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Assessment of Sustainability Practices in Recently Constructed Commercial Buildings in Ethiopia

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Abstract

Amid increasing global focus on sustainable development, the integration of sustainability into the construction sectors of developing countries remains underexplored, with Ethiopia's rapid urban growth offering a vital case for study. This research assesses the level of sustainability practices incorporated into recently constructed medium- and large-scale commercial buildings in urban Ethiopia, utilizing a locally adapted, indicator-based assessment framework. Based on international standards, national sustainability goals, and expert insights, an initial set of 36 indicators was refined by 41 experts through Likert-scale surveys and the Relative Importance Index (RII), resulting in a core set of 24 prioritized indicators covering environmental, social, and economic dimensions. The framework was applied to 23 purposefully selected commercial buildings, categorized by gross floor area into medium (5000–20,000 m^2) and large (>20,000 m^2) groups, according to local definitions. Results reveal very low adoption of sustainability practices across both groups, with over 70% of buildings scoring below 15%, highlighting a significant gap in sustainable construction. This study presents a context-specific, empirically based evaluation tool aligned with Ethiopia's expanding sustainable building initiatives. It establishes key benchmarks for policymaking, supports targeted efforts, and enhances the broader understanding of sustainability practices in developing countries.

Keywords: sustainable construction; commercial buildings; indicator-based assessment; sustainability indicators; developing countries

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1. Introduction

The global construction sector continues to be a significant contributor to climate change, responsible for substantial greenhouse gas emissions and energy consumption. According to the UNEP Global Status Report for Buildings and Construction (2024/25), buildings and construction, including emissions from building materials and operations, accounted for approximately 34% of global energy demand and 34% of CO_2 emissions in 2023. This highlights the pressing need to integrate sustainability into construction practices, particularly in rapidly urbanizing regions.

In developing countries, urban expansion has intensified the environmental and socio-economic challenges associated with unregulated growth [1]. As cities continue to grow, embedding sustainable practices in building design, construction, and operation becomes

increasingly vital to address issues such as resource depletion, pollution, and climate vulnerability [2].

Ethiopia, in particular, is undergoing rapid urbanization and infrastructure development, especially in the commercial building sector. This growth is driven by economic development, demographic shifts, and internal migration [3]. Despite the momentum, the adoption of sustainable construction practices remains limited. Most commercial buildings continue to be designed and constructed using conventional approaches that give little consideration to environmental efficiency, occupant well-being, or long-term cost-effectiveness [1]. Furthermore, the absence of a nationally adopted sustainable building rating system and the weak enforcement of sustainability-related regulations have exacerbated the problem [4].

In addition to these institutional and regulatory gaps, there is also a notable absence of empirical data on the actual implementation of sustainability practices within Ethiopia's commercial building sector. While global frameworks and theoretical models exist, few studies have systematically evaluated real-world sustainability performance in Ethiopian construction [5]. This lack of field-based evidence limits the ability of policymakers, professionals, and developers to assess progress, identify critical challenges, or make informed decisions to support sustainable transformation [6].

Globally, a range of sustainability assessment frameworks such as LEED (USA), BREEAM (UK), and EDGE (IFC/World Bank) have been developed to guide the construction of environmentally responsible buildings [7]. However, these systems are often costly, data-intensive, and complex to apply in low-resource contexts such as Ethiopia [8]. Their lack of alignment with local construction practices, socio-economic conditions, and institutional capacities has limited their practical use [9].

In response, indicator-based sustainability assessment methods have emerged as context-sensitive alternatives. These approaches allow for the selection and customization of indicators that reflect local priorities, construction realities, and policy frameworks [10]. Such frameworks offer a more feasible means of evaluating building performance in developing countries, where formal certification processes may be impractical [11].

This research aims to evaluate the implementation of sustainability practices in newly constructed commercial buildings in Ethiopia using a locally adapted, expert-informed indicator-based assessment framework. To guide this investigation, the study addresses the following research questions:

1. Which sustainability indicators are most relevant for assessing recently constructed commercial buildings in Ethiopia?
2. To what extent are sustainability practices implemented in recently constructed commercial buildings in Ethiopia?

By focusing specifically on commercial buildings, a category that represents a significant and rapidly expanding component of Ethiopia's urban infrastructure, this study addresses a critical and underexplored area in the national discourse on sustainable development. Despite their high visibility, resource intensity, and potential to set sector-wide precedents, commercial buildings in Ethiopia have received limited scholarly attention in terms of their sustainability performance. This research bridges that gap by offering a context-specific and empirically grounded assessment framework tailored to the Ethiopian construction environment.

The study contributes to academic and professional knowledge by developing and applying a context-specific set of sustainability indicators tailored to low-resource, rapidly urbanizing environments. It establishes a foundation for consistent performance monitoring, informed policy formulation, and professional development across the construction sector [12]. Additionally, the indicator-based framework offers replicable and scalable tools

that can support the integration of sustainability principles into future building projects and regulatory strategies [13].

Importantly, the findings are intended to inform and engage a wide range of stakeholders, including government agencies, urban planners, architects, developers, and environmental regulators who play a pivotal role in shaping Ethiopia's urban future. By providing actionable insights into current gaps and opportunities, the research supports the transition toward more inclusive, resource-efficient, and climate-resilient cities. In doing so, it aligns directly with Ethiopia's national development goals and global commitments, particularly the United Nations Sustainable Development Goals, most notably SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) [14].

Globally, several policies and tools have contributed to measurable improvements in building sustainability. Singapore's Green Mark system focuses on performance-based energy and water targets, utility benchmarking, and post-occupancy evaluations [15]. The UAE's Estidama Pearl system enforces minimum water budgets, material disclosures, and waste management during construction [16]. South Africa's SANS 10400-XA specifies envelope performance standards and efficient hot-water systems [17]. Rwanda's Green Building Minimum Compliance encourages passive cooling, daylight access, and low-flow fixtures in new permits [18]. India's Energy Conservation Building Code mandates efficiency standards for building envelopes and systems in large commercial structures [19]. Well-defined baselines, straightforward compliance procedures, and routine inspections characterize these initiatives.

In Ethiopia, similar outcomes are constrained by data gaps, limited enforcement, and the absence of a national rating or code that sets measurable thresholds for energy, water, and waste [20]. Capital budgets favor first cost over life-cycle performance. Project teams have limited access to commissioning and post-occupancy tools. These gaps explain the very low implementation scores observed in this study.

2. Materials and Methods

2.1. Sustainability in Commercial Buildings

Sustainability in commercial building construction has become a central concern in global policy and research, given the sector's substantial environmental, social, and economic impacts [21]. Integrating sustainability into construction is no longer solely an environmental imperative; it is increasingly recognized as essential for achieving long-term economic resilience and social well-being [22].

In Ethiopia, however, there is currently no nationally adopted sustainable building standard. Although institutions such as the Ethiopian Construction Authority and the Ministry of Urban Development and Construction have made efforts to promote sustainable urban planning and energy-efficient design, these initiatives have yet to result in a formal, enforceable framework [23]. These national priorities were taken into account during the selection of indicators for this study.

2.2. Sustainability Assessment and Tools

Sustainability assessment is a critical tool for guiding responsible decision-making throughout the lifecycle of construction projects. By evaluating environmental, social, and economic impacts, it ensures that development meets present needs without compromising the ability of future generations to meet theirs [6]. In the commercial building sector, sustainability assessment supports risk identification, resource efficiency, carbon reduction, and improved occupant well-being [24].

