DRAFT

MINISTRY OF HOUSING AND PUBLIC WORKS

Design for Environment and Sustainable Habitats

With financial support from:
Federal Ministry for Economic Cooperation and Development

MINISTRY OF HOUSING AND PUBLIC WORKS

FRAMEWORK

FOR THE DEVELOPMENT OF A NATIONAL SUSTAINABLE BUILDING ASSESSMENT SYSTEM

FOR BANGLADESH

DRAFT

March 2025

Project

Transforming the Built Environment Through Sustainable Materials

UNOPS

in collaboration with

Housing and Building Research Institute (HBRI)

With financial support from:

Federal Ministry for Economic Cooperation and Development

Acknowledgements

The Framework for the Development of A National Sustainable Building Assessment System for Bangladesh was prepared by Dr. Md. Ashikur Rahman Joarder, Health, Safety, Social and Environmental Specialist, with contributions from Dr. Giasuddin Haider, Director General, HBRI; Dr. Morshed Alam, Swinburne University of Technology, Australia; Dr. Usha Iyer-Raniga, RMIT University, Australia; Celia Martinez Juez, UNEP, Ar. Umang Agarwal, Global EDGE Expert and Green Building Auditor; Ar. Muktadir Abedin, HBRI; Engr. Syed Ahmed Tasnim, HBRI; Engr. Md Ibnul Warah, HBRI; and Engr. Mariam Hossain Nupur, HBRI.

The preparation of this technical report was made possible through the collaborative efforts, institutional support and professional guidance of several national and international organizations and different individuals committed to advancing sustainable development in Bangladesh's built environment. We gratefully acknowledge the Ministry of Housing and Public Works (MoHPW), Government of the People's Republic of Bangladesh, for providing overall policy guidance and strategic direction in advancing the agenda of green building and sustainable construction. Special appreciation is extended to the Housing and Building Research Institute (HBRI) for its technical leadership, domain expertise and continuous support throughout the benchmarking, assessment and framework development process.

This work was undertaken with the support of the United Nations Office for Project Services (UNOPS), whose coordination, technical oversight and project management contributions were instrumental in ensuring the quality and rigor of the study. We also acknowledge the valuable support of the UN Environment Programme (UNEP), German Federal Ministry for Economic Cooperation and Development (BMZ) and GlobalABC, particularly in relation to global best practices, sustainability frameworks and policy alignment. Financial and technical assistance provided through international cooperation partners is gratefully recognized.

The study benefited significantly from the contributions of the different project consultants and global experts, whose insights into international rating systems, performance-based assessment methodologies and regional adaptation strategies strengthened the analytical foundation of the report. Appreciation is also extended to the working team members, researchers and technical staff who supported data collection, comparative analysis and documentation.

Finally, we acknowledge the broader community of practitioners, policymakers and academics whose prior research and professional work informed this benchmarking exercise. Their collective efforts have laid a robust foundation for a context-responsive, nationally integrated, sustainable building assessment system for Bangladesh.

Executive Summary

The building and construction sector in Bangladesh is a major contributor to energy consumption, water use, material extraction and greenhouse gas emissions. Rapid urbanization, increasing development density and escalating climate risks, including flooding, cyclones, heat stress and salinity intrusion, have significantly intensified the environmental and socio-economic pressures on the built environment. In this context, sustainable building assessment systems are essential policy and technical instruments to guide environmentally responsible, resource-efficient and climate-resilient development.

This report presents a comprehensive benchmarking and critical review of leading global, regional and national green building assessment systems, including Leadership in Energy and Environmental Design (LEED), USA; Excellence in Design for Greater Efficiencies (EDGE), IFC; Building Research Establishment Environmental Assessment Method (BREEAM), UK; Comprehensive Assessment System for Built Environment Efficiency (CASBEE), Japan; Green Rating for Integrated Habitat Assessment (GRIHA), India; GREEN^{SL} Rating System of the Green Building Council Sri Lanka (GBCSL), Sri Lanka; Building Energy Efficiency and Environment Rating (BEEER), Bangladesh; and Green Affordable and Resilient Certification for Habitats (GreenARCH), Bangladesh. The analysis identifies best practices, methodological gaps and contextual limitations, forming the basis for a nationally appropriate system. The benchmarking exercise highlights that, although existing green building assessment systems provide valuable technical foundations, none fully address Bangladesh's specific climatic, environmental and socio-economic conditions. International frameworks often emphasize technology-driven solutions suited to temperate climates, while existing national systems remain limited in scope and methodological consistency. This creates a critical need for a unified, context-responsive framework that integrates global best practices with local priorities such as climate resilience, passive design and individual behavior. Building on this foundation, the report proposes the design and operationalization of the DESH (Design for Environment and Sustainable Habitats) web-based platform. "DESH" (দেশ), meaning "country" in Bengali, represents a nationally contextualized, emission-governed and performance-verified assessment system tailored to Bangladesh's climatic, urban and socio-economic conditions. The platform is conceived not only as a certification mechanism but also as a dynamic design-support and evaluation tool.

The DESH framework aligns with Bangladesh's national policies and international climate commitments. The Bangladesh Climate Change Strategy and Action Plan (2009) established the foundation for climate-responsive development, while the National Adaptation Plan (2023–2050) prioritizes resilient urban systems. The Climate Action Roadmap for Buildings and Construction Sector (2024) provides sector-specific guidance on decarbonization and lifecycle assessment. Bangladesh's Nationally Determined Contributions (NDCs) under the Paris Agreement emphasize emission reductions in the building sector. Together, these frameworks provide a strong policy basis for DESH.

The DESH framework adopts a holistic, performance-driven methodology that integrates embodied and operational carbon within a circular life-cycle perspective, supporting long-term decarbonization. It strategically prioritizes residential buildings, recognizing their dominant contribution to energy use and emissions in Bangladesh, thereby maximizing early impact. The framework views buildings as dynamic, living systems whose performance evolves and is influenced by both design decisions and user behavior. The assessment process is structured as a diagnostic tool (similar to medical science), in which performance gaps are identified, monitored and addressed through evidence-based interventions. The methodology introduces a shift from prescriptive and additive approaches toward a preventive assessment logic that discourages environmentally harmful practices from the outset. It further incorporates location-sensitive evaluation, accounting for urban density, microclimate and surrounding built form. Organized across key thematic domains, including Climate Adaptation and Resilience; Site Sustainability and Planning; Materials and Resources; Water and Waste Management; Energy Conservation and Environmental Quality; Energy Efficiency and Renewable Energy; and Lifestyle, Social, Health and Safety, the system is operationalized through a digitally enabled platform. This platform supports real-time performance evaluation, dynamic labeling across design, construction and operational stages, and the integration of simulation, BIM, and geospatial data, ultimately contributing to the transition toward healthy, nearly Zero Emission Communities (neZECom: নিজে কম).

The implementation of DESH is expected to significantly reduce energy demand, carbon emissions and resource use while enhancing climate resilience and occupant health. It promotes passive design, renewable energy integration and circular construction practices, enabling evidence-based decision-making across the building lifecycle. The framework also supports improved policy alignment, market transformation and increased adoption of sustainable practices in both new and existing buildings. A phased implementation strategy is proposed, including institutional development, stakeholder engagement, capacity building and pilot projects. The deployment of a web-based platform will facilitate accessibility and transparency. Policy support mechanisms, such as financial incentives, regulatory integration and certification-linked benefits, will encourage adoption. Continuous monitoring, feedback and periodic updates will ensure long-term relevance. Overall, DESH represents a transformative, context-responsive framework to support Bangladesh's sustainable development goals and global climate commitments.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BEE	Building Environmental Efficiency
BEEER	Building Energy Efficiency and Environment Rating
BER	Building Energy Rating
BNBC	Bangladesh National Building Code
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
EDGE	Excellence in Design for Greater Efficiencies
GreenARCH	Green Affordable and Resilient Certification for Habitats
GREEN^{SL}	Sri Lanka Green Building Rating System
GRIHA	Green Rating for Integrated Habitat Assessment
HBRI	Housing and Building Research Institute
IFC	International Finance Corporation
LEED	Leadership in Energy and Environmental Design
RMG	Ready-Made Garment
SREDA	Sustainable and Renewable Energy Development Authority
TERI	The Energy and Resources Institute
USGBC	U.S. Green Building Council
WB	World Bank

1 Introduction

The building sector accounts for a substantial proportion of national electricity consumption, water use and material demand in Bangladesh, while also contributing significantly to greenhouse gas emissions and urban environmental degradation. As cities expand and building stock increases, the need for sustainable, resource-efficient and climate-resilient buildings has become a national priority.

Globally, green building certification and assessment systems have been developed to provide structured frameworks for evaluating and improving building performance across the entire life cycle, from site selection and design to construction, operation, and eventual refurbishment. These systems serve not only as technical assessment tools but also as market mechanisms that incentivize higher environmental performance and inform policy development.

Bangladesh's vulnerability to climate change, combined with socio-economic constraints and capacity limitations, necessitates a sustainable/green building assessment system that is locally contextualized, affordable and aligned with national regulatory frameworks. This report reviews benchmark global and regional systems to inform the formulation of a sustainable building assessment system for Bangladesh.

2 Background

Since the early 1990s, green building rating systems such as the Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED) have evolved to address growing concerns about energy efficiency, environmental protection, and occupant health. Over time, these systems have expanded to incorporate lifecycle assessment, carbon reduction and performance verification.

In Asia, national systems such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE), Japan; Green Rating for Integrated Habitat Assessment (GRIHA), India; and the GREENSL Rating System of the Green Building Council Sri Lanka (GBCSL), Sri Lanka, have emerged in response to the limitations of adopting international systems without contextual adaptation. These systems prioritize climate responsiveness, local materials and affordability.

In Bangladesh, the Bangladesh National Building Code (BNBC 2020) establishes mandatory minimum standards for safety, energy efficiency and accessibility. Complementary initiatives such as the Building Energy Efficiency and Environment Rating (BEEER), implemented by the Sustainable and Renewable Energy Development Authority (SREDA), and the Green Affordable and Resilient Certification for Habitats (GreenARCH), developed by the Housing and Building Research Institute (HBRI), promote enhanced sustainability performance beyond regulatory compliance. However, the absence of an integrated national sustainable/green building assessment system underscores the need for a new one in Bangladesh.

3 Aim and Objectives

This study aims to benchmark selected global and regional green building certification systems to inform the development of a nationally appropriate sustainable building assessment system for Bangladesh.

Specific objectives include the following.

- To review the scope, philosophy and assessment methodologies of benchmark systems.
- To compare evaluation categories and credit structures.
- To identify strengths, limitations and contextual relevance for Bangladesh.

- To develop a comparative credit-level mapping matrix.
- To formulate policy and technical recommendations for a new sustainable building assessment system for Bangladesh.

4 Methodology

The methodology for developing the sustainable building assessment system for Bangladesh is grounded in a context-specific, health-centered, and performance-driven philosophy. Rather than adopting or replicating an existing international green building certification model, the proposed methodology follows a critical and adaptive process aimed at identifying the limitations of prevailing national and international rating systems and translating those lessons into a framework that is better suited to Bangladesh's climatic conditions, construction practices, energy consumption patterns, and socio-economic realities. The approach recognizes buildings as complex, living systems whose environmental performance directly affects human health, safety, and well-being, and therefore treats building assessment as a diagnostic and preventive process rather than a post-design compliance exercise.

At the core of the methodology is the "healthy building design concept," which frames the assessment process as a health check-up of the building. This analogy underscores the importance of accurate, context-appropriate evaluation tools and indicators. Just as incorrect medical tests can lead to misdiagnosis, inappropriate assessment criteria can incorrectly classify buildings as green or non-green. The methodological emphasis is therefore placed on diagnostic accuracy, contextual relevance, and early-stage design integration. Figure 1 presents the methodology for developing the sustainable building assessment system for Bangladesh.

Figure 1. The methodology for developing the sustainable building assessment system for Bangladesh.

4.1 Review and Critical Analysis of Existing Rating Systems

The first methodological step involves a comprehensive review of existing international and national green building rating systems that are currently applied or referenced in Bangladesh. This employed a qualitative benchmarking method, informed by an extensive review of secondary sources, including official rating manuals, technical guidelines, policy documents and institutional publications. The benchmark systems reviewed include LEED, EDGE, BREEAM, CASBEE, GRIHA, GREEN^{SL}, BEEER and GreenARCH. Each system was evaluated against common criteria, including rating philosophy, assessment categories, credit weighting, certification process, verification mechanisms and applicability to developing-country contexts. A comparative matrix was prepared to map credit-level equivalencies with a new assessment system for Bangladesh. This review does not seek to identify a single "best" system for direct adoption. Instead, it systematically examines the structure, indicators, scoring logic, climatic assumptions, and implementation mechanisms of existing systems to identify their strengths, limitations, and contextual mismatches when applied in Bangladesh.

Particular attention was given to how these systems address climate responsiveness, energy performance, occupant comfort, urban context, and residential buildings. The analysis explicitly considers the limitations of rating systems developed for temperate climates, where heating demand and seasonal variation dominate, in contrast to Bangladesh's hot–humid climate, where cooling, ventilation, and moisture control are the primary concerns. The findings of this critical review served as the empirical basis for redefining evaluation categories, performance benchmarks, and assessment logic within a Bangladesh-specific framework.

4.2 Coordination with the National Building Code

The methodology explicitly defines the relationship between the proposed assessment system and the Bangladesh National Building Code (BNBC, 2020), which is currently under revision. The building code is treated as the minimum acceptable standard for health, safety, and performance, while the assessment system was intended to encourage performance beyond code compliance.

To avoid redundancy and confusion, the methodology ensures that points are not awarded for merely meeting code requirements. Instead, performance improvements above the code baseline, such as demonstrable reductions in energy use or carbon emissions relative to a defined reference building typology, were rewarded. This clear differentiation allowed the code and the assessment system to "speak to each other" while serving distinct but complementary roles.

4.3 Alignment with National Climate Goals and Policy Frameworks

A critical methodological requirement is alignment with Bangladesh's national climate strategies and Nationally Determined Contributions (NDC). The assessment system is designed not merely as a voluntary market instrument but as a policy-support tool that contributes directly to national decarbonization and resilience objectives. Existing work from the first phase of the project, including the 'Bangladesh Climate Action Roadmap for the Buildings and Construction Sector' developed under the Ministry of Housing & Public Works (MoHPW, 2024), provides a foundational policy and institutional reference for this alignment.

The methodology envisions an initial voluntary implementation phase to encourage market uptake, followed by a gradual transition toward mandatory application in line with national policy goals. This phased approach ensures feasibility while maintaining long-term ambition.

Together, this framework establishes a transparent, performance-driven, and Bangladesh-specific methodology focusing on calculating carbon emissions. By linking building-level performance to national climate commitments, the framework ensures that carbon assessments contribute meaningfully to Bangladesh's pathway toward low-carbon, healthy, and nearly zero-emission communities.

4.4 Institutional Development and Stakeholder Engagement

The methodology includes the formation of dedicated committees and institutional bodies to guide, review, and update the assessment system over time. This institutional framework ensures continuity, transparency, and adaptability, enabling the assessment system to evolve in response to emerging challenges and new data.

Focus group discussions were conducted with construction professionals, facility managers, policymakers, and building occupants to assess the capacity of the national construction and building sectors to adopt low-carbon practices. These engagements also explore how improvements enhance occupant health, comfort, and quality of life, reinforcing the healthy building design concept that underpins the assessment system.

Broad and continuous stakeholder consultation is a foundational element of the methodology. The development process actively engages relevant government ministries, regulatory bodies, public works departments, academic institutions, and private-sector actors, particularly real estate developers, who play a decisive role in shaping the built environment. Early engagement with institutions such as the National Board of Revenue (NBR) is also considered essential for designing effective incentive structures.

4.5 National Validation and Standards Development

National-level stakeholder workshops were organized to validate the carbon calculation framework, align it with emerging standards and certification pathways, and assess its suitability for implementation within Bangladesh's regulatory and institutional context. These workshops support the co-development of operational carbon benchmarks, performance thresholds, and assessment criteria.

4.1 Training and Long-Term Implementation

Based on outcomes from stakeholder consultations and workshops, targeted training programs were developed to build long-term capacity among designers, engineers, facility managers, and regulators. These programs support consistent application, monitoring, and future refinement of the operational carbon framework as an integral component of the building assessment system.

4.2 Incentive Mechanisms and Economic Viability

Recognizing that higher environmental performance often requires additional upfront investment, the methodology incorporates the development of incentive mechanisms as an integral component of the assessment system. These incentives are intended to ensure economic viability and market acceptance, particularly among private sector developers and building owners.

Potential incentive mechanisms include fiscal measures, such as tax benefits, as well as other regulatory or financial advantages linked to higher achievement levels. The methodology emphasizes that the success of the assessment system depends not only on technical rigor but also on its ability to create tangible value for stakeholders.

4.1 Economic and Financial Feasibility Assessment

The economic and financial implications of carbon-reduction strategies were assessed alongside their technical performance. Life-cycle cost analysis, payback periods, and affordability considerations are incorporated to ensure that recommended measures are economically viable and scalable, particularly for public and residential buildings with limited capital investment capacity.

4.2 Next Steps and Continuous Development

The immediate next step in the methodology involves the formal establishment of committees and working bodies to oversee green building initiatives on a sustained basis. In parallel, the development of a functional demonstration version of the assessment platform serves as a communication and validation tool for stakeholders. Through iterative testing, feedback, and refinement, the methodology supports a continuous improvement process that strengthens the assessment system's technical credibility, policy relevance, and practical impact.

5 Benchmark Green Building Assessment Systems

Despite growing awareness of sustainable construction, the adoption of green building practices in Bangladesh remains limited due to persistent misconceptions about costs, technical complexity, and return on investment. Green building design is often perceived as expensive and reliant on advanced technologies, which discourages adoption, particularly in the residential sector, where small- and medium-scale developers dominate. These perceptions highlight the importance of critically examining existing green building certification and assessment systems (Figure 2) to evaluate their relevance, limitations and adaptability within the national context.

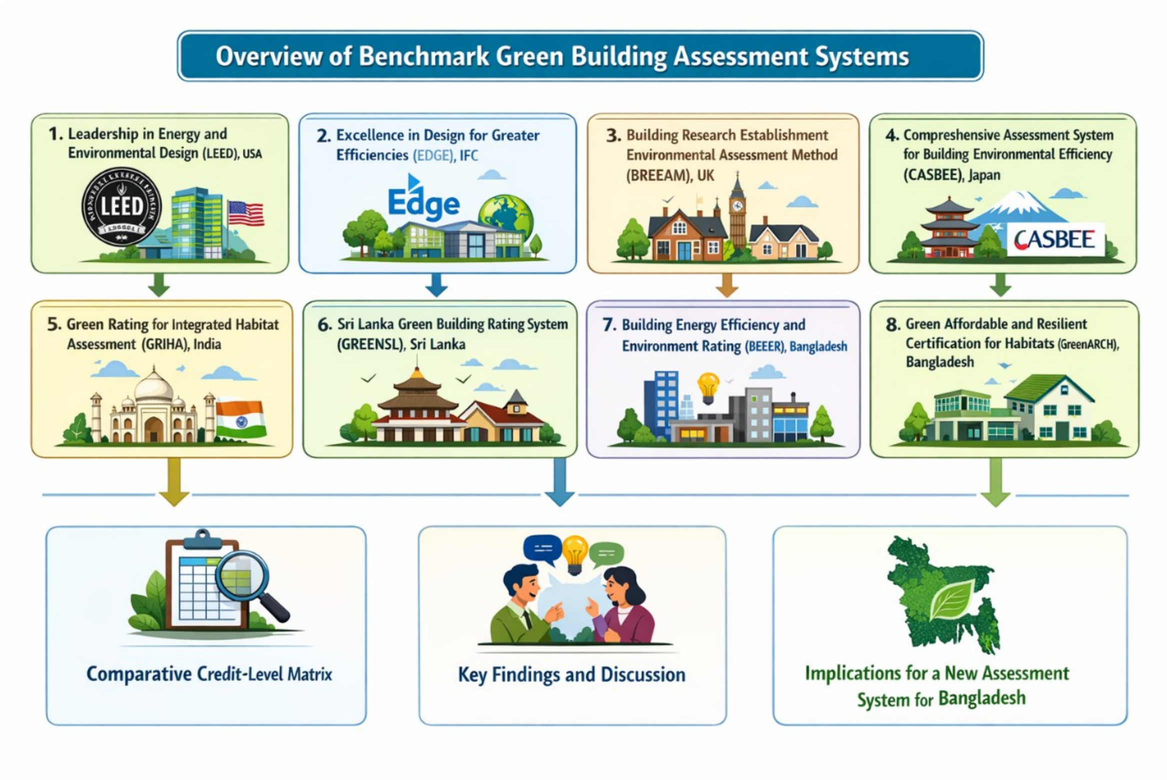


Figure 2. Overview of benchmark green building assessment systems

Globally recognized rating systems such as LEED, EDGE, BREEAM and CASBEE have played a significant role in advancing standardized sustainability benchmarks internationally. These systems provide structured methodologies for assessing environmental performance in both new and existing buildings across commercial and residential sectors. Their applicability in developing-country contexts varies considerably due to differences in cost structures, documentation requirements and technical capacity.

