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Green Building Concepts and Technologies in Ethiopia: The Case of Wegagen Bank Headquarters Building

Eshetu Gelan

Department of Architecture, School of Civil Engineering and Architecture, Adama Science and Technology University (ASTU), Adama P.O. Box 1888, Ethiopia; eshetu.tgelan@gmail.com

Abstract: The building sector is a key contributor to climate change, accounting for 40% of global energy consumption and 39% of CO_2 emissions. Presently, green buildings have been viewed as crucial strategies to reduce the negative effects of the construction sector. Yet green building research is often carried out in developed countries, while relatively little is known in sub-Saharan African countries. Therefore, this study attempts to investigate the extent of adoption of green building concepts and technologies in Ethiopian buildings, with particular reference to the Wegagen Bank Headquarters building. The study employed an interview, which was underpinned by observation. The quantitative data were analyzed through descriptive statistics while the qualitative data were analyzed through content and context analysis. Results revealed that while the building provides convenient access to transportation; it lacks designated open spaces. Based on the findings, the widely used technologies were energy-saving lighting, highly efficient plumbing fixtures, and external solar shading system. Lack of awareness, lack of policy, insufficient professional skills, the perception that green buildings are expensive, and lack of green building materials hindered the adoption of the concepts. Therefore, the study suggests developing green building policy and rating systems, professional capacity building, and awareness creation as important measures.

Keywords: Ethiopia; Wegagen Bank; green building; energy efficiency; sustainable site

Citation: Gelan, E. Green Building Concepts and Technologies in Ethiopia: The Case of Wegagen Bank Headquarters Building. *Technologies* **2023**, *11*, 2. https://doi.org/10.3390/technologies11010002

Academic Editor: Jung-heum Yeon

Received: 30 October 2022
Revised: 23 November 2022
Accepted: 10 December 2022
Published: 21 December 2022

1. Introduction

The United Nation report indicates that, the world will continue to urbanize over the next three decades, increasing from 56% in 2021 to 68% in 2050 [1]. This increasing population coupled with rapid urbanization globally increases the demand for housing, resulting in enormous investments in the construction of new housing and infrastructure [2].

The building industry has a substantial impact on the use of land, the consumption of resources, the quality of the indoor environment, and natural and social settings [3]. By its very nature, the construction process has a negative impact on the environment, from the material supply to the resources used during construction to the aftereffects on the ecosystem [4].

The construction industry is responsible for 39% of the world's greenhouse gas emissions, with 44% of those emissions coming from residential buildings, 28% from non-residential buildings, and 28% from other projects [5]. For example, according to the UK Green Building Council, buildings contributed about 50% of the UK's CO_2 emissions and another 7% due to new building construction [6]. Apart from global greenhouse gas emissions, the energy consumption of residential and non-residential buildings accounts for up to 30%, and the building construction industry represents 35% of global energy use as of 2019 [7]. For instance, the EU's buildings account for over 40% of the region's overall energy consumption and 36% of its greenhouse gas emissions [8]. Africa's overall national power usage is anticipated to be 56% of the energy utilized in buildings [9].

Besides, up to 40% of raw materials extracted from the lithosphere [10] and approximately 16% of the total water are consumed by the construction sector [11]. For instance,

in the US, 40% of the minerals that are extracted are used in the production of building materials and the construction process itself [12]. Not only consuming, the building sector is also responsible for 25% of the solid waste generated worldwide [13]; in developing nations such as Brazil, this percentage can be even higher at over 60% [14]. According to Nowak et al. [15], in the European Union countries, the construction industry generates a substantial amount of the total waste output resulting in between two and five times the quantities of household waste.

The occupants of the buildings are also harmed by the construction industry [16]. For instance, building owners are exposed to indoor air quality settings that impact people's health, safety, welfare, and performance through their interiors [17]. Moreover, the thermal discomfort that building inhabitants endure throughout the hot season results in worsened physical and emotional health, including heart disease, insomnia, headaches, lethargy, boredom, and low arousal [18].

The aforementioned effects have led to the advocacy of a number of appropriate strategies during the last ten years to minimize or mitigate the effects. Adopting green building principles and technologies is considered as one of the appropriate measures for the majority of the aforementioned negative consequences [19] and it has been touted as the surest way to address the challenges posed by buildings on the environment and way of life [20].

According to researches, green building is a technique that makes use of designs and materials to better utilize natural resources, improve indoor air quality, increase the productivity and well-being of building occupants, and reduce waste, emissions, and environmental deterioration [21–23]. Additionally, according to Khoshnava et al. [24], the concept helps to reduce the consumption of energy, water, and recycled or even recyclable non-toxic materials with low toxic emissions.

Studies revealed that by using bio-climatic design techniques and efficient building materials and construction methods, green buildings maximize the utilization of on-site sources and sinks [25,26]. Besides that, it maximizes the use of renewable energy sources [27], uses effective waste and water management practices [28], uses minimal energy to power itself, and uses efficient equipment to meet its lighting, air conditioning, and other needs [26].

Nowadays, many countries around the world have adopted the principles and technologies of green building. This is evident in many European countries, America, and Australia. Asian countries such as Singapore, China, and Japan also use environmentally friendly techniques and technologies in the design and construction of the built environment [29]. Nearly every nation in Europe, the United States, Canada, Australia, Japan, Hong Kong, and South Africa currently has its own green building rating system or tool [30]. The Building Environment Establishment Assessment Method (BREEAM) was the first established green building rating system by the UK in 1990, followed by the Building Environmental Assessment Method (BEAM) in Hong Kong, Ecology, Energy Saving, Waste Reduction, Health (EEWH) in Taiwan, Leadership in Energy and Environmental Design (LEED) in the USA, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, Green Mark (GM) in Singapore, and Evaluation Standard for Green Building (ESGB) in China [31,32].

Green building rating systems, in accordance with Florez [33], are techniques used to certify green buildings and serve as a means of minimizing construction impacts throughout the whole life cycle. It could be used as a manual or guideline for methodically organizing building design, construction, operation, and maintenance in addition to serving the primary purpose of certification [34].

Besides, several initiatives are being employed by numerous governments in the industrialized countries to promote the use of green building concepts and technologies [35]. Incentives such as mortgage loans and discount loans have been designed by governments in the US, UK, and Canada to encourage the adoption of green elements and technologies [36].

The construction industry in developing countries is not adopting green building techniques and technologies at the same rate as those in developed countries, despite the fact that there are strong reasons to do so [37]. In developing countries, the construction sector still mostly uses cement, sand, coarse aggregates, hollow concrete blocks, and reinforcement bars as the primary building materials for conventional buildings which are not eco-friendly [38].

Although adopting green building practices and technologies has many advantages, Ethiopian developers and professionals in the construction sector have not been adopting the concepts at the rate that one may have anticipated. The practice of building construction in Ethiopia in general, and in the city of Addis Ababa in particular, just as in any other African city, disregards the numerous solutions of green building practices that have been researched and used in the majority of developed countries. Most buildings in Addis Ababa have glass facades, which increase energy consumption, create glare, and cause overheating [39]. Additionally, the majority of buildings use low-albedo building materials, which directly increase heat gain through a building's envelope and resulting high cooling energy use [40].

