.2. Statement of the Problem

About green is the concern of our world. But many studies indicate urbanization with fast growing population is damaging green spaces as world as well as our country. Gelan is one of the fast growing cities in terms of population growth and industrialization. This population growth and industrialization have high impact on distribution and accessibility of green space in Gelan Town. Currently, the Percent of land for green space is small. Standard says 30% of land should be green space in cities. But this cannot be found on ground in the Towns. On the other hand the green space have no form and not clean /not protected well/. People dump waste in it and it is grazing place for animals. So what we have to know is that, having many green spaces only is not the goal; the existing should be well developed and well protected. Otherwise it cannot be recreation area, in contrast will be dirty area and cause other problem. So the city should have enough distribution and accessible green space with clean and well developed green space.

But attention is not given to the green space in Gelan. Even the existing Green spaces are under degradation due to expansion of housing, industries, hospital and construction of many other institutions expansion.

For our cities this problem is not studied and given solution. Even though the distribution, accessibility and quality problem for our city urban green space is almost similar for our cities, what makes Gelan different is that Gelan Town is industry zone and should be given more attention by green infrastructure. But there is no study done about this case for the Town. So intention of this study is to fill this gap.

1.3 .Objectives

1.3.1. General objective

The general objective of the study is to investigate the accessibility and distribution of green space in Gelan town.

1.3.2. Specific objectives

The specific objectives of the study are:-

I. To assess accessibility of green space in Gelan Town
II. To determine the distribution of green space in the study town
III. To assess whether the structural plan and green space on ground match or not.

1.4. Questions

IV. What do accessibility and distribution of Gelan City green space looks like?
V. What is a solution to this accessibility and distribution problem?
VI. How is the distribution and accessibility of the existing green space of the study town when we compere it with Structural Plan of the Town?

1.5. Significance of the Study

The study's goal is to examine accessibility and distribution of Gelan City green space. The final output of this study will provide information for Policymakers, urban planners, land administration, and environmental protection office: -

- ✓ To form and implement more coherent and sustainable urban planning strategies regarding green space planning, managing and monitoring of natural resources.
- ✓ And to serve as an input parameter in many fields as geology, hydrology, and environmental studies.
- ✓ Further researcher will be interested in the findings of this analysis because it will add to the current realistic and theoretical knowledge base on urban green space.

1.6. Scope of the study

The Geographical scope of this study is Gelan town which is known as industry zone and the research covers the whole area of the town. Conceptually, this research focus mainly on Green Space analysis of current time and recommend the best accessibility and distribution of green space for the town. The research assess the accessibility and distribution of green space in Gelan town, compere with national and international standards and give recommendation of the best accessibility and distribution of Green Space for the town to create sustainable city. The study used Primary and secondary type of data to assess the condition of the green space in the Town and also used both qualitative and quantitative type of research.

1.7. Limitation of the study

The accuracy and reliability of the predicted accessibility and distribution of urban green space will ultimately depends on input data and the Analysis methodologies. The high spatial resolution of remote sensing data interpretation is required to obtain better results when we do analysis (Chaudhuri & Clarke, 2013). In this research photo from Google earth pro which is difficult to identify green space is used. But the accurate map was a challenge from such images of coarse resolution. It was difficult to make a clear distinction between different land use features classes. using High Spatial resolution Satellite image such as Quick bird, IKONOS, Geo Eye, World view, and SPOT will provides better and detail information with good quality to analysis and overall accuracy may greater than the value obtained in research.

1.8. Operational Definitions

Accessibility indicates how far the residents are from green space; and is measured in meter. It measures if the resident can get green space in a distance less than 500m from their home or cannot. Our country Standards recommend Residents of urban should get at list 0.3 hectare of green space within 500m. That means 0.3 hectare is the list requirement.

Distribution indicates how the green spaces are distributed in the city. It shows if the green space is similarly distributed over the whole City or not; that is it indicates whether one neighbor have many green spaces and other do not have or not. Distribution is the matter of equity. Green space should be equally distributed in the town; it should not be competed in some area.

Chapter Two

2. Literature Review

This chapter focuses on the theoretical and empirical literatures regarding distribution and accessibility of open space and findings of relevant literature are reviewed and discussed. The review focuses on the basic concepts of green space distribution and accessibility as well reviews how to analysis urban green space accessibility and distribution.

2.1 Theories of green space

Researchers have started to focus on the distribution of green space access in urban settings. Different countries use different standards of green space. Comber et al. (2008) studied green space access for different religious and ethnic groups in Leicester, UK. Kuta et al. (2014) studied urban green space accessibility for different socio-economic groups in the UK as well and they found that socio-economically deprived group lack access to green space within 300m from the residence. Sotoudehnia and Comber (2011) studied physical and perceived accessibility to urban green space in the UK, and they found that only 15% of the population meets the physical access up to 300m. The above examples indicate that the awareness of environmental justice and urban green space are increasing and more people care about environmental inequality. More importantly, these studies found that environmental inequality does exist in many places in the world. It is necessary to understand how to solve this inequality issue that is using the correct principles accessibility and distribution.

According to Davis et al. (2015), green space planning is understood as a process targeted at strengthening connectivity between individual green spaces while recognizing and supporting their multiple functions and promoting social cohesion. Different scholars presented different principles that have to be followed in designing urban green spaces. Kambites and Owen (2006), Lennon and Scott (2014), and Hansen and Pauleit (2014) presented four basic principles. According to Lennon and Scott (2014), multi functionality is one of the principles that refer to the ability of green spaces to provide several functions and benefits on the same special area. Thereby, hypothesizing this principle is to combine ecological, social, economic and cultural functions of the green space (Pauleit et al. 2017). According to Pauleit et al. (2017), planning of green spaces for multi functionality has to be built on understanding of society’s demand which has to strive for access to multiple green space benefits regardless of socioeconomic benefits.

Green-Grey integration is the other principle. Green-Grey integration is creating physical and functional integration and coordination of green spaces with other urban infrastructure (Hansen and Pauleit 23 2014). Different studies pointed out that storm water management is amongst the prominent function of green-grey integration of urban green spaces. Furthermore, infrastructures like bike paths, green corridors for natural ventilation and green roofs for cooling are also the benefits that can be entertained from the design principle of green-grey integration (Hansen et al. 2017).

According to Pauleit (2014), Connectivity is the third important principle. Connectivity in green space design is applied to improve social connectivity (better accessibility), ecological connectivity (dispersal of plants and animals), abiotic connectivity (water and climate regulation). Lennon and Scott (2014), explain greens pace connectivity in different way; which is spatial, scalar and institutional connectivity. Spatial connectivity refers the physical connection of different green spaces across the landscape. Scalar connectivity deals with the need for coordination and consistency among spatial and administrative scales. Institutional connectivity implies, partnerships and cooperation among different administrative organizations and integrated governance should be considered in the planning of green spaces.

According to Pauleit et al. (2017) the fourth principle is Social-inclusiveness. Social-inclusiveness is a process of ensuring equal opportunities for all society without segregation regardless of their background (Hansen and Pauleit 2014). Urban green space plan which fails to fulfill this principle of social cohesion increase social inequalities. Socially inclusive urban in urban green space planning can help to foster social cohesion and to address questions of equal access to urban green infrastructure and user needs into account (Hansen et al. 2017). “The construction of UGS can continuously improve the urban environment and form a good urban brand, thereby increasing the visibility of the city year by year” (Pang et al., 2023).

(UN-HABITAT 2010) says The pursuit of carbon-neutral cities, through the increase in green areas within cities and the use of ecological services, often combined with efforts to close the energy/materials loops of cities, decentralize renewal energy production and reuse waste, has recently emerged as a way to increase synergies between build and natural environment in cities; Patterns of urban growth can be influenced to reduce carbon emission, by promoting more compact cities, and ensuring better access to collective or non-motorized transport. Also United Nations Human Settlements Programme (UN-HABITAT), 2010 says Resilience to potential environmental disasters can be increased through proper urban and land use planning.

As Manual for development of open green spaces in communal housing areas (2015), the most recognized benefits of green spaces around areas built up for human habitation include:

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

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

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

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

The presence of well-developed and well managed green spaces in and around residential areas in general contributes to the rise in property values.

• The annual energy saving due to cooling effect of green components around living quarters in hot climate areas or during hot seasons has been estimated in monetary terms to be very huge sum of money. The presence of trees in close vicinity of residential buildings brings a great deal of cooling effect in and around living quarters by absorbing solar radiation.

• Open green spaces also provide ecological benefits related to the provision of habitat to wildlife and biodiversity conservation.

• Climate amelioration and reduction of urban heat island in built areas is another very significant ecological benefit of greening the built up areas

• Trees and shrubs absorb carbon dioxide and thus contribute to the mitigation of the impacts of climate change.

2.2 Role of green space for Cities

Urban heat island can be expected to become a major challenge in the future urban life. In general, the methods currently available for this purpose can be categorized into four groups as seen from studies: the use of vegetation cover like trees, shrubs and lawns at different scales (Gago et al., 2013; Mackey et al., 2012), the stack night ventilation (Kolokotroni et al., 2006), the use of water bodies(Gunawardena et al., 2017; Moyer and Hawkins, 2017; Daniel et al., 2018), and the use of materials with high albedo rating for pavement and other ground surfaces (Pacheco-Torgal, 2015; Santamouris, 2013; Li et al., 2013a,b; Taha et al., 1988). So we also should plan and use these options for our city Gelan.

The effectiveness of green infrastructure in reducing urban thermal islands is already proven through measurements (filed measurements, scale models, and thermal remote sensing), and computer simulation (Farhadi et al., 2019; Lai et al., 2019; Z€olch et al., 2016; Norton et al., 2015; Chow and Brazel, 2012; Wong and Yu, 2005). The literature related to this subject consists of broad investigations into green infrastructure of different shapes and scales (Wang and Banzhaf, 2018), including small local parks(Ca et al., 1998; Aram et al., 2019), large urban parks (Petralli et al., 2009; Buyadi et al., 2015), urban forests (Oke et al., 1989; Brandt et al., 2016), urban gardens (Mazhar et al., 2015), green roofs (Santamouris, 2014; Alcazar et al., 2016; Besir and Cuce, 2018), green facades (Demuzere et al., 2014; Manso and Castro-Gomes, 2015), and street trees (Lobaccaro andAcero, 2015; Shahidan et al., 2010; Klemm et al., 2015).

The majority of investigations into the effect of features and dimensions of urban green spaces (UGSs) on UHI have been conducted over the past ten years (Akbari and Dionysia, 2016). According to a review study published in 2010 (Bowler et al.), green infrastructure (trees, parks, forests, and green roofs) have a higher level of thermal comfort than other urban spaces. This is especially true for larger parks and urban forests (UGS), which can have up to 0.94 _C lower daytime temperatures. So Gelan City should have the correct green space distribution and accessibility.

Recent review study has shown that thermal comfort and the UHI reduction effect of a UGS depends on its size and shape. According to this study, the cooling effect of an UGS is directly correlated with its vegetation cover and tree shade area (Jamei et al., 2016). In a recent review paper by Taleghani (2018), among the strategies for reducing the effect of UHI, the role of effective UGSs has been emphasized. By taking six Urban Parks Studies (UGS) into account, it has been demonstrated that these spaces play a major role in UHI reductions. Hence, thanks to their vast area and diverse vegetation cover, urban parks have a much more significant cooling and thermal comfort impact than small green spaces (Givoni, 1991). As a result, these parks have become known as effective countermeasures against the UHI effect. In the urban studies and sustainability literature, the cold aura around urban parks has become known as “Park Cool Island” (PCI) (Cao et al., 2010; Spronken Smith and Oke, 1998) and lately, as “Green Space Cool Island” (GCI) (Martins et al., 2016; Du et al., 2017). A recent study by Bartesaghi Koc et al. (2018) showed that from all the studies conducted on the cooling effect of green infrastructure, the contribution of the cooling effect of parks and UGSs was 10.9% (PCIs: 6.7% and GCIs 4.2%). PCI or GCI generally refers to the cooling impact of an UGS not only on the area within the park but on the surrounding area as well. Modern development planning science considers the UGS cooling effect to be a highly effective solution for dealing with thermal islands. Although the growing public and academic attention to UHI has encouraged research into this subject, the studies and findings in relation to the cooling effect of UGSs are yet to be summarized in a review. While there are some review studies on the cooling effect of urban parks, they are not specific and also cover other green infrastructure such as street trees, green roofs and green facade (Bowler et al., 2010; Jamei et al., 2016; Taleghani, 2018). The present study aims to review and categorize the recent studies carried out regarding the relation of characteristics of UGSs to their cooling effect, in order to facilitate the study of data collection and analysis methods commonly used in this area, and thus assist future planning and development attempts to use urban parks and urban gardens for creating the cooling effect and countering the UHI effect.

2.3 Best practice about urban green space planning in urban area

China: Supporting Sustainable Urbanization

The UN-HABITAT Sustainable Urbanization Project in China has developed viable models for Chinese cities to integrate local Environmental Planning and Management (EPM) processes into urban strategic planning, with sustainable urban development as a long-term goal. The project was introduced in Shenyang and Wuhan cities, where rapid economic growth has caused significant environmental degradation. The project supported the environmental bureaus in the cities to formulate and implement environmental response strategies and detailed action plans which addressed priorities such as air pollution, liquid and solid waste management, and the depletion of water resources through innovative participatory environmental governance mechanisms. Environmental issues were brought to the forefront of urban development planning and decision making processes through the application and testing of innovative participatory environmental governance mechanisms.

One of the outcomes of the project, the Shenyang City Air Quality Management Strategy helped the city to drop out of the list of the 20 most polluted cities in the world. Lessons learned were developed into national guidelines by China's Administrative Centre for Agenda21 (ACCA21) based in Beijing and applied to three other cities: Guiyang, Hailin and Panzhihua, which went on to improve their city environmental planning and management capacities.

Figure 2. 1 beautiful green space

Increasing the amount of vegetation is one of the most effective strategies to mitigate the effects of the urban microclimate (Wilmers, 1988; Dimoudi and Nikolopoulou, 2003; Synnefa, 2008; Takebayashi and Moriyama, 2009; Xua et al., 2010). This can be achieved by tree plantation both in residential and municipal tree plantation programs (Sailor 2006). Trees contribute to reducing the heat island effect by their evapotranspiration (Akbari 2001; Dimoudi and Nikolopoulou 2003). Again, trees have a direct effect on reducing the UHI effect as it absorbs CO2 (Akbari 2001).

According to Robitu 2006 and Pearlmutter 2009 empirical derivations also demonstrated reduced temperature if green vegetation is applied. The statement is also backed by Steenveld 2011 and Heusinkveld 2012. In the heart of cities, as the human gathering is huge, the emission of huge amount CO2 leads to the increase of temperature. Increased number of trees will help to mitigate the condition by absorbing CO2. Theuwes carried out an experiment in Rotterdem by using two tricycle equipped with instruments to measure 3D radiation components, temperature, humidity and wind speed. Their bike traverse supported the finding of the previous research. According to Theuwes temperature usually decreases by 0.6K for each 10% addition of vegetation. For this mitigation strategy, it should also be taken into account that trees hinder the natural flow of air within the urban areas (Heisler 1989). So, cooling breezes may not work effectively.

Shade trees are those with a huge canopy and can provide protection to houses and pedestrians from direct sunlight keeping them comparatively cool. Shade trees also help to cut down the temperature by evapotranspiration process (Sailor 2006). In the United States, near about 200,000 shade trees were planted every year between 1992 and 1996 as a strategy to mitigate heat islands, protect climate, and improve air quality in urban areas (Scott 1999).

The principal role of shade trees is that sunlight is intercepted by it keeping the buildings comparatively cool (Akbari 2001). It reduces the building air conditioning, lowers the air temperature and improves the air quality. Planting shade trees involve some sort of maintenances and cost pertaining to it. Estimation given by Akbari (2001) states that the savings associated with the benefits of shade trees may be up to $200 in its' entire life.; and the maintenance cost may range between $10 to $500 per tree.

At the same time, shade trees need several years to grow up and start protecting a building from severe heat. Shade trees are also vulnerable to extreme storms posing threat to human life (Sailor 2006). The routes of these trees may also affect the foundation of the adjacent buildings and streets. Again, there may not be enough space in a land property to plant a shade tree. This is a problem in densely populated countries like Bangladesh, India, China, etc. So, before going for this option, careful judgment should be made to handle all the situations properly.

Adinna (2009) assessed the impact of urban heat island effect in the Enugu city of Nigeria and suggested adaptive measures to keep UHI effect under control in the city. Their study concluded that the use of high dense green vegetation roofing materials and lightening of pavement materials can reduce the effect in Enugu urban.

Yamamoto(2006) described several mitigation measures for UHI effect and also gave description about some mitigation projects in Japan and other counties including the wind paths in Freiburg in Germany. He recommended some key mitigation measures like energy saving buildings and traffic systems, restoring green areas in urban areas and improvement airflow. Sadoudi (2014) simulated three different strategies using ENVI-met to observe their usefulness to mitigate the UHI effect in Tehran. They considered the following three measures: (1) High Albedo Materials (HAM) (2) Vegetation and Green roofs (VEG) and (3) Combination of both of them (HYBRID). According to them HYBRID was the most effective mitigation measure as the result showed that it reduces the temperature of Tehran city by 4.2K at daytime. On the other hand, only 0.5K of cooling effect can be achieved at daytime by using HAM.