In many cases, international certification systems have limited alignment with low-cost passive design strategies commonly used in tropical and subtropical climates, such as natural ventilation, daylighting, and low-energy construction methods. As a result, direct application of such systems may not adequately address affordability and climate responsiveness, particularly for mass housing and residential developments in Bangladesh.

Recognizing these limitations, several countries have developed national or regional green building assessment systems tailored to local climatic, economic and institutional conditions. GRIHA in India and GREEN^{SL} in Sri Lanka emphasize climate-responsive design, use of local materials, and incremental performance improvement. In Bangladesh, initiatives such as the BEEER and GreenARCH reflect increasing efforts to integrate green building assessment with national energy policies, regulatory frameworks and climate resilience priorities.

This study benchmarks global, regional and national rating systems to identify transferable best practices and contextual gaps. The comparative assessment provides an evidence-based foundation for developing an assessment system for Bangladesh that is technically sound, economically feasible and aligned with national development goals, regulatory instruments and local construction practices.

5.1 Leadership in Energy and Environmental Design (LEED), USA

LEED is a globally recognized green building certification system developed and administered by the U.S. Green Building Council (USGBC). Since its introduction in 1998, LEED has become one of the most widely adopted sustainability assessment frameworks worldwide, with applications across diverse building typologies, including new construction, existing buildings, interiors, residential projects, neighborhoods and cities. LEED operates on a points-based system, awarding certification levels (e.g., Certified, Silver, Gold and Platinum) based on cumulative performance across multiple sustainability categories.

The LEED framework evaluates building performance across key thematic areas, including location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and regional priority. A defining feature of LEED is its strong emphasis on energy performance, greenhouse gas reduction, lifecycle assessment of materials, and verification through energy modeling and commissioning. LEED also places significant importance on occupant health and well-being by promoting daylighting, thermal comfort, indoor air quality and low-emitting materials.

The adoption of the LEED certification system in Bangladesh accelerated significantly after 2013 (Figure 3), particularly within the Ready-Made Garment (RMG) sector. This shift followed the collapse of the Rana Plaza building in Dhaka in April 2013. This catastrophic structural failure resulted in the loss of more than one thousand lives and injuries to several thousand workers. The incident drew unprecedented national and international attention to deficiencies in building safety, construction practices and workplace conditions in Bangladesh's industrial sector (BBC, 2013; Alam, 2013; Tansy, 2015).

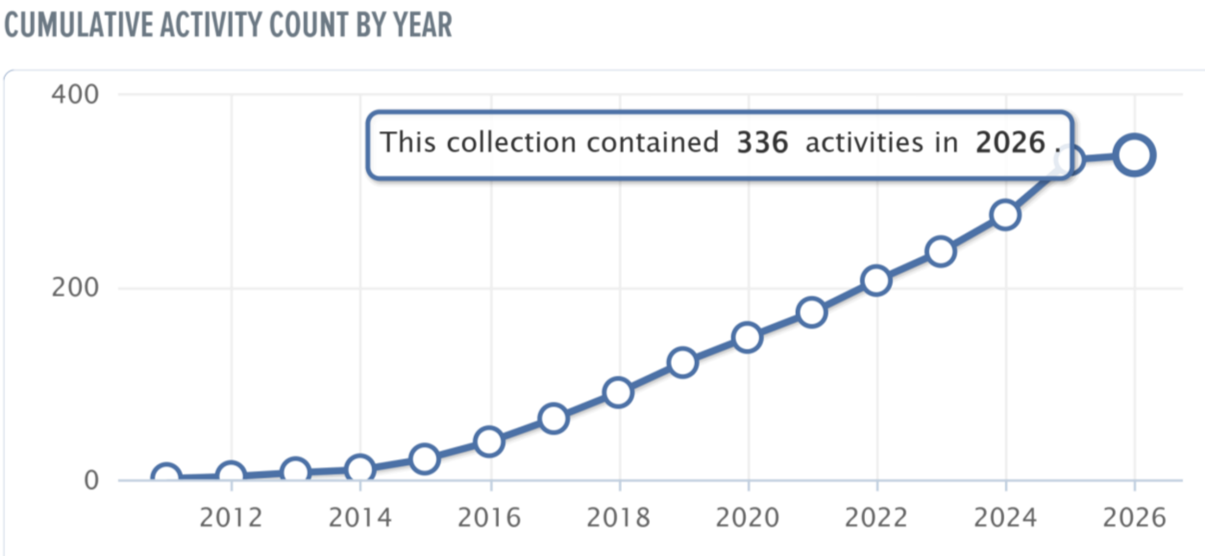


Figure 3. Cumulative LEED Activity in Bangladesh[1].

[1] Source: LEED website: https://www.gbig.org/collections/analyze_search?action=analyze&search%5Bactivity_brand_id%5D=1&search%5Bplace_ids%5D=77

LEED was actively promoted to garment factory owners not only as an environmental certification but also as a means to enhance indoor environmental quality, site safety, and overall building performance. As a result, Bangladesh became one of the leading countries globally in terms of LEED-certified industrial buildings, particularly in new factory construction. The certification process contributed to improvements in several areas, including site hazard assessment, material quality control, construction documentation and adherence to recognized building standards.

LEED's methodological rigor and global credibility have contributed to its acceptance by multinational developers, investors and financial institutions. The system requires advanced technical expertise, extensive documentation and relatively high certification costs. These factors limit its accessibility in developing-country contexts, i.e., Bangladesh. Despite these technical improvements, questions emerged regarding the overall suitability and economic effectiveness of LEED in the Bangladeshi context. Many factory owners expressed frustration with the high certification costs and the limited financial returns from international buyers. Although LEED-certified factories typically involved higher construction costs, often estimated at 20 to 30 percent above conventional industrial buildings, these investments were not consistently matched by higher product prices or long-term commercial incentives. This experience highlights the challenges of relying on international certification systems without adequate alignment to local economic conditions, regulatory frameworks and incentive mechanisms in Bangladesh. Despite these limitations, LEED remains a valuable global benchmark, offering best practices and technical depth that can inform the development of nationally adapted systems.

5.2 Excellence in Design for Greater Efficiencies (EDGE), IFC

EDGE is a green building certification system developed by the International Finance Corporation (IFC), part of the World Bank (WB) Group. EDGE was specifically designed to support sustainable construction in emerging markets by offering a simplified, performance-based and cost-effective certification approach. Unlike comprehensive rating systems that assess a wide range of sustainability indicators, EDGE focuses on achieving measurable improvements in resource efficiency.

To qualify for EDGE certification, a project must demonstrate at least 20 percent savings in operational energy use, water consumption, and embodied energy in construction materials compared to a locally defined baseline. These savings are assessed using the EDGE software tool, which incorporates country-specific climate data, construction practices and utility benchmarks. Certification is available at three levels: EDGE Certified, EDGE Advanced (requiring at least 40 percent energy savings), and Zero Carbon.

EDGE's principal strength lies in its simplicity and accessibility. The streamlined assessment process, limited documentation requirements and clear performance thresholds make it particularly attractive to developers, housing authorities and financial institutions in low- and middle-income countries. EDGE has been widely adopted in residential, commercial, and mixed-use developments and is often linked to green financing and incentive mechanisms.

EDGE's narrow scope means that several sustainability dimensions, such as indoor environmental quality, site ecology, climate resilience and social considerations, are not comprehensively addressed. EDGE functions most effectively as an entry-level or complementary system. For Bangladesh, EDGE provides a useful model for performance-based efficiency assessment; however, it requires integration with broader sustainability criteria under a comprehensive national framework.

5.3 Building Research Establishment Environmental Assessment Method (BREEAM), UK

BREEAM, developed by the UK-based Building Research Establishment (BRE) in 1990, is one of the oldest and most widely recognized green building certification systems worldwide. Similar to LEED and EDGE, BREEAM provides a comprehensive framework for assessing the environmental performance of buildings across their entire lifecycle, from design and construction to operation and maintenance. The system evaluates multiple sustainability categories, including energy efficiency, water usage, materials, waste management, land use, ecology, pollution, health and well-being, and innovation.

BREEAM uses a point-based scoring system in which buildings earn credits for implementing sustainable practices. Based on the total score, a project can achieve ratings ranging from Pass, Good, Very Good, Excellent, to Outstanding. This encourages continuous improvement, innovation and adoption of best practices in sustainable construction. BREEAM certifications are applicable to a wide range of building types, including commercial, residential, industrial and infrastructure projects, making it highly versatile for global adoption.

The system not only helps reduce environmental impacts but also promotes economic and social benefits, such as operational cost savings, enhanced occupant comfort and increased asset value. BREEAM emphasizes a holistic approach to sustainability, integrating energy efficiency with broader ecological, social and economic considerations. Its rigorous methodology and adaptability have made it a benchmark for sustainable building assessment, comparable in scope and influence to other global rating systems.

5.4 Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Japan

CASBEE is Japan's national green building assessment system, developed through a collaborative effort involving the Japanese government, academic institutions and industry experts. CASBEE was introduced to promote environmentally responsible building design and operation while balancing environmental performance with occupant comfort and urban impact. The Japan Sustainable Building Consortium administers the system and is widely applied across public- and private-sector developments in Japan.

CASBEE adopts a distinctive assessment methodology based on the concept of "Building Environmental Efficiency (BEE)," which evaluates the relationship between building environmental quality and environmental load. Unlike conventional point-based systems, CASBEE assesses performance by comparing the quality of the indoor and built environment (Q) against the environmental impact imposed on the surrounding environment (L). The resulting BEE value provides an integrated measure of sustainability efficiency. Certification levels range from C (Poor) to S (Excellent), offering a clear performance hierarchy.

The assessment framework covers key areas such as energy efficiency, resource conservation, indoor environmental quality, service life planning and impact on the local and global environment. CASBEE places strong emphasis on lifecycle performance, durability and long-term adaptability of buildings, reflecting Japan's focus on resource efficiency and resilience.

While CASBEE is technically robust and conceptually innovative, its methodology requires advanced technical capacity and detailed data inputs, which may limit direct transferability to developing-country contexts. CASBEE offers valuable lessons for Bangladesh, particularly in integrating environmental quality, lifecycle thinking and efficiency-based performance metrics. Elements of CASBEE's Q–L balance concept can inform the development of assessment systems for Bangladesh by encouraging holistic assessment beyond isolated efficiency measures.

5.5 Green Rating for Integrated Habitat Assessment (GRIHA), India

GRIHA is India's national green building rating system, developed through a joint initiative involving The Energy and Resources Institute (TERI) and the Government of India. GRIHA was established to provide a contextually appropriate alternative to international rating systems, addressing India's diverse climatic conditions, construction practices and socio-economic realities.

GRIHA adopts a lifecycle-based assessment approach, evaluating building performance from site planning and design through construction, operation and maintenance. The system uses a star-based rating structure and includes mandatory minimum requirements alongside optional credits. Key assessment categories include site planning, energy efficiency, renewable energy integration, water management, materials and resources, waste management, indoor environmental quality, and social and cultural aspects.

A distinguishing feature of GRIHA is its strong emphasis on climate-responsive and passive design strategies. The system encourages building orientation optimization, natural ventilation, daylighting, shading and thermal comfort, reducing reliance on mechanical systems. GRIHA also promotes the use of locally available materials and traditional construction knowledge, supporting resource efficiency and cultural continuity.

GRIHA demonstrates how a nationally rooted rating system can align sustainability objectives with policy frameworks, climatic zones and institutional capacities. Its governance model, technical structure and emphasis on contextual adaptation offer valuable lessons for Bangladesh.

Many of GRIHA's principles and methodologies are directly relevant to the formulation of assessment systems for Bangladesh that are both credible and locally responsive.

5.6 Sri Lanka Green Building Rating System (GREEN^{SL}), Sri Lanka

The Sri Lanka Green Building Council administers GREENSL as a voluntary certification framework to promote sustainable building practices. Developed in response to national environmental challenges and tropical climatic conditions, GREEN^{SL} emphasizes contextual relevance, affordability, and incremental improvement in building performance.

GREEN^{SL} assesses buildings across several categories, including sustainable sites, energy efficiency, water efficiency, materials and resources, indoor environmental quality and innovation. The system is designed to be flexible and adaptable to various building typologies, scales and budget levels, making it accessible to a wide range of stakeholders. Certification levels are awarded based on cumulative performance across assessment categories.

A notable strength of GREEN^{SL} is its focus on tropical design principles and passive strategies such as natural ventilation, shading and daylighting. The system actively encourages the use of local materials and construction techniques, reducing environmental impacts while supporting local economies. GREEN^{SL} also places importance on awareness-raising and professional capacity development, contributing to gradual market transformation.

GREEN^{SL} demonstrates how a voluntary, nationally managed system can effectively promote sustainable construction without imposing excessive technical or financial burdens. Its approach offers valuable insights for Bangladesh, particularly in striking a balance between technical rigor and market accessibility and in fostering widespread adoption through education and incentives.

5.7 Building Energy Efficiency and Environment Rating (BEEER), Bangladesh

BEEER is a national building rating framework developed and implemented by SREDA under the Government of Bangladesh. BEEER is closely aligned with national energy efficiency policies, climate change commitments, and the energy-related provisions of the BNBC (2020).

BEEER primarily focuses on improving the energy performance of buildings by establishing benchmarks based on building type, size and use. The system promotes the adoption of energy-efficient design strategies, building envelopes, mechanical systems, lighting and equipment. By emphasizing energy performance, BEEER directly supports national objectives to reduce electricity demand, peak load pressure, and greenhouse gas emissions.

One of BEEER's key strengths is its institutional legitimacy and policy relevance. As a government-led initiative, it provides a credible mechanism for mainstreaming energy efficiency across both public and private-sector buildings. BEEER also plays an important role in building awareness and technical capacity among professionals and developers regarding performance-based evaluation.

BEEER's focus is largely limited to energy and selected environmental parameters, with limited coverage of water management, materials lifecycle impacts, indoor environmental quality, climate resilience and social dimensions. These limitations highlight the need to integrate BEEER within a broader, multidimensional framework, such as a new assessment system for Bangladesh that makes energy efficiency a core pillar alongside other sustainability and resilience criteria, including energy conservation, passive design, and life-cycle carbon assessments.

5.8 Green Affordable and Resilient Certification for Habitats (GreenARCH), Bangladesh

GreenARCH is a nationally developed green building certification framework initiated by the HBRI, Bangladesh. The system has been specifically designed to address the country's unique climatic risks, socio-economic conditions and housing needs, with a strong focus on affordability, resilience and inclusivity.

Unlike many international rating systems, GreenARCH explicitly integrates climate adaptation and disaster resilience into its assessment criteria. It addresses critical issues such as flood resilience, cyclone resistance, thermal comfort under extreme heat and durability of materials in humid and saline environments. The system also promotes the use of locally available, low-cost, low-carbon materials, supporting circular-economy principles and local livelihoods.

GreenARCH places particular emphasis on residential and community-scale developments, recognizing the importance of sustainable housing in achieving national development goals. Social considerations, including health, safety, accessibility and community well-being, are integral components of the assessment framework.

GreenARCH places strong emphasis on resilience, affordability, and social responsiveness, addressing several important gaps often observed in many international building assessment frameworks and reflecting the practical realities of Bangladesh's built environment. However, there are opportunities to strengthen its technical clarity and methodological consistency further. In its current form, some criteria overlap, leading to multiple points being awarded for similar activities, while several indicators could benefit from clearer definitions and more objective, measurable performance metrics. In some cases, binary (yes/no) questions are used where performance-based or quantitative evaluation would be more appropriate, and points are occasionally awarded for the installation of equipment without adequately considering their actual use or operational performance. A substantial portion of points is linked to compliance with the BNBC; however, sustainability assessment frameworks typically encourage performance improvements beyond minimum regulatory requirements. Therefore, rewarding measurable improvements above the code baseline, such as reductions in energy use or carbon emissions relative to a defined reference building typology, may enhance the system's effectiveness. Nevertheless, integrating some of GreenARCH's issues into a refined national assessment framework could enhance the framework's contextual relevance and implementation effectiveness in Bangladesh.

5.9 Comparative Credit-Level Matrix

The benchmarking exercise indicates that while international systems provide comprehensive assessment tools, they require contextual adaptation to be effective in Bangladesh. Regional and national systems demonstrate greater relevance in addressing climate resilience, affordability and social inclusion.

Benchmarking global, regional and national green building certification and assessment systems yields several critical insights for developing a sustainable building assessment system for Bangladesh. The analysis confirms that while internationally recognized systems provide comprehensive and technically robust assessment frameworks, their direct application in Bangladesh is constrained by contextual, institutional and market-related factors. These findings underscore the necessity of a nationally adapted assessment system that balances global best practices with local realities.

International systems such as LEED demonstrate high methodological rigor, covering a wide spectrum of sustainability dimensions, including energy efficiency, water conservation, materials lifecycle impacts, indoor environmental quality and innovation. Their structured credit systems, verification protocols and performance modeling approaches have contributed significantly to advancing global green building standards. The benchmarking exercise highlights that these systems often involve complex documentation procedures, high certification costs and reliance on advanced technical expertise. In Bangladesh, where construction practices are dominated by small- and medium-scale developers and institutional and professional capacity remains uneven, such requirements can limit widespread adoption.

In contrast, performance-oriented systems such as EDGE offer a more accessible entry point to green building certification. By focusing on quantifiable reductions in energy, water and embodied energy, EDGE demonstrates how simplified metrics and digital assessment tools can drive rapid market uptake, particularly in residential and commercial developments. The limited scope of such systems also becomes evident, as critical issues related to climate adaptation, indoor environmental quality, site ecology and social dimensions remain underrepresented. This finding suggests that while performance-based efficiency thresholds are valuable, they must be complemented by broader sustainability criteria to address Bangladesh's multifaceted environmental challenges.

Regional and national systems, including CASBEE, GRIHA, GREEN^{SL}, BEEER, and GreenARCH, demonstrate greater contextual relevance. These systems incorporate climate-responsive design strategies, promote the use of local materials, and recognize affordability and incremental improvement as essential considerations. GRIHA and GREEN^{SL}, in particular, illustrate how nationally governed frameworks can align sustainability objectives with climatic zones, cultural practices and institutional capacities. BEEER's alignment with national energy policies further emphasizes the importance of integrating green building assessment with regulatory and policy instruments.

A particularly significant finding is the emphasis placed by national initiatives such as GreenARCH on climate resilience and social response. Bangladesh's exposure to flooding, cyclones, heat stress and salinity intrusion necessitates integrating resilience and adaptation criteria into the green building framework. These dimensions are often marginal or optional in international systems; however, they are critical for long-term sustainability in Bangladesh.

The comparative analysis presented in Table 1 demonstrates that while international green building assessment systems share several common sustainability priorities, their emphasis and methodological approaches vary significantly across categories. Energy efficiency and renewable energy are the most consistently addressed dimensions across systems, reflecting the global focus on reducing operational energy consumption and carbon emissions in buildings. Similarly, water management and material efficiency are widely incorporated, although systems such as LEED, BREEAM, and CASBEE offer more comprehensive lifecycle-based approaches than the simplified performance thresholds used in tools such as EDGE or BEEER. In contrast, categories related to climate adaptation, lifestyle and health, and social integration show considerable variation, with region- or nationally developed frameworks such as GRIHA, GREEN^{SL} and GreenARCH demonstrating stronger responsiveness to local climatic conditions, cultural practices and community needs. Table 1 indicates that while international and national rating systems provide valuable technical benchmarks, a more specific framework would benefit from integrating these global best practices while placing greater emphasis on climate resilience, social response and local environmental conditions.

Table 1. Comparative mapping of benchmark green building rating systems toward a new assessment system for Bangladesh.