Few buildings in Ethiopia adopt green building concepts and are certified by international organizations. HoA-REC&N's headquarters building, CBE's New Head Quarter Building Project and the U.S. Department of State Office are the only Ethiopian buildings that received the LEED certification award by satisfying different requirements of LEED criteria [41]. However, the construction of high-rise buildings has continued to grow within Ethiopia and unless appropriate measures are put into place, development of unsustainable buildings will not stop [42]. This paper therefore aims at addressing the underlying challenges that hindered the adoption of green building concepts and technologies in Ethiopian buildings by assessing the extent of adoption.

While green building concepts and technologies have received sufficient research and literature in developed countries [43–46], little has been done and the notion is still novel in developing and least-developed nations such as Ethiopia [19–38]. For instance, in Ethiopia, only one study was conducted by Anshebo et al. [47], focusing on identifying the most relevant green building assessment tools for Ethiopian buildings. The study conducted by Anshebo et al. [47] did not focus on the extent of the adoption of the green building concepts and their challenges. However, identifying the level of the adoption of the green building concepts and technologies is important to develop strategies that enhance their adoption [48].

It is evident therefore that there is no research that attempted to investigate adoption of green building concepts and technology in Ethiopia. There is a clear knowledge gap in this area, and the need for answers to this question is one of the many motivations directing this research. In order to fill this gap, the present study seeks to investigate the extent of the adoption of green building concepts and technology in Ethiopian buildings, with particular reference to the Wegagen Bank Headquarters building in Addis Ababa. It also aims to identify perceived adoption and implementation bottlenecks with the intention of developing recommendations that aimed at enhancing adoption.

2. Materials and Methods

2.1. Study Area

The financial buildings found in the Addis Ababa city have been chosen as case study buildings. The adoption of green building principles and technologies are key strategies that enhance the productivity of building occupants, which is the primary reason why this study's focus was on financial buildings. Financial institutions found in Ethiopia typically require productive manpower to compete in financial markets. Addis Ababa was selected due to its status as Ethiopia's capital city and as a major hub for the construction industry, especially modern high-rise financial buildings. According to the city's structural plan, the main center of Kirkos sub-city has been zoned for financial institution headquarter buildings and associated facilities. In this sub-city there are different high-rise financial buildings

including Awash, Abyssinia, United, NIB, and Wegagen Bank Headquarters building and of these buildings, Wegagen Bank Headquarters building was selected purposively for this study (Figure 1).

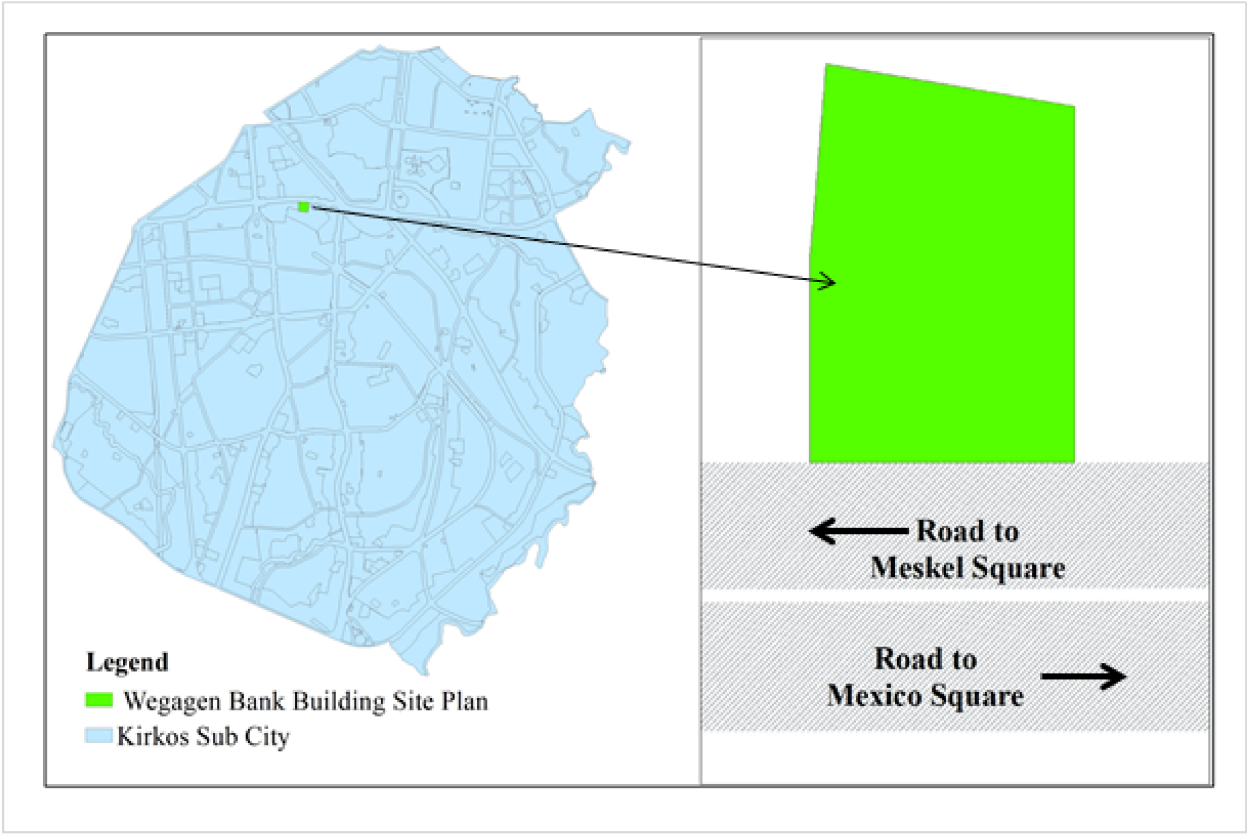

Figure 1. Map of the study area.

The following factors were taken into consideration when choosing the case study building. The first major criterion is that the buildings chosen for this study should be high-rise financial buildings situated in areas designated for financial institutions according to the structural plan. Buildings that were constructed with environmentally friendly materials meet the second criterion. Buildings that aspired to obtain green building certification from international organizations make up the third criterion. Hence, based on the aforementioned factors, the Wegagen Bank Headquarters building was purposively selected from the high-rise buildings located in the area delineated as the financial zone.

Wegagen Bank SC was established on the 11th of June 1997 with initial paid-in capital of 30 million ETB. The Wegagen 23-story Headquarters building construction was completed in 2017 and aimed to achieve LEED-CS silver status. The headquarter is 107 m high and covers 1800 square meters in Ras Mekonnen Street near the Addis Ababa National Stadium.

2.2. Methods

Data were collected from both primary and secondary sources. Primary data were collected from key informant interview and inspection checklists. Semi structured interviews were conducted with 15 purposively selected experts, researchers, policy makers, engineers, architects, and consultants from consulting companies participating in design, supervision, and construction of the Wegagen Bank Headquarters building, the Ministry of Urban Development, and Housing and Academic Institutions. The key informants were selected based on the following criteria:

- ❖ Those involved in the design, supervision, and construction of the Wegagen Bank Headquarters building;
- ❖ Those who have experiences and background issues related to green building;
- ❖ Construction industry policy makers;
- ❖ Those interested in and keen on beingd part of the research.

