The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City

Abdo Bedru Nassir

Thesis Submitted to

The department of Architecture

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Masters of Science in Environmental Architecture

Office of Graduate Studies

Adama Science and Technology University

November, 2022

Adama, Ethiopia

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Approval of Board of Examiner

I, the advisors of the thesis entitled **"The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City"** and developed by **Abdo Bedru**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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We, the undersigned, members of the Board of Examiners of the thesis by **Abdo Bedru** have read and evaluated the thesis entitled **"The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Environmental Architecture.

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Declaration

I hereby declare that this Master Thesis entitled **“The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa 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 appropriate citation.

Abdo Bedru	____________________	________________
Name of student	Signature	Date

Recommendation

I, the advisor of this thesis, hereby certify that I have read the the revised version of the thesis entitled **"The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City"** prepared under my guidance by Abdo Bedru submitted in partial fulfillment of the requirements for the degree of Mater's of Science in Environmental Architecture. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Major Advisor	Signature	Date
Yared Girma (PhD)	________________	________________

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AACA	Addis Ababa City Administration
AAU	Addis Ababa University
ADA	Amhara development Association
AUGH	Africa union grand hotel
BE	Building Envelope
CO2	Carbon Dioxide
EMA	Environmental Management Agency
ENEB	Ethiopian national election board
EPA	Environmental Protection Authority
FUPI	Federal Urban Planning Institution
GBE	Greenery on Building Envelope
GI	Green Infrastructure
LEED	Leadership in Energy and Environmental Design
UHI	Urban Heat Island
UN	United Nations
UNEP	United Nations Environment Program
WGBT	World Green Building Trends

ABSTRACT

Greenery in the built environment benefits more than just people's health and well-being. It indorses biodiversity in built-up areas; and can help to mitigate the effect of flooding and noise pollution. However, greenery and plants are highly depleted due to unplanned urban development in the central part of Addis Ababa which has a significant impact on the built environment. The most effective way to overcome the aforementioned challenges is to incorporate vegetation into the building. As a result, the purpose of this research is to assess the current challenges and potential for incorporating greenery into Addis Ababa's buildings. In the study area, twelve buildings from various weredas were selected to examine the challenges and possibilities. For the perception and willingness investigation, 178 respondents were chosen at random from the study area's community. Clinometer and software such as Autodesk Revit and AutoCAD were used to calculate the surface area of the building envelopes. Based on the result of the study 80% of the respondent have positive perception and good will to practice Green building envelope. The study also found that buildings have a suitable building envelope surface for integrating greenery that accounts for an average of 83.1% of the building's footprint. Majority of respondents chose spot flowers, balcony gardening and terrace gardening to install on the buildings because they are simple to install and maintain. The installation cost, shortage of water, and lack of maintenance technician are raised as the major challenges to practice green building envelope. According to the study's findings, about 45% of respondents have no experience with green building envelopes due to poor awareness. The finding revealed that absence of special provision in building regulation concerning green building envelope has also lead to poor practices. According to the findings, the municipality should develop and enact a special building regulation that enforces the use of greenery on building envelopes; the urban greenery and beautification bureau should raise community awareness about the use of green building envelopes; and the cost of greening building envelopes technologies should be partly subsidized.

Keywords: Green roof, Green wall, Building envelope, Green depletion, Urban Rooftop

CHAPTER ONE

INTRODUCTION

This chapter deals with the background of the study, statement of the problem, objectives of the study, research questions, scope of the study, the significance of the study, limitation of the study and Organization of the report.

1.1. Background of the study

In recent decades, there has been an ever-growing number of pressing climate change challenges. Architects and urban planners have been proposing sustainable building designs as an approach that can contribute to the problem's solution, as it has the potential to reduce energy demand, minimize environmental impacts, and alleviate the heat island effect (Kohler et al., 2002). Green roofs, green facades, and living walls are sustainable building design elements that are steadily gaining importance and being increasingly widely applied (Pe´rez-Urrestarazu, 2016).

As ever-expanding cities become more densely compacted, built structures are a source of untapped potential, where 'green' spaces can make cities more attractive and resilient, as vegetation filters fine particles from the air. The effective introduction of green building envelopes can result in local reduction in pollution of around 10-20% (Hargrave, 2016).

Integrating vegetation into architecture has become widely recognized as a multi-beneficial practice in architecture and engineering design to combat an array of environmental issues. The integration of vegetative green space in urban planning, coupled with highly reflective materials in place of conventional paved surfaces on roads and rooftops have proven to be effective methods of urban heat island mitigation. While as separate entities these methods are effective, innovative technology has brought forth greening roofs which allows vegetation to compensate where other roof-cooling strategies fall short. Substantially, vertical greenery systems compensate where greening roofs fall short. (Price, Jones et al., 2015).

The green roof and façade areas aim to improve the environment by replacing a significant amount of the ground on which cities have been built in dense urban agglomerations. It could replace 30% of the total sealed areas of cities by offering about 20 - 25% of the buildings and making use of about 20 - 25% of each building envelope, i.e. They have significant benefits in terms of enhancing city microclimates (Scheuermann, 2013).

In Africa the phenomenon is characterized by rapid and uncontrolled urban growth (Shishay, 2011); resulting destruction of natural environment and sensitive areas of urban area. The level of urbanization in Africa was about 58% at 2008 in the glove (UN-Habitat, 2009). As part of sub-Saharan country, Ethiopia has experienced rapid urbanization and increase urban population in the last few years due to more rural-urban migration (FDRE PCC, 2008). It is also indicated that, the urban forest and other green components of Addis Ababa city are distracting (Fetene & Worku, 2013).

Addis Ababa is the capital city of Ethiopia, currently a rapidly transforming and developing city. As a result of rapid urbanization, the city is facing a complex environmental sustainability challenges and thus GBE practices can be used to address these concerns. GBE have the capability to address the numerous issues that the city is facing and replace the depleted urban green space in the sub city. The core (inner) city of Addis Ababa basically encompasses four major sub cities, where population density and settlement is relatively high. These sub-cities account for 31% of the total city population on only 8% of the city's land cover (Ass, 2011). When compared to other sub cities, Kirkos has the smallest amount of land cover and high rise buildings are dominantly existed.

There is a limited research on the green building envelope implementation challenge of using greenery on buildings to safeguard the urban environment. Very few studies have been conducted on green building envelopes. However, most of the studies focused on the green roof and green walls independently. Taeka Haileleul (2015) investigated the Green Building Features of Selected Addis Ababa Buildings, whereas Nura Mohammed (2018) investigated the Constraints and Opportunities in the Application of LEED Green Building Principles. The practice of green wall to improve thermal comfort in campus buildings was also one of the previously studied by Abduahab Yahya, (2016). The study focused on the identification of optimal bare walls to apply green wall that improve the thermal comfort. The study was not identified the challenge and opportunities of the practice. Therefore, there is a need to understand the community perception; challenge and opportunities of practicing GBE to address the gaps in the previous studies.

1.2. Statement of the problem

Urban densification and other infrastructure development in the city are the main cause to increase the space need which deplete the greenery and plantation. This depletion directly or indirectly affect the environment. Urban green depletion will increase risks of flooding, overheating and drought, through hotter drier seasons.

The Addis Ababa City Administration (AACA) currently launched different projects related to redevelopment in its Sub-cities, and one of them is Kirkos Sub-city. All these projects took the land to be implemented. The sub city chosen due to high rise buildings are concentrated in Kirkos sub city such as Commercial bank of Ethiopia, Wogagen bank, Nani building and so on. Almost majority of the projects do not pay adequate thought to providing enough green space. Due to a paucity of land in the sub city, the urban green in the sub city has been depleted. The high energy consumption along with lack of greeneries around the city buildings which are useful in evapotranspiration, reduction of rainwater run-off and absorbing carbon will lead to the formation of urban heat islands. In addition, the usage of low albedo construction material and impervious surfaces is trapping heat and glass is causing glares on adjacent areas (Nura Mohammed, 2018).

The Municipality of Addis Ababa city has made efforts to improve greenery of the city through beautification movement, watering and maintaining street trees and road construction. The maintaining of street tree is not sufficient to increase the city's greenness and green coverage rather it should be expanding to the practice of green building envelope to upsurge green space in the city.

Taeka Haileleul (2015) and Nura Mohammed (2018), the practice of green building features and principles in Addis Ababa buildings were studied by both of them. Their research focused on the use of greenery on buildings as a single criterion for evaluating green buildings. There were no implications of how people perceive practicing greenery on buildings and how much building surface is suited for practicing greenery. As a result, the aim of this thesis is to fill the gap in the practice of greenery in buildings by examining the challenges, opportunities and people's perceptions and practices in the selected buildings.

1.3. Objective

General Objective:

To examine the challenges and prospects of the practice of greenery on buildings.

Specific objectives:

1. To assess the existing condition of the selected buildings with respect to the practice of greenery on buildings.
2. To identify the factors that hiders the integration of greenery on buildings.
3. To assess the perception and willingness of the society to adopt greenery on buildings.

1.4. Research questions

Main Question:

What are the challenges and prospects of the practice of greenery on buildings?

Specific Question:

1. What is the existing practice of greenery on buildings?
2. What are the factors that affect the practice of greenery on buildings?
3. How the people perceive and willing to practice greenery on buildings?

1.5. Significance

The study examines the benefits and drawbacks of using greenery in the building envelope in order to make recommendations that would contribute in the solution of urban green depletion problem. The findings of the study will be utilized to determine future environmental regulations and incentives. For researcher, it can serve as a starting point for further research; it can be used by the students as a guide or a reference for further research on the related topics. It benefits the community, government authorities, and policymakers because the research may be used as a guide and reference for architectural and urban environment policy practice.

1.6. The scope

Spatially, the study covered kirkos sub city which is a city center of Addis Ababa that the financial and high rise buildings are dominantly existed. Twelve buildings selected from seven woredas of the sub city.

The focus of the thematic scope is on identifying challenges and potential envelope surface areas on the selected buildings, as well as determining whether surfaces are suitable for the practice of greenery on buildings. The focus of this study is on the appropriateness of building envelopes and the challenges of integrating green building envelopes, as well as determining the community's willingness and perception of the practice of greenery on buildings.

1.7. Limitation

Obtaining permission to access the building documents was the most difficult aspect of this study. The study intended to measure the heights of the structures, but It was difficult to acquire a digital clinometer with which to do so. As a result, a clinometer created by hand was used. As a result, the precision may be uncertain. It was also difficult to use the laser meter in direct sunlight. So the data was gathered, organized and digitalized.to overcome these constraints.

1.8. Organization of the report

There are five chapters in this research. The first chapter covered the problem statements, objective, significance, scope, and limitations. The second chapter examines the existing literature on the issue. The third chapter explains the research approach adopted and why it was chosen. The research's materials and methods is also detailed. The population's data source and sample size are stated. The fourth chapter examines the current situation as well as the chosen structures in the research region. The study's result and discussions are presented in this Chapter. The study's conclusions, and suggestions are discussed in Chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1. Theoretical Review

2.1.1. Green Building Envelope

The concept of a building envelope relates to design and construction of the exterior of the buildings. The building envelope of the house consists of its roof, sub floor, exterior door and window, and of course the exterior walls.

A building envelope is defined as the parts of the structure that separates the outdoor environment from the interior environment, according to the Building Science Corporation. Basically, the building envelope surrounds the conditioned living space and separates it from any unconditioned space in the home, as well as the outside elements (Amanda Ringler, 2018).

The building envelope (or the more modern term, building enclosure) is all of the elements of the outer shell that maintain a dry, heated, or cooled indoor environment and facilitate its climate control. Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and indoor climate control (Jermey Gibberd, 2009).

2.1.2. The concept of green building envelope

Incorporating Green plants into the building envelopes has some design possibilities. There are two options for building to make it green. Plants can be integrating at external part of the building. It can be done on roofs, outer vertical walls (Afrin S., 2009). Various types of coatings planting systems like roofing and green wall coverings include coverings without planting systems (traditional type), all-over covering systems with greening structures (non-modular type) and modular greening systems for covering respectively, (Afrin S., 2009). Green covering of the building contributes to the positive role of buildings: reduces the negative impact of buildings on the environment, and also supports the national economy for the sustainable development (Korol et al., 2019).

2.1.3. Historical development of the practice of Greenery on Building

History of the practice of GBE started from roof gardens. The first known historical reference to a roof garden above grade is for the stone temples in the region of Mesopotamia

(Werthmann, 2007). Civilizations in Mesopotamia built roof gardens thousands of years ago on the landings of Ziggurats, or stepped pyramids. The plantings of trees and shrubs softened the climb, provided shade and relief from the heat (Dunnett & Kingsbury, 2008). The next known successor to the roof gardens are the Hanging Gardens of Babylon built by the Persians around the 500 B.C (Weiler & Barth, 2009).

Traditional built-in green roofs were first developed in Europe and are still widely adopted in the market. These green roofs are more complex, permanent and expensive than modular systems. They have certain limitations, including complex logistic installation, overweight, long installation time and difficulty of maintenance. Once a built-in green roof is put in place, it cannot be changed easily (Korol1 et al., 2019).

The concept of green walls is also an ancient one, with examples in architectural history reaching back to the Babylonians with the famous Hanging Gardens of Babylon, one of the seven ancient wonders of the world. Highlights of the history of green walls are 3rd C. BCE to 17th C. AD: Throughout the Mediterranean, Romans train grape vines (Vitis species) on garden trellises and on villa walls. Manors and castles with climbing roses are symbols of secret gardens (GRHC, 2016). In 1920s the British and North American garden city movement promote the integration of house and garden through features such as pergolas, trellis structures and self-clinging climbing plants (GRHC, 2016).

Figure 1: Various types of the green covering systems (source: Mehmet Sinan, 2020)

2.1.4. Functions of Green or green components on the building

As Phillip Pulfrey said that all he wants is to stand in a field and to smell green, to taste air, to feel the earth want him, without all this concrete hating himself. Integrating green in the built environment is crucial to live healthy life (Phillip Pulfrey, 2018).

The role of urban trees and green spaces in reducing urban air temperatures

Cities and towns are often affected by the urban heat island effect, whereby air temperatures are higher than those in surrounding rural environments. According to V. Monteiro, how the urban environment can limit cooling from vegetation evaluated by.

2.2. Green Walls

Green facades are a type of vertical greenery system in which climbing plants or cascading ground covers are trained to cover specially designed to support structures. The plants are either grown in the ground or in elevated containers where they are water and fertilized. (Dunnett & Kingsbury, 2008).

2.2.1. Green wall systems:

The green wall system represents one of the low impact development (LID) solutions able to increase the green spaces in urban area, aiming at enhancing the aesthetic value of the building and leading several benefits in terms of reduction of the environmental impacts caused by urbanization and climate change (Palermo & Turco, 2020).

Since with the term “green wall system”, we refer to each form of vegetation for facades, the first applications can be found 2500 years ago in the hanging Gardens of Babylon; similar examples were also in the Roman Empire. Many applications occurred over the centuries, until the 19th century, when these techniques were used in several European and North America cities, as ornamental elements and for thermal purposes (Palermo & Turco, 2020).

2.2.2. Types of green walls

There are two major categories: green façades and living walls.

Green façades are wall systems where climbing plants or cascading groundcovers are trained to cover specially designed supporting structures. Plant materials can be rooted at the base of the structures, in intermediate planters, or on rooftops. Green façades can be attached to existing walls or built as freestanding structures (Gonchar, 2009).

Living walls (also called vertical gardens) are composed of pre-vegetated panels or integrated fabric systems that are affixed to a structural wall or frame. Modular panels can be comprised of polypropylene plastic containers, geotextiles, irrigation, and growing medium and vegetation. This system supports a great diversity of plant species, including a mixture of groundcovers, ferns, low shrubs, perennial flowers, and edible plants. Living walls perform well in full sun, shade, and interior applications also, and can be used in both tropical and temperate locations (Sharp, 2007). Various patterns through cross clamps (Elgizawy, 2016).

The types involved in the green wall topology listed below:

A. Vertical green

Vertical greenery is plantations installed in the vertical elements such as; Green Facades (planted in to the soil and planted planter boxes); Living Wall system (prefabricated and in situ); Wall vegetation (Natural vegetation and prefabricated panels for vegetation); and also Vertical Gardens, Hanging Gardens, Bio-shades and Bio-Facades.

The following two green facades systems are frequently used:

1. Modular trellis Panel System

This system makes advantageous use of a unique three-dimensional design that provides not only the horizontal and vertical supports necessary for plant propagation but also an element of structural depth that promotes greater plant density and support by effective capturing plant material within its dimension.

The three-dimensional panel made from a powder coated galvanized and welded steel wire that supports plants with both a face grid and a panel depth. Each modular unit, sized at a standard width of 4 ft.(1.2m) and a length which can range from 6-14ft (1.8 - 4.2m) is comprised of a rectangular trellis panel offset from secondary vertical layer by a series of supplementary diagonal climbing supports which thread themselves upwards though horizontal members (Elgizawy, 2016).

2. Cable and wire rope system

It uses either cable and/or wire-ropes net. Cables are usually designed for faster growing climbing plants whereas wire ropes nets are used for supporting slower growing plants that need support at closer interval. Those systems use high tensile steel cable, anchors and supplementary equipment. And many different sizes and patterns can be used as flexible vertical and horizontal wire-ropes to give variable shapes which enable the designer to create

2.2.3. Methods of installation

There are four popular methods of green wall installation.

1. Cassette system 2. Planter system 3. Pocket system 4. Support system

Figure 2: Methods of green wall installation (kampong admiralty, 2006)

2.3. Green roofs

The popularity of modern day green roofs can be traced to the European countries where environmentalists, radical groups and scientific research utilized the technology of the time to develop green roof installations. Known to exist for centuries, in form of Sod roofs in Scandinavia, vegetated roofs provided extra warmth and insulation in the cold, wet climate (Snodgrass & McIntyre, 2010).

Green roofs which are also known as eco roofs, planted roofs or vegetated roofs may be beneficial for an individual building or a number of buildings at the urban scale, due to the various benefits they offer. Vegetated roofs shade and prevent incoming solar radiation from reaching the structure below (Castleton et al., 2010).

At the urban scale, green roofs reduce the impact of urbanization, through filtration; purification of air and percolation of moisture (Cantor, 2008). One study used computational modeling technique to estimate this thermal benefit. It was estimated that green roofs if placed on 50-60% of rooftops in densely populated cities may reduce the summertime temperature substantially (Luckett, 2009). Cooler cities during peak demand hours help reduce energy consumption and lower carbon emission levels (Weiler & Barth, 2009).

2.3.1. Types of Green roof

Truett (2003) categorized green roofs in to two: Extensive green roofs and Intensive living roofs.

Extensive green roofs are shallow (less than 6"), unirrigated, light-weight at 15-50 pounds (7-23 kilograms) per square foot, roof covers offer low cost and low maintenance with high performance value. Extensive living roofs are typically planted with sedums, low drought tolerant ground covers that thrive in a shallow, rapidly draining growth media and are resistant to harsh rooftop conditions. Sedums come in numerous varieties and can provide beautiful contrast of color and texture. Extensive green roofs usually exist solely for their environmental benefits and don't function as accessible rooftop gardens (Truett, 2003).

Green Grid system and Green roof block system

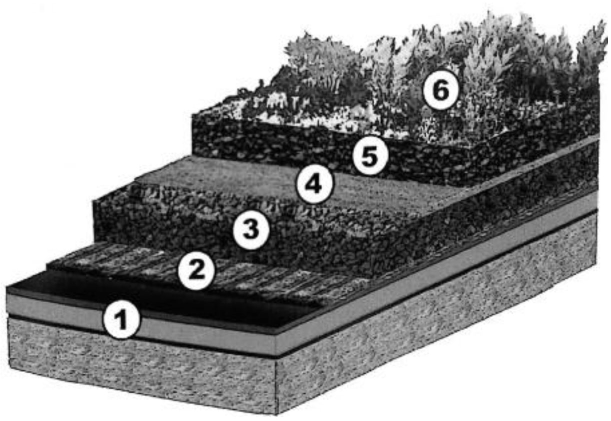
This system are examples of modular systems which is suitable for all type of roof system.

Figure 3: Green Grid system (Adapted from St. Louis Metalworks Company).