Rosenweig (2006) used regional climate model (MM5) combining meteorological data, satellite and GIS data to determine the influence of urban forestry, living roofs and light surfaces on UHI effect in the New York metropolitan area. They analyzed the New York City heat island effect model by taking six case study areas and tested the mitigation strategies. They found that vegetation helps to keep surfaces cool more effectively than increasing the albedo.

But they suggested that in order to reduce the temperature in New York City, replacement of low albedo materials with high albedo light colored materials will work great as 64% of the surface area of the city can be replaced easily. A study was conducted using a mesoscale model (MM5, version 3-6-1) over the city of Athens, Greece. They considered two scenarios: a moderate and a large scale increase in albedo scenario. They concluded that use of high albedo materials in a massive scale can lower the temperature.

2.4 Typology of open space

An urban open space typology had recently been proposed by the green spaces taskforce, two major types of urban open spaces which are green spaces and civic spaces. The purpose of this typology is to provide a nationwide basis for planning and development of open spaces strategies. Typology of open spaces according to (Herzele and Wiedeman, 2003) had been done from the user's point of view into three groupings; domestic, neighborhood and civic based upon the concept of home range and discussed in detail as follows:

2.4.1 Domestic urban open spaces

Domestic open spaces are physically associated most closely with the home and socially are likely to be used mainly by the family, friends and neighbors. Domestic open spaces are further divided into; Housing, Private gardens, Community gardens and Allotments. (Huang and Wang, 2009)

a. **Housing: -** Some people’s homes are set within a network of green spaces and so these maybe experienced while living in this location from childhood through youth, adult life and into old age.

b. **Private gardens: -** Private gardens can often be the first experience of open spaces in life. As a child these can be very important places for individual and group play with memories that are carried into adult life. In adult life the garden can play a different role relaxation, gardening, games and passive recreation.

c. **Community gardens:-**Community garden is understood to be a communal garden that is a semiprivate space shared between a small numbers of dwellings.

d. **Allotments: -** The contemporary use of allotments is usually for growing fruit and vegetables, although some people use these spaces for growing flowers. The use of allotments over the years has varied with changes being influenced by national land use requirements, legislation and personal choice.

2.4.2 Neighborhood urban open spaces

Neighborhood urban open spaces are physically not directly related to the home but to the neighborhood and community within which one lives. Socially, these spaces will be used not only by family, friends and neighbors but also, predominantly, by others within the community who are likely to live within the vicinity of the space.

Neighborhood urban open spaces are those that are part of the neighborhood in two ways according to (Stein and lee, 1995).

a. **Parks:-**Parks are experienced very early in life very often the playground used by young children is in their local park. But parks are also used at different times of life and perhaps early use of a park in childhood encourages adult use.

b. **Playgrounds:-**A playground should not be 'an island' isolated from the rest of the neighborhood, but one of the places that children have access to in the neighborhood Playgrounds, one assumes, are predominantly provided for children even if they are not designed in the ideal way a child might like. But it must also be acknowledged that playgrounds provide opportunities for some parents and careers to meet and discuss issues of school, health, community and life in general.

c. **Playing fields and sports grounds: -** Playing fields and sports grounds are the open spaces within the urban framework that most directly provide opportunities for active activities, and thereby for improving physical health. In this way playing fields become a part of life, and the regular weekly routine, for some people within our communities but not for everyone.

d. **School playgrounds:-**School playgrounds are experienced by everyone because everyone attends school; thus the impact that school playgrounds have on childhood is very important and very often overlooked in life. An imaginatively designed and well maintained school playground can have a positive impact on early life, while a poorly designed and maintained school playground can result in a range of social and educational problems.

e. **Streets:-**Streets are experienced by all from a young age, but the quality of that experience is vastly different. If a street has a lot of traffic then the experience will be dominated by vehicles and the concept that the street is only for travelling along as fast as is possible. When a street has a lower level of traffic it may be more person-friendly and in some instances may allow for play, in a way that many streets did in the past.

f. **City farms: -** City farms are available in some urban locations. They give an opportunity for experience with farm animals together with other forms of nature and are considered important as an educational resource for children and as a community resource for adults.

g. **Incidental spaces and natural green space: -** Incidental spaces can be used as they provide a range of opportunities for people in the city, including play for children. This has clearly been the case with community gardens where such facilities have often sprung up on plots of land following the demolition of other buildings.

2.4.3 Civic urban open spaces

Civic urban open spaces are those that are set within the urban context but which are, usually, physically farthest from the home or are places at strategic or specific locations. Such spaces are more of a social mix where one is most likely to meet people from different walks of life and from a different physical part of the conurbation. Open spaces within this group naturally fall into the separate groupings of commercial, health and education, transport and recreational.

Commercial: - Include squares, plazas, water features and office grounds**.** Squares, plazas and spaces associated with offices have an obvious commercial link, while water features not necessarily a space within their own right but often an element within a space may not, and might argue that these should have been included with health or recreational open spaces or even within the neighborhood category. Of course water features of different types can exist in any type of urban open space, but they have been included with civic commercial spaces because they are often to be found within the setting of a square or office grounds.

Plazas: are larger urban spaces than squares, not small, confined areas but significant spaces in size. They may be designed for one purpose but used for others. This has particularly been the experience in many American cities over the last forty years.

Water features: often appear in squares or plazas, places that one might consider to be part of adult business and retail life.

Office grounds: are definitely adult experiences but are not experienced by all adults only those who work in such locations.

a. **health and education:-**Hospital grounds and university campuses seem to form a sub-grouping and although courtyards and roof gardens could be, and sometimes are, associated with spaces such as offices, they are included here because there is a tradition of these types of spaces being associated with these two major types of buildings.

b. **Transport:-**Urban open spaces relating to the transport system of a conurbation can easily be overlooked, or even completely forgotten about Some of these spaces are no longer used for their original purpose such as some ports and docks while transport and waterway corridors such as rivers, canals, railways and roads are still primarily used as part of the transport network and in the case of the last are constantly increasing in volume.

c. **Recreational:-**Recreational urban open spaces are those which hold specific importance for a conurbation, not just a neighborhood, and where the primary use by people rather than the desire of the creator of the spaces is for recreation((Irum,Alamgir, Gul and Osman, 2002)

2.5 Planning standards About Accessibilities and Distribution of Urban Green Space

Different countries have their own different standards and principles of urban green space accessibility and distribution. WHO (2017) say, all urban green space should be physically accessible within a short distance of local residences with obvious and safe entrance points as well as safe and pleasant access routes (e.g. not having to walk across busy roads or through dangerous areas); Often, a 5 minute walk or a distance of up to 300m are defined as an acceptable distance.

Urban green space should be designed for universal access, with wheelchair friendly access points and trails and braille information signs; municipalities need to further ensure that the urban green space is also socially accessible –free of charge and welcoming and inclusive for all community groups (WHO, 2017). The literature related to this subject consists of broad investigations into green infrastructure of different shapes and scales (Wang and Banzhaf, 2018), including small local parks(Ca et al., 1998; Aram et al., 2019), large urban parks (Petralli et al., 2009; Buyadi et al., 2015), urban forests (Oke et al., 1989; Brandt et al.,

As standard of our country, 30% of our city should be green space, but manual by Ministry of Urban Development, Housing and Construction says, In Ethiopia, the establishment and management of UGIs across the urban centers have not been uniform and there is a great deal of variation among the urban centers.

2.6 Methodologies for Urban Green Space Accessibility and distribution Analysis

Researchers use GIS for analyzing green spaces accessibility, distribution and environmental justice. There are two common methodologies to study green space accessibility using GIS; buffering and network analysis (Nicholls, 2001). Nicholls (2001) says, from these, buffering is the simplest methods to measure accessibility and it defines the green space accessibility according to a specific distance and is represented by a buffer zone. As have seen from many researches, the reason why it is called the buffer approach is that, people who are within the buffer zone are considered they have access to the green space.

We can create the buffer zone around a point, a line, or a polygon by entering a specific distance. Studies use the buffer approach because the concept of a buffer is easy to understand and it plays an important role in many geo processing workflows involving proximity analysis (Flater 2011). Another method is called the network analysis approach. It is based on the actual distance of a point along the roads.

The network analysis approach is based on the actual speed and types of road. For this thesis, it is a desirable method to analyze the accessibility of urban green spaces because residents follow the actual road to the green space rather than using a straight line buffer radius to the nearby public green space, so it is more accurate for the analysis.

2.6.1 Buffer Approach to Measure Urban Green Space

The buffer approach, also known as the Euclidean buffer or covering approach, is based on a straight line distance and does not take any barriers, even if no road or walking patterns into account. GIS buffer analysis is used in several studies (Coutts 2010, 2013; Garg et al. 2018). Although this approach is simple and easy to understand (Coutts et al. 2013), it has shortcomings that it depends on Euclidian straight line distance that doesn’t consider real-world actual walking distance required to travel from location to location. It can be created based on a point, a line, or a polygon feature class in ArcGIS as we can see on figure 2.2. Ghanbari (2013) argues that the buffer approach can be efficient for simple and general analyses. However, for some complicated and that needs accurate analyses, the buffer approach is not a good because of its accuracy problems.

Photo from UCGIS

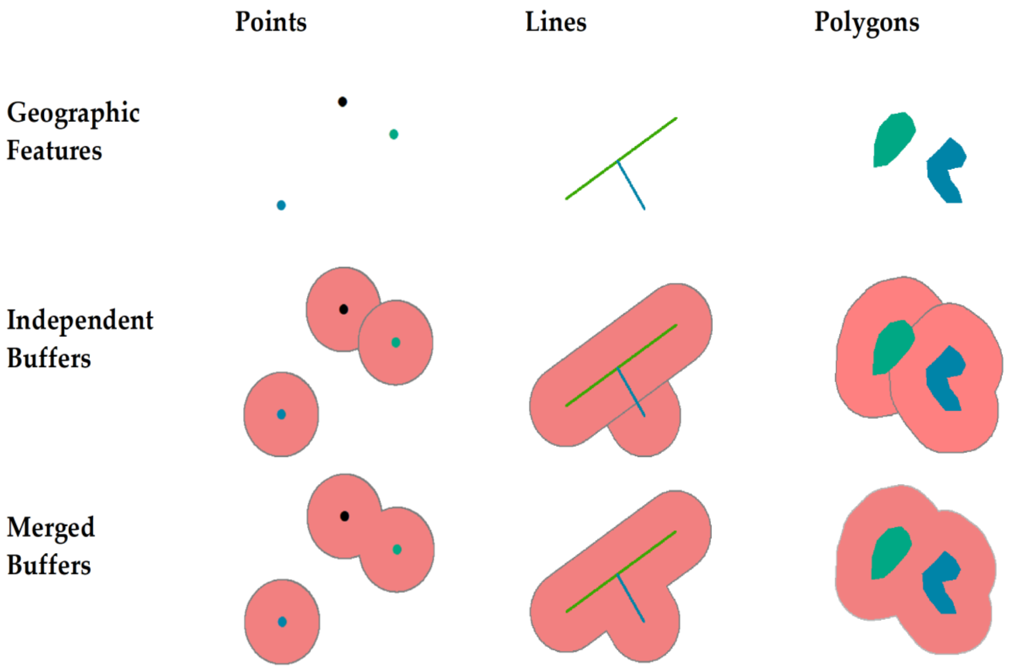

Figure2. 2 buffer around point, line and polygons

For example, Coutts et al. (2010) and Coutts et al. (2013) use the Euclidean buffer analysis in their research study. Both studies are quite similar and about how human health is related to green space access. Their study areas are in Florida and they use the census tract level and county-level as their scales. The Euclidean distance was adapted in this research which made this research less accurate as Euclidean distance is based on the straight-line, not the road network. In addition, Euclidean distance is a distance around a given location with a fixed distance or time and is shorter than the actual routes. As a result, errors occur when the user is following the actual routes to the parks or green space. It is less accurate to calculate the distance and time from one place to the parks and green spaces as it does not take barriers blockages into account.

2.6.2 Network Analysis Approach to Measure Urban Green Space

GIS Network analysis is frequently used in recent studies (Kuta et al. 2014, Kang et al. 2018, Ojiako et al. 2018) as it gives more accurate results. This is due to the fact that it calculates how much distance is required to travel from one place to another based on the network of existing roads and actual walking patterns (Kuta et al. 2014; Ojiako et al. 2018).

Network analysis, as mentioned above, calculates the access based on the road network and the types of road. In a network dataset, a junction is represented by a node and a street and other route is represented by a straight or curved line. A service area in network analysis approach is a region that encompasses all accessible streets that are within a specific parameter (ESRI ArcGIS Resources). For example, a 500m green space service area includes all the streets that can be reached within 500m from the green space access point.

The service area can be used to identify how many people can access the green space if the population within the service area is known. Furthermore, it can be used to calculate the shortest route from one point to other point and to provide the best routes between the points. The network analysis approach provides a much more accurate result than the buffer approach. Instead of using the covering or buffer approach, many studies prefer using the network analysis approach. For example, Comber et al. (2008) used network analysis to determine the parks and green space access for different ethnic and religious groups in the UK. Bennet et al. (2012) also used network analysis approach to measure the walking distance to the nearest playground and to estimate the number of users of a playground using the playground's service area. Kuta et al. (2014) applied network analysis approach to determine the accessibility to green space for socio-economically deprived groups. Pearce et al. (2006) utilized network analysis approach to measure community resource accessibility in New Zealand.

2.6.3 Comparing Two Approaches

By comparing the above two approaches, the network analysis approach is more accurate and suitable for analysis of urban green space accessibility. Why network analysis approach is preferred is that, it has an advantage over the covering approach as it reflects the actual travel and avoids all the barriers that make routes inaccessible by pedestrians (Moseleya et al. 2013).

Higgs et al. (2012) found that the results of the distance to green spaces will be affected when the research used the undesirable methodology. Using the wrong method leads to inaccurate results and wrong conclusion. The buffer approach could be used in some general and simple analysis. However, urban planning, for example, should consider using network analysis approach. Ghanbari (2013) compared the buffer approach and the network analysis approach and found that there are differences between these two approaches. The authors argue that barriers and times are the important factors that cause this errors in the buffer approach, and that urban planners should pay attention to these for planning and spatial management (Ghanbari 2013).

The buffer approach would be suitable when the researcher is interested in studying the geographic distance between points while network analysis approach is suitable when the researcher is studying transportation and travel times (Morganstern 2015). In addition, the network analysis approach is suitable when the scale is large so that the readers can clearly see the routes or areas in more detail. In this research, accessibility is calculated according to the street network due to that, the network analysis approach is the most suitable and appropriate to use.

Chapter Three

3. Materials and Methods

3.1. Description of the study area

3.1.1 Location

Gelan town is located in Special Zone surrounding Finfine. It is 25 km away from Finfine in South-East direction and nearly 7 km west of Dukem Town administration. Astronomically, it is located between 70 12’-9014’N Latitudes and 38032’ – 39032’ E Longitudes.

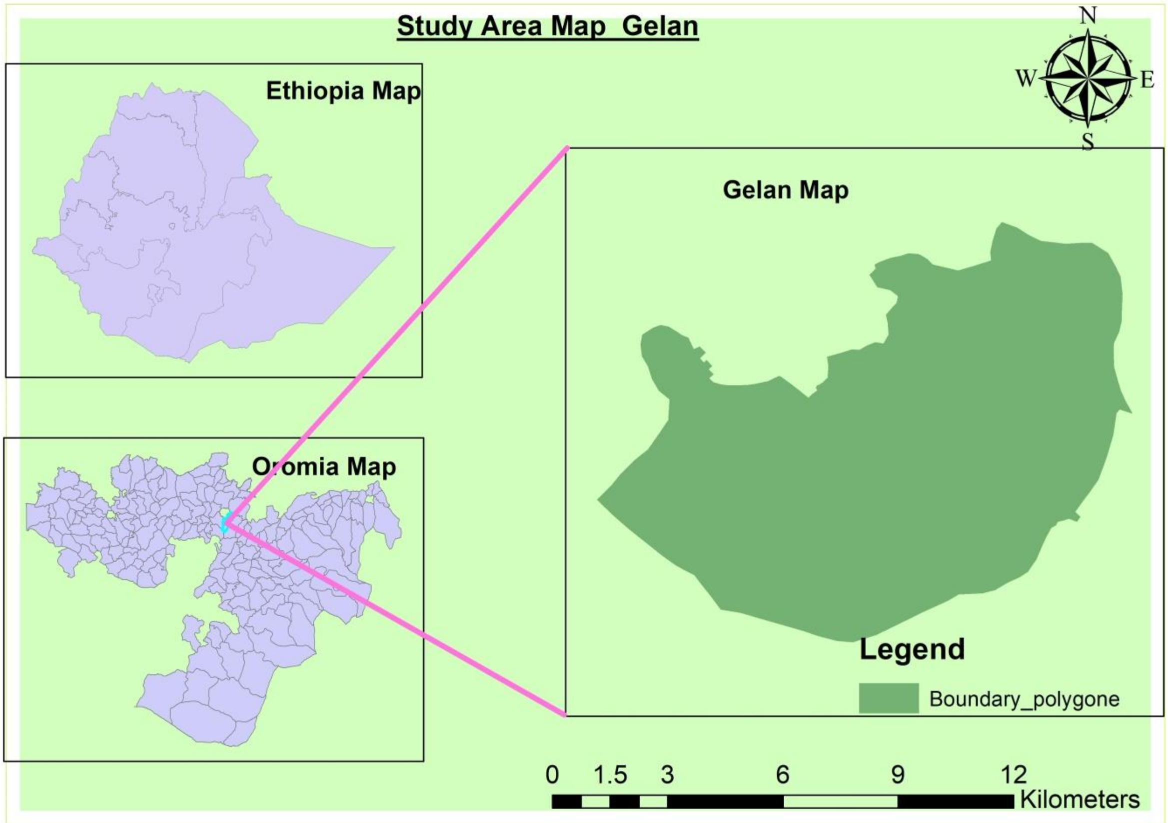

Figure 3. 1: Location Map of Gelan Town

3. 1.2 Ecology and Natural Resources

As written data about Gelan from the city administration shows, ecologically the area lies in wet land ecosystem. It is categorized in “Weinadega” Zone. The town is bounded by forest and nit soil and the climate is suitable for both human being and other living things.