The level of education, area of expertise, and work experience of interviewed key informants (KI) are summarized in Table 1.

Table 1. Level of education, area of expertise, institutions, and work experience of interviewed key informants.

No.	Institutions	Level of Education	Area of Expertise	Work Experience
KI-1	ETG Designers and Consultants Sh.Co.	BSc	Architecture	Architectural design and supervision of buildings
KI-2	ETG Designers and Consultants Sh.Co.	BSc	Architecture	Architectural design and supervision of buildings
KI-3	ETG Designers and Consultants Sh.Co.	MSc	Civil engineer	Structural design, construction, and supervision of buildings
KI-4	ETG Designers and Consultants Sh.Co.	MSc	Mechanical engineer	Mechanical design, construction, and supervision of buildings
KI-5	ETG Designers and Consultants Sh.Co.	BSc	Electrical engineer	Electrical design, construction, and supervision of buildings
KI-6	Arcon Design Building PLC	BSc	Sanitary engineer	Building sanitary design, and supervision
KI-7	Ministry of Urban Development and Housing	MSc	Construction technology and management	Construction-related policy making
KI-8	Ministry of Urban Development and Housing	MSc	Urban planning and design	Construction-related policy making
KI-9	Arcon Design Building PLC	MSc	Project management	Supervision and management of buildings
KI-10	Arcon Design Building PLC	BSc	Surveyor	Bill of quantity preparation and surveying for buildings
KI-11	Addis Ababa University	PhD	Urban landscape design	Assistant Professor in urban landscape design and researcher
KI-12	ETG Designers and Consultants Sh.Co.	MSc	Environmental and safety expert	Environmental impact assessment of buildings and health and safety assessment of building occupants
KI-13	Adama Sciences and Technology University	MSc	Architectural engineering	Researcher and consultant on architectural engineering
KI-14	Adama Sciences and Technology University	PhD	Urban environmental Planning	Assistant Professor, researcher, and consultant on urban environmental planning
KI-15	Adama Sciences and Technology University	MSc	Environmental architecture	Researcher and consultant on environmental architecture

In this study, semi-structured interviews, which contained open-ended questions, were used as the main instrument to interview the key informants. The semi-structured interview was focused on how the main principles and technologies of green building, including sustainable site, energy efficiency, water efficiency, material efficiency, and indoor environmental quality, were considered during the design and construction phases of the

Wegagen Bank Headquarters building. The constraints preventing the adoption of green building concepts and technologies in Ethiopian buildings in general and the Wegagen Bank Headquarters building in particular were also included in the semi-structured interview. The key informants also inquired about basic techniques for effectively implementing the concepts and technologies of green building in Ethiopia's construction industry. Interviews with the key informants were conducted in July 2022 for approximately 20 min per individual respondent.

Besides, primary data were also collected regarding the building according to the prepared inspection checklist. A checklist was created to assess the integration of the main principle of green building in the Wegagen Bank Headquarters building, based on the findings of the literature review where similar checklists were applied. Different criteria were adopted to evaluate the practices of green building in different parts of the world [49]; nonetheless, the following criteria are the most frequently used:

- ❖ Sustainable site
- ❖ Energy efficiency
- ❖ Water efficiency
- ❖ Material efficiency
- ❖ Indoor environmental quality

Based on its application and acceptance all over the world [50], the abovementioned criteria were used to assess the adoption of green building concepts and technologies in Wegagen Bank Headquarters building.

Secondary data were obtained from reviews of different books, articles, and government publications. The review was focused on literature which contains comprehensive data and information on the concepts and technologies of green building. International guidelines for green building construction of new buildings and renovation were used to identify the criteria based on different categories of green building issues.

A theoretical proposition strategy recommended by Yin [51] was used to analyze the data obtained from the key informant interviews and field observations through a checklist. Based on this strategy, the responses were categorized under themes such as adoption of the concepts and technologies of green building, challenges for integration of the principles of green building, and appropriate strategies for properly implementing the principles and technologies of green building in the construction industry of Ethiopia. For further discussion, the data obtained from key informant interviews were supported by personal observations and document review.

3. Results and Discussion

3.1. Adoption of Green Building Concepts and Technologies

3.1.1. Sustainable Site

Proper site selection and planning is one of the most important components of a green and sustainable building. Careful planning, orienting buildings, and landscaping can all reduce energy usage. Furthermore, locating sustainable building projects near to social services such as healthcare, retail, recreation, and public transportation would minimize the development of the built environment and the habitation of agricultural and environmentally sensitive areas [50]. Hence, the first goal of the study was to determine how far Wegagen Bank Headquarters building had adopted the idea of being a sustainable site. According to information from the inspection checklist and on-site observations, Wegagen Bank Headquarters building is situated in the center of the city and is conveniently close to transit options. Additionally, a range of facility services, such as hospitals, hotels, shops, and recreation spaces, are located adjacent to the headquarters building (Figure 2).