Category	LEED	EDGE	BREEAM	CASBEE	GRIHA	GREENSL	BEEER	GreenARCH	Key Observations
Climate Adaptation and Resilience	Innovation and resilience strategies	Not covered	Resilience and climate adaptation	Durability and load reduction	Climate-responsive design	Passive and tropical design	Implicit	Resilience credits	BREEAM, CASBEE and GreenARCH explicitly address resilience; EDGE and some national systems treat it indirectly or implicitly.
Site Sustainability and Planning	Location and Transportation; Sustainable Sites	Limited	Land use, ecology, transport and site impact	Site and urban environmental impact (Q/L)	Site planning	Sustainable sites	Site prerequisites	Site credits	BREEAM provides the most comprehensive framework for linking transport, ecology, and land use; CASBEE evaluates broader urban impacts; EDGE has limited site considerations.
Materials and Resources	Materials and resources; lifecycle considerations	Embodied energy reduction	Materials, waste and lifecycle impact	Resources and materials (lifecycle)	Materials management	Materials and resources	Limited coverage	Materials credits	LEED and CASBEE emphasize lifecycle analysis; BREEAM integrates waste and recycling strategies; national systems focus more on practical material use and affordability.
Water and Waste	Water efficiency;	≥20% water	Water consumption	Water efficiency and	Water management	Water efficiency	Water credits	Water credits	Most systems prioritize water efficiency; BREEAM

Category	LEED	EDGE	BREEAM	CASBEE	GRIHA	GREENSL	BEEER	GreenARCH	Key Observations
Management	wastewater strategies	savings	, reuse and management	load reduction	nt				and LEED include broader water management strategies, including reuse and rainwater harvesting.
Energy Conservation and Environmental Quality (EQ)	Energy and atmosphere; IEQ	Indirect	IEQ and operational efficiency	IEQ (Q)	IEQ	IEQ	Basic IEQ requirements	IEQ credits	CASBEE and BREEAM place strong emphasis on environmental quality; EDGE addresses these aspects indirectly through efficiency measures.
Energy Efficiency and Renewable Energy	Energy performance and renewable energy integration	≥20% energy savings	Energy, carbon and low-emission design	Energy efficiency (Q/L)	Energy performance	Energy performance	Core focus	Energy credits	Energy performance is the highest priority across different systems; BREEAM and CASBEE incorporate operational carbon and renewable energy strategies.
Lifestyle, Social, Health and Safety	Occupant health, comfort and awareness	Indirect	Health, well-being and safety	User comfort and environmental quality	Occupant comfort and health	User comfort and wellbeing	Basic	Health and comfort credits	BREEAM provides the most comprehensive approach to occupant wellbeing; other systems integrate comfort through IEQ-related criteria.

Overall, the benchmarking exercise indicated that no single existing system can fully address Bangladesh's environmental, climatic and socio-economic priorities. The findings support the adoption of a hybrid approach for a new assessment system for Bangladesh, combining the technical rigor and performance verification of international systems with the contextual sensitivity, affordability and resilience focus of regional and national frameworks. Such an approach can enhance credibility, facilitate market uptake and ensure alignment with national development goals and regulatory frameworks.

5.10 Key Limitations to Overcome

Climate change has emerged as one of the most critical global challenges, influencing the design and operation of the built environment and prompting the development of green and energy-efficient building concepts primarily in developed countries. These concepts and the international rating systems that operationalize them were formulated largely in response to rising operational energy demand and carbon emissions associated with energy-intensive buildings in temperate and cold climates. Consequently, frameworks such as LEED, BREEAM and similar systems emphasize advanced mechanical systems, high-performance envelopes and technology-driven solutions, reflecting the socio-economic capacities, climatic conditions, and regulatory environments of their regions of origin. While these systems have played a pivotal role in shaping global sustainability discourse, their underlying assumptions often limit their direct applicability in developing and climate-vulnerable contexts.

In Bangladesh, the impacts of climate change are both immediate and fundamentally different, characterized by sea-level rise, recurrent flooding, land subsidence, salinity intrusion and population displacement. Within this context, sustainability in the built environment must prioritize mitigating environmental pollution and reducing greenhouse gas emissions to enhance long-term climate resilience. Emission-reduction strategies, through passive design, efficient use of local materials and low-carbon construction practices, simultaneously reduce energy demand and improve building sustainability without relying on resource-intensive technologies. The uncritical adoption of international green building rating systems risks misalignment with Bangladesh's climatic realities, development priorities and adaptive capacity.

Therefore, the critical limitation of many internationally recognized green building rating systems is their limited responsiveness to local climatic, environmental, and socio-cultural conditions. Systems developed primarily for temperate climates prioritize issues such as heating efficiency and seasonal daylight variation, whereas Bangladesh experiences a hot-humid climate, where cooling demand, natural ventilation, and moisture control are far more critical. As a result, buildings in Bangladesh may achieve high certification levels without necessarily being climate-responsive or energy-efficient in local terms. The dense urban fabric of Bangladeshi cities, characterized by narrow roads, closely spaced buildings, and limited open spaces, is rarely adequately addressed in conventional rating frameworks. This lack of contextual sensitivity undermines the credibility and effectiveness of imported rating models.

Another limitation arises from the misalignment between environmental health challenges addressed by international rating systems and those actually faced in Bangladesh. Certain environmental or psychological issues prevalent in colder or less densely populated regions have limited relevance locally, while critical challenges such as heat stress, flooding risk, indoor air quality in naturally ventilated buildings, and resilience to extreme weather events are insufficiently emphasized. This highlights the necessity of first identifying locally relevant environmental "diseases" before prescribing design and technological "treatments" through an assessment system.

5.11 Implications for a new assessment system for Bangladesh

The findings support the development of a hybrid building assessment system for Bangladesh that integrates performance-based thresholds with a weighted point system aligned with BNBC and national policies. A tiered certification framework and strong institutional governance are recommended.

Bangladesh currently lacks an overarching national strategy or a dedicated regulatory instrument for green building development. Although provisions on energy efficiency, safety and environmental performance are incorporated into existing regulations, such as the BNBC (2020), these measures are fragmented and do not constitute a comprehensive green building framework. This institutional gap highlights the need for a nationally coordinated rating/assessment system that establishes clear benchmarks, promotes best practices, and guides implementation across different building types.

Green building initiatives in Bangladesh have largely depended on international certification frameworks. While these systems provide structured methodologies and global credibility, their application in the Bangladeshi context is often constrained by high certification costs, complex documentation requirements, and limited compatibility with local construction practices and climatic conditions. As a result, such systems remain inaccessible to a large segment of the construction sector, particularly residential and small-scale developments.

Bangladesh's climatic conditions, characterized by relatively high temperatures, humidity, and negligible heating demand, require a sustainability approach distinct from that of temperate regions. Green building strategies should therefore prioritize reducing cooling energy demand, efficient building services, and passive design measures such as natural ventilation, daylight utilization, shading, and appropriate orientation. These principles align closely with traditional and vernacular architectural practices that have evolved in response to local environmental conditions.

The development of a national building assessment system should adopt a regionally responsive framework that incorporates environmental factors such as geography, topography, climate and site characteristics. Equally important is the integration of passive design techniques, locally available materials, indigenous construction techniques, labor skills and community participation. By embedding these considerations, a Bangladesh-specific building assessment system can promote sustainability that is not only environmentally effective but also economically feasible, culturally appropriate and socially inclusive.

6 Overview of Framework

Bangladesh is undergoing rapid urban growth accompanied by increasing demand for energy, materials and infrastructure, placing significant pressure on environmental resources and public health. The building and construction sector plays a decisive role in this transformation, accounting for a substantial proportion of national electricity consumption and carbon emissions. In response to these challenges, there is an urgent need for a nationally appropriate building assessment system that promotes energy conservation and environmental responsibility while safeguarding occupant health and long-term resilience. This framework presents the philosophical foundation, operational approach, and system vision for developing a national building assessment system tailored to Bangladesh's climatic, socio-economic and institutional context (Figure 4).

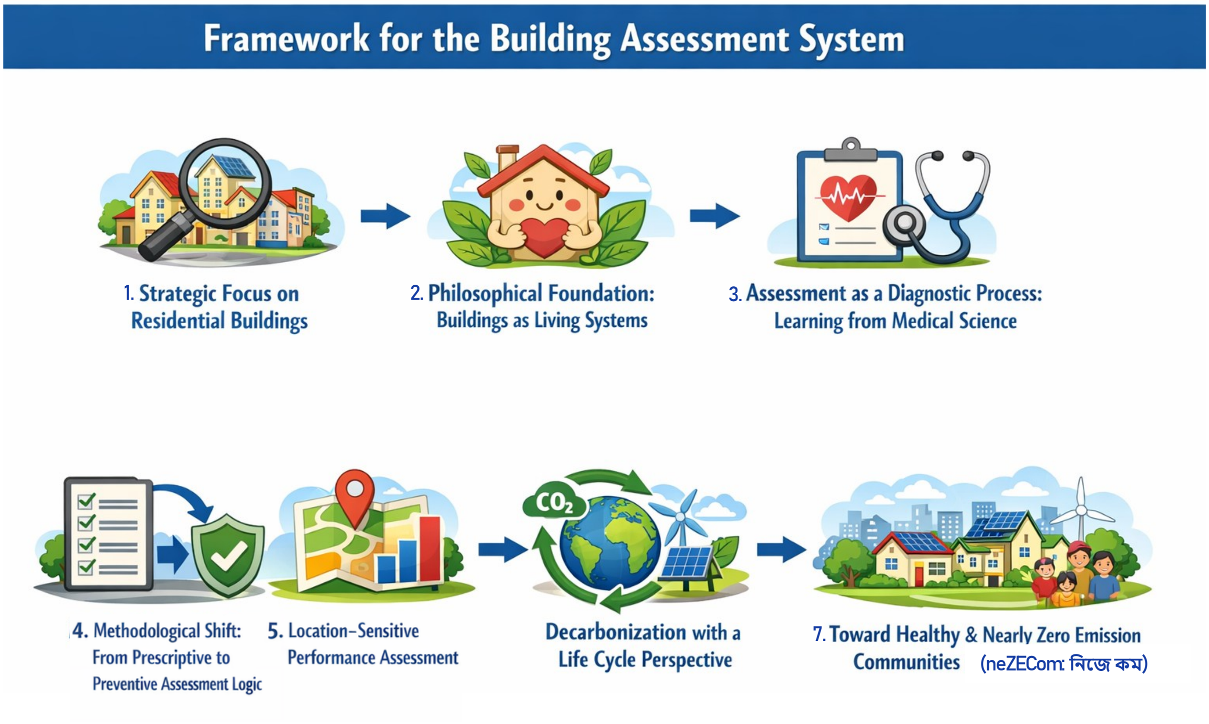


Figure 4. Framework for the building assessment system.

6.1 Strategic Focus on Residential Buildings and Decarbonization

Residential buildings represent the single largest opportunity for reducing energy demand and carbon emissions in Bangladesh. In Dhaka alone, residential buildings account for nearly 90% of the total building stock and more than half of overall electricity consumption (Figure 5). In response to this dominance, the proposed building assessment system prioritizes residential buildings during its initial phase of implementation, ensuring that early policy interventions target the sector with the highest mitigation potential.

This strategic focus enables the assessment system to directly influence national decarbonization outcomes by addressing the primary drivers of operational energy use at scale. The framework emphasizes passive design performance, energy-efficient building systems, low-carbon appliances, and responsible occupant behavior, recognizing that residential energy demand is shaped not only by design and technology but also by everyday usage patterns. By integrating these dimensions, the system moves beyond prescriptive compliance and toward performance-based outcomes.

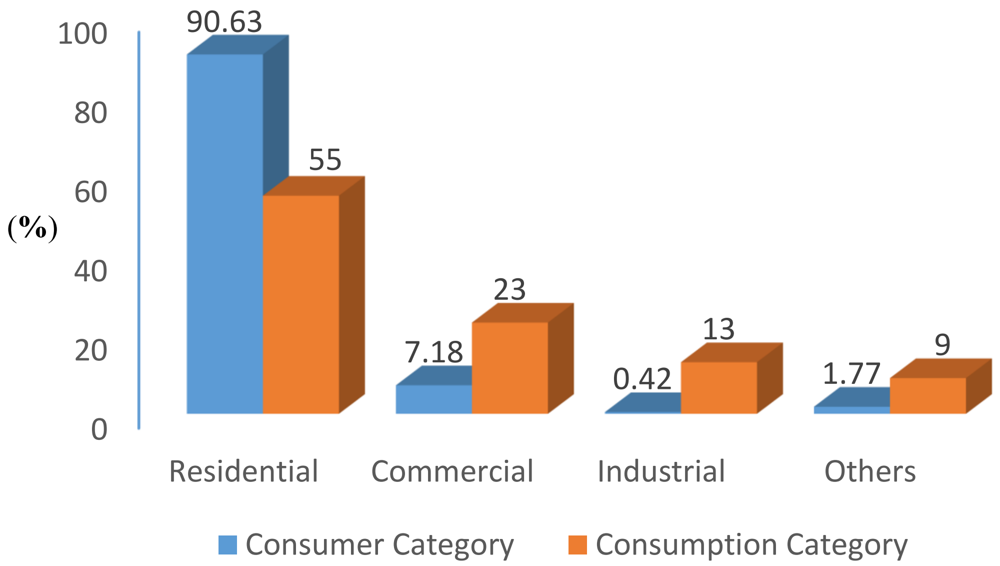


Figure 5. Sector-wise electricity energy consumption in Dhaka, Bangladesh [DESCO, 2021].

The prioritization of residential buildings is grounded in national energy consumption data and aligns with Bangladesh's long-term commitments to decarbonize the building and construction sector by 2050. Concentrating on residential typologies during the early stages of implementation establishes a clear, achievable pathway for emissions reduction, market transformation, and behavioral change, while creating a scalable foundation for the later inclusion of other building types.

6.2 Philosophical Foundation: Buildings as Living Systems

In existing national and international rating systems, the building's surrounding context, occupants' health and user behavior, and the building's role within communities receive limited consideration. The assessment system is grounded in the Healthy Building Design Concept, a research-driven approach developed at BUET since 2005 and subsequently presented in national and international academic forums, including the *3rd International Conference on Green Architecture (ICGrA 2025): Healthy Buildings on the Path to nearly Zero Emission Communities (neZECom - নিজে কম)*, held on 04–05 December 2025 in Chattogram, Bangladesh, and the *Healthy Building Research and Innovation Concept (HealBRIC): Implementing Circularity for Zero Emission Communities (neZECom- নিজে কম)* iLab Lecture, organized by the Immersive Visualization Lab (iLab), Department of Architectural Studies, University of Missouri (MU), Columbia, Missouri, USA, on 11 August 2025.

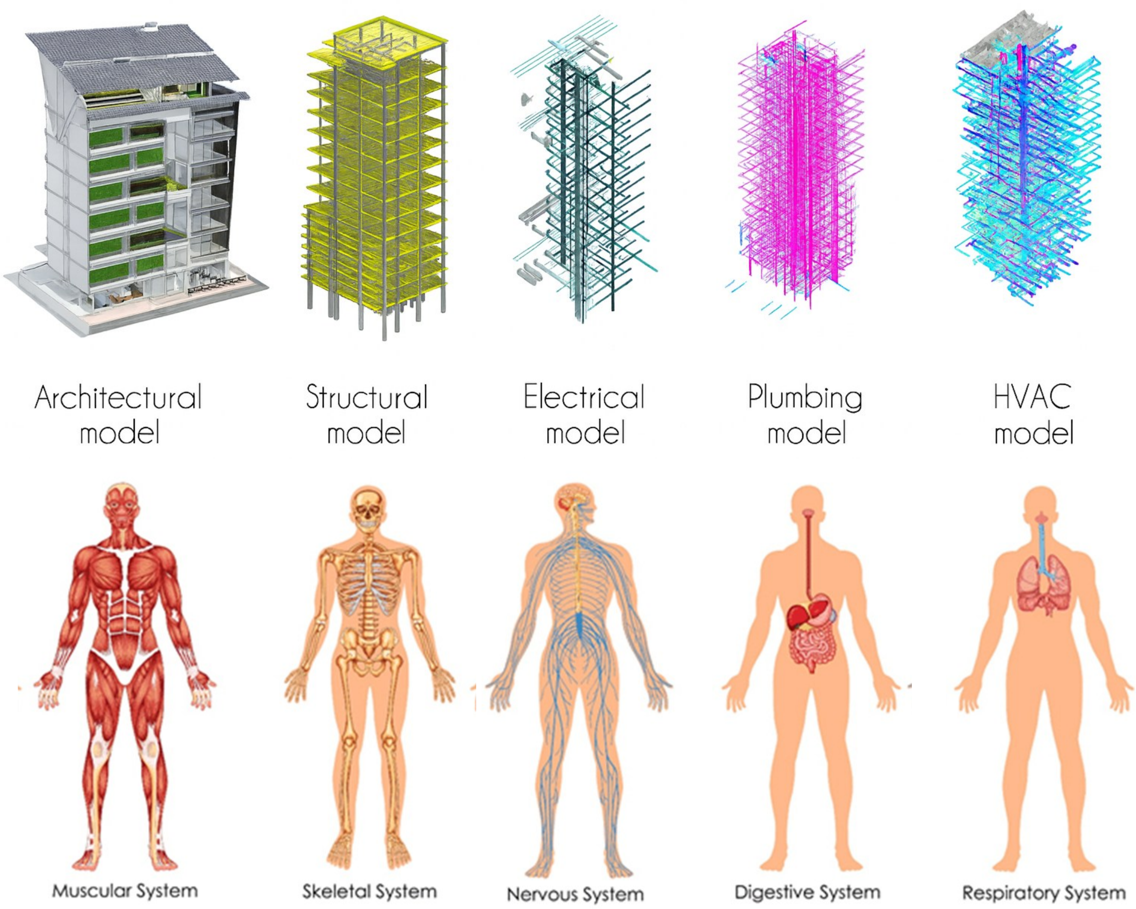


Figure 6. Buildings are living and sensitive systems, comparable to the human body in their complexity and interdependence of components.

This philosophy conceptualizes buildings as living and sensitive systems, comparable to the human body in their complexity and interdependence of components. For example, structural systems are likened to the skeletal framework; ventilation systems to respiratory functions; the digestive system to the plumbing system; electrical systems to the nervous system; and energy and material flows to metabolic processes (Figure 6). From this perspective, the health of a building directly influences the physical and psychological well-being of its occupants. Consequently, a green building assessment system should not be perceived merely as a compliance tool but as an instrument for evaluating and improving building health, thereby ensuring healthier living and working environments.

6.3 Assessment as a Diagnostic Process: Learning from Medical Science

In alignment with the healthy building philosophy, the process of assessment a building is framed similar to a medical diagnostic procedure. Just as a physician first determines whether a disease is present before assessing its severity, a building assessment system must accurately identify whether a building is environmentally and socially responsible before assigning performance levels. Diagnostic accuracy depends heavily on the relevance and appropriateness of the tests used. If unsuitable or context-insensitive assessment methods are applied, the resulting diagnosis may be misleading, classifying non-green buildings as sustainable or overlooking genuinely high-performing ones. Many existing national and international assessment systems face this challenge when applied in Bangladesh, as their evaluation criteria and benchmarks are often derived from vastly different climatic and urban contexts.

6.1 Methodological Shift: From Prescriptive to Preventive Assessment Logic

Most existing green building assessment systems rely on an additive methodology, in which a conventionally designed building accumulates points by selectively including green technologies or features. While effective in certain contexts, this approach often treats sustainability as an enhancement applied after fundamental design decisions have already been made. In Bangladesh, such a methodology risks legitimizing inherently inefficient or climate-inappropriate designs through compensatory measures.

The proposed national building assessment system introduces a preventive, subtractive logic that prioritizes avoiding environmentally harmful design practices from the outset. Rather than rewarding incremental add-ons, the methodology explicitly identifies and discourages common but detrimental practices prevalent in local construction, such as excessive poor orientation, inadequate natural ventilation, unshaded glazing, and premature reliance on mechanical cooling where passive solutions are feasible.

This preventive approach is particularly well suited to Bangladesh's climatic and cultural context, where traditional architecture historically achieved thermal comfort and environmental responsiveness through passive design strategies and low-energy construction methods. By formalizing this design intelligence within a contemporary assessment framework, the system repositions sustainability as a baseline requirement rather than an optional upgrade. The methodology, therefore, emphasizes prevention over remediation, ensuring that buildings achieve environmental performance by design rather than through post hoc technological compensation.