As data from the city land administration: Currently the greenery area covers Small Area hectare which is only 5.76% area of the city; including forests, urban agriculture, unoccupied areas and other vegetation's (plantation) in parks or road sides;

3.1.3 Relief, Drainage and climate

The altitude of its land mass is found between 1500-3100m above sea level and highest place is known as Gara Bushu.

Photo from Gelan City Administration

Figure 3. 2: people watering plants +relief of the area

On the other hand, the lower elevation (1750m) is around "Merino Kebele" and the land mass has sub-tropical (Woinadega) which has an average of maximum temperature of about 170Centigrade (62.600f). Therefore, the mean annual temperature is 200c which is similar with the areas of tropical and sub-tropical climatic characteristics. This kind of temperature is ideal (suitable) for human habitation. Whereas an average rain fall distribution ranges from 700 up to 800mm and the mean annual rainfall is about 800-1800mm while the mean monthly is 154mm.

The town has no metrological station that can measure and predict its weather condition. However, an attempt has been made to adapt the Addis -Akaki weather condition which is the nearest metrological station. Accordingly, the south east trade winds account about 50% i.e. easterly winds are the dominant winds in the year.

The town is situated about 2140 meters above sea level. There are some hill side area, plateaus and plains of different elevations found in the town.

3.1.4 Vegetation and wildlife

3.1.4.1 Vegetation:

There is natural as well as man-made plantation. But not well protected and not developed

Photo from field survey

Figure3. 3: Unprotected and undeveloped green space

The surrounding mountains like "Gara Bushu, Tullu Guracha and Dambi Gara-Dhera" are covered by Eucalyptus trees. But East, North- East and south East direction of the town is covered with grass which is mixed with sparsely distributed acacia trees. On the other hand, naturally old trees (oda) are found here. Moreover the private compounds and business organization like:-The Wood Lands, Ramasa and Gelan recreation centers and Atlas Resort are covered with different species of trees. In addition manufacturing industries are also trying to implement the program of green by planting different species of trees in their reserved area for this purpose. This is because to mitigate or reduce the currently increasing Global warming.

3.1.4.2 Wildlife:

There is no reserved area for wild life conservation (parks). However, some species of wild animal such as rabbit, hyena, boar, foxes and echidna are found. In addition some species of birds are also live in different places of the town.

3.1.5. Socio-Economic Conditions

3.1.5.1 Population

Population dynamics of a given area is characterized on the variables such as fertility, mortality and migration. These demographic processes are complex phenomena that are affected by social, cultural, economic, political, and psychological factors. In urban environment, migration pre-dominates the role in changing the population characteristics and reflects the urbanization rate of towns. Migration refers to the spatial movement and change of residence of human population with in definite time and area. Migration is increasing from time to time because of industrial attraction for employment purposes. Additionally, seeking low live conditions especially from “Finfine” and other areas migrate to the town. This in turn increases the number of populations in some way or another.

There are many nations & nationalities that live in the town. They live & work together in harmony and also keep their identity and exercise their culture freely. Occupation wise, most of the residents are engaged in commercial activities, daily labor, farming and also employers in industries. The rest is retired people and kids.

According to data from the City Administration there are 85,115 total populations (Male 40232 and female 44883). But information from the City Administration show that the boundary of the city changed and so the population number may vary.

3.2. Research Design

To have a clear concept, assessing existing green space accessibility and distribution, the study was employed a descriptive research type which involve both qualitative and quantitative approach of data collection. And the research used different soft wares such as ArcGIS 10.5, AutoCAD, Google earth pro, Microsoft office word, Microsoft office excel to collect and process data. In addition related literatures were reviewed for further understanding of the problem that also would help the study as descriptive survey.

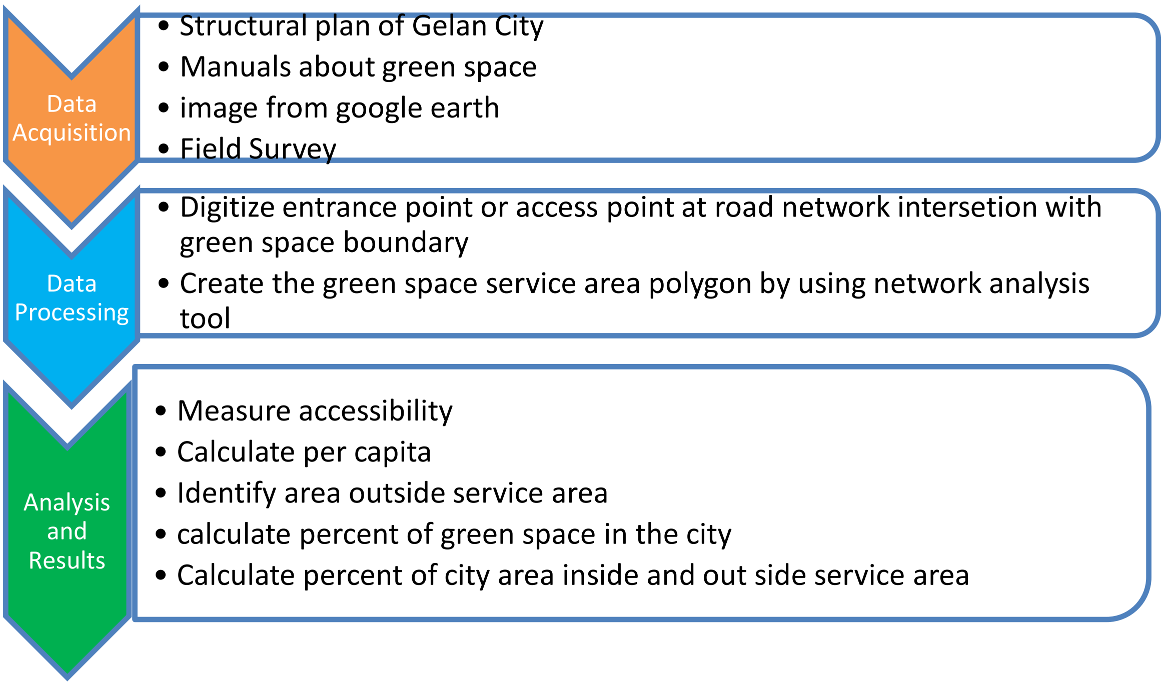

Figure 3. 4: summary of work flow

3.3. Research approaches

In the study both qualitative and quantitative approaches was used. Since qualitative approach deals with the subjective assessment of attitudes, opinion and behavior of researcher in the field survey about the urban green space. In addition to this, quantitative approach is also used to measure percentages and ratios of situation and existing factors relating to the accessibility and distribution of green space. The study use Network Analysis tool to get service area of the green space that can be accessed within 500m as the recommendation of National Urban Green Infrastructure Standard of Ethiopia. The National Urban Green Infrastructure Standard of Ethiopia propose 15m² per capita public green open space with in 500m from a public green open space that is at least 0.3 hectares in size. Besides recognizing that all methods have some shortcomings the use of both qualitative and quantitative is to ensure that biases inbuilt in either method will be neutralized by the strength of the other.

3.4. Data Type and Sources

The study used primary and secondary data. Many of the data used in the research were from Gelan Town Administration, from Land Administration and Land Administration Engineers of Gelan Town.

Types of data used in the research were, Structural Plan of the Town, areal image of the Town, Manuals and standards of urban green space of Ethiopia, and demographic data of the Town.

Table 3. 1: Showing Data Source and Purpose

No	Data	Purpose
1	Structural plan	To get the plan for the green space in the City. We can get area, distribution and accessibility of the green space using ArcGis10.5 from this data.
2	Arial photo	To cross check the plan and truth on the ground about the green space plan and its implementation.
3	Manuals	Used as guide for the analysis

And this data processed by different tools of different extensions of ArcGis10.5 software to get Maps and attributes.

Table 3. 2: Software and Purse used for

No	Software	Purpose
1	ArcGis10.5	Visualization, Analysis, map layout and give result in the form of map and table.
2	Google Earth Pro	Shows current photo of the study area /Gelan City/ to Cross check the structural plan with current condition of the green space
3	Microsoft office	Writing, chart preparing, graphs and statistical analysis.

Interviews: interview for Municipality, Environment, forest and Climate change office managers and Sanitary and beautification process owner of the town and Environmentalist, urban planners and sanitary and beautification officials to collect qualitative and quantitative data about the current green space situation.

Observation: observation was done through visiting the green spaces to have a look at what is currently happening with regard to the existing quality, size, current use and encroachment to open space by taking a note and photo. And also use satellite images.

3.5. Study Population

According to data from the City Administration there are 85,115 total populations (Male 40232 and female 44883). But information from the City Administration show that the boundary of the city changed and so the population number may vary.

3.6. Sample size

Including the mini green space, neighborhood, community green space, and forest, there are a total of 295 municipal Green Space in number with total green space area of 2,123,058.68 m^2 on the structural plan that is needed to be analyzed and the study used all green space for the analysis. This study does not use what Boone et al. (2009) suggested, which is to use a centroid as the access point for small parks, and determines park access points for all parks. Since the green areas do not have fence, we could use any place as entrance or access point. So using the structural plan on an ArcMap, the study used the intersection of the green space boundary and the city road network as the entrance, and the green space access points were determined. That intersection points were digitized. So there are a total of 1199 park access points after digitizing.

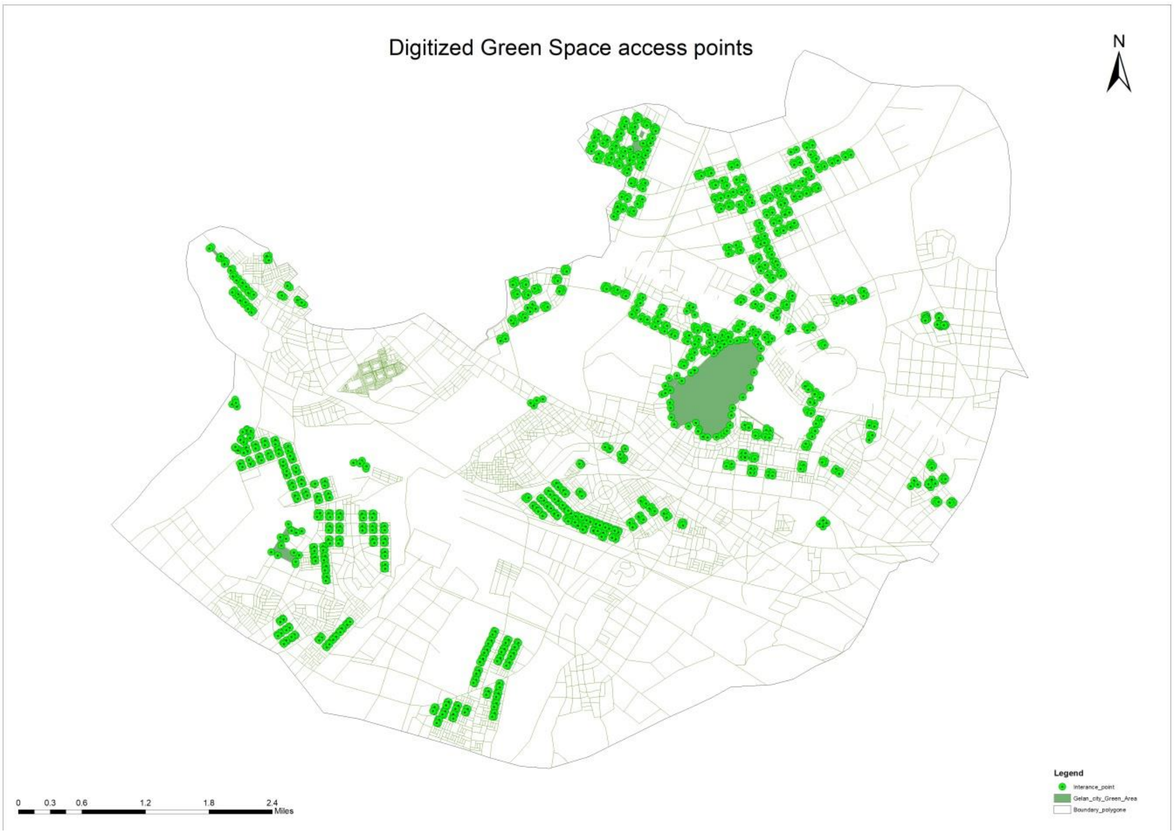

Figure 3. 5 : Green Space access points

Digitizing manually has the potential to introduce errors, but this error is presumably smaller than using a buffer zone created from the perimeter of a park as a measure of accessibility. And the method of the research was using these all access points to get the service area polygon.

Other important data was demographic data. According to data from the City Administration there are 85,115 total populations (Male 40232 and female 44883 the total population to calculate the green space per capita.

And the other important data was to get the current condition of the green space. To get that the green space location on the Structural Plan is over lapped with areal image and seen whether it is really green area or not. Using this method only 43 out of 295 Green space was identified as urban green space. The 43 urban green spaces have an area of 1371772.22m² with 5224427.54 m² service area.

From these data we can use these formulas:-

$$GS \text{ per capita on } SP = TP \div \text{Area of } GS \text{ on } SP$$

$$GS \text{ per capita } OG = TP \div \text{Area of } GS\ OG$$

$$PGS = TGSA \div TCA * 100\%$$

$$PCGSSA = GSSA \div TCA * 100\%$$

$$AOSSA = TCA - SA$$

Where:-

GS represents green space

SP shows structural plan and

OG represents on ground

TP means Total population

PGS is Percent of Green Space

TGSA is Total Green Space Service Area

TCA is Total City Area

PCGSSA is Percent of City Green Space Service Area

SA is Service Area

AOSSA is Area Out Side Service Area

3.7. Techniques

The methodology used GIS tools to analysis road network analysis to get service area of the green space and area outside the service area using both the green space on the structural plan and on the ground for the analysis. To do that the entrance points are digitized at intersection point of roads and boundary of the green spaces. After digitizing the access points of the green spaces, network analysis is performed. New service area polygons are created using Network Analyst. All the green space access points are loaded to the facilities in this category as this layer stores the network locations that are used as facilities in service area analysis. Rings created around each digitized points to show the service areas within 500m, which are the walking distances that people are willing to walk to public green spaces or urban green space from their home. In addition the study used Google earth pro to get the current condition of the green space. The research also used data from municipality such as structural plan, population size and area of the city to calculate the green space per capita. Green space per capita is calculated by dividing total green space area by total population to get how much area of green area can one person get in Gelan Town.

3.8. Data collection tools

In order to analysis the accessibility and distribution of green space in Gelan city, the study mainly examined land use condition of green space using structural plan from the municipality; and also used Photo camera and not book for field survey. In addition the researcher used areal image from Google earth pro software and computer for data collection.

3.9. Data analysis and interpretation

Analyzing the data is a crucial part of a research. The researcher used ArcGIS10.5 software specially Network Analyst tool for the analysis. In order to achieve objectives, the researcher used both qualitative and quantitative methods since it is more appropriate to describe the existing urban green space accessibility and distribution. The researcher analyzed and interpreted both qualitative and quantitative data by using the appropriate tools and instruments such as percentage, tables, charts, plates, maps and others to facilitate the interpretations of the results.

Chapter Four

4. Result and Discussion

4.1. Introduction

The ultimate goal of the research is to assess the accessibility and distribution of urban green space for the resident of Gelan Town. In this chapter the detailed analysis and discussion of the data analyzed by different soft wares on Assessment of green space analysis in the case of the Town is presented. This chapter also presents the results and interpretation parts of this study. This method utilizes the green space access points or entrances that have been digitized using the green space boundary and road intersection. The service area is calculated using the Network Analyst Tool in ArcGIS10.5. This method mostly depends on the Network Analyst to get the green space service area to identify which area of the city is within service area and which part of the city is out of the service area. So the results for the green space accessibility and distribution that shows part that is within service area and out of service area is reported in this chapter.

4.2. Accessibility and distribution of green space On Structural Plan of Gelan Town

4.2.1. Overall green Space

This section summarizes the total public green spaces that are accessible as of the structural plan for Gelan City residents. As mentioned in Chapter 3, the Network Analysis is conducted using 500m as the acceptable distances. Ministry of Urban Development and Housing (2016) recommends 500m distance from a public green open space of the size of 0.3 hectare. So, the assessment of the available amenity green space in residential areas should make reference to the standard.

As we can see on the figure below, it simple to understand the distribution of green space on the structural plan is not fair. The green space is compacted on some parts of the city.

As have seen on the network Analysis these green space service area polygon cover small part of the Town; only 18902509.76m² out of 90698190.13m² Town Area which shows it small percent of the town area. Other thing that has seen on the analysis is that, the service area overlaps at same parts and dot not tech much part of the city.

The following map shows the total urban green space distribution and its' size that is on the structural plan.