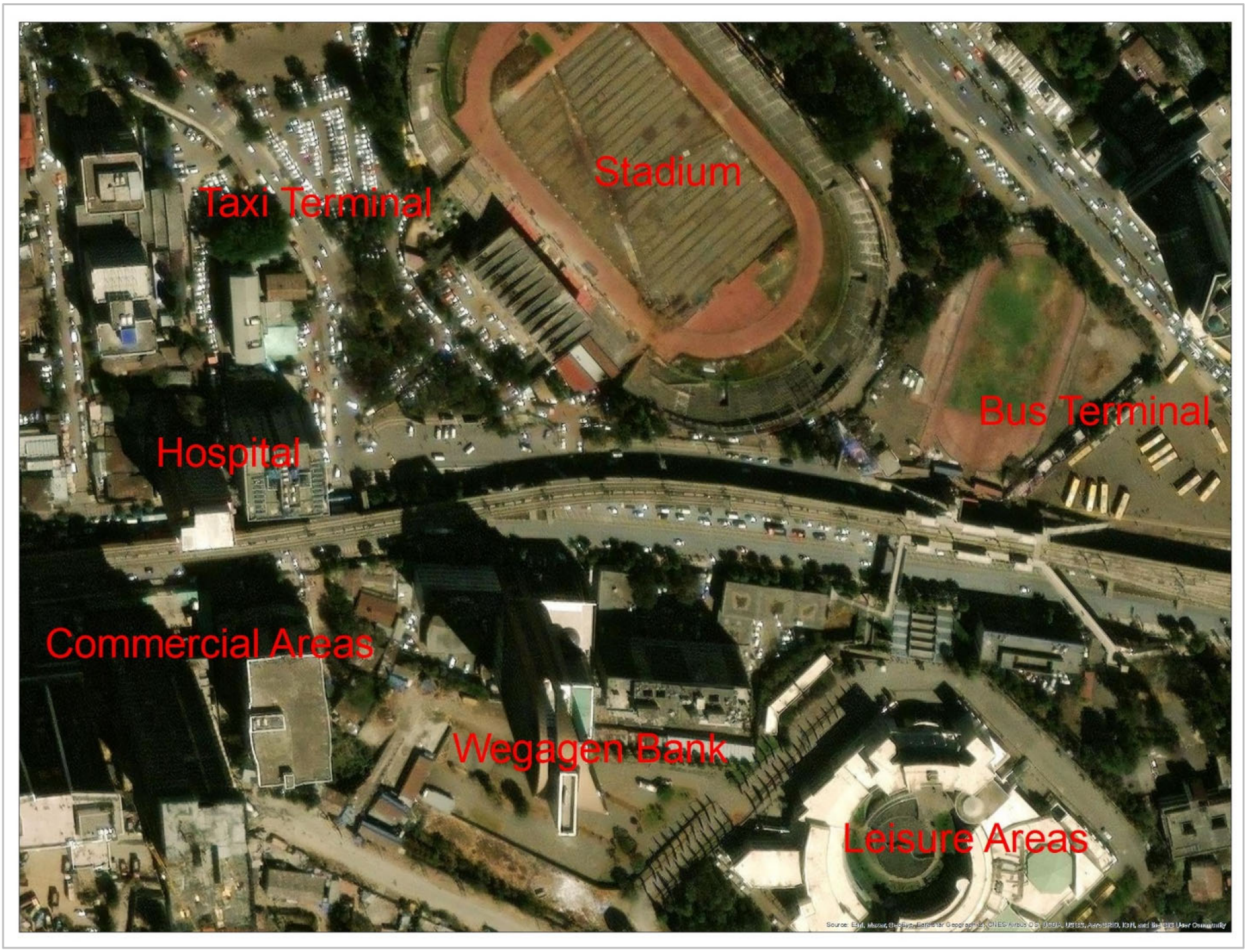

Figure 2. Difference service close to the building.

The headquarter building was constructed in a manner that maximizes space, for example, underground parking is used and this method of design ensures minimum space consumption in the building. Based on the information obtained from the key informant interviews the unground parking space has three basements with a capacity of 100 cars (Figure 3).

Having enough green space is one of the requirements for a sustainable site. However, according to the on-site observations, there is no green space in the neighborhood that may be considered as a component of urban green infrastructure. Based on this finding, site landscaping and maintenance of existing vegetation were not considered during the designing and development of the headquarters building. Additionally, it appears that the design of the headquarters building did not take into account the possibility of a green roof, which can aid in cooling down the building. This finding backs up the ideas put forth by Adebayo [52] and Tessema et al. [53]. According to Adebayo [52] and Tessema et al. [53], many African metropolitan regions, particularly cities, have constructed buildings that totally enclose their sites, disregarding the natural environment.

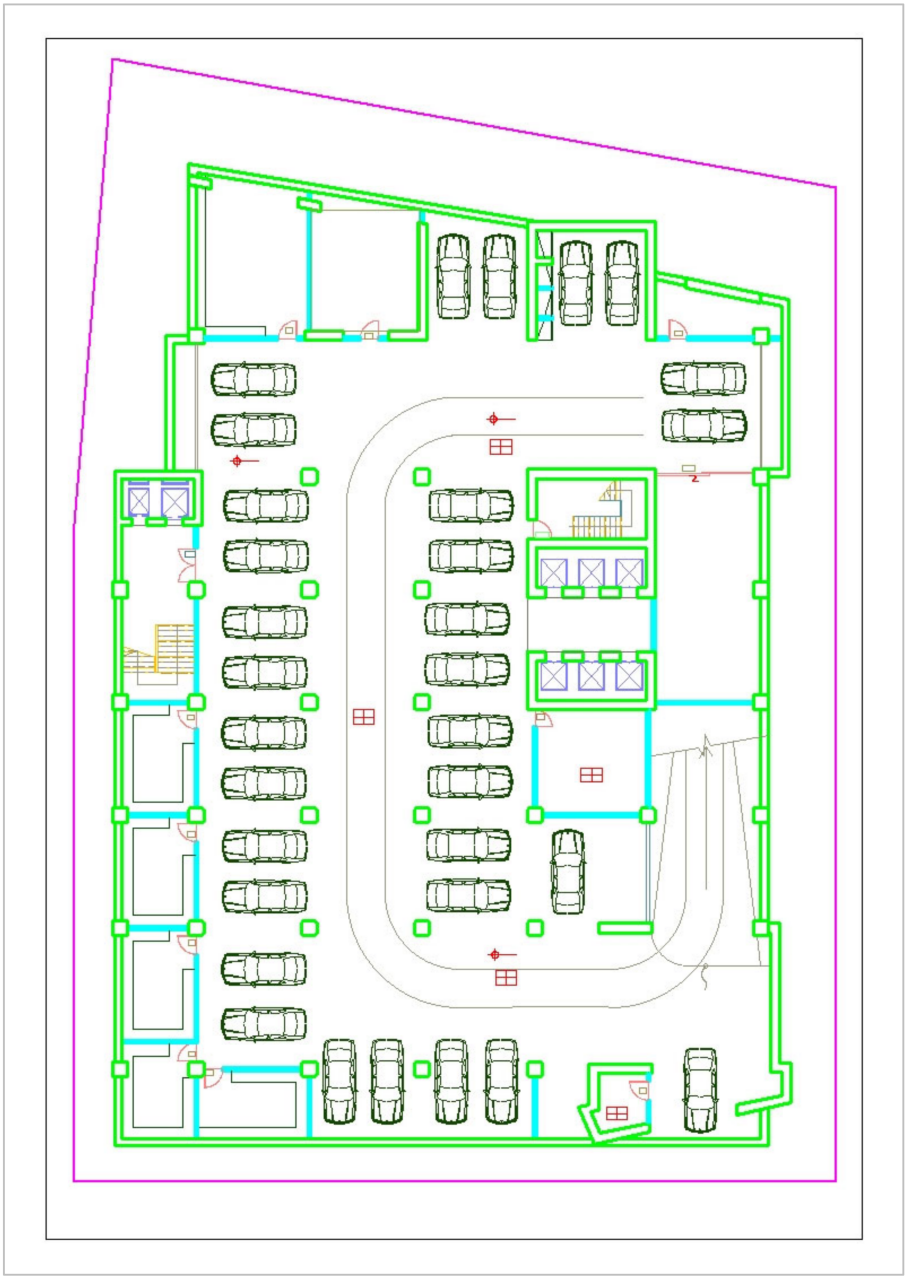

Figure 3. Floor plan for underground parking (source: ETG Designers and Consultants Sh.Co.).

3.1.2. Water Efficiency

In order to maximize water efficiency in green buildings, numerous technologies are now being deployed, including rainwater collection, grey water recycling and reuse, low-flow fixtures, sensors, etc. Water efficiency measures in buildings can greatly reduce water waste, yielding lower sewage volumes, reduced energy use, and bring in financial benefits too [54]. Data from the inspection checklist and on-site observations indicate that high-efficiency plumbing fixtures were used in the headquarters building to reduce water consumption, including dual flushing and a laser hand wash that automatically turns off when not in use. According to a study by Basak et al. [55], utilizing water-efficient plumbing fixtures can reduce water consumption by 30–40%.

Field observations indicate that the main source of water for indoor and outdoor activities, as well as toilets, is municipal tap water. Wastewater and rainwater are not recycled or used again. The views reflected by most of the participant key informants also

confirmed that the majority of the buildings in the city, including Wegagen Bank Headquarters building, are dependent on municipal water provision and can be summarized by the following statement:

> " . . . reusing wastewater and rainwater is crucial for sustainable and adequate use of water in cities, and it has the potential to reduce freshwater demand. However, practically every building in Addis Ababa city relies on municipal water for various activities because of a lack of knowledge and advanced technologies, resulting in inefficient water usage." (Key informant interview, 2022).