Intensive living roofs are made with deep soil (greater than 6") and greater organic content to support broad variety of plant varieties. Design variations are practically limitless. Most any garden that can be created on the ground can be created on a rooftop, including such elements as trees, shrubs, walkways, patios, ponds, etc. The foot or more of growing medium needed for an intensive green roof creates a load of 80-150 pounds (36-68 kilograms) per square foot. Possibilities are only limited by overall weight of the system and its effect on the cost of the supporting construction (Truett, 2003).

2.3.2. Green roof system components

Green roofs consist of both horticultural elements and traditional roofing components. There are three distinct layers in a green roof from the bottom (Barrio, 1998). Elements that provide structural integrity; an engineered growing medium (which may or may not include soil) and the plant canopy (components selected as per particular application).



1. Roof Deck, Insulation, waterproofing
2. Protection Layer – root barrier
3. Drainage Layer
4. Root permeable filter layer
5. Growing Media
6. Vegetation, Plants

Figure 4: Green Roof Assembly showing the various layers (Snodgrass, 2010).

2.4. Benefits of practicing Green building envelope

Numerous benefits can result from the adoption of green building envelope. Besides the obvious aesthetic and psychological benefits of being surrounded by garden-like settings, common ecological and economic benefits include the recovery of green space, moderation of the urban heat island effect, improved storm-water management, water and air purification, and a reduction in energy consumption (Truett, 2003).

2.4.1. Benefits of Green building envelope integrated with Architecture

Greenery in our living environment benefits more than just our health and well-being. It also facilitates water management and promotes biodiversity in built-up areas, and can help reduce the effects of noise pollution. Greenery also helps to raise the property value of homes and offices (FAO, 2016).

Green envelopes can offer a broad range of benefits energy, heat island and air quality benefits as discussed in this report, but also storm water management, habitat creation or urban agriculture, roof longevity, real estate value improvement and human wellness through basophilic (Weeks & Schepers, 2016).

The main benefits connected to a green building envelope regard environmental practices, economics, and social aspects, as the greenhouse gases output reduction, climate change adaptation, air quality and indoor and outdoor comfort conditions improvement, urban wildlife (biodiversity), human health, etc. These benefits concern several fields, which are all related and operated on a scale range; some only work if a large surface in the same area is greened and their benefits are only apparent at a neighborhood or city scale, others operate directly on the building scale (Perini & Novi, 2016).

In ever denser cities the space for "green infrastructure" such as parks, green recreational spots and trees in street canyons is being depleted. What is often considered and belittled as "green architectural decoration" is however an important element in our built environment which must not be underestimated. Besides the many health and well-being aspects resulting in significant stress relief for human beings, there are a number of effects which have serious influence on the micro-climate in our built environment and the sustainability of building operation (Scheuermann, 2016).

2.4.2. The Green building envelopes benefits in Urban Scale

The Urban heat island effect is reduced: The most frequently observed and documented climatic effect of urbanization is the increase in surface and air temperatures over the urban area, as compared to the rural surroundings. Oke (1995) simply defines an urban heat island (UHI) as the 'characteristic warmth' of a town or city. The introduction of vegetation into the cities through a green wall or green roofs will help in reducing the UHI effect. The plants that are grown will help in absorbing the large amount of heat which help in creating a micro-climate. These helps in increasing the humidity effects and shelter the building from direct heat and wind (Samar & Nourhan, 2012).

The air quality is improved: The process of photosynthesis facilitated by plants would transmit the carbon dioxide, water, and the solar radiation into oxygen and glucose. Building construction will occupy the horizontal space that is to occupy by plants. This results in a reduction of oxygen production and hence the air quality. So, the incorporation of vegetation into the oxygen-deprived areas in the cities. This can be done using green building envelope systems.

Air filtration, air quality, and oxygenation internally is carried out: The plants will help in trapping the airborne particles from the atmosphere. Heavy metals, copper, lead, and zinc are absorbed by the plants. Builders suggest green walls improve the interior quality. With over eight years of research at the University of Guelph, there is significant data on the effectiveness of Living Wall in improving indoor air quality (Darlington, 2008). Cool walls and green roofs are discussed by Kats (2003) in terms of their possible indirect effect of lowering CO_2 emissions from power plants by reducing demand for summertime peak-period cooling. In urban forestry research, Johnson and Newton (1993) estimate that 2,000

m^2 of un-mowed grass on a roof might trap as much as 4,000 kg of particles from the surrounding air.

Psychological Impact: In addition to their aesthetic features, the green building envelope provide tangible relief from high sun radiation that is radiated from the building surfaces and streets. This would give a calming effect to the urbanites (Samar & Nourhan, 2012).

Benefits for health: Individual psychological and physiological health conditions are affected by the positive effects of green building envelopes. This helps in bringing a visual connection for the occupants with the exterior vegetation. This will help in giving positive emotions for the occupants. Breathing diseases suffering people are greatly benefited by the air filtering and the oxygenating abilities (Samar & Nourhan, 2012).

Improvement of biodiversity and creating natural animal habitats: The studies have shown that certain species of plants and animals are favored by the biodiversity obtained through the green building walls and the facades. Algae and lichens are some of these organisms. They also help the dwellers like mosses, ferns, liverworts and some coniferous plants (Samar & Nourhan, 2012).

Green amenity space: Green roofs provide a tangible, accessible natural viewing environment for social interaction, enjoyment, and relaxation to city dwellers, providing a demonstrable psychological benefit. A view of their green roof "provides sanity and relief" from the demands of crowded urban living, according to research on graduate students at 30 Charles Street in Toronto (Bass et al. 2004).

2.4.3. The Green building envelopes benefits in building Scale

Deadening of sound: Green building envelope will act as a sound insulator for the building. It worked as a barrier for noise, dust and protect the building envelope as a shell. The occupants of the buildings located in the cities face a huge problem of noise pollution hard surfaces tends to amplify the sound and get redirected. The Incorporation of thick vegetated green building envelope would reduce the deadening effect caused due to urban noises. Sound attenuation qualities are highly gained by the green building envelope topology. The transmission of noise is transmitted into the interior of the building (Samar & Nourhan, 2012). In Truett (2003) tests indicate that green roofs can reduce indoor sound by as much as 40 decibels by absorbing, reflecting, or deflecting sound waves produced by machinery, traffic, or airplanes. A green roof's substrate tends to block lower sound frequencies and the plants block higher frequencies.

Aesthetic Appeal: The structures are embellished by the benefit of green building envelope system these are a concept more suggested by the builders to deal with aesthetics. Various plans are available with different texture and colors that can be skillfully arranged to decorate the building facade. Existing complementary spaces can be recreated by this method (Samar & Nourhan, 2012).

Protection of envelope: The wall and roofs are protected from the ultraviolet layer. This direct effect will cause the complete deterioration of the structure. The internal stresses within the wall are decreased by creating the temperature fluctuations. And also escalation the thermal comfort inside the building (Truett, 2003).

Building Energy efficiency is improved: The thermal performance of the building is significantly increased by the plants on the envelopes. This will involve the increase of insulating property of the walls (mainly in colder regions), the facade shading property is increased (mainly in hotter climates), and the evapotranspiration will cool the air and also will reduce the wind near the facade.

During summer, hot walls cause temperature to rise inside buildings increasing demand on cooling systems and consuming more energy. A Green Wall surface temperature is reduced by up to 10°C when covered with plants and moist soil. In 1979, Green Wall research by Akira Hoyano (Professor, Tokyo Institute of Technology), a pioneer in passive and low-energy architecture, revealed that the heat energy that passed through a Green Wall was significantly lower than a concrete wall.

Energy budgets of individual buildings: Akbari et al. (1999, 2001) investigated means of reducing building energy in mid-latitude cities as one of several means for reducing the urban heat island (UHI) effect and documented the enhanced air conditioning demands (up to 10%) brought about by the UHI. By making roofs cooler, designers can reduce the amount of absorbed solar energy, and consequently reduce the amount of heat conduction into buildings. This reduces daytime net energy inputs (Akbari and Konopacki, 2004).

Effect of soil moisture content on Energy Savings: A Green Roof can be thought of as an external "heat" insulation material. The adiabatic efficiency of typical insulation is measured by the materials heat resistance value and its thickness. However, soil is different in that as its moisture content increases its insulating efficiency also increases. Because of this inconsistency, soil is not considered an effective insulation (Yamada, 2008).

Extend Roof Life: Ultraviolet (UV) radiation and extreme daily temperature fluctuations are the two leading factors that act to deteriorate and ultimately destroy the waterproofing elements on traditional roofs cited by Truett (2003). A green roof buffers the underlying waterproofing from these damaging natural elements, which can in turn more than double the roof's life expectancy. Green roofs also add extra buffering protection from hail damage.

Economic Benefit: Long-term economic benefits of green roof system already outweigh the start-up costs. The initial expense of green rooftops often turns away prospective clients. Because green roofs require professional design, careful structural analysis and multiple layers and systems (Shahrina Afrin, 2009).

Reduce HVAC Cooling loads: On hot summer days, the surface of a typical rooftop can be up to 90°F warmer than the ambient air temperature, according to Truett (2003). Some roofs can reach temperatures of 20^0 degrees. The heat from these roofs both travels downward into the structure and radiates upward, affecting inefficient operation of roof-mounted HVAC equipment.

Storm-water management implications: Numerous studies have demonstrated quantitatively that a properly installed and maintained green roof will absorb water and release it slowly over a period of time, as opposed to a conventional roof where storm-water is immediately discharged. Typical extensive green roofs, depending on the substrate depth, can retain 60 to 100% of the storm-water they receive (Thompson, 1998). In addition, according to the ZinCo planning guide (1997), living roofs are normally able to retain 70 to 90% of the storm-water that falls on them during the summer months, depending on the frequency of rain and drying rates. In winter months, green roofs are predicted to retain 40 - 50% of the storm-water.

2.5. The role of green building envelope addressing green depletion

The integration of buildings into vegetation has become a necessity in many metropolitan areas of the world today. It expands the potential of vertical and horizontal, exterior and interior, exposed and enclosed spaces in a building that can be used to accommodate plants. Green infrastructures have benefits both on urban and building scales. They can be categorized into green roofs and vertical greenery systems that can be divided further into green façade, green wall, green terraces, elevated forest and vertical forest (Wang et al., 2019).

This phenomenon makes greening cities a priority, because it is in our nature to be surrounded by trees and flowers. Their lack affects negatively the inhabitants, whose unbridled enthusiasm and well-being creates the true heart of the city (Expo, 2014).

Green roof and facades for example are an important cost-effective solution to reducing pollution and improving both indoor and outdoor air quality, which is the key role of green structures especially in urban areas (Michael, 2010). A changing in natural land through urban densification and settlement presents a challenge to the planners and designers of the built environment. Building professionals need to incorporate strategies that consider future climate change within their context. Green building envelope function as the urban greenery by reducing the urban heat island effect.

By improving the design of commercial, industrial, and residential buildings, Different professionals can help building owners, occupants and other users to reduce or replace the natural resource use while maintaining a better indoor and outdoor environment.

2.6. Main Ways of Integrating Green Components in to the Built Mass

Integration of green elements such as vegetation within our built environments can be a very effective means of addressing several problems of modern cities and buildings. Plants in our cities and buildings not only improve the microclimate, but they also benefit the people who live there in terms of health and comfort. They also help to mitigate the detrimental effects of the 'concrete and glass jungles' we are creating in our cities. To incorporate vegetation (as a component of GBE design) into the architecture of the structures, it is important to look at some typical construction techniques and elements that can be employed in buildings.

It has to be distinguished the level of the green component to integrate the components in the built mass. It has to add Street side trees, open spaces, parks in the urban level. When it need integrate in the building level or its surrounding level, the Pockets of private gardens, Fences will be introduced in its surrounding and the Pockets of private gardens, Fences, Facades, Balconies, Terrace gardens, Interior spaces and circulation, Roofs will be used in the building parts.

2.7. Retrofitting with Green Envelopes

These buildings have great potential to contribute to improving the conditions of our cities, not only within the buildings but also on the streets. The ability of green façades to reduce the cooling loads on buildings is well known and has been quantified. What is possibly less well understood is that green façades can improve the air quality in city streets (Jofeh & Jimmy, 2018).

Plants can remove not only carbon dioxide but also particulate air pollutants such as smoke and dust. Inhalation of smaller dust particles can cause health problems, and public health is improved if dust concentrations are reduced. Vegetated environments are good for people. Exposure to Nature provides relief from the pressures of high-density living, improves people's ability to focus, cope with stress and generate creative ideas, and decreases anti-social behavior (Jofeh & Jimmy, 2018).

2.8. Empirical review

2.8.1. Practice of Green building envelope in developed countries

The developed countries like Europeans and North Americans have better practice on the integration of GBE in the buildings. They also have the guideline and evaluation methods for the practice of GBE. Australia is one of the exemplary developed country that developed a guideline for the implementation of GBE which is RICS (Royal Institution of Chartered Surveyors) professional guidance, Australia. The guideline includes checklist for appraising roofs for suitability for green roof retrofit.

Germany, Canada, Japan, Singapore and Hong Kong have widely adopted green building envelopes in urban areas in order to reduce the negative impact construction activities especially in the cities. Each one of these countries has their own methods of encouraging building owners to adopt greenery on roofs and facades. They have taken their fair share in applying green roofs into their building industry (Zulhabri & Haziq, 2012).

Case study 1. One Central Park, Sydney Australia.

One Central is a 34 story building with in the height of 116m located in downtown Sydney. Its developers and designers used the opportunity to make a powerful and visible green statement with a tall building that is environmentally responsive on multiple levels (Jean Nouvel, 2014).

Greenery on the building was well-practiced across the project's suitable parts of the building envelopes. The intensive and extensive green roofs were included into the green roof. The majority of the building envelope is made up of a modular trellis panel system and a Grid system. Beyond the mere function of shading apartments, the towering green presence of the building's 180,000 plants is also a universal sign of life on earth (Jean Nouvel, 2014).

Figure 5: One Central Park, Sydney Australia (Source: John Gollings, 2014).

Case study 2. Pritzker Family Children's Zoo

Pritzker Family Children's Zoo located at Lincoln Park Zoo, Chicago, and new integration of GBE applied on the date of implementation at 2004. The size building envelope surface used to integrate GBE is 4,000 sq.ft. Basically the project used green Wall System which is Cable System. The plants used in the GBE implementation were Vitus Riparia; Riverbank Grape (Special Hybrid).

Figure 6: Pritzker Family Children's Zoo (Source: Carl Stahl Décor Cable Innovations)

The vine support system that fronts the west side of the zoo building achieves several goals: it helps control late afternoon summer heat gain by functioning as a natural sunshade; and it allows winter heat gain for natural heating when the deciduous vine leaves drop in the fall. Because the cross clamps enable the horizontal rods to slip as force is applied, the structure is quite safe.

Structurally, 4mm stainless steel vertical wire ropes and 4mm diameter of horizontal wire rods connected in a rectangular grid using UV-Resistant cross clamps. Hand-installed terminal end fittings allowed field trimming of ropes and rods for simplified installation. System attachment and tensioning allows easy dismount/remount for plant control and building maintenance.

Case study 3. Vancouver Convention Centre West (Vancouver, Canada)

Vancouver Convention Centre West is an urban oasis in bustling Vancouver is one of the example of dreamily practicing GBE. The project found in Canada opened in 2009. More than 50% of the envelope covered by Green. The project design developed by LMN Architects.

Great things are happening on the roof of the Vancouver Convention Centre West, the first building of its kind to get a double LEED platinum designation.

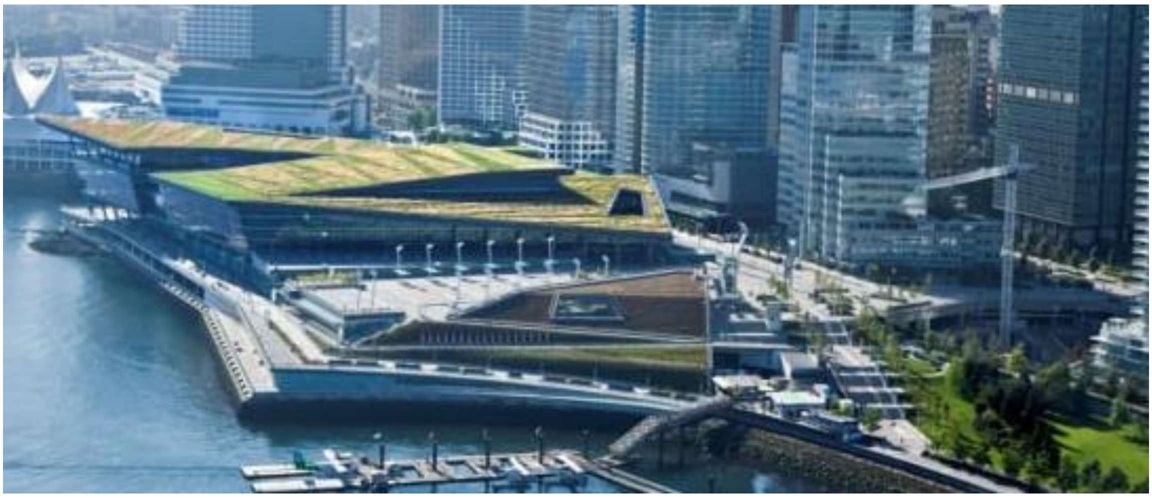


Figure 7: Vancouver Convention Centre West (Source: LMN Architects, 2009)

Four hives of European honey bees have been installed to pollinate the roof's plants and grasses, which in turn help reduce heat build-up in summer and retain it in winter. On top of that, the roof's sloping shape also assists with water drainage and the distribution of seeds. But not all the action is on the roof. Some of the project is built over the water on piles (columns) that help support a marine ecosystem that includes native crabs, salmon and shellfish (LMN Architects, 2009).

2.8.2. Practice of Green building envelope in developing countries

The practice of green building envelopes is rarely used in the design of buildings in impoverished nations like Africa. They don't even have a policy or criteria in place to assess the building's long-term viability. South Africa is a developing country with unique needs and thus aiming to implement green rooftop systems might require a different approach to first world cities with already the successful implementation of green rooftop systems. Green buildings are necessary to culture healthy cities and green rooftop systems contribute to changing buildings to being green to some degree. Green rooftop systems might be a new concept for South Africans and a lack of knowledge goes with it (Garrett Rd, 2014).

According to Garrett Rd (2014), there is a shortage of understanding about the construction of green rooftop systems among professional team members in the construction sector. They also noticed that there is a dearth of understanding about the benefits that green rooftop systems provide. The cost impact of constructing green roofing systems is a major concern, and it is a factor that is inhibiting green rooftop system development in South Africa. Government incentives will assist in the deployment of green roofing systems.

Case study 1. House Jones, Johannesburg, South Africa

The House Jones designed by ERA Architects at the year of 2012. It is an example of all-round sustainable architecture owned by Mr. Ivor Jones. Everything about this building is designed to reduce its environmental impact. It is a perfect example of environmentally aware approach to design, where sun protection, solar radiation, energy and water consumption, landscaping and sustainable home automation are carefully integrated to create a unique, attractive and sustainable home.

Figure 8: House Jones, Johannesburg (source: Leon Krige – Courtesy, 2019)

Many solutions have been devised to keep down the building's impact: site materials were reclaimed and reused, rainwater is harvested and stored in tanks that can hold up to 40,000 liters onsite, and energy use in the building was reduced. The green wall helps integrate the internal and external spaces, but it also actively creates microclimate "bubbles" around the home, surrounded by greenery and with a green core. The plants that complete the dwelling and its environmental strategy will be fully grown and developed by 2014 (Green Homes - Living Synergy, 2019).

The primary concept of the design is the mediation between interior and exterior spaces. To this end, a second envelope of planted steel structures creates individual ''green bubbles'' of tempered microclimates for each living space to open onto. These provide cooler intermediary spaces in summer and sunny protected areas that collect warmth in winter. The results are mediating spaces that naturally pre–condition the air that enters and circulates into the home. The same planted steel framework concept is used for solar shading and results in a living cladding that almost envelops the entire northern façade. The building is able to change in appearance and environmental response as the seasons transform the surrounding landscape (Garrett Rd, 2014).

The building reduce energy us through sun angles were carefully used to design the shading and planted structures to minimize direct summer sun and maximize winter sun. The planting attached to the building creates ‘‘bubbles’’ of tempered microclimates where the building opens onto, integrating the internal and external spaces, both in summer and winter (Garrett Rd, 2014). It Enhance Biodiversity through landscape design as a natural ecosystem. The planting around the house (GBE) also creates many areas where various, birds and insects can make a home. The planted screens around the house create their own individual microclimates. Building materials were chosen for maximum life span, low maintenance and high recyclability Reduced transport distance to site Paints, solvents adhesives so on (Garrett Rd, 2014).