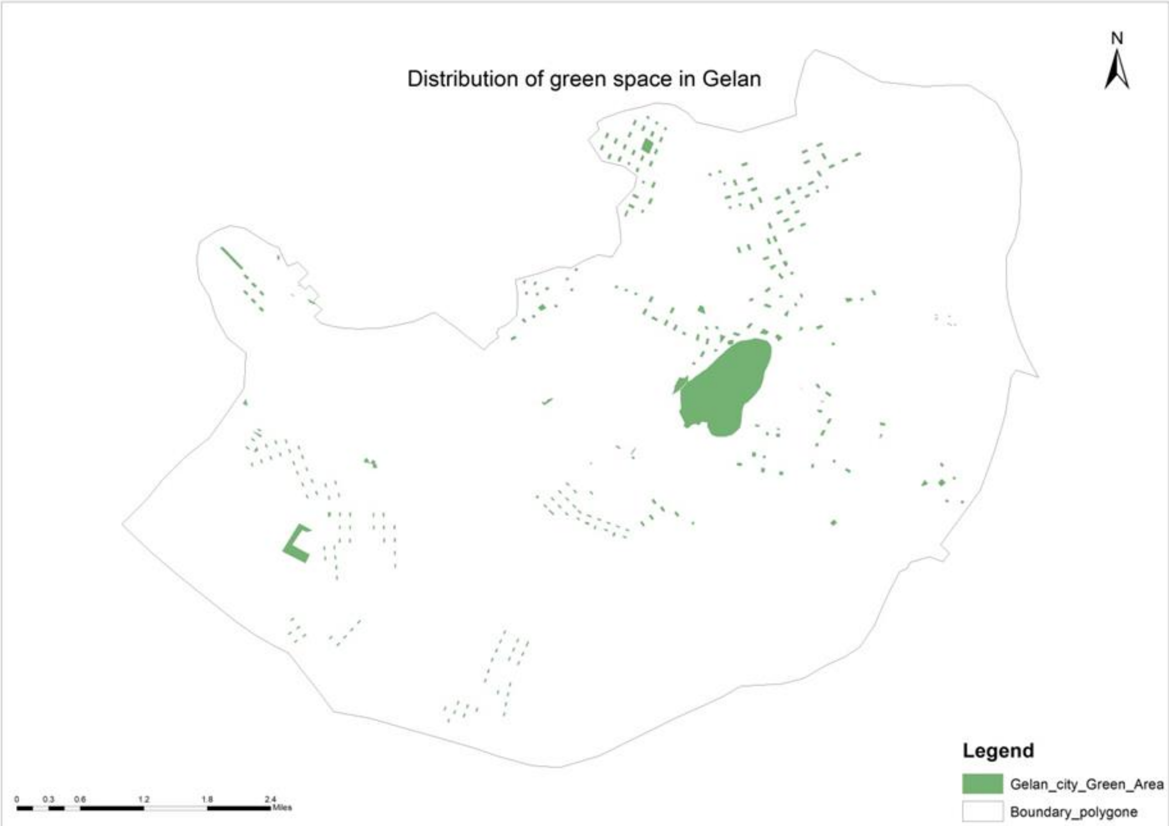

Figure 4. 1: Distribution of Green Space in Gelan as of SP

The following table shows the sum of the green space Area

Table 4. 1: Showing Sum of Green Space Area

No	Total No of Green Space	Sum of the green Space Area in m²
1	295	2123058.68

Using the equation under sub topic 3.6 that is *GS per capita on SP = TP ÷ Area of GS on SP*, I can calculate the Area per person.

Therefore 2123058.68 m²/85,115person = 24.94 m²/person.

This shows that the resident of Gelan City will have more than enough share of urban green space area if the green area on the structural plan is also on ground. The National

Urban Green Infrastructure Standard of Ethiopia propose 15m² per capita public green open space with in 500m from a public green open space that is at least 0.3 hectares in size. So it is more than recommendation and good when seen with the recommendation. But the problem here is that, only 105 green spaces have area more than 0.3 hectare from 295 green spaces.

Also using the equation total green space area divided by total city area times one hundred percent we can get percent of city green space.

$$\text{That is } 2123058.68\text{m}^2/90698190.13\text{m}^2 * 100\% = 2.34\%$$

The percent is so much below standard. The standard recommends thirty percent (30%) green space for urban areas of Ethiopia.

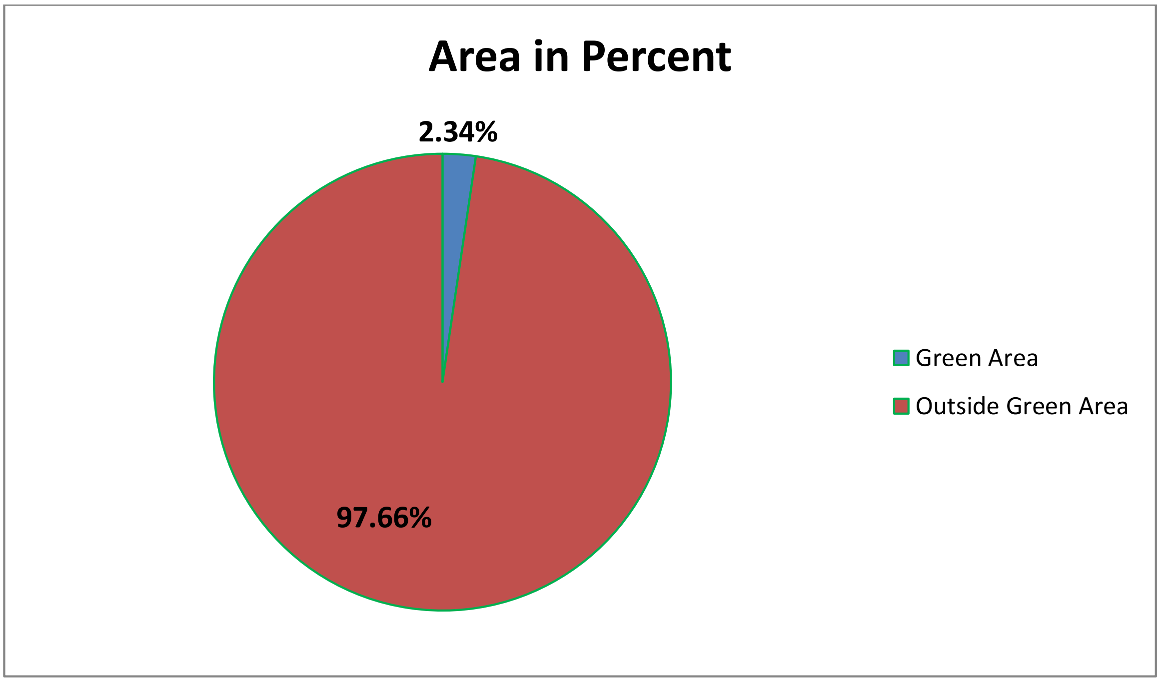

Figure 4. 2: showing percent of green area in Gelan City

Standard recommends 30% green space out of total city area. So the percent of green space in the city is so much below the standard.

4.2.2 Overall Green Space Service Area As area on Structural Plan

This section summarizes the total public green spaces that are accessible for residents. As mentioned in Chapter 3, the Network Analysis is conducted using 500m distance to the green space along road network. The following table shows the total green space service area that is covered by the 500m Green Space service area polygons, total city area and the number of people of Gelan City.

Table 4. 2: Showing Green Space Service Area

	Area
Gelan town total Area	90698190.13m²
Service Area Polygon area without over lap	18902509.76m²
Service Area with over lap	360176896.30 m²
Total Population	85,115

By network analysis tools, two types of service area polygon was created; polygon that overlap and that do not overlap. As we can get from attribute table and indicated on the above table too, the area created by overlap is many folds higher than that of without overlap. This shows us that the distribution of the green space within the City is not fair. If it were equally distributed, there could not many overlaps of the service area polygons and the areas of the polygons that of with overlap and without overlap could be similar.

The following Maps show Map of service area that are created by without overlap and service area polygon with overlap respectively.

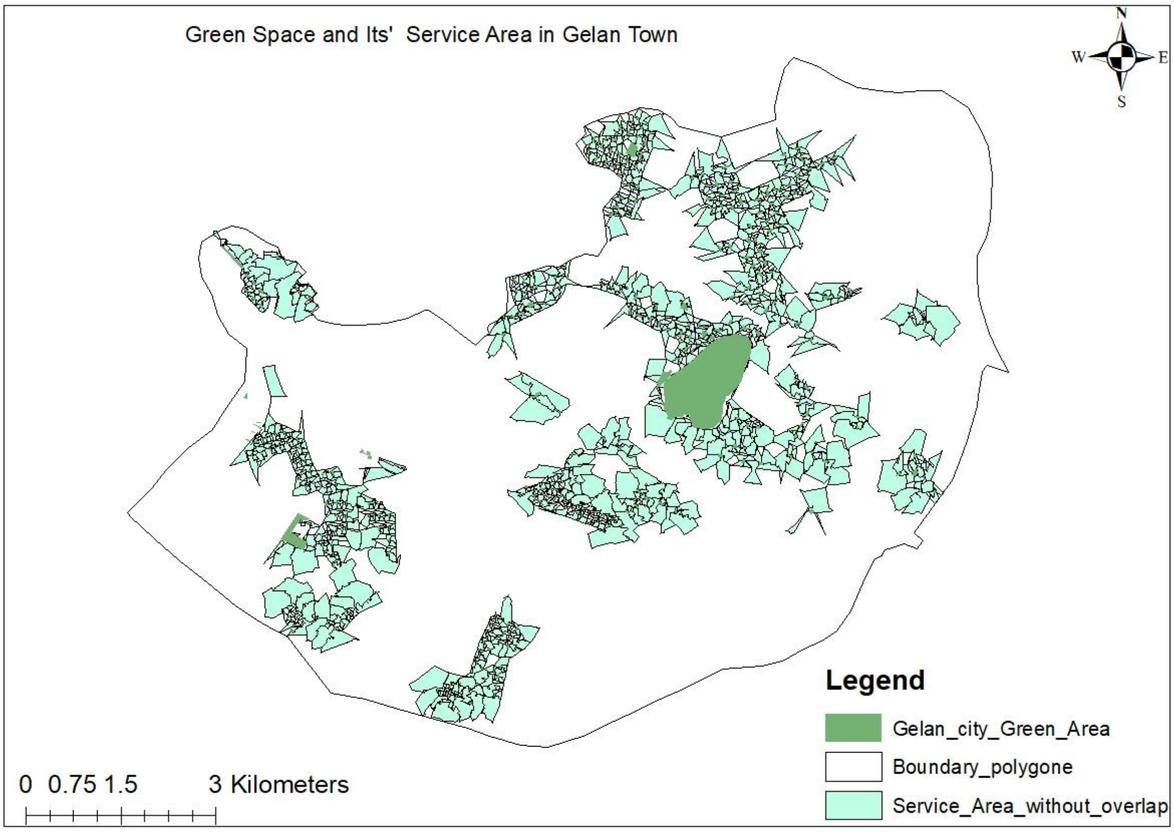

Figure 4. 3: Green Space and Service Area without overlap

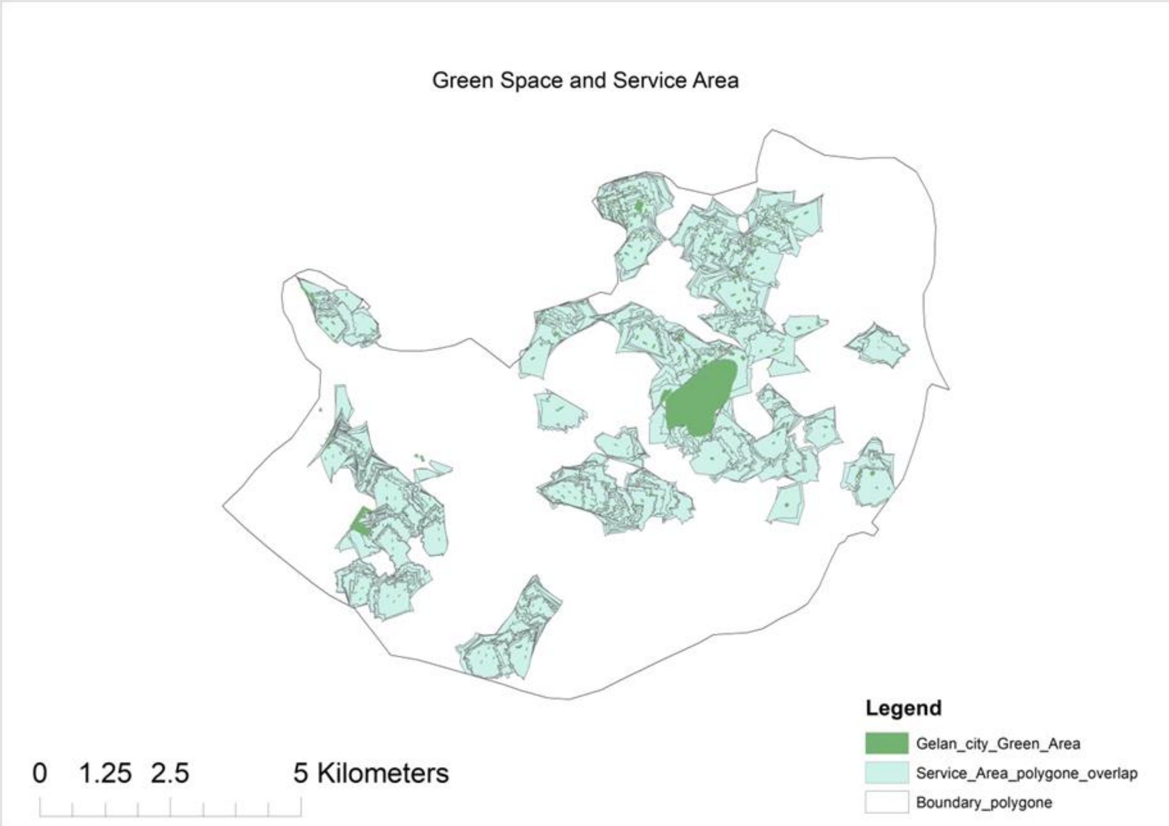

Figure 4. 4: Green Space and Service Area with overlap Figure

Using table 4.2 we can do different interpretation also. Using equation of service area without overlap divided City total area times one hundred percent we can get percent of city that is covered by service area.

That is 18902509.76m² / 90698190.13m²* 100% = 20.84%.

This shows that only 20.84% of city area is within 500m service area polygon. This result shows that 79.16% is out of the service area. From this due to unfair distribution of green space, 79.16% of the city area is out of the green space service area and we can understand what should consider is not only quantity but also should consider distribution when we plan urban green space.

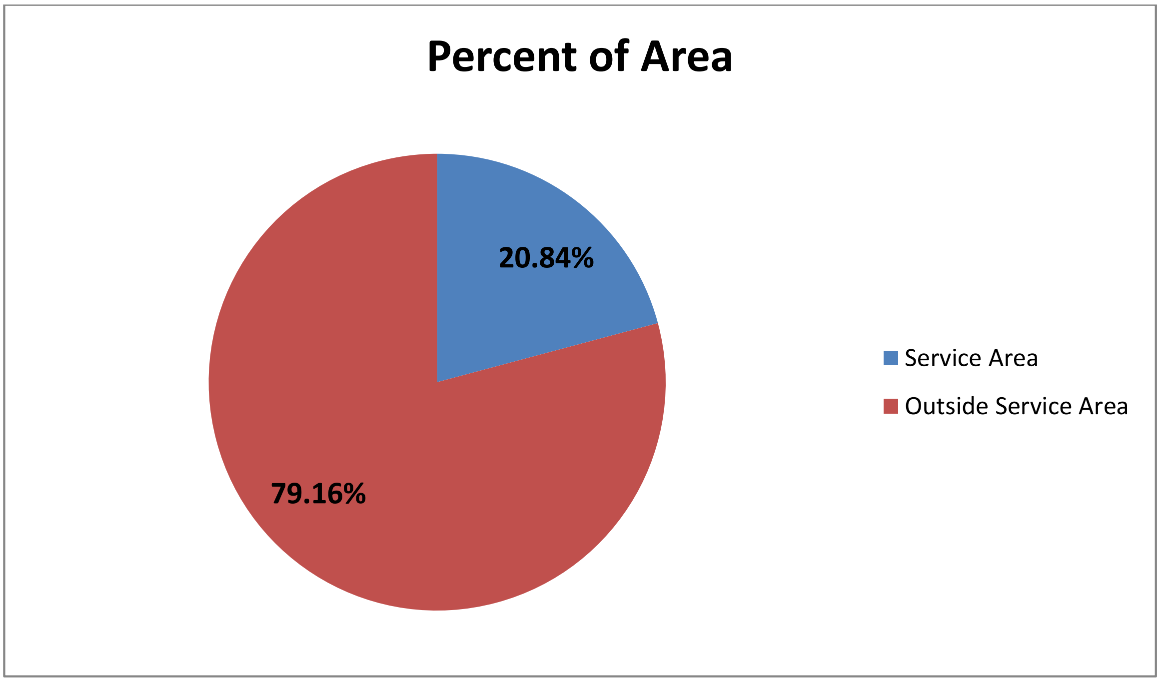

Figure 4. 5: showing percent of UGS service area in Gelan City

Using the equation of the total service area polygon that is created by service area with overlap times one hundred percent divided by City total area, we can get percent of city that could be covered by service area.