6.1 Location-Sensitive Performance-Based Assessment

Building environmental performance is strongly influenced by its spatial and urban context, including surrounding buildings, street geometry, land-use intensity, and local microclimatic conditions. Recognizing this interdependence, the proposed framework establishes contextualized and location-sensitive assessment as a foundational principle of the national building assessment system. Rather than evaluating buildings as isolated entities, performance is assessed in relation to the physical, environmental and urban systems within which they operate, ensuring that assessments reflect real-world conditions.

Recent advances in digital building modeling, geospatial analysis and the increasing availability of open-access urban data enable the systematic incorporation of contextual parameters into performance evaluation. The framework will integrate factors such as urban density, adjacent building height and spacing, street width, shading patterns, airflow potential, and localized thermal conditions to improve the accuracy and reliability of environmental performance outcomes. This approach is particularly critical in high-density cities such as Dhaka, where contextual effects often dominate energy demand, daylight availability, ventilation potential and outdoor comfort.

6.1 Decarbonization with a Circular Life Cycle Perspective

The proposed conceptual framework adopts a comprehensive life-cycle perspective that extends beyond operational energy use to encompass embodied carbon, material sourcing, construction practices, building operations, maintenance and end-of-life management (Figure 7). User behavior is explicitly recognized as a cross-cutting determinant of performance, influencing energy consumption and environmental impacts throughout the building's lifespan. Evidence from recent research and applied projects in Bangladesh, including initiatives supported by international development partners, demonstrates that decisions made during the planning and design stages, particularly material selection and structural optimization, have the greatest influence on long-term sustainability outcomes. Accordingly, the assessment system places strategic emphasis on these early stages, where interventions are most cost-effective and yield the highest environmental returns.

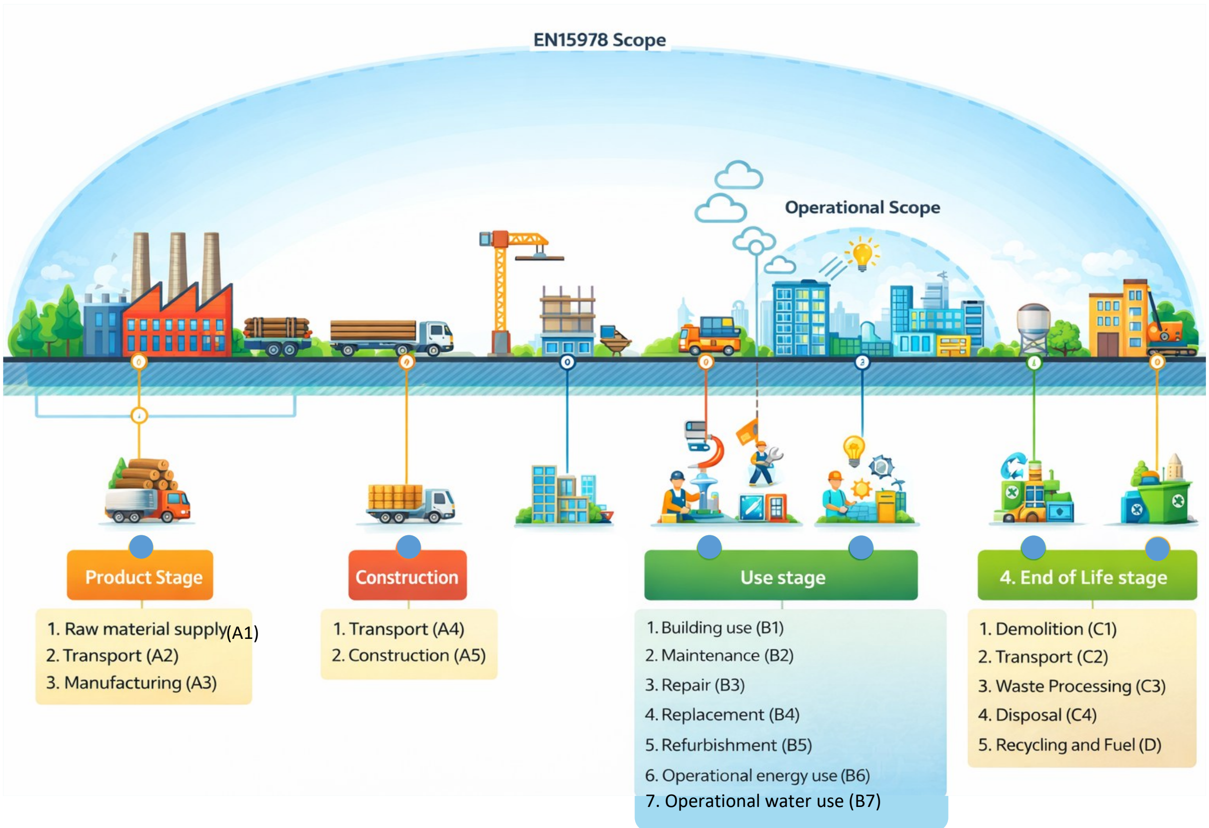


Figure 7. Decarbonization with a life cycle perspective.

Life cycle assessment (LCA) is embedded within the practice to operationalize circular economy principles, encouraging reduced material intensity, reuse and recycling, extended service life, and responsible end-of-life management. By linking embodied and operational impacts within a unified assessment framework, the system supports a shift from isolated green buildings toward scalable, low-carbon and resource-efficient communities. Long-term environmental performance is therefore assessed as the cumulative outcome of integrated design decisions, material choices, system efficiencies, and occupant behavior.

6.1 Toward Healthy and nearly Zero Emission Communities (neZECom: নিজেকম)

The ultimate objective of the proposed assessment system extends beyond individual buildings to the formation of healthy and sustainable communities. By encouraging environmentally responsible design practices, efficient resource use, and informed occupant behavior, the system contributes to collective reductions in emissions and improvements in quality of life. In this framework, zero-emission performance is treated as an overarching goal that inherently encompasses principles of green building, circularity, sustainability, and human health.

7 Country Context and International Commitments

Bangladesh has demonstrated a strong commitment to addressing climate change through a series of national policies, strategies, and international obligations that can influence the development of a sustainable building assessment system. As one of the most climate-vulnerable countries in the world, Bangladesh has progressively aligned its development trajectory with low-carbon, climate-resilient growth, particularly within the buildings and construction sector.

The 'Bangladesh Climate Change Strategy and Action Plan (2009)' established the foundational framework for integrating climate resilience into national development. It emphasizes mitigation and adaptation across key sectors, including infrastructure and housing and promotes energy efficiency, sustainable materials and resilient construction practices. This strategy laid the groundwork for recognizing buildings as critical contributors to both emissions and climate vulnerability.

The ‘National Adaptation Plan (NAP) 2023–2050’ provides a long-term roadmap for climate adaptation, with explicit focus on urban resilience, sustainable housing and infrastructure development. The NAP highlights the need for climate-responsive design, resource efficiency and the incorporation of nature-based solutions, which are necessary to emphasis on contextual and performance-based assessment.

Further sector-specific guidance is provided by the ‘Bangladesh Climate Action Roadmap for Buildings and Construction Sector (2024)’, which identifies the buildings sector as a major opportunity for achieving decarbonization. The roadmap promotes nearly Zero Emissions Communities (neZECom), energy-efficient materials, lifecycle-based assessments and integration of renewable energy systems. It also underscores the importance of digital tools, performance verification and capacity building as key principles to be embedded within a framework.

At the international level, Bangladesh’s commitments under the Nationally Determined Contributions (NDC 3.0) of Bangladesh, aligned with the Paris Agreement, establish clear targets for greenhouse gas emissions reduction. The NDC identifies the buildings sector as one of the priority areas for mitigation, with strategies focusing on energy efficiency, sustainable urbanization, and the adoption of low-carbon technologies. These commitments reinforce the need for measurable, transparent, and performance-based assessment systems.

Collectively, these policy frameworks create a strong enabling environment for the proposed assessment system, ensuring alignment with national priorities and international obligations. By integrating these commitments into its methodology, a strategic tool is needed to operationalize climate goals, support evidence-based decision-making and accelerate the transition toward zero-emission, climate-resilient buildings in Bangladesh.

8 Holistic Assessment Approach

Figure 8 illustrates a framework for integrating embodied and operational carbon emissions into LCA to support circular-economy evaluation in buildings. The framework combines secondary data from literature and primary data collected from field investigations, which together inform a parametric analytical approach. This approach enables systematic evaluation of how variations in materials, design parameters, and operational conditions influence the overall carbon footprint of buildings throughout their life cycle.

The framework begins with two primary information streams: material evaluation and building performance assessment. Material evaluation relies on existing databases and literature sources to obtain environmental performance indicators of construction materials such as concrete, steel, glass, and aluminum. At the same time, building performance data is collected through field measurements, surveys, and operational observations. These two data streams converge within a parametric modeling structure, allowing multiple design and performance variables to be tested and compared.

Within the product stage, the framework evaluates the embodied carbon associated with building materials and construction processes. At this stage, material information and building design information are integrated into a building information modeling (BIM) environment. The BIM platform enables the quantification of material quantities and their associated embodied carbon factors. Through this process, the total embodied carbon of the building components can be calculated, reflecting the environmental impact generated during material extraction, manufacturing, transportation and construction.

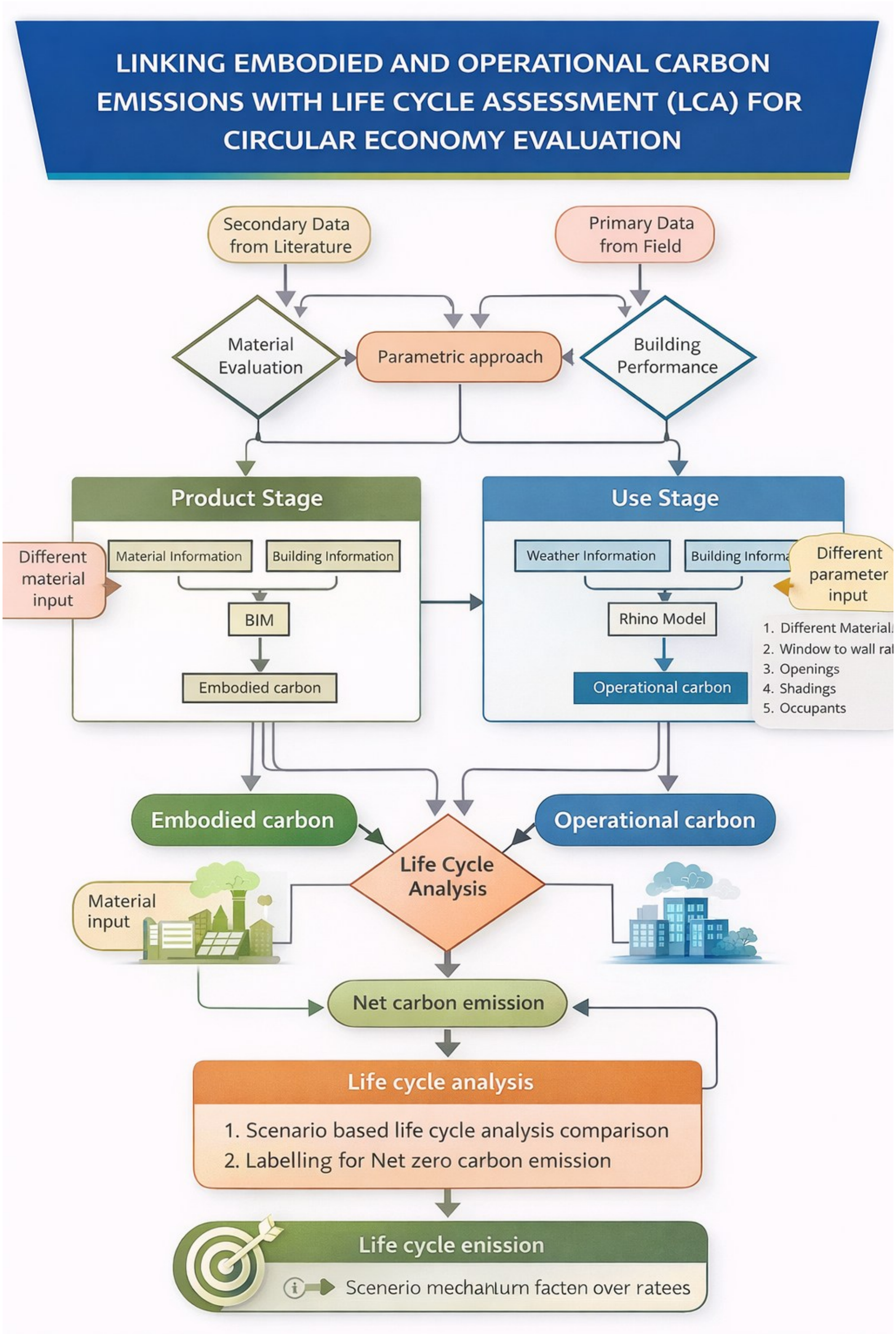


Figure 8. Framework for integrating embodied and operational carbon emissions through life cycle assessment (LCA) to support circular-economy evaluation in buildings.

Parallel to this, the use stage focuses on operational carbon emissions generated during building operation. This stage integrates weather data and building operational information to simulate building performance using parametric simulation tools and environmental modeling platforms. The simulation process evaluates energy consumption patterns influenced by design parameters, including material selection, window-to-wall ratio, façade openings, shading devices, and occupant behavior. By modeling these parameters, the framework estimates the operational carbon emissions resulting from heating, cooling, lighting, and other building energy uses.

The outputs from both stages are then integrated into an LCA process, enabling a comprehensive evaluation of environmental impacts across the entire building life cycle. The LCA stage combines embodied carbon and operational carbon results to identify total carbon emissions associated with the building. Through multi-objective optimization, the framework can evaluate alternative design scenarios to identify solutions that minimize life-cycle carbon emissions while maintaining functional performance.

The framework further incorporates renewable energy integration, which helps reduce the building's net carbon emissions. By considering renewable energy generation and efficiency strategies, the assessment moves beyond simple emission accounting and supports the development of low-carbon or net-zero carbon building pathways.

Finally, the results of the LCA are used to support scenario-based comparisons and labeling mechanisms for net-zero carbon performance. This enables stakeholders to evaluate alternative material and design configurations and determine their effectiveness in achieving carbon reduction targets. The overall framework, therefore, establishes a systematic link among embodied carbon, operational carbon, and life-cycle assessment, providing a robust analytical foundation for circular-economy evaluation in the building sector, where material efficiency, lifecycle performance, and carbon neutrality are key decision-making criteria.

9 Embodied Carbon Emissions

Embodied emissions represent the greenhouse gas emissions associated with materials and processes throughout a building's life cycle, excluding operational energy use (Figure 9). In Bangladesh, where operational energy demand is high but construction volume is rapidly increasing, embodied emissions are becoming a critical contributor to total life-cycle carbon impacts. The proposed assessment system, therefore, incorporates a structured, transparent framework for embodied emissions calculation to support performance-based assessment, informed material selection, and long-term decarbonization of the building and construction sector.

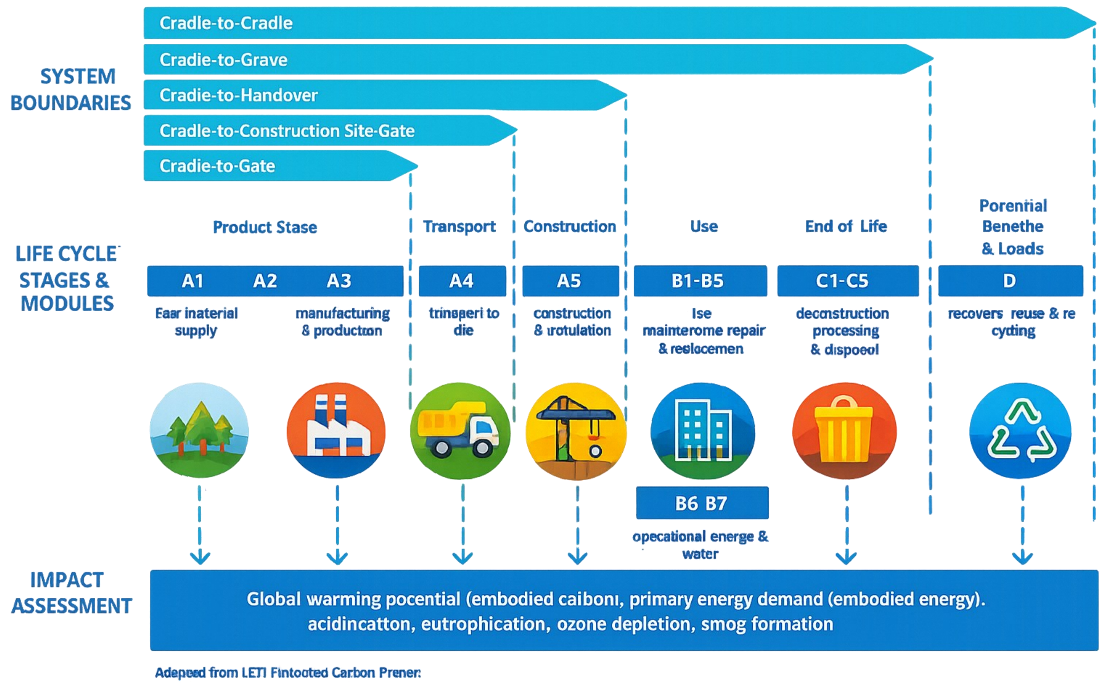


Figure 9. Frameworks for Carbon Emissions[2].

This framework adopts internationally recognized life-cycle assessment principles while ensuring contextual relevance to Bangladesh, including material sourcing, transportation distances, manufacturing practices, grid

[2] Source: https://www.communityenergy.ca/projects/embodied-emissions/

emission factors, and construction site realities. The methodological foundation follows the European Standard EN 15978, adapted for national application.

9.1 Life-Cycle Boundary and Standard Reference

The embodied emission calculation framework is structured according to the EN 15978 life-cycle stages, which divide a building's life cycle into product, construction, use and end-of-life stages. These stages include the product stage (A1-A3), construction stage (A4-A5), use stage (B1-B7), and end-of-life stage (C1-C4). Within the current phase of the assessment system development, primary emphasis is placed on the product stage (A1–A3) and construction stage (A4–A5), as these stages are most directly influenced by design and material decisions and can be reliably quantified in the Bangladesh context.

The framework distinguishes between product-related embodied emissions, which are largely material- and manufacturer-dependent, and building-related embodied emissions, which depend on project location, logistics, construction practices, and user behavior.

9.2 Functional Unit and Data Normalization

To ensure consistency and comparability across projects, embodied emissions are calculated using clearly defined functional units. At the material level, emissions are usually expressed per kilogram of material or per square meter of building element, depending on data availability and material type. At the building level, results are aggregated and normalized per square meter of gross floor area for each building type (e.g., residential, office or industrial). This dual-level normalization allows both material-level benchmarking and whole-building performance assessment within the assessment system. Representative emission factor data are prioritized from sources relevant to Bangladesh, including local manufacturers, national statistics, and regionally appropriate life-cycle databases where local data are unavailable.

9.3 Product Stage Emissions (A1–A3)

The boundary for modules A1 to A3 covers the 'cradle to gate' processes for the materials and services used in the construction; the rules for determining their impacts and aspects are defined in EN 15804.

9.3.1 A1: Raw Material Extraction and Processing

The A1 stage accounts for emissions associated with the extraction, processing, and preparation of raw materials before transportation. In this framework, A1 calculations begin with a detailed breakdown of material composition for each construction product. For example, for autoclaved aerated concrete (AAC or AC block), the material composition can be defined by mass percentage, including cement, sand, lime, gypsum and aluminum powder.

Each constituent material is assigned an emission factor representative of Bangladesh or the nearest regional context. For instance, cement production is assumed to emit approximately 0.83 kilograms of carbon dioxide equivalent per kilogram of cement. The A1 emission for the product is calculated by multiplying each constituent's mass fraction by its corresponding emission factor and summing the results. This approach ensures transparency and traceability while allowing substitution of improved data as national databases evolve.

9.3.2 A2: Transportation to Factory Gate

The A2 stage includes emissions associated with transporting raw materials and secondary inputs from their extraction or processing sites to the manufacturing facility. This framework adopts a distance-based transport emission model, using an emission factor of approximately 0.02 kilograms of carbon dioxide equivalent per ton-kilometer, consistent with commonly accepted freight transport values.