Summary of case studies

In this cases summary, three projects with GBE have been laid out and analyzed, has given insights on GBE fundamentals Benefits, potential, strengths, and on the other hand challenges and threats reflected. GBE fundamentally provides, environmental responsive buildings, desirable place to live, sign of nature, visual dynamics in buildings external view, Composition, reduce buildings energy needs for cooling, clean air, shading, maintain external cleaning costs , diminishes heat gains, and attract the lost birds as well as bees; GBE, with its basics benefits several challenges reflected, additional loads on buildings, adds additional design, add construction resources, add various maintenances and installation costs. Although the case studies well reflected the physical, environmental, and social aspects of GBE to the buildings and cities.

Table 1: Summary of Case Studies

	Summary of case studies	
1	Strengths and potentials of GBE	• Environmental learning. • Environmental responsive buildings. • Green façade, beyond the mere functions of shading apartments, also a universal sign of life. Vegetation deeply ingrained in human consciousness, so buildings with green cover been the most desirable places to live. • Used various species of plants to cover green. • Vegetation forms dynamics in buildings external visual composition through time on the façade. • Buildings with green façade cover reduces its energy needs for cooling. • Provide clean air around and shading. • Diminishes heat gains, summer heat, from external buildings surface. • The plants trap CO2, emit oxygen and reflect less heat back into the city, than covering the building with metallic louvers and other buildings components. • Maintain the of cleaning of louvers. • Bees hiving, great actions to attract wildlife, insects and birds. The natural ecosystem could enhance. • Green facades display an intension to keep architecture and nature in a dialogue.
2	Challenges and Threats of GBE	• The modernist resistance to surface layer, especially additional various layers of greenery and its facilities. • To integrate and build vertically on the external surface of the building. • It adds additional design, construction resources. • It adds various maintenance, like green roofs with through time leakage. • Installation and maintenance.

2.9. Green building envelope in Addis Ababa

Now urbanization is increasing at an alarming rate in developing countries. This is due to fastest growth rate of world's population and change in human settlement preferences. This urbanization process was manifested through the urban physical/horizontal expansion to their peripheral land. Such urban expansion affects more of the green environment. Generally, one of the basic problems that affect the environment is unplanned urban densification. This invasion process leads to the loss of green lands and reduction of plants (Barney Cohen, 2006).

Although Addis Ababa was relatively recently founded city, it has experienced considerable change with respect to its demographic, socio-economic and physical development (UNEP, 2014). Today, Addis Ababa is the country's largest urban center. The city constitutes approximately 28%, of Ethiopia's urban population. The accelerated growth of Addis Ababa attributed to natural increase, boundary expansion and rural-urban migration and its physical development has been influenced by periods of sporadic growth, with inefficient land use and costly infrastructure development. This pattern of settlement and rapid urban renewal infrastructure has resulted green depletion and scattering of green structures (CLUVA, 2013).

Based on the land use and land cover change analysis made for Addis Ababa between 1986 –2010, there is significant decrease of green components while the built up area is increasing very rapidly. The built-up area was only concentrated on the central part of the city (source: Leulsegged, IoUoAAC). Kirkos sub city is one of the central part of the city with less green cover. Some experiences of integrating green building envelope throughout the city is was taken as the example to address the depleted green cover. Some examples are taken below from different architectural projects with different design programs.

Residential building

Residential buildings are located on Kolfe keranio sub city, around Bethel and Alem bank area with their grand green envelope on the front facade could be the best example to integrate greenery in the building facade. In other hand the spot flowers in balcony and the external envelopes also practiced.

Figure 9: Residential buildings ((a) Betel and (b) Alem bank area)

Hope University College (library)

The Henk De Pagter library is found within the Hope University compound. Hope University is located in Nifas-silk Lafto Sub-city, woreda 01 around Jemo area. The library is located on the left side of the main entrance. The design was done by GelukTreurniet Architecten of the Netherlands, in collaboration with ABBA architects from Ethiopia.

Figure 10: Hope university College Lebu area (Source: Nura Mohammed, 2017)

De Leopol Hotel

The main road that takes us from meskel square to Urael church defines the building informally named “De Leopol Hotel”. This building is located between the Bambis supermarket and the Ethiopian Commercial bank building. One of GBE integrated hotel buildings owned by the private are located around the research area.

Figure 11: De Leopol Hotel around Bambis super market

Desalegn Lounge

Desalegn Lounge is located in Laphto Sub-city, Woreda 06 on the Lesotho Street from Bisrate gebreal round about to Mekanisa. It is a villa house the front façade treated on the green components. It is a restaurant building. The building is orientated towards the South west direction.

Figure 12: Desalegn Lounge around Sost kuter Mazoriya (Source: Researcher, 2021)

Nega Bonger hotel building

The building located around Saris Addey Ababa area. Which faces the west direction with full advantage of receiving morning sun. It stands on the same side with other buildings around the area.

Figure 13: Nega Bonger hotel around Saris Adey Ababa (Source: Researcher, 2021)

Peace building

The building located around Mekanisa area. Which faces the south west direction receiving harsh sun in the afternoon. It is a five story mixed use building built in 2008.

Figure 14: Peace building around Mekanisa (Source: Researcher, 2021)

Varnero Apartment

Varnero real estate compound lies in the Nifas-silk Lafto Sub-city, woreda 01, around Lebu. Varnero Construction created the estate, which includes both villas and five-story apartments. The compound has a total of eight apartment buildings. The building is located on the left side of the back entrance. It is entirely used for residence with two and three bedroom apartments. The building has a square shape facing the North direction.

Figure 15: Varnero Apartment Lebu area (Source: Abdulhakim, 2021)

Ministry of Mines

Office of the ministry of mines located in Yeka Sub-city, around Gurd Shola round about. There are two office buildings on the compound. The building is located on the center of the plot area. On the verandah's roof, there is a green roof practice. Greenery integration on the fences was also practiced in two ways. Plants on the fence were integrated using multiple soil pockets and half-sectioned PVC pipe.

Figure 16: Ministry of Mines

Summary of Green building envelope practices in Addis Ababa

Green building envelope practice in Addis Ababa was recently founded and experienced considerable change with multi-dimensional respect. Demographic, socio-economic and physical development dimensions. With the increasing of built up lands in Addis Ababa lessening the green coverage. Addressing Green building envelope in Addis Ababa taken as enhance the depleting green cover.

Table 2: Summary of Green building envelope practices in Addis Ababa

Progress of GBE	• GBE construction already started but not satisfying.
Challenges / Gaps of GBE	• GBE is not included in building regulations that means Including GBE in buildings not supported by legal frames. • No legal bases • Workmanship and construction skills • Less availability of GBE technology and GBE Construction materials • Less in research and practical experiments of GBE within Higher Education institutions. • Mostly GBE on constructed buildings were not designed before construction, integrated after based on the clients need. • Less construction and designing skills • No forcing firms/ Institutions • Lack of local standards to design and construct. • Less awareness and willingness
Recommendations for GBE development locally	• Higher education institution should research and experiment on practical. Although provide prototypes and domestic skills/ GBE knowledge for the construction industries. • Need to set standards for design and construction to professionals as well as for the construction crew.

2.10. Summary and gaps of the Theoretical review

2.10.1. Summary of the Theoretical review

As it can be understood from the aforesaid surveyed documents, the existence and practice of green building envelope in Addis Ababa city is poor and lack of standards. On the practices of living wall, green roof, and green spaces there is a gap of awareness how to integrate it. The city of Addis Ababa needs more technologies on GBE practices to recover the depleted green environment and to be comfortable for its dwellers. Accordingly, on this paper the primarily focused on the practice of GBE to enhance the Green urban environment by assessing the challenge and positive opportunities of using GBE. The land consumed by the urban built structure can negotiate by having a huge amount of suitable roof and walls to integrate GBE in the urban fabric.

2.10.2. Gaps of the Theoretical review

In this exploration phase, while assessing different sources and studies in the related field of Green building envelope and green infrastructure is discussed in different aspects of environments. But, some of the studies have some limitations which can be summarized as follows;

- The research paper "Enhancing Green Infrastructure and the Thermal Quality of Bare Walls through Vertical Greenery Technology, (2018)" was published. Abdulwahab Yaheya conducted research on the EiABC campus buildings of AAU. However, the study was broadened to include condominium buildings, which have more ground open space than other private buildings. There is a gap in this study literature since it was limited to condominium buildings and was not tested for other buildings of the city. There have been no objections concerning the community's willingness or perception of the use of greenery on buildings.
- The thesis conducted by Nura Mohammed (2018) assessed the nature of selected buildings based on the green building principles in order to understand the gap, its challenges, opportunities and proper approaches for application and implementation in Addis Ababa with a concentration on the design and development of vertical greenery because vertical greeneries contribute to securing up to 18 credits under the LEED rating system by dealing with most of the green building principles. According to Nura (2018), it was found that most of the surveyed buildings have poor indoor quality sometimes contributing to occupant's illness, rely on imported materials rather than using local and low impact materials, consume large amount of unnecessary energy and little consideration is given to water efficiency or the surrounding area (Nura Mohammed 2018).
- According to Nura (2018), despite the proposal's intent to examine existing selected structures using green building principles in order to attain sustainability, there were no implications that proved the application of remedial greenery practices to Addis Ababa buildings. Nura exclusively used LEED principles to appraise the buildings.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Choice of research method

This research was designed to study the Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City. In order to make the finding credible and to get deeper understanding to integration of green building Envelop, case study was chosen as a research method based on the objective, source and type of data, no of sample, and method of analysis which were used based on experience from empirical review of topic under study. The survey was conducted to select the case buildings from the target area and based on checklist developed from experience from empirical study. The selected samples were analyzed in such that allows drawing conclusions on practice of green building envelope.

Case study being defined by Merriam (1998) explained that the single most defining characteristic of case study research lies in delimiting the object of study: the case. The case is a thing, unit, entity, or phenomenon with defined boundaries. A case can also be a person such as a student, a teacher, a principal, a program, a group, a specific policy, and so on. The case study focuses on holistic description and explanation.

Selection of Study area

According to empirical review and practical observation, check list was developed to decide the study area and to select case buildings. For this study Kirkos sub city was selected. There are numerous features which makes the sub city suitable from other sub city for this study. Some of them are

a. It’s a sub city is one of oldest settlement which accounts back to the establishment of Addis Ababa city with a highly dense building settlement and scarcity of urban land.
b. It is the financial city centers of Addis Ababa where the built capitalist highly dominated.
c. It is also home for different architectural building typology like, National Stadium, National Theater, Meskel Square; Exhibition center and the Gottera interchange the first modern and sophisticated road are located in the sub-city. Filwuha spa which is unique features for the establishment of Addis Ababa.
d. Kirkos is a commercially vibrant sub-city with several commercial center centers, including more than 35 star-rated hotels. The main financial institutions have also

placed their headquarters in this sub-city. This sub city also comprises a variety of national and international governmental institutions.

3.2. Description of the study area

Addis Ababa, the capital of Ethiopia, is located at the geographical center of the country. Its absolute location is between 8º55´ and 9º05´ North latitude, and 38º40´ and 38º50´ East longitude. The City was established in 1887 and has shown a great geographical expansion to the area of about 540km² Addis Ababa has an average temperature of 16°C and its altitude ranges from 2,326m.a.s. (Bole International Airport) to 3,200m.a.s.l (Entoto mountains).

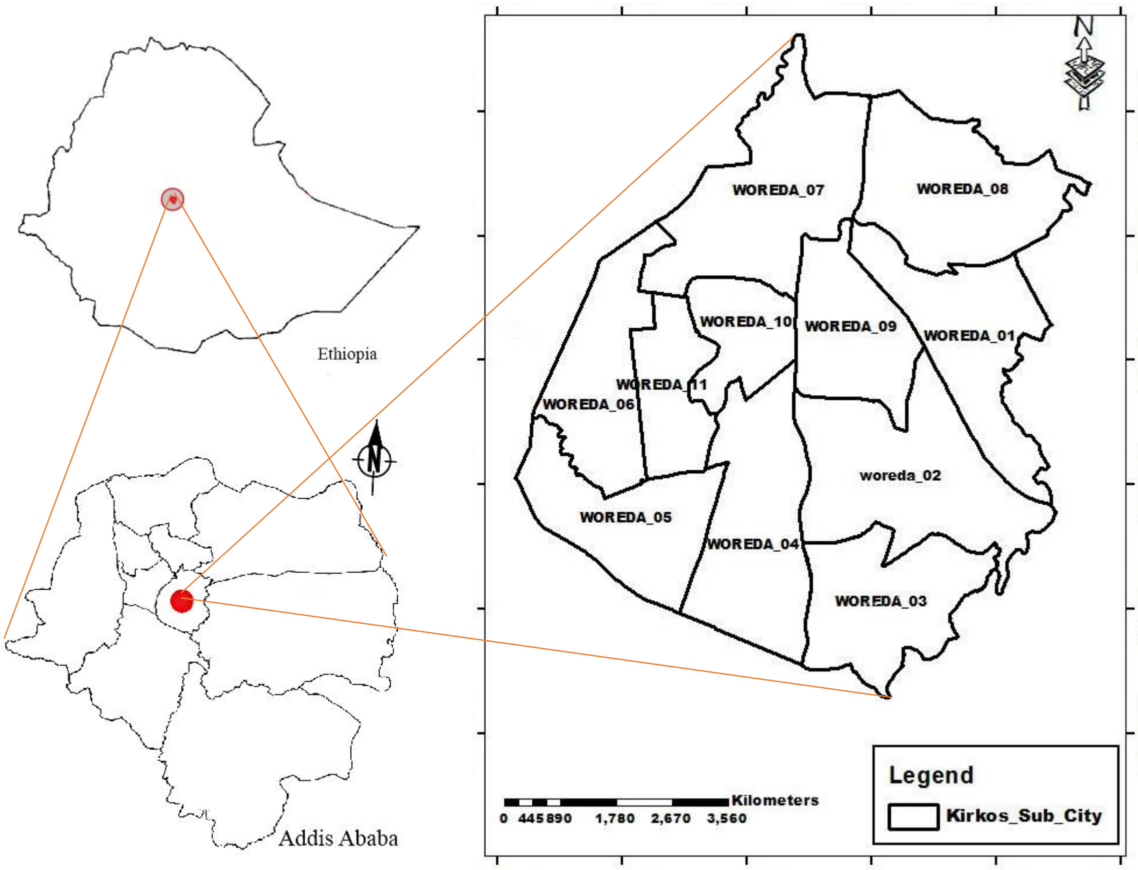


Figure 17: Location map of the study area

3.3. Sampling Technique and Sample Size

Sampling Technique

Two types of sampling procedures were employed for this study: the first was the selection of buildings to meet the first specific objective, and the second was the selection of community respondents to fulfill the next two specific objectives.

Sample buildings selection

The first particular objective is achieved through the selection of case buildings from the research area. To select specific case buildings, survey was conducted which fit the study objective. The majority of buildings selected from the study area based on empirical review and Information from Kikos sub city land administration bureau. Some of the criteria for Sample Building selection are:

a. Midrise and high-rise buildings have large building surface areas, however the majority of the city's buildings are midrise, thus midrise buildings were selected.
b. The buildings were chosen with different architectural projects in order to investigate how building function affects GBE practice.
c. The selection criteria also included the building envelope material utilized; the area of land needed to build; the provision of green space; the potential of the building envelope to incorporate the GBE; and existing GBE practice.
d. Building ownership is also one of the selection criteria. When selecting private and government buildings, the level of GBE practice is taken into account.

According to these parameters, three buildings were selected from wereda 07. Three separate buildings were picked from the weredas 01, 02, and 05, one from each. Six different buildings were also chosen from the weredas 04, 08, and 09, two from each.

Depending on the check list for pre assessed survey a total of 12 buildings were selected to be studied from various parts of the research area. The selected buildings comprised the Residential (Apartment and Condominium), Office, Mixed commercial, and Institute types of building clusters.

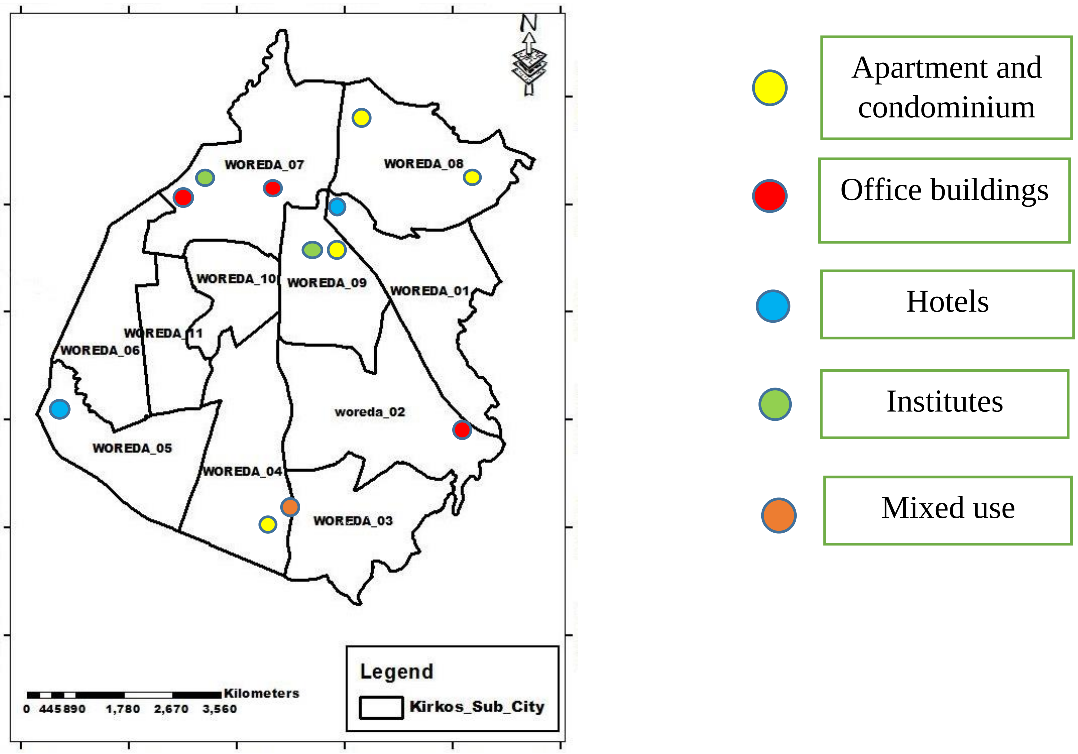


Figure 18: Location of the selected buildings

Sample respondents' selection

The second sample selection strategy is to choose sample respondents who are required to achieve the next two specified objectives. A random sampling technique was used to select respondents from general public which are users or inhabitants of the building during data collection, so that each building users or household has an equal probability of being selected. The sample frame registered household list collected through census by support of Central Statistical Authority. Purposive sampling was used to integrate and investigate respondents from different professional in order to examine their perception from different professional background.

For this study interview, questioner and group discussion were conducted for users and households in the sub city. So, to determine sample size from the total population of the sub city 220,991, 178 sample size was determined using mathematical formula by Yemane (1967). It was difficult to reach a significant number of respondents due to the Corona epidemic, which made respondents apprehensive to respond. As a result, the sample was completed with a 92.5% precision and 7.5% predicted error.

N = total population = 220,991. Male 103,314. Female 117,677 (Addis Ababa City Administration, 2016).

$$n = \frac{N}{1 + N(e)^2} \quad \Rightarrow \quad n = \frac{220991}{1 + 220991(0.075)^2}$$

$$n = \frac{220991}{1 + 220991(0.0056)} \quad \Rightarrow \quad n = \frac{220991}{1 + 1237.55}$$

$$n = \frac{220991}{1238.55} \quad \Rightarrow \quad n \cong 178$$

Therefore, $\underline{n = 178}$

Where: n= sample size

N= no of house hold in study area

e= sampling error (level of precision=7.5%) i.e. (0.075)

3.4. Sources of data and collection Instruments

Different sources of data had been used for the purpose of investigating challenges and opportunities and how the community perceive the Greenery Integration on Buildings in the study area. As illustrated by all the data necessary to conduct the study was gathered through observation, site survey, questionnaires, interviews and relevant document review.