That is 360176896.30 m^2*100% / 90698190.13m^2 = 397.12%.

This shows us that the area of the service area is approximately four fold higher than the area of the City. This means that, the area of the green space in the City is high. But due to the improper distribution of the green space, only 20.84% of the city part will get green space within 500m distance. Only small percent of the part the city get green area within less than 500m distance.

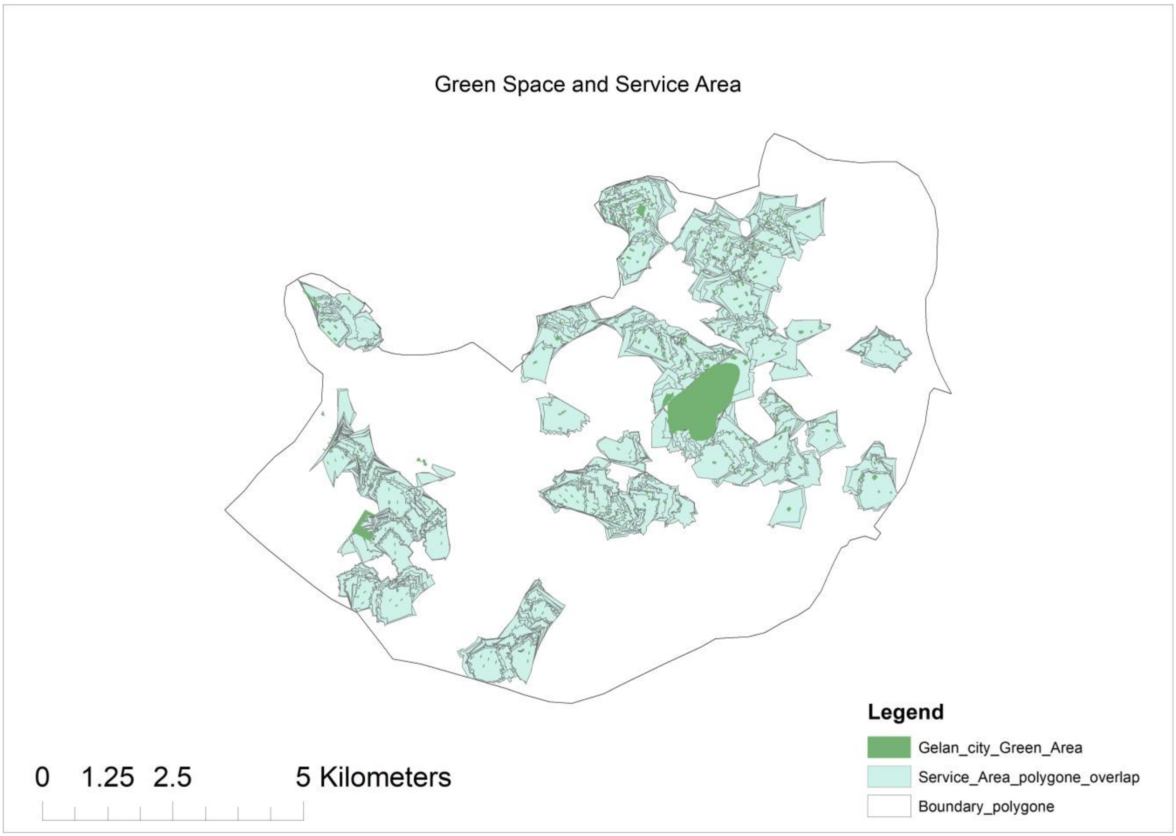

Figure 4. 6: Green Space and Service Area

The Area of the City is 90698190.13m² and the service polygon is 18902509.76m². This means 71,795,680.37m² is outside of the service area. When we compare it with the city area, 79.16% is out of service area and only 20.84 part of the city get green space within 500m distance.

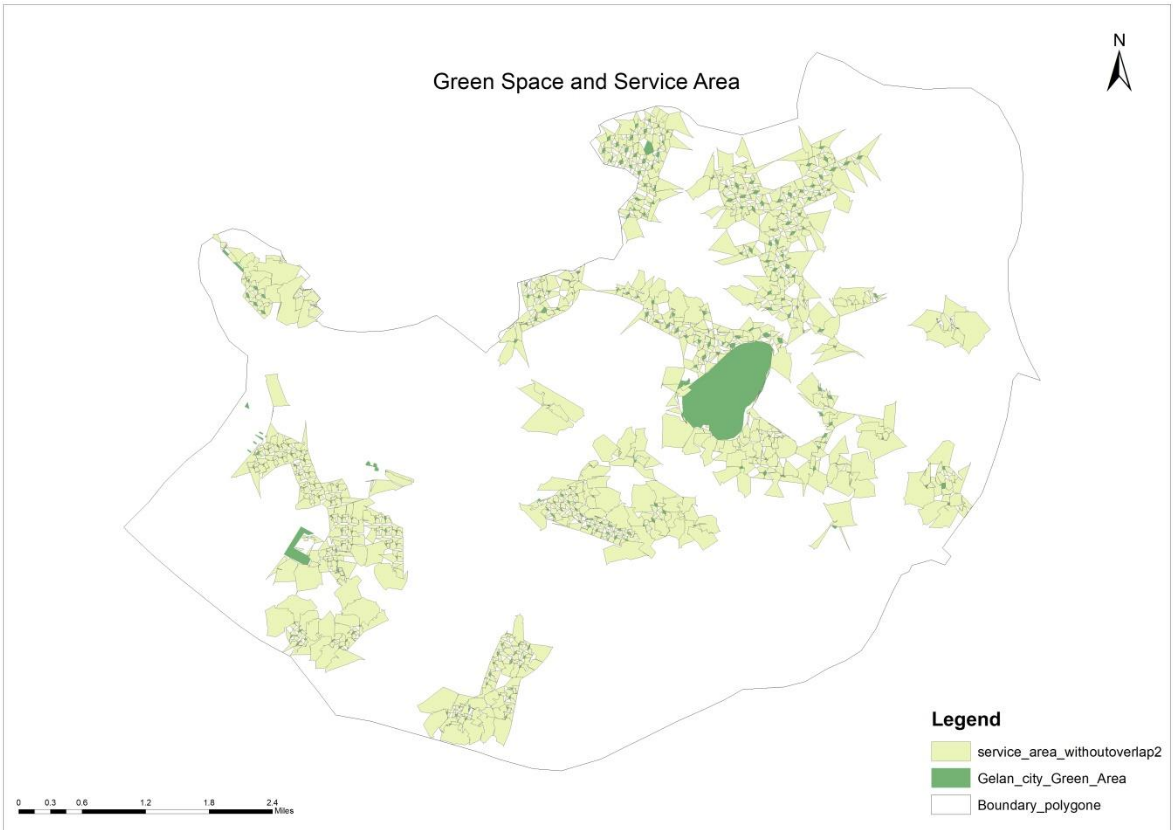

Figure 4. 7: Green Space and Service Area without overlap

4.3. Green Space on ground In Gelan City

4.3.1 Green Space on ground in Gelan City Using Google Earth

This section summarizes the total public green spaces that are accessible for Gelan City residents. As mentioned in Chapter 3, the Network Analysis is conducted using 500m as the acceptable distances. The following figure shows the total urban green space distribution and its' size that is on ground.

As we can see on the figure below, it simple to understand the accessibility of green space on the ground is not satisfactory due there are little green space on ground in the city. In addition the existing green spaces are not fairly and equally distributed. The existing green space is compacted on some parts of the city known as Genda Kore.

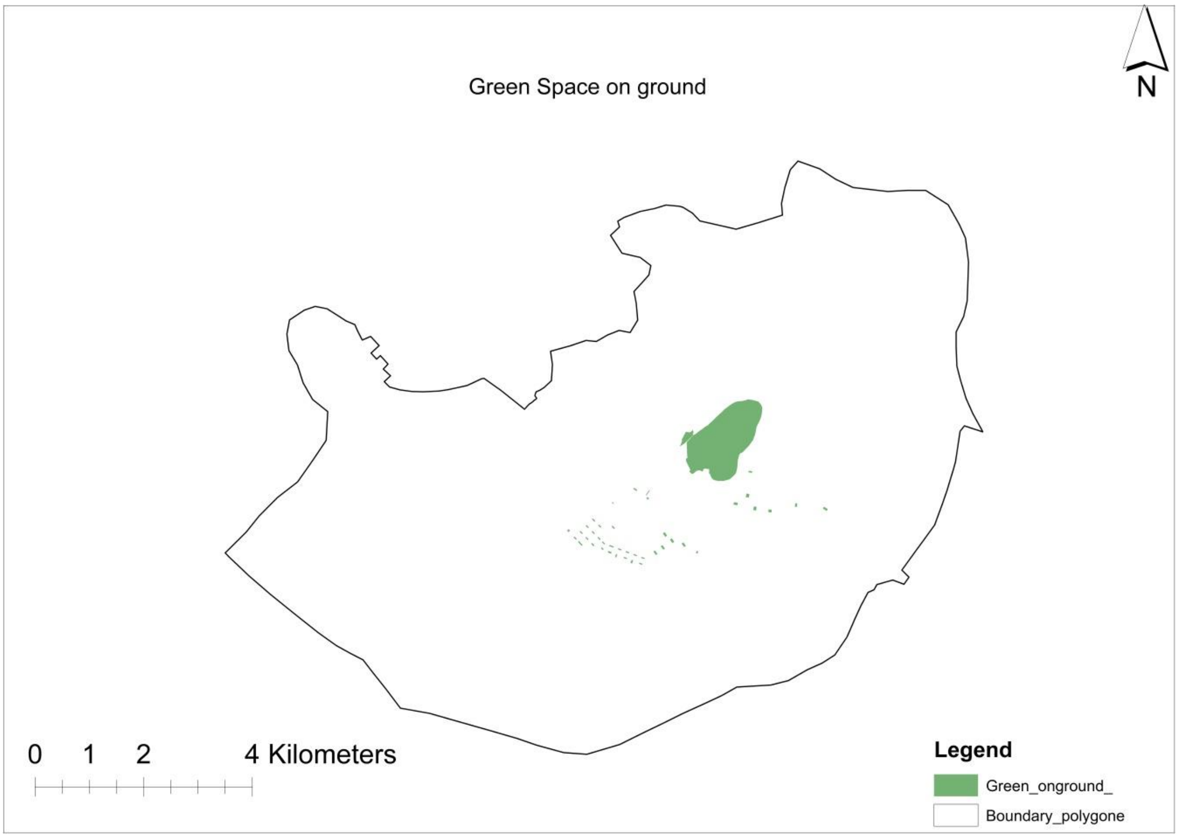

Figure 4. 8: Green Space as Seen on Area Photo

The following table shows the sum of the green space Area.

Table 4. 3: Showing Sum of Green Space Area

No	Total No of Green Space	Sum of the green Space Area In m²
1	43	1371772.22

Using the equation of the total green space area divided by the total city population, I can then calculate the Area per person.

Therefore 1371772.22m²/85,115person = 16.12m²/person. This shows that the resident of Gelan City have more than enough share of urban green space area The National Urban Green Infrastructure Standard of Ethiopia propose 15m² per capita public green open space with in 500m from a public green open space that is at least 0.3 hectares in size. So it is good when we compare with recommendation. But there is little green space that fills 0.3 hectare area.

Also using the equation of total green space area divided by the total city area we can get percent of city green space.

That is1371772.22 / 90698190.13m²*100%= 1.51%.

The standard recommends 30% green space out of total city area. So the percent of green space in the city is so much less than the standard that is almost none.

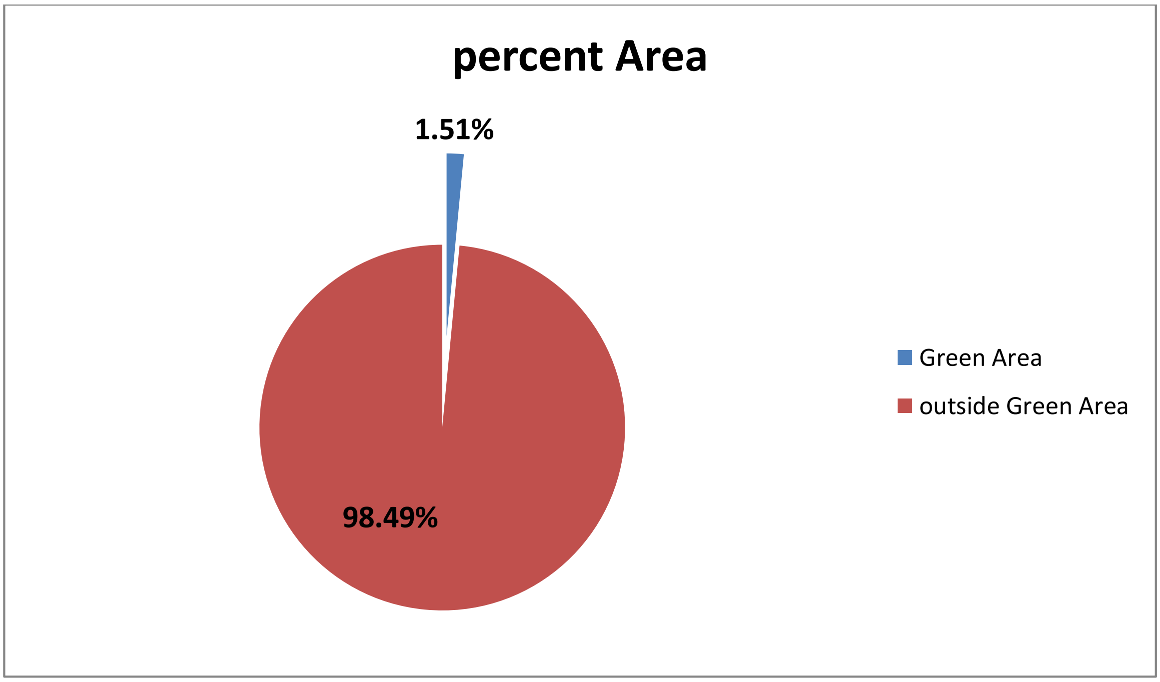

Figure 4. 9: UGS percent in Gelan City

4.3.2 Green Space Service Area

This section summarizes the total public green spaces that are accessible for residents within 500m. As mentioned in Chapter 3, the Network Analysis is conducted using 500m distance to the green space along road network. By network analysis tools, two types of service area polygon were created; polygon that overlap and that do not overlap. As we can get from attribute table and indicated on table 4.4 below, the area created by overlap is many folds higher than that of without overlap. This shows us that the distribution of the green space within the City is not fair. If it were equally distributed, there could not many overlaps of the service area polygons and the areas of the polygons that of with overlap and without overlap could be similar.

The following table shows the total green space service area that is covered by the 500m Green Space service area polygons, total city area and the number of population of Gelan City.

Table 4. 4: Showing Green Space Service Area

City Area	90698190.13m²
Service Area Polygon area without over lap	5224427.54m²
Service Area with over lap	360176896.30 m²
Total Population	85,115

As haven seen by the analysis, the green space in Gelan Town is small and not equally distributed. The following Maps exported from the analysis show Map of service area that are created by service area polygon without overlap and service area polygon with overlap respectively.

