Built Up Area Densification And Its Impact On Urban Green Space: The Case Of Gondar City

Ermias Tamru Wochefo

A Thesis Submitted to the Department of Architecture

School of Civil Engineering and Architecture.

Presented in Partial Fulfilment of the Requirement for the Degree of Master's

in Environmental Architecture

Office of Graduate Studies

Adama Science and Technology University

Adama, Ethiopia

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APPROVAL OF BOARD OF EXAMINERS

I, the advisors of the thesis entitled **"Built up area Densification and its Impact on Urban Green Space: The Case of Gondar City."** and developed by Mr. Ermias Tamru , hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

__________________________	__________________	_______________
Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Mr. Ermias Tamru have read and evaluated the thesis entitled **"Built up area Densification and its Impact on Urban Green Space: The Case of Gondar City"** and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Environmental Architecture**.

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Finally, approval and acceptance of the thesis are contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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Office of Postgraduate Studies, Dean	Signature	Date

DECLARATION

I hereby declare that this MSc Thesis entitled **"Built up area Densification and its Impact on Urban Green Space: The Case of Gondar City"** is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Ermias Tamru ____________________ ________________

Name of the student Signature Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled **"Built up area Densification and its Impact on Urban Green Space: The Case of Gondar City"** prepared under my guidance by Mr. **Ermias Tamru** submitted in partial fulfillment of the requirements for the degree of Masters of Science in **Environmental Architecture**. Therefore, I recommend the submission of a revised version of the thesis to the department following the applicable procedures.

Dr. Eshetu Temesgen	____________________	________________
Advisor	Signature	Date

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LIST OF ABBREVIATIONS AND ACRONYMS

E.C	Ethiopian calendar
EPRDF	Ethiopian people Revolutionary Democratic Front
FGD	focus group discussion
GIS	Geographic Information System
GPS	Global Positioning System
KML	Keyhole Markup Language
LC	Land Cover
LULC	Land use/land cover
LULCC	Land use/land cover Change
RS	Remote Sensing
SPSS	Statistical package for social science
UGI	Urban Green Infrastructure
UN	United Nation
UNCHS	United nation center for human settlement
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WGS	World Geodetic System

ABSTRACT

Densification is critical to implementing the strategy of urbanization for sustainability within the cities in developing and under-developing countries. Horizontal densification is a common type of urbanization in developing and under-developing countries. However, studies focusing on explaining how horizontal densification influence the provision of the urban green area is rare, especially in developing countries such as Ethiopia. Hence, this research aims to investigate the effect of horizontal densification on the urban green area in the case of Gondar city. The data were collected through a questionnaire survey with 195 respondents who have been living in the case study area minimum for 5 years and urban agriculture farmers, focus group discussions were with 6 professionals with city green development officials, study area observation, and finally LULU change of the sub-city in last twenty years. The result shows that LULC of urban green area changes to the built environment, horizontal densification The green area coverage of Arada sub-city from 320.83 Ha(78.75%) in 2000, to 310.59 Ha (76.17%) in 2010 then 272.52 Ha (66.87 %) in 2020. The proportion of built-up areas in 2000 was 21.25% of the entire study area. In 2010 the percentage of the built-up area is 23.83% of the entire area, which is 2.58% more than before. For 2020 was 33.13% of area coverage was. the building density (FAR) of the study area is 0.02 FAR in 2000 , 0.23 In 2010 and 0.33 in 2020 it shows the study area is under densificasion From the respondent's point of view, the major barrier that challenge the green environment through the last twenty years is 33.3% indicated that the main challenge is Lack of strong protection of green area in government, 27.0% both Improper domestic waste management and green areas replaced by new buildings, at the list 12.7% respondent said The land value increasing is the main challenge for the green area in the city Housing is a problem for city residents, as housing prices in cities can be very high, and usually higher than in rural areas, and the residents' incomes are typically very low.the researcher sugest to develop highly functional green space under compact conditions,.

Keyword : ***building densification, urbanization, green infrastructure, eco-friendly, LULC change, horizontal densification***

CHAPTER ONE

1. INTRODUCTION

This chapter deals with the background information around the topic area that has been done before, Describes; the problem, objective, research question, scope, the significance of the study, and organization of the paper. The motivation of the study was because of the following basic reasons: The first reason was the observation of the existing green area of the city is diminishing, and serves as illegal trash dumping and land use is changing. Secondly, urbanization causes the current issue of global warming and degrades the natural environment.

1.1 Background of the Study

As people have tended to move from rural to urban areas, and the boundaries of those urban areas have been constrained by natural topography or policies such as the protection of the green belt, those areas have become more densely occupied with buildings expanding upwards and downwards, green areas and brownfield sites being developed and homes becoming more compact and closer together (UNDESA , 2014).

According to Beatley (2000), built up area densification (Infill development) is the process of developing vacant (natural areas) or under-used parcels within existing urban areas. Most communities have significant vacant land within city limits, which, for various reasons, has been passed over in the normal course of urbanization (Washington , 1997). Currently, urban planners and designers take densification as a strategy to prevent urban sprawl while addressing housing shortages to accommodate a growing population (Haaland and van Den Bosch , 2015), and as the most relevant strategy for ecological modernization (Petter, Saglie & Tim , 2020).

Even though densification fulfills the housing demand of society's, uses less energy per person than rural or suburban areas, more efficient infrastructure and it is easy to public amenities within walking distance (Neilson and Associates, 1985; Bunker et al., 2002; Buxton & Tieman, 2005), it also has several negative impacts. These possible environmental impacts from extremely dense urban environments include air pollution, shortage of semi-private/private green space Acioly (2000), increased land and housing prices in selected areas, lack of privacy, increased negative environmental impacts arising from increased energy demand/gas emissions, changes to microclimates caused by the increased amount of built form Petter et al (2018), and reduced and trees green spaces and unsealed surfaces McCrea and Walters (2012). The above environmental limits threat to sustainable urban development(Amer,2007) and climate change treaty (Petroski,2016) even more challenging task to combine climate change mitigation and adaptation strategies in urban land use (Næss, 2011). The green city concept is a more suitable solution for our cities.

More generally there is a need to focus on actual processes of densification to assess the effectiveness of compact city/in-fill development policies adopted by cities and regions (Petter et al ., 2018). In another way, densification could be vertical or horizontal densification, which, is most likely urban sprawl. The goal of this thesis was to evaluate Built up area densification and its impact on urban green space in Godar city in the case of Arada sub-city and Propose alternative strategies to promote sustainable urban green infrastructure.

1.2 Statement of the Problem

Building residential areas are recognized as the basic activity in human life. during the rapid urbanization and population growth increase the demand for shelter working place and recreational areas to satisfy the society. This time urban areas expanding dramatically while the land resource is limited within this situation, land consumption should be wise for the sustainability of the ecosystem but less concern and awareness of this critical condition create a gap in the way of urbanization in developing countries. Currently, the human race is facing challenges due to resource depletion due to fast-expanding cities this leased to the conversion of green areas and produce waste. urban life trend in a developing country is creating great land consumption problems that could lead to crises. conservation and protection of a green environment are necessary for sustainability. Ethiopia relies on its diverse biological resources mainly on forests for its socio-economic development. However, these resources are now under severe pressure. Its forest has shrunk from covering 65% of the country and 90% of the highlands to 2.2% and 5.6%, respectively (Berry, 2003; EEPFE, 2005). As a result, land degradation in the form of soil erosion and loss of soil fertility is a typical phenomenon in many areas of Ethiopia (EARO 2000; Asefa et al., 2003).

The study was undertaken by Tewodros Ferede (2011) in Gondar city green areas are declining from lack of attention, poor maintenance, management, lack of development, and rapid urbanization. The green coverage is drastically decreasing as open and green areas are invaded by the construction of buildings. The city lacks sufficient places for children, elders, and adults to play and recreate in a healthy environment.

The Specific problem of the city is; Decreasing the consideration of natural green area in the city, The vegetation covers of the city is changing, Green infrastructure problems such as quality, access and service of existing green area and decreasing garden area In households.




Figure 1: Existing green space condition

Source: Own Survey (2021)

Generally, green space is an endangered element of the city. It is therefore high time for the city of Gondar to question the situation of its green spaces. There is a gap that describes the consequence of densification, land value, and land use land cover change on green area. The main focus of this research is assessing the existing land use land cover change and its impact on the green area under the densification process.

1.3 Research Objectives

General objective

To Investigate the nature of Built up area densification and its impact on urban green space: the case of Gondar city.

Specific objectives

The specific objectives of the study are to:

I. Assess the land use /cover change of Gonder town within 20 years.
II. Examine the impact of built up area densification on green areas.
III. Propose alternative strategies that promote sustainable urban green infrastructure

1.4 Research Questions

- How is the land use /cover change of Gonder town within 20 years?
- How does built up area densification affect green space?
- What are alternative strategies that promote sustainable urban green infrastructure?

1.5 Significance of the Study

The land is a limited resource so we have to use it effectively to sustain. Citys are expanding rapidly and affects directly green areas, which is the lung of the earth. this study analyzes the changes between 2000 and 2020 to contribute to the developments of urban land and monitoring of environmental management and monitoring plan of the areas. to understand the impacts of built up area densification on green areas and to identify the inefficiency of green infrastructure to improve the green infrastructure of Gondar city. Moreover, the final findings and output of this paper can also be used as a standpoint and spring for further research work in the related sectors and subject matter for one with interest.

1.6 Scope of the Study

The study had evaluated the change of green area by building densification in Arada sub-city in Gondar city and all kebeles (kebele 06,07,08,09,10)in the sub-city had passed. which is the densest sub-city in Gondar city. Thematically the study had focused on the Built Up Area Densification dynamic of the sub-city, land cover change of green area, people's perceptions about the green area. Furthermore, the study had assessed the land use land cover change(LULC) to analyze the density of the built-up area.

1.7 Organization of the Thesis

The thesis is categorized into five chapters.

Chapter One: Introduction to the study will introduce the thesis by lighting the main topic of the study, research problems, objectives, questions, significance and, scope detail.

Chapter Two: concentrates on the literature review and related work for this study. This section presents brief perceptive densification, a measure of densification, green area consequence of densification of land use, and land cover changes.

Chapter Three: The third chapter focuses on the general methodology, This chapter discusses all the procedures and techniques applied for data collection and analysis in detail.

Chapter Four: The results and discussions is the fourth chapter which presents the results of qualitative and quantitative data findings. The qualitative data are analyzed based on a questionnaire survey, field observation, interview and focus group discussion.

Chapter Five: The last chapter presents conclusions and recommendations. In this section, key findings and critical points that need further treatment have been forwarded as a recommendation for future work.

1.8 Operational Definition

The terms that are emphasized highly in the study are solid waste management, and solid waste recycling/composting

Agricultural land -Generally, the area used in one way or another for agricultural purposes Includes grazing areas cultivated landsand urban agriculture

Built Up Area (BUA)- It is the total area being developed or constructed. It is the Gross Floor Area plus Parking plus any Service Area of associated with the subject building or project

Built up area densification - Construct a new building in a vacant plot nearby built-up areas or between the existing buildings. (Brunner and Cozens, 2013).

Land use land cover change– The result of intricate interactions between humans and the surrounding physical environment, by which LULC involves the conversion of various land use categories (Yadav et al, 2019).

Natural Environment -These include the living and non living things that were made by Nature.E.g Mountains, Lakes, Rivers, land, Vegetation, Soil, Natural disasters etc.

Shrub/grass - An area of greenery , vegetation set apart for recreational or aesthetic purposes and open spaces which exist in city .

CHAPTER TWO

2. LITERATURE REVIEW

Theoretical Literature review

2.1 Background of building densification

Most of the research shows that; Socioeconomic development, due to significant population and economic growth, (Williams,1997) (Defries & Rosenzweig,2010) and contentious migration from rural to urban areas will give rise to the large-scale need for the built environment to fulfill the need of society for work, residence, and recreation purpose. As the world, the percentage of people living in urban areas will grow from 50% in 2010 to nearly 70% by 2050 (united nations, 2013). The scholar said that all this need for a built environment led to expansion and/or densification of urban areas. (Wolff, Haase & Haase,1990) in consequence of these trends, UN-habitat has identified planned city infill, redevelopment, and densification. Today cities are expanding in all possible directions to satisfy increasing populations as well as to accommodate the demand for different lifestyles. These population changes lead to other changes in land use, economic activity, and culture. **A**ccording to Beatley (2000) , Building density refers to the degree of centralization or decentralization of urban structures and to the intensity of development of a city .

2.1.1 Urban Densification

According to review of the literature on the issues indicates that there is no universally accepted definition for density. The definition depends on intended usage and objectives. Densification is a term used by planners, designers, developers, and theorists to describe the increasing density of people living in urban areas. previous studies indicate that urban densification has for some decades been considered the most relevant strategy for ecological modernization within the field of urban spatial development. Netherlands Environmental Assessment Agency (2015) and (CPB &PBL,2015). Densification is usually a step-by-step process. Rotterdam has already shown that densification can contribute to creating a successful city. densification process (i.e., urban intensity expansion) despite its importance to both planning and subsequent impacts to the environment and local economies. As people have tended to move from rural to urban areas, and the boundaries of those urban areas have been constrained by policies such as the protection of the green belt, those areas have become more densely occupied, with buildings expanding upwards and downwards, green areas and brownfield sites being developed and homes becoming more compact and closer together.

The density of urban populations makes it easier and less costly for the government and utilities to provide essential goods and services (Brockerhoff, 2000). For example, the supply of basic facilities such as fresh water and electricity can be achieved with less effort and less cost per person.

2.1.2 Type of Densification

In general densification process can typically be determined through two variables, i.e. Through the increase of population and jobs or the increase of built floor area within a defined area. These two variables are related but may present divergences over time and space. This is especially the case when buildings undergo subdivision and subletting, which may imply an increase of population densities that goes faster than the corresponding increase of built areas (Broitman & Koomen, 2015).

However, the commodification of housing may imply a subsequent growth of the building stock (and an increase in built form) without a corresponding uptake by inhabitants/occupiers or fewer people in larger dwellings. Monitoring the divergence between built and occupational densification is a key indicator of ongoing urbanization dynamics. These indicators are to be contrasted with other variables like the quality of life or the economic development of cities. More generally there is a need to focus on actual processes of densification to assess the effectiveness of compact city/in-fill development policies adopted by cities and regions (Petter et al., 2018) .in another way densification could be vertical or horizontal densification, which, most likely urban sprawl. In central city areas, densification (also called intensification and compaction; Williams, 2000) can be achieved either by establishing new buildings in areas not built-up previously (infill), in built-up areas previously having other purposes (brownfield), or in areas with lower-density buildings which are replaced by high-rise buildings. Densification is also termed consolidation when referring to the compaction of the inner city and peripheral areas (Bunker et al., 2002). Densification can thus mean different building forms and processes, depending on the context (e.g., an Australian suburb or an inner-city of Hong Kong).

Table 1: Different urban densification approaches

Approaches	Description
Infill	Construct a new building in a vacant plot nearby built-up areas or between the existing buildings. (Brunner and Cozens, 2013).
Filling backyard	Implement by constructing a new building in the backyard of an existing building and refers to horizontal extension (Attia, 2015).
Demolish and rebuild	Demolish the existing building and reconstruct the high-rise building in a low-density area. It has a higher potential to increase density and new design strategies can also be applied (Attia, 2015).
Roof stacking	Easily applicable to the existing building by adding one or two stories over the rooftop (Floerke et al., 2014).
RoofTransformation	A very easy and quick approach to transform the saddle roof to another story with the use of existing and minimal space (Attia, 2015).
Adaptive reuse	Use of existing buildings such as old factories, commercial buildings for the development of residential buildings (Shipley et al., 2006).

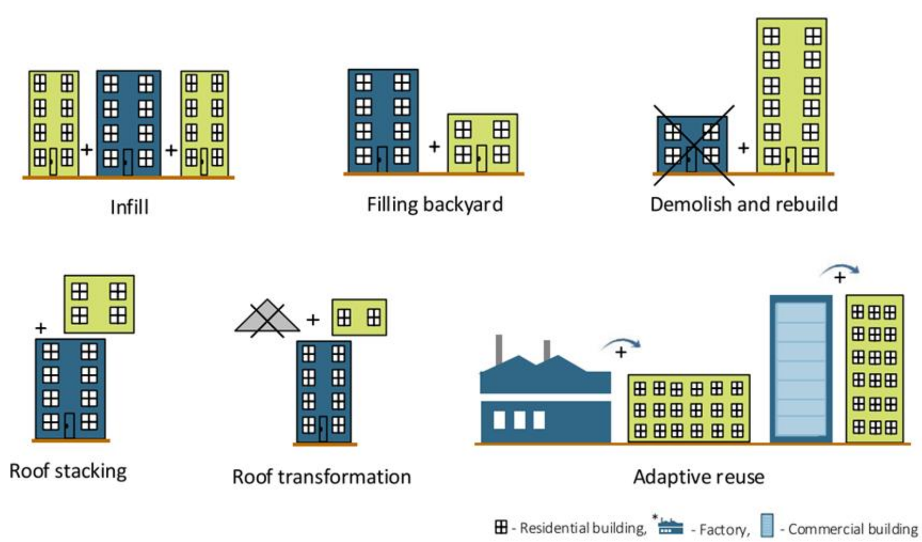


Figure 2: Different urban densification approaches

Source (Petter Næss, Inger-Lise Saglie & Tim Richardson (2019))

2.1.3 The Consequence of Building Densification

Densification has its potential negative effects. uses less energy per person than rural or suburban areas, reduced land consumption, improved organization of public transport, improved thermal performance of buildings, and the increased vibrant nature of existing districts. more efficient infrastructure and it is easy to public amenities within walking distance.in areas of high density and ensure more efficient use of land and existing infrastructure (Neilson and Associates, 1985; Bunker et al., 2002; Buxton & Tieman, 2005).

The negative impacts also include the physical and mental health implications of stress from reduced living space, increased traffic congestion and concentration of air pollution in densely populated areas, overshadowing of the view from existing buildings, shortage of semi-private/private green space, loss of access to public amenities (crowded public spaces), increased land and housing prices in selected areas, lack of privacy, increased exposure to noise as well as negative environmental impacts arising from increased energy demand/gas emissions, changes to microclimates caused by an increased amount of built form, and reduced and trees green spaces and unsealed surfaces (Petter et al., 2018 ; Mc Crea and Walters ,2012), even more, challenging task to combine climate change mitigation and adaptation strategies in urban land use (Næss, 2011).

2.2 Green Area

Un-built Environment: this can be a natural environment or area provided by planners and designers. Green space (land that is partly or completely covered with grass, trees, shrubs, or other vegetation). Green space includes parks, community gardens, Open space can include: Schoolyards, Playgrounds, Public seating areas, and cemeteries. Open space provides recreational areas for residents and helps to enhance the beauty and environmental quality of neighborhoods. But with this broad range of recreational sites comes an equally broad range of environmental issues. Green infrastructure also serves to provide an ecological framework for the social, economic, and environmental health of the surroundings (Nachhaltiges investment , 2016). Byomkesh et al,. (2012) indicated that urban green spaces are those lands that are covered with natural or man-made vegetation but are present in built-up areas.green spaces are multi-functional, offering not just a single land use solution, but the opportunity to achieve social, environmental and economic added value .

2.2.1 Types of Green Infrastructure

Urban forests: infrastructure, green infrastructure has the potential to enhance existing ecosystems and make them more stable, a declaration on environment and development that was designed to alleviate the social and economic consequences of environmental degradation (UNDSD , 1992).

Green roofs: improve air and water quality while reducing energy costs. The plants and soil provide more green space and insulation on roofs.

Rain gardens: rain gardens are a form of stormwater management using water capture. Rain gardens are shallow depressed areas in the landscape, planted with shrubs and plants that are used to collect rainwater from roofs or pavement and allow for the stormwater to slowly infiltrate into the ground (U.S. Environmental Protection Agency,2017) .

The green alleys: will provide open space on top of these ecological benefits, converting spaces that used to feel unsafe, or used for dumping into a playground, and walking/biking corridor (Tuhus-Dubrow, Rebecca , 2014) .

Green schoolyards: Schoolyard infrastructure to capture and store rainwater: Rain garden, rain barrel, tree groves with pervious pavers, and an artificial field with a turf base (Ngom, Gosselin &Blais, 2016).

Minimum standards for urban green spaces.

Table 2 : Minimum standards for urban green spaces.

Functional level	Maximum diatance from home (m)	Minimum surface (ha)
Residential green	150	
Neighbourhood green	400	1
Quarter green	800	5
District green	1600	10
City green	3200	60
Urban forest	5000	>200(smaller towns) >300(big cities)

Source: Herzele and Wiedemann, 2003.

2.2.2 Green Area Under Densification

Urban consolidation and the reduction in area per lot that results, together with the current practice of building very large private dwellings (Timms, 2006), means that the private outdoor area, and are available for planting, is reduced in size. This, together with an adjustment in planning controls allowing for reduced setbacks and smaller private open space areas (Hall, 2010), and the 'in-vogue' approach to minimalist gardening has seriously reduced the amount of planting on private lots in recent times. Over the past 40 years in Australia, the average size of a new block of land has halved while that of the suburban house has more than doubled (Hall, 2010).

The built-up areas of cities and the fragmentation of open space in and around them the perception of sprawl. Under horizontal development focuses attention on the relationship between the built-up area and the remaining open spaces in a given urban landscape and between T1 and T2. The equation of sprawl with the amount of left-over open space in the urban development process is the one adopted by Burchfield and her colleagues (Burchfield *et. al,* 2005) .

Table 3 : the relationship between the built-up area and the remaining open spaces

Development process	Inform
New development	built-up pixels existing in the land cover for T2 but not T1
Infill	new deveopment occurring within the T1 urbanized open space
Extension	non-infill new deveopment intersecting the T1 urban footprint
Leapfrog	new development not intersecting the T1 urban footprint
Openness index	the average percentage of open space within a 1 km2 neighborhood for all built-up pixels
Open space contiguity	the probability that a built-up pixel will be adjacent to an open space pixel
Open space fragmentation	the ratio of the combined urbanized and peripheral open space area to the built-up area

Source (ASPRS 2007 Annual Conference)

2.3 Effect of Building Densification on the Green Area

Findings confirm that urban densification processes, including consolidation and infill development, threaten urban green space. Several ways are identified to deal with these challenges, while also highlighting, e.g., green cover diminishes, decreases green area quality, changes its multifunctional activity and it changes people's perception about the green area.

2.3.1 Land cover area decrease

According to Beatley (2000), the high conversion of natural areas and farmland into built-up areas leads to an increasing urban expansion and densification process.it diminishes in the surrounding green area. lack of urban green space in densified urban areas and the removal of green space when densifying city areas (e.g., Jim, 2004; Fuller and Gaston, 2009; Brunner and Cozens, 2013). Moreover, they have resulted in the destruction and or fragmentation of natural or semi-natural vegetation at the urban periphery and in rural areas (Johnson, 2001). providing evidence of changes in green space pattern over time (e.g., fragmentation; Hanoi, Vietnam: Uy and Nakagoshi, 2007; Mashad, Iran: Rafifiee et al., 2009; Karachi, Pakistan: Qureshi et al., 2010) and dramatic decline also in inner-city areas, due to building development (Hong Kong, China: Jim, 2005; Mashad, Iran: Rafifiee et al., 2009). There is evidence that urban green space is under pressure due to densification processes such as infill development (Pauleit et al., 2005; Rafifiee et al., 2009; Byomkesh et al., 2012).

Urban consolidation and the reduction in area per lot that results, together with the current practice of building very large private dwellings (Timms, 2006), means that the private outdoor area, and the area available for planting, are reduced in size. (Hall, 2010). Some scholars showed that increased land prices and Informal peri-urban land market in densified areas, reduced trees green spaces, and unsealed surfaces (Petter et al , 2018 ; McCrea and Walters , 2012 ; Adam, 2014b & Holden et al. 2008).

2.3.2 Green area Quality Decrease

The authors argue that infill development without planning for more public green space can decrease living standards in an entire neighborhood. Smith et al. (2009) note the almost total absence of tree plantings in green space and monotonous, poorly diversified other plantings on redeveloped sites in England, and ask for better quality in the green space provided. Reasons for poor quality greening were low maintenance efforts, fear of or experiencing vandalism by tenants, or providing what was expected by tenants.

Studies show that The negative effects of densification at a local level are often due to habitat loss and dense building forms are related to negative biodiversity potential (Tratalos et al., 2007). The urgent need for studies of biodiversity concerning urban growth at the city scale is shared by other authors (e.g., Lin and Fuller, 2013).

2.3.3 Changes its multifunctional activity

Based on vegetation's association with edification-related behavioral changes (Kuo and Sullivan, 2001; Velarde et al., 2007), environmental probabilism and aesthetic appeal, the prevention of illegal dumping appears to be another potential function. Hence, landscaping efforts on illegal dumping sites along streets or vacant lots have been referred to in a few studies. Bonham and Smith (2008) reported that greening vacant lots in Philadelphia,

Most dense districts' insufficient public garbage collection services and facilities are also known to increase illegal dumping (Matsumoto and Takeuchi, 2011; Zapata Campos and Zapata, 2013).while the spatial characteristic factor of unclear ownership is responsible for increased IDHG (Yatmo et al., 2013). Physical characteristics, namely disorderly, uncared-for scenes or aesthetically unappealing looks, and spaces where dumping has already occurred, seem to attract illegal dumping (Wilson and Kelling,1982; Crofts et al., 2010; Yatmo et al., 2013).

2.3.4 It changes peoples perception about the Green area

Researchers find that the displacement compensation does not represent compensation for the loss of land use rights (Ambaye, 2013; Abdo, 2015) also state that farmers prefer an informal land sale to informal settlers.

Through lack of interest of available data and knowledge on existing green space problematic is illegal building on green space Tian et al., 2012). This development seems rooted in a lack of interest or economic incentive for developers to preserve green space and a lack of regulations to prevent its removal (Brunner and Cozens, 2013).

Residents expressed wishes regarding more greenery, tree plantings, and sports facilities. The importance of green space for residents has been also investigated in economic terms in form of residential prices for dwellings near green space. Higher housing prices for flats with views of green space e.g., China (Jim and Chen, 2006a, 2007, 2010) and for property values in Adelaide, Australia (Mahmoudi et al., 2013).

2.4 Empirical literature

2.4.1 Residential density (building density)

Assessing residential density changes is essential for evaluating land consumption, the conservation of natural capital and ecosystems, air quality and related health problems in cities, and the corresponding challenges for urban and regional planning (Nilsson et al., 2014). In this respect, residential density is a simple but powerful indicator for urban growth/decline (Kasanko et al., 2006), the patterns that these trends reveal for the city, and how they change over time (Batty, Besussi & Chin , 2003)

The amount of development per acre permitted on a parcel under the applicable zoning, commonly measured as dwelling units per acre (du/ac).

Gross Density Gross density means the number of residential units per acre of land. This is calculated by taking the total lot area divided by the number of units. For example: if a ten-acre property contains 40 residential lots, the gross density is 4 units per acre (40-units/10-acres = 4 units/acre).

Net Density ; Net Density is defined as the number of units (typically expressed in residential units) per acre of land after required infrastructure and critical areas are deducted from the gross area – thus leaving only the area devoted to the lots themselves. In many cases, net density may be calculated by adding the cumulative area of all lots together and dividing that sum by the number of lots in a given area, typically within one subdivision. "Required infrastructure and critical areas" includes, but is not limited to, required public or private roads, infrastructure such as stormwater ponds, required public parks or trails, critical areas, and their required buffers (Petter, Inger & Tim , 2017).

Floor Area Ratio; Floor Area Ratio For parcels proposed for development, gross FAR is calculated by dividing the total floor area on the parcel proposed for development by the base site area (Hays, 2016).

Density varies greatly depending on the base land area used in the density calculation (parcel, block, neighbourhood, sub-city and city level). threshold densities that are proposed for developing nations by (UN-Habitat) are applied for comparison. The thresholds include net dwelling less than 15du/ha for low, 15-40du/ha for low to medium, 40-120du/ha medium, 120-500du/ha high and greater than 500du/ha for very high density .Maps of Green Index and Building Density is the another way of studing density Both the green index and building density were determined by counting their percentage in a cell (Table 2).

Table 4 : Various parameters and their responding measure of quality of green.

Parameter	Indicator and Description	Percentage	Value (pj)	Quality of UGS
Green index	Percentage of green in each cell	0–25 25–50 50–75 75–100	0.25 0.5 0.75 1	Low Moderate High Very high
Building density	Percentage of buildings area in each cell, exclude the open space without vegetation	0–25 25–50 50–75 75–100	1 0.75 0.5 0.25	Very high High Moderate low

Source (ASPRS 2007 Annual Conference)

2.5 Method of land use/cover change detection

GIS, Remote Sensing, land cover modeling tools are tools used to land use/cover studies. Remote Sensing (RS) and Geographic Information System (GIS).are tools used for spatiotemporal land use/cover studies.it is a kind of software that helps in generating custom maps and analyzing different aspects of geographic data.

2.5.1 Remote Sensing (RS)

"Remote sensing is the science and art of obtaining information about the Earth's surface through the analysis of data acquired by a device which is at a distance from the surface"(Lambin , 2004). In this kind of RS analysis, aerial photographs and images from Earth-observing satellites are most commonly used.

2.5.2 Geographic Information System (GIS)

Geographic Information Systems (GISs) are defined as software, which refers to the earth's surface information (Good child, 2001).GIS support any operation on geographic information: acquisition, editing, manipulation, analysis, modeling, visualization, publication, and storage. GIS has four basic subsystems: input, storage, analysis, and output. All these things act as a perfect system. RS and GIS techniques are comprehensively used for analytical purposes in numerous fields' like-urban planning, geography, environmental planning, and so on.

2.5.3 Land Use/Land Cover changes

Land cover refers to the observed biophysical cover on the earth's surface including vegetation, bare soil, hard surfaces, and water bodies. Whereas land use is the utilization of land cover type by human activities for agriculture, forestry, settlement, and grazing land by altering land surface processes including biogeochemistry, hydrology, and biodiversity (Di Gregorio and Jansen, 2000).

2.5.4 Use of Remote Sensing and GIS for Land use Land cover Change

Remote sensing is defined as the use of an electromagnetic radiation sensor to record images of the environment which can be interpreted to yield useful information. Remote sensing and GIS are being increasingly used in combination spatial analysis. GIS databases are used to improve the extraction of relevant information from remote sensing imagery, whereas remote sensing data provide periodic pictures of geometric and thematic characteristics of terrain objects, improving our ability to detect changes and update GIS databases. RS can provide researchers with valuable multi-temporal data for monitoring land-use patterns and processes and GIS techniques make possible the analysis and mapping of these patterns (Netsanet, 2007).

2.5.5 Urban Land use/Land Cover Dynamics

Due to several reasons, urban centers expand to the surrounding environment. The outskirts of urban areas usually referred to as rural-urban-fringe, are characterized by farming land, forest cover, and source of water supply. The trend of urban growth towards the urban-rural fringe has an impact on the surrounding ecosystem. One of the major impacts of urban land cover change is diminishing in surrounding forest and agricultural land. It is also likely that large amounts of valuable agricultural or irrigated lands are converted to non-agricultural areas (e.g. built-up areas).

2.5.6 Application of Remote Sensing on Urban Dynamics Study

As mentioned in Addis (2009), for decades the visual interpretation of aerial photography of urban areas has been based on the hierarchical relationships of basic image elements. Several urban remote sensing applications to date have shown the potential to map and monitor urban land use and infrastructure and to help estimate a variety of socio-economic data (Jenson and Cowen, 1999). However, much of the expert knowledge of the human image interpreter was lost in the transition from air photo interpretations to the digital analysis of satellite imagery.

It is well known that the great strength of remote sensing is that it can provide spatially consistent data sets that cover large areas with both high detail and high temporal frequency, including historical time series. This has been becoming more effective with the emerging sensors that provide high spectral, spatial, and temporal resolution data to researchers. (Herold, et al., 2003).

Considering the recent improvements in spatial, spectral, and temporal resolution, remote sensing technology can provide special advantages in studying growth and land use/land cover change processes and analysis of the growth pattern and their fragmentations. Remote sensing and spatial datasets obtained through remote sensing are consistent over great areas and over time. They provide information at a greater variety of geographic scales with a greater degree of detail. The information derived from remote sensing can help describe the urban environment and leading an understanding of urban planning and management (Longley and Mesev, 2000).

2.6 Contextual literature

2.6.1 Urbanization trend of Gondar

is one of the three metropolitan cities in Amhara National Regional State with a direct link to Bahir Dar-the region's capital. Even if the recent urban planning categorizes urban land use into commercial, residential and agricultural/industrial sectors, one cannot easily find such clear demarcations on the ground. Gondar can be characterized by three major land use types namely agriculture, built up and green areas .inner city of Gondar is dominated by built up areas while in periurban areas, agriculture is dominant. During the last few three decades the growth of Gondar city was dramatic. The population of the city grew from 109,817 in 1991 to 390,644 in 2019 (City Administration 2019) resulting in pressure on the city to avail more land for different purposes. Besides, the Area of the city expanded from 8.7 hectare to 26,027.6 hectare . The growth of the city brings a change in land use land cover. Green areas are gradually diminishing while other land use types are expanding (Kassie et al, 2016). Although LULCC is not a recent phenomenon in Ethiopia (Hailemariam et al. 2016), it is change by the scale, speed and long-term nature of urbanization (Msofe et al. 2011). Most studies on LULCC in Ethiopia have centred on land degradation and associated consequences due to expansion of deforestation (Taddese 2001; Tsegaye et al. 2010). The transformation of land use/ land cover types leads to a change in the structure and function of green infrastructure services (Lei and Zhu 2017). Te need to balance economic, social and ecological ecosystems is becoming increasingly urgent because LULCC is in the direction of rapid urbanization (Song et al. 2016).

2.6.2 Trends of land use land cover change in Gondar city

The city of Gondar, where this study has been conducted, is one of the fastest growing cities in the country. The urban area is believed to be in a dynamic state of expansion following the direction of north to south direction. This is may be the topographical nature of the city for this rapid expansion. Especially during the last thirty years in the urban land use conversion in the city is expanded in a very rapid nature with intentional and sprawl condition which is like a leap frog development for many reasons. These were different types of driving forces i.e Biophysical, socio-economic, technological, political or institutional change .(astede et al.2019)

2.7 Lesson learned

Rapid urbanization causes disorganized and unplanned growth of the towns and cities. The pressure of an ever growing population becomes the burden on the limited civic amenities which are virtually collapsing; there is the need to balance present requirements of land against future needs.

This Rapid urbanization also promoted the economic and social development as well as a physical land use land cover change. To understand the change Land use land cover information is a very important aspect in the management of urban areas.

remote sensing represents a cost-effective method to generate land cover information. The ability to analyze remote sensing data is important because it allows changes in earth's surface to be monitored as they occur.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Introduction

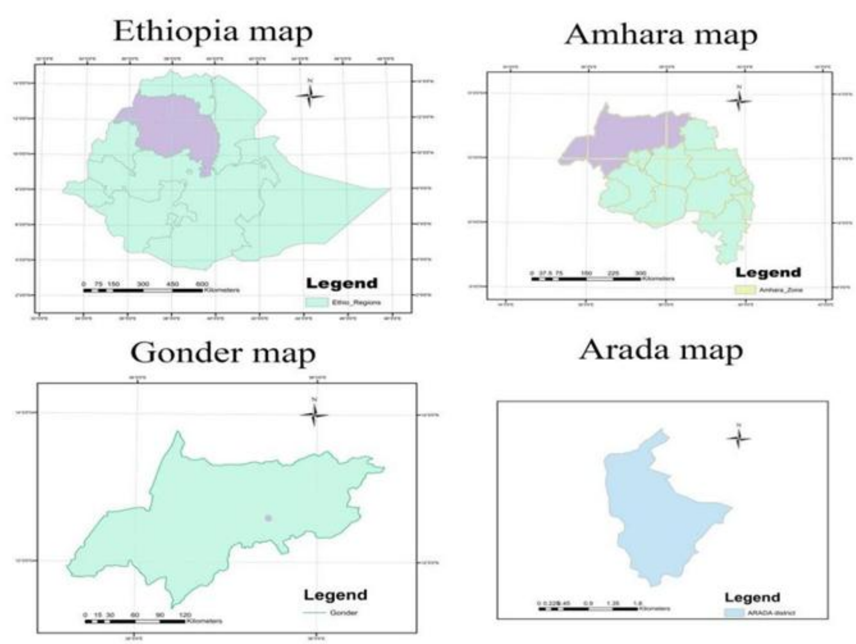
This chapter presents the detail of the research methods and techniques used for gathering and analyzing data to answer the research questions. And covers the research strategy, methods, and techniques used for data collection and analysis.

3.2 General description of methods and design

The nature of this research is a descriptive type of research. The researcher has tried to explore the effect of built up area densification on the green area and its dynamics. involving both qualitative and quantitative data collection approaches. The qualitative research approach is concerned with subjective assessment of participants' experience and their perception whereas the quantitative approach is the one that expressed in numeric value.

3.3 The Study Area

Figure 3: The study area Arada sub-city



Source: Own design (2021)

Gondar is a city in Amhara Region, Ethiopia. Located in the Central Gondar Zone of the Amhara Region, Gondar is north of Tana Lake on the Lesser Angereb River and southwest of the Simien Mountains. It has a latitude and longitude of 12°36′N 37°28′E with an elevation of 2133 meters above sea level. As of 2016, Gondara has a population of 299,969. It covers an Area Total of 192.27 km2and a Density of 1,600/km2. Arada sub-city is one of the oldest sub city in Gondar city which covers 407.5 hectares.

3.4 Case selection (Arada kifleketema)

The main reason to select the site is first, The sub-city is the commercial area of the city with the great market of the city, As its the oldest area of the city with relativity high density than the rest of the city. Secondly, Arada sub-city from observation the site has flooding during the rainy season, compact housing structure, also The sub-city contain and connected with urban forest natural green area, hillside, and rivers from east, west and south direction so it's easy to assess the effect of densification on the green area than urban sprawl.

3.5 Source of Data

To achieve the intended objective of the stud both primary and secondary data sources were used in this study.

Primary data Source: The Primary data was collected through questionnaires, interviews, and informal discussion with:- residents, Arada sub-city green development officials, and Arada sub-city urban agriculture farmers. All surveys were in Amharic. In addition to this primary data were collected through Personal Observation of the site including a checklist, taking photographs to understand the spatial feature of the site.

Secondary Data Source: The secondary data was collected from books, published journals articles, official reports concerning government bodies and understood the theoretical background, google earth, and another source which was relevant for this study.

3.6 Sampling Technique and Sampling size

Target population:- Arada sub-city Total number of population in sub-city was N= 49921, Arada sub-city green development officers N=6 and total Arada sub-city urban agriculture farmers was N= 53

Non-probability sampling techniques were used. The purposive sampling technique was used for getting information from elders who knows the spatial expansion of the city in the last two decade, agriculture farmers (they have a strong connection with the urban green area), and Green development officials. Purposeful sampling is selecting a strategically and purposefully portion that has a higher degree of information (Information-rich cases) (Patton, 2002, p. 243).

Sampling size

Table 5: Arada sub-city Population Size by Age Group current time

Age Group	Male	Female	Total	Share (%)
0-14	9884	12181	22065	44.2
15-24	4507	5427	9934	19.9
25-54	6215	8362	14577	29.2
55-64	793	1153	1946	3.9
>65	533	864	1397	2.8
Total	20,967	28,954	49,921	100

Source: Arada sub-city Finance and Economic Development Office, (2021)

According to the Arada sub-city data, the current population total target population is any residence is N= 49921 whom 17920 were aged above 25 years. the sample was extracted by using the Taro Yamane (1967:886) sampling formula. the formula for determining sample size.

Formula 1: n = N / (1 + Ne2)

Where; n= sample size, N = population size (17920), and e = Margin of error (MoE) which is 0.07 for 93% confident level. The total sample size of elder respondent is is 202.

Tables 3.2 present the samples per each Kebele using the method of proportional allocation defined by the formula:

Formula 2: $n_{per\ Kebele} = n_{total} \times p_{per\ kebele}$;

Formula 3: $p_{per\ Kebele} = \frac{N_{Per\ Kebele}}{N_t}$

Table 6: Samples per kebele

Kebele	Total number of residences with a private connection (population)	Sample size
kirkos	4,948	33
Addis Alem	2,624	18
Kidame gebiya	1,244	8
Abiye egziy	3,415	23
total		202

Source: Arada sub-city Finance and Economic Development Office, (2021)

3.7 Data collection techniques

3.7.1 Qualitative Data collection Technique

Interview: face to face interview of concerned Arada sub-city urban agriculture farmers to gather the data related to their farming experience. The researcher asked about 14 farmers randomly in different sits and collected the same information then it considered as the whole (refer to APPENDICES III).

focus group discussion (FGD):- this is informant interview discussion under this part was include factors of LU-LC, before and after conversion, the forces behind the land-use conversion, identifying the major determinants of land use land cover change in the city challenges, and the solution forward. The questions which were presented to the FGD with Arada sub-city green development officials are presented (refer to APPENDICES II).

Questionnaire:- To assess the change of green area; case of Arada sub-city structured interview has been applied to collect data from the respondents in order get information from elders who knows the spatial change of the green area of the sub-city in the last two decade (refer APPENDICES I). The questionnaire has six sections:

- Section “1”, is on personal data of the respondents; ·

- Section "2" questions contain perception and experience about the green area and its change in the sub-city in the last two decades; ·

Physical observation:- Checklists were prepared to observe the existing condition of the study area (refer to APPENDICES IV). The main points which be included under the checklist include the multi-function of the green area, the topography of the area, density of settlements, and quality of the green area.

3.7.2 Quantitative Data collection Technique

Quantitative data were used to calculate building density (built area ratio) and its change in the last decade. And also used to examine the impact of building densification on green area coverage.Mapping the existing land use land cover changes (Remote sensing & GIS)

Satellite Imagery

A cloud-free image of the city was acquired from the website with Landsat imagery of the years (2000, 2010, 2020) from the United States Geological Survey (USGS) Earth Explorer website and spatially referenced in the Universal Transverse Mercator (UTM) projection with datum World Geodetic System (WGS) 1984 UTM zone 37N by which the data were used to produce the study areas land use/ land cover maps and urban expansion changes.

Land use/land cover mapping

By considering the impacts of Adama city growth on the greenbelt, LU/LC maps of the study area were prepared over the past 20 years by the time interval of 10 years (2000, 2010,2020) GC.

Table 7: LULC class Description

LULC class Description	LULC class Description
agricultural la	Generally, the area used in one way or another for agricultural purposes Includes grazing areas cultivated lands,
built-up area	Includes areas with all types of artificial surfaces, including residential, commercial, and industrial land use as well as transportation infrastructure
shrub/grass	An area of grass, trees, or other vegetation set apart for recreational or aesthetic purposes.
forest	Includes areas with dense vegetation cover

Source: Own Servey, (2021)

Using the city's base map the existing land-uses were mapped using ArcGIS (version 10.6). Furthermore, satellite images of 2000, 2010, and 2020 were used to trace back the previous land use - the land cover of the study area caused the green pattern of the city has begun to change since 2000. The google image intervals were selected to consider the major land-use changes.

This study requires data acquired at different periods in the same space. In the light of this Landsat imagery was downloaded starting from 2000 up to 2020 within the 10-year interval during the accusation of Landsat time serious data quality criteria like single data run, phenology, and collection level are considered to minimize the error during classification.

Table 8: Data set sources and types

Dataset	**Date**	**Source**	**Resolution**
Landsat 7	January 8 ,2000	http://earthexplore.usgs.gov	30 m
Landsat 7	January 15 , 2010		30 m
Landsat 8	February 12, 2020		30 m

Source: Own Servey, (2021)

3.8 Data Analysis Methods

The tools used for quantitative data analysis are descriptive statistics using the statistical package for social science (SPSS) computer software program. Descriptive statistics such as frequency and tables are used to analyze quantitative data.

Regarding quantitative data, descriptive statistics will be conducted for attempting and collecting quantifiable information to be used for statistical analysis of the population sample using table and percentage. On the other hand, maps are analyzed using GIS software and personal observation.

3.8.1 Qualitative data analysis techniques

The qualitative data questionnaires, interviews, focus group discussion, and images were analyzed as follows.

Table 9: Qualitative data analysis techniques

Types	Descriptions	The software's used
Content analysis	The collected data were processed and categorized into verbal data to classify, summarize, and organize the data.	SPSS, Excel, and Word 2016 were used to analyze interviews, and surveys.
Discourse analysis	The interviews and all forms of text data were analyzed.	
Framework analysis	Finally, formalization, identifying a thematic framework, coding, charting, and interpretation were employed.	

Source: Own Servey, (2021)

Qualitative data analysis; was analyzed through the frequency distribution tables and made use of relative measures, such as percentages, which includes the mean, and finally, tables were prepared.

3.8.2 Quantitative data analysis techniques

The researcher used a range of datasets to analyze LUCs in the Arada sub-city (Table 1). As the United States geological survey (USGS) Landsat images are frequently updated and publicly available through Earth Explorer, in this study, we used the overtime Landsat images on a 30-m resolution for 2000, 2010, and 2020. These images have cloudiness of less than 10% and were acquired in the winter season in which the area experiences little cloud cover, and there are fewer atmospheric errors.

3.8.2.1 Image classification

Image classification is a complex and time-consuming process. To improve the classification accuracy, the selection of an appropriate classification method was required. In this study, the following classification techniques were employed.

- The Supervised classification technique was used for Landsat 7, Landsat 7, and Landsat 8 image
- Training sites were chosen 10 samples for each of the four classes
- After clustering the pixels to the required class each class was identified

- The three years 2000, 2010, and 2020 images were classified The google image intervals were selected to consider the major land-use changes that happened with the emerging of the EPRDF regime, the 1992 E.C. (2010) election period, and the present situation.

3.8.3 Change Detection Techniques using a remotely Sensed Data

The selection of a suitable method or algorithm for change detection is important in producing a more accurate change detection result since constraints such as spatial, spectral, thematic, and temporal properties affect digital change detection. Some techniques such as image differencing can only provide change or non-change information, while some techniques such as post-classification comparison can provide a complete matrix of change directions. According to Bekalo (2009), different change detection methods could produce different changes of maps depending on the algorithm they followed. Although there are many change detection methods in remote sensing of image classification, recently researchers divided it into image ratio, image regression, image differencing, and the method of change detection after classification (post-classification method) (Xu et al, 2009; Bekalo, 2009). The classification of methods mainly depends on data transformation procedures if exist and analysis techniques applied. So, based on these conditions the current common methods of change detection are discussed below:

3.8.3.1 Image Regression Method

In the image regression method of change detection, pixels from time t1 are assumed to be a linear function of the time t2 pixels (Singh, 1989). Under this assumption, it is possible to find an estimate of the image obtained from t2 by using least-squares regression. According to Abuelgasim et al (1999), the image regression technique takes into account differences in the mean and variance between pixel values for different dates. This consideration minimizes the influence of differences in atmospheric conditions. In detecting changes in urban areas the regression procedure has more advantages than the image differencing technique.

3.8.3.2 Image Ratio Method

In the image ratio method, images must be registered beforehand and rationed band by band. The results of the image ratio are interpreted with a threshold of values. If the ratio of the two images is 1, it means that there is no change in the land cover classes whereas a ratio value of greater or less than 1 indicates a change in land cover classes (Singh, 1989; Bekalo, 2009). This method rapidly identifies areas of changes in relative terms.

3.8.3.3 Image Differencing Method

Image difference is one of the most extensively applied change detection methods. It can be applied to a wide variety of images and geographical environments. In this technique, images of the same area, obtained from times t1 and t2, are subtracted pixel-wise. It is generally conducted based on a grayscale which is used to show the spatial extent of changes in the two images. A threshold value is required for the gray of the difference image to examine the changed and unchanged regions (Xu et al, 2009).

3.8.3.4 Post Classification Method

This method is the most simple and obvious change detection based on the comparison of independently classified images (Singh, 1989).

3.8.3.5 Accuracy assessment

The need for accuracy assessment is that we need to show whether the pixels that are classified or a particular class classification belongs to that particular class or not. Or it is the agreement between the classified image and the reference image. For this technique, the following activities were performed.

- In Arc GIS 10.6 by using Arc toolbox random points were created
- 70 sample points each were taken for the three-year image
- Shapefile was created then Shapefile was changed into KML file format
- The KML file with random points was opened in Google earth image
- Truth points were filled in attribute tables of Arc GIS
- Error matrix table was developed
- Accuracy assessment percentage was formulated

3.8.3.6 Overall Accuracy

This is calculated by dividing the total number of correctly classified pixels or the diagonal value (Xii) by the total number of pixels in the matrix (N).

$$\textbf{Overall Accuracy} = \sum xii/N$$

The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data is at least 85 percent (Anderson,1983) by which A minimum level of accuracy of about 85 to 90 percent or better should be approached in that interpretation of the imagery being used (Anderson,1971).

3.8.3.7 Producer Accuracy

The conditional chance of accurately mapping a place assuming that it is the true class is referred to as producer accuracy (Stehman et al, 2003). The producer of the classification is interested in how well a certain area can be classified and so producer accuracy is the total number of correct samples in a category (Number correctly identified in a given map class) is divided by the total number of samples of that category (Number claimed to be in that map class) as derived from the reference data (i.e., the column total) (Congalton, 2001).

3.8.3.8 User Accuracy

The conditional chance of accurately categorizing a location assuming that it has been mapped as the class is referred to as user accuracy (Stehman et al, 2003). The chance that a sample classified on the map/image represents that category on the ground, and hence the overall number of correct samples in a category, is determined by the user's accuracy or dependability or reliability (Number correctly identified in reference plots of a given class) is divided by the total number of samples that were classified in that category (Number actually in that reference class), then this result is a measure of commission error (Congalton, 2001).

3.8.3.9 Kappa Analysis

Kappa coefficient, which is one of the most popular measures in addressing the difference between the actual agreement and change agreement, was also calculated. The kappa was a discrete multivariate accuracy measurement tool. (Yimam, 2017).

The Kappa coefficient (K) is calculated by using the following adopted formula given by Congalton, 1991

$$K = \frac{N \; {}_{r\,i=1} X_{ii} - {}_{r\,i=1} (X_{ii} \times X_{i+1})}{N2 - {}_{r\,i=1} (X_{i+} \times X_{i+1})}$$

Where: r = is the number of rows in the matrix;

Xii = is the number of observations in rows i and column i (along the major diagonal);

Xi+ = the marginal total of row i (right of the matrix);

Xi+1 are the marginal totals of column i (bottom of the matrix);

N is the total number of observations (Berisa, 2012)

3.9 Data Presentation

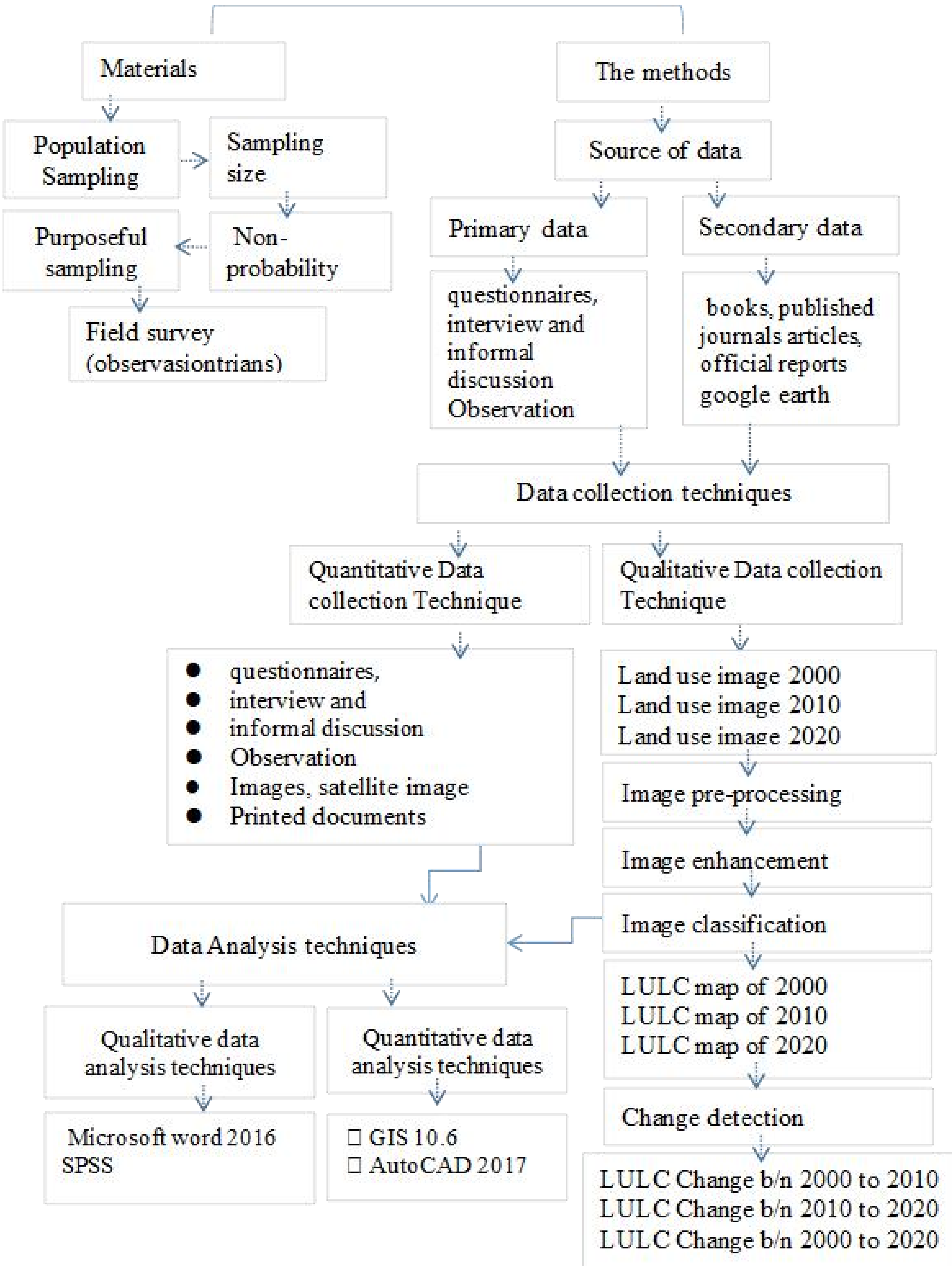
The analyzed data were presented using statistical tools such as Tables, Graphs, and maps. To produce the final output of this research various applications were in use. For the data collection and analysis, Google Forms from google, SPSS, and MS Excel for the data analysis, and to formulate the final word document MS word 2016 was used.

Table 10: Data collection techniques used

No	Specific objective	Data used	Source of data	Collection method
1	Assess the building densification in Gonder town within 20 years	Interview LULC change	Google Earth, and residents	interview GIS LULC change detection and officials published literature
2	Examine the impact of building densification on green areas.	Observation, questionnaire LULCchange analysis. , and interview	Sampled residents, government officials, and farmers	Interview, questionnaires
3	Propose alternative strategies to promote sustainable urban green infrastructure	Written document	Published books, strategies, policy, and observation	Secondary data (customers report), and published literature sources

Source: Researcher compilation, (2021)

Figure 4: Methodological Design



Source: Own design (2021)

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 Result

This chapter discusses the analysis of the data and presents the analyzed data, which is collected during the study to ensure the objectives of the research. These analyzed data in this chapter are the outputs of collected data by observation, questionnaires, and interviews including the secondary data sources.

4.1.1 Characteristics of the Respondents

The background information of the respondent is presented in the next table. the following variables Age, living year in the sub-city are important personal characteristics because the respondent needs to have a better understanding of green space change.

Table 11: Background information of the respondents

Characteristic	Frequency	Percent %
Gender of the respondent		
Male	105	53.8
female	90	46.2
Age of respondent		
20-30	81	41.5
31-40	63	32.3
41-50	30	15.4
>50	21	10.8
Year of living in the sub-city		
5-10	42	21.5
11-20	60	30.8
21-30	48	24.6
>30	45	23.1
total	195	100%

Source: Field survey, 2021

Among the 202 sample respondents, only 195 survey questionnaires were responded which is 192 responses. Among 195 respondents,105 which is 53.8 % of the total, were males and the rest 90 were filled by the female which is 46.2 % of the total. About the age of the respondents, the major portion (41.5%) of the respondents is between 20-30; (32.3%) of the respondent is between the age of 31-40, and respondent between 41-50 is 63 (15.4%) and respondent above 50 is 21 which is 10.8 percent of the total. Moreover, all the respondents had a minimum living experience of 5 years in the sub-city, with 21.5% with 56% having 5-10 years experience, 30.8% having 11-20 years experience, 24.6% having 21-30, and 23.1% having over 30 years experience in the sub-city. This result could be deemed reasonable. The respondents' living and experience helped to ensure and enhance the reliability of the research findings.

4.1.2 Educational status of the respondents

Table 12: Educational status of the respondents.

Educational status		
	Frequency	Percent
Illiterate	6	3.1
Write and read	15	7.7
1-8	30	15.4
9-12	87	44.6
Collage and above	57	29.2
Total	195	100.0

Source: Field survey, 2021

With Educational status, 3.1%, 7.7%, and 15.4% of the respondents were Illiteratet, Write and read, and basic elementary from grade 1 to 8 (1-8), respectively. In terms of secondary and higher education, 9-12 (44.6%) formed the majority of the respondents, followed by College and above (29.2%) respondents.

4.1.3 Perception of the respondent about the green area

Table 13: Illustrates the perception of green areas in the city by Educational status group. Among the conducted 195 onsite surveys all respondents from each educational group have forwarded their perception about the green area from their point of view. Area covered by pant 53.3%, Its beautiful area 23.07%, refreshment place 13.8%, and 3% is the major recommendation for respondents between Collage and above,1-8, and Write and read educational status groups respectively in descending order. But for 9-12 educational group respondents, the beautiful area is the most forwarded perception respectively.

Table 13:Perception of the respondent about the green area

	Green area					
	Frequency					
Educational status	beauty	plants	playground	refreshment	undeveloped area	total
Illiterate	-	6	-	-	-	6
Write and read	3	12	-	3	3	21
1-8	3	21	0	-	-	24
9-12	21	9	9	18	-	87
Collage and above	18	24	-	6	9	57
total	45	102	9	27	12	195
	Percentage					
Illiterate	-	3%	-	-	-	3%
Write and read	1.5%	6.15%	-	1.5%	1.5%	10.7%
1-8	1.5%	10.7%	-	-	-	12.18%
9-12	10.7%	4.6%	4.6%	9.2	-	44.6%
Collage and above	9.2	12.18%	-	3%	4.6%	29.2%
total	23.07%	53.3%	4.6%	13.8%	6.15%	100%

4.1.4 Perception of the respondent about the green area

From the data (Table:14) is clearly shown that 84(44.6%) has a private green area and the rest 111(55.4) respondents have no green area which is 83.8% of respondents have land scarcity problems; About8.1% problem of soil and the last 8.1% experience with low water supply problems. And all (0%) of the respondents reported they need private green areas. These figures indicate that the shortage of land around the surrounding of the respondent is the main reason for the barrier of green area.

Table 14:Perception of the respondent about the green area

Characteristic	Frequency	Percent %
garden area		
yes	84	44.6
no	111	55.4
total	195	100.0
If the answer for Q# 3 is 'No' Why don't you have a garden in your compound?		
we don't have free space	93	83.8
poor soil quality	9	8.1
low water supply	9	8.1
Total	111	100
The necessity of green area		
yes	189	96.9
no	0	0
Missing system	6	3.1
total	195	100.0

Source: Field survey, 2021

4.1.5 Status of green environment in the last 20 years

In the following table respondents compare Arada sub-city green environment in the last 20 years and the present time

Table 15: Status of green environment in the last 20 years

comparison Arada sub-city green environment in past and the present time	Time duration				total
	Frequency				
	5-10	11-20	21-30	>30	
1	9	8	13	9	39
2	16	29	27	33	105
3	3	12	9	6	30
total	28	49	49	48	174
%					
good progress	5.1	4.6	7.5	5.1	22.4%
bad progress	9.2	16.7	15.5	18.9	60.3%
no change	1.7	6.9	5.1	3.5	17.2%
total	16%	28.2%	28.2%	27.6%	100%

Source: Field survey, 2021

Table:15, Shows that respondent's perception about the change of green space in the last two decades Among the conducted 195onsite surveys 174 respondents replied from each staying time group has compared the green area with their experience on their point of view 60.3% of the green area is in bad progress, 22.4% replied good progress and the rest 17.2% there is no change.

4.1.6 Willing to improve the existing green space

Table:16, Elaborates if the respondent gets the chance to change the existing green area, respondents recommendations for the existing green area to change by Educational status group. Among the conducted 195onsite surveys all respondents from each educational group have forwarded recommendations for the green area to be improved from their point of view. green 57%, build residential area 23.1%, changing into Working area 13.8% is the major recommendation for respondents between Collage and above, 9-12, Write and read, 1-8 and

Illiterate educational group respectively in descending order. all educational groups recommended the green area to continue as it is.

Table:16 Respondents willing to change the existing green are

respondents recommendation	Educational status						Frequency			
	Frequency						House ownership			
	Illiterate	Write and read	1-8	9-12	Collage and above	total	kebele	private	rental	total
residence	1	4	14	14	12	45	16	8	21	45
road	-	2	2	9	-	13	5	4	3	12
Working area	1	5		22	-	28	13	11	3	27
green	4	10	8	42	45	109	50	46	15	111
total	6	21	24	87	57	195	84	69	42	195
	Percentage									
residence	0.5%	2%	7.18%	7.18%	6.15%	23.1%	8.2%	4.1%	10.8%	23.1%
road	-	1%	1%	4.6%	-	6.7%	2.6%	2%	1.5%	6.1%
Working area	0.5%	2.6%		11.3%	-	14.4%	6.7%	5.6%	1.5%	13.8%
green	2%	5.1%	4.1%	21.5%	23.07%	55.9%	25.6%	23.6%	7.7%	57%
total	3%	10.7%	12.18%	45%	29.2%	100%	43.2%	35.3%	21.5%	100%

Source: Field survey, 2021

Table:16 illustrates if the respondent gets the chance to change the existing green area, respondents recommendations for the existing green area to change by Educational status group. Among the conducted 195onsite surveys all respondents from each educational group have forwarded recommendations for the green area to be improved from their point of view. green 55.9%, build residential area 23.1%, changing into Working area 14.4% is the major recommendation for respondents between kebele house, private owners and rental housing owners group respectively in descending order. all housing owners groups recommended the green area to continue as it is.

4.1.7 Respondents response for the cause of this impacts on the green area

The next table represents the respondents' point of view on major drivers of green area change in both educational status groups and living time in the sub-city group.

Table:17 Respondents response for the cause of this impacts on the green area

	Educational status						Life duration				
	Frequency						Frequency				
What is the cause of these impacts on the green area?	Illiterate	Write and read	1-8	9-12	Collage and above	total	5-10	11-20	21-30	>30	total
Lack of strong protection of green area in government	1	6	14	20	21	62	18	37	1	8	63
It replaced by new buildings	3	2	3	27	14	49	4	17	11	19	51
The land value increase	0	6	3	10	7	26	5	3	6	6	24
Improper domestic waste management	2	1	7	27	15	52	15	3	21	12	51
total	6	15	27	84	57	189	42	60	39	45	189
	Percentage										
1	0.5%	3.1%	7.4%	10.6%	11.1%	32.8%	9.5%	19.6%	0.5%	4.2%	33.3%
2	1.6%	1%	1.6%	14.2%	7.4%	25.9%	2.1%	9%	5.8%	10%	27%
3	-	3.1%	1.6%	5.2%	3.7%	13.7%	2.6%	1.6%	3.1%	3.1%	13%
4	1%	0.5%	3.7%	14.2%	7.9%	27.5%	7.9%	1.6%	11.1%	6.3%	27%
total	3.1%	7.7%	14.3%	44.2%	30.1%	100					

Source: Field survey, 2021

Table:17, Respondents' response for the cause of this impact on green area respondents' recommendations for the existing green area to change by Educational status group and life duration. Among the conducted 195onsite surveys 189 respondents Educational status group and the life duration group have forwarded major drivers of green area diminishing to be improved from their point of view. Lack of strong protection of green area in government 32.8%, Improper domestic waste management 27.5%, It replaced by new buildings 25.9% and The land value increase 13.7 % are the major drivers of green area demising recommendation for respondents.

4.1.8 Respondents recommendation to mitigate green space diminishing

Table:18 Respondents recommendation to mitigate this impact

the solution to mitigate this impact	Educational status						Frequency		
	Frequency						sex of respondent		
	Illiterate	Write and read	1-8	9-12	Collage and above	total	female	male l	total
government and society based	-	5	11	26	24	69	33	35	68
urbanization based	-	3	1	8	10	24	8	16	24
afforestation	5	1	9	28	16	57	28	28	56
pollution	1	0	6	22	7	33	18	17	35
total	6	9	27	84	57	183	87	96	183
%	Percentage								
government and society based	-	2.7%	6.0%	14.2%	13.1%	37.7%	18	19	37.1
urbanization based	-	1.6%	0.5%	4.3%	5.5%	13.2%	4.3%	8.7	13.1
afforestation	2.7%	0.5%	5%	15.3%	8.7%	31.1%	15.3%	15.3%	30.6
pollution	0.5%	-	3.3%	12%	3.8%	18%	9.8	9.2	19.1
total	3.3%	4.9%	14.8%	45.9%	31%	100%	47.5%	52.5%	100%

Source: Field survey, 2021

Table :18, Illustrates if the respondent gets the chance to change the existing green area, respondents' recommendations for the existing green area to change by Educational status group. Among the conducted 195onsite surveys all respondents from each educational group have forwarded recommendations for the green area to be improved from their point of view. government and society based 37.7%, afforestation practice 31.1%, urbanization based 13.2% is the major recommendation for respondents between Collage and above, 1-8 and Write and read educational group respectively in descending order. But for 9-12 and Illiterate group respondents, pollution management as, the most forwarded recommendation respectively.

4.2 Land Use/Land Cover Change Detection of Arada sub- City

4.2.1 Land Use/Land Cover in 2000 GC

In the year 2000GC, the data obtained from the land use/land cover change detection showed that agricultural land held the dominant area coverage with a staggering total area of 135.45Ha (33.24%) followed by the shrub (natural vegetative area) area covered by which held a total area of about 113.94Ha (27.96%). The built up area at that time was about 86.58Ha (21.25%) with minimal area coverage. Urban forest held an area coverage of about71.46Ha (17.55%) . The land use/land cover change detection in the following years of the study area and study time intervals were based on the above area coverage.

Table:19 Area and percentage land use classes of 2000GC

Class Name (2000)	Area in hectare	Area in percent
agricultural land	135.45	33.24
shrub/grass	113.94	27.96
built up area	86.58	21.25
forest	71.46	17.55
total		100

Source: Analysis of Satellite images, 2022GC

4.2.2 Land Use/Land Cover in 2010 GC

In the year 2010GC, the data obtained from the land use/land cover change detection showed that agricultural land held the dominant area coverage with a staggering total area of 154.89Ha (38.02%) followed by the shrub (natural vegetative area) area covered by which held a total area of about 102.87Ha (25.25%). The built up area at that time was about 97.118Ha (23.83%) with minimal area coverage. Urban forest held an area coverage of about52.83Ha (12.97%) . The land use/land cover change detection in the following years of the study area and study time intervals were based on the above area coverage.

Table:20 Area and percentage land use classes of 2010GC

Class Name (2010)	Area in hectare	Area in percent
agricultural land	154.89	38.02
shrub/grass	102.87	25.25
built up area	97.11	23.83
forest	52.83	12.97
total		100

Source: Analysis of Satellite images, 2022GC

4.2.3 Land Use/Land Cover in 2020 GC

In the year 2020GC, the data obtained from the land use/land cover change detection showed that agricultural land held the dominant area coverage with a staggering total area of 159.3Ha (39.1%) followed by the area covered by built up area which held a total area of about 135Ha (33.13%). The shrub (natural vegetative area) at that time was about 58.68Ha (14.4%) with minimal area coverage. Urban forest held an area coverage of about54.54Ha (13.39%) . The land use/land cover change detection in the following years of the study area and study time intervals were based on the above area coverage.

Table:21 Area and percentage land use classes of 2010GC

Class Name (2020)	Area in hectare	Area in percent
agricultural land	159.3	39.1
shrub/grass	58.68	14.4
built up area	135	33.13
forest	54.54	13.39
total		100

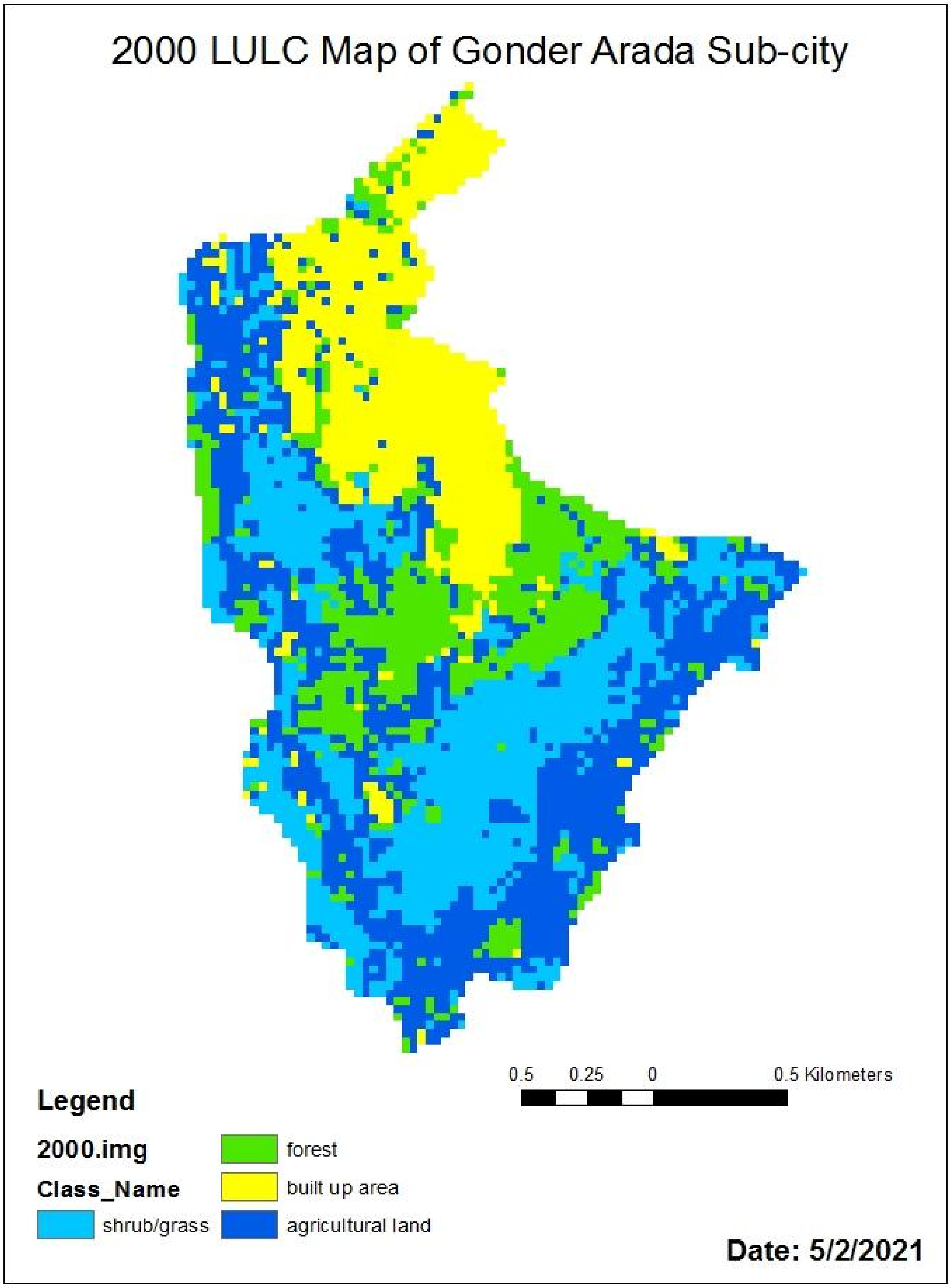


Figure 5: Land cover map of Arada sub-city in 2000

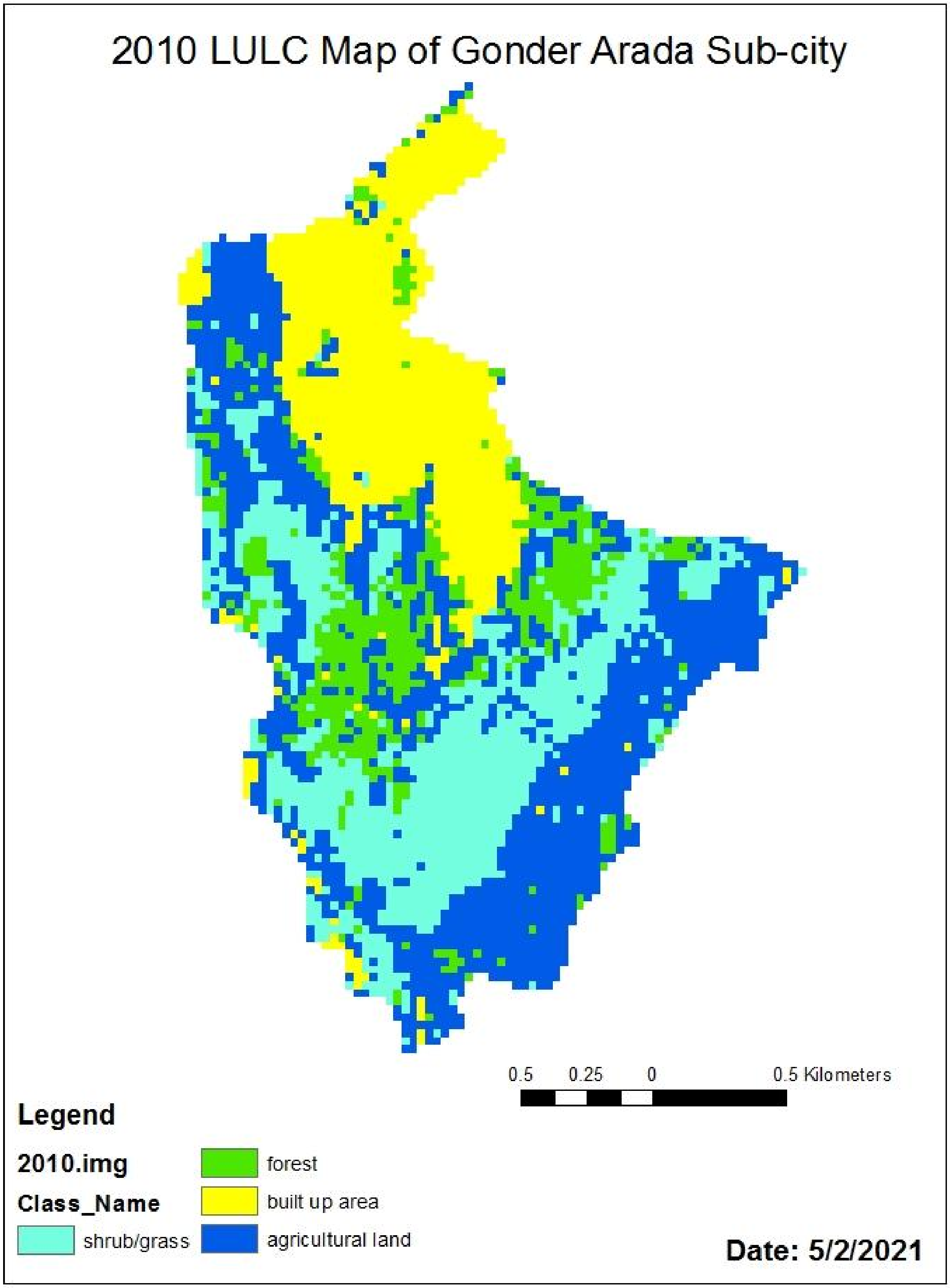


Figure 6: Land cover map of Arada sub-city in 2010

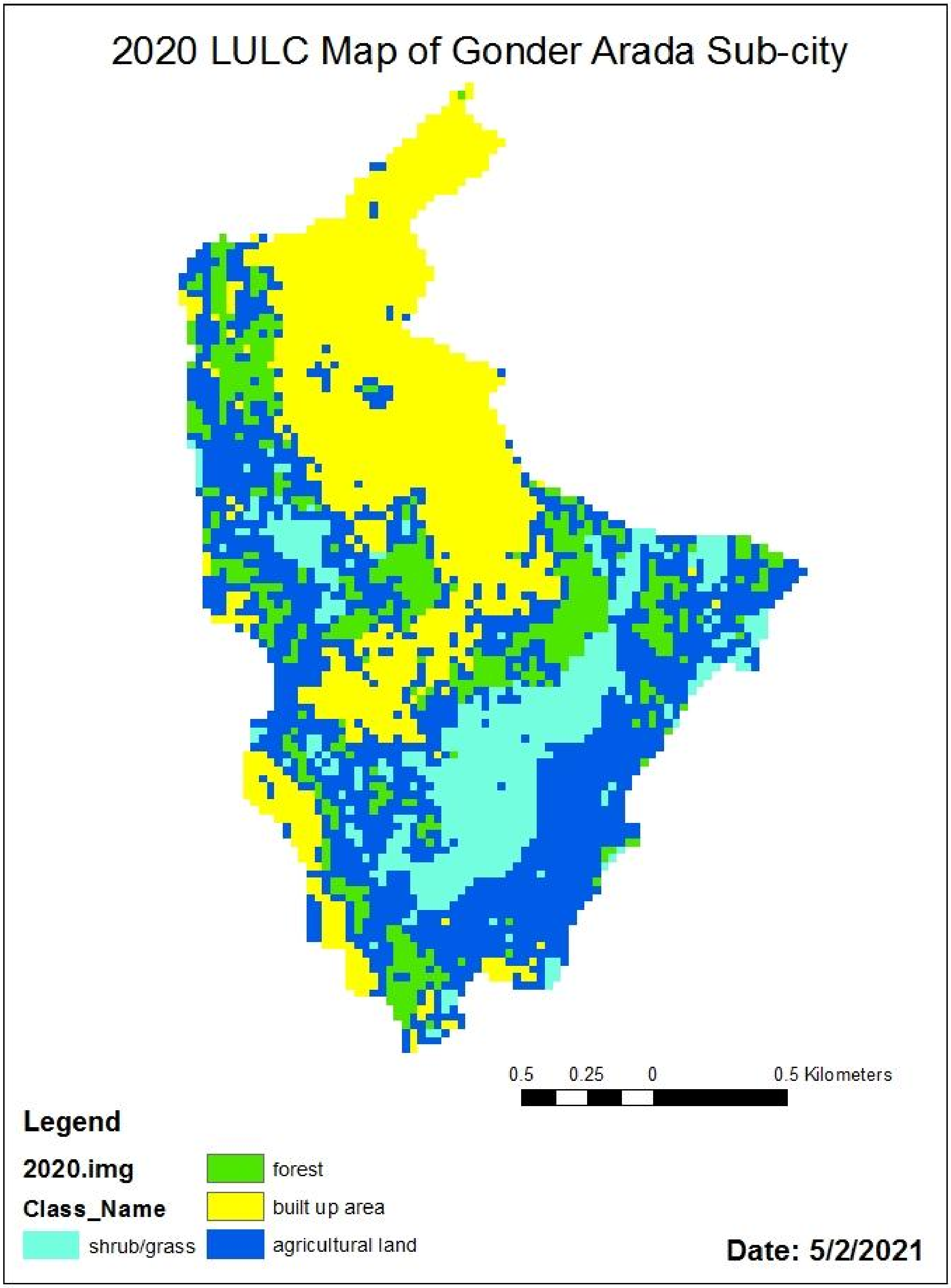


Figure 7: Land cover map of Arada sub-city in 2020

4.3 User's Accuracy

Users' accuracy represents the probability that a pixel classified into a given category represents that category on the ground. Results of user's accuracy in this study showed that in 2000 the maximum class accuracy was 98.00%which were shrub/grass and the minimum built-up area class with an accuracy of 74.00% as presented in table 21: below. In 2010, the class accuracies range from 79.00% to 90.00% whereas, in the period 2020, it ranges from78.00% to 100.00%.

The lowest values of class accuracy were mis-classified due to spectral property similarities among other land cover classes. As shown from tables 22, 23, and 24, the user's accuracy was lowest for agricultural in 2000 (74.00%), for the periods of 2010 and 2020, built-up area and shrub/grass was the lowest by 79.00%, and forest and agricultural land 78.00% respectively. Moreover, the time of image acquisition has a great role in such misclassification problems. In addition to this, the spatial resolution of Landsat data could influence the image classification. According to Zhou et al (2009) for detailed urban land cover mapping at very fine scales, high spatial resolution imagery from satellite sensors such as IKONOS and Quick Bird become more accurate.

4.4 Producer's Accuracy

Producer's accuracy refers to the number of correctly classified pixels in each class (category) divided by the total number of pixels in the reference data to be of that category (column total). This value represents how well reference pixels of the ground cover type are classified. As showed in the following highest values were in table 4.10, agricultural 92.50%, agricultural 97.83% in table 4.11, in table4.12 forest were 97.30%

Table 22: Classification accuracy assessment report 2000

Class name	Reference total	Classified total	Number correct	Producers accuracy	Users accuracy
Unclassified					
agricultural la	40	50	37	92.50%	74.00%
shrub/grass	70	50	49	77.00%	98.00%
built-up area	36	50	32	88.89%	93.00%
forest	54	50	44	81.48%	88.00%
total	200	200	162		

Overall Classification Accuracy = 86.6%

Source: Researcher compilation, (2021)

Table 23: classification accuracy assessment report 2010

Class name	Reference total	Classified total	Number correct	Producers accuracy	Users accuracy
Unclassified	0				
agricultural la	46	50	45	97.83%	90.00%
built-up area	55	50	37	81.27%	79.00%
shrub/grass	40	50	37	92.50%	79.00%
forest	59	50	42	71.19%	84.00%
total	200	200	161		

Overall Classification Accuracy = 85.01%

Source: Researcher compilation, (2021)

Table 24: classification accuracy assessment report 2020

Class name	Reference total	Classified total	Number correct	Producers accuracy	Users accuracy
Unclassified	0	0	0		
agricultural la	45	50	36	80.00%	82.00%
shrub/grass	74	50	50	77.57%	100.00%
built-up area	44	50	38	86.36%	78.00%
forest	37	50	36	97.30%	82.00%
total	200	200	160		

Overall Classification Accuracy = 85.40%

Source: Researcher compilation, (2021)

4.5 Overall Accuracy

It is computed by dividing the total number of correctly classified pixels (i.e., the sum of the elements along the major diagonal) by the total number of reference pixels. It shows the overall results of the tabular error matrix. The overall Accuracy performed in this study period in 2000 was were86.6% (table 22), in 2010 was 85.01% (table 23) and during 2020 it was 85.40% (table 24). As mentioned by Anderson et al (1976) for a reliable land cover classification, the minimum overall accuracy value computed from an error matrix should be 85%. However, Foody (2002) showed that this baseline makes no sense to be a universal standard for accuracy under practical applications. This is because a universal standard is not exactly related to any specific study area. Foody (2002) also noted that Anderson et al (1976) do not explain in detail the criteria of map evaluation for universal applications. Moreover, Lu et al (2004) noted that the accuracies of change detection results depend on many factors, such as availability and quality of ground truth data, the complexity of landscape of the study area, the change detection methods or algorithms used as well as classification and change detection schemes. So, the overall accuracies for all maps were above 85% based on Anderson's criteria.

4.6 Land use land covers changes and its descriptive statistical analysis

The classified images were quantified and the results are presented in Table 25: , for the three study periods. The change in hectares and percentage of individual class area is also presented. As shown from the figure, there has been an increase of agricultural land has been increased between study periods as shown in the table. It increases 33.24% in 2010 to 38.02 % in 2020 to 39.1% in 2010 and shrub/grass 27.96% 2000 to 25.25 % 2010 (decreased), and decreased 14.4 %2010.

Table 25: Percentages of land use/land cover in Arada sub City (2000-2020)

LU/LC type	2000		2010		2020	
	Ha.	%	Ha.	%	Ha.	%
agricultural land	135.45	33.24	154.89	38.02	159.3	39.1
shrub/grass	113.94	27.96	102.87	25.25	58.68	14.4
built up area	86.58	21.25	97.11	23.83	135	33.13
forest	71.46	17.55	52.83	12.97	54.54	13.39
total		100		100		100

Source: Researcher compilation, (2021)

As shown above, built-up areas with values 21.25% of the study area in 2000 to 23.83% in 2010 to 33.13% in 2020. Forestlands decreases 17.55% in 2000 to 12.97 % in 2010, 12.97% in 2020 to 13.39% in 2020 .

4.6.1 Contribution of Land use Land Covers Classes to Built-up Area

The land cover changes between the study periods were quantified by using differences from the late periods to early study periods. Table 26 below shows the changes that have been seen in the past three distinct study years.

The contributions of other LU/LC to urban areas are presented in table 26 below. It has been clearly (2000-2010)shown that shrub areas contributed a majority of about 37.62ha (38.78% of Urban area), forest land has the second contribution by 9.18ha (9.46% of Urban area) infinitely agriculture the less contribution by 8.01ha (8.25%) and 11.92ha (12.28%) respectively. As indicated in table 26 b agriculture areas contribute the majority of the total increase in built-up areas (20.7ha), which represents about 21.1% of the entire urban area in 2000-2020 as indicated in table 26 a. Next to the forest, take the second contribution to the total increase in built-up areas by about 16.92 ha (17.44% of the urban area). The last shrub contributes 6.3 ha (6.49% of the Urban area).

Table 26: Land use land cover changed to built-up areas.

Change 2000-2010	Area in Hectare
agriculture--built up	8.01
built-up--built up	76.05
forest--built up	9.18
shrub--built up	37.62

a) 2000-2010

Change in LULC 2010-2020	Area in hectare
built-up---built up	91.08
agriculture--- built up	20.7
forest---built up	16.92
shrub---built up	6.3

b) 2010-2020

Source: Researcher compilation, (2021)

4.6.2 Net Changes of Land Use land Cover of 2000-2020

Net change is the percentage of the difference of gain and loss to the total study area. From table 27: built-up area increased through all study periods 38.07 (1973-2000) and 44.28 ha(2000-2010) shrub/grass which highly contribute to urban area decrease in a net change of loss of 44.19 ha (2000-2010) and 11.07ha (2010-2020). the agricultural land decreased from 23.89 ha(1973-2000) to 14.49 ha(2000-2010) to, forestland has net change gain of 1.17 ha (2000-2010) to loss of 18.72 ha (2010-2020).

Table 27: Net changes of land use/land cover change in Arada sub-city(2000 – 2020)

Land cover classes	Change 2000-2010	Change 2010-2020
	Area (ha)	Area (ha)
agricultural land	-23.89	-14.49
shrub/grass	-44.19	-11.07
built-up area	38.07	44.28
forest	1.71	-18.72

Source: Researcher compilation, (2021)

4.6.3 Land cover changes of Built-up areas and green area

The increment in infrastructure development of Arada sub City from time to time has played a major influence on the expansion of built-up areas. The main focus of this study was assessing and examining the spatial extents of built-up areas within the three study periods. To achieve this, a reclassification was made As clearly seen in table 28, the proportion of built-up areas in 2000 was 21.25% of the entire study area. In 2010 the percentage of the built-up area is 23.83% of the entire area, which is 2.58% more than before. For 2020 was 33.13% of area coverage was.

Table 28: Built and non-built-up areas (2000- 2020)

LU/LC type	2000		2010		2020	
	Ha.	%	Ha.	%	Ha.	%
Non-Built-up area (green area)	320.85	78.75	310.59	76.17	272.52	66.87
built-up area (building)	86.58	21.25	97.11	23.83	135	33.13
total	407.43	100	407.7	100	407.52	100

Source: Researcher compilation, (2021)

4.6.4 Land Use Land Cover Change Analysis by Gains and losses

The results of the cross-tabulation comparison of both land use and land cover maps in Table 29 and Table 30: below showed that there have been marked changes in all land use and land cover classes between 2000, 2010 and 2020. During the period 2000 - 2010 the total built up areas increased by 54.81ha gains (representing an increase of 7.63 % of the total study area) and lost 10.56 ha (2.6 % of the study area) and net change gain of 44.25 ha (10.87 %), While shrub decreased 45.45 ha (11.16% of the total study area) and gained 34.38 ha with a net loss of11.07 ha.Similarly agricultural land lost 47.16 ha (11.58%) and gained 32.67 ha (8.02%). Forestland decreases by loss of 42.93 ha (10.54%) and gain 24.21 ha (5.95%). and net change of in the period 2010-2020 shown in Table 4.16 built up areas by loss of 5.5 ha (1.35%), gains 43.92 ha (10.8%) and net change gain of 38.07 ha (9.35%). While shrub decreased 114.93 ha (28.23% of the total study area) and gained 18.1 ha with a net loss of 100.79 ha .while agricultural land gained 67.59 ha (16.6%) lost 63.18 ha (15.5%) and net change loss of 4.41 ha (1.08%).

Change 2000-2010	**Area in Hectare**
agrculture--built up	**8.01**
agriculture--agriculture	**88.29**
agriculture--forest	**16.11**
agriculture--shrub	**23.04**
built up--agriculture	**4.95**
built up--built up	**76.05**
built up--forest	**3.96**
built up--shrub	**1.62**
forest--agriculture	**24.03**
forest--built up	**9.18**
forest--forest	**28.53**
forest--shrub	**9.72**
shrub-agriculture	**3.69**
shrub--bult up	**37.62**
shrub--forest	**4.14**
shrub--shurb	68.49

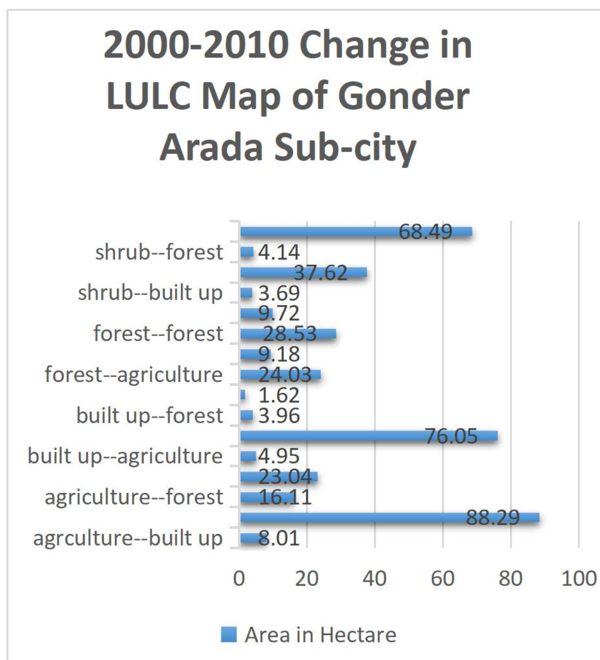
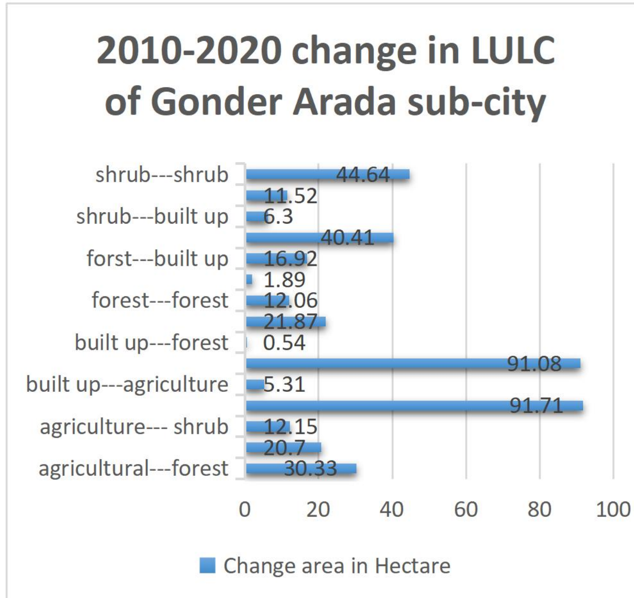


Table 29: Gains and losses between 2000-2010

Table 30: Gains and losses between 2010-2020

Change in LULC 2010-2020	Area in hectare
agriculture--agriculture	91.71
built up---built up	91.08
shrub---shrub	44.64
shrub---agriculture	40.41
agricultural---forest	30.33
forest---agriculture	21.87
agriculture--- built up	20.7
forst---built up	16.92
agriculture--- shrub	12.15
forest---forest	12.06
shrub---forest	11.52
shrub---built up	6.3
built up---agriculture	5.31
built up---shrub	4.1
forest---shrub	1.89
built up---forest	0.54



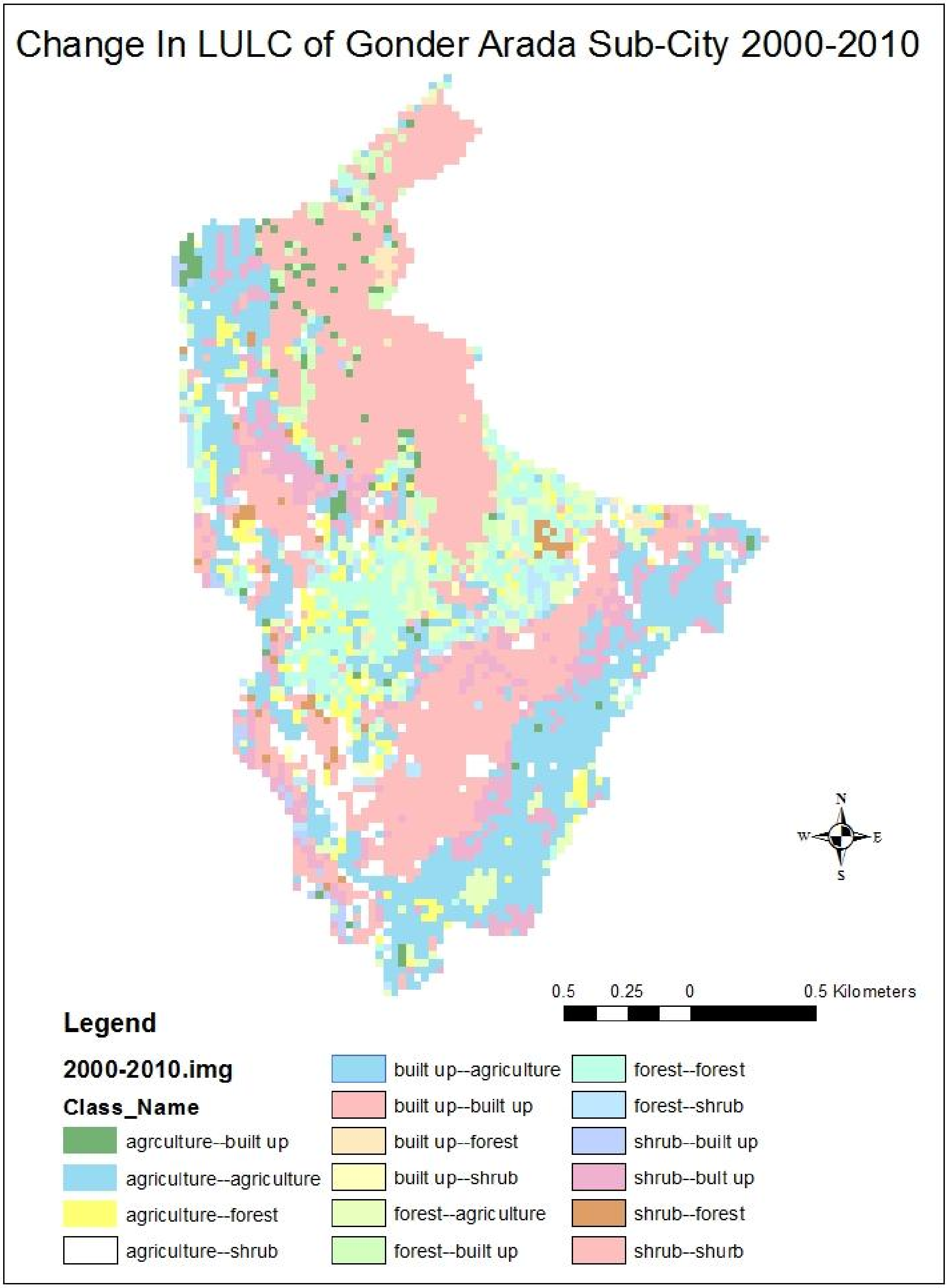


Figure 8: Gains and losses between 2000-2010

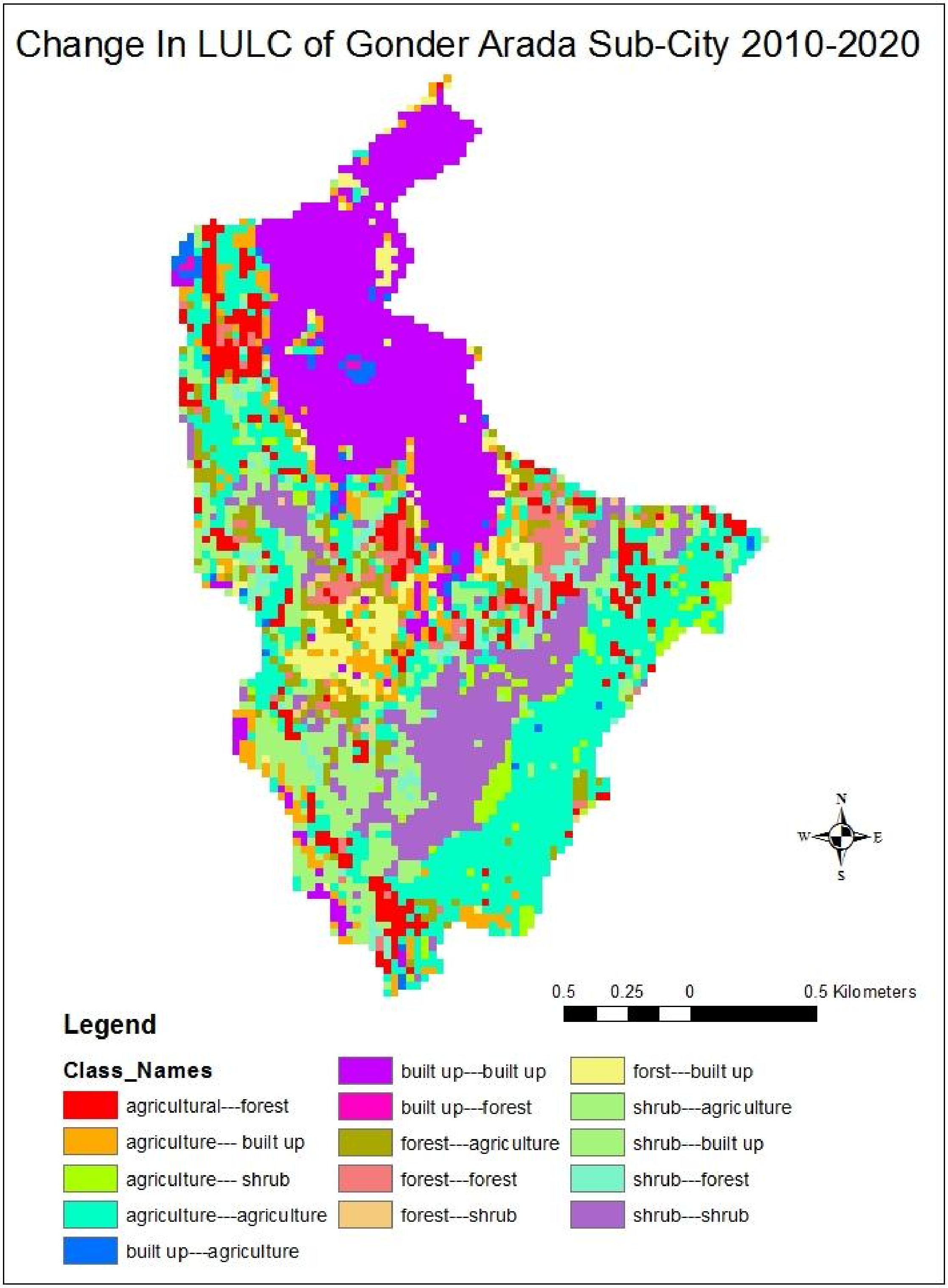


Figure 9: Gains and losses between 2010-2020

4.6.5 Net Density of Built-up areas

The density (ratio) of the built-up area on the total area of the study area was calculated as the total floor area of buildings in a given time divided by the total land area of the lot upon which the buildings are built Rowlands (2017) Floor area ratio of built-up area.

The floor area ratio of built-up area

The floor area ratio of built-up area: $FAR\ of\ built - up\ area = \frac{built\ up\ area}{total\ area}$

Table 31: Net Density of Built-up areas

Quantity	Year			Remark
	2000	2010	2020	
Built-up area	86.58 Ha	97.11 Ha	135 Ha	
Total area	407.43 Ha	407.7 Ha	407.52 Ha	
FAR	0.21 FAR	0.23 FAR	0.33 FAR	

Source: Researcher compilation, (2021)

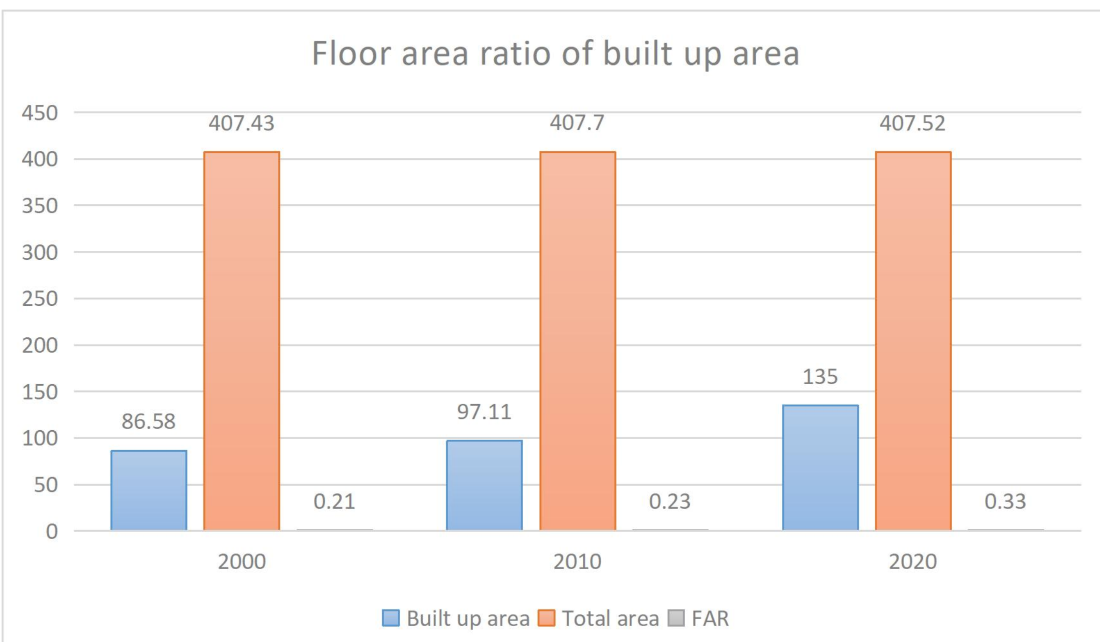


Figure 10: Net Density of Built-up areas

Source: Researcher compilation, (2021)

The density (ratio) of the built-up area on the total area of the study is represented in table 4.14, the building density (FAR) of the study area is 0.20 FAR in 2000 urban areas are concentrated in very high-quality green space (building density of 0%–25%) , 0.23 FAR In 2010 urban areas are concentrated in very high-quality green space (building density of 0%–25%, and 0.33 FAR in 2020 the area has moderate green space with urban density (25%-50%). it shows the study area is under densification and the green covarage is diminishing .

4.7 Discussion

Although some of the issues obtained from the result were discussed in the result and analysis part here the discussion focused on the two basic objectives of the study obtained from both the spatial and socio-economic of the study area.In this research, a questionnaire and interview were proposed to investigate the impact of building densification on the urban green area in Gondar city, ARADA sub-city. The result shows Major features of building densification including; change in societies' perception about green and its dynamic, Multi-function of green area, Land cover changes of urban green area to the built-up area.

4.7.1 Land-use conversion trend of Arada sub-city in the last two decade

The increment in infrastructure development of Arada sub City from time to time has played a major influence on the expansion of built-up areas. The main focus of this study was assessing and examining the spatial extents of built-up areas within the three study periods. As we discussed in the result the proportion of built-up areas in 2000 was 21.25% of the entire study area. In 2010 the percentage of the built-up area is 23.83% of the entire area, which is 2.58% more than before. For 2020 was 33.13% of area coverage was. That means totally in the last twenty years the unbuilt environment (agricultural land, shrubs, and forests) decrease it's 48.42 he (11.8%) of its area in total of 407 area. Densification is usually a step-by-step process. green areas and brownfield sites are being developed and homes becoming more compact and closer together. more land is usually converted into built-up areas when development takes place as an outward urban expansion than by densification (Environmental Assessment Agency , 2015 ; CPB &PBL, 201 and Gordon and Richardson (1997).

4.7.2 Major change of green space type under densification process

changes in green space (unbuilt environment) between 2000, 2010, and 2020. During the period 2000 - 2010 the total green space areas decreased by 10.26 hectares (320.85 which is 78.75% total area of the sub-city to 310.59 which is 76.17% total area of the sub-city) from this type of green space under densification is changed Agricultural land convert into 16.11 hectares to the forest,23.04 to shrub 88.29 hectares remains as agricultural land Forest land convert into 24.03 hectares to agriculture land,9.72 hectares to shrub 28.53 hectares remains as forest land and shrubs convert into 3.69 hectares to agriculture land,4.14 hectares to forest 68.49 hectares remains as forest land. During the period 2000 - 2010 the total green space decreased by 38.07 hectares (310.59 which is 76.17% total area of the sub-city to 272.52 which is 66.87 % of the total area of the sub-city) from this Agricultural land convert to 30.33 hectares to the forest,12.15 to shrub 91.71 hectares remains as agricultural land Forest land converts into 21.87 hectares to agriculture land,1.89 hectares to shrub 12.06 hectares remains as forest land and shrubs convert into 40.41 hectares to agriculture land,11.52 hectares to forest 44.64 hectares remains as forest land. According to Timms (2006), under the densifying city, very conversion of green spaces will happen large shrub and private gardens areas available for planting is reduced in size. According to Beatley (2000), contemporary urban development implies a high conversion of natural areas and farmland into urbanized land and most of this has resulted from outward urban expansion.

4.7.3 Major change of Respondents perception about green space under the dense city

As the data (Table 13) is clearly shown (55.4 %) respondents have no green area which is 83.8% of respondents have land scarcity problems. These figures indicate that the respondent's shortage of land around their surrounding of the respondent is the main reason for the barrier of green area. even about 80.1% of the respondent if they got a chance to change the existing green space of the sub-city wanted to change to the residential and working area. from their point of view. Lack of strong protection of green area in government 32.8%, Improper domestic waste management 27.5% and It replaced by new buildings 25.9% Table 16 , Illustrates the major barrier to existing green space. According to Petter et al (2018) the increased amount of built form reduced and trees green spaces and unsealed surfaces, (McCrea and Walters , 2012) The negative impacts reduced living space, shortage of semi-private/private green space. Timms (2006) and Hall (2010) those who pointed out that the reduction in area per lot that results, together with the current practice of building very large private dwellings the private outdoor area, and areas available for planting, is reduced in size This, together with an adjustment in planning controls allowing for reduced setbacks and smaller private open space area.

4.7.4 Respondents perception about green area dynamic in the last twenty years

As respondent survey from 195 respondents; 105 (53.8%) agrees on green areas are diminishing throughout time and in the day to day activity then The green area are changing to new settlements, waste disposal site and source of firewoods they are in bad progress now. the other respondent 39(20.0%) said that the culture of plantation is increasing from year to year now a lot of new green area is in our surroundings and the rest 30(15.4)respondents they cant observe any change; it is almost the same as the last years. While several compelling arguments in the literature support this finding (Petter et al,2018) increased amount of built form reduced trees' green spaces and unsealed surfaces, (McCrea and Walters ,2012)The negative impacts reduced living space, shortage of semi-private/private green space.

4.7.5 Assessment of Multi-function of green area in the densifying city

As Waste disposal: from the site observation green area in the sub-city serves as both liquid and solid waste disposal site for residential waste, commercial and urban agriculture wastes. some of the society also use the green area for criminal activity including, gambling practices, using drugs, and robbed activities Some research finds that one-third of the homeless are victims of violence or theft during the year; this rate of victimization is four times higher than that in the general urban dense population (Wenzel, Leake, & Gelberg, 2001) and the rest which uses the area for retreat, playing with friends reading and generally for recreational purpose.

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

Gondar is one of the oldest cities in Ethiopia .This puts pressure on the infill development along with poor management, increase building demand with land price and per capital income, and less awareness of societies and government officials towards green environment and conservation. The green area coverage of Arada sub-city from 320.83 Ha(78.75%) in 2000, to 310.59 Ha (76.17%) in 2010 then 272.52 Ha (66.87 %) in 2020. The proportion of built-up areas in 2000 was 21.25% of the entire study area. In 2010 the percentage of the built-up area is 23.83% of the entire area, which is 2.58% more than before. For 2020 was 33.13% of area coverage was.

According to qualitative data the respondent 39(20.0%) said that the culture of plantation is increasing from year to year now a lot of new green area is in our surroundings and the rest 30(15.4)respondents they cant observe any change As a respondent survey from 195 respondents; 105 (53.8%) agrees on green areas are diminishing throughout time and in the day to day activity then the green area is changing to new settlements, waste disposal site and source of firewoods they are in bad progress now. the study shows that all respondent 100 % has positive understanding about green environment and agreed on necessity green area for urban life. from the site observation green area in the sub-city serve as both liquid and solid waste disposal site for residential waste, commercial and urban agriculture wastes , some of the society use the green area for criminal activity and the rest uses the area for retreat , playing with friends reading and generally for recreational purpose From the respondents point of view the major barrier that challenge green environment through the last twenty years is 33.3% indicated that the main challenge is Lack of strong protection of green area in government , 27.0% both Improper domestic waste management and green areas totally replaced by new buildings ,at the list 12.7% respondent said The land value increasing is the main challenge for green area in the city Housing is a problem for city residents, as housing prices in cities can be very high, and usually higher than in rural areas, and the residents' incomes are typically very low.

5.2 Recommendation

- One of the impacts of built up area densification on green space is diminishing green area coverage area by infill development and new buildings therefore working on this area with the concerned body is very important to improve the overall spatial planning and urban planning challenges. And also controlling illegal construction and slum development requires the right policy packages by national and regional governments such as awareness creation, green infrastructure development, and conservation work are some of the actions taken by the city administration.
- The city is expanding horizontally at the expense of other land use like forest or vegetation and farmland coverage without considering its future land value of the area, in the absence of planning principles and overall beautification and tourism attraction because this city is a historic cultural city that contributed a great potential for the dwellers in its topographical and cultural advantage.
- The sub-city has no proposed green infrastructure which serves the dwellers so Research is needed on how to develop highly functional green space under compact conditions, e.g., using technical innovation such as roof and vertical greening including their implementation on private properties.
- Gondar residents should have to be aware of the importance of; appropriate disposal of waste management, private gardening habits, and Frameworks and tools that enable successful public participation and resident perspective in cases of densification.
- The subsidy is under densification which needs to be developed with knowledge, research, and awareness. The overall process should be supported with such studies, awareness-raising, and education which are very important for changing the current trend and developing a sustainable society.Compact city form is often justified as a way to save land on the city periphery from exploitation. How much land is saved by densification and compaction has been little explored.
- Identification of successful policies, legislation, and practices that prevent green space degradation during compaction and enable development of well-functioning urban green space.

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APPENDIX

APPENDIX I

Questionnaire survey

BUILDING DENSIFICATION AND ITS IMPACT ON URBAN GREEN AREA: CASE OF GONDAR CITY

Adama science and Technology University

School of Civil Engineering and Architecture

Master of Science in Environmental Architecture

Sample no: -----------------

Code of respondent --------

Date: -------/-------/--------

Research questionnaires for Gondar arada sub-city residences

Appendix: Questionnaire form

This questionnaire is designed to gather data for research on the **BUILDING DENSIFICATION AND ITS IMPACT ON URBAN GREEN AREA: CASE OF GONDAR CITY .** The objective of the study is to evaluate Building densification and its impact on urban green infrastructure: case of Gondar city and to propose alternative strategies promote sustainable urban green infrastructure .The information requested is purely for academic purpose and also, you are kindly requested to feel free and respond all of the questions as honestly and confidentially as possible. Thank you in advance for your cooperation.

Prepared by : ERMIAS TAMRU

Environmental architecture MSc

Signature___________________

General information

Please put √ in the appropriate box/ boxes for your answer

Part one:- Socio-demographic data			
Q. No	Questions	Possible answer	Skip
1. 1	sex	Male ☐ Female ☐	
2.	How old are you now?	I am _________years	
3.	For how-long do you live here sub city	I lived here for______years	
4.	Educational status	1) Illiterate ☐ 2) Write and read ☐ 3) 1-8 ☐ 4) 9-12 ☐ 5) Collage and above ☐	
5.	House owner type	1. Government ☐ 2. Slum/chereka ☐ 3. rental ☐ 4. private ☐	

6. What is Green area ?

   ____

   ____

7. Do you have garden area in your compound?

   Yes ☐ No ☐

8. If the answer for Q# 7 is 'No' Why don't you have garden in your compound?
   1. we don't have free space
   2. poor soil quality
   3. low water supply
   4. we don't want
   5. other

9. Do you think green environment is necessary for urban life?

   Yes ☐ No ☐

10. If the government give you the chance to change this green area for other purpose what would you prefer to ?
    1. residence ☐
    2. road way ☐
    3. work place ☐
    4. I don't want to be changed ☐
    5. Other ____

11. How do you compare arada sub city green environment in past and the present time

____

____

____

12. Do you think that the current situation of the city affect the green environment ?
    1. yes ☐
    2. no ☐
13. If the answer for question "No 12"yes how it affect ?
    1. The willingness of officers get lost ☐
    2. It totally replaced by new buildings ☐
    3. The coverage area decreases time to time ☐
    4. the area dominate by domestic waste ☐
    5. Other ____

14. What is the cause of this impacts on green area? *You can select more than one*
    1. Lack of strong protection of green area in government ☐
    2. It totally replaced by new buildings ☐
    3. The land value increase ☐
    4. Improper domestic waste management ☐
    5. Other ____

15. What will the solution to mitigate this impact

____

____

____

APPENDICES II

BUILDING DENSIFICATION AND ITS IMPACT ON URBAN GREEN AREA: CASE OF GONDAR CITY

Adama science and Technology UniversitySchool of Civil Engineering and Architecture

Master of Science in Environmental Architecture

Sample no: -----------------

Code of respondent --------
--

Date: -------/-------/--------

Prepared by : ERMIAS TAMRU

Environmental architecture MSc

Research interview for Gondar arada subcity officers, green development stakeholders with selected municipal administrative bodies and involved organizations.

The objective of the study is to **evaluate Building densification and its impact on urban green infrastructure: case of Gondar city and to propose alternative strategies promote sustainable urban green infrastructure** .The information requested is purely for academic purpose and also, you are kindly requested to feel free and respond all of the questions as honestly and confidentially as possible. Thank you in advance for your cooperation.

1. What looks the housing provision in this sub city ?
2. What kind of places are preferred for expansion site ?
3. Do you use construction material from the green environment?
4. How do you control urban expansion in this sub city?
5. What looks the liquid and solid waste management of the sub city?
6. Does the green environment ,which exist in this sub city helps you properly?
7. If no why they not?
8. Do you think that protect and develop this area is essential in current condition?
9. What looks the current green infrastructure development movements that exist in sub city?
10. What are the main challenge that faces while green area protection and development process ?

APPENDICES III

BUILDING DENSIFICATION AND ITS IMPACT ON URBAN GREEN AREA: CASE OF GONDAR CITY

Adama science and Technology UniversitySchool of Civil Engineering and Architecture

Master of Science in Environmental Architecture

Sample no: ----------------

Code of respondent --------

Date: -------/-------/--------

Prepared by : ERMIAS TAMRU

Environmental architecture MSc

Research interview for Gondar arada subcity urban agriculture farmers

The objective of the study is to **evaluate Building densification and its impact on urban green infrastructure: case of Gondar city and to propose alternative strategies promote sustainable urban green infrastructure** .The information requested is purely for academic purpose and also, you are kindly requested to feel free and respond all of the questions as honestly and confidentially as possible. Thank you in advance for your cooperation.

1. Do you offer enough water for your agricultural purpose /cattle's ?
2. Do you use streams and rivers water as a source?
3. Do you have adequate space for grazing of your cattle's ?
4. Where do you take them for grazing ?
5. How often do you take your cattle's for grazing to the forest?
6. How do you exposed your waste during summer and winter?

APPENDICES IV

Observation of Existing green area

APPENDICES IIV

Multi-function of green area

- Urban Agricultural activity around existing green area





APPENDICES IIIV

Green infrastructure
Site Assessment Checklist

Table for kebele 08

GENERAL INFORMATION		Site ID: 08
Name person(s) completing assessment: ERMIAS TAMRU		Date:
Location Address and Cross Streets:	Neighborhood:	
Name of Nearest Waterway: KEHA RIVER	Property Owner / she-Ali Gondar mosque	
Contact Information:		
SITE DESCRIPTION		
Most of covered with private green area , natural forest and shrub land with sloppy topography and under flow river .		

- Is there green space in the sub-city? If yes list type of green space

	Type of green space in the site	yes	no	remark
1.	Private green space	√		
2.	Public gardens		√	
3.	Street green area		√	
4.	Playing area		√	
5.	Flower garden		√	
6.	Setback green area		√	
7.	Pocket gardens		√	
8.	Green Parking		√	
9.	Shrub	√		
10.	Urban Agricultural land	√		
11.	Riverside buffer	√		
12.	forest	√		

Table for kebele 09

GENERAL INFORMATION		Site ID: 09
Name person(s) completing assessment: ERMIAS TAMRU		Date:
Location Address and Cross Streets:	Neighborhood:	
Name of Nearest Waterway: KEHA RIVER	Property Owner / BEATA church	
Contact Information:		
SITE DESCRIPTION		

Most of covered with natural forest and shrub land with sloppy topography and under flow river .

- Is there green space in the sub-city? If yes list type of green space

	Type of green space in the site	yes	no	remark
13.	Private green space		√	
14.	Public gardens		√	
15.	Street green area		√	
16.	Playing area		√	
17.	Flower garden		√	
18.	Setback green area		√	
19.	Pocket gardens		√	
20.	Green Parking		√	
21.	Shrub		√	
22.	Urban Agricultural land	√		
23.	Riverside buffer	√		
24.	forest	√		

Table for kebele 06 and 07

GENERAL INFORMATION	Site ID: 06&07
Name person(s) completing assessment: ERMIAS TAMRU	Date:
Location Address and Cross Streets:	Neighborhood:
Name of Nearest Waterway: angereb RIVER	Property Owner / ABO,MARIYAM church,private farm land
Contact Information:	
SITE DESCRIPTION	
Most of covered with natural forest, Agricultural land and shrub land with sloppy topography and under flow river .	

- Is there green space in the sub-city? If yes list type of green space

	Type of green space in the site	yes	no	remark
25.	Private green space		√	
26.	Public gardens		√	
27.	Street green area		√	
28.	Playing area		√	
29.	Flower garden		√	
30.	Setback green area		√	
31.	Pocket gardens		√	
32.	Green Parking		√	
33.	Shrub		√	
34.	Urban Agricultural land	√		
35.	Riverside buffer	√		
36.	forest	√		