Transportation emissions are calculated for each raw material based on estimated transport distances within Bangladesh, then aggregated to determine the total A2 emission factor. This stage also accounts for the processing and transportation of recycled or secondary materials, where applicable, ensuring that local supply chain characteristics are reflected in the calculation.

9.3.3 A3: Manufacturing and Waste

The A3 stage captures emissions from the manufacturing process itself, including electricity consumption, fuel use, and production-related waste. For AC block production, for example, manufacturing energy demand is estimated at approximately 0.055 kilowatt-hours per kilogram of product. This energy consumption is multiplied by Bangladesh's grid electricity emission factor, currently estimated at 0.61 kilograms of carbon dioxide equivalent per kilowatt-hour, to determine energy-related manufacturing emissions.

In addition to energy use, production waste is included in the A3 calculation. Typical manufacturing waste for AC blocks in Bangladesh is estimated at approximately 10 percent, and the associated emissions are added to the total A3 value. The combined emissions from energy use and wastage result in a comprehensive manufacturing-stage emission factor. The sum of A1, A2, and A3 constitutes the total product-stage embodied emission factor, which serves as a key input to the assessment system.

9.4 Construction Stage Emissions (A4–A5)

The construction process stage covers the processes from the factory gate of the different construction products to the practical completion of the construction work.

9.4.1 A4: Transportation to Building Site

The A4 stage accounts for emissions associated with transporting finished construction products from the factory gate to the building site. This includes emissions from vehicle fuel use as well as the environmental impact of packaging materials, such as cardboard, commonly used for product protection during transport.

Transport distances are estimated based on typical supply routes within Bangladesh, and emissions are calculated using the same ton-kilometer methodology applied in the A2 stage. By incorporating A4 emissions, the framework captures location-specific impacts that vary between urban and rural projects.

9.4.2 A5: Construction and Installation

The A5 stage includes emissions from material handling, on-site storage, installation processes, and construction-stage waste. In the Bangladesh context, installation-stage wastage is typically estimated at approximately 5 percent for masonry and similar materials. The emissions associated with this wastage are calculated by applying the product-stage emission factor to the wasted material fraction.

The A5 stage also includes minor energy use during installation, where data are available. The resulting A5 emission factor represents building-related embodied emissions that are directly influenced by construction practices and site management.

9.5 Use Stage Considerations (B1–B7)

While the primary focus of embodied emission assessment lies in stages A1 to A5, the framework acknowledges the importance of the building use stage in life-cycle carbon performance. Stages B1 to B5 include maintenance, repair, replacement, and refurbishment activities, which may occur multiple times over a building's lifespan. For example, components such as doors or finishes may require replacement several times, and their embodied emissions are accumulated accordingly.

Stages B6 and B7 address operational energy and water use during the building's use stage, which are assessed using climate-responsive building energy simulation tools. Then, operational carbon emissions are calculated by multiplying operational energy consumption by local grid emission factors.

9.6 End-of-Life Stage (C1–C4)

The end-of-life stage includes emissions from demolition, waste transportation, waste processing, and final disposal. While detailed end-of-life modeling may be introduced in later phases of the assessment system, the framework establishes a clear boundary for incorporating these emissions as national data availability improves. This ensures future compatibility with full life-cycle carbon accounting and circular economy objectives.

9.7 Integration with Performance-Based Assessment System

Embodied emission results are integrated into the broader performance-based assessment system by linking material- and building-level emission factors with design parameters such as window-to-wall ratio, building orientation, and surrounding urban context. This integration allows designers to understand how material choices interact with operational performance and contextual conditions to influence total carbon impact.

The assessment system uses embodied-emission benchmarks derived from baseline buildings compliant with the national building code, ensuring that improvements are measured relative to a meaningful reference rather than solely on absolute values.

10 Operational Carbon Emissions

The framework for calculating operational carbon emissions (Figure 10) within the building assessment system is designed to ensure that building operational performance is evaluated in a scientifically robust, context-responsive, and policy-aligned manner. Operational carbon emissions are defined as greenhouse gas emissions resulting from energy and resource consumption during the building use phase, including energy for cooling,

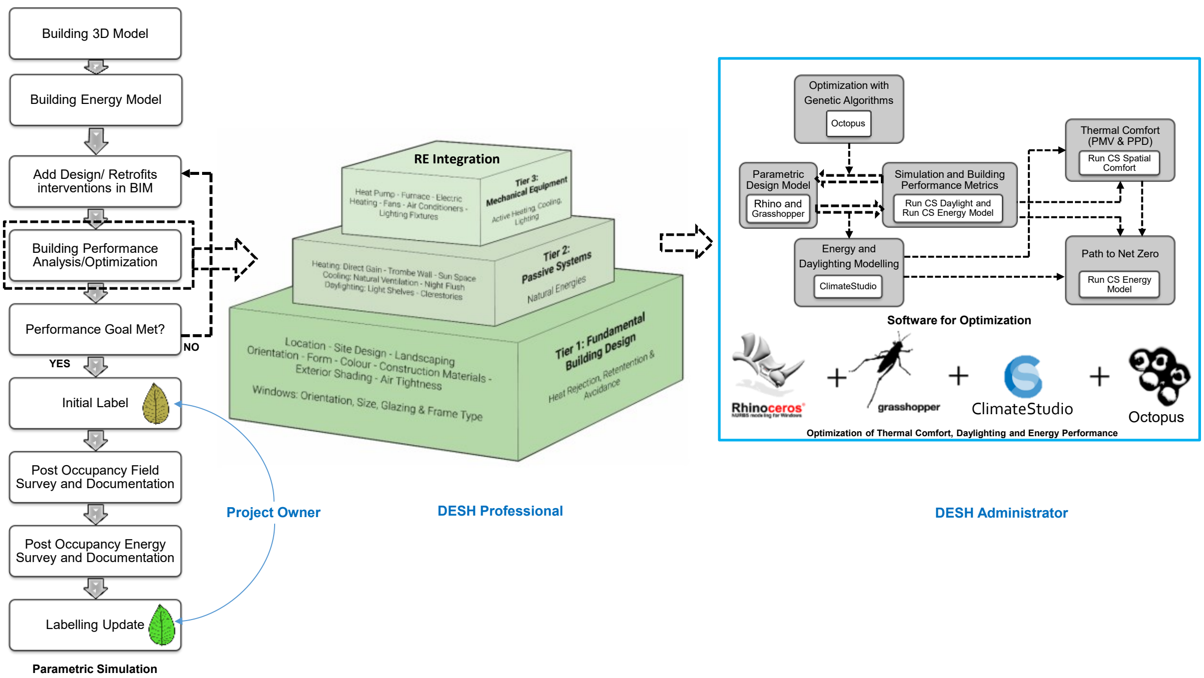


Figure 10. The framework for calculating operational carbon emissions.

lighting, appliances, water pumping, and other building services. This framework supports Bangladesh's national decarbonization goals by linking operational energy demand, user behavior, building design decisions, and system efficiencies to measurable carbon outcomes.

10.1 Review of International and Regional Best Practices

The methodological foundation of this framework begins with an extensive review of international and regional best practices in operational energy and carbon assessment, drawing lessons from established green building certification systems while critically identifying their limitations in tropical, high-density, and energy-constrained contexts such as Bangladesh. This review informs the development of a nationally appropriate operational carbon calculation approach that reflects local climate conditions, energy mix, occupancy patterns, and regulatory benchmarks, particularly the BNBC 2020 and national climate commitments under the NDC.

10.2 Selection of Representative Case Study Buildings

To ground the framework in real-world conditions, empirical data were collected through detailed surveys of representative public buildings in major divisions of Bangladesh. These buildings are selected to capture climatic, urban, and functional diversity and to ensure that operational carbon calculations are representative of national building performance trends rather than isolated examples.

10.3 Development of Building Information Models

For each selected building, a BIM was developed to serve as the central data environment for operational carbon assessment. Information required to develop BIM models was collected through field measurements, walkthrough energy surveys, architectural and services drawings, and document reviews. These models integrate building geometry, envelope properties, system specifications, occupancy profiles, and operational schedules necessary for accurate energy and carbon simulations.

10.4 Application of the Energy Pyramid Principle

Operational energy demand and associated carbon emissions were evaluated using the energy pyramid principle, which prioritizes demand reduction and passive design strategies before introducing mechanical systems and advanced technologies. This approach ensures that the framework rewards low-energy design decisions, such as optimized orientation, shading, envelope performance, daylighting, and natural ventilation, before considering system efficiencies and renewable energy integration. Embedding the energy pyramid logic reinforces prevention-oriented, cost-effective carbon reduction strategies.

10.5 Parametric Simulation and Performance Analysis

Advanced technical assessments were conducted using parametric simulation tools to evaluate thermal comfort, daylight performance, energy consumption, and corresponding carbon emissions under varying design and operational scenarios. These simulations allow systematic exploration of the impact of design variables, such as window-to-wall ratio and surrounding building context, on operational carbon outcomes, thereby supporting evidence-based decision-making.

10.6 Multi-Objective Optimization and Genetic Algorithms

Where appropriate, multi-objective optimization techniques and genetic algorithms were applied to analyze trade-offs between energy use, carbon emissions, occupant comfort, and service quality. This optimization-based approach enables the identification and ranking of alternative operational performance pathways, ensuring that carbon calculations reflect optimized building performance rather than static or default operating conditions.

10.7 Calculation of Operational Carbon Emissions

Operational carbon emissions are calculated by combining estimated, simulated or measured annual energy consumption with nationally appropriate emission factors for electricity and other energy sources. The framework accounts for energy used to maintain indoor thermal comfort, lighting levels, appliance and equipment operation, and water pumping, in accordance with BNBC-defined comfort criteria and occupancy types. Renewable energy contributions are incorporated by deducting the proportion of energy supplied by on-site or off-site renewable sources, thereby determining net operational carbon emissions.

10.8 Integration of User Behavior and Operational Practices

User behavior and building operation practices are explicitly integrated into the operational carbon calculation framework, recognizing their significant influence on actual energy consumption in Bangladeshi buildings. Occupancy schedules, equipment usage patterns, and operational controls are treated as dynamic variables that affect annual carbon emissions, aligning the framework with real-life building use rather than theoretical performance alone.

11 Case Study (HBRI Building- Extended Part)

This case study is undertaken to demonstrate an application of the proposed LCA framework for a public office building in Bangladesh. Later, this case study will be extended to demonstrate an application of the proposed framework for a comprehensive sustainable building assessment system in Bangladesh. The extended part of the HBRI building is shown in Figure 11 was considered for this case study. In this study, EN 15978 served as the methodological framework for assessing environmental performance, as detailed in a previous section. The standard provided a consistent LCA-based approach to quantify environmental impacts across the building life-cycle stages, including product manufacture, construction, use, end-of-life and benefits beyond the system boundary. Applying EN 15978 enabled transparent reporting and comparability of results, supporting evidence-based decision-making for sustainable public building design and policy evaluation in the Bangladeshi context.

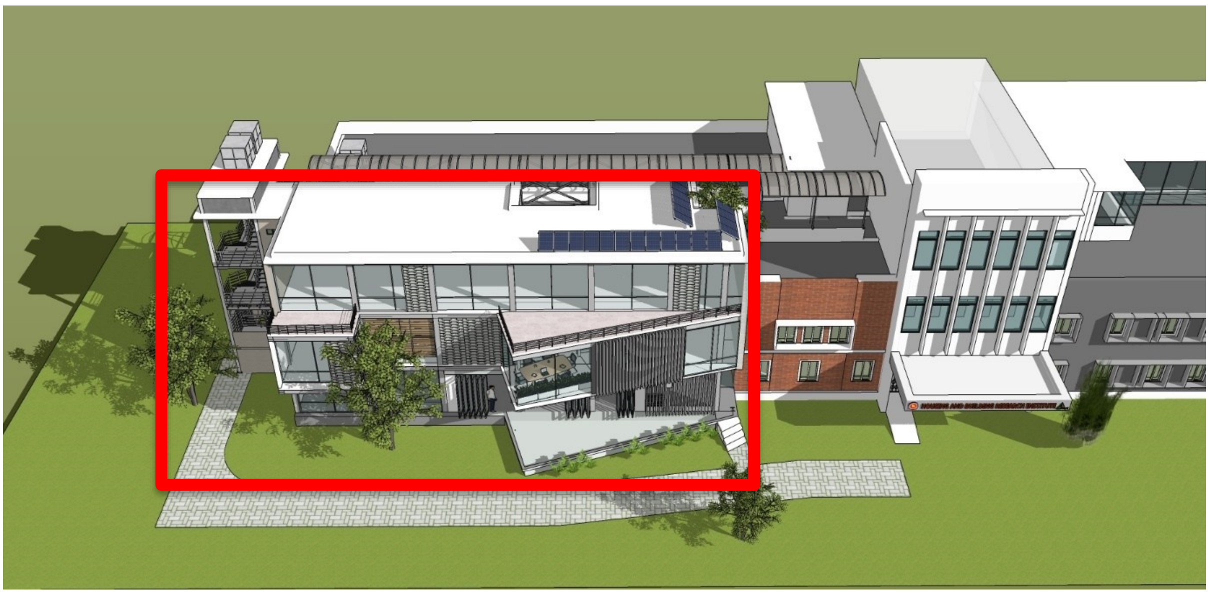


Figure 11. 3D virtual model of the HBRI building with the extended part highlighted in a red box.

1.1 Embodied Carbon Calculation:

This section describes the methodology adopted to calculate the product-stage embodied carbon (A1–A3) of the extended part of the HBRI building. The purpose of this assessment is to quantify the greenhouse gas emissions associated with the production of construction materials used in the building and to establish a transparent, replicable baseline for future whole-life carbon assessments.

The embodied carbon assessment was conducted in accordance with the following standards.

- EN 15978, which defined the calculation method, system boundaries, data requirements and reporting structure for building-level environmental performance assessment.
- EN 15804, which provided the product category rules for construction products and was used specifically to develop a product-specific emission factor for AAC blocks, an HBRI-manufactured product.

Consistent with EN 15978, the assessment was modular, and only Modules A1 (raw material supply), A2 (transport to manufacturing) and A3 (manufacturing) were included at this stage.

11.1.1 System Boundary (A1–A3)

The system boundary corresponded to the product stage (cradle-to-gate) as defined in EN 15978 and EN 15804 and included the following.

- Extraction and processing of raw materials (A1)
- Transport of raw materials to manufacturing facilities (A2)
- Manufacturing processes, including energy use and ancillary materials, up to the factory gate (A3)

Construction, use, end-of-life stages, and benefits beyond the system boundary (A4–D) are excluded from this phase of the assessment and will be addressed later once more data is available. The operational-stage emission (B6-B7) is reported in a later section.

11.1.2 Quantity Take-Off and Calculation Method

a) Source of Quantities

Material quantities used in the embodied carbon calculation were derived from the following sources (details available in Appendix A).

- 2D architectural and structural CAD drawings
- Technical specifications provided by the HBRI staff
- Clarifications obtained through email correspondence and coordination meetings

b) Quantity Calculation Method

Quantities were calculated for major building elements, including: Foundations and structural concrete; Reinforcement steel; AAC masonry walls; Floor slabs and roof slabs; Structural steel members; Glazing, doors, and finishes (where within scope). The quantities for building services (e.g., Mechanical, Electrical and Plumbing) and interior design were not included at this stage. However, they will be included in a future update once more information becomes available.

Geometric dimensions (e.g., length, width, height, area and volume) were extracted from drawings and models. These were converted to mass or volume using standard material densities where required. The resulting quantities represent net material quantities, consistent with EN 15978 practice at the design stage.

11.1.3 Emission Factors for Construction Materials

For most construction materials used in the HBRI building, existing emission factor databases were used. These databases include product-level or generic embodied carbon data as follows.

- Regionally representative of South-East Asia
- Derived from recognized LCA databases and published EPDs
- Considered appropriate proxies in the absence of Bangladesh-specific datasets

EN 15978 explicitly allows the use of non-local but regionally representative data, provided that assumptions and limitations are clearly documented, which has been done in this study.

11.1.4 Emission factor calculation of AAC as an HBRI product

Autoclaved Aerated Concrete (AAC) blocks were a core HBRI product, and therefore, a different approach was adopted for this material. Instead of using a generic database value, the AAC emission factor was calculated specifically in accordance with EN 15804, resulting in a product-specific A1–A3 emission factor for AAC, ensuring higher accuracy and direct relevance to HBRI's manufacturing context.

a) Declared Unit

The declared unit for this assessment is 1 kg of AAC block at the factory gate. Different material inputs, transport activities, and manufacturing energy use were normalized to this declared unit, enabling aggregation of A1–A3 results as permitted under Clause 7.5 of EN 15804.

b) System Boundary Definition

The system boundary for AAC block product stage emission factor calculation followed a cradle-to-gate approach and included the following.

- AAC Raw materials production and upstream processing (A1)
- Transport of raw materials to the AAC manufacturing facility (A2)
- On-site manufacturing processes, including autoclaving and energy consumption (A3)

Downstream life-cycle stages (A4 onwards) were excluded from this calculation and were not included in the reported product-stage emission factor.

c) A1 Raw Material Emission Calculation

Table 2 shows the material composition of the AAC block (per 1 kg of AAC) and associated emissions.

Table 2. Material composition of the AAC block (per 1 kg AAC).

Material	Mass (kg)	Emission Factor (kg CO_2-e/kg)	Emissions (kg CO_2-e)
Cement	0.15	0.83	0.1245
Sand	0.60	0.005	0.0030
Lime	0.229	0.75	0.1718
Gypsum	0.02	0.003	0.00006
Aluminium powder	0.001	15.0	0.0150
Total A1			0.31431

These emission factors represented cradle-to-gate (A1) generic emission factors, consistent with EN 15804 requirements for upstream data. Emissions for each raw material were calculated using the following Eq. 1.

$$\text{A1 Emissions} = \sum(m_i \times EF_i) \quad \text{...Eq. 1}$$

Where:

- m_i= mass of material *i* (kg)
- EF_i= emission factor of material *i* (kg CO_2-e/kg)

☑ **A1 emission factor = 0.31431 kg CO_2-e per kg AAC**

d) A2 – Transport of Raw Materials to Factory

Transport emissions were calculated with the following assumptions.

- Vehicle type: Truck
- Average transport distance: 50 km
- Transported mass: 0.001 tonne (1 kg AAC equivalent)
- Transport emission factor: 0.2 kg CO_2-e / tonne-km

$$\text{A2 Emissions} = \text{Distance} \times \text{Mass} \times \text{Transport EF}$$
$$= 50 \times 0.001 \times 0.2$$

☑ **A2 emission factor = 0.010 kg CO_2-e per kg AAC**

e) A3 – Emissions associated with Manufacturing Processes

Module A3 included the following.

- Energy consumption during AAC production

- Autoclaving process (high-pressure steam curing)
- On-site electricity and fuel use

Table 3 shows A3 emission calculations based on the consumption data for manufacturing and electricity and gas emission factor of Bangladesh.

Table 3. A3 emission calculations.

Energy Source	Consumption	Emission Factor	Emissions (kg CO_2-e)
Electricity	0.05 kWh/kg	0.61 kg CO_2-e/kWh	0.0305
Natural gas	0.6 MJ/kg	0.055 kg CO_2-e/MJ	0.0330
Total A3			0.0635

☑ **A3 emission factor = 0.0635 kg CO_2-e per kg AAC**

f) Total Product Stage Emission Factor (A1–A3)

In accordance with EN 15804 Clause 7.5, modules A1, A2, and A3 may be aggregated.

$$\text{A1–A3} = A1 + A2 + A3$$
$$= 0.31431 + 0.01000 + 0.06350$$

Hence, the total product stage emission factor (A1–A3) for AAC block is 0.38781 kg CO_2-e per kg of AAC block.

The AAC calculation served as a methodological template. The same EN 15804-based approach can be applied in the future to different locally produced concrete, bricks and blocks, steel products and other HBRI or Bangladesh-manufactured materials. These product-specific calculations will be developed in subsequent phases of the project as data becomes available.

11.1.5 Calculation of Product Stage Embodied Carbon (A1–A3)

For each construction material, embodied carbon was calculated using the EN 15978 matrix-based approach as shown in Eq. 2.

$$\text{Embodied Carbon}_{A1-A3} = \sum(Q_i \times EF_i) \quad \text{... Eq. 2}$$

Where:

- Q_i= Quantity of material *i* (kg, m^3, or m^2 as appropriate)
- EF_i= A1–A3 emission factor of material *i* (kg CO_2-eq per unit)

The embodied carbon contributions of individual materials were then aggregated to obtain the following.

- Total product stage embodied carbon: 114,076 kgCO_2-eq
- Product stage embodied carbon intensity: 287.2 kg CO_2-eq per m^2 of floor area

Table 4 presents the detail calculation of the total product stage emission factor for the HBRI building.

11.1.6 Data Quality, Assumptions, and Limitations

- The quantities related to building services (e.g., Mechanical, Electrical and Plumbing) and interior design were not included at this stage. However, they will be included in a future update once more information becomes available.
- Generic emission factors were used where product-specific EPDs were unavailable.
- Regional (South-East Asia) datasets were used as proxies due to limited Bangladesh-specific data.
- AAC was the only material with a bespoke, EN 15804-compliant emission factor at this stage.

Table 4. Detail calculation of the total product stage emission factor for the HBRI building.

Sl No	Location	Construction Component	Area (m2)	Volume (m3)	Mass (ton)	A1 to A3 emission factor			Total $kgCO_2$-eq
						($kgCO_2$ /m^3)	($kgCO_2$ /m^2)	($kgCO_2$ /kg)	
1	Foundation	Spread Footing Concrete		5.60		300			1,680.00
		RCC Spread Footing Concrete		56.00		300			16,800.00
		Rebar (60G-400W) (Assumed 90kg rebar per m3 of concrete)			5.04			2.1	10,584.00
2	Ground Floor	AAC Wall	127.06	12.71	8.35			0.38781	3,239.35
		Glass Wall (Sliding)	30.60				38		1,162.80
		Glass Wall (Folding)	32.35				38		1,229.30
		Fixed Glass	33.50				38		1,273.00
		W10x49 wide-flange column			3.06			1.4	4,286.52
		W10x49 wide-flange Beam			3.11			1.4	4,357.96
		Floor Rebar SL72	132.42		0.79			1.94	1,525.96
		Floor slab	132.42			300			7945.2
		Floor tiles	132.42				15		1,986.30
		Door							75.00
		Slab-Steel metal deck (floor of 1st floor)	132.42				11		1,456.62

Sl No	Location	Construction Component	Area (m2)	Volume (m3)	Mass (ton)	A1 to A3 emission factor			Total kgCO₂-eq
						($kgCO_2$ /m^3)	($kgCO_2$ /m^2)	($kgCO_2$ /kg)	
		Roof Slab rebar SL 72 (Assume 5.4kg/m2 and 10% overlap) (floor of 1st floor)	132.42		0.79			1.94	1,525.96
		Slab- RCC (floor of 1st floor)	132.42			300			3972.6
3	1st Floor	AAC Wall	165.05	16.51	10.85			0.38781	4,207.89
		Glass Wall (Sliding)	45.60				38		1,732.80
		Glass Wall (Folding)	-						-
		Door					15		135.00
		Fixed Glass	42.00				38		1,596.00
		Floor tiles	132.42				15		1,986.30
		W10x49 wide-flange column			3.06			1.4	4,286.52
		W10x49 wide-flange Beam			3.11			1.4	4,357.96
		Slab-Steel metal deck (floor of the 2nd floor)	132.42				11		1,456.62
		Roof Slab rebar SL 72 (Assume 5.4kg/m2 and 10% overlap) (floor of 2nd floor)	132.42		0.79			1.94	1,525.96
		Slab- RCC (floor of 2nd floor)	132.42			300			3972.6
4	2nd Floor	AAC Wall	197.66	19.77	12.99			0.38781	5,039.27
		Glass Wall (Sliding)	64.07				38		2,434.66
		Glass Wall (Folding)	-						-
		Fixed Glass	15.35				38		583.30
		W10x49 wide-flange column			3.06			1.4	4,286.52

Sl No	Location	Construction Component	Area (m2)	Volume (m3)	Mass (ton)	A1 to A3 emission factor			Total $kgCO_2$-eq
						($kgCO_2$ /m^3)	($kgCO_2$ /m^2)	($kgCO_2$ /kg)	
		W10x49 wide-flange Beam			3.11			1.4	4,357.96
		Floor tiles	132.42				15		1,986.30
		Door							75.00
		Slab-Steel metal deck (Roof of 2nd floor)	132.42				11		1,456.62
		Roof Slab rebar SL 72 (Assume 5.4kg/m2 and 10% overlap) (Roof of 2nd floor)	132.42		0.79			1.94	1,525.96
		Slab- RCC (Roof of 2nd floor)	132.42			300			3972.6
				Total Product stage emission (A1-A3) kgCO2-eq					**114,076.39**
				Product stage emission per floor area kgCO2-eq/m^2					**287.16**

11.2 Operational Carbon Calculation

This section presents the methodology and results for the operational energy use and operational carbon emissions (Module B6) of the HBRI buildings extended part at the design stage, in accordance with EN 15978: Sustainability of construction works - Assessment of environmental performance of buildings. The assessment was focused on operational energy consumption associated with building-integrated systems, including cooling, lighting and electrical equipment. Operational water use (Module B7) is not quantified in this phase due to data limitations.

The operational carbon assessment was conducted based on the following.

- EN 15978, which defined the calculation framework for building-level operational energy (B6) and associated greenhouse gas emissions.
- Building energy simulation best practices suitable for early-to-detailed design stages.

The assessment was design-stage based and intended to support performance benchmarking, optimization and future carbon-reduction strategies.

11.2.1 Building Energy Simulation Model Development

A whole-building energy simulation model was developed using open-source building simulation software (i.e., OpenStudio) to estimate annual operational energy consumption. The model represented the building geometry, fabric, systems and operational characteristics based on the available design information. The energy model was developed using the following inputs.

- 2D and 3D CAD drawings (architectural and building layout)
- Building orientation, zoning and floor-to-floor heights derived from drawings
- External shading information approximated from Google Maps and communication with staff
- Building material specifications, including envelope construction and glazing
- Operational information, including occupancy density, schedules, and space use, obtained through meetings and email correspondence.

The simulation was conducted using Dhaka Typical Meteorological Year (TMY) weather data, representing local climatic conditions, including temperature, humidity, solar radiation and wind patterns. This ensures the results are representative of the building's operational context in Bangladesh. A screenshot of the developed energy model is shown in Figure 12. Table 5 summarises the key input parameters used in the building energy simulation model.

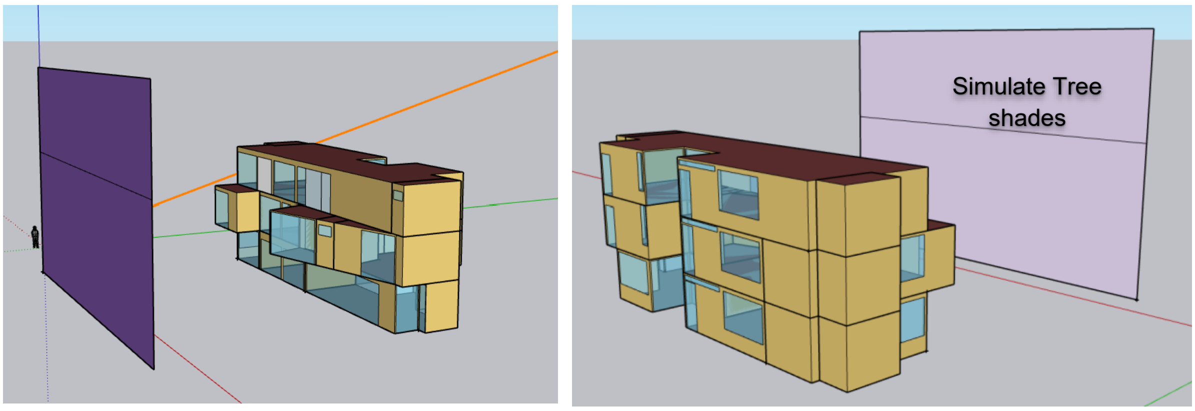


Figure 12. Snapshot of the HBRI Building simulation model developed in SketchUp and OpenStudio.

Table 5. Summary of Building Energy Model Input Parameters.

Element	Type	Parameter
External Wall	AAC block	Thermal Conductivity 0.132 W/mk Density 657 Kg/m^3 Specific Heat: 900 J/kgK
Sliding, Folding and Fixed Glass	Double glazing 6mm tempered glass with 12mm argon gas void	U value $3W/m^2K$ SHGC 0.7
Floor and roof	Concrete Floor	100mm thick, Thermal Conductivity 2.3 W/mk Density 2322 Kg/m^3 Specific Heat: 832 J/kgK
Load	People	1 person per 22m2 floor area CO2 generation 0.000038 L/s-W
Load	Lights	5 W/m^2
Load	Electric Equipment	6.9 W/m^2
Schedule	Office operational time	8 am to 6 pm Weekdays
Schedule	Window operation	Open the window when the indoor temperature is between 15 °C and 26 °C. The outdoor temperature is at least 3°C cooler than the indoor temperature. If the indoor temperature is higher than 26°C and the outdoor temperature is at least 3°C lower, close the window.
Schedule	Cooling operation	Turn on the AC for cooling if the indoor temperature is higher than 26°C
Shading to represent tree shading	An opaque shading element	25m wide and 15m high

11.2.2 Energy Simulation Results

The building energy simulation was run annually. The results are reported as final energy consumption by end use. Table 6 shows annual operational energy consumption.

Table 6. Annual Operational Energy Consumption

End Use	Energy Use (kWh/m^2. year)
Cooling (Assuming COP 4 of the split system for cooling)	47.35
Lighting	14.4
Equipment and others	17.6
Total Energy Use Intensity per year	79.35

Total Energy consumption in one year = Total building floor area X intensity

= 414 X 79.35

= 32,851 kWh

11.2.3 Carbon Calculation Method

Operational carbon emissions for Module B6 were calculated using the EN 15978 approach as follows.

Operational Carbon (B6) = Annual Electricity Consumption (kWh) × Grid Emission Factor of Bangladesh (kg CO_2-eq/kWh)

= 32,851 X 0.61

= 20,039 kg CO_2-eq or 48.4 kg CO_2-eq/m^2 of total building area

11.2.4 Exclusion of Operational Water Use (Module B7)

Operational water use and associated carbon emissions (Module B7) were not assessed in this phase due to the absence of reliable water consumption data and water-related emission factors. This limitation was consistent with

EN 15978, which allows partial life-cycle reporting provided that exclusions are transparently documented. Module B7 may be assessed in future stages when detailed water system design and usage data become available.

11.2.5 Opportunities for Energy, Carbon, and Comfort Optimization

The developed energy model provided a robust platform for design optimization. Potential improvement strategies include the following.

- **Envelope optimization: using alternative low-carbon** materials, improving glazing performance and shading devices to reduce cooling demand.
- **Passive design measures**: orientation refinement, natural ventilation potential and daylight optimization.
- **Lighting efficiency**: use of high-efficiency LED lighting combined with daylight and occupancy controls.
- **Operational schedules**: refinement of occupancy, lighting and equipment schedules to reflect realistic usage patterns.
- **Thermal comfort enhancement**: balancing indoor temperature setpoints, air movement and humidity control to reduce energy use while maintaining occupant comfort.

These optimization measures can be tested iteratively within the energy model to evaluate trade-offs between energy consumption, operational carbon emissions, and indoor comfort.

12 Interactive Web-Based Platform

To ensure accessibility and usability, the framework supports the use of open-source and user-friendly energy and carbon analysis tools. Selected software will be identified as a preferred tool for operational energy analysis, considering its integration with widely used modeling platforms. This enables rapid assessment of energy performance in early design stages, complementing embodied emission calculations and reinforcing the system's preventive, design-integrated philosophy.

This embodied emission calculation framework provides a transparent, standardized, and context-sensitive methodology for assessing material- and construction-related carbon impacts in Bangladesh. By aligning international life-cycle standards with national data, construction practices, and policy objectives, the framework ensures that embodied emissions are meaningfully integrated into the national green building assessment system. This approach supports informed design decisions, material innovation, and long-term decarbonization of the building sector while remaining practical and adaptable as data quality and institutional capacity evolve.

12.1 Digital Platform as the Operational Backbone

The proposed assessment system is operationalized through an interactive, web-based performance evaluation platform that serves as its primary implementation mechanism. The platform enables users to input building information either through structured data entry or by uploading three-dimensional building models generated using widely adopted design software. Upon data submission, the system integrates climate data, urban context, and performance parameters to generate real-time feedback on building performance across key assessment criteria.

While the analytical processes underpinning the platform involve multiple layers of simulation, calculation, and data integration, the user interface is deliberately designed to remain simple, intuitive, and accessible. This ensures that architects, engineers, planners, and regulatory authorities can effectively use the system without requiring advanced expertise in simulation tools or computational modeling.

The platform is designed to evolve incrementally. In its initial phase, it supports rapid, indicative assessments based on essential building and site information, facilitating early-stage decision-making. In subsequent phases, the system progressively incorporates three-dimensional modeling, georeferenced urban datasets, and context-sensitive simulation capabilities, enabling more precise and location-specific performance evaluations. Throughout this staged development, the platform maintains a careful balance between technical rigor and practical usability, translating complex analytical outputs into clear, actionable insights suitable for design guidance, regulatory review, and policy monitoring.

12.2 Platform Vision and Objectives

The interactive web-based platform is envisioned as a national digital decision-support tool that enables early-stage evaluation, optimization, and benchmarking of building design performance. The platform allows designers, developers, and policymakers to assess sustainability performance before construction. Its primary purpose is to support climate-responsive, resource-efficient, and resilient building design by translating complex environmental data into actionable insights. The platform is intended to bridge the gap between conceptual design and formal certification or assessment systems by providing transparent performance feedback aligned with national standards such as BNBC.

12.3 Project Setup and Climate Data Integration

At the initial stage, users would define basic project information, including location, building typology, floor area, occupancy profile, and intended use. Once the project location is selected, the platform would automatically integrate location-specific climate data using standardized weather files, enabling context-sensitive analysis similar to the climate-based workflows used on some popular environmental assessment websites. The system would classify projects by Bangladesh's climatic zones and establish baseline performance benchmarks based on the BNBC and national energy efficiency standards. This step ensures that subsequent performance assessments are grounded in locally relevant environmental and regulatory conditions rather than generic international baselines.

12.4 Design Performance Simulation

Following project setup, the platform would estimate key aspects of building performance using simplified yet robust calculation models suitable for early design stages. Energy performance estimation would focus on orientation, shading, envelope efficiency and natural ventilation potential, reflecting Bangladesh's tropical climate, where cooling loads dominate. In parallel, the platform would estimate water consumption based on fixture efficiency and occupancy assumptions, and calculate the embodied environmental impacts of major construction materials. In addition, climate resilience indicators, such as exposure to flooding, heat stress, and site vulnerability, would be assessed to reflect national climate adaptation priorities. These estimations aim to balance accuracy and usability, avoiding excessive technical complexity while still informing meaningful design decisions.

12.5 Performance Scoring and Feedback Mechanism

Based on simulation outputs, the platform would generate a multi-criteria performance scorecard presented through an intuitive dashboard. Key indicators such as percentage energy savings, water efficiency, material impact, indoor comfort potential, and resilience performance would be visualized using graphs, color-coded scales, and comparative benchmarks. Project performance would be compared against a defined baseline, allowing users to understand whether minimum thresholds or higher performance tiers have been achieved. This immediate feedback mechanism enables iterative design improvement and supports evidence-based decision-making throughout the design process.

12.6 Optimization and Design Guidance

To enhance usability and impact, the platform would incorporate an automated design guidance engine that translates performance results into practical recommendations. For example, if cooling demand is excessive, the system may suggest improved shading, alternative orientations, or envelope modifications. Where feasible, indicative cost implications and payback periods would be presented, enabling developers to weigh sustainability measures against financial considerations. This feature mirrors the cost-benefit logic and is essential for promoting uptake in cost-sensitive markets such as Bangladesh.

12.7 Certification and Assessment Pathway Integration

Beyond performance evaluation, the platform would function as a preparatory gateway for certification or assessment processes. Projects that meet predefined thresholds may be flagged as eligible for national assessment schemes or voluntary certification pathways. The system could support document uploads, compliance tracking, and progress monitoring, thereby reducing administrative burdens and improving transparency. Over time, this module could be integrated with a national registry to support policy monitoring, reporting, and incentive mechanisms.

12.8 Technical Architecture and System Design

From a technical perspective, the platform would be developed as a modular web-based system comprising an interactive front-end interface, a backend calculation engine, and a centralized database. The front-end would focus on user-friendly interaction through dashboards, sliders, and visual analytics, while the backend would host climate datasets, building archetypes, and performance calculation algorithms. Open APIs would enable future integration with external tools, certification bodies, or government databases, ensuring scalability and long-term adaptability.

12.9 User Access and Capacity Building

To maximize adoption, the platform would support role-based access tailored to different user groups. Architects and engineers would have access to input data for detailed simulation and optimization features, while developers and building owners could view summarized performance outcomes and financial implications. Reviewers and assessors can access, review, and comment on the assessment's progress, with the necessary instructions to communicate virtually with the applicants. Regulators and policymakers would be able to access aggregated benchmarking data for planning and monitoring purposes. Multilingual support, particularly in Bangla, and a mobile-friendly design would further enhance accessibility and capacity-building across the sector.

12.10 Relevance to Bangladesh's National Context

By integrating climate-responsive design logic, simplified performance modeling, and nationally aligned benchmarks, the proposed platform would provide a practical foundation for scaling sustainable building practices in Bangladesh. It supports the transition from awareness-based tools to performance-driven decision-making while remaining inclusive of local construction practices and institutional capacities. In this way, the platform represents a strategic convergence of climate intelligence and performance scoring, adapted to serve Bangladesh's environmental, economic, and policy priorities.

13 Design for Environment and Sustainable Habitats (DESH)

The initial target is to design, develop, deploy, and operationalize the above web-based evaluation platform, incorporating a sustainable building assessment system termed 'Design for Environment and Sustainable Habitats (DESH)' (Figure 13). The word "DESH" (দেশ), meaning "country" in Bengali, also forms part of the name Bangladesh (বাংলাদেশ). 'Design for Environment (DfE)' is a standard technical term commonly used in academic, engineering, and environmental contexts, referring to the practice of reducing an object's environmental impact throughout its lifecycle. 'Sustainable Habitats' is also a commonly used term in urban planning and ecology to describe living spaces or ecosystems designed to function without depleting natural resources. The term "environment" refers to the surrounding conditions in which living organisms exist, encompassing both natural and human-made elements. It includes components such as air, water, soil, and biodiversity, which are essential for sustaining life. DESH represents a nationally contextualized sustainable building assessment framework intended to promote zero-operational-carbon sites and zero-emissions building design and construction practices. The system is conceived as an emission-governed, digitally dynamic, and performance-verified framework that reflects Bangladesh's climatic, urban, and socio-economic context. DESH framework is anchored in four core ideas: ensuring design suitability to local climatic and cultural contexts; minimizing environmental impacts across the life cycle; promoting sustainable resource use for future generations; and ensuring that habitats at different scales demonstrate optimized energy performance, reducing operational demands while promoting individuals' health, comfort, safety and well-being.

Figure 13. Symbol of Design for Environment and Sustainable Habitats (DESH-দেশ)

The initiative to develop DESH responds to the need for a locally appropriate system that moves beyond replicating international assessment models and instead prioritizes measurable carbon performance, contextual design responsiveness, and life-cycle environmental accountability. The platform is intended not only as an assessment mechanism but also as a design-support and evaluation tool that enables architects, engineers, developers, and policymakers to assess and improve building performance continuously.

13.1 System Architecture and Technical Requirements

The web-based assessment platform incorporates user management, data processing, carbon accounting algorithms, integration with geographic context, visualization dashboards, and automated label generation. User Management and Authentication includes: secure login and role-based access; multi-level access (Architect, Developer, Verifier, Authority); and two-factor authentication. The system allows building projects to be registered through a geolocated interface integrated with mapping services.

The location data enable contextual analysis, including public transport accessibility calculations and climatic overlays relevant to ventilation and energy modeling.

The platform supports uploading energy models generated by BIM-based tools and simulation software. At the same time, it provides a simplified internal modeling interface for smaller or less complex buildings that do not require external modeling software. The system can extract and validate parameters such as total floor area, number of stories, window-to-wall ratio, and system specifications. A carbon accounting engine calculates embodied carbon based on material inputs and databases, operational carbon based on predicted and measured energy use, and total life-cycle carbon intensity (Embodied + Operational).

The system will be a secure, cloud-based, modular architecture capable of scaling nationally. The system will incorporate role-based authentication and encrypted data storage. Automated calculation engines will process user inputs and generate standardized outputs, including carbon-intensity metrics, renewable-energy contributions, and performance comparisons. The visualization interface will present carbon breakdown charts, contextual maps, progress indicators, and exportable reports. The system will allow structured data export in standard formats suitable for regulatory and policy integration.

13.2 Labeling Structure

Sustainable building/product evaluation frameworks can be broadly categorized into certification, rating, and labeling systems based on their scope, assessment rigor, and implementation mode. Certification systems are characterized by formal third-party verification processes that result in the issuance of an official certificate upon compliance with predefined sustainability criteria. Among the reviewed systems, LEED (USA), EDGE (IFC), and BREEAM (UK) fall within this category, as they require independent audits and award graded certification levels that are widely recognized internationally. In Bangladesh, GreenARCH, developed by the HBRI, primarily functions as a certification system, offering structured evaluation and formal recognition while emphasizing affordability, resilience, and local construction practices.

Rating systems, in contrast, focus on performance benchmarking through point-based scoring, star ratings, or index-based evaluation, enabling buildings to be compared. CASBEE (Japan) exemplifies this approach through its building environmental efficiency (BEE) index, which balances environmental quality with reduced environmental load. Similarly, GRIHA (India) operates as a national rating system that awards star ratings based on cumulative performance across climate-responsive design, resource efficiency, and socio-environmental criteria. The GREEN^{SL} (Sri Lanka) also adopts a rating-based methodology, promoting voluntary uptake of sustainable building practices with strong contextual relevance to local materials, climate, and construction traditions.

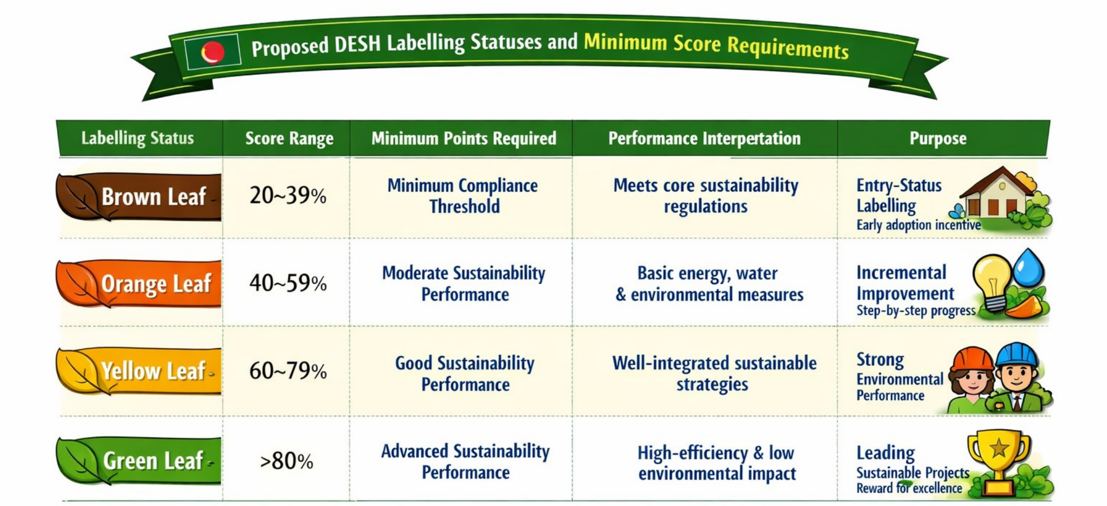
Labeling systems prioritize simplified disclosure and communication of key performance indicators to support transparency, awareness, and policy enforcement. These systems typically rely on a limited number of measurable parameters and are designed for ease of interpretation by building owners, occupants, and regulators. By providing clear, accessible performance labels aligned with national energy conservation objectives, labeling supports large-scale adoption and regulatory integration, making it especially suitable for residential and public building stock.

Together, these classifications highlight the complementary roles of certification, rating, and labeling systems (Table 7) and underscore the importance of adopting a hybrid approach when developing a context-responsive green building framework for Bangladesh.

In the Bangladeshi context, building labeling represents a more pragmatic and scalable approach to promoting sustainability than certification or rating systems. Rapid urbanization, affordability constraints, and limited regulatory enforcement capacity necessitate a framework that can reach a broad spectrum of building types and actors. Labeling enables immediate market visibility, enhances awareness among occupants and buyers, and supports incremental behavioral change at a national scale. It aligns well with Bangladesh's predominantly residential building stock and enables progressive improvement without excluding small developers or informal construction practices. While certification and rating systems remain valuable for flagship projects, institutional benchmarking, and international reporting, labeling provides the most effective foundation for mass adoption, policy integration, and long-term transformation of the built environment in Bangladesh.

Table 7. Different categories of sustainable/green building assessment systems

System	Category
LEED (USA)	Certification
EDGE (IFC)	Certification
BREEAM (UK)	Certification
CASBEE (Japan)	Rating
GRIHA (India)	Rating
GREENSL (Sri Lanka)	Rating
BEEER (Bangladesh)	Rating
GreenARCH (Bangladesh)	Certification



Labelling Status	Score Range	Minimum Points Required	Performance Interpetation	Purpose
Brown Leaf	20~39%	Minimum Compliance Threshold	Meets core sustainability regulations	Entry-Status Labelling Early adoption incentive
Orange Leaf	40~59%	Moderate Sustainability Performance	Basic energy, water & environmental measures	Incremental Improvement Step-by-step progress
Yellow Leaf	60~79%	Good Sustainability Performance	Well-integrated sustainable strategies	Strong Environmental Performance
Green Leaf	>80%	Advanced Sustainability Performance	High-efficiency & low environmental impact	Leading Sustainable Projects Reward for excellence

Figure 14. Proposed labeling structure.

DESH will issue performance-based labels rather than conventional rating tiers (Figure 14). The labeling structure reflects energy and emissions performance thresholds expressed as percentage improvements or carbon-intensity benchmarks. The platform visually displays progression between label categories, as shown in Table 8.

Table 8. Proposed DESH labeling statuses and minimum score requirements

Labelling Status	Score Range (%)	Minimum Points Required	Performance Interpretation	Purpose
Brown Leaf 	20-39%	Minimum compliance threshold	Demonstrates compliance with core sustainability requirements and national regulatory standards	Entry-status labeling encourages early adoption.
Orange Leaf 	40–59%	Moderate sustainability performance	Indicates basic integration of energy, water, and environmental performance measures	Encourages incremental improvement
Yellow Leaf 	60–79%	Good sustainability performance	Demonstrates well-integrated sustainable design strategies across multiple categories	Represents strong environmental performance
Green Leaf 	>80%	Advanced sustainability performance	Indicates high-performance building systems and significant reductions in energy and environmental impacts	Recognizes leading sustainable projects

Notes

- Projects must satisfy minimum mandatory criteria (20%) before scoring points toward labeling status.
- Points are accumulated across multiple sustainability categories,

including energy efficiency, water conservation, materials, indoor environmental quality, and site sustainability.
- Higher labeling status requires minimum performance thresholds in critical categories such as energy and water.

The platform will be able to do the following.

- Automatically compute progress
- Visually display a live progress bar
- Show transition from Brown → Orange → Yellow → Green (Figure 15, Figure 16)

Figure 15. Actual photo showing transition from Brown → Orange → Yellow → Green (Photo taken on 02 March 2026 at BUET).

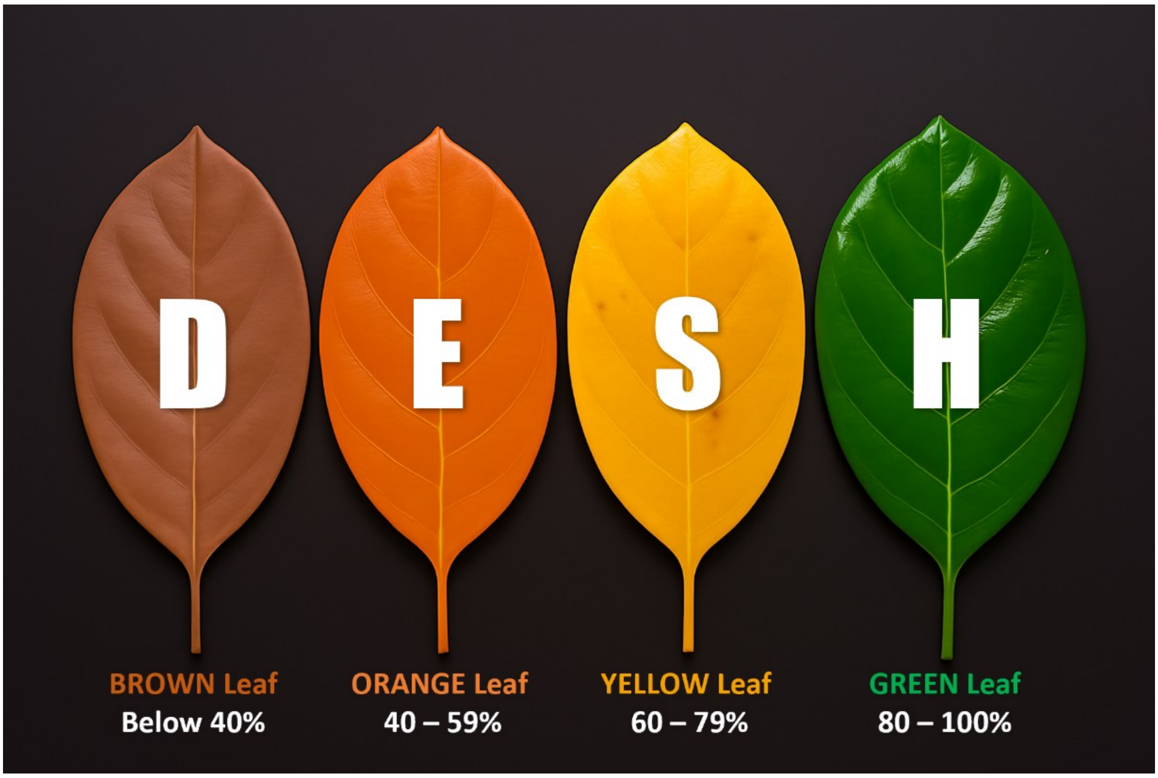


Figure 16. Transition from Brown → Orange → Yellow → Green.

13.3 Labeling Stages

The labeling will dynamically update based on recalculated values. Renewable energy production is incorporated into operational carbon deductions. Therefore, DESH is structured around an emission-based methodology that calculates, verifies, and aggregates both embodied and operational carbon. The system prioritizes carbon intensity per square meter per year as a central metric and links this to a progressive labeling structure. The platform will support three labeling stages as follows (Figure 17).

Stage 1: Before Construction (Planning Stage): Design (Prediction/ Simulation)

- Context analysis (location-based factors)

- Embodied carbon estimation
- Operational carbon prediction [$kgCO_2e/(m^2year)$]
- Renewable energy estimation
- Upload of energy models (BIM-based or simplified online modeling)

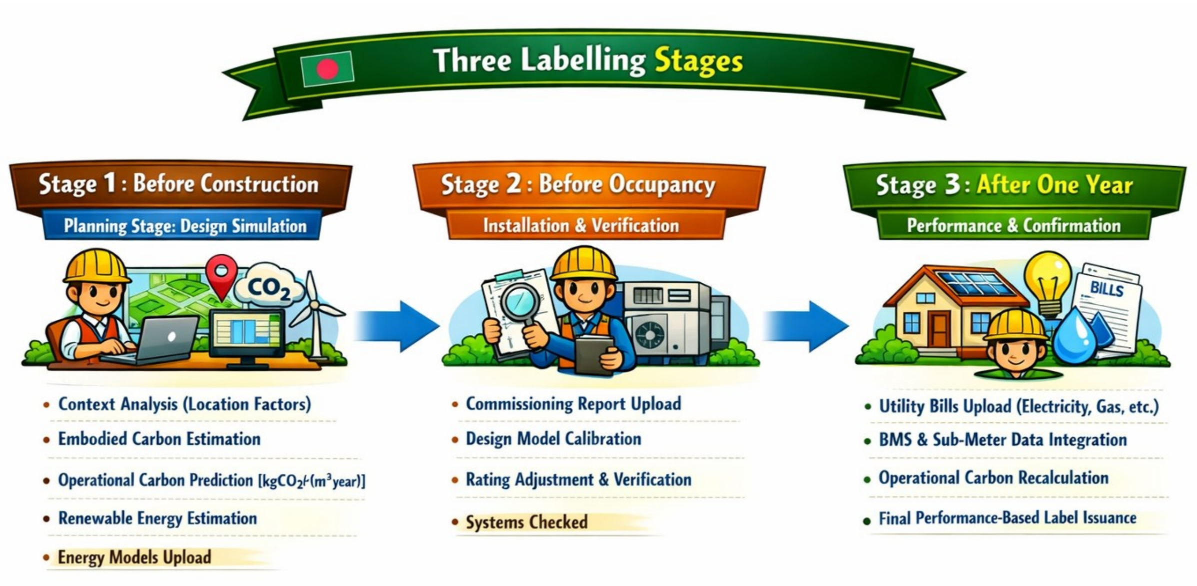


Figure 17. Three labeling stages.

Stage 2: Before Occupancy (After Construction): Installation and Verification

- Commissioning report upload
- Calibration of the design model with installed systems
- Adjustment of rating based on verified specifications

Stage 3: After One Year of Occupancy (and periodically thereafter): Performance (measurement and confirmation)

- Utility bill upload (electricity, gas, etc.)
- BMS or sub-meter data integration

- Operational carbon recalculation
- Final performance-based label issuance

The platform enables real-time recalculation, allowing modifications made during construction or occupancy to update the building's performance profile and corresponding label automatically. As a result, the labeling outcome remains dynamic, reflecting differences between design intent, construction practices, and operational performance. The system also maintains a traceable audit trail to document performance changes across these stages.

13.4 Development Phases

The DESH web-based platform was designed, developed, and implemented across Versions 1-4. A secure, scalable, and user-friendly digital system has been developed that can handle predictive simulation data, installation verification records, and operational performance measurements. The platform enables continuous recalibration of building labels using verified data throughout the full building life cycle.

a) Version 1 – Foundational Interface and Scoring Framework

The purpose of this version is to establish a stable structural backbone that allows future integration of automated processing and advanced simulation features.

Features of Version 1

- Design of the website of the labeling system with all its functionality and operation (visually working)
- User-accessible web interface

- Secure authentication and login system
- Manual data input modules
- Foundational scoring architecture
- Basic dashboard visualization
- Modular database structure to support future automation

b) Version 2 – Calculation Engine and Labeling Logic

The purpose of this version is to operationalize the scientific framework and embed structured certification intelligence into the system.

Features of Version 2

- Development of a reference spreadsheet to calculate the carbon emission values using equations.
- Development of a validated carbon and energy calculation engine.
- Translation of reference spreadsheet-based equations into: Structured JavaScript logic and JSON-based data models
- Automated generation of: Carbon results, Energy performance indicators, Certification outputs
- Integration of leaf labeling logic, i.e., GREEN Leaf: 100 – 80 %; YELLOW Leaf: 79 – 60 %; ORANGE Leaf: 59 – 40 %; BROWN Leaf: below 40%.

c) Version 3 – Automation and Institutional Functionality

The purpose of this version is to enhance scalability and usability for institutional users and policy-level applications.

Features of Version 3

- Generation of input and output Excel and CSV files from environmental simulation platforms to assess the energy performance of a building.
- Excel and CSV upload functionality in the web.
- Automated data parsing and validation
- Project comparison modules
- Sensitivity analysis visualization tools
- Aggregated reporting capabilities
- Institutional dashboard for multi-project tracking

d) Version 4 – Cloud Deployment and Simulation Engine

The purpose of this version is to transform DESH into a scalable, optimization-enabled, interoperable smart environmental assessment ecosystem.

Features of Version 4

- Cloud infrastructure deployment
- REST-based API endpoint development
- Iterative simulation engine for multiple performance scenarios
- Optimization-ready architecture
- Interoperability preparation with environmental simulation platforms

13.5 Supporting Thematic Categories

The system will incorporate several thematic domains (Figure 18), including Climate Adaptation and Resilience; Site Sustainability and Planning; Materials and Resources; Water and Waste Management; Energy Conservation and Environmental Quality (EQ); Energy Efficiency and Renewable Energy; and Lifestyle, Social, Health and Safety (Table 9, details in Appendix C). These domains will operate through a structured scoring framework that dynamically updates as relevant data are entered into the system. For example, public transport accessibility will be evaluated based on the walking distance from the building site to nearby transit nodes, with distances automatically calculated using geospatial tools.

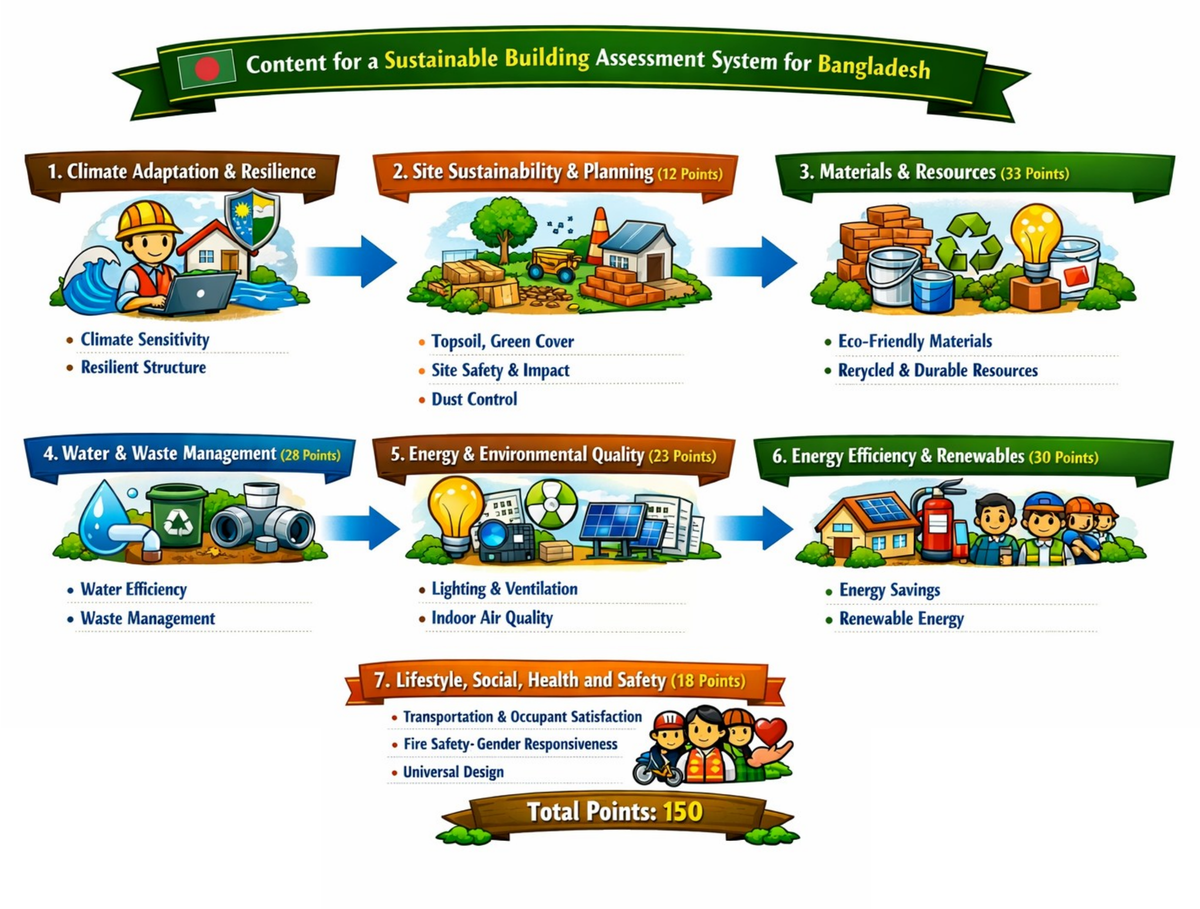


Figure 18. Thematic categories of DESH.

Table 9. Content for a sustainable building assessment system for Bangladesh.

Sl. No	Categories and Sub-categories	Max Points
1	**Climate Adaptation and Resilience**	**16**
1.1	Climate Sensitivity	8
1.2	Resilient Structure	8
2	**Site Sustainability and Planning**	**12**
2.1	Topsoil Preservation	2
2.2	Green Cover	2
2.3	Site Facilities	2
2.4	Dust Control	2
2.5	Site Safety	2
2.6	Environmental Impact	2
3	**Materials and Resources**	**38**
3.1	Building Materials	8
3.2	Reused/Recycled Building Materials	4
3.3	Building Material Durability	2
3.4	Building Materials Wastage	4
3.5	Low-Emission Building Materials	2
3.6	Interior Finishes and Materials	8
3.7	Reused/ Recycled Interior Materials	4
3.8	Interior Material Durability	2
3.9	Interior Materials Wastage	2
3.1	Low-VOC Interior Materials	2
4	**Water and Waste Management**	**28**
4.1	Construction Water Use	8
4.2	Construction Water Sourced from Surface	2
4.3	Construction Water Sourced from Rain	2
4.4	Operational Water Use	8
4.5	Operational Water Sourced from Surface	2
4.6	Operational Water Sourced from Rain	2
4.7	Waste Management	4
5	**Energy Conservation and Environmental Quality**	**22**
5.1	Interior Lighting	4
5.2	Exterior Lighting	2
5.3	Indoor Cooling	4
5.4	Ventilation	4
5.5	Indoor Air Humidity	2
5.6	Exhaust Systems	2
5.7	Building Acoustics	2
5.8	Indoor and Water Heating	2
6	**Energy Efficiency and Renewables**	**24**
6.1	Energy-Saving Equipment	8

Sl. No	Categories and Sub-categories	Max Points
6.2	Energy-Saving Cooking	8
6.3	Renewable Energy	8
7	**Lifestyle, Social, Health and Safety**	**10**
7.1	Transportation and Lifestyle	2
7.2	Occupant satisfaction	2
7.3	Fire Safety	2
7.4	Gender Responsiveness	2
7.5	Universal Design	2
	Total	**150**

13.6 Output

The output is a comprehensive system architecture document, a user interface prototype, fully functional versions of the platform in accordance with the phased development plan, administrative and user manuals, structured training sessions, and a maintenance and support framework.

DESH aims to establish Bangladesh's first emission-based sustainable building labeling system, integrating life-cycle carbon accounting, contextual design assessment, and post-occupancy verification within a unified digital environment. The platform is intended to serve as both a regulatory instrument and a design optimization tool, supporting national climate goals and long-term sustainability transitions.

14 Implementation Strategies

Projects applying for labeling under the DESH assessment tool shall follow a structured, transparent process from project registration through final labeling (Figure 19).

Figure 19. DESH process schedule.

The process integrates digital submission, design review, construction verification, and operational performance confirmation assessments to ensure that labeled buildings meet the required environmental and carbon performance standards.

14.1 Project Registration

Applicants shall register their project and pay the registration fees through the DESH web-based platform by submitting basic project information, including project type, location, size, and ownership details. Upon payment of the applicable registration fee, the project will receive a unique Project ID.

14.2 Pre-Assessment and Target Setting

At an early stage, project teams may participate in an optional pre-assessment consultation or user workshop, arranged by HBRI on a regular basis. This step provides guidance on the DESH criteria, expected documentation, and potential strategies to achieve the intended labeling status, enabling design teams to integrate sustainability considerations from the outset.

14.3 Design Phase Review

During the design phase, project teams shall submit architectural, engineering, and environmental documentation through the DESH platform. Upon payment of the appropriate labeling fee, a DESH reviewer will be assigned to the Project ID to start the review process. Reviewers will evaluate the proposed design against applicable performance indicators, including energy, water, materials, and climate-responsive design measures. Where appropriate, provisional approvals will be issued.

14.4 Construction Phase Verification

During construction, project teams shall provide evidence that approved design measures are implemented as specified. This may include material documentation, construction records, and site photographs. Upon the DESH Reviewer's recommendation, independent DESH assessors may conduct site audits or request additional documentation to verify compliance.

14.5 Commissioning and Performance Verification

Before project completion, key building systems, including energy, water, ventilation, and renewable energy installations, shall undergo commissioning to ensure effective installation and operation. Where applicable, monitoring systems should be installed to track operational performance and confirm alignment with projected performance targets.

Upon the DESH Reviewer's recommendation, independent DESH assessors may conduct site audits or request additional documentation to verify compliance.

14.6 Final Labeling Review

Upon project completion, the applicant shall submit as-built documentation, commissioning reports, and any required performance data through the DESH platform. A final review will confirm whether the project meets the required criteria and determine the appropriate labeling status. Upon the DESH Reviewer's recommendation, independent DESH assessors may conduct site audits or request additional documentation to verify compliance.

14.7 Relabelling and Operational Performance Review

To ensure continued environmental performance, labeled buildings will undergo relabelling based on operational data at regular intervals, typically each year. This process evaluates ongoing energy, water, and environmental performance and may lead to renewal, upgrade, or adjustment of the labeling status. Upon the DESH Reviewer's recommendation, independent DESH assessors may conduct site audits or request additional documentation to verify compliance.

14.8 Applicability Across Building Life Cycle Stages

The DESH labeling system is designed to be flexible and inclusive, allowing projects to register for assessment at any stage of the building life cycle, including design, construction, or occupancy. This approach ensures broad applicability across both new and existing buildings, enabling stakeholders to engage with the system irrespective of project maturity. For new developments, early-stage registration during the design phase supports predictive assessment, informed decision-making, and optimization of performance outcomes prior to construction. Projects entering the construction stage can undergo verification of installed systems and material specifications to ensure alignment with intended performance targets. Buildings registered during occupancy are evaluated using actual operational data, enabling performance validation and continuous improvement.

This multi-entry framework reflects a scientifically grounded LCA approach, recognizing that environmental performance evolves over time and is influenced by design intent, construction quality, and operational practices. By accommodating entry at different stages, the system facilitates both prospective and retrospective performance evaluation, thereby supporting the transition from design-based compliance to performance-based verification. Consequently, the DESH framework enables a unified assessment methodology applicable to new construction, renovations, and existing building stock, promoting long-term decarbonization and sustainability across the built environment.

15 Documentation and Compliance Protocols

All submissions must be uploaded through the DESH digital platform using the prescribed templates, standardized calculation sheets, and approved digital formats (e.g., PDF, XLSX, CAD/BIM extracts). Documents must follow consistent naming conventions, version control, and metadata tagging to ensure traceability, transparency, and ease of review. Each submission must be signed or verified by the responsible design professional.

15.1 Code and Regulatory Compliance

Projects must demonstrate full compliance with applicable national and local regulations, including the BNBC, the Building Construction Act (Bidhimala), the Fire Prevention and Extinction Act, the Department of Environment, Bangladesh's environmental clearance requirements, and other relevant municipal or sectoral regulations. Compliance documents must be submitted before labeling review.

15.2 Calculation and Performance Assessment Methodologies

All performance calculations must follow approved DESH methodologies. Energy assessments should compare the proposed building's performance with standardized baseline buildings set by HBRI. Design assessments must include projected demand, conservation measures, reuse volumes and management systems. Material evaluations should quantify recycled content, local sourcing, durability, and embodied carbon where applicable. Indoor environmental quality assessments must address ventilation, thermal comfort, daylighting, and pollutant control.

15.3 On-Site and Off-Site Verification Procedures

Verification will include design review, site inspections, commissioning reports, environmental performance measurements, and verification of installed systems. Upon the DESH Reviewer's recommendation, independent DESH Assessors may conduct audits of construction practices, metering systems, indoor air quality parameters, and operational readiness before labeling is granted.

15.4 Conformance Management and Corrective Actions

If non-conformities are identified during the documentation review or on-site verification process, the project team shall submit appropriate corrective actions within five (5) working days. This may include the provision of revised documentation, updated calculations, or additional verification evidence as requested by the DESH Reviewer. Failure to adequately address the identified non-conformities within the specified timeframe may result in the withholding of awarded points, delays in certification or labeling, or suspension of the application until full compliance is achieved. In cases of significant or repeated non-compliance, the governing body reserves the right to impose penalties, including the withdrawal of previously awarded points, incentives, or certification status in accordance with the established program regulations.

16 Proposed Fees

Anyone can open an account and assess a building for free using the DESH board. A fee will be required to obtain a labeling certificate and access associated incentives. The proposed fee structure for the DESH labeling system adopts an area-based labeling model similar to many internationally recognized systems, while adjusting fee levels to Bangladesh's economic and development context. Fees include registration, review, and site visit costs (Figure 20).

Registration fee includes project registration, project ID creation, access to the DESH digital platform, preliminary documentation upload and initial project record setup. The labeling fee includes administrative processing. Additional fees may be required upon the DESH Reviewer's recommendation if independent DESH assessors need to conduct audits of construction practices, metering systems, indoor air quality parameters, and operational readiness before final labeling is granted. Public buildings and green-financed projects may receive concessional rates. Table 10 presents the details of DESH labeling fees by building area and Table 11 shows Additional DESH assessment and administrative fees.

Table 10. DESH labeling fees by building area

Building Typology	Registration Fee (BDT)	Gross Floor Area (m^2)	Labeling Fee (BDT)
Residential Buildings (A)	5,000	Up to 1,000	50,000
		1,001 – 2,500	60,000
		2,501 – 5,000	70,000
		5,001 – 10,000	80,000
		10,001 – 20,000	90,000
		Above 20,000	100,000 + 5.00 BDT/m^2 (additional area)
Institutional / Mixed-Use Buildings (B, C, D, I and M)	7,000	Up to 1,000	70,000
		1,001 – 2,500	85,000
		2,501 – 5,000	100,000
		5,001 – 10,000	115,000
		10,001 – 20,000	130,000
		Above 20,000	150,000 + 7.00 BDT/m^2 (additional area)
Office / Commercial Buildings (E, F, G, H, J, K and L)	10,000	Up to 1,000	100,000
		1,001 – 2,500	120,000
		2,501 – 5,000	140,000
		5,001 – 10,000	160,000
		10,001 – 20,000	180,000
		Above 20,000	200,000 + 10.00 BDT/m^2 (additional area)

Table 11. Additional DESH assessment and administrative fees

Fee Category	Fee Range (BDT)	Description
Site Audit / Verification	20,000	Covers field inspections, documentation verification, and compliance assessment
Performance Verification	15,000	Includes commissioning review and operational performance validation
Relabelling (Existing Buildings)	25,000	Applicable every 5 years for operational performance reassessment

Figure 20. Proposed fees for DESH labeling.

17 Proposed Incentive Areas

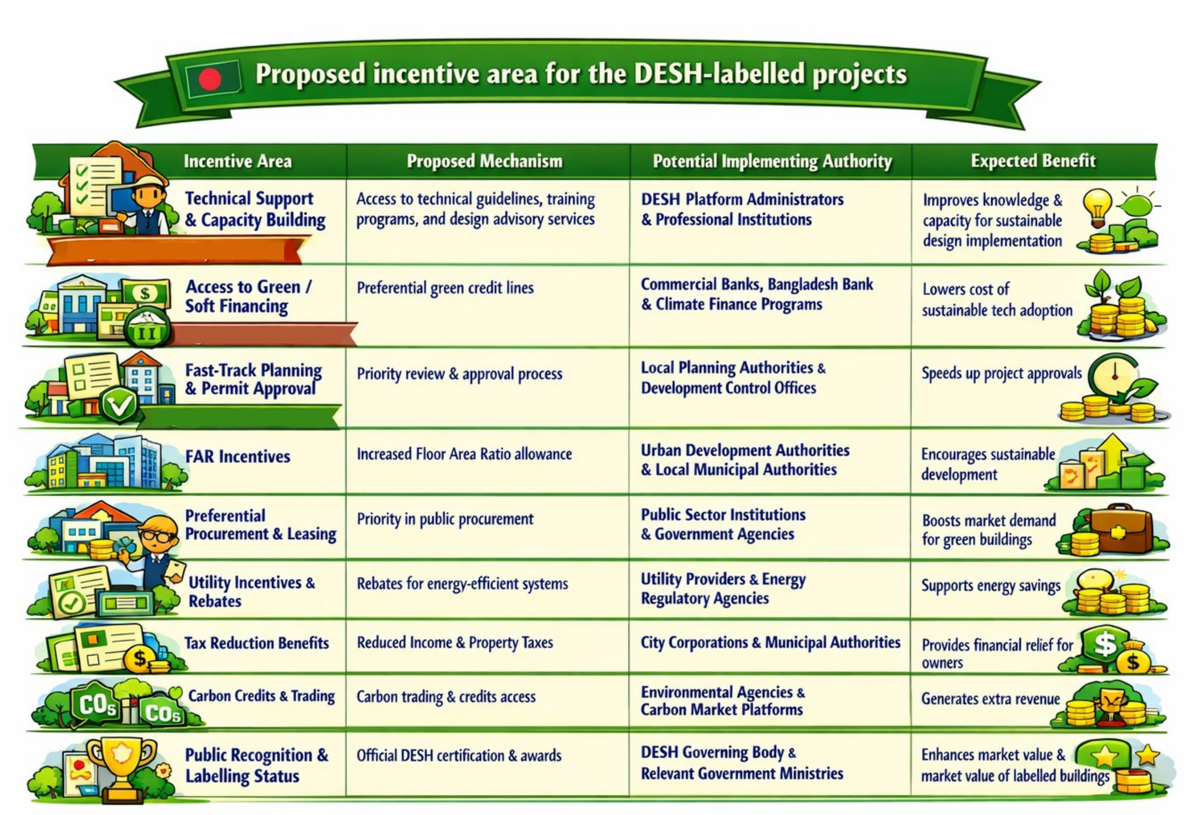
The proposed incentive framework for the DESH labeling system aims to encourage voluntary adoption of sustainable building practices by providing financial, regulatory, and recognition-based benefits (Table 12). Similar incentive mechanisms have been implemented in international green building certification/rating systems, where regulatory incentives, tax reductions, and financing benefits help offset the initial investment required for high-performance buildings. By integrating these incentives into Bangladesh's policy framework, the DESH platform can accelerate the transition toward low-carbon, environmentally responsible built environments.

Proposed incentive area for the DESH-labeled projects (Figure 21), structured into a framework suitable for inclusion in a guideline. The incentives are aligned with sustainable development policies and building regulations in Bangladesh.

Table 12. Proposed incentive area for the DESH-labeled projects

Incentive Area	Proposed Mechanism	Potential Implementing Authority	Expected Benefit
Technical Support and Capacity Building	Access to technical guidelines, training programs, and design advisory services	DESH platform administrators and professional institutions	Improves knowledge and capacity for sustainable design implementation
Access to Green / Soft Financing	Preferential interest rates or dedicated green credit lines for projects proportional to the estimated/achieved DESH label	Commercial Banks, Bangladesh Bank, Climate Finance Programs	Reduces the upfront cost of sustainable design and technology adoption
Fast-Track Planning and Permit Approval	Priority review process for planning approval and construction permits for projects proportional to the estimated DESH label.	Local Planning Authorities and Development Control Offices	Reduces project approval timelines and administrative delays
Floor Area Ratio (FAR) Incentives	Full or partial FAR allowance for projects proportional to the estimated/achieved DESH label	Urban Development Authorities and Local Municipal Authorities	Encourages developers to adopt sustainable design strategies

Incentive Area	Proposed Mechanism	Potential Implementing Authority	Expected Benefit
Preferential Procurement and Leasing	Public and private agencies may prioritize leasing or procurement from DESH-labeled buildings.	Public sector institutions and government agencies	Encourages market demand for sustainable buildings
Utility Incentives and Rebates	Rebates or reduced connection charges for energy-efficient systems or renewable energy installations for projects proportional to the achieved DESH label	Utility providers and energy regulatory agencies	Supports investment in energy-efficient technologies
Income Tax, Property Tax and Holding Tax Reduction	Partial reduction in taxes for projects proportional to the achieved DESH label	City Corporations and Municipal Authorities	Provides long-term financial savings for building owners
Carbon Credit and Emission Trading	Eligibility to participate in carbon trading or climate finance markets for verified emission reductions for projects proportional to the achieved DESH label	Environmental regulatory agencies and carbon market platforms	Creates additional revenue streams through carbon reduction
Public Recognition and Labeling Status	Official recognition through DESH labeling plaques, listings, and national sustainability awards	DESH Governing Body and relevant government ministries	Enhances the reputation and market value of labeled buildings



Proposed incentive area for the DESH-labelled projects

Incentive Area	Proposed Mechanism	Potential Implementing Authority	Expected Benefit
Technical Support & Capacity Building	Access to technical guidelines, training programs, and design advisory services	DESH Platform Administrators & Professional Institutions	Improves knowledge & capacity for sustainable design implementation
Access to Green / Soft Financing	Preferential green credit lines	Commercial Banks, Bangladesh Bank & Climate Finance Programs	Lowers cost of sustainable tech adoption
Fast-Track Planning & Permit Approval	Priority review & approval process	Local Planning Authorities & Development Control Offices	Speeds up project approvals
FAR Incentives	Increased Floor Area Ratio allowance	Urban Development Authorities & Local Municipal Authorities	Encourages sustainable development
Preferential Procurement & Leasing	Priority in public procurement	Public Sector Institutions & Government Agencies	Boosts market demand for green buildings
Utility Incentives & Rebates	Rebates for energy-efficient systems	Utility Providers & Energy Regulatory Agencies	Supports energy savings
Tax Reduction Benefits	Reduced Income & Property Taxes	City Corporations & Municipal Authorities	Provides financial relief for owners
Carbon Credits & Trading	Carbon trading & credits access	Environmental Agencies & Carbon Market Platforms	Generates extra revenue
Public Recognition & Labelling Status	Official DESH certification & awards	DESH Governing Body & Relevant Government Ministries	Enhances market value & market value of labelled buildings

Figure 21. Proposed incentive area for the DESH-labeled projects

18 Governance and Quality Assurance

The proposed framework is designed to align closely with national building regulations, climate policies, and international sustainability commitments. Institutional capacity building is recognized as a critical enabler of successful implementation. Accordingly, the development process involves collaboration among senior experts, academic institutions, junior professionals, and policy stakeholders. This inclusive and multidisciplinary approach ensures both technical robustness and long-term institutional ownership of the assessment system.

The governance and quality assurance framework of DESH is designed to ensure transparency, credibility, and consistency in the operation of the web-based building labeling platform. The system follows a structured institutional arrangement supported by independent technical review, accredited professionals, standardized documentation procedures, and periodic system updates. These mechanisms collectively ensure that labeling decisions are reliable, evidence-based, and aligned with national regulatory requirements and international sustainability assessment practices. These mechanisms will also strengthen the governance and credibility of the DESH framework and align with structures used in international rating/certification systems.

18.1 Governance Structure

The governance structure of DESH comprises several institutional bodies responsible for strategic oversight, technical evaluation, and operational management (Table 13). A Governing Board provides overall policy direction, approves updates to labeling criteria, and ensures alignment with national sustainability and climate objectives. The Technical Review Committees, consisting of independent experts from relevant disciplines such as architecture, engineering, environmental science, and urban planning, evaluate project submissions and assess compliance with DESH performance criteria. A Labeling Secretariat manages the platform's administrative operations, including project registration, document management, review coordination, and communication with project applicants. In addition, a Digital Platform Management Unit maintains the web-based system infrastructure, ensuring secure data handling, digital submission processes, and performance monitoring within the platform. Figure 22 shows the proposed governance and institutional structure for DESH implementation.

Table 13. Proposed governance and institutional structure for DESH implementation.

Institutional Role	Responsible Entity	Key Responsibilities	Expected Contribution
National Governing Body	Ministry of Housing and Public Works	Policy oversight, national framework development, and regulatory alignment	Ensures national legitimacy and policy integration
Technical Secretariat / DESH Administration	Dedicated DESH platform management unit in HBRI	Operation of the web-based assessment system, labeling management, and reviewer and assessor coordination	Maintains transparency and operational efficiency
Technical Advisory Committee	Experts from academia, industry, and professional organizations	Develops technical criteria, updates assessment methodologies, and reviews system performance	Ensures scientific and technical credibility
Labeling Review Panel	Accredited professionals and sustainability experts	Conducts project reviews, verifies documentation, and approves labeling outcomes	Maintains objectivity and quality assurance
Monitoring and Verification Unit	Independent assessors and verification agencies	Conducts site inspections, performance monitoring, and compliance verification	Ensures the integrity of the labeling process
Data and Digital Platform Management	DESH digital platform team	Maintains the web-based labeling tool, database management, and performance reporting	Enables digital transparency and data-driven decision making
Professional Accreditation Body	Professional institutions and training providers	Develops training programs for DESH consultants and professionals	Builds national capacity for sustainable building practices