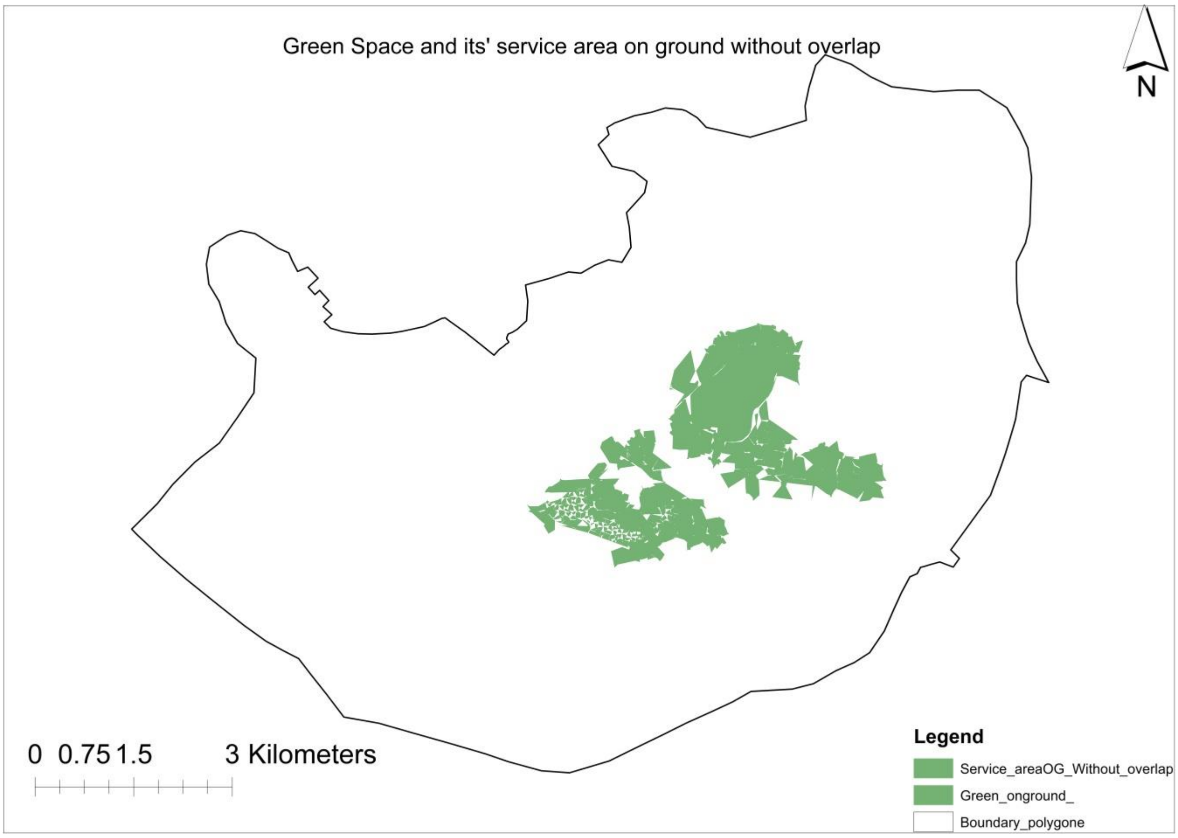

Figure 4. 10: Green Space and Service Area Without Overlap

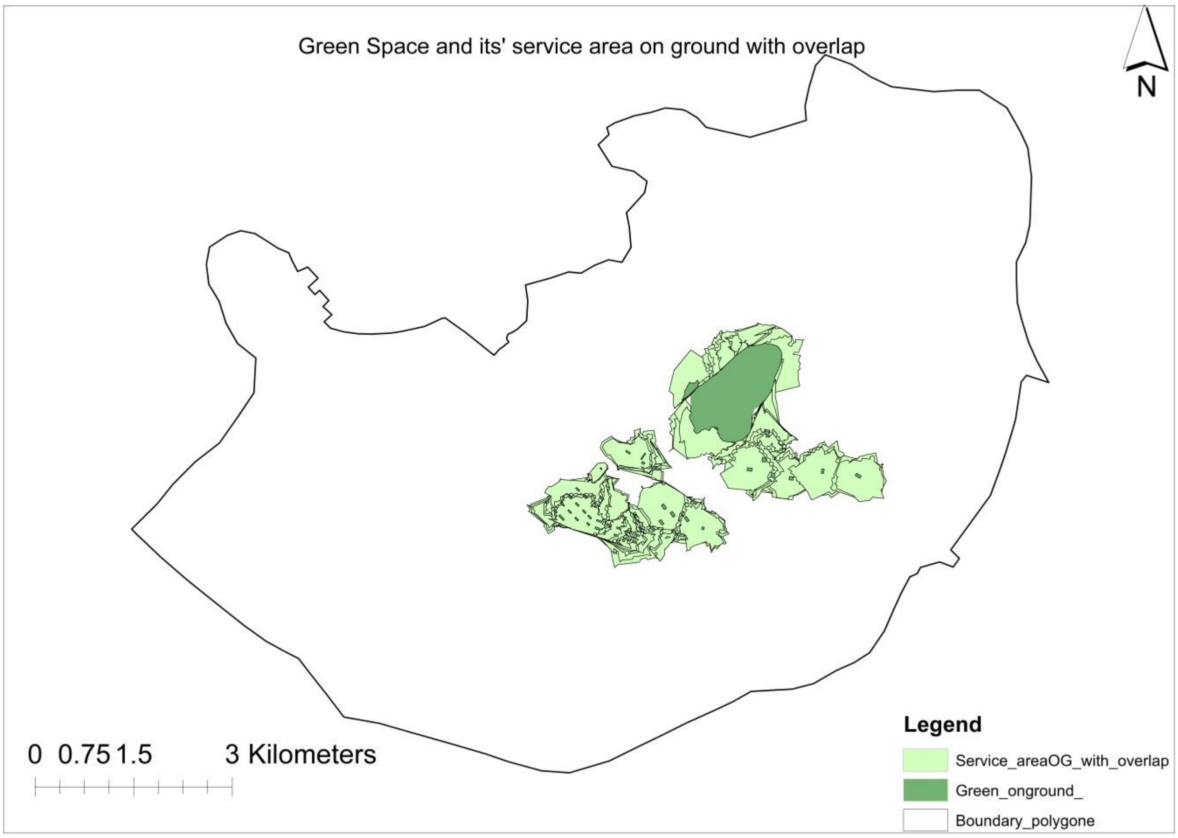

Figure 4. 11: Green Space and Service Area With Overlap

Using table 4.4, we can do different interpretation also. Using equation of service area without overlap divided City total area times one hundred percent we get percent of city that is covered by service area.

That is 5224427.54m² / 90698190.13m²* 100% = 5.76%.

This shows that only 5.76% of city area is within 500m service area polygon. This result shows that 94.24% is out of the service area. From this we can conclude that the total service area of green space in the city is so much small.

If the green space were distributed equally, the service area would increase. But due to the existing green space is compacted around same part of the city the service area of the green space within 500m distance is so much small. As we can understand from the following figure, the service area overlaps at same part, Ganda Kore.

The Area of the City is 90698190.13m² and the service polygon is 5224427.540707m².

By equation Total area minus service area, we can get area out of service area.

That is 90698190.13m² - 5224427.54m²= 85473762.59 m² area is out of 500m distance service area.

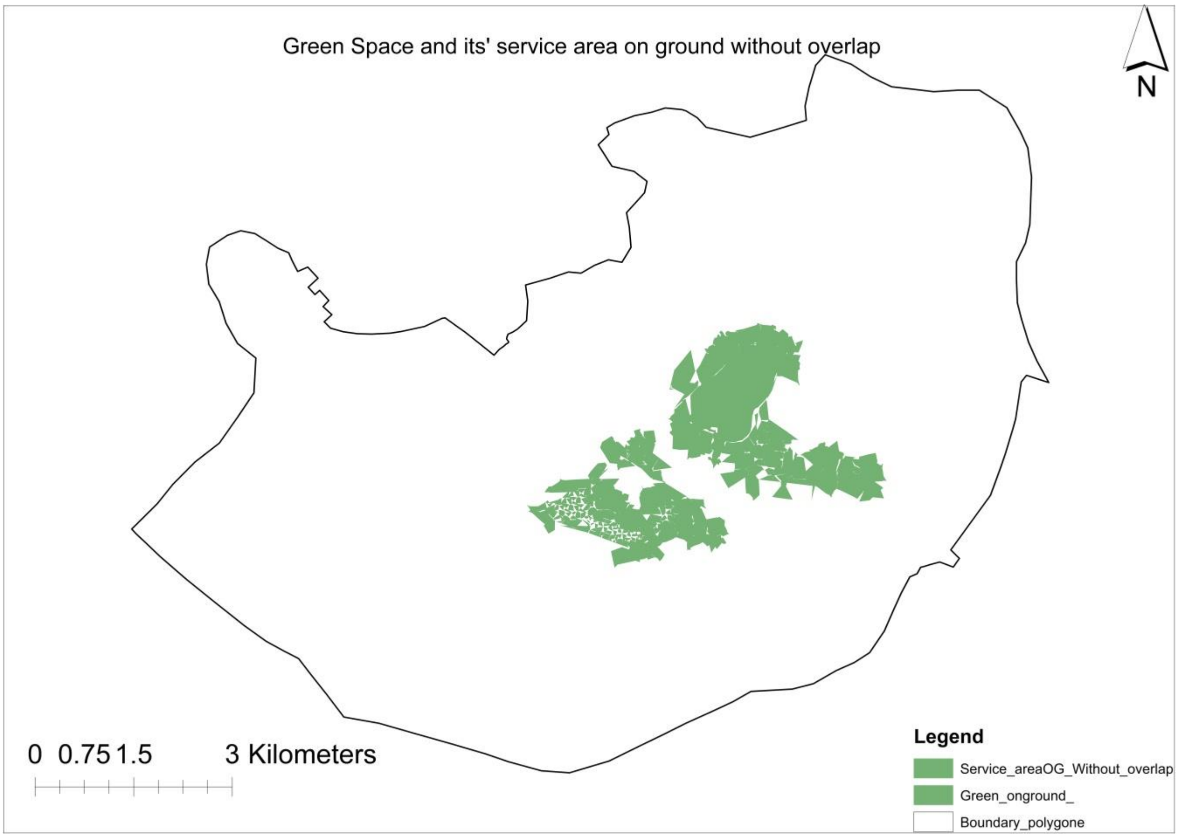

Figure 4. 12: Green Space and Service Area on Ground Without Overlap

4.3.3 Existing condition of the Green Space

Development of Amenity Green Space in Residential Areas (2016) says Accessible and safe green spaces may be important to people's sense of well-being and mental health and be a positive influence on levels of physical activity. Again the manual says Besides, people's perceptions of safety can be influenced by various factors, one of which is indicated to be the presence of a green neighborhood, with high tree canopies and grass preserving visibility across spaces.

But based on the filed observation there is no development of the green area, no infrastructure seen. Infrastructure in urban green space includes, for example, walking paths, streetlights, and public toilets; the leisure facilities include, for example, fitness facilities and sports fields (Biernaka et al., 2020). But these facilities do not exist in Gelan Town green spaces. Manual from Ministry of Urban Development and Housing (2016) confirm this by saying, the urban centers of Ethiopia have not fostered the development of UGIs in general and amenity green spaces around residential areas in particular. And also as identified by this research we can't say there is green space in the city due to the green space is not developed. Manual by Ministry of Urban Development and Housing (2016) confirms this by saying, at this moment, amenity green spaces are not in good condition and are not providing the services they are expected to provide; this indicates that the problem of urban green space is country wide, not only problem in Gelan Town. At same places people use the green space to dump waste in it.

"Furthermore, amenity green spaces should be planned, as much as possible, in such a way that they improve the quality of life around residential areas by providing clean and attractive green spaces for informal recreation of people in the neighborhoods, contribute to the development of climate resilient green economy (CRGE), address the issues of food in-security in urban centers and reduce poverty through job creation" (Ministry of Urban Development and Housing, 2016) But as we can see from following photos, photo that are taken during site visit to show the condition of green space in Gelan City as a sample, the sites could not be recreation area. If it is green space it should have has the intended quality. A good quality green space refers to green space that is "fit of purpose" which means that it is accessible, safe, welcoming and performing the expected function Green space (Scotland 2008).

Photo From Field survey

Figure 4. 13: Photo Showing Condition of Green Space On ground

To summarize, as we have seen from the analysis and calculation the green space in Gelan City do not fit standards and recommendation. If we see it with graphs it will be as follows.

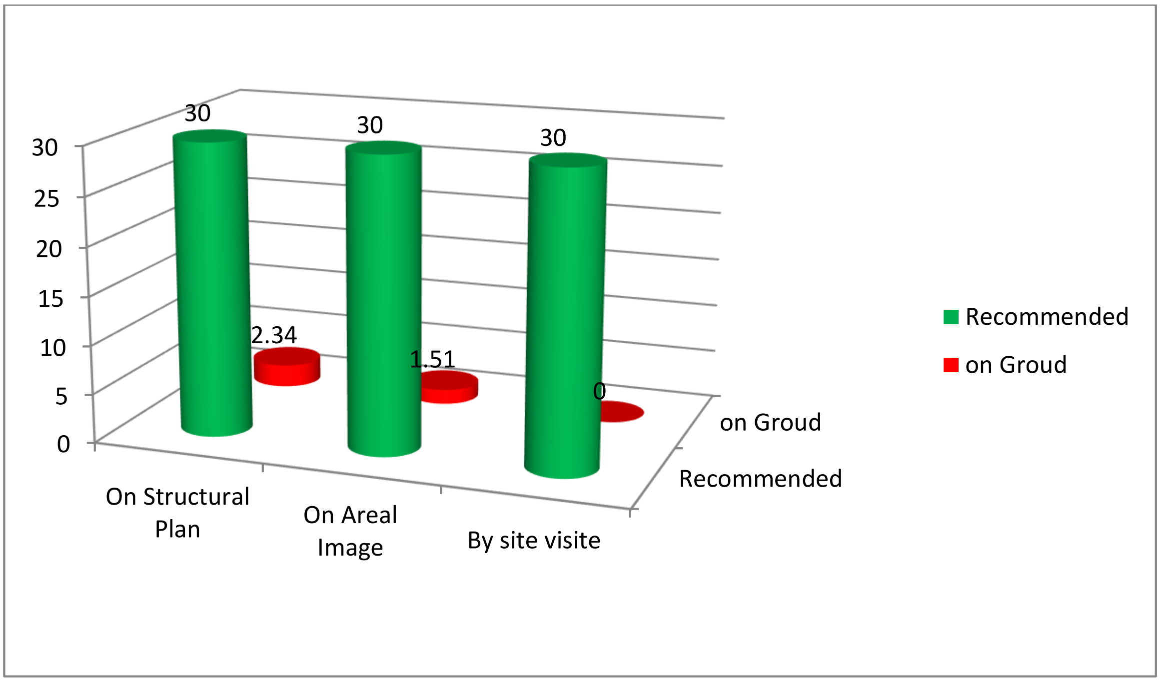

Figure 4. 14: Showing what is on ground and what is recommended Green area

So it is good if we modify our urban green space as it fit the intended purpose. A good quality green space refers to green space that is "fit of purpose" which means that it is accessible, safe, attractive and performing the expected function (Greenspace Scotland 2008).

The following photos are from internet as good examples of beautiful, welcoming, safe and developed green space. People enjoy at such attractive green space. But if it is not developed and not attractive, people do not use. That is it do not fit purpose. May be it will become dirty area and cause other problem than serving as recreation for people of the city.

Photo from internet

Figure 4. 15: clean and attractive urban green space

4.4 General condition of Gelan Town green space accessibility and distribution

AS we have seen from the analysis, the accessibility and distribution of green space in the city is not good. The problem is not only the lack of green space. The problem is that, even the existing green space is not fairly distribution; it is compacted at little areas of the city. Due that 79.16% of the city can’t get green space within 500m distance. So the city planner should plan new green space in the city considering all residents get green space within 500m distance.

Table 4. 5: Showing Condition of Green Space Service Area

	Area in percent
City area within service area on SP	20.84%
City area outside service area on SP	79.16%
City area within service area on Ground	5.76%
City area outside service area on Ground	94.24%

To show this table by Graph:-

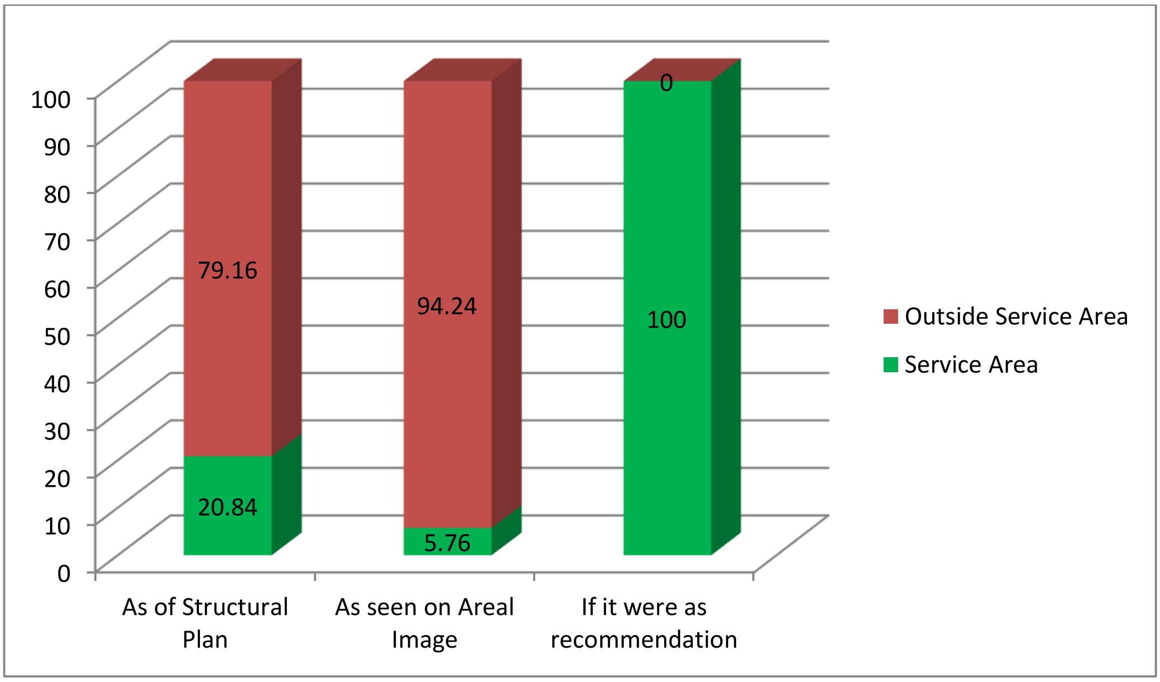

Figure 4. 16: Showing condition of UGS Service area in Gelan City

As we can see it on the graph, the much percent of Gelan City residents could not get green space within 500m.

The sites that are outside the service area are as shown on the map below. The pink shaded area is the area outside the service area. Even this is if the green space on the structural plan is also on ground.