The view reflected by the key informant indicates that the concept of water efficiency in the Wegagen Bank Headquarters building is not properly implemented and its water consumption is unsustainable and wastewater effluents are high. The study by Silva-Afonso and Pimentel-Rodrigues [56], however, revealed that increased water usage efficiency in buildings leads to a reduction in water consumption and wastewater effluents.

3.1.3. Energy Efficiency

Energy efficiency is crucial for achieving sustainability in the construction industry [57]. According to studies, the key strategies for improving energy efficiency include optimizing building forms and orientation, lowering internal loads by improving the shell and lighting, and transferring loads to off-peak hours so that the best orientation for the building may be determined [58–61]. Based on the information obtained from field observation and key informant interview, all light fixtures in the buildings are LED and florescent which is comparatively the least energy consuming equipment and have the capacity of saving energy. The results presented here are in line with studies conducted in Accra, Ghana and Esfahan, Iran, respectively, by Darko et al. [62] and Roufechaei et al. [63], which determined that the use of energy-efficient lighting systems was the most crucial green building technology to achieve sustainable development.

Although the Wegagen Bank Headquarters building is well-oriented and effectively utilizes natural lighting and ventilation, both of which are essential for energy efficiency, the daytime usage of artificial lighting in some rooms by occupants is noticeable. According to Akadiri et al. [50], the use of passive energy design, such as natural ventilation and building orientation, can help to achieve thermal and visual comfort inside the building, resulting in a notable decrease in energy usage.

According to data gathered from the field observation and key informant interviews, the building's primary source for electrical power is the national grid, and a fuel-powered generator serves as its backup power source. However, the building does not use any renewable energy at all for its electrical power supply.

3.1.4. Indoor Environmental Quality

One of the primary aims of green buildings is to reduce adverse effects on building inhabitants by creating a healthy, comfortable, and productive indoor environment. Indoor air quality, lighting, thermal conditions, acoustics, ergonomics/architecture, and their impacts on occupants are all included in what is known as indoor environmental quality (IEQ) [64]. A high-quality indoor environment can boost occupant satisfaction, improve performance and productivity, decrease liability, and lower operations and maintenance costs [65]. Even though the building's occupants negligently use artificial light during the daytime, the information from the observation checklist showed that the Wegagen Bank Headquarters building has enough windows to provide adequate light for the interior areas of the building and stairways, resulting in good thermal comfort and visual quality. Additionally, according to data gathered from the key informants, these windows produce positive psychological reactions associated with a feeling of openness and freedom. To gain a better understanding, the participants of the key informant interviews were asked about access to daylight and productivity of the building occupants. The views reflected by most of the participants were more or less similar and can be summarized as follows:

> "...all of the installed windows in the Wegagen bank headquarter building are transparent and enable daylight to pass, making the building bright, which leads to user comfort and safety as well as stimulating the visual system of building occupants when compared to artificial light." (Key informant interview, 2022).

> " . . . ..the amount of daylighting at the workplace has a significant impact on the productivity and quality of life of office workers. For instance, the uniform and sufficient daylighting of the Wegagen bank headquarters building has increased building occupant productivity." (Key informant interview, 2022).

The key informant's point of view demonstrates that daylight directly affects everyone's wellbeing, boosting productivity and fostering a sense of fulfillment on a general level. Numerous studies have also shown that daylighting increases productivity, mood, and attentiveness while lowering stress and supporting healthy circadian cycles [66–68].

Furthermore, the information obtained from the field observation revealed that, as a means of achieving an ideal indoor environment, external solar shading technology was used in the Wegagen Bank Headquarters building to reduce the impact of the solar radiation in indoor environments. The solar shading technology used in the building was vertical fins made from aluminum oriented eastwards (Figure 4). The studies conducted by Evola et al. [69] confirmed that that solar shading elements help to mitigate overheating conditions, which otherwise leads to thermal discomfort, reduced performance, and health issues. Moreover, shading devices help to limit the amount of light that enters a building, reducing thermal overheating, glare, and other unpleasant effects [70].

Figure 4. Solar shading technology used in the building.

Besides, the building's acoustics quality is also a vital component of indoor environmental quality and is crucial to the wellness, comfort, satisfaction, and productivity of those who occupy interior spaces [71]. However, in this regard, the Wegagen Bank Headquarters building is situated a few meters from the major road and railway, and considerable noise pollution from heavy vehicle and rail traffic has been noticed in the building (Figure 5). The study's findings showed that the headquarter building's acoustics quality was not taken into consideration when it was designed and built.