The data for the selected buildings were collected through field survey by through direct observation and picture taken from the site, and the quantitative and qualitative data were also collected through questioner and interview from community and experts; interviews with the general public, and representative of government bodies.

A. Site Survey/Field observation

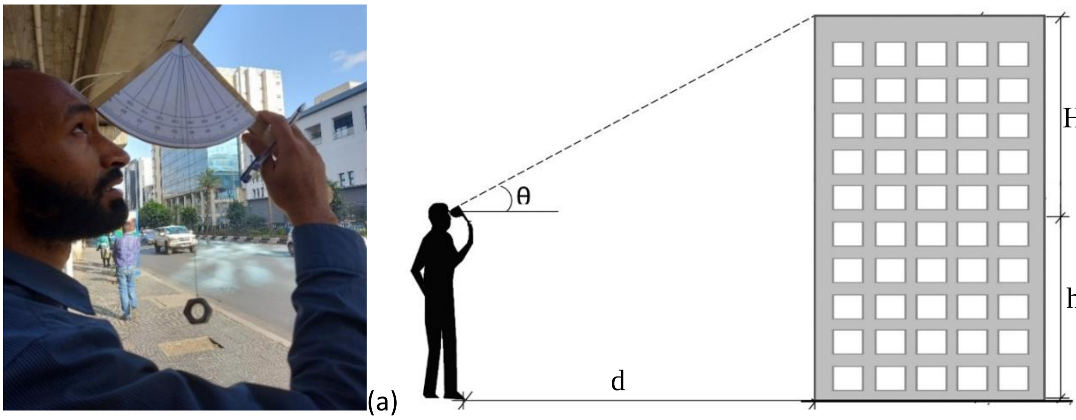
For this study, therefore, observation of case buildings was conducted repetitively in order to get the information needed for the study, and pictures of case buildings were taken and analyzed graphically and geometrically in urban space. Site survey checklist was used to analyze the current situation of the study area by visiting the selected buildings and independently assessing the existing condition of green building envelope practices. To analyze their GBE practice, suitable surface area, building footprint, and envelope material employed, a checklist that defines the existing condition of the buildings was created. Photographs and sketches, along with field notes, were employed to record crucial data that reflected the area's true state.

B. Clinometer (Handmade clinometer)

The surface area of the envelopes was observed and measured by using different instruments. The height of the buildings was measured using a handmade clinometer and the remaining envelope surface were measured by using digital meter as depicted in figure 19 below. Equipment and Materials used to produce handmade clinometer are Template (Protractor), 6mm thick MDF board, nail, Nut and String shown in figure 20. The look at the height (h) from ground with in the horizontal distance (d) from the building through the edge of the clinometer to the top of the building to measure the height (H). And someone helps to read the angle marked by the hanging string.

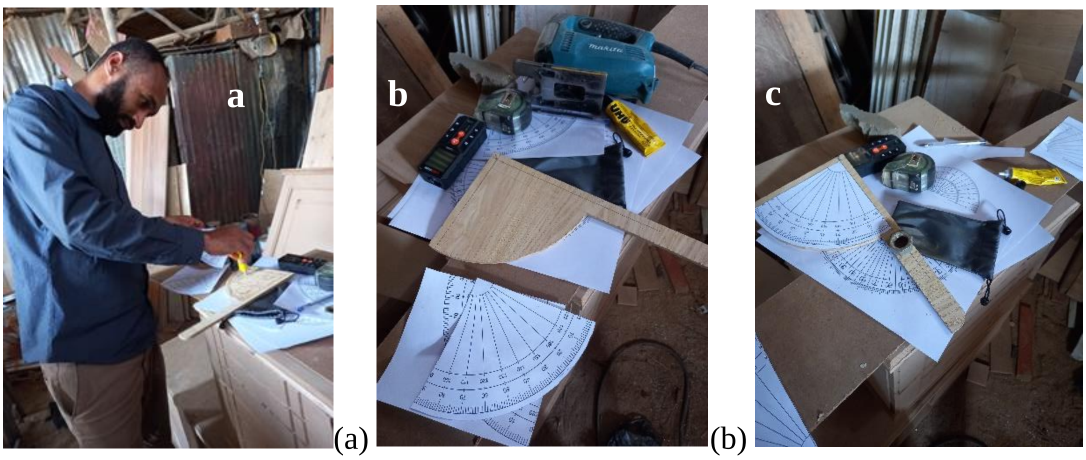
In general, mathematical formula used (trigonometric method) to calculate the height of the building. θ = Vertical angle $H' = d \tan \theta$,

Height of the building is $H = H' + h$



(a) (b)

Figure 19: (a) Clinometer height measurement and (b) Measuring diagram



(a) (b) (c)

Figure 20: Clinometer ((a) making process, (b) Digital Meter and (c) Manual Meter))

C. Map, satellite image and documents

For this research maps and satellite image were also used. To collect data on current conditions of the case area will analyzed by using satellite image and existing land use from the settlement land administration authority office. Google earth also used for additional information. AutoCAD is used to map drawing.

Another data was collected from building documents, published and unpublished material. Building envelope analysis (elevation, footprint, wall and roof material and type), plot (plot area, built-up area and green space area) has designed to be tools for describing the potential of the existing buildings to practice GBE in the research area.

D. Questionnaire

To analyze the factor that hinder GBE practice, as well as the community's perception and willingness, the following measures were utilized to collect data. To improve the efficiency and dependability of the data, a combination of open-ended and closed-ended questions were used. This strategy was utilized to confirm information acquired from theoretical documents and compare it to the responses of interviewees, which disclosed their own experiences. Two questionnaires were designed, one for the community and the other for construction industry professionals.

E. Interviews and Questioner

Interviews with members of the community, building managers or owners, and professionals were used to gather information regarding their knowledge, attitudes, willingness, opinions, and understanding of GBE. The interviews were open-ended and primarily targeted at community members as well as building owners and managers. Interviews were conducted in a semi-structured format. This Study used both interviews, and questioners as a main tool to gather information that cannot be obtained by observation and visitation. Interview is one of the data collection techniques where questions are forwarded from the interviewer to respondent in a face-to-face situation. There are three kinds of interviews: Structured, semi-structured and unstructured (Abiy Zegeye, et.al, 2009). Structured and unstructured interviews and open-ended which, allows a to collect large number of interviews with limited time and capital. Further Robert.K.Yin, (1994) described an open-ended form of interview is most commonly used for case study interviews. These techniques were used to measure the attitudes, perceptions and motivation of people about green building envelop in the study area. In this regard an interview was conduct using structured, semi- structured and open-ended manner in this study. In this regard two clusters were developed for questioner which if for general public or local community and professionals and two clusters for structured and semi structured interview for building owners and professionals:

3.5. Analysis techniques

The data gathered from observation, site surveys, and measuring of building envelope surfaces were analyzed and examined the existing conditions of greenery practice in buildings by comparing them with the standards and the reviewed literature. Photos, graphs and maps were used to examine and present the building's greenery and the improved building envelope. The analyzed and processed data are presented through narratives, and descriptive data was processed and presented in the form of charts and graphs. Different software such as Google Earth, Excel, AutoCAD, and Revit were used to support the analysis. Soft wares such as SPSS and excel were used to analyze the data in a descriptive and statistical method including surface area as an opportunity, level suitability and percentages. The appropriate building envelope surface has been measured and presented in tabular style.

Data from the questionnaires, interviews and observations results were analyzed to answer the research question 'What are the factors that affect the practice of greenery on buildings?' and 'How the people perceive and willing to practice greenery on buildings? The factors that affect the practice of greenery; as well as the community's perception and willingness to practice greenery on building were investigated, and then analyzed and presented on chart and graph formats. Data analysis included systematically reaching and arranging the interview records, filled questionnaire, field notes and other material accumulated to increase understanding of the respondent's subjective experiences.

3.6. Ethical consideration

For the confidentiality of the study output concern given on creating awareness on purpose and objectives of the study. During the data gathering process, each study participant's permission was obtained. The information's privacy and confidentiality have been protected. Every selected building administrators and building owner representatives have given their permission to study on buildings. All sources of information used in the study have been acknowledged. Throughout the session, every eligible participant gave their permission to be photographed. The data was assessed in relation to the specific objectives only.

3.7. Research Framework

The research strategy provided a framework for designing a systematic study that would address the study's objectives and questions. This study was conducted to identify Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City. The study framework below reflects the logical flow from the problem statement that initiated findings of the study.

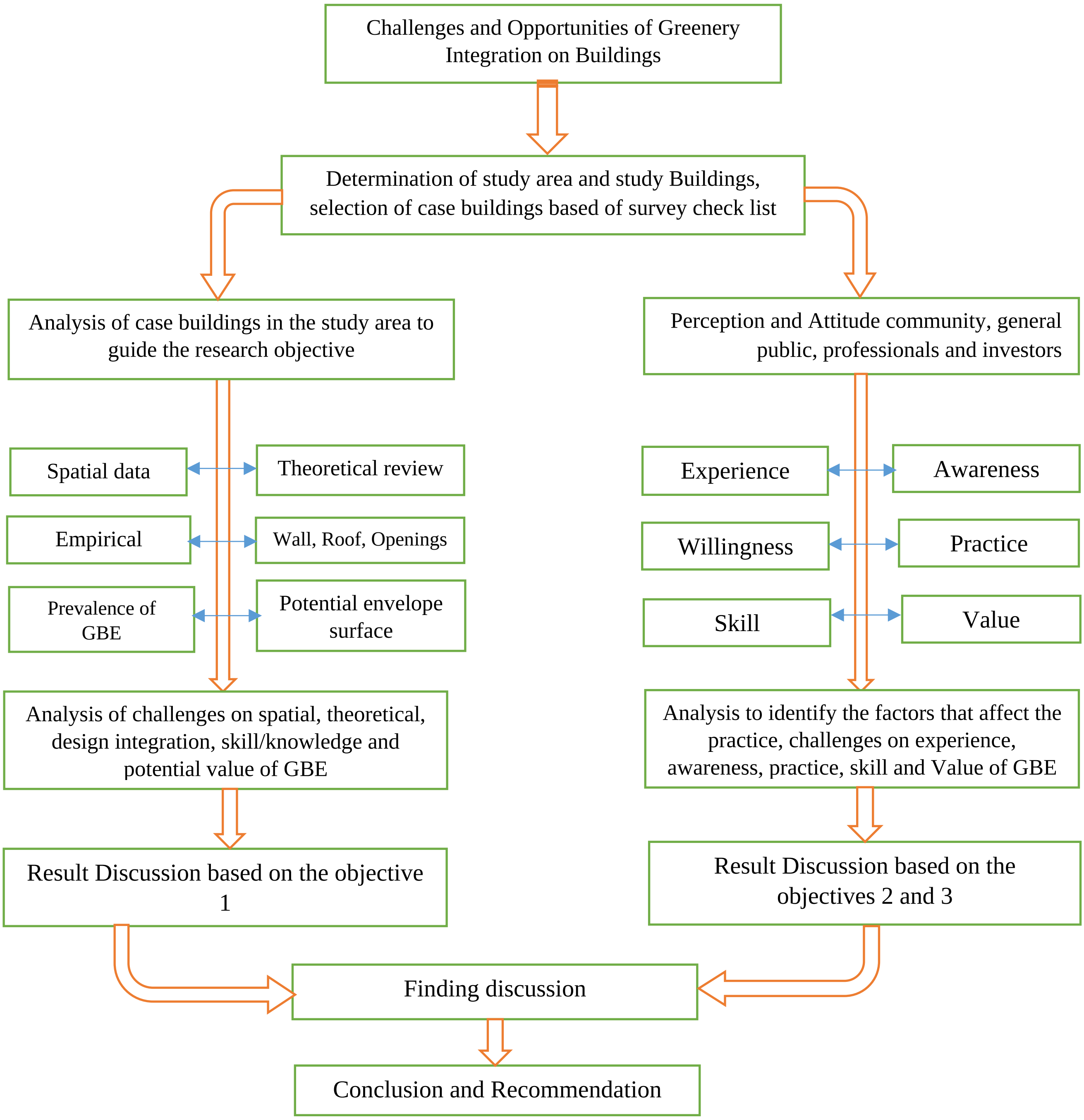


Figure 21: Research Framework

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter deals with the challenges and potentials for integrating greenery on the building envelopes of the selected twelve midrise buildings. The buildings' bare walls, openings, and roof surfaces have been physically and analytically assessed. The external building envelope material was also investigated. The measured surface area of the building's envelope is also discussed. The perception and willingness of the individuals to integrate GBE in the building were also analyzed and discussed.

The study analyzes the existing conditions of the selected buildings and summarizes the population's willingness and perceptions of the practice of green building envelope. The factor that hiders the integration of green building envelope also discussed.

4.1. RESULT

4.1. Background of the respondents

4.1.1. Status of participants

The respondents' attachments to the selected buildings were utilized to determine their willingness and perceptions of GBE practice, as well as its influence on the user. Given that people were asked to respond based on their own experiences and understanding of the consequences of practicing GBE.

There were 44 building users and 12 building owners among the total number of responders. The permanent residents made up 114 of the total responders, with 8 being building managers.

Table 3: Summary of the selection of respondents and their attachments

position of participants'	**Building owner(manager)**	**Building user**	**Permanent Resident**	**Institute manager**	**Total**
No. participant	12	44	114	8	178
Percentage	6.8%	24.7%	64%	4.5%	100%

4.2. Existing condition of the selected buildings

The existing condition of the selected buildings are assessed and briefly discussed. The overall surface area of the building's envelope and the exterior openings on the envelope were measured and reported. The greenery and plantation practices in buildings, as well as the most commonly employed plantation in buildings, were investigated and reported.

Existing building condition in terms of green building envelope practice

4.2.1. Hyatt regency

This hotel project lacks sufficient ground space. The building occupied the entire available piece of land for the project. The building façade system has horizontal structural components which have the ability to incorporate plants. Within a perimeter of the building, there are several plantations. As the majority of the city's character, the concrete pavement and asphalt in the project constitute a solitary impermeable environment.

Location map

The hotel is situated in front of the main road that circles the Addis Ababa stadium. Through Greenery practice, it currently has the most experience.

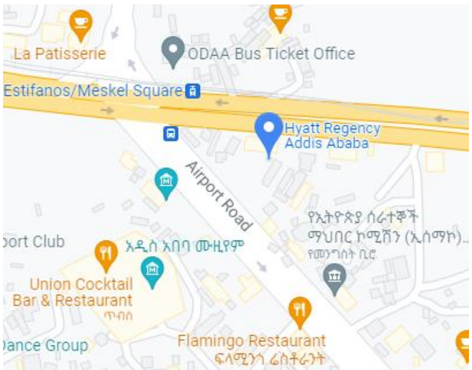


Figure 22: Location of Hyatt regency

The height of the building is 46.25. it was computed by using a handmade clinometer from a horizontal distance of 47.7m and a vertical distance of 1.77m from the ground within an angle of 43^0 (William Abney, 1880).

$H = 1.77 + (47.7(\tan 43^0))$

Height is 46.25m

Table 4: Envelope surface area description of Hyatt regency

Hyatt Regency	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	11,000m^2	8100 m^2	46.25 m	19000 m^2	2431 m^2	12785 m^2


(a)

(b)

Figure 23: Hyatt regency ((a) Roof top view and (b) Intensive roof garden)

The building's small windows, which are located on the bigger side of its opposite façade, accentuate the bare concrete. Though provided with a flat roof with full potential to support vegetation. The Hotel project has a much better practiced GBE in comparison to other buildings in the sub city, as well as a higher and improved green surface in and outside the compound as well as within the building envelops. It is the leading case inside the considered range for using the most extreme suited green building surface and envelopes.

Exterior envelope materials

The structure and envelope of the building are composed of concrete; the concrete flat roof is the most accessible and suitable portion of the building. For exterior wall finishing, HCB walls that have been plastered and painted are used (white oil paint wall finish). The roof of the podium level is flat concrete which is suitable to implement green components, while the roofs of the two towers are EGA sheet roofs which is the challenge to integrate greenery.

Table 5: Exterior envelope materials of Hyatt regency

Hyatt regency	Exterior envelope materials	
	Wall	Roof
	Concrete	EGA sheet and concrete roof

4.2.2. Africa Union Grand hotel

It is a hotel apartment building located beside AU head office on the road from Sar-bet to Bulgaria. The bare concrete bare surface area of the building is less than the area of the building footprint. It accounts for around 30% of the building's footprint. The project's roofing system is a concrete flat roof, which is appropriate for incorporating greenery. The vertical elements in the façade is another potential to integrate greenery in the building envelope. Currently there is a poor practice of greenery in this project. Only a portion of the roof top of the podium part of the hotel structure was used for greenery.

Location Map

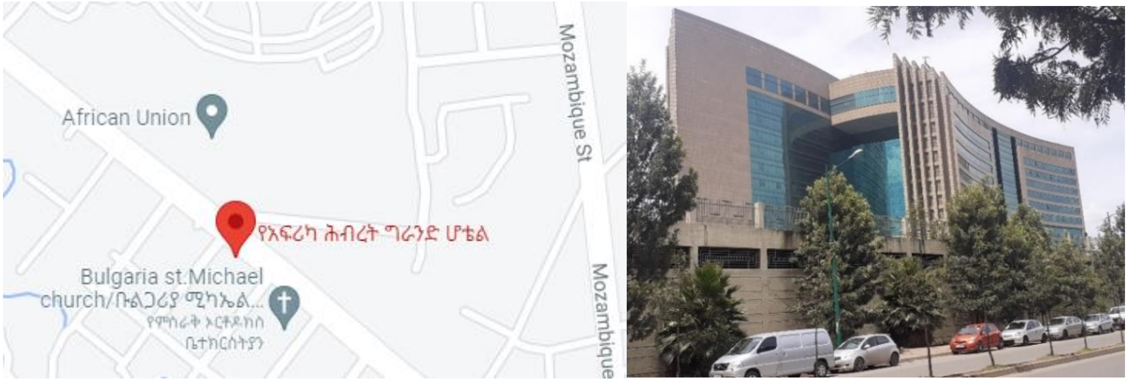


Figure 24: Location of African Union Grand Hotel

The hotel building project was developed in 2020 GC. The entire plot size of the Project is 50,060 m^2. The structure was built on a 47,807 m^2 footprint. The top most height of the building from the ground is 58 meter. The curtain wall in this project's external façade system is the main challenge in incorporating vegetation. Some of the building's façade, which is bare concrete, is appropriate for incorporating plants.

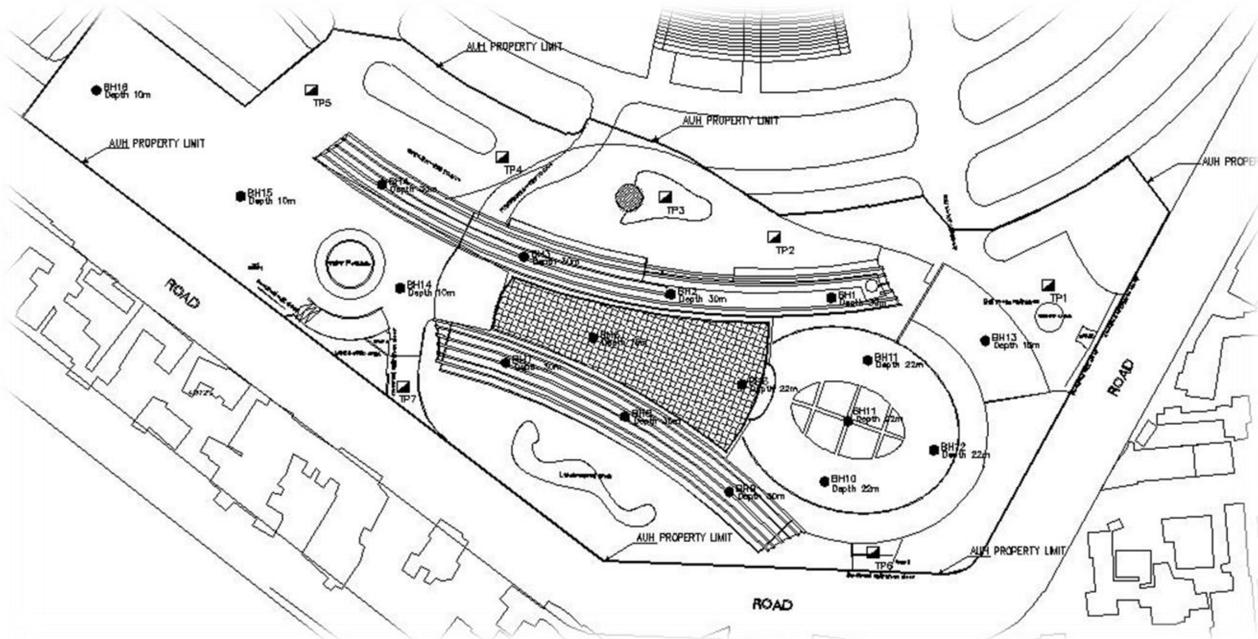


Figure 25: Site plan of Africa union grand hotel (Source: Medoc Ethiopia, 2019)

The total surface area of the building envelope for the project is 85700 m^2. The 10940 m^2 building envelope (bare wall and roof) is an adequate surface area for incorporating GBE. On the parking roof level, the project aimed to provide area for gardening or green cover, covering 5890 m^2.