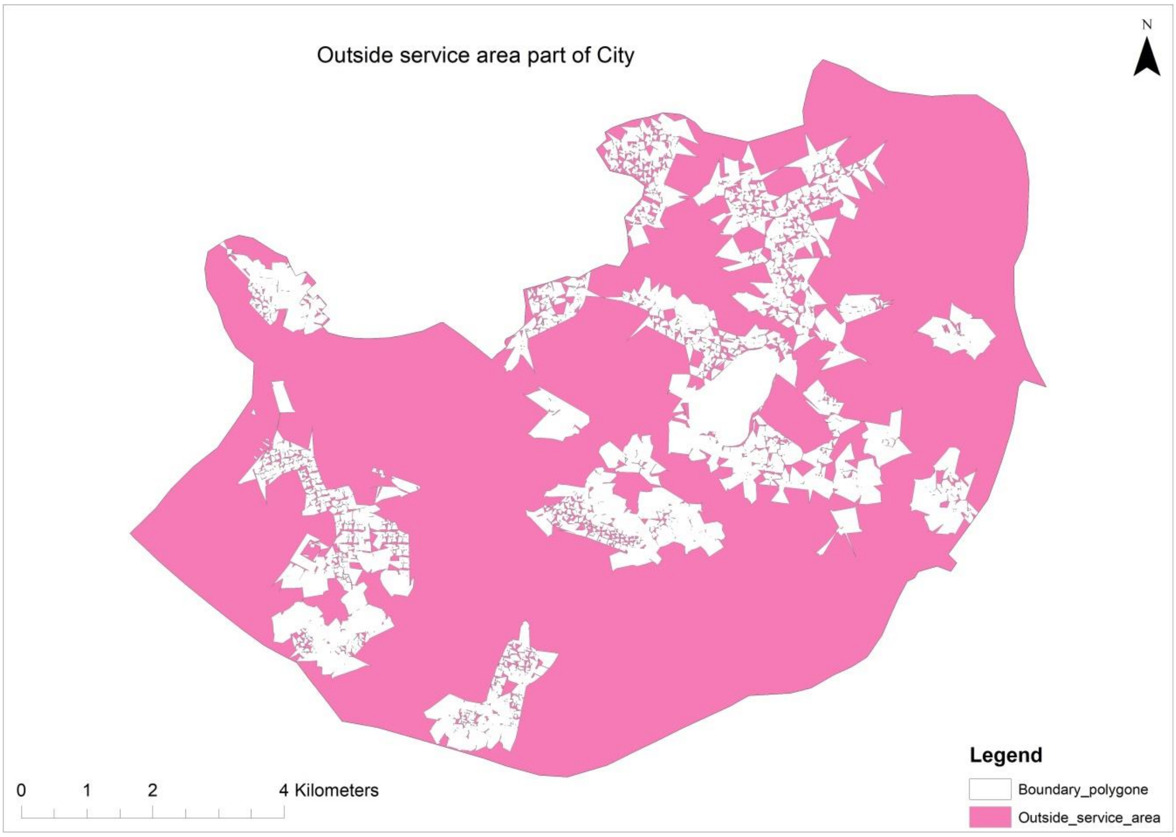

Figure 4. 17: Showing Area Outside Service Area

The above map is a map created on ArcGIS from data from structural plan of Gelan City. As we can see from the map, the green space service area does not include much percent of the City Area. It is due to that, there is little green area proposed for the city. It is so much far from standard that says 30% of our city should be covered with green space.

The green area service area polygon on the areal image is as follow.

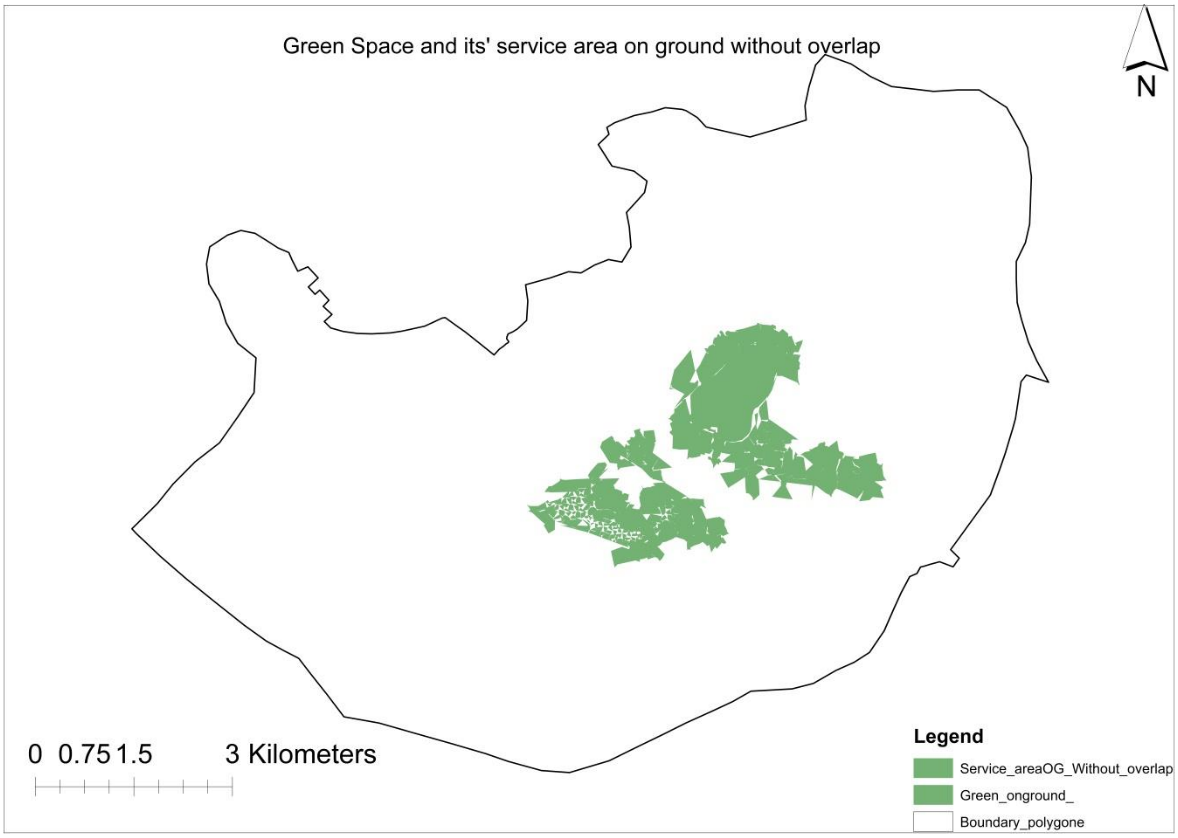

Figure 4. 18: Showing Service Area on ground

As we can see from the above map the green space on ground is so much less than even that of on the structural plan. The standard that says 30% green space as well the plan do not implemented in Gelan City. Even though it is even difficult to say the green areas in the City are green space, the green spaces in the City is so much below the standard and structural plan. It violates the standard.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study used ArcGis10.5 to analysis the accessibility and distribution of green space in Gelan City from City Structural Plan. And also Google earth pro is used to see the current condition of the sites.

Using these soft wares I have seen the analysis by comparing the green area on the ground with that of on the structural plan. Doing that the accessibility problem and distribution problem is detected. Also using site visit some sites detected do not even been planted and it is difficult to say it is green space. So the green Area should be fairly distributed within the city. And residents should get green space within 500m.

The green space on the structural plan is seen by overlapping with the areal image. The green space seen by over lapping is so little and it is seen by site visit. As have seen it is difficult to say it is green space. There is no amenity; so the existing green space should be clean, amenity should be included and developed to serve the residents. If it is not developed and clean, it will be harmful site than recreation area, it will cause health problem than health benefit.

5.2. Recommendations.

Now a day urban green space is an important infrastructure in urban areas to overcome the rapid urbanization and industrialization effect on environment and human health. It is also a crucial infrastructure for sustainable and rapid urban developments. This study is done on the concept of green space accessibility and distribution, however further green space studies like urban green space plan and implementation, development of green space, methods of improved green space management, quality of urban green spaces and participation of public and private sectors on urban green space protection and development should be conducted to solve the complex urban environment related challenges. So, competent sectors, Universities and any research centers should encourage researchers to conduct their studies on this issue.

On the basis of this research the following future prospects and recommendation can be made for Gelan Town Urban planners:

- From the research, Green space accessibility identified does not fit the national as well international standards. Even what is on plan is not fully on ground and also that have seen on ground is difficulty to say it is green space due to the quality problem of the green spaces.
- Better if the city revises the accessibility and distribution of the green space. The green space is almost compacted at same parts known as Ganda Kore. Much part of the city can’t get green space within 500m distance.
- The existing site should be developed and serve as green space. But if not developed and proceeds by this condition, it will be waste site and harms residents than serving as recreation area.

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APPENDICES

Appendix-A Green Space on SP

FID	Shape	Area in m²	Area in hectare
0	Polygon	1389.298855	0.13893
1	Polygon	1389.298855	0.13893
2	Polygon	1389.298855	0.13893
3	Polygon	1389.298855	0.13893
4	Polygon	1389.298855	0.13893
5	Polygon	1389.298855	0.13893
6	Polygon	1389.298855	0.13893
7	Polygon	1389.298855	0.13893
8	Polygon	1389.298855	0.13893
9	Polygon	1389.298855	0.13893
10	Polygon	1389.298855	0.13893
11	Polygon	1389.298855	0.13893
12	Polygon	1389.298855	0.13893
13	Polygon	1389.298855	0.13893
14	Polygon	1389.298855	0.13893
15	Polygon	1389.298855	0.13893
16	Polygon	1389.298855	0.13893
17	Polygon	1389.298855	0.13893
18	Polygon	1389.298855	0.13893
19	Polygon	1389.298855	0.13893
20	Polygon	1878.991338	0.187899
21	Polygon	1389.298855	0.13893

22	Polygon	1389.298855	0.13893
23	Polygon	1389.298855	0.13893
24	Polygon	1389.298855	0.13893
25	Polygon	1389.298855	0.13893
26	Polygon	1389.298855	0.13893
27	Polygon	1389.298855	0.13893
28	Polygon	1389.298855	0.13893
29	Polygon	1389.298855	0.13893
30	Polygon	1389.298855	0.13893
31	Polygon	1389.298855	0.13893
32	Polygon	1389.298855	0.13893
33	Polygon	1389.298855	0.13893
34	Polygon	1389.298855	0.13893
35	Polygon	1389.298855	0.13893
36	Polygon	1389.298855	0.13893
37	Polygon	1389.298855	0.13893
38	Polygon	1389.298855	0.13893
39	Polygon	1389.298855	0.13893
40	Polygon	1389.298855	0.13893
41	Polygon	1389.298855	0.13893
42	Polygon	1389.298855	0.13893
43	Polygon	1389.298855	0.13893
44	Polygon	1389.298855	0.13893
45	Polygon	1389.282334	0.138928
46	Polygon	1868.981231	0.186898
47	Polygon	1389.282334	0.138928

48	Polygon	1389.294297	0.138929
49	Polygon	1389.298855	0.13893
50	Polygon	1389.298855	0.13893
51	Polygon	1389.298855	0.13893
52	Polygon	1389.298855	0.13893
53	Polygon	1389.298855	0.13893
54	Polygon	1389.282689	0.138928
55	Polygon	1389.298855	0.13893
56	Polygon	97567.49277	9.756749
57	Polygon	1389.284864	0.138928
58	Polygon	1868.990828	0.186899
59	Polygon	1279.877049	0.127988
60	Polygon	2709.83413	0.270983
61	Polygon	5249.585908	0.524959
62	Polygon	1389.284864	0.138928
63	Polygon	1154.105972	0.115411
64	Polygon	2912.714004	0.291271
65	Polygon	1860.575431	0.186058
66	Polygon	1389.298855	0.13893
67	Polygon	1389.298855	0.13893
68	Polygon	1389.298855	0.13893
69	Polygon	1389.298855	0.13893
70	Polygon	1389.286172	0.138929
71	Polygon	2949.488829	0.294949
72	Polygon	1430.838029	0.143084
73	Polygon	2372.288675	0.237229

74	Polygon	3238.250175	0.323825
75	Polygon	1389.287617	0.138929
76	Polygon	1389.282849	0.138928
77	Polygon	1389.281783	0.138928
78	Polygon	1601.700612	0.16017
79	Polygon	1781.981744	0.178198
80	Polygon	3199.980447	0.319998
81	Polygon	1389.281783	0.138928
82	Polygon	1389.281812	0.138928
83	Polygon	1389.298855	0.13893
84	Polygon	1440.000676	0.144
85	Polygon	1389.298855	0.13893
86	Polygon	1389.298855	0.13893
87	Polygon	1389.298855	0.13893
88	Polygon	1405.329508	0.140533
89	Polygon	1352.947377	0.135295
90	Polygon	1389.298855	0.13893
91	Polygon	1500.568014	0.150057
92	Polygon	1389.298855	0.13893
93	Polygon	1389.298855	0.13893
94	Polygon	4811.03232	0.481103
95	Polygon	1389.298855	0.13893
96	Polygon	7159.434303	0.715943
97	Polygon	1608.196699	0.16082
98	Polygon	3008.232004	0.300823
99	Polygon	1389.298855	0.13893

100	Polygon	3330.541517	0.333054
101	Polygon	3463.836881	0.346384
102	Polygon	1389.298855	0.13893
103	Polygon	2832.926195	0.283293
104	Polygon	2375.236148	0.237524
105	Polygon	3377.360494	0.337736
106	Polygon	1389.298855	0.13893
107	Polygon	519.001032	0.0519
108	Polygon	2216.206131	0.221621
109	Polygon	1389.298855	0.13893
110	Polygon	3609.907737	0.360991
111	Polygon	1621.945817	0.162195
112	Polygon	1389.298855	0.13893
113	Polygon	4292.099087	0.42921
114	Polygon	1272.477136	0.127248
115	Polygon	1389.298855	0.13893
116	Polygon	1600.000092	0.16
117	Polygon	1389.298855	0.13893
118	Polygon	1389.298855	0.13893
119	Polygon	3690.973952	0.369097
120	Polygon	1389.298855	0.13893
121	Polygon	1646.971747	0.164697
122	Polygon	2727.250264	0.272725
123	Polygon	1389.298855	0.13893
124	Polygon	1389.298855	0.13893
125	Polygon	1715.230097	0.171523

126	Polygon	1389.298855	0.13893
127	Polygon	2091.437733	0.209144
128	Polygon	1389.298855	0.13893
129	Polygon	1389.298855	0.13893
130	Polygon	1389.298855	0.13893
131	Polygon	1433.885965	0.143389
132	Polygon	2897.710213	0.289771
133	Polygon	1933.854628	0.193385
134	Polygon	2766.929559	0.276693
135	Polygon	1389.298855	0.13893
136	Polygon	1057.7897	0.105779
137	Polygon	2022.108245	0.202211
138	Polygon	3284.569755	0.328457
139	Polygon	3242.467042	0.324247
140	Polygon	698.310735	0.069831
141	Polygon	3524.782499	0.352478
142	Polygon	5734.026002	0.573403
143	Polygon	3695.441417	0.369544
144	Polygon	2818.657468	0.281866
145	Polygon	28949.87604	2.894988
146	Polygon	1604.042473	0.160404
147	Polygon	3687.801433	0.36878
148	Polygon	1692.783246	0.169278
149	Polygon	1679.387078	0.167939
150	Polygon	5663.768472	0.566377
151	Polygon	1264439.245	126.44392

152	Polygon	3692.750056	0.369275
153	Polygon	3254.167538	0.325417
154	Polygon	5917.483534	0.591748
155	Polygon	6393.866882	0.639387
156	Polygon	3727.125309	0.372713
157	Polygon	3900.222967	0.390022
158	Polygon	2199.121697	0.219912
159	Polygon	7067.110228	0.706711
160	Polygon	2237.700408	0.22377
161	Polygon	1815.026136	0.181503
162	Polygon	1899.085551	0.189909
163	Polygon	4540.734763	0.454073
164	Polygon	3680.188862	0.368019
165	Polygon	499.932355	0.049993
166	Polygon	499.935597	0.049994
167	Polygon	3886.323041	0.388632
168	Polygon	499.961799	0.049996
169	Polygon	3681.430362	0.368143
170	Polygon	501.875931	0.050188
171	Polygon	2647.810278	0.264781
172	Polygon	268.952497	0.026895
173	Polygon	3681.430362	0.368143
174	Polygon	500.221215	0.050022
175	Polygon	1978.023076	0.197802
176	Polygon	500.021434	0.050002
177	Polygon	3306.200577	0.33062

178	Polygon	3681.430362	0.368143
179	Polygon	3646.066407	0.364607
180	Polygon	3199.980447	0.319998
181	Polygon	9104.670316	0.910467
182	Polygon	1632.428758	0.163243
183	Polygon	7164.021963	0.716402
184	Polygon	4121.916524	0.412192
185	Polygon	1733.395588	0.17334
186	Polygon	2592.439505	0.259244
187	Polygon	3199.980447	0.319998
188	Polygon	2350.873316	0.235087
189	Polygon	5543.916845	0.554392
190	Polygon	1602.869025	0.160287
191	Polygon	3681.130327	0.368113
192	Polygon	1823.662081	0.182366
193	Polygon	512.779057	0.051278
194	Polygon	1964.083604	0.196408
195	Polygon	1602.322968	0.160232
196	Polygon	1667.788154	0.166779
197	Polygon	1697.348649	0.169735
198	Polygon	3199.980447	0.319998
199	Polygon	3199.980447	0.319998
200	Polygon	1616.044801	0.161604
201	Polygon	1655.512304	0.165551
202	Polygon	3510.266171	0.351027
203	Polygon	1967.614227	0.196761