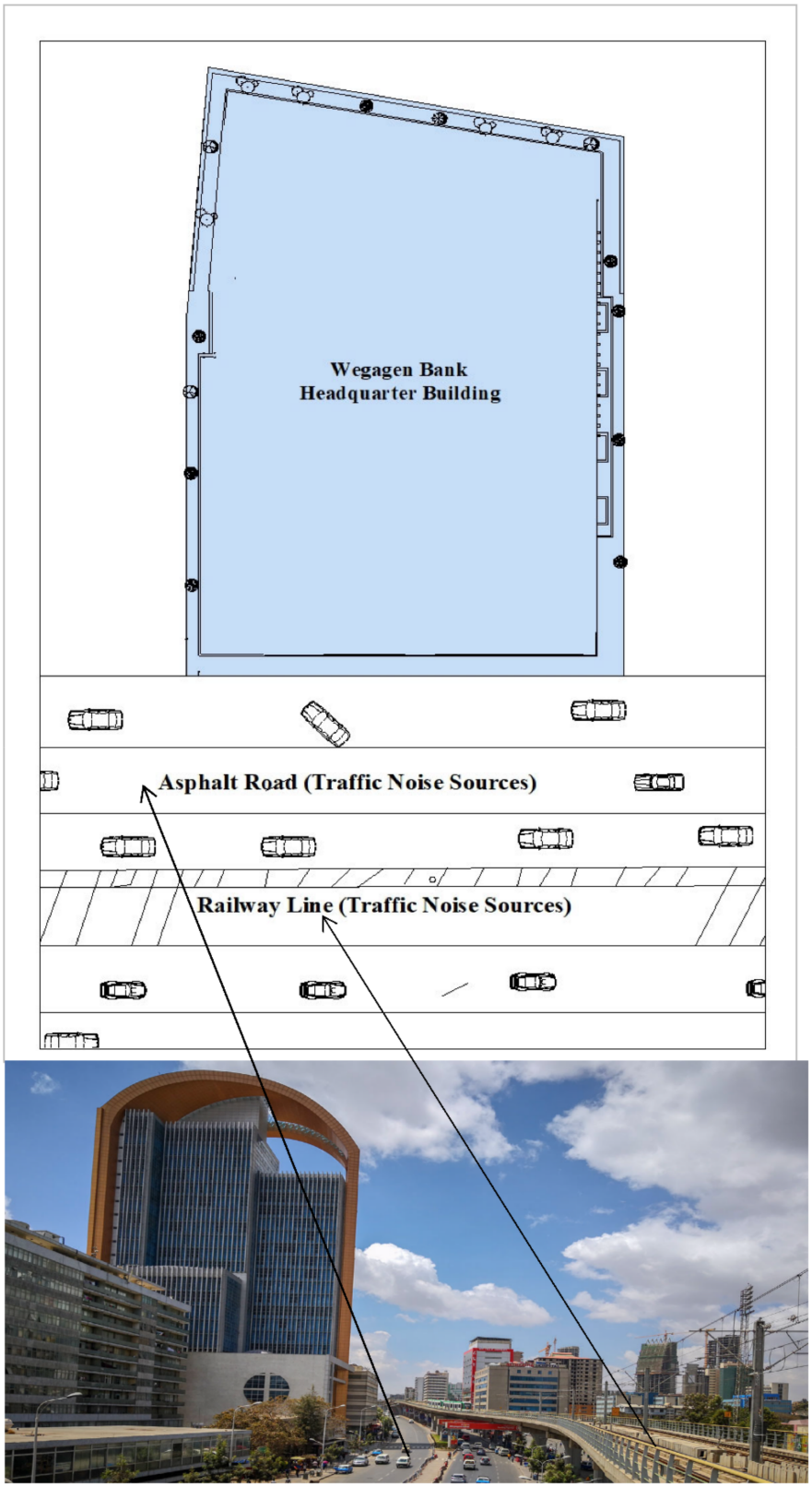

Figure 5. Traffic noise pollution sources near to the building.

3.1.5. Materials and Resource Efficiency

Other features of green building include the efficient use of materials and resources. This is accomplished by using lightweight structures, reducing waste, enhancing durability and service life, using secondary materials, using locally sourced materials, and increasing

the appropriate flexibility [72]. With regards to the Wegagen Bank Headquarters building, all of the construction materials were not locally sourced or recycled. According to key informant interviews, materials containing volatile organic compounds were used in the building construction and finishing.

3.2. Barriers Preventing the Adoption of Green Building Concepts and Technology

In the quest for sustainable development, the concept of green building has become central in the construction industries of developed countries [73]. Nevertheless, there are a number of barriers associated with implementing the concepts and technology in the construction industry of the particular study area and in Ethiopia in general. The barriers have been related to the following five potential factors.

3.2.1. Lack of Awareness and Understanding of the Concept

The results of this study showed that the main barrier that prevents the adoption and implementation of the concepts and technology of green building in Ethiopian buildings generally and in the study area specifically is the lack of awareness of the concept and its benefits among stakeholders in the construction industry. According to the key informant interviews, architects, engineers, and other stakeholders are not familiar with the concept of green construction, making it more difficult to mainstream it in the building sector. Regarding this, key informants reported that:

> "...I don't think the developers, architects, engineers, planners, policymakers, and decision-makers are at all aware of the concept and principles of green buildings, such as energy, material, and water efficiency. Moreover, the concept of green building is new to most of the policy and decision makers. Because of this, architects, engineers, and decision-makers have not paid enough attention to effectively integrating the principles of green building into the way that buildings are now constructed. Even if they are concerned about environmental issues, the construction company's goal to incorporate green building principles into projects is hampered by the stakeholders' lack of awareness." (Key informant interview, 2022).

This comment demonstrates how lack of awareness and understanding among the key players in the nation's construction sector, such as architects, engineers, and senior management, prevents them from incorporating green building principles into the current construction practices of the country. The absence or limited number of exemplary green building projects in Ethiopia is to blame for the lack of awareness. Similar to this study, lack of awareness and knowledge on green building concepts were noted in a number of recent studies in Africa, including Djokoto et al. [74] in Ghana, Hoffman and Cloete [75] in South Africa, and Baloi [76] in Mozambique.

3.2.2. Lack of Policy and Regulatory Frameworks

There is no distinctive policy and legislation on green building at national and regional levels, but there are several laws related to buildings. Respondents revealed that a lack of policies, laws, and regulations poses challenges for mainstreaming the practice of green building in the construction sector of Ethiopia in general and in the study area in particular. Respondents further argued that the benefits of green buildings are not recognized by policy makers and translated into regulations and building codes. The views reflected by most of the key informant interview participants were more or less similar and can be summarized as follows:

> " . . . there are different construction laws and building legislation including Construction Industry Policy of 2012, National Building Code of 1995, Building Proclamation No. 624/2009, Building Regulation no. 243/2011, Building Directive No. 5/2012, and the like. The legislation and laws cover a wide range of activities in the construction sector, but they do not specifically address how green

> building concepts and technologies will be adopted and implemented during the development of construction projects." (Key informant interview, 2022).
>
> " . . . lack of green building policy and regulatory frameworks enables architects, engineers, and developers to use traditional building designs from other countries, particularly those in Europe and Asia, without considering how those designs will affect the built environment of our country and with little effort to meet local authority building codes in order to obtain a building permit. Additionally, the usage of ecologically unfavourable building materials in the country is a result of a lack of legislative and regulatory frameworks." (Key informant interview, 2022).

According to Aktas and Ozorhon [77], legislation, guidelines, policy documents, and standards have an important potential to properly adopt the concepts and technologies of green buildings. The study conducted by Darko and Chan [78] expressed that, enacting laws and mandatory codes, is critical for the proper adoption and implementation of green buildings. The finding of this study is in full agreement with the above finding. The concepts and technologies of green buildings and how they will be adopted and applied throughout the development of construction projects were not adequately addressed by the policy and regulatory frameworks, which led to the unsustainable growth of the construction sector in the country. In contrast, many Western countries have formulated a number of specific policies and guidelines that oversee green building and promote its implementation [79].

3.2.3. Lack of Professional Skills and Experience

The environmental benefit and multi-functionality benefits of green buildings necessitate skilled professionals with a variety of disciplinary backgrounds, and they play a crucial role in the design, construction, operation, and maintenance of green buildings as well as the instruction of others [80]. However, the findings of this research revealed that there is a lack of qualified and well-experienced professionals in the field of green buildings; resulting in difficulties in adopting and properly implementing the concepts and principles of green building in the construction industry of the country in general and the study area in particular. All the key informants concurred that the nation suffers from a shortage of skilled professionals, which is a problem that has to be resolved right away. Regarding this, one of the key informants reported that:

> " . . . while I am studying architecture, I am not really sure what green buildings entail. When I initially heard about green buildings, I assumed they were merely structures with vegetation on their roofs and façade. In the public or private sectors, we do not have sufficient numbers of professionals in green buildings and sustainable construction. There is only one university that educate professionals in the field of Environmental Architecture which are important for adopting and properly implementing the concepts and principles of green building. Moreover, there is lack of on job training on issues related to green building principles and its implementation. This condition has created problems in getting qualified professionals in the field." (Key informant interview, 2022).

The aforementioned statements demonstrate that experts in the country's construction industry lack the skills and knowledge necessary to embark on projects involving green building. This finding is consistent with a study by Darko et al. [81], which claims that the successful implementation of the green building concept would be greatly hindered by insufficient expertise. A particular study in the South African province of KwaZulu-Natal indicates a similar conclusion, namely, that the development and adoption of green techniques in the building industry is constrained by a lack of technical skills [82]. In their study, Hankinson and Breytenbach [82] found that professionals working in the building environment are not yet completely trained in green construction concepts and consequently lack the education and expertise necessary to implement these practices

correctly. This is because, despite being a specialized subject of study, it was not thoroughly explored or addressed at higher education institutions.

3.2.4. The Perception That Green Buildings Are Expensive

It was discovered that a major obstacle to fully adopting and putting into practice the green building concept and principles is the perception that investing in a green building will cost more money. According to the information obtained from the key informants, the notion that green buildings are expensive is another major obstacle to the mainstreaming of green building practices in Ethiopia's construction industry. The respondent asserts that developers are not eager to contribute more to green construction projects' capital costs than they have to in other conventional projects. The views reflected by most of the key informant interview participants were more or less similar and can be summarized as follows:

> " . . . .the initial cost of a green building is higher than the cost of a conventional building, and the price of green technologies and materials is also too expensive. Reusing materials, purifying wastewater, and reusing water are all expensive. Every story of a green building needs space for plants, and the facades should be made of expensive special glass that lets light through but not heat. To shade the building, we will also construct canopies and shades to provide shade for the building, which increased the cost. Although there will be significant long-term cost savings, the developers only consider the initial costs listed above and choose for the less expensive option." (Key informant interview, 2022).

This quote indicates that investing in green building practices is seen as having a higher cost than investing in a conventional building. It is also pointed out that there is a cost savings during the building life. According to research by McGraw-Hill [83], the biggest barrier preventing green building from becoming more widely adopted is thought to be the expense of doing so. Therefore, this result is consistent with the McGraw-Hill report. The high cost of green building was also noted by several researchers as an obstacle [79,84].

3.2.5. Lack of Green Building Materials and Technologies on the Local Market

According to the study's findings, the lack of green building materials and technology in the building construction sector is another obstacle to the adoption and application of the green building concept. The information obtained from the key informants indicates that environmentally friendly materials that have a lower environmental impact and are required for the application of green building principles are not easily and quickly available in the local market. Regarding this, key informants reported that:

> "...in our country, there are various resources that can be used as environmentally friendly building materials and that can be classified as locally produced with little to no additional imported inputs. Despite their availability, they are often manufactured by the informal sector and remain a small-scale industry for the most part. For instance, bamboo is one of the nation's most environmentally friendly building materials, but still needs to be developed more before it can be used as a viable modern substitute for materials like steel, wood, and concrete. Currently, due to limited availability of green materials on the local market more than 80% of the construction materials in Ethiopia, including steel and glass, are imported. Therefore, more companies that manufacture green building materials are needed for the growth and development of green building in our country." (Key informant interview, 2022).

Even if there are various locally available green building materials in the study area, as the aforementioned quotation demonstrated, they are not rapidly and easily available for use in the building construction sector. The results of this study are consistent with a study by Davies and Davies [85], which demonstrated that a significant obstacle to the

adoption of green building ideas is the lack of locally accessible green construction supplies and materials in nations such as Nigeria.

3.3. Implications for Promoting Widespread Adoption of Green Building Concepts

Based on insights gained from literature, stakeholders' interviews, and field observation study provides some important practical implications for properly implementing green building concepts and technologies in the construction industry of Ethiopia in general and the study area in particular.

Developing green building policy: the study's findings indicate that the lack of a regulatory and legal framework makes it extremely difficult for the country's construction industry to adopt and implement the concept of green building and its principles. However, government regulations and laws would significantly affect the adoption of green building concepts since they would place regulations on companies and stakeholders to implement them [62]. Therefore, this study has recommended the development of green building policy, a legal and institutional framework that prioritizes the proper implementation of the main principles of green building including energy, water, and material efficiency; indoor environmental quality; and sustainable sites in the construction industry of the country.

Throughout the world, green building is ambiguous and essentially "a contested concept". The concept has not yet been defined explicitly, as different practitioners and academicians attach different environmental, social, and economic meanings to it. Therefore, efforts should be made on the policy to clearly insert the concepts of green building and capture its values in the context of Ethiopia. Once the concept is well captured, there is greater opportunity to understand how it is used and what it might look like in practice.

The policy statement should also emphasize green building principles such as energy, material, and water efficiency, improving indoor environmental quality, reducing waste and emissions, and promoting sustainable sites. For instance, developing energy, material, and water-efferent buildings around urban areas should be proclaimed as one of the policy objectives. The policy should identify departments/agencies that should be involved in decision making regarding green building concept adoption and implementation and the roles, standards, codes, and regulations that need to be updated to implement the green building principles in the construction industry.

Several studies have agreed that mandated green building laws and regulations are a key driver of the adoption of green building since they push and influence stakeholders to adopt green building concepts and principles in order to avoid penalties [86–88].

Professional capacity building: the availability of a sufficient number of skilled professionals is a prerequisite for properly implementing green building concepts in the construction industry of the country. This can be achieved in two ways. First, government should facilitate green building-oriented long- and short-term on-the-job training for unskilled professionals and improve the image of the construction sector. Secondly, it should sign memorandum of agreements with higher institutions to design curriculum and to launch training that relates to green building and its implementation. Higher education institutions must also finance and implement structured training on the concept of green building for those involved in the construction sector in order for them to gain a deeper grasp of it in practice. According to Manoliadis [89], education and training in green building concepts and practices is the most important way to guarantee the adoption and implementation of sustainable construction.

Public awareness and campaigning: developers, stakeholders, policymakers, and decision-makers need to be made more aware of the importance of green building and its critical role in achieving sustainability in built environments. In addition, architects, engineers, and planners need to be made aware of the concept and the need to think creatively in implementing green building principles. The awareness creation can be done through workshops, seminars, and by using the mass media. Based on the experience of different countries, increasing knowledge and awareness of all stakeholders on the benefits of green building is important to enhance the widespread adoption of green building [20].

There is a perception that green buildings will cost more than conventional ones, according to the information gathered from the key informants in the study area. However, because they have lower operating expenses over the long-term, they are more cost-effective. As a result, they are typically a wise investment. In contrast to traditional buildings, green buildings offer economic advantages. These advantages include a reduction in waste, a reduction in energy and water use, an improvement in indoor environmental quality, a rise in staff productivity and comfort, a decrease in employee health expenses, and a decrease in operations and maintenance costs. Therefore, to overcome the obstacles related to the misunderstanding that green buildings will cost more and to enhance its wider application, it is crucial to raise awareness among developers and other stakeholders about the financial benefits that green buildings will provide when compared to conventional buildings.

Developing green rating and labeling system: green building rating systems must be developed and put into place in order to encourage the adoption of green buildings. Ethiopia, however, does not currently have its own green building rating systems, thus it uses the US's LEED rating systems for the certification of HoA-REC&N headquarters building, the CBE's New Headquarter Building Project, and the U.S. Department of State Office. Although Ethiopia may benefit from using this international rating system to encourage the development of green buildings, localized rating systems that take into consideration national sustainability priorities and climates and environmental conditions would be more beneficial.

Implement integrated green building lifecycle framework: The result of the key informant interviews and field observation revealed that green building concepts, technologies, and principles identified as sustainable sites, energy, water, and material efficiency, and indoor environmental quality were not properly adopted in the building industry of the country. In order to achieve a sustainable future in the building industry, Asif et al. [90] suggest adoption of multi-disciplinary approaches and frameworks covering a number of features, such as energy saving, improved use of materials, material waste minimization, pollution and emissions control, etc. [50]. An integrated green building lifecycle framework would support stakeholders' efforts to successfully implement green building strategies and technologies during the construction phase of the building development process [91]. Hence, this study has developed an integrated green building lifecycle framework that can be used by developers, architects, engineers, and policy makers to enhance the adoption of green building concepts, technologies, and principles, specifically sustainable sites, energy, water, and material efficiency, and indoor environmental quality, in the country's construction industry (Figure 6).

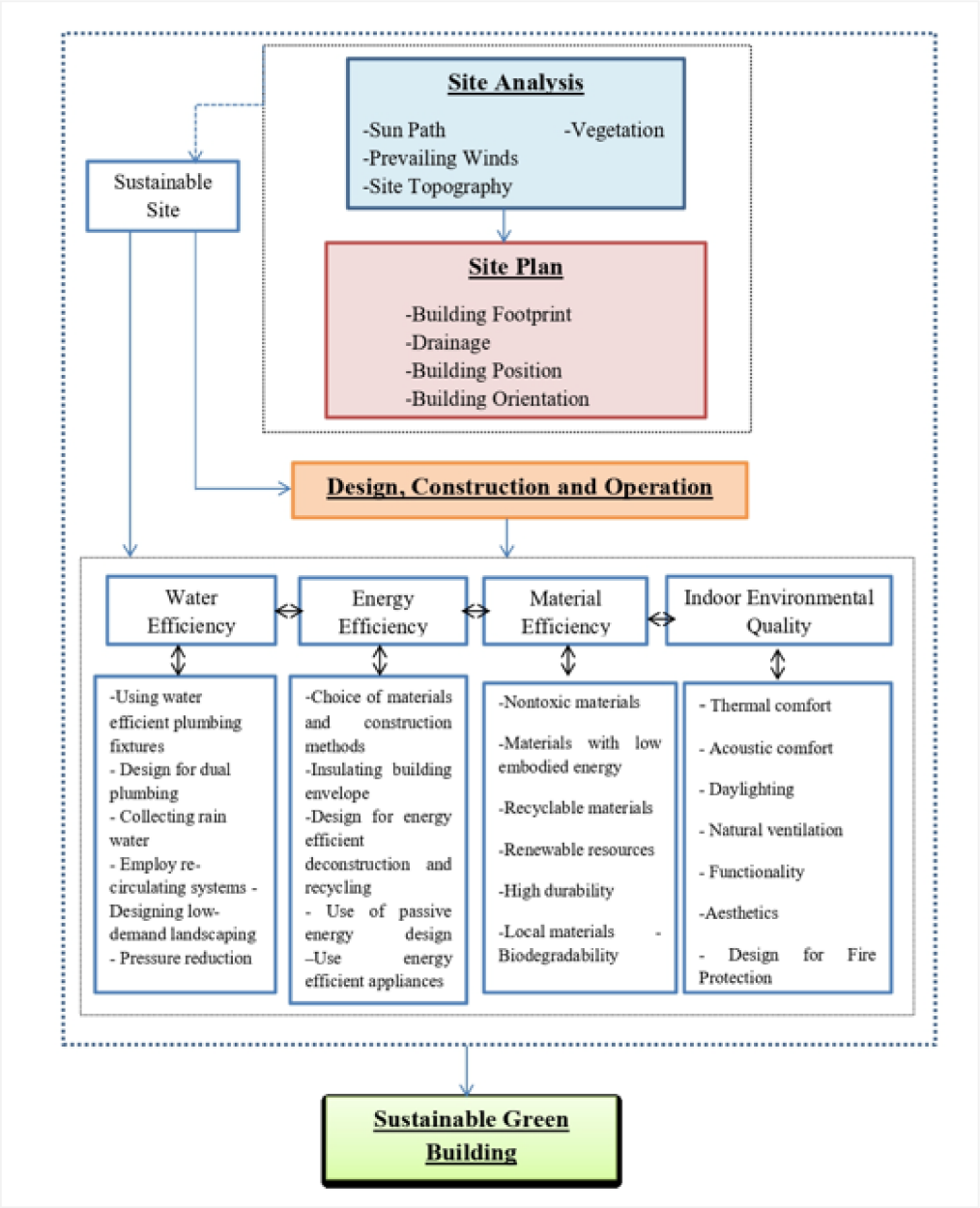

Figure 6. Framework for adopting the concepts and technologies of green building.

4. Conclusions

The general objective of the study was to evaluate the extent to which green building concepts, technologies, and principles identified as sustainable sites, energy, water, and material efficiency, and indoor environmental quality were adopted and implanted into the Ethiopian construction industry, with particular reference to the Wegagen Bank Headquarters building in Addis Ababa and to indicate major action needed to increase the adoption and implementation by identifying the key challenges arising from their adoption.

The study's results showed that while the Wegagen Bank Headquarters building provides convenient access to bus, train, and taxi services, it lacks designated open spaces and sustainable rainwater management practices. The analysis also reveals that the building incorporates green characteristics such as careful orientation, low-energy lighting design, and the greatest possible utilization of natural daylighting. According to the study's findings, however, excessive usage of incandescent lights throughout the day and a lack of information about how to use renewable energy show unhealthy consumption of energy

in the building. The study's findings indicate that water efficiency is one of the least adopted green building concepts; municipal water is the major source of water and is used excessively without being recycled or reused. Utilizing local resources and materials is quite uncommon in the Wegagen Bank Headquarters building.

The study also identifies lack of awareness and understanding of the green building concept, lack of clear policy and legal framework, insufficient professional knowledge and experiences, the perception that green buildings are expensive, and lack of green building materials and technologies on the local market as the major barriers that hindered the adoption and proper implementation of the concept and technologies in the construction industry of the country. Therefore, the study indicates that:

- ➢ Developing green building policy and legal frameworks;
- ➢ Professional capacity building;
- ➢ Awareness creation on the benefit of green building; and
- ➢ Developing green rating and labeling system are urgently needed in order to adopt and properly implement the concept and principles of green buildings in the construction industry of the country.

Findings of the study will add new information to the green building literature in order to understand how the main principles of green building including sustainable site, energy water and material efficiency and indoor environmental quality have been incorporated in current construction practices of Ethiopia. Due to scant literature, the findings from this research have wider applicability to urban areas in sub-Saharan Africa. Moreover, the findings will inform practitioners and policy makers in their decision-making process on how to adopt and implement the concepts of green building in order to enhance the sustainability of the Ethiopian construction sector in general and the study area in particular.

Finally, future research should focus on developing tools, which help to transfer the main principles of green buildings into practice, such as information, decision-supporting and technical tools. The sample size used in this study was very small; thus, future studies should use a larger sample size and expand the scope of the investigation to validate and generalize the current findings. Thus, such studies will significantly advance our understanding of the adoption and implementation of green building concepts and technologies into the construction industry of Ethiopia in particular and more widely in sub-Saharan Africa.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: All available data is contained within the paper.

Acknowledgments: I am indebted to the Ministry of Urban and Housing Development, ETG Designers and Consultants Sh.Co. and Adama Science and Technology University for providing valuable information for this study.

Conflicts of Interest: The author declares no conflict of interest.

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