Table 6: Envelope surface area description of African Union Grand Hotel

African Union Grand Hotel	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	50,060m^2	47,807m^2	58 m	85700 m^2	5890 m^2	14815 m^2

Exterior envelope materials

The main building's structural material is concrete, with wall ceramic and aluminum glazing as exterior wall finishing materials. The roofing material is a concrete flat roof with a ceramic floor finish.

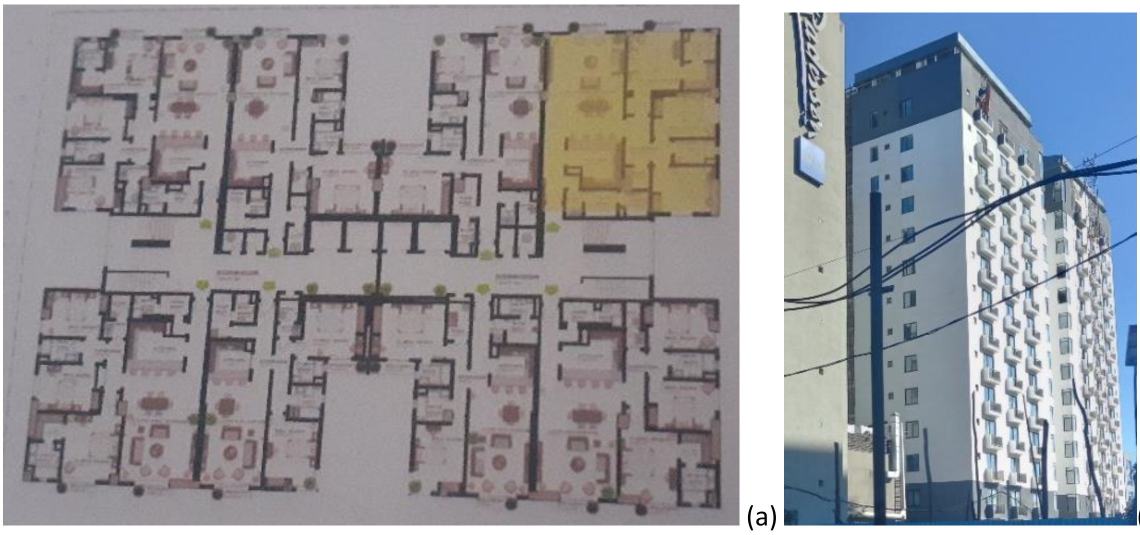
Table 7: Exterior envelope materials of African Union Grand Hotel

African Union Grand Hotel	Exterior envelope materials	
	Wall	Roof
	Concrete and Aluminum	Flat concrete roof and sky light

4.2.3. Sacuur real estate (Apartment)

Apartment building developed by Sacuur real estate plc. in 2019. The building accommodates 12 households in each floor. The vertical building envelope has an excessive number of window apertures spaced too closely together. The planting of spot flowers on the balcony promotes greenery practice in this project.

Figure 26: Location of Sacuur Apartment



(a) (b)

Figure 27: Sacuur Apartment ((a) Floor plan and (b) 3D view)

The apartment developed on the total plot area of 2000 m^2. The building laid its footprint at the area of 1440 m^2. The uppermost height of the building is about 47.5m high. The building's entire envelop surface area, including roof cover, was 10260 m^2. The suitable building envelope surface (bare walls and roof) of the building is 6620 m^2, which demonstrates the potential for greenery in the project. The only barrier to implement greenery in the building is the window openings in the exterior surface.

Table 8: Envelope surface area description of Sacuur Apartment

Sacuur Apartment	**Project plot size**	**Building footprint**	**Height of the building**	**Building envelope**	**Utilized envelope**	**Suitable envelope for greenery**
	2000m^2	1440 m^2	47.5 m	10260 m^2	34m^2	6620 m^2

Exterior envelope materials

Mainly the building structural material is concrete structure. Finishing material used for exterior walls is plastered and painted HCB wall.

Table 9: Exterior envelope materials of Sacuur Apartment

Sacuur Apartment	**Exterior envelope materials**	
	Wall	**Roof**
	Concrete	Concrete roof

4.2.4. Flintstone Urael Apartment

Urael apartment are located near Urael Church, the building structure includes 11 stories and 29 apartment units that are divided into 1, 2, and 3 bedroom types. There is insufficient ground space in this apartment project to provide greenery and plantation. The volumetric patterns of the façade system complement the bare concrete surface, which is appropriate for incorporating plants. However, there is poor GBE practice in this project.

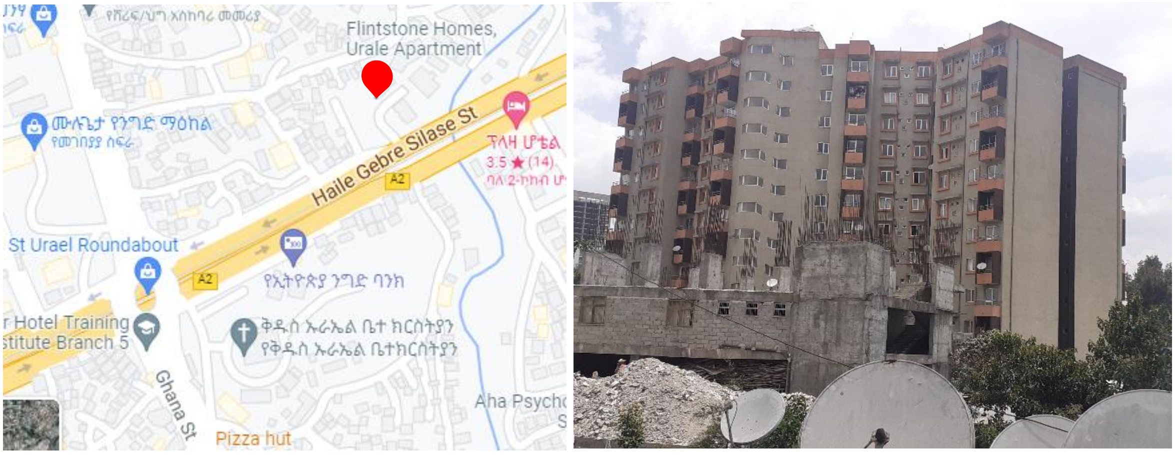


Figure 28: Location of Flintstone Apartment

The vertical building envelope has as well numerous window openings among a little interval. The overhangs on the vertical envelopes moreover have the potential to put spot blossoms and other green components. The only barrier in this project to implement greenery in the structure is the window opening in the envelope surface. The building's entire envelope surface area, including roof cover, was 6905m^2. The building's suitable building envelope surface (bare walls and roof) to integrate GBE is 2228 m^2. There is no green space provided on the ground level in this project.

Table 10: Envelope surface area description of Flintstone Urael Apartment

Flintstone Urael Apartment	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	1248m^2	808 m^2	35 m	6905 m^2	0 m^2	8232 m^2

Exterior envelope materials

Mainly the building structural material is concrete structure. Finishing material used for exterior walls is plastered and painted HCB wall.

Table 11: Exterior envelope materials of Flintstone Urael apartment

Flintstone Urael Apartment	Exterior envelope materials	
	Wall	Roof
	Concrete	Flat concrete roof

4.2.5. Flamingo Apartment

The constructed building structure includes a large backyard with several trees that maximize the greenery. Almost all balconies are appropriate for the installation of green plants. The majority of the external walls were painted with oil paint. Because the building envelope is 90% concrete and 10% window and glazing doors, the 10% opening surface in the vertical envelope is the greatest barrier to incorporating vegetation in this building. Greenery can be included into 90% of the vertical exterior surface. Some of the building's concrete flat roof surface is also suitable for green roof practice. However, there is a poor GBE practice on it.

Figure 29: Location of Flamingo apartment

The total Project plot area cover 938 m^2. From this the building laid with the area of 604 m^2 footprint. A clinometer was used to measure the building's highest point. The calculated height at a distance of 28.3m from the building is shown below (William Abney, 1880).

Angle θ is 47^0, Horizontal Distance is 28.3 and Vertical Distance is 1.77

$H = 1.77 + (28.3\ (\tan 47^0))$

Height is 32.1m

The Project have a total surface area of 2919 m^2 building envelope including roof cover. Only 1640 m^2 envelope surface area is appropriate (bare wall and roof) to integrate GBE.

Table 12: Envelope surface area description of Flamingo apartment

Flamingo apartment	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	938m^2	604 m^2	32.1 m	2919 m^2	50 m^2	1640 m^2

Exterior envelope materials

The main structural material used for the building is concrete structure. The finishing materials used for exterior walls is plastered and painted HCB wall. The volumetric patterns and balcony areas produced by the external façade system allow for more greenery in the structure.

Table 13: Exterior envelope materials of Flamingo apartment

Flamingo apartment	Exterior envelope materials	
	Wall	Roof
	Concrete	Flat concrete roof

4.2.6. Gotera condominium

It is a condominium residential building located near to Gotera interchange. In comparison to other buildings, there is a better provision of ground green spaces. The condominium building has a pitched EGA sheet roof that requires particular parameters in order to integrate greenery. Buildings with a modest number of window openings and a quartz coated concrete wall have the most suitable surface area to incorporate greenery. As a result, the primary challenge in incorporating greenery into the building envelope is window openings in the vertical facade system, as well as the material and slope of the roofing system. The concrete bare surface of the façade, on the other hand, represents the building's potential for GBE practice.

Figure 30: Location of Gotera condominium building

The individual condominium block in the project developed on the total plot area of about 490 m^2. From this area the building laid on the footprint of 325 m^2. The uppermost height of the building is 18m.

The Project total building envelope surface including roof is about 1525 m^2. 1045 m^2 surface area of the envelope is the potential surface to integrate greenery on the building. The building has 1200 m^2 wall surface from the surface about 155 m^2 used for openings. The project developer provided about 14 m^2 area of the ground floor for green cover for each building block.

Table 14: Envelope surface area description of Gotera condominium building

Gotera condominium	**Project plot size**	**Building footprint**	**Height of the building**	**Building envelope**	**Utilized envelope**	**Suitable envelope for greenery**
	490m^2	325 m^2	18 m	1525 m^2	14 m^2	1307 m^2

Exterior envelope materials

Mainly the building structural material is concrete structure. Finishing material used for exterior walls is plastered and painted HCB wall.

Table 15: Exterior envelope materials of Gotera condominium

Gotera condominium	**Exterior envelope materials**	
	Wall	**Roof**
	Concrete	EGA sheet roof cover

4.2.7. Awash bank head office

The commercial office building Awash Bank is located near Churchill Road that was erected in 2009. In two bearings, the building's façade is somewhat bowed. The building has a two story level podium and two towers.

Concrete is used to construct the building's main structure. The majority of the towers in this project are surrounded by a glass wall, making it difficult to integrate green components. The influence of the combination of finishing and building materials on its applicability is different. The use of spot flowers on the corridors of each floor of the building is a common greening practice. GBE can be integrated into the building's ceramic-coated concrete façade surface, which is a potential surface for greenery integration. There is a wide surface area ideal for incorporating plants on the roof terrace.

Figure 31: Location of Awash bank head office building

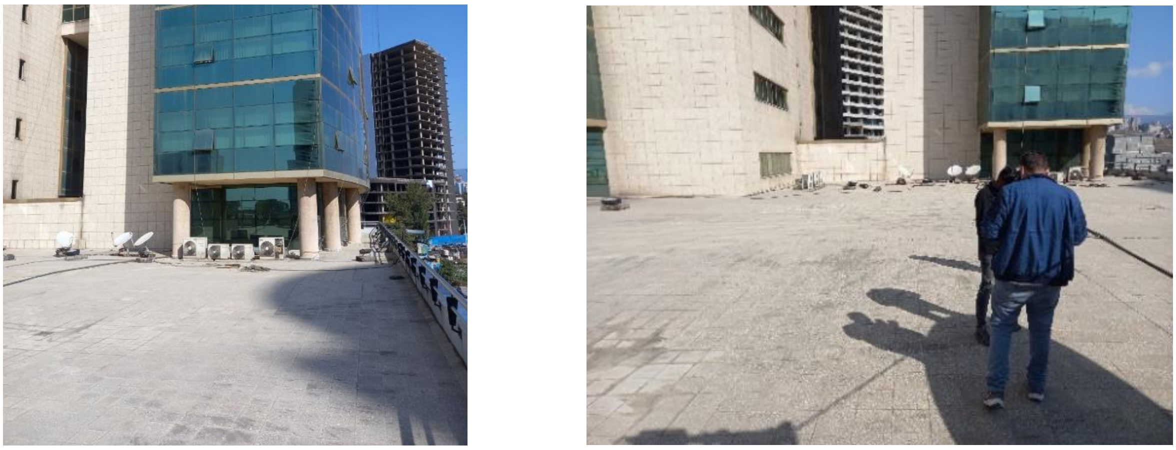


Figure 32: Awash bank head office roof terrace view

The total Project plot area is about 2856 m^2. The building laid on the footprint area of 1961 m^2. The uppermost height of the building from the ground is 60.5m. The Project have a total surface area of 13933 m^2 building envelope. From this 4091 m^2 surface area of the building envelope is suitable to integrate GBE (Bare wall and Roof). The project did not contemplate providing space for gardening or green cover on the ground level, but the building is currently introducing floral spots on the internal and outdoor spaces.

Table 16: Envelope surface area description of Awash bank head office building

Awash bank head office	**Project plot size**	**Building footprint**	**Height of the building**	**Building envelope**	**Utilized envelope**	**Suitable envelope for greenery**
	2856m^2	1961 m^2	60.5 m	13933 m^2		4091 m^2

Exterior envelope materials

The building structural material is concrete structure with the exterior finishing material of wall ceramic tiles and aluminum glazing. Roofing material concrete roof and terrazzo floor finished cover for two towers and the roof terrace on the podium top floor level.

Table 17: Exterior envelope materials of Awash bank head office

Awash bank head office building	**Exterior envelope materials**	
	Wall	**Roof**
	Concrete and Aluminum cladding	Flat concrete roof

4.2.8. Amhara development association building (ADAB)

The building is located on Bole Street, next to the main road. The building has a pitched EGA sheet roof, which requires specific parameters for greenery integration. The horizontal structural elements introduced on the concrete beam is the potential element to integrate plants. The building has enough bare concrete walls on the envelope surface to accommodate plants. However, currently there is a poor practice of GBE on this project.

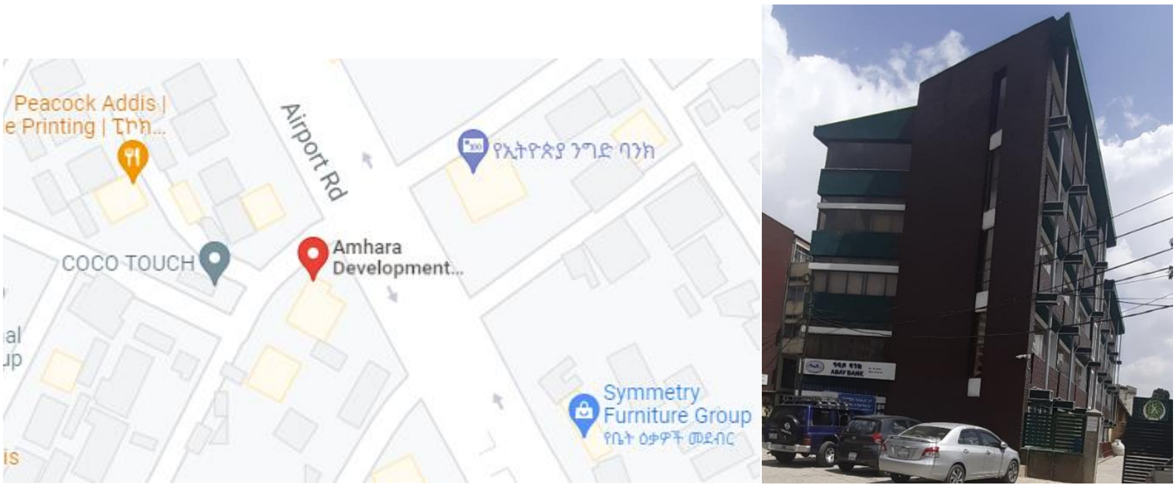


Figure 33: Location of Amhara development association building

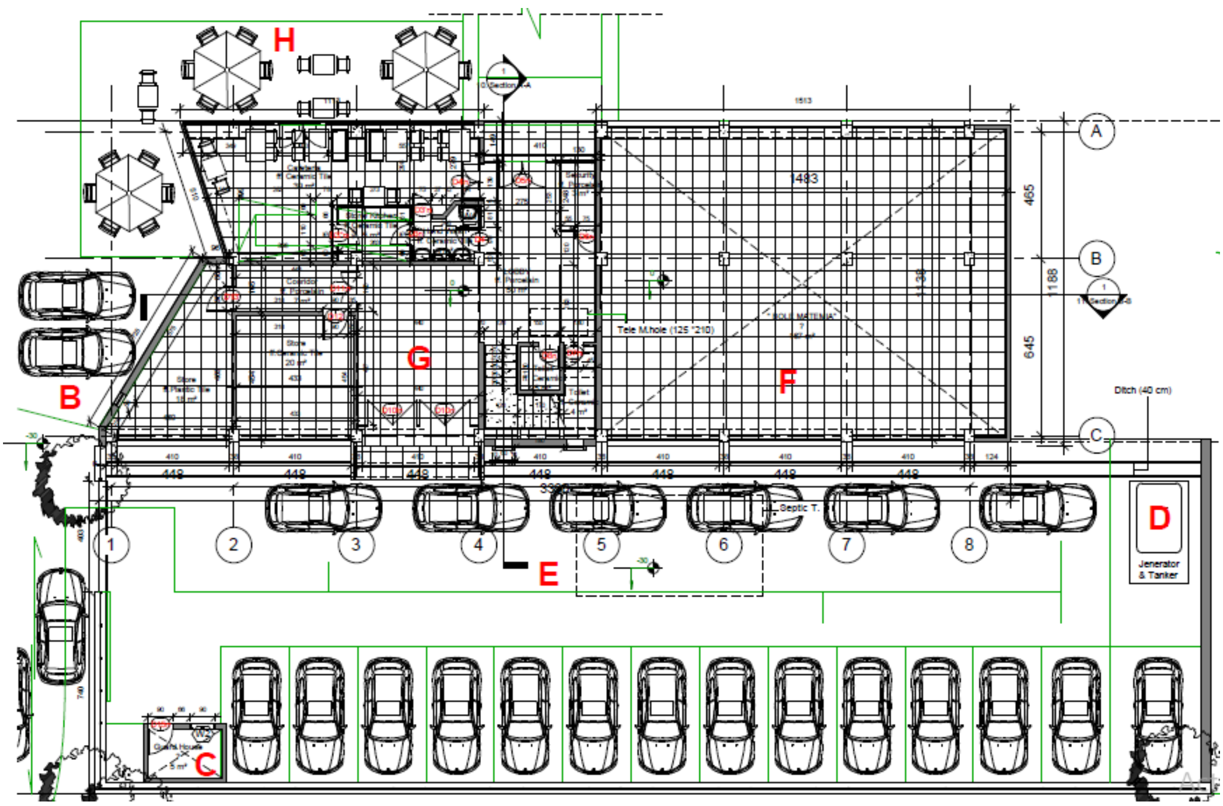


Figure 34: Amhara development association building Ground floor plan

The total plot area provided for the building is 852 m^2, from this area the building laid on the footprint area of 368 m^2. The building is 16m high. The total building have1609 m^2 surface area on its envelope. Only 523 m^2 surface area is considered as the potential envelope to integrate GBE. The larger window openings in the vertical building envelope, as well as the lack of balconies on envelopes, are regarded the main hurdles to integrating GBE, although the suspended beam has the potential to incorporate green components in the envelopes surface.