204	Polygon	1624.879807	0.162488
205	Polygon	298.969477	0.029897
206	Polygon	3199.980447	0.319998
207	Polygon	1772.159568	0.177216
208	Polygon	1852.959288	0.185296
209	Polygon	1606.13146	0.160613
210	Polygon	3199.980447	0.319998
211	Polygon	3691.480623	0.369148
212	Polygon	1829.678278	0.182968
213	Polygon	1610.079109	0.161008
214	Polygon	3962.357268	0.396236
215	Polygon	4254.885016	0.425489
216	Polygon	3688.247644	0.368825
217	Polygon	4326.470167	0.432647
218	Polygon	3680.008475	0.368001
219	Polygon	3763.632491	0.376363
220	Polygon	14810.50012	1.48105
221	Polygon	3694.613035	0.369461
222	Polygon	3683.6015	0.36836
223	Polygon	3680.008475	0.368001
224	Polygon	3680.092751	0.368009
225	Polygon	3196.501043	0.31965
226	Polygon	3696.417916	0.369642
227	Polygon	3663.924077	0.366392
228	Polygon	2761.793981	0.276179
229	Polygon	2934.055034	0.293406

230	Polygon	3684.405933	0.368441
231	Polygon	1601.039989	0.160104
232	Polygon	1606.353493	0.160635
233	Polygon	3682.391975	0.368239
234	Polygon	3690.138214	0.369014
235	Polygon	1606.353493	0.160635
236	Polygon	2527.551617	0.252755
237	Polygon	3680.271693	0.368027
238	Polygon	3680.775613	0.368078
239	Polygon	3524.214371	0.352421
240	Polygon	3751.660019	0.375166
241	Polygon	3682.391975	0.368239
242	Polygon	3014.813389	0.301481
243	Polygon	3705.908362	0.370591
244	Polygon	1607.248244	0.160725
245	Polygon	4646.286709	0.464629
246	Polygon	3956.821086	0.395682
247	Polygon	2540.706196	0.254071
248	Polygon	1607.248244	0.160725
249	Polygon	1606.768906	0.160677
250	Polygon	3682.391975	0.368239
251	Polygon	3616.30855	0.361631
252	Polygon	1601.039989	0.160104
253	Polygon	3695.568485	0.369557
254	Polygon	3680.763806	0.368076
255	Polygon	1609.886831	0.160989

256	Polygon	3696.670962	0.369667
257	Polygon	1610.680608	0.161068
258	Polygon	2601.485016	0.260149
259	Polygon	3696.670962	0.369667
260	Polygon	3680.763815	0.368076
261	Polygon	1626.649267	0.162665
262	Polygon	3336.241461	0.333624
263	Polygon	3696.670962	0.369667
264	Polygon	3696.670962	0.369667
265	Polygon	3260.69704	0.32607
266	Polygon	3260.69704	0.32607
267	Polygon	3258.419992	0.325842
268	Polygon	3817.21458	0.381721
269	Polygon	3696.670962	0.369667
270	Polygon	3260.69704	0.32607
271	Polygon	3696.670962	0.369667
272	Polygon	3260.69704	0.32607
273	Polygon	3260.69704	0.32607
274	Polygon	3260.69704	0.32607
275	Polygon	3696.670962	0.369667
276	Polygon	3260.69704	0.32607
277	Polygon	27050.33453	2.705033
278	Polygon	3260.69704	0.32607
279	Polygon	3260.69704	0.32607
280	Polygon	3260.69704	0.32607
281	Polygon	3260.69704	0.32607

282	Polygon	1626.649267	0.162665
283	Polygon	3260.69704	0.32607
284	Polygon	1626.649267	0.162665
285	Polygon	3260.69704	0.32607
286	Polygon	1626.649267	0.162665
287	Polygon	3117.374568	0.311737
288	Polygon	287.11015	0.028711
289	Polygon	2833.744705	0.283374
290	Polygon	3618.451947	0.361845
291	Polygon	2164.889303	0.216489
292	Polygon	2723.781223	0.272378
293	Polygon	1505.325006	0.150533
294	Polygon	1319.602622	0.13196

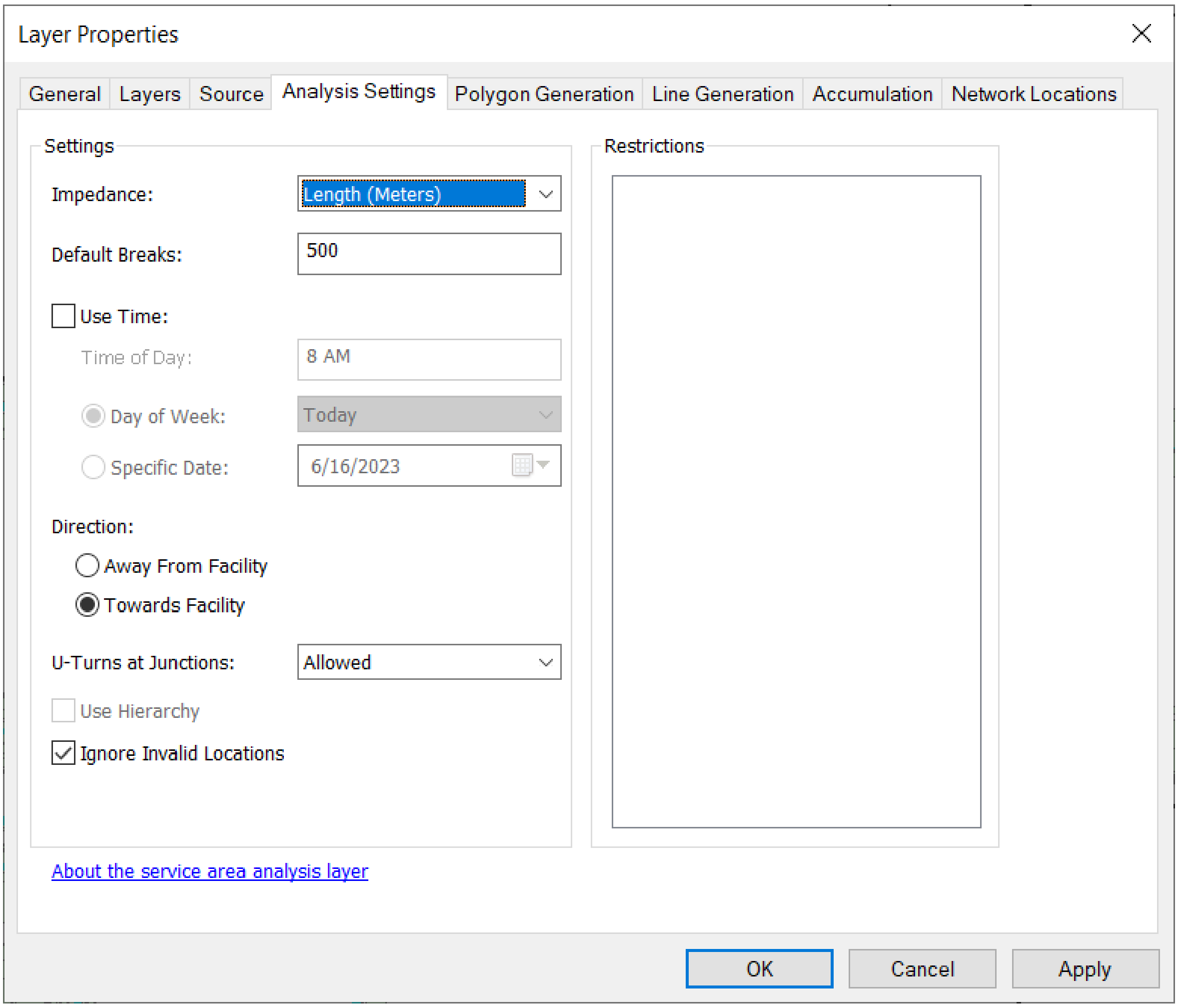
Appendix-B Green Space Seen on Areal Photo

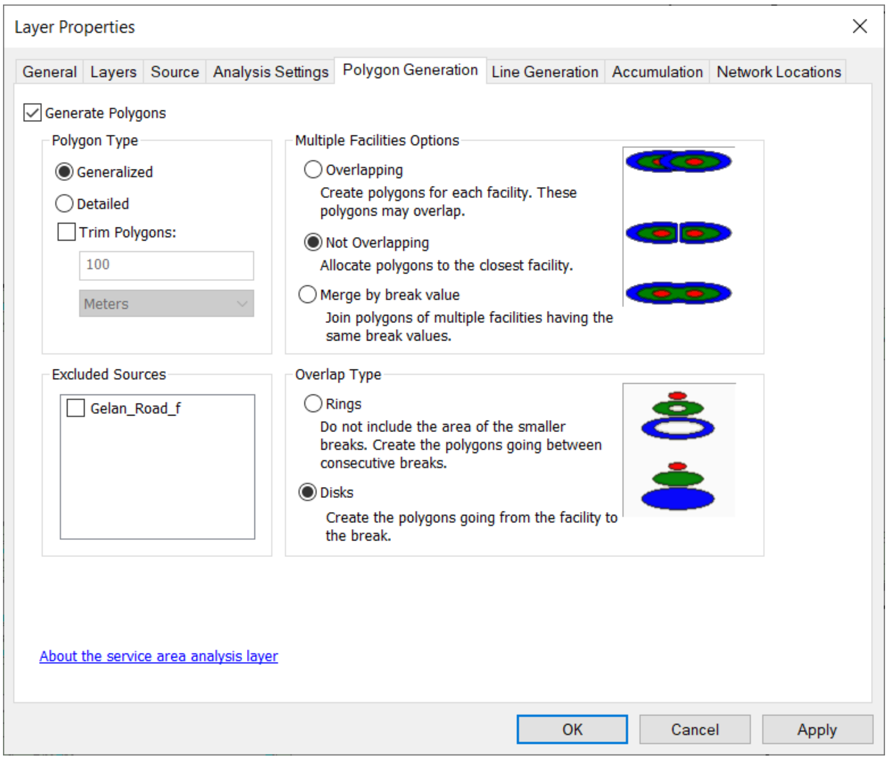
FID	Shape	Area in m²	Area in hectare
0	Polygon	1389.282	0.138928
1	Polygon	1389.282	0.138928
2	Polygon	1868.981	0.186898
3	Polygon	1389.283	0.138928
4	Polygon	1389.294	0.138929
5	Polygon	1389.285	0.138928
6	Polygon	1389.299	0.13893
7	Polygon	1868.991	0.186899
8	Polygon	1389.285	0.138928

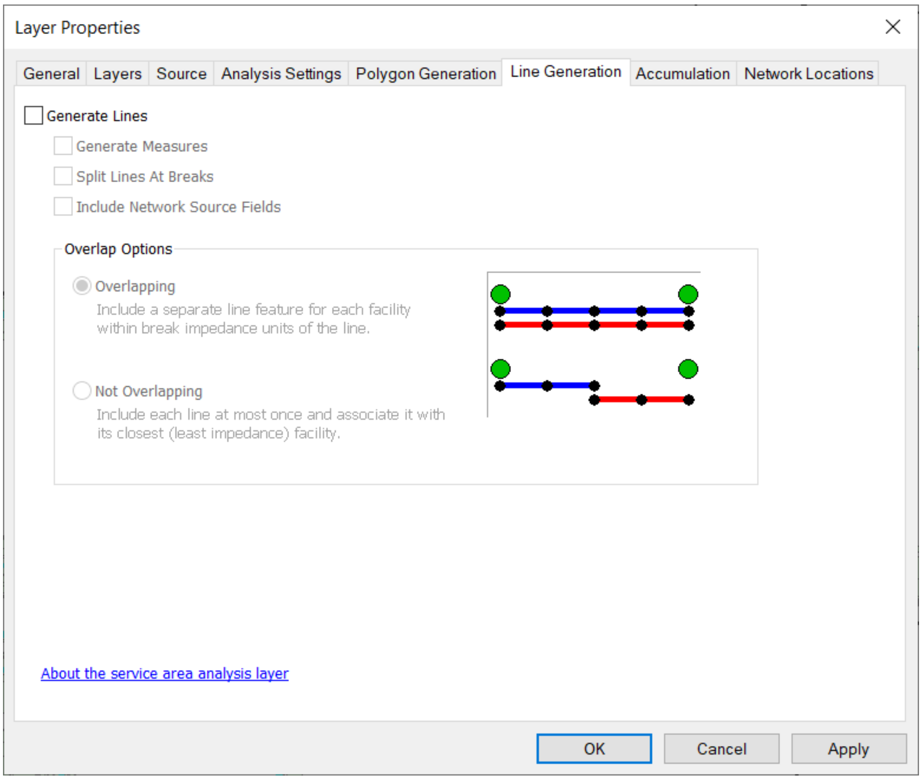
9	Polygon	1860.575	0.186058
10	Polygon	1154.106	0.115411
11	Polygon	1430.838	0.143084
12	Polygon	1389.283	0.138928
13	Polygon	1389.286	0.138929
14	Polygon	1389.288	0.138929
15	Polygon	2372.289	0.237229
16	Polygon	1389.282	0.138928
17	Polygon	1389.282	0.138928
18	Polygon	1440.001	0.144
19	Polygon	1405.33	0.140533
20	Polygon	1389.282	0.138928
21	Polygon	1715.23	0.171523
22	Polygon	1646.972	0.164697
23	Polygon	1272.477	0.127248
24	Polygon	1263999	126.399905
25	Polygon	2709.834	0.270983
26	Polygon	2912.714	0.291271
27	Polygon	2949.489	0.294949
28	Polygon	3238.25	0.323825
29	Polygon	3199.98	0.319998
30	Polygon	1500.568	0.150057
31	Polygon	1352.947	0.135295
32	Polygon	1505.325	0.150533
33	Polygon	519.001	0.0519
34	Polygon	29331.44	2.933144

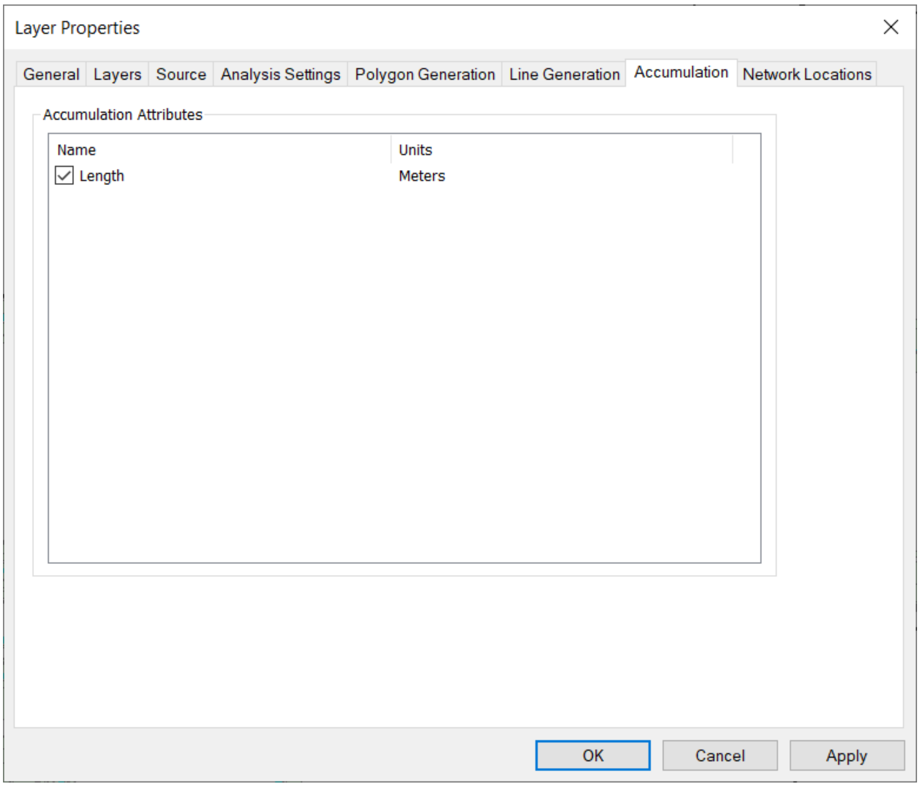
35	Polygon	1279.877	0.127988
36	Polygon	2375.236	0.237524
37	Polygon	3008.232	0.300823
38	Polygon	3463.84	0.346384
39	Polygon	3286.311	0.328631
40	Polygon	3690.974	0.369097
41	Polygon	3330.542	0.333054
42	Polygon	2022.108	0.202211

Appendix-C same AcrGIS analysis settings




Layer Properties
General
Layers
Source
Analysis Settings
Polygon Generation
Line Generation
Accumulation
Network Locations
Generate Polygons
Polygon Type
Generalized
Detailed
Trim Polygons:
100
Meters
Multiple Facilities Options
Overlapping
Create polygons for each facility. These polygons may overlap.
Not Overlapping
Allocate polygons to the closest facility.
Merge by break value
Join polygons of multiple facilities having the same break values.
Excluded Sources
Gelan_Road_f
Overlap Type
Rings
Do not include the area of the smaller breaks. Create the polygons going between consecutive breaks.
Disks
Create the polygons going from the facility to the break.
About the service area analysis layer
OK
Cancel
Apply


Layer Properties
General
Layers
Source
Analysis Settings
Polygon Generation
Line Generation
Accumulation
Network Locations
Generate Lines
Generate Measures
Split Lines At Breaks
Include Network Source Fields
Overlap Options
Overlapping
Include a separate line feature for each facility within break impedance units of the line.
Not Overlapping
Include each line at most once and associate it with its closest (least impedance) facility.
About the service area analysis layer
OK
Cancel
Apply


Layer Properties
General
Layers
Source
Analysis Settings
Polygon Generation
Line Generation
Accumulation
Network Locations
Accumulation Attributes
Name
Units
Length
Meters
OK
Cancel
Apply