Sustainability assessment frameworks have been developed globally, are often criticized for their complexity, have a high implementation cost, and have limited adaptability

to the institutional and socio-economic conditions of developing countries [25]. They also tend to emphasize environmental performance while underrepresenting social and cultural dimensions of sustainability. Therefore, effective sustainability assessment requires a holistic and inclusive approach that integrates local knowledge, stakeholder participation, and context-specific priorities to achieve equitable and resilient development [24,25].

The development of the Ethiopian Sustainable Building Assessment Tool (Ethio-SBAT) by Abebe et al. [1] Represents an important advancement toward localized sustainability assessment in Ethiopia. Ethio-SBAT adapts international rating systems such as LEED and BREEAM to Ethiopian conditions by incorporating context-specific environmental and socio-economic parameters. However, it primarily functions as a design-stage evaluation framework, requiring detailed documentation, modeled energy and water data, and simulation inputs that were unavailable for the completed buildings examined in this study. In contrast, the present research employs a field-based, indicator-driven assessment aimed at measuring the actual implementation of sustainability practices in existing commercial buildings.

While Ethio-SBAT provides a conceptual and regulatory benchmark for future projects, this study complements it by generating empirical evidence of implementation performance across multiple buildings. The proposed indicator framework relies on expert-validated indicators and Relative Importance Index (RII) prioritization, enabling a quantitative evaluation of real-world practices rather than projected design performance. This approach enhances practical understanding of the gaps between design intent and operational reality in Ethiopia's commercial construction sector. In low-resource contexts such as Ethiopia, simpler and more adaptable tools like indicator-based assessment methods are increasingly favored for their practicality, flexibility, and contextual relevance [26]. This study adopts such a framework, specifically tailored to reflect Ethiopia's construction environment and sustainability priorities.

The comparison presented in Table 1 was developed based on an extensive review of international studies, technical manuals, and comparative analyses of sustainability assessment frameworks such as LEED, BREEAM, EDGE, LCA, and MCDA. The identification of each tool's strengths and limitations was guided by four criteria commonly discussed in the literature: (i) methodological rigor and data intensity, (ii) adaptability to local socio-economic contexts, (iii) cost and administrative feasibility, and (iv) applicability to different stages of the building lifecycle (design, construction, and operation) [8,27]. This synthesis ensures that the comparison reflects evidence-based evaluations rather than subjective interpretation, summarizing how each method performs in practice across diverse contexts.

Table 1. Major Sustainability Assessment Tools.

Method	Description	Strengths	Limitations	Typical Use
Rating and Certification Systems [28]	Systems like LEED, BREEAM, WELL, EDGE.	Widely known and comprehensive.	Expensive, complex, and may not suit local needs.	Certified, high-profile building projects.
Life Cycle Assessment (LCA) [29]	Measures environmental impact over a building's entire life.	Scientifically thorough and detailed.	Needs lots of data and expert knowledge.	Deep environmental impact studies.
Life Cycle Cost Analysis (LCCA) [30]	Calculates total cost over a building's life.	Helps with long-term financial planning.	Cost data can be uncertain or variable.	Budgeting and investment decisions.
Multi-Criteria Decision Analysis (MCDA) [10]	Compares multiple factors using stakeholder input.	Flexible and includes different perspectives.	Can be subjective; depends on chosen measurement.	Early planning and design stages.
Post-Occupancy Evaluation (POE) [27]	Evaluates performance after the building is in use.	Gives real-world performance feedback.	Only works after construction is done.	Improve future building performance.
Indicator-Based Assessment [10]	Uses key indicators based on local needs and goals.	Simple, practical, and easy to adapt.	Not as detailed as LCA or formal rating systems.	Local, context-specific evaluations.

Although effective in their original settings, many of these sustainability assessment methods are too resource-heavy, complicated, or incompatible with local construction practices in countries like Ethiopia [1]. They often require extensive data, specialized skills, and significant financial resources that are not easily accessible in the Ethiopian construction industry.

2.3. Indicator-Based Assessment, Expert Consultation, and the Relative Importance Index (RII)

In the built environment, indicator-based assessment methods are increasingly used to evaluate sustainability across environmental, social, and economic dimensions. This approach allows for the selection of measurable, context-specific criteria and is particularly well-suited to developing countries like Ethiopia, where global certification systems such as LEED and BREEAM are often cost-prohibitive and poorly aligned with local realities [26].

The indicator-based framework adopted in this study offers a flexible and structured evaluation method that accommodates local priorities and resource constraints. To enhance reliability and contextual relevance, the indicators were refined through expert consultation and prioritized using the Relative Importance Index (RII), a method commonly used in construction and sustainability research to rank variables based on stakeholder input [31]. Expert consultation provides valuable qualitative insight and ensures that selected indicators reflect both global best practices and local conditions. When combined with RII, it supports a balanced process of framework validation that is both statistically robust and practically grounded, bridging the gap between theory and real-world application in resource-constrained environments [32].

Weighting techniques are central to sustainability assessment frameworks, allowing indicators to be prioritized based on expert judgment, contextual relevance, and decision transparency. The Analytical Hierarchy Process (AHP), introduced by Saaty [33], remains one of the most extensively used MCDM techniques, employing pairwise comparisons to derive consistent hierarchical weights. Its methodological rigor has established it as a preferred approach in green building evaluations, infrastructure planning, and environmental decision-making [34].

Conversely, the Relative Importance Index (RII) offers a more pragmatic and scalable alternative, particularly for studies in developing contexts. RII simplifies expert evaluation through Likert-scale surveys and yields statistically interpretable rankings of indicators. It has been effectively applied in construction management and sustainability research to capture expert consensus and prioritize performance criteria [35]. Its operational simplicity, adaptability, and minimal data requirements make it particularly suited for exploratory assessments involving multiple expert groups.

While AHP offers greater analytical precision and internal consistency testing, its computational complexity and intensive data requirements may limit its application in low-resource environments. Therefore, this study adopted the RII method to ensure methodological relevance, operational feasibility, and alignment with the practical realities of Ethiopia's construction sector.

While this study applied the Relative Importance Index (RII) to prioritize indicators because of its suitability for expert surveys and modest data requirements in low-resource contexts, future research in Ethiopia could apply the Analytic Hierarchy Process (AHP) to derive hierarchical weights through pairwise comparisons and to test internal consistency [33]. Using AHP alongside RII would allow cross-validation of indicator weights and provide a structured basis for sensitivity analysis and methodological refinement.

3. Methodology

This study used an exploratory sequential mixed-methods design to evaluate sustainability practices in newly constructed commercial buildings in Ethiopia. An indicator-based assessment approach was adopted due to the lack of a national rating system, ensuring flexibility and local relevance. The research was carried out in both methods: first, qualitative methods such as expert consultation and literature review were used to develop and validate indicators using the Relative Importance Index; second, quantitative methods were applied to assess sustainability implementation in 23 selected buildings.

3.1. Analytical Framework

The analytical framework for this study was developed to provide a structured and context-sensitive approach to evaluating the implementation of sustainability practices in commercial buildings. It comprises three interrelated stages that reflect the logical progression of the research.

Stage 1: Sustainability indicators were identified through a comprehensive review of international sustainable building standards and adapted to the Ethiopian context. These indicators were then validated and prioritized using expert input and the Relative Importance Index (RII), ensuring both local relevance and conceptual rigor. The reliability of the indicator set was confirmed through Cronbach's Alpha to ensure internal consistency [36].

Stage 2: The validated indicators were operationalized into a structured Likert-scale survey, which was administered to stakeholders of 23 purposively selected commercial buildings. The survey data were quantified to generate implementation scores for each building, reflecting the degree of sustainability integration.

Stage 3: The implementation scores were normalized and categorized into five levels, ranging from very low to very high, allowing for comparative analysis across cases. Overall, the analytical framework provided a coherent method for translating complex sustainability concepts into measurable, actionable insights tailored to the realities of Ethiopia's built environment.