Table 18: Envelope surface area description of Amhara Development Association

Amhara Development Association	**Project plot size**	**Building footprint**	**Height of the building**	**Building envelope**	**Utilized envelope**	**Suitable envelope for greenery**
	852m^2	368 m^2	17.5 m	1609 m^2	12 m^2	928 m^2

Exterior envelope materials

The building structural material is concrete structure with the exterior finishing material of Brick wall. EGA sheet roof cover is used as the roofing material which is also considered as the challenge to integrate plants.

Table 19: Exterior envelope materials of Amhara development association

Amhara Development Association	Exterior envelope materials	
	Wall	**Roof**
	Brick	EGA sheet roof cover

4.2.9. Lion House No 01 (Anbesa building)

The building is situated alongside the major road. The building has a concrete flat roof suitable for incorporating GBE. There is enough bare concrete surface area on the building's façade to practice GBE. However, there is no space for flora or plantation on the ground surface. This project currently has a poor GBE practice.

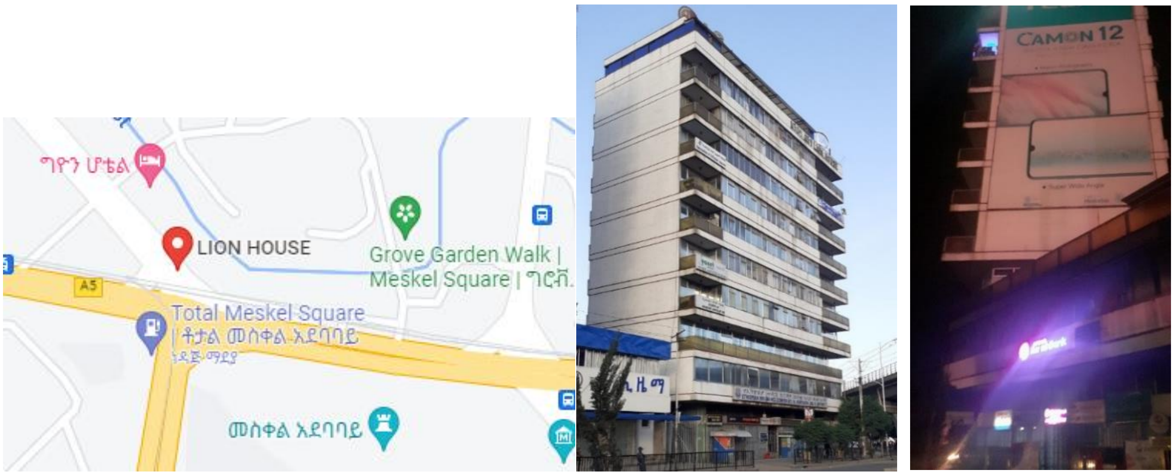


Figure 35: Location of Lion House NO. 1

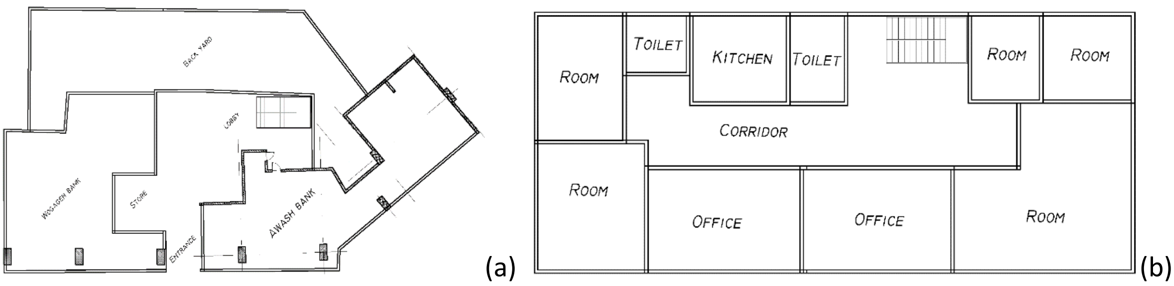


Figure 36: Lion House floor plans ((a) Ground and (b) Typical (First to Tenth))

The total project plot area is 780 m^2 and laid on the area of 599 m^2 footprint. The uppermost building height is 34m. The project total building envelope including roof is 6740 m^2. 575 m^2 of the total vertical surface is the potential surface on the envelope (bare wall and roof) to integrate GBE. There is no space provision on the ground level for green space. The glass surface in the façade system is the only challenge practice GBE in this structure.

Table 20: Envelope surface area description of Lion House No. 1

Lion House No. 1	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	780m^2	599 m^2	34 m	6740 m^2		955 m^2

Exterior envelope materials

The main building structural material used to construct this building is concrete structure. The exterior wall finishing material is plastered and painted HCB wall. Greenery has the ability to be integrated into the roofing material used for roof cover, which is concrete flat floor.

Table 21: Exterior envelope materials of Lion House No. 1

Lion House No. 1	Exterior envelope materials	
	Wall	Roof
	Concrete	Flat concrete roof

4.2.10. Baleker tower

It is a commercial building located near Gotera along a major route. The front façade of this structure is slightly inclined eastward. The building has a concrete flat roof that can accommodate GBE. There is enough bare concrete surface area on the building's façade for plants to be incorporated. However, the GBE practices in this building are deplorable.

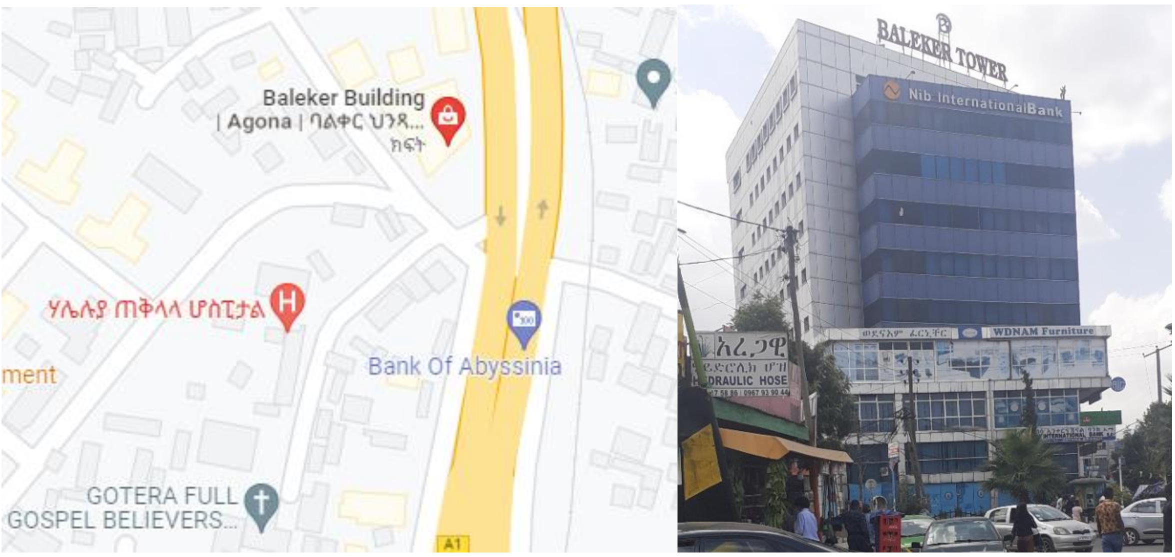


Figure 37: Location of Baleker tower

Project total area have in the ground for the building 1375 m^2. The building proposed on 940 m^2 total plot area. The building laid on 520 m^2 area and it has the 34m building height. The overall building exterior envelope is about 3625 m^2, of which 1256 m^2 is suitable for integrating greenery.

Table 22: Envelope surface area description of Baleker tower

Baleker tower	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	1375m^2	520 m^2	34 m	3625 m^2	8 m^2	1256 m^2

Exterior envelope materials

The main building structural material used to construct this building is concrete structure. The exterior finishing material is Aluminum glazing finishing on the HCB wall. The roof is constructed by flat concrete roofing materials which is considered as the potential to implement green roof.

Table 23: Exterior envelope materials of Baleker tower

Baleker tower	Exterior envelope materials	
	Wall	Roof
	Concrete and Aluminum cladding	Flat concrete roof

4.2.11. Ethiopian national electoral board building

The building is located on Bole Street, near the sub-road. The building was constructed with a brick wall and a flat concrete roof. Vertical structural elements are suited for incorporating GBE. In the facade system, there is a substantial amount of concrete bare surface envelope. The project compound has 122 m^2 of ground green space. The rest of the compound was paved. This project, however, has unsatisfactory GBE practice.

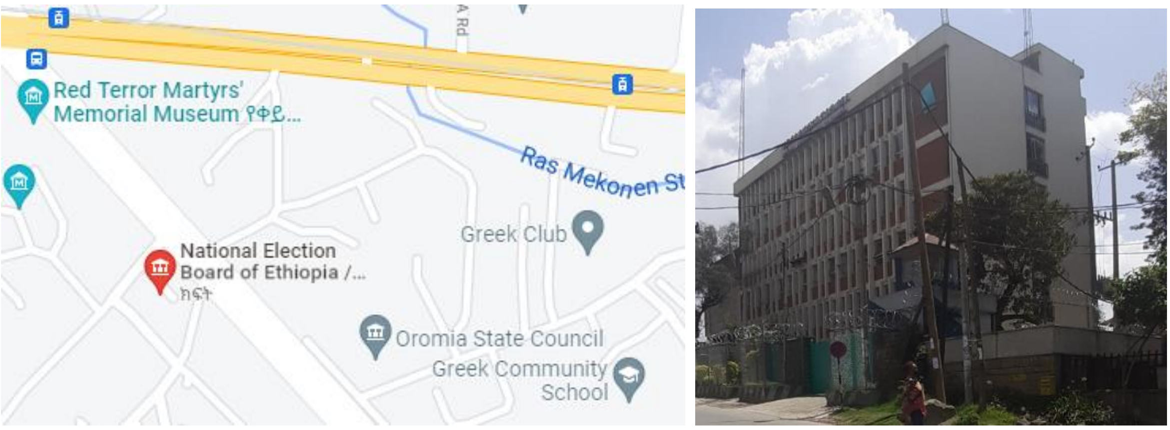


Figure 38: Location of Ethiopian national election board building

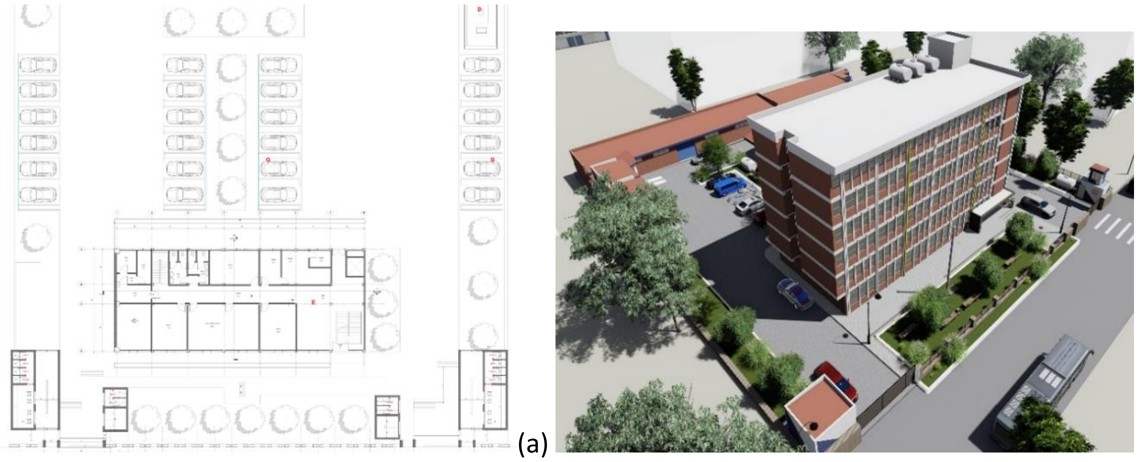


Figure 39: ENEB ((a) Ground Floor plan and (b) Areal view) (Source: ENEB, 2021)

Table 24: Envelope surface area description of Ethiopian National Election Board building

Ethiopian National Election Board	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	$3065m^2$	$390\ m^2$	19 m	$1583\ m^2$		$1098\ m^2$

Exterior envelope materials

Building structural material is concrete with the finishing material of Brick wall. There is a glass windows. The roofing material is concrete flat roof cover, which has the potential to integrate green roof.

Table 25: Exterior envelope materials of Ethiopian National Election Board

Ethiopian National Election Board	Exterior envelope materials	
	Wall	**Roof**
	Brick	Flat concrete roof

4.2.12. Ethiopian National Theater

The building is located on Churchill Street. The building was constructed with a concrete wall and a pinched EGA sheet roof.

Figure 40: Location of Ethiopian National Theater building

The majority of the building's façade system is covered by bare concrete walls that are appropriate for incorporating plants. False window apertures in the façade system maximize the exposed façade surface of the building, making it appropriate for GBE integration. The building currently has a poor track record with GBE practice. The height of the building was measured with a clinometer. The computed height is shown below (William Abney, 1880).

Angle θ is 43^0, Horizontal Distance is 14.5 and Vertical Distance is 1.10

$H = 1.10 + (14.5(\tan 40^0))$

Height is 13.3m

Table 26: Envelope surface area description of Ethiopian National Theater

Ethiopian National Theater	Project plot size	Building footprint	Height of the building	Building envelope	Utilized envelope	Suitable envelope for greenery
	$5113m^2$	$2500\ m^2$	13.3 m	$8430\ m^2$		$6640\ m^2$

Exterior envelope materials

The building's main structural material is concrete. The ground space in the project has 600 m^2 of green cover. The walls were finished with a plastered and painted HCB wall. This building's roofing material is EGA roof cover, which is regarded the main challenge in integrating plants onto the roof surface.

Table 27: Exterior envelope materials of Ethiopian National Theater

Ethiopian National Theater	**Exterior envelope materials**	
	Wall	**Roof**
	Concrete	EGA sheet roof cover

4.2.13. Summary of the assessed buildings

Building finishing materials, envelope surface area, apertures, integrated vegetation in the building, urban environment, function, and footprint were the criteria utilized to analyze the assessed buildings. The assessment of the selected buildings will be done concurrently along the comparison in this section. It will aid in understanding the character of buildings that affect GBE practice when assessing them. The finest and worst exemplary buildings will be described under each criterion.

Table 28: Summary of the envelope surface of the selected buildings

Name of the selected buildings	**Function**	**Project total plot area (m^2)**	**Building footprint (m^2)**	**Project total surface of building envelope (m^2)**	**Potential surface of the building envelope (m^2)**	**Building height (m)**
Hyatt regency	Hotel	11,000	8100	19000	12785	46.2
AUGH	Hotel	50,061	47,807	85700	14815	58
Sacuur Apartment	Apartment	2000	1440	10260	6620	49
Urael Apartment	Apartment	1248	808	6905	2228	36
Flamingo Apartment	Apartment	938	604	2919	1640	36
Gotera Condominium	Condominium	490	325	1525	1307	18
Awash bank	Office	2856	1961	13933	4091	60
ADA	Office	853	368	1609	928	16
Lion House 01	Office	780	599	6740	955	34
Baleker Tower	Mixed use	940(1375)	520	3625	1256	34
ENEB	Institute	3065	390	1583	1098	19
National Theater	Office	5113	2500	8430	6640	13.3

Table 29: Summery of Potential surface of the building envelope

Selected buildings	Total envelope (m^2)	Total envelope area (m^2)		Window (Glass) area (m^2)	Net surface area for greening (m^2)		Total Area (m^2)
		Wall	Roof		Wall	Roof	
Hyatt regency	19000	12706	3864	2430	10275	2510	12785
AUGH	85700	31386	7643	46671	10940	3875	14815
Sacuur Apartment	10260	6045	1170	3045	5635	985	6620
Urael Apartment	6905	4847	758	1300	1548	680	2228
Flamingo Apartment	2919	1800	520	599	1230	410	1640
Gotera Condominium	1525	1105	313	108	1045	262	1307
Awash bank	13933	4087	1778	8068	2641	1450	4091
ADA	1609	680	405	524	523	405	928
Lion House 01	6740	3374	441	2902	575	380	955
Baleker Tower	3625	1776	566	1283	776	480	1256
ENEB	1583	709	376	498	770	328	1098
National Theater	8430	5723	2501	206	4990	1650	6640

Hotel buildings

Hyatt regency and Africa union grand hotel (AUGH)

The EGA sheet roof cover and the window openings in the facade system are the main challenges in this building. The remaining envelope surfaces offer the opportunity to incorporate greenery within the building. Overhanging features in façade systems offer another opportunity to include greenery. This project is the best example of GBE practiced buildings in comparison.

The Africa Union Grand Hotel has a wide range glass surface of the façade system and the paved surface of the lower level roof for parking are the key challenges of this project to integrate plants. The Africa Union Grand Hotel is the only building with a footprint larger than the building envelope's potential surface area. The project has a total area of 85700 m^2 building envelope surfaces, of which 10940m^2 is potential envelope surface area suitable for

GBE integration. A suitable building envelope covers only 30% of its footprint. This project is the most deficient example of GBE practiced building.

Apartment (Condominium) buildings

Sacuur, Flintstone, Flamingo and Gotera condominium

Greenery integration in building envelopes is a comparable difficulty on apartment buildings. A variety of different sized window openings and the roofing system are among the challenges. Another difficulty in installing and maintaining the greenery in the building is collective ownership. They have varying levels of knowledge and interests in GBE. The volumetric pattern and introduced balconies in the façade systems are the common greenery integration potentials of these buildings. The area of suitable building envelopes to integrate greenery is larger than the area of the building footprint for the four apartment buildings.

Office buildings

Awash Bank Head office, Amhara Development Association (ADA) and Lion house

Similar issues exist for office buildings in terms of incorporating vegetation into the building envelopes. Some of the challenges include a number of glazed surfaces of the façade system and the roofing materials and function of the roofing system, as well as the fact that some office buildings used their roof for service areas. The shared potentials of these structures to integrate greenery include structural features in the façade systems and broader bare walls in the façade systems. The area of appropriate building envelopes to integrate greenery is larger than the area of the building footprint for the three office buildings.

Institute buildings

National theater, Ethiopian national election board (ENEB)

Similar issues exist on Institute buildings to incorporate greenery into the building envelopes. Window openings in ENEB and the National Theater's EGA sheet roofing system are two of the challenges. The shared potentials of these structures to integrate greenery are the structural features and patterns incorporated in the façade systems. The area of suitable building envelopes to integrate greenery is larger than the area of the construction footprint for these buildings.

Mixed use buildings

Baleker Tower

The challenges in incorporating greenery into the building envelopes in this project are a larger glazed surface of the façade system including windows and the roof used for service area. The volumetric pattern and the multi-level roof system are the building's common potentials for integrating flora. The area of suitable building envelope to integrate vegetation for this mixed-use structure is larger than the area of the project's footprint.

Materials and surface area of the building envelope

The exterior walls of the buildings were made from a diverse range of materials, including plastered and painted HCB walls, aluminum glazing, and other finishing materials. Except for the National Theater, every building has a window. Only the glass surface of the envelope portion making it difficult to integrate green components. The concrete bare surface of the building envelope is the potential surface of the building envelope. The most appropriate roofing material for incorporating greenery is concrete flat roof; most of the selected midrise buildings employed concrete flat roofs, however practically all of the selected buildings lack a service floor and use their flat roof as a service room. Surface area of glass surface and window openings, terraces, balconies, and other particular elements are also important factors to consider when implementing vegetation in a building.