Overall, the analytical framework provided a coherent method for translating complex sustainability concepts into measurable, actionable insights responsive to the realities of Ethiopia's built environment.

As illustrated in Figure 1, the research methodology followed a multi-stage sequence encompassing conceptual development, expert validation, and quantitative assessment, designed to ensure methodological rigor and contextual relevance to sustainability practices in Ethiopian commercial buildings.

3.2. Target Population and Sampling Approach

The study targeted professionals from both industry and academia with demonstrated expertise in sustainability, balancing practical insights from construction practitioners with theoretical perspectives from scholars. Using purposive sampling, 41 experts were selected: 28 from construction and real estate (e.g., contractors, engineers, project managers, consultants) and 13 from academic institutions (professors, lecturers, researchers, and doctoral candidates in architecture and sustainable development). This expert-based, non-random sampling was appropriate for exploratory research requiring specialized knowledge [31].

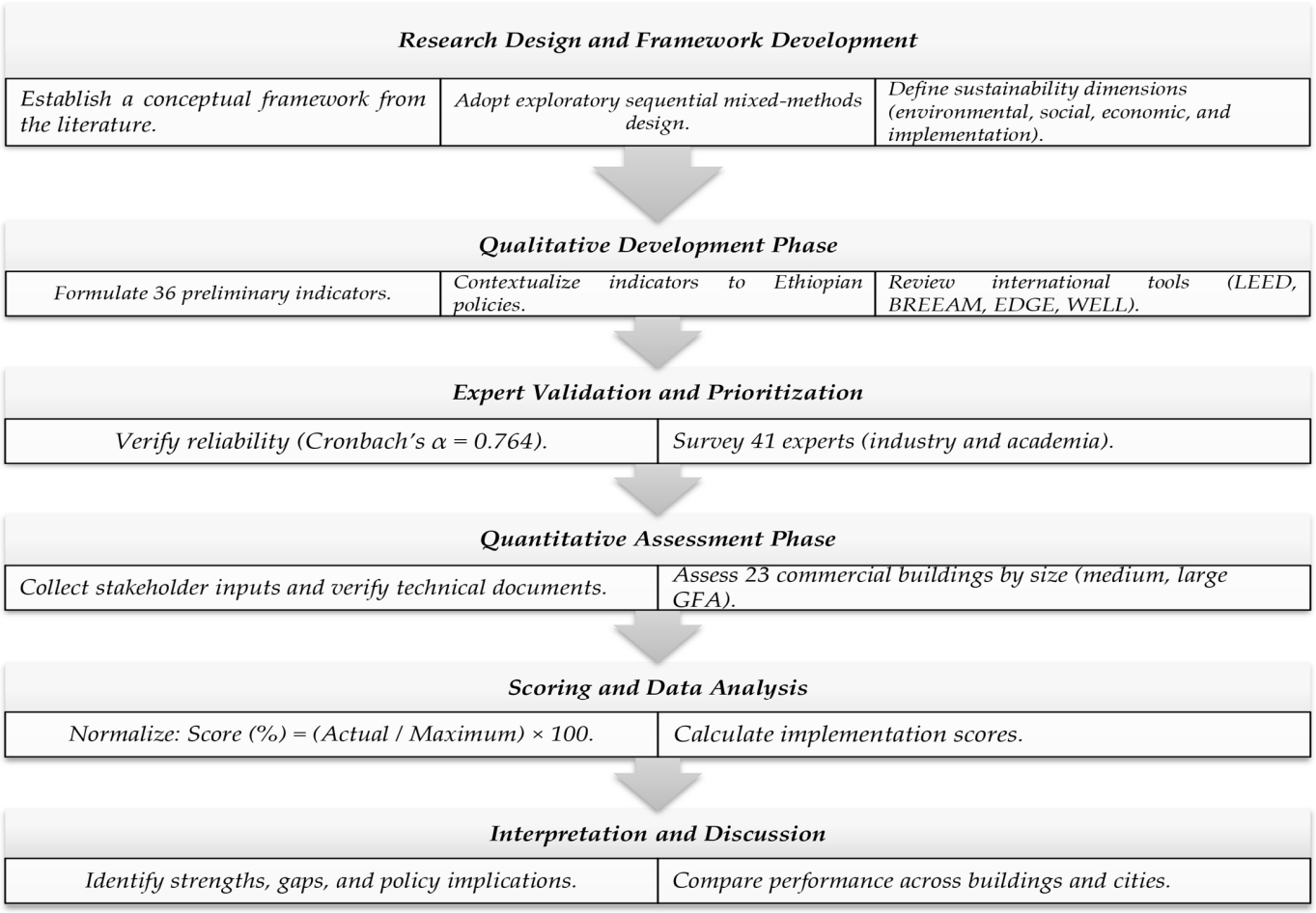


Figure 1. Methodology Flowchart: Sequential framework for assessing sustainability practices in commercial buildings in Ethiopia.

3.3. Sampling Technique and Size for Commercial Buildings

A purposive sampling method was applied to select 23 commercial buildings located in major urban centers, including Addis Ababa, Bahir Dar, Gondar, Gorgora, Hayk, and Dessie. The selection criteria considered building type, construction status, sustainability features, and gross floor area. The sample comprised 10 office buildings, 7 mixed-use developments (combining office and retail functions), 4 retail buildings, and 2 hotel or resort buildings, reflecting the diversity of Ethiopia's urban commercial construction sector. Among these, 16 buildings were completed and operational, while 7 were recently completed or in the final finishing stages. Based on national classification, 14 buildings were categorized as medium-scale (5000–20,000 m^2 gross floor area) and 9 as large-scale (>20,000 m^2).

This classification ensured representation across varied functional types, project sizes, and construction stages, allowing for a more comprehensive understanding of sustainability implementation patterns. The sample size was mathematically justified using Yamane's formula [37] for finite populations:

$$n = \frac{N}{1 + N(e2)} \quad (1)$$

where N = 80 (estimated population of newly constructed commercial buildings in the target cities) and e = 0.1 (10% margin of error). The resulting n = 23 confirms the adequacy of the selected sample for exploratory research in the context of Ethiopia's commercial building sector. Purposive sampling is widely recognized as an appropriate non-probability

technique for expert-driven sustainability studies that require specialized knowledge and representativeness across typologies, rather than random distribution [37–39]. This approach ensured statistical sufficiency while maintaining feasibility for field-based sustainability assessment across multiple locations.

As shown in Figure 2, the assessed commercial buildings are geographically distributed across six major Ethiopian cities, representing both medium- and large-scale developments selected to capture regional diversity in construction practices.