Summary of the selected existed buildings in the study area

A total of 12 midrise buildings in the study area were surveyed, as detailed above. The buildings were chosen based on the previously established selection criteria, and their function and ownership are summarized in the graph shown below. Two hotel buildings, four residential apartment buildings, three office buildings, two institutional buildings, and one mixed-use structure were surveyed in total. In addition, they were built using a similar method. The standard building procedures were used. Only one hotel, the Hyatt Regency, practiced GBE in the project, out of the surveyed buildings. The remaining structures were not subjected to GBE. The survey of GBE practice in existing buildings encompasses a wide variety of potentials and challenges. According to the research, a minority of people accept and strengthen GBE practice in the study area; diverse challenges confront GBE integration in the building construction industry; GBE practice is subject to continuous development of new technologies, integrated management of the construction process, consistent standards, and GBE-friendly policies; however, the city ignores GBE development subjects. As a result, GBE development in the research area is hindered.

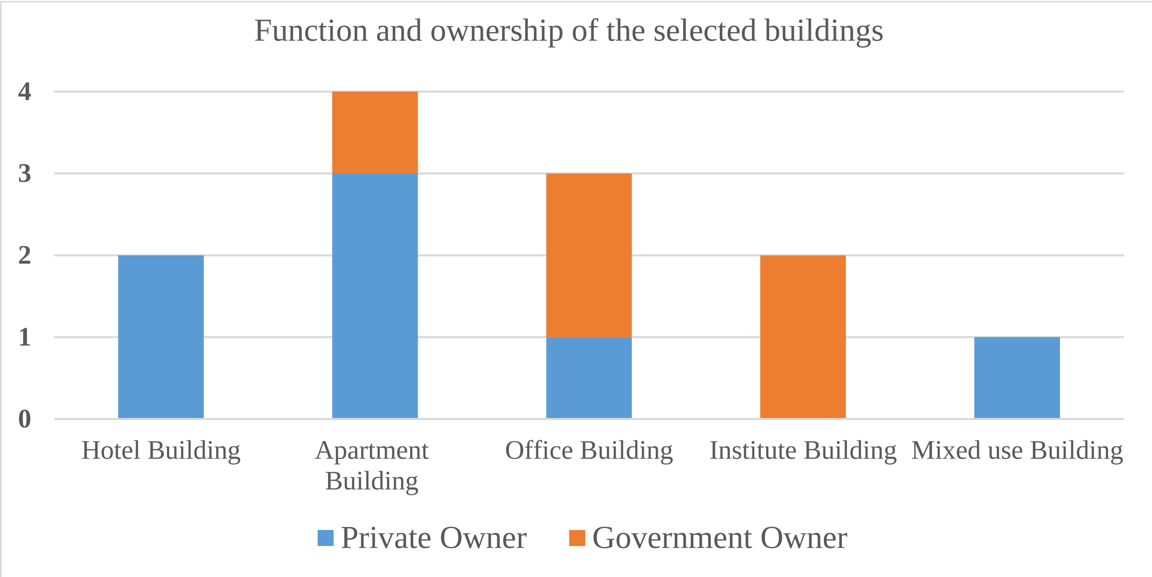


Figure 41: Summery of function and ownership of the selected building

Table 30: Summary of the potential and challenges of the practice

Potential	• The building envelope has a lot of bare surface. • The façade systems' with the structural elements and patterns. • The volumetric pattern and the inclusion of balconies in the façade system.
Challenges	• A larger glazed surface on the façade system. • The uses of a flat roof for service facilities. • Various window opening sizes, as well as roofing material and system. • It is also difficult to practice and encourage greenery in the building through collective ownership. • A diversity of knowledge and interests in GBE practice.

The finding from the surveyed buildings

According to the survey, the practical and spatial challenges make it difficult to incorporate vegetation into the building. A bigger surface of the façade system has an impact on practice by increasing the difficulty and requirement of technical knowledge to integrate greenery. There are also numerous opportunities to incorporate greenery into the building, which contributes to an improvement in GBE practice. The balcony space in the building, for example, encouraged people to incorporate greenery due to the ease with which the flower spot and other greenery components could be placed.

The study also discovered that raising public awareness of the practice had an impact on improving GBE practice by boosting knowledge about GBE practice beyond beautification. The community's perception of greenery in buildings is limited to beautification: this understanding has a direct impact on practice improvement. Beyond beauty, it is crucial to raise knowledge about the benefits of GBE practice in order to maintain the environment.

4.3. The factor that hiders the integration of green building envelope

4.3.1. Building regulation

According to the study, there is no specific building regulation in the study area that encourages the use of green building envelopes. However, based on the survey results (see Figure: 48 (a)), it can be inferred that special provisions in building regulations regarding green building envelopes are not one of the key impediments to individuals integrating green building envelopes. Based on the responses, it seems that 15% of respondents agreed and 30% strongly agreed that a special provision in building regulation about green building envelope is considered as requirement. To promote the practice of GBE, special care should be given to building regulations. Another struggle with the building regulation is its implementation and enforcement owing to construction and servicing periods.

4.3. 2. Cost of green building envelope

The study found that one of the challenges that prevents the implementation of green building envelope in the study area is the expensiveness of incorporating GBE. According to the information gathered from the respondents, one of the barriers preventing buildings from incorporating GBE is the greater cost of green installation. The government, on the other hand, should be aware of the problem and provide financial and technical assistance to building owners who want to use green building envelopes. Authorities can create a platform for building owners and developers to entice toward the incorporation of green building envelopes through such efforts. According to the research, as showed in Figure 42, 70% of respondents above agreed that cost is a hindrance in the adaptation of greenery into the building.

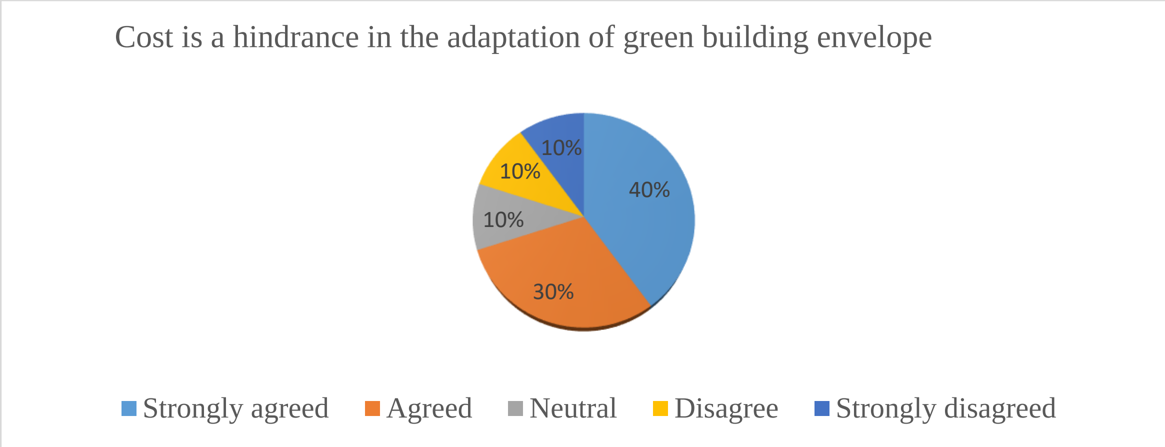


Figure 42: Cost is a hindrance in the adaptation of green building envelope

The collected data indicate that most of the respondents agreed with the cost of the technology was also the major hindrance to practice GBE. Some of the respondents replied their opinion to the hindrance of the GBE practice installation and maintenance cost. GBE costs of the technology are divided into two categories. There is an investment cost in the first phase, and there is also a maintenance cost in the second phase. As indicated in figure 43, 29% of those surveyed thought that the cost of technology is a key barrier to integrating greenery into buildings.

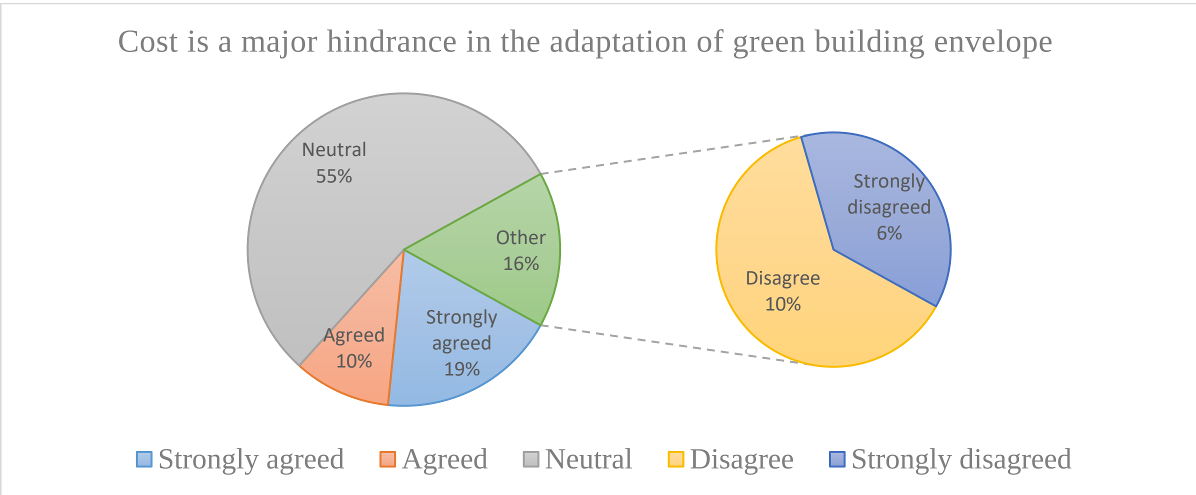


Figure 43: Cost of the technology is a major hindrance in the adaptation of GBE

4.3. 3. Poor awareness about green building envelope

The study found that a lack of community awareness regarding the practice of GBE is a hurdle that hinders the use of green building envelopes in the study area. According to the data acquired, roughly 30% of the respondents believe that their lack of awareness is a barrier to the practice of GBE.

4.3.4. Technical issues and need of special skill

According to the data acquired, technical issues and the necessity for special expertise are the issues for about 20 % of the respondents. Installation of GBE requires specialized skills, and technical concerns such as water supply, installation process, and maintenance are additional factors that obstruct the practice of GBE.

4.3.5. Appropriate space to integrate GBE

According to the data acquired, roughly 16 percent of respondents cited the appropriation of space in the building as a barrier to GBE practice. This identified that there is no space consideration on the envelope to integrate the GBE during the design and building stages.

4.3.6. Poor Government enforcement

According to the information received, there is no official promotion or enforcement of GBE. Around 1% of respondents said the government should promote and enforce GBE in the community. The government should play a bigger role in promoting GBE in the research area. The respondents from the community verified that the factor which affect the practice of GBE in their community. The factors that respondents perceived as difficulties to the practice of GBE in the community were sorted sequentially from major to minor challenges based on the community respondents assessed. The challenges to practice of GBE in the community were summarized in the table shown below.

Table 31: Challenges to practice of GBE in the community

Factors	Number of respondents' chosen			Number of respondents above agreed in percentage
	Agreed	**Strongly agreed**	**Above agreed from the total respondents**	
Awareness	17	38	55	**30.9%**
Investment and maintenance cost	7	35	42	**23.6%**
Need of special skill	30	2	32	**18%**
Need of proficiency Access appropriate space	21	8	29	**16.3%**
Regulation	11	1	12	**6.7**
Technical issues	5	0	5	**2.8%**
Less enforcement by the government.	2	0	2	**1.1%**
Water facility	1	0	1	**0.6%**
Environmental challenges	0	0	0	**0%**
Total	**94**	**84**	**178**	**100%**

4.4. The perception of the society to adopt green building envelope

A. Impact of practicing of green building envelope

Residents and building owners are polled on whether they believe that using a green building envelope improves quality of life by reducing urban green depletion. In this light, 48% of respondents strongly agreed and 32% agreed that adopting GBE promotes a healthy lifestyle because a lack of greenery has negative consequences. Total of 80% of the respondents believe GBE practices have a good impact on the built environment. Their perception extends beyond aesthetics.

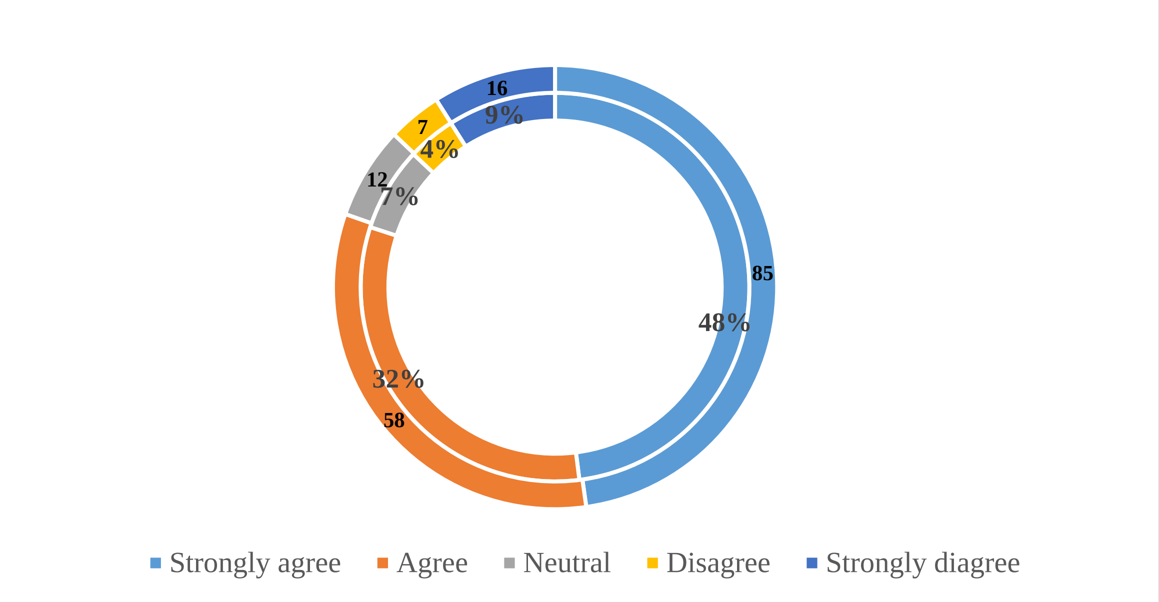


Figure 44: GBE practice improves our quality of life by reducing green depletion

B. The commonly practiced green building envelope in the community

Introducing spot flowers on the appropriate part of the buildings is one of the most regularly used GBE components in the research area. It covers approximately 70% of the entire practice. The second practiced GBE components on the study area are hanging garden, which accounts for around 17% of the overall practice. Green along the envelope (ivy) is another GBE component used in the study, accounting for approximately 8% of the overall practice. Vertical gardens, living walls, green roofs, and bio-shades were all used sparingly. 11 of the total respondents did not respond to the question on the most commonly utilized GBE components.

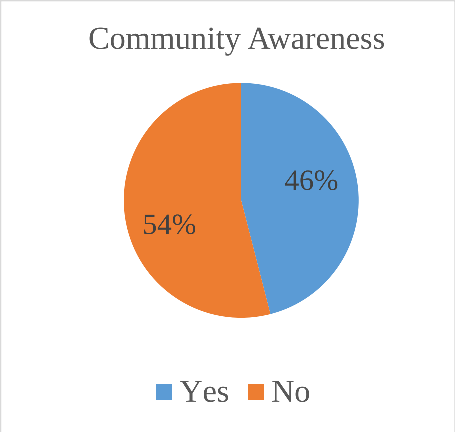
Table 32: Commonly used green building envelope components

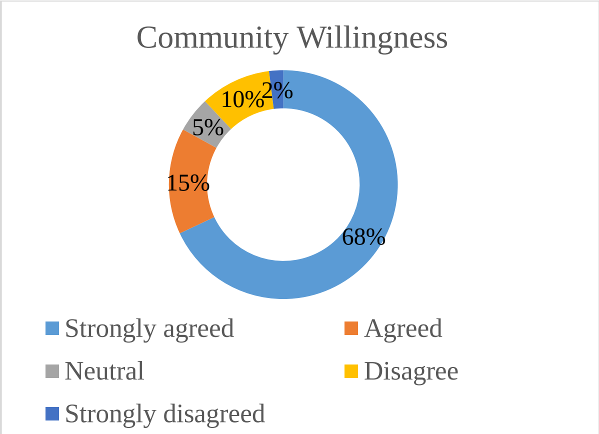
Common GBE practice	Number of respondents	Number of respondents in percentage
Vertical gardens (Living walls)	4	2.4%
Green roof	1	0.6%
Green along the envelope (ivy)	13	7.8%
Hanging garden	29	17.3 %
Bio-facades	0	0%
Bio-shades	0	0%
Flower pot	118	70.7%
Other	2	1.2%
Total	167	100%

C. Awareness and willingness

In order to improve the practice of GBE that responds to urban green depletion, it is important to consider the attitude of people in the research area about green building envelopes.

It also represents one's attitude, likes, intentions, and spatial choices. According to survey results, 54% of the respondents are aware of green building envelope at the building, while 46% are unaware, as shown in Figure 45 (a), yet, there is a clear need for improved advertising and promotional efforts promoting green building envelope installation and benefits. But 68% of the population strongly agreed and 15% agreed to practice green building envelope, as shown in Figure 45(b). Moreover, the analysis in Figure 46 insights that the local community and the government have to play its role through enforcing the law and providing subsidies for integration of green building envelopes.



(a)


(b)

Figure 45: Community ((a) Awareness and (b) Willingness)

The respondents' willingness was influenced by their knowledge of the practice. Respondents who are aware have a higher desire than those who are oblivious. This demonstrated that community awareness has an impact on people's perceptions of GBE and their willingness to implement it.

D. Role of the government on the practice of GBE

Integrating a green and natural atmosphere into the building envelope helps to improve the urban and building status of cities. As a result, respondents are being questioned if the government should promote the use of green building envelopes. In this regard, roughly 18 percent of individuals stated that the government should take such steps, as seen by the responses to the inclusion of a green building envelope in building regulations. In this regard, 50% of respondents strongly agreed, while 10% agreed with some of the suggestions as illustrated in figure 46.

The government was expected to promote GBE, according to the respondents. Approximately half of the respondents expected the government to be involved in GBE. Only 10% of respondents believed the government had no role to play in GBE practice in the community. About 12% of the respondents were neutral when it came to the government's participation in GBE. In general, most of the community believes that the government should be more involved in GBE practice. The government will play a role by providing the necessary resources.

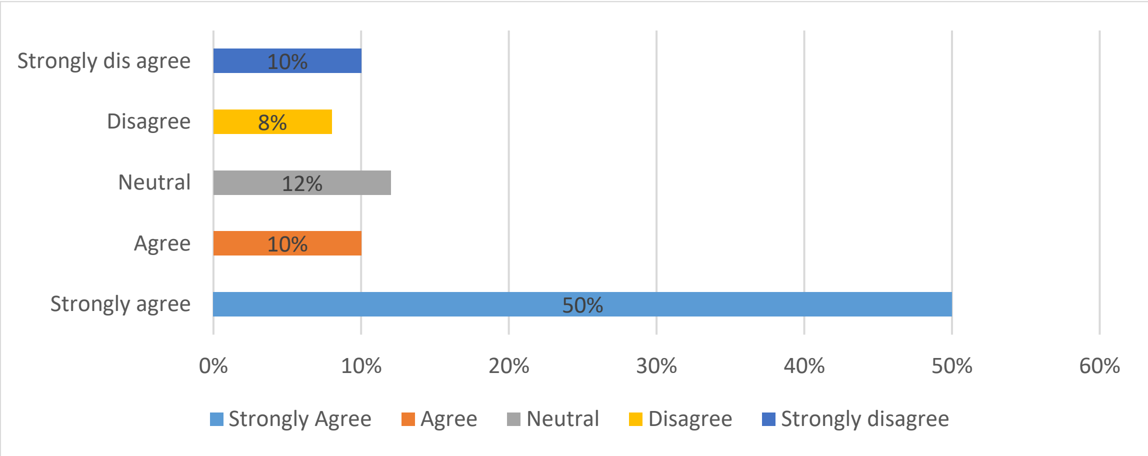


Figure 46: Role of the government on the practice of GBE

In the research area, there is no official promotion or appreciation for the installation of GBE. People, on the other hand, are eager to install GBE in their structures. They also expect the government to make some provisions, such as providing proper plantation, technical assistance, and so on. As a result, the government should encourage the installation of green building envelopes in order to improve environmental sustainability. In general, the government's participation in improving GBE practice is critical.

E. Awareness about Sustainable environment

The practice of green building envelopes is now widely believed to be utilized to reduce or eliminate issues such as the urban heat island effect, water runoff, and air and water pollution (Wong et al. 2003). People are more sensitive of the environment in recent years; yet, this awareness encourages them to incorporate green building envelopes.