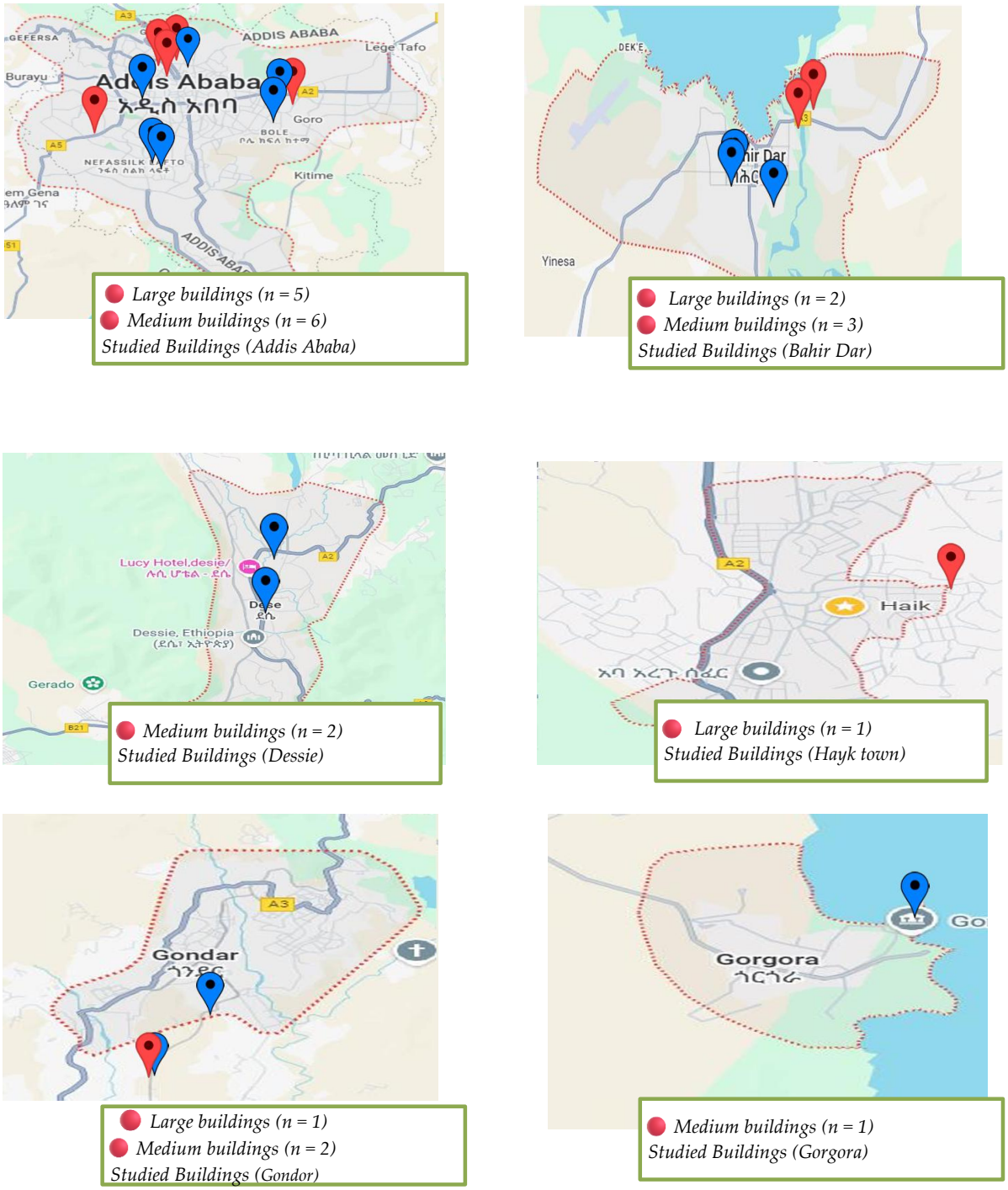


Figure 2. Geographic distribution of the 23 assessed commercial buildings across six Ethiopian cities.

3.4. Data Collection

Data collection proceeded in two phases. First, a structured questionnaire was distributed to the 41 experts, who evaluated 36 proposed sustainability indicators using a five-point Likert scale, informing the validation and refinement of the framework. In the second phase, the 24 validated indicators were used to assess sustainability implementation across the 23 selected buildings through surveys with engineers, facility managers, and project representatives. Responses were cross-validated with project documentation, including architectural drawings, technical specifications, reports, and permit files to ensure accuracy and reliability.

3.5. Data Analysis and Indicator Selection

The responses were analyzed using the Relative Importance Index (RII) to prioritize the indicators based on the consensus of expert opinion [31]. The RII was calculated using the following formula:

$$RII = \frac{\sum W}{AxN} \quad (2)$$

where

- W = the weight assigned to each indicator by respondents
- A = The highest possible weight (5)
- N = The total number of respondents (41)

Indicators were ranked based on their RII values. A cut-off point of approximately 0.72 was established to select the most significant indicators, reflecting a high level of agreement among experts regarding their relevance.

3.5.1. Instrument Reliability

Cronbach's Alpha is a widely used statistical tool for assessing the internal consistency of research instruments. A value above 0.70 generally indicates acceptable reliability, meaning the items in a scale are closely related and measure the same underlying construct [40]. This test helps ensure that data collected through questionnaires or indicator sets is consistent and trustworthy for further analysis [41].

3.5.2. Scoring Framework for Sustainability Implementation in Commercial Buildings

To assess the extent to which commercial buildings in Ethiopia are incorporating sustainability principles into their design, construction, and operational practices, this study applied a structured scoring framework based on the 24 validated sustainability indicators. Each indicator was rated on a five-point Likert scale, where a score of 1 represented "Not Implemented" and 5 represented "Fully Implemented."

The scoring system assumes a minimum possible score of 24, representing the baseline scenario in which none of the indicators is implemented (i.e., each rated at 1). The maximum possible score is 120, which corresponds to full implementation of all 24 indicators at the highest rating (5 per indicator).

❖ Scoring Framework

- Minimum possible score = 24 (Baseline, if none of the indicators are implemented)
- Maximum possible score = 120 (Full implementation of all 24 indicators at highest weight)
- Implementation Score (%):

$$ImpI.\ Score\ (\%) = \frac{(Total\ Score - 24)}{96} \times 100 \quad (3)$$

This percentage-based scoring method makes it easy to measure how well sustainability is being applied. It allows for comparing different buildings and helps group them by performance level, making it useful for analysis and setting future standards in Ethiopia's commercial building sector.

3.5.3. Development of Sustainability Indicators

The sustainability indicators selected for this study were derived from internationally recognized sustainable building assessment frameworks that are widely acknowledged for their comprehensiveness and global applicability. Table 2 presents each indicator alongside its corresponding source(s), demonstrating alignment with globally established sustainability principles while remaining adaptable to the Ethiopian construction context.

Table 2. Sustainability indicators and their corresponding sources.

No.	Code	Indicator	Sources
1	EnvI_01	Energy efficiency measures installed	LEED, EDGE, ASHRAE 90.1
2	EnvI_02	Use of renewable energy sources	LEED, BREEAM, EDGE
3	EnvI_03	Water conservation systems	LEED, EDGE, BREEAM
4	EnvI_04	Waste management during construction	LEED, BREEAM, ISO 14001
5	EnvI_05	Use of sustainable building materials	LEED, BREEAM, EDGE
6	EnvI_06	Green roof or green space integration	LEED, BREEAM, WELL Building Standard
7	EnvI_07	Indoor air quality measures	LEED, WELL, ASHRAE 62.1
8	EnvI_08	Sustainable landscaping	LEED, BREEAM
9	EnvI_09	Environmental certification obtained	LEED, BREEAM, EDGE, WELL
10	EnvI_10	Efficient HVAC systems	LEED, ASHRAE 90.1, EDGE
11	EnvI_11	Daylighting and natural ventilation	LEED, WELL, BREEAM
12	EnvI_12	Low-emission construction equipment is used	LEED, ISO 14001, Envision
13	EnvI_13	Erosion and sediment control practices	LEED, BREEAM, ISO 14001
14	EnvI_14	Storm water management system installed	LEED, BREEAM
15	EnvI_15	Light pollution reduction strategies	LEED, BREEAM
16	SocI_01	Accessibility and inclusivity in design	WELL, Universal Design
17	SocI_02	Health and well-being features for occupants	WELL Building Standard, LEED
18	SocI_03	Community engagement in planning/design	Envision, LEED for Neighborhood Development
19	SocI_04	Worker health and safety compliance during construction	ISO 45001, OSHA Standards
20	SocI_05	Noise and air pollution mitigation during construction	LEED, BREEAM, ISO 14001
21	SocI_06	Safety signage and hazard communication on site	OSHA Standards, ISO 45001
22	SocI_07	Stakeholder education and awareness programs	LEED, ISO 26000, Envision
23	SocI_08	Availability of public/shared transportation options	LEED, BREEAM, SDGs
24	SocI_09	Provision of green or wellness spaces for users	WELL, LEED, BREEAM
25	EcoI_01	Life-cycle cost analysis conducted	ISO 15686, Envision, LEED
26	EcoI_02	Operational cost savings forecasted	EDGE, LEED
27	EcoI_03	Use of local labor and materials	LEED, BREEAM, EDGE
28	EcoI_04	Long-term maintenance plan for sustainability features	LEED O + M, ISO 55000
29	EcoI_05	Incentives or subsidies secured	LEED, BREEAM, National Green Building Programs
30	EcoI_06	Return on investment (ROI) for sustainability upgrades	EDGE, LEED
31	ImpI_01	Sustainability goals defined in project plan	ISO 14001, LEED
32	ImpI_02	Monitoring and reporting of sustainability metrics	LEED, GRESB, GRI
33	ImpI_03	Sustainability officer or consultant involved	ISO 14001, LEED, CSR
34	ImpI_04	Staff training on sustainable practices	ISO 14001, LEED, ISO 45001
35	ImpI_05	Post-occupancy evaluation planned or conducted	LEED, Building Performance Evaluation
36	ImpI_06	Sustainability performance reviewed at project milestones	LEED, Envision, PMI Sustainability Guidelines

Note: Green Building Rating Systems: LEED (Leadership in Energy and Environmental Design) [42]; BREEAM (Building Research Establishment Environmental Assessment Method) [43], EDGE (Excellence in Design for Greater Efficiencies) [44], WELL (WELL Building Standard) [45], Envision (Sustainable Infrastructure Framework) [46]. International Standards (ISO): ISO 14001 (Environmental Management) [47], ISO 15686 (Life Cycle Costing) [48], ISO 45001 (Occupational Health and Safety) [49], ISO 26000 (Social Responsibility) [50], ISO 55000 (Asset Management) [51]. Professional Standards: ASHRAE 90.1 (Energy Efficiency) [52], ASHRAE 62.1 (Ventilation) [53], OSHA Standards (Worker Safety) [54]. Sustainability & Corporate Frameworks: GRI (Global Reporting Initiative) [55], GRESB (Global Real Estate Sustainability Benchmark) [56], CSR (Corporate Social Responsibility), SDGs (Sustainable Development Goals) [57], PMI (Project Management Institute Sustainability Guidelines) [58].

4. Results

This section presents the findings of the study, organized according to the two main research questions. The first part addresses Research Question 1, which focuses on identifying

the most relevant sustainability indicators for assessing commercial buildings in Ethiopia. It includes the results of expert evaluations and the ranking process used to develop a context-specific assessment framework. The second part addresses Research Question 2, which examines the extent to which sustainability indicators have been implemented in recently constructed commercial buildings. It presents the results of a field assessment conducted across 23 commercial buildings using the validated indicators. Together, the findings provide a comprehensive understanding of current sustainability practices, reveal key performance gaps, and offer insights for improving the integration of sustainability in Ethiopia's commercial building sector.

To address Research Question 1, which focuses on identifying the most relevant sustainability indicators for assessing commercial buildings in Ethiopia, the study began by evaluating the reliability of the initial set of indicators. A reliability test using Cronbach's Alpha was conducted on the initial 36 sustainability indicators using MS Excel 2024 and IBM SPSS Statistics 29 software. The result, a value of 0.764, indicates good internal consistency, confirming that the indicators were statistically reliable for expert evaluation and further analysis.

The internal consistency of the 36 sustainability indicators was evaluated using Cronbach's Alpha, yielding a reliability coefficient of 0.764, as presented in Table 3.

Table 3. Reliability test for the initial set of sustainability indicators.

Reliability Statistics	
Cronbach's Alpha	**N of Items**
0.764	36

Thus, the instrument used in this study demonstrates sufficient reliability, supporting the credibility of the subsequent findings and analyses.

4.1. Ranking of Sustainability Indicators

To develop a context-specific framework for evaluating sustainability in commercial buildings, an initial set of 36 indicators was evaluated based on expert input. Table 4 presents these indicators along with their corresponding statistical metrics and ranks. Of the 36 indicators, 24 met the predefined threshold criteria and were selected for inclusion in the final sustainability assessment framework. The table includes the sum of weights ($\sum W$), the maximum possible weight ($A \times N = 5 \times 41 = 205$), mean score, standard deviation, calculated Relative Importance Index (RII), and the resulting rank of each indicator. Indicators with higher RII values were considered more significant, reflecting stronger consensus among experts.

Table 4. Final Set of Sustainability Indicators Grouped by Project Phase.

No.	*Code*	*Indicator*	*Project Phase*	*Mean*	*Std. Dev.*	*RII*	*Rank*
1	EnvI_04	Waste management during construction	Construction	4.341	0.575	0.868	2
2	EnvI_12	Low-emission construction equipment is used	Construction	4.293	0.642	0.859	3
3	SocI_04	Worker health and safety compliance during construction	Construction	4.122	0.64	0.824	9
4	SocI_05	Noise and air pollution mitigation during construction	Construction	4.024	0.651	0.805	11
5	EnvI_05	Use of sustainable building materials	Construction	4	0.592	0.8	12
6	EnvI_13	Erosion and sediment control practices	Construction	4.146	0.615	0.829	6
7	EnvI_14	Storm water management system installed	Construction	3.927	0.565	0.785	16
8	EnvI_02	Use of renewable energy sources	Operation	4.39	0.628	0.878	1
9	EnvI_10	Efficient HVAC systems	Operation	4.22	0.613	0.844	5
10	EnvI_03	Water conservation systems	Operation	4.146	0.573	0.829	6
11	EnvI_07	Indoor air quality measures	Operation	3.878	0.557	0.776	18

Table 4. *Cont.*

No.	*Code*	*Indicator*	*Project Phase*	*Mean*	*Std. Dev.*	*RII*	*Rank*
12	EnvI_11	Daylighting and natural ventilation	Operation	3.61	0.666	0.722	22
13	EnvI_15	Light pollution reduction strategies	Operation	3.976	0.612	0.795	13
14	EnvI_06	Green roof or green space integration	Operation	3.951	0.773	0.79	15
15	EnvI_08	Sustainable landscaping	Operation	4.293	0.559	0.859	3
16	SocI_01	Accessibility and inclusivity in design	Operation	3.927	0.721	0.785	16
17	SocI_02	Health and well-being features for occupants	Operation	3.878	0.557	0.776	18
18	SocI_03	Community engagement in planning/design	Cross-cutting	4.122	0.678	0.824	9
19	ImpI_01	Sustainability goals are defined in the project plan	Cross-cutting	3.024	0.57	0.776	18
20	ImpI_04	Staff training on sustainable practices	Cross-cutting	3.585	0.631	0.717	24
21	ImpI_05	Post-occupancy evaluation planned or conducted	Cross-cutting	3.61	0.628	0.722	22
22	EnvI_09	Environmental certification obtained	Cross-cutting	4.146	0.654	0.829	6
23	EcoI_05	Incentives or subsidies secured	Cross-cutting	3	0.592	0.771	21
24	EnvI_01	Energy efficiency measures installed	Cross-cutting	3.976	0.612	0.795	13

4.2. Final Set of Sustainability Indicators for Commercial Building Assessment in Ethiopia

Table 5 presents the final set of 24 sustainability indicators selected for assessing commercial buildings in Ethiopia. These indicators were identified based on their Relative Importance Index (RII), derived from expert ratings on a 5-point Likert scale (1 = Not important to 5 = extremely important). A threshold RII value of 0.717, corresponding approximately to a mean rating of 3.6, was applied to determine inclusion. This cutoff aligns with established practices in the literature [31], ensuring that the selected indicators reflect strong expert consensus and are both statistically valid and contextually relevant.

Table 5. Reliability test for sustainability implementation indicators across 23 commercial buildings.

Reliability Statistics	
Cronbach's Alpha	**N of Items**
0.743	24

The final set of sustainability indicators was grouped according to project phase. Construction-phase indicators capture site-based and material-related sustainability actions, while operation-phase indicators focus on energy, water, and occupant comfort performance. Cross-cutting indicators reflect managerial, policy, and training elements applicable throughout the project lifecycle. This classification supports a more holistic understanding of sustainability integration across design, construction, and operational stages.

4.3. Sustainability Implementation Assessment Results for Commercial Buildings

To address Research Question 2, which investigates the extent to which sustainability indicators have been implemented in recently constructed commercial buildings in Ethiopia, the study conducted an implementation assessment across 23 buildings using the validated set of indicators.

To evaluate the practical application of sustainability principles in commercial buildings, implementation scores were calculated for the 23 buildings using the standardized scoring framework. Each building was assessed against 24 validated indicators, with total scores normalized to a percentage scale ranging from 0% (no implementation) to 100% (full implementation).

Before analyzing the results, the internal consistency of the 24 selected indicators was tested using Cronbach's Alpha. The reliability test was conducted using SPSS software, and the resulting alpha value was 0.743, indicating a good level of internal consistency among the indicators. This confirms that the instrument used to measure sustainability implementation across the buildings was statistically reliable and suitable for quantitative analysis.

Table 6 presents the total raw score for each building, along with the corresponding implementation percentage. This enables a comparative understanding of how effectively each building incorporates sustainability measures into its design, construction, and operation within the Ethiopian context.

Table 6. Implementation Score for Each Commercial Building.

Commercial Building ID	*Total Sum*	*Min_Score*	*Max_Score*	*ImpI. Score (%)*
CB01	45	24	120	21.88
CB02	28	24	120	4.17
CB03	50	24	120	27.08
CB04	44	24	120	20.83
CB05	31	24	120	7.29
CB06	31	24	120	7.29
CB07	31	24	120	7.29
CB08	30	24	120	6.25
CB09	31	24	120	7.29
CB10	36	24	120	12.50
CB11	32	24	120	8.33
CB12	30	24	120	6.25
CB13	29	24	120	5.21
CB14	31	24	120	7.29
CB15	34	24	120	10.42
CB16	34	24	120	10.42
CB17	30	24	120	6.25
CB18	39	24	120	15.63
CB19	33	24	120	9.38
CB20	36	24	120	12.50
CB21	40	24	120	16.67
CB22	29	24	120	5.21
CB23	33	24	120	9.38

4.4. Summary of the Results

The implementation scores across the 23 commercial buildings ranged from 4.17% to 27.08%, reflecting an overall low level of sustainability adoption. The highest score was achieved by Building CB03, with 27.08%, followed by CB21 and CB18, which scored 16.67% and 15.63%, respectively. On the lower end, Building CB02 recorded the lowest score at 4.17%, with CB13 and CB22 following closely at 5.21% each. Notably, more than 70% of the buildings scored below 15%, highlighting the limited integration of sustainability measures within current commercial building practices in Ethiopia. Figure 3 shows the categorization of implementation levels based on percentage scores, classifying buildings into Very Low, Low, Moderate, High, and Very High categories.

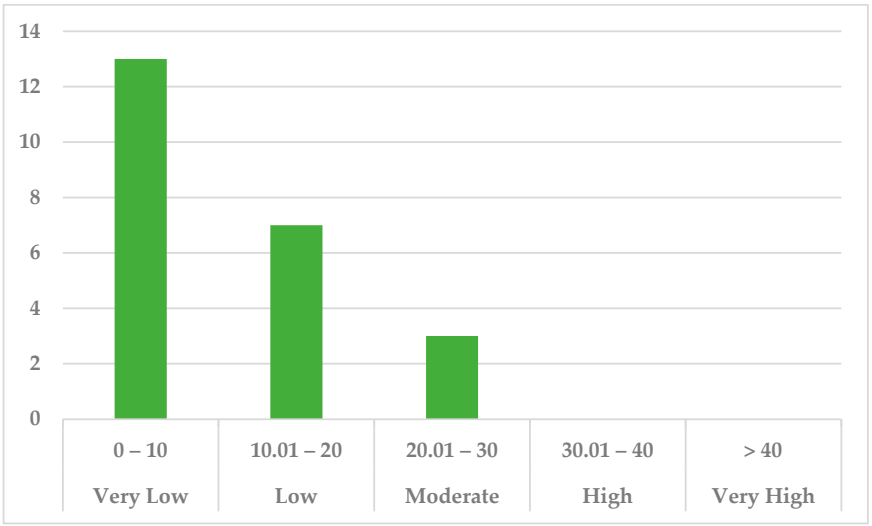


Figure 3. Categorization of Implementation Levels.

This score indicates the extent to which the sustainability measures have been implemented across the commercial buildings. However, it does not capture the absolute quality or specific scope of implementation activities. Instead, it indicates the relative degree of compliance with the selected indicators.

5. Discussion

The first research question aimed to identify sustainability indicators most relevant to Ethiopia's commercial construction sector. Through an extensive review of international sustainable building assessment systems, 36 indicators were initially chosen. Each indicator was backed by at least two independent sources and considered suitable for adaptation in developing countries. These indicators were then prioritized through expert assessment using the Relative Importance Index (RII) method. Based on a threshold RII value of 0.717, which corresponds to a mean rating of about 3.6, As a result, 24 indicators were retained for the final assessment framework, following established sustainability research methods.

5.1. Sustainability Assessment Indicators for Ethiopia's Commercial Construction Sector

The results of this study reveal that environmental indicators dominate sustainability priorities in Ethiopia's commercial building sector. The highest-ranked parameters use of renewable energy sources (RII = 0.878), waste management during construction (0.868), sustainable landscaping (0.859), low-emission construction equipment (0.859), and efficient HVAC systems (0.844) demonstrate a strong emphasis on environmental performance. This finding is consistent with international literature, which identifies energy efficiency, waste reduction, and sustainable material use as core dimensions of green construction [1,26,59]. These priorities are also reflected in global rating frameworks such as LEED and BREEAM, where environmental categories typically account for the largest share of total assessment scores [60].

The prominence of environmental factors aligns with the observations of Zarghami and Fatourehchi [8], who noted that developing countries often emphasize quantifiable, technology-driven sustainability measures that are easier to monitor and justify to stakeholders. This tendency may be attributed to the relative ease of implementing environmental technologies compared to the more complex institutional reforms required for social and economic sustainability.

Social indicators also ranked highly in this study, particularly community engagement in planning and worker health and safety compliance. These results support earlier findings that social well-being and participatory decision-making are gaining traction in construction sustainability discourse [9,13]. However, lower-ranked indicators such as stakeholder education programs and public transportation access suggest that social sustainability remains underdeveloped in Ethiopia's commercial projects. This mirrors global trends where social dimensions are often overshadowed by environmental metrics due to limited regulatory enforcement and public awareness [61].

Economic indicators, including incentives or subsidies secured (RII = 0.771) and life-cycle cost considerations, were among the lowest-ranked. This pattern is consistent with studies by Kinemo [31] and Rwanda GBC [18], which highlight financial constraints and weak policy enforcement as major barriers to sustainable investment in sub-Saharan Africa. The low prioritization of economic factors may also reflect the absence of reliable cost data and fiscal mechanisms that incentivize long-term sustainability planning.

Implementation indicators, such as defining sustainability goals in project plans, post-occupancy evaluation, and staff training, received moderate to low attention. This is in line with findings from Häkkinen and Belloni [62] and Darko and Chan [61], who emphasized that fragmented project management systems and limited technical capacity often hinder

the systematic integration of sustainability metrics. The relatively low ranking of post-occupancy evaluation (RII = 0.722) underscores a persistent gap between design intent and operational performance. Similar challenges have been documented in South Africa and India, where post-construction monitoring remains underutilized [19].

The distribution of indicator rankings confirms that Ethiopia's commercial building sector is in the early stages of sustainability integration. While environmental actions are acknowledged, their application is inconsistent. Social and economic pillars require stronger institutional frameworks, targeted incentives, and capacity-building efforts. These findings reinforce earlier research suggesting that sustainability adoption in developing countries is constrained less by awareness and more by enforcement, training, and financial support mechanisms [13,61]. The proposed indicator framework offers a context-sensitive, empirically grounded tool for establishing national benchmarks and guiding policy toward balanced, lifecycle-oriented sustainability practices in Ethiopia.

Given that Ethiopia currently lacks a formal national sustainability assessment framework, future research could integrate the Analytic Hierarchy Process (AHP) with the Relative Importance Index (RII) to strengthen methodological rigor and support the gradual establishment of such a framework. While RII offers practicality and contextual relevance for current low-resource conditions, AHP can provide hierarchical weighting and consistency testing that enhance analytical reliability. Combining these methods would allow deeper examination of indicator prioritization and lay the groundwork for a standardized and evidence-based sustainability assessment model suitable for Ethiopia's construction sector.

5.2. Sustainability Implementation Assessment in Recently Constructed Commercial Buildings in Ethiopia

The empirical assessment of 23 recently constructed commercial buildings revealed that the level of sustainability implementation across Ethiopia's urban construction sector remains extremely low. Building implementation scores ranged from 4.17% to 27.08%, with an average score of 10.64%, indicating that sustainability principles are only marginally integrated into current practice. More than 70% of the assessed buildings scored below 15%, underscoring the limited adoption of sustainability measures during both the design and operational phases.

This outcome confirms that sustainability remains at an early stage of implementation within Ethiopia's construction industry. Similar findings have been reported in other developing countries, where weak policy frameworks and resource limitations constrain progress. For instance, Assefa et al. [3] observed an average sustainability compliance level of about 40% in pilot-rated Ethiopian projects, while Zarghami and Fatourehchi [8] reported 35–55% compliance rates in developing countries implementing adapted EDGE systems. Compared to these studies, the 10.64% average score in this research highlights a more pronounced implementation gap in Ethiopia's commercial building sector.

The low scores can be attributed to several interrelated barriers. Institutional challenges such as limited enforcement of existing sustainability regulations, lack of standardized building performance metrics, and absence of incentive mechanisms continue to hinder progress. Financial constraints also play a major role, as developers tend to prioritize short-term cost savings over long-term environmental and social benefits. Darko and Chan [61] and Boz and El-Adaway [13] similarly noted that the absence of fiscal policies and technical capacity in developing countries prevents the mainstreaming of sustainability principles.

Moreover, the minimal difference between the highest (27.08%) and lowest (4.17%) performing buildings suggests that sustainability adoption is not limited to project-specific conditions but reflects a system-wide underperformance. The findings therefore align with previous research emphasizing the need for national frameworks, training programs,

and performance-based incentives to bridge the gap between sustainability awareness and implementation.

5.3. General Observations and Patterns

The results indicate that sustainability implementation in the assessed buildings is minimal and highly inconsistent. Only three buildings, CB03, CB01, and CB04, exceeded the 20% threshold, with CB03 scoring the highest at 27.08%. These higher-performing cases likely reflect isolated efforts rather than systemic industry trends. In contrast, buildings such as CB02, CB08, CB12, CB13, CB17, and CB22 scored below 7%, with CB02 performing the lowest at 4.17%. A larger group, including CB05-CB09, CB11-CB14, CB17, CB19, CB22, and CB23, clustered in the 5–10% range. This pattern suggests that only superficial or fragmented sustainability measures are being adopted, lacking strategic integration into the design or construction processes.

As illustrated in Figure 4, the implementation scores of the assessed commercial buildings show considerable variation, with most projects achieving values below 15%, indicating limited integration of sustainability measures during construction and operation. A few buildings, particularly CB01, CB03, and CB18, exhibit relatively higher performance, reflecting partial application of sustainable design strategies and compliance with selected sustainability criteria. These results highlight the uneven adoption of sustainability practices among commercial developments in Ethiopia and underscore the need for stronger regulatory frameworks, institutional capacity, and awareness to promote consistent implementation across the sector.

5.4. Central Tendencies and Dispersion

The average sustainability implementation score across all 23 buildings was 10.64%. Notably, over 69.56% of buildings scored below this average. The narrow score range and minimal variance suggest that underperformance is not limited to specific projects but reflects broader, systemic deficiencies within the commercial construction sector. The consistently low scores across different building types and locations also highlight the absence of supportive policy frameworks, technical expertise, and sustainability awareness among industry professionals [61].

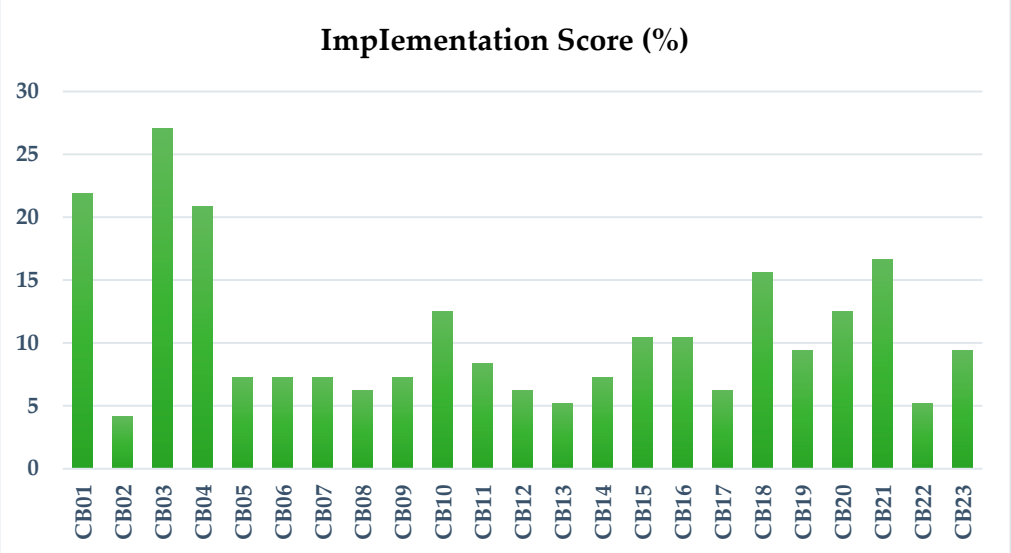


Figure 4. Sustainability implementation score in Ethiopian commercial buildings.

5.5. Implications of Uniformly Low Implementation Score

The assessment reveals a consistently low level of sustainable construction implementation. This widespread underperformance indicates systemic challenges rather than isolated project issues and has serious implications for environmental, economic, and social sustainability.

Although earlier reports [23] noted limited progress in enforcing sustainability-related regulations in Ethiopia, more recent developments indicate modest but notable improvements. The Ethiopian Building Proclamation No. 624/2009 and the Construction Industry Policy [63] remain the principal legal instruments governing building practices, while the National Building Energy Code [64] and the Green Building Minimum Compliance Framework [65] are emerging initiatives aimed at improving energy efficiency, water conservation, and environmental performance in urban construction. Despite these advances, enforcement and adoption remain inconsistent, largely due to resource constraints, low institutional capacity, and limited awareness among project stakeholders [63–65]. Widespread integration across the commercial building sector remains limited, underscoring the need for stronger regulatory mechanisms and local capacity-building to sustain the benefits of such international cooperation.

The findings also point to significant capacity and knowledge gaps within the construction industry. Most professionals lack training in sustainable design and materials, and there is limited access to sustainable technologies and building systems. Without targeted education and certification programs, sustainable practices will remain underutilized [32].

Financially, the failure to implement sustainable strategies results in higher long-term operational costs for building owners and tenants [66]. In urban centers like Addis Ababa, this trend places additional pressure on the electricity grid and public infrastructure, increasing environmental degradation and energy insecurity [67].

Socially, the implications are also profound. Many commercial buildings fail to provide adequate indoor air quality, natural lighting, and thermal comfort issues which disproportionately affect workers in retail, office, and service industries. This not only undermines health and productivity but also contradicts Ethiopia's national Ten-Year development goals tied to equitable urban growth [68].

To address these problems, a coordinated response is necessary: reinforcing enforcement of building codes, incorporating sustainability into technical training, and offering financial and regulatory incentives for developers [30]. Without these measures, Ethiopia risks committing to inefficient, unsustainable infrastructure that will be expensive to retrofit and harmful to long-term development goals [5].

5.6. Benchmarking and International Comparison

When benchmarked against global sustainability frameworks, the results indicate that Ethiopia's commercial buildings perform substantially below international certification thresholds. Global rating systems, such as LEED, BREEAM, and EDGE, generally require projects to meet at least 50% of the total assessment criteria to achieve entry-level certification [60]. In contrast, the highest-performing building in this study attained only 27.08%, confirming that sustainability implementation within Ethiopia's commercial building sector is still at an early developmental stage.

Similar performance gaps have been reported in other developing nations. Zarghami and Fatourehchi [8] found that buildings in countries such as Iran and Malaysia achieved between 35% and 55% of assessment criteria, while Boz and El-Adaway [13] observed that African and Middle Eastern projects frequently fall below 40% due to weak institutional enforcement and insufficient awareness of sustainability guidelines. Studies in Rwanda and Kenya have also shown that limited government incentives and the absence

of national benchmarking frameworks hinder full integration of sustainable construction practices [9,18].

In contrast, countries that have established their own localized rating frameworks, such as India with the Energy Conservation Building Code (ECBC) [6] and Singapore with the Green Mark system, have achieved measurable improvements in sustainable design and operational performance [60]. These comparative insights reinforce that national-level policy alignment, capacity development, and funding mechanisms are critical drivers of progress.

The persistent performance gap observed in Ethiopia reflects the same structural barriers reported by Abebe et al. [1] and Gashaw et al. [26], including limited technical expertise, lack of professional training, and weak policy implementation. Addressing these challenges will require the establishment of a national sustainability rating framework, stronger institutional mechanisms, and targeted investment programs. Without such coordinated efforts, Ethiopia is unlikely to achieve the sustainability milestones defined under SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) [57].

6. Conclusions

This study provides one of the first empirical assessments of sustainability implementation in Ethiopia's commercial building sector, addressing a significant gap in both academic research and national policy. A total of 36 sustainability indicators were initially identified from international frameworks such as LEED, BREEAM, EDGE, and WELL. Through expert evaluation and application of the Relative Importance Index (RII), the list was refined to 24 validated indicators, supported by a Cronbach's alpha reliability coefficient of 0.764, indicating strong internal consistency. Among these, the highest-ranked indicators were the use of renewable energy sources (RII = 0.878), waste management during construction (RII = 0.868), sustainable landscaping (RII = 0.859), and low-emission construction equipment (RII = 0.859). These results highlight a clear prioritization of environmental factors, reflecting the global shift toward energy efficiency and resource-conscious design.

In terms of practical implementation, the assessment of 23 commercial buildings demonstrated very limited integration of sustainability practices. Implementation scores ranged from 4.17% to 27.08%, with an average of 10.64%, and more than 70% of the evaluated buildings scored below 15%. This outcome indicates that sustainable construction remains at an early stage of adoption. The findings point to several systemic barriers, including weak institutional enforcement, low technical capacity, limited awareness among professionals, and insufficient financial or regulatory incentives.

Despite these challenges, the indicator-based framework developed in this study provides a quantitative and replicable foundation for sustainability benchmarking in low-resource settings. By integrating expert-validated indicators and a structured scoring methodology, the framework enables continuous performance tracking and evidence-based policy formulation.

To advance sustainability in Ethiopia's commercial construction sector, a coordinated national strategy is essential. This should include mandatory sustainability benchmarks, capacity-building programs, and financial incentives to motivate developers. Increasing the current average sustainability score of 10.64% toward the 50% threshold required for entry-level global certification (e.g., LEED or BREEAM) would represent a major milestone in aligning Ethiopia's construction practices with international standards.

We recommend that future studies extend this work by, first, applying the Analytic Hierarchy Process (AHP) to the validated indicator set to obtain hierarchical weights and evaluate judgment consistency. Second, conducting triangulation between the Relative Importance Index (RII) and AHP, along with formal sensitivity analysis, to test the reliability

of indicator rankings across methods. Third, integrating AHP-derived weights into pilot scoring of additional buildings, ideally alongside post-occupancy data, to examine effects on building-level scores and policy targets.

Ultimately, embedding sustainability within Ethiopia's rapidly urbanizing construction landscape is vital to reducing environmental impacts, improving building performance, and fulfilling national commitments to the United Nations Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). The study therefore contributes both a methodological innovation and a quantitative evidence base for guiding the Ethiopian construction industry toward a more sustainable and resilient future.

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Institutional Review Board Statement: According to the BDU Senate Legislation 2020, given that the study involved a non-interventional questionnaire without sensitive health data or clinical procedures, and that informed consent and anonymity were strictly maintained, it falls under the category of research that does not require formal Ethics Committee approval per institutional legislation.

Informed Consent Statement: Informed consent was obtained from all participants involved in the study. Participation was voluntary, and respondents were informed about the purpose of the research, their right to withdraw at any time, and the confidentiality of their responses. No personal identifiers were collected, and all responses were analyzed anonymously.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

RII	Relative Importance Index
LEED	Leadership in Energy and Environmental Design
BREEAM	Building Research Establishment Environmental Assessment Method
EDGE	Excellence in Design for Greater Efficiencies
WELL	WELL Building Standard
ISO	International Organization for Standardization
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
OSHA	Occupational Safety and Health Administration
GRI	Global Reporting Initiative
GRESB	Global Real Estate Sustainability Benchmark
CSR	Corporate Social Responsibility
SDG	Sustainable Development Goal
SDGs	Sustainable Development Goals
PMI	Project Management Institute
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
MCDA	Multi Criteria Decision Analysis
POE	Post Occupancy Evaluation
HVAC	Heating, Ventilation, and Air Conditioning

IEQ	Indoor Environmental Quality
ROI	Return on Investment
IRB	Institutional Review Board
UNEP	United Nations Environment Programme
IFC	International Finance Corporation
IWBI	International WELL Building Institute
ISI	Institute for Sustainable Infrastructure
O + M	Operations and Maintenance
SPSS	Statistical Package for the Social Sciences
MS	Microsoft
CB	Commercial Building
CO_2	Carbon dioxide
m^2	Square meters
ESIA	Environmental and Social Impact Assessment
EEP	Ethiopian Electric Power
PDC	Planning and Development Commission
FDRE	Federal Democratic Republic of Ethiopia

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