According to the response of the respondents, with roughly 25% and 38% of respondents agreeing and strongly agreeing on it, respectively, as seen in Figure 47. The respondents' survey results on community awareness of sustainability were identified as the community is well aware of the environment and sustainability.

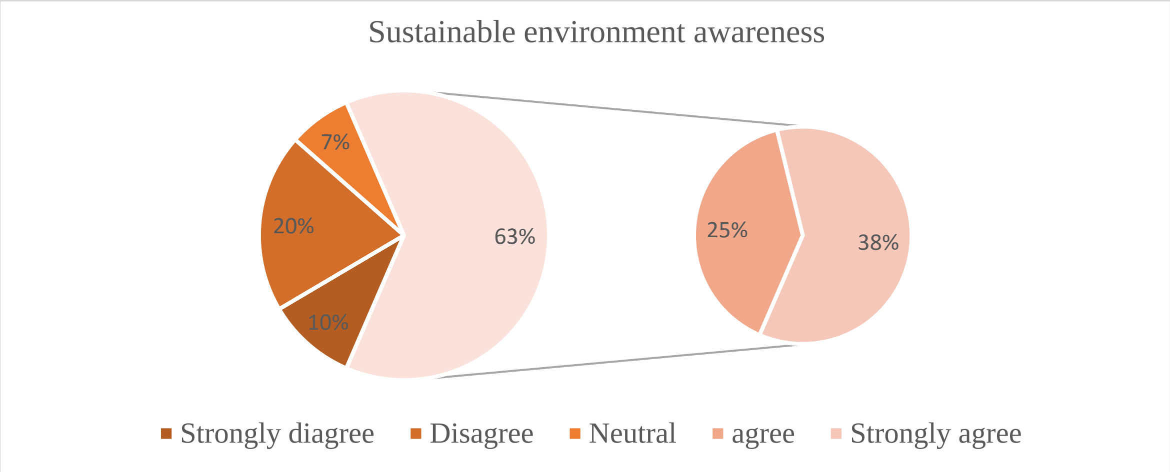
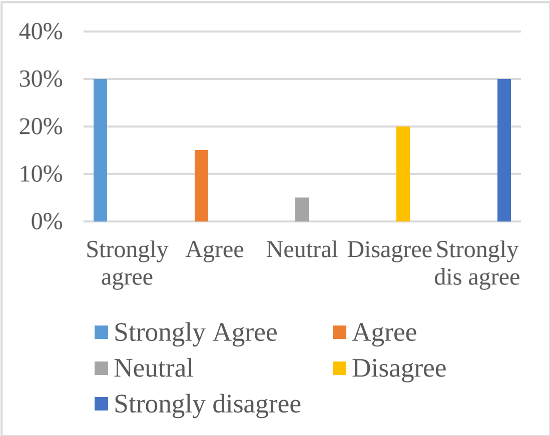


Figure 47: Sustainable environment awareness

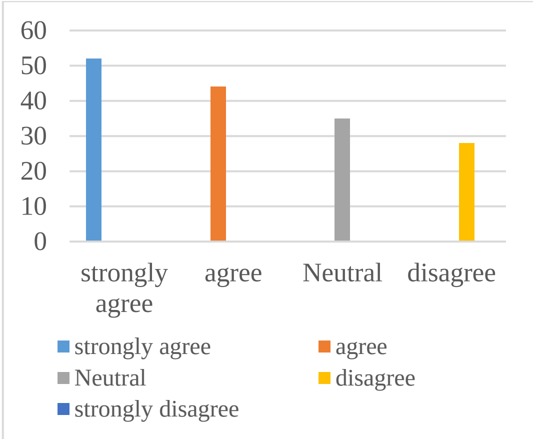
F. Special provision in building regulation about green building envelope

There is a building regulation stated on the building construction to be applied throughout the design approval process. The regulation command to provide 4 m^2 green cover per every 100 m^2 plot areas. But the gap on the implementation and enforcement due to construction and service period is another issue that hinder the practice of GBE. The responses of respondents to the regulation provision are summarized in the charts below.

According to the survey summary, 45% of all respondents agreed that the government should be in charge of implementing strong regulations to enhance GBE practice, as demonstrated in the figure 48 chart (a). As shown in the chart of figure 48(b), 96 respondents agreed that the government should do a better job of encouraging GBE practice and should build a free GBE practice facility.



(a)



(b)

Figure 48: Government provide ((a) strong regulations and (b) facility)

4.5. Discussion

Challenges and Potentials to incorporate greenery in the building

The study looked at the study area's difficulties and opportunities. The urban heat Iceland effect, which is a source of increased average yearly temperature and pollution in the city due to reduced greenery, has been recognized as an issue as a result of the data analysis. Despite the fact that a suitable roofing and wall system exists to integrate GBE, there is poor GBE practice in the area.

GBE promotes biodiversity (if the plants used are native or non-invasive), reduces the effects of rain spills from buildings, reduces air pollution, lowers the temperature of building walls and roofs, etc. It has many positive effects on the urban environment. Reduces the urban heat island effect. The plant's "evapotranspiration" (a mixture of water evaporation and water vapor release) contributes to the cooling of the building's integument and protects the building from direct sunlight. During the hot summer months, planting the integument of a building can significantly reduce the temperature of the integument of the building. On hot days, recent studies in Italy have shown that three different variations of these "living walls" can be 20 ° C lower than bare walls (Mazzali, U., Peron, F., et al. 2013).

The potential of greenery in the building shows how the existing built structure can be changed into a part of urban green by using the GBE components. This study demonstrated that there are two major opportunities for integrating GBE. The bare surface of the building envelopes is the first key potential for integrating greenery in the building, as is the community's desire and positive perception of GBE.

Contribution of implementing GBE

The use of GBE in the building has three major implications. These are to compensate for the depleted urban land (green space) taken to build the structure, the reduction of UHI and the utilization of storm water runoff. in Kirkos, there is only one building with correctly built green walls and roofs. On the balconies and roof terraces of the majority of the buildings, there are flower beds.

Green roofs, often known as rooftop gardens, are roofs that have been covered whole or partially with plants to give a range of benefits. Rooftop gardens are not only beautiful, but they are also good for the environment. In a conventional roofing system, green roofs were successful in decreasing high temperatures and diurnal temperature changes experienced by the roof membrane. (Karen Liu and Bas Baskaran, 2014).

Summary of the finding from the surveyed respondents

The GBE practice in Kirkos was evaluated in this study. The study's key findings are broken down into two groups. The practice of GBE is held in high regard in the society. The challenges and potentials with regarding to the willingness to practice GBE was also surveyed, and the community expressed their willingness to do so. The majority of people agreed that GBE improves our quality of life by reducing environmental depletion. According to the data gathered and reviewed, the main challenges are limited awareness and the high cost of GBE practice. So that a greater awareness of the environment's sustainability leads to the incorporation of GBE.

The community is keen to put the commonly used GBE components into effect on their buildings. The purpose of the study was to determine their willingness to use alternate design approaches to practice GBE. If no special skills are required, the responses are also willing. The summary of the survey results from the respondents indicated that, the government should be in charge of developing strong regulations to improve GBE practice. The government also needs to do a better job of promoting GBE practice and should establish a free GBE practice facility. In general, the government's participation in improving GBE practice is critical.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

The city of Addis Ababa's green surface has been diminished as a result of urbanization and other urban infrastructure improvements. However, by enhancing the utilization of horizontal and vertical surfaces of structures to integrate greenery, these issues can be addressed. Only the Hyatt Regency had a good practice of greenery on its envelope, while most buildings have some flower pots on their top terraces and balconies. The green surface of the selected sub city is dominated by grey infrastructures, and the research analyzed the sub city's practice of greenery on buildings. The findings revealed that incorporating greenery on buildings helped to protect the environment and solve urban green depletion. The natural service of green given by placing plants on the building envelopes has increased as a result of the elimination of artificial concrete and gray surroundings.

5.1. Conclusion

Lack of a national and local policy framework that encourages the installation of greenery on the building envelopes; lack of a common standard for GBE; cost of installations and maintenance issues; lack of expertise and skills; structural issues; and leakage and damage to the building envelope are all perceived barriers to practice GBE implementation in the sub city. However, when it comes to maintenance difficulties, GBE can really be advantageous rather than a problem.

In the study area most of the land surface is covered by grey infrastructures and the research has evaluated the suitable green building envelope compared with their building footprint. Almost all of the selected buildings have suitable to integrate GBE more than their built up footprint. As the study identified the community have good perception about urban green and GB. 74% of the respondent considered GBE as the beatification tool. The remaining 26% of the respondents have the idea of GBE to safeguard the environment.

GBE practice on the sub city summarized as follows. The majority of the selected buildings have the potential to incorporate greenery. However, practicing GBE is challenged by a lack of advanced expertise and training in related institutions, as well as a lack of community awareness, poor government enforcement of GBE practices, higher technology costs, lack of legal framework for contracting and related processes, and unclear long-term effects and risks.

According to the study, communities' willingness and attitudes are mainly based on their knowledge of GBE. In the community, there is a lack of understanding of GBE. They are, nonetheless, willing to practice GBE for aesthetic purposes and have a favorable attitude towards it. All professionals and other stakeholders have a positive impression of GBE and are willing to incorporate it into existing and new structures.

5.2. Recommendations

- The office of urban greenery and beautification bureau should raise awareness in order to change the public's perception of GBE.
- Compelling building owner to be willing and giving the importance of the practice of the GBE, as well as the designer's inclusion of detail drawings and specifications documents during the design stage.
- The building owner suggested to practice GBE to save the energy.
- GBE recommended to be implemented, monitored, and considered as an element of design and construction in the city's building sector.
- Establishing and investing in research work on energy and resource utilization in the city to adapt technology advancement on the existing building towards the practice of GBE.
- The municipality should enact legislation and specific regulations requiring the use of GBE in combination with architectural design and construction, which should be strictly enforced.
- GBE should be included in the building construction permission process by the municipality.
- Ministry of construction need to set standards for design and construction to professionals as well as for the construction crew.
- Urban farmers advocate that urban farming be done within the building envelope.
- The supplier recommended to provide a plantation and water facility with a least price to assist the client in improving their GBE practice.
- The architects should conduct research and follow a systematic strategy to improve the practice.
- The contractors demonstrate exemplary projects to boost society's desire to GBE and its favorable perception of it.
- Maintenance technician should provide a guideline to preserve the incorporated GBE.
- Higher education institution should research and experiment on practical. Although provide prototypes and domestic skills/ GBE knowledge for the construction industries.

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APPENDIX

Structured Questionnaire

1. Survey questionnaire for local community

Questionnaire for the local community

Questioner _____

I am a master’s student in environmental architecture program at Adama science and technology university School of Civil Engineering and Architecture, Department of Architecture. It aims to collect information related to the challenges and opportunities of greenery integration on buildings of Addis Ababa city. The information given in this questioner is for academic purpose only and will be treated as very confidential. Any form of support is greatly appreciated.

I am undertaking a research entitled ‘‘The Challenges and Opportunities of Greenery Integration on Buildings of Addis Ababa City’’. The study aims to examine the challenges and opportunities of greenery integration on buildings and study the overall practice of greenery on the building envelope. I would like to thank you for your information and data provision.

Instruction

Fill your answer on space provided or Please put (X) on the box for the answers you choose.

1. Personal Information

   Education Level a. Degree and above b. Diploma level

   c. High school d. Elementary school level

2. What position do you have in this Place?

   (a) Property (building) owner, (b) shop keeper, (c) Permanent resident,

   (d) Office worker, (e) user (f) other

3. How many years have you held this position?

   (a) Aged b/n 1-5 (b) Aged b/n 6 - 15 (c) Aged above 16

4. Is there enough green cover in your neighborhood? A, Yes [ ] b, No [ ]

5. If you answer for Q4 is no, what are the main reason for the green depletion?

a, scarcity of urban land b, lack of knowledge

c, government attention for greenery d, other specify ________________

6. Is there any practice of greenery or plantation in your community to compensate the depleted green cover? Yes [ ] (Specify) ________________

No [ ]

7. Do you have the understanding of green building envelope (Green wall and roof in the building) in the Environment? a. Yes [ ] b. No [ ]

8. Is there any practice of green building envelope in your neighborhood at your residential or working area? a. Yes [ ] b. No [ ]

8.1. If your answer to question is yes, what kind of green building envelope is it?

a. Vertical gardens (Living walls) [ ] b. Green roof [ ] c. Green along the envelope (ivy) [ ] d. Hanging garden [ ] e. Bio-facades [ ] f. Bio-shades [ ] g. Others (Specify) __________________

8.2. If your answer to question is No, what do you think is the reason?

a. Lack of knowledge about GBE [ ] b. need of special skill [ ] c. Lack of appropriate space design to integrate GBE [ ]
d. high investment and maintenance cost [ ] e. environmental challenges [ ] f. no forcing regulation to integrate GBE g. Lack of greenery affects quality of life
h. Others (Specify) _____

8.3. What do you suggest to improve the practice of GBE?

a. Creating awareness about GBE [ ] b. provide appropriate space to integrate GBE at the design stage [ ] c. Government shall subsidize [ ]

d. Government shall develop forcing regulation to integrate GBE
e. Others (Specify) __________

9. How willing you are to practice green building in the building (your building)?

a. Strongly appreciates b. Appreciates c. Neutral

d. Depreciates e. Strongly depreciates

10. Do you have garden or green component in your building or house as a building envelope?

a) Yes, (Specify) _________________

b) No, I don't have.

11. Which GBE component is the most used by builder (building owner)?

a. Green along the wall (liana) [ ] b. Spot flower [ ] c. Roof grass [ ]

d. Others (Specify) ________________

12. What are the purposes using GBE in your building?

a. Physical beauty [ ] b. Thermal comfort [ ] c. Shading the wall [ ]

d. Gardening [ ] e. For Vegetation f. Other (specify) _____________

13. How long does it takes to install green building envelope?

a. less than 3 months [ ] b. between 4 to 6 months [ ]

c. between 7 to 12 months [ ] d. More than one year [ ]

14. Are there any problems associated with using green building envelope in your building?

A. Yes [ ] _____________________ B. No [ ]

15. If your answer to No. 15 is yes, what are the problems? (Specify) ____

16. What are the factors that hiders you from practicing green building envelops? ____

17. Is there any advantage of using green building envelope to lessen green depletion or upsurge the urban green space?

____

18. Is there any disadvantage of using green building envelope to lessen green depletion or upsurge the urban green space?

____

19. Please give your general comments on how to improve our practice of using green building envelope?

____

_

2. Survey questionnaire for professionals

This questionnaire is prepared by a Master's student in Adama Science and Technology University, School of Civil Engineering and Architecture, Department of Architecture and urban planning in environmental architecture program. The study aims to assess the the overall practice, application, challenges and opportunities of greenery integration on buildings of Addis Ababa City. I would like to thank you for your information and data provision.

Name of Company: ____

Respondent's profession/Job title: ________________________________

Professional Experience

a. Below 5yrs b. 6 – 10yrs c. 11 – 15yrs d. 16 – 20yrs e. Over 20yrs

1. How familiar are you with the concept 'green building envelope and design'?

   A-Not familiar at all B. Familiar C. Completely familiar

2. What is your understanding of the term green building envelope and green building design? Please indicate the most important features of green building envelope.

   ____

3. Have your company ever been used a green building envelope in the project?

   □ Yes □ No □ I'm not sure

4. If yes, please provide some detail of the most recent such type of GBE.

   a. Green roof b. Green wall (vertical greenery) c. Both
   d. other (please specify) ____

5. Do you think that practicing of GBE has the benefits to respond the environmental challenges? □ Yes □ No □ I'm not sure

If yes how? ____.

6. Do you think that the practices of GBE have an advantage? □ Yes □ No □ I'm not sure

If yes please list the advantages ____

7. Do you think using of GBE have a disadvantage? □ Yes □ No □ I'm not sure

If yes please list out the disadvantage ______________________________
____

8. Is there any difficulty on practicing GBE in Addis Ababa buildings?

□ Yes □ No □ I'm not sure

If yes, why? ____

9. Is there is any other special need of material or techniques to use GBE in Addis Ababa buildings? □ Yes □ No □ I'm not sure

If Yes (please specify) ____
____

10. Which aspects of a green building envelope will be environmentally and aesthetically acceptable in your experience in our context?

a. Green roof b. Green wall (vertical greenery) c. Both
d. other (please specify) ____

11. As a professional rate the following statements, on a scale of 1 to 5, according to the best of your knowledge.

1. Fully agree 2. Agree 3. Neutral 4. Disagree 5. Fully disagree

No		Rate
1	I usually recommend to my clients to incorporate green building envelope in their designs?	
2	Recently there has been more interest in green building envelope by your clients.	
3	Information and training about green building envelope is available to all stakeholders.	
4	There is an interest in green building envelope by building practitioners (e.g. town planners, builders, etc.)	
5	I mostly recommend that green building envelope are used in the walls and roofs of buildings	
6	Practicing green building envelope in the existing and new buildings will enhance better environment.	

12. What are the challenges or opportunities present for applying the of Green Building envelope in Addis Ababa buildings? ____

13. Do you think professionals' in your company are adequately qualified to integrate green building envelope in designing and construction level?

□ Yes □ No □ I'm not sure

14. Which of the following approaches do you think would promote Green Building envelope concepts in existing and new Buildings in Addis Ababa?

a. Vertical gardens (Living walls) [ ] b. Green roof [ ]
c. Green along the envelope (ivy) [ ] d. Hanging garden [ ] e. Bio-facades [ ] f. Bio-shades [ ] g. Others (Specify) ________________ ________________

15. Use a 5-point scale to Rank the strategies to be implemented, where 1 is the lowest and 5 the highest Rank on the box provided.

- Education and training focusing on green building envelopes [ ]
- Improved enforcement by local governments [ ]
- Public Awareness and campaign [ ]
- Promoting Green building envelope [ ]
- Establishing a green building rating system [ ]

- Other strategies to be implement ________________________

16. In your opinion, what can to be done to upsurge the idea of integrating green building envelope in the building in Addis Ababa?

____

3. Interview with building owner or manager

1. Do you have any idea about GBE? Yes [ ] No [ ]

2. Do you have experience of using GBE on your building? Yes [ ] No [ ]

3. Is there green components or garden in your building? Yes [ ] No [ ]

4. If your answers for question 3 is yes, what is the main reason to use or not to use green building envelope for your building? __________________________

5. Is there any complexity in the application of GBE?

Yes [ ] (Specify) _________________________ No [ ]

6. How much time do you spend to install and conserve the greenery in your building (if any)?

7. What type of material is used for the exterior and interior of the building envelope for greenery?

8. What kind of benefits do you observed by using GBE.

9. Does the cost of integrating GBE strongly affect the practice of GBE in the sub city?

Yes [ ] (How?) _________________________ No [ ]

4. Interview questions for professionals

1. What are the main gaps and limitations to practice green building envelope?
2. To what possible extent are the green building envelope can be practiced?
3. What do you think are the main barriers to adopt green building envelope in the existing and new possible buildings?
4. What are the factors that affect the practice of Greenery on buildings?

5. Are there adequate legal and instructional frameworks that promote to use green building envelope?

7. Do you expect the awareness promote green building envelope?

8. Is there any benefits of using GBE?

9. Which of the following approaches do you think would promote Green Building envelope concepts in existing and new Buildings?

   - Use a 5-point scale to Rank the strategies where 1 is the lowest and 5 the highest Rank on the box provided.
   - Education and training focusing on green building envelopes [ ]
   - Improved enforcement by local governments [ ]
   - Public Awareness and campaign [ ]
   - Promoting Green building envelope [ ]
   - Establishing a green building rating system [ ]

5. Checklist for physical review of the selected buildings

- Building function (office, commercial, residential, institute and other).
- Assessment of the area of land needed to build.
- How much potential envelope the building has to integrate GBE (green wall and roof)?
- Assessing the building envelope and identifying the potential wall and roof surfaces to install greenery on the building.
- A comparison of benefit between a green building envelope (Green wall and roof) and a conventional building envelope (wall and roof) based on the following point of view: -

  Temperature mitigation, Urban Heat Island Mitigation, Air Quality, Energy Conservation, Vegetation or Green Space (Replaces green spaces lost to due to the building footprint), Other (Buffers noise, alternative aesthetic, offers passive recreation) Total Costs and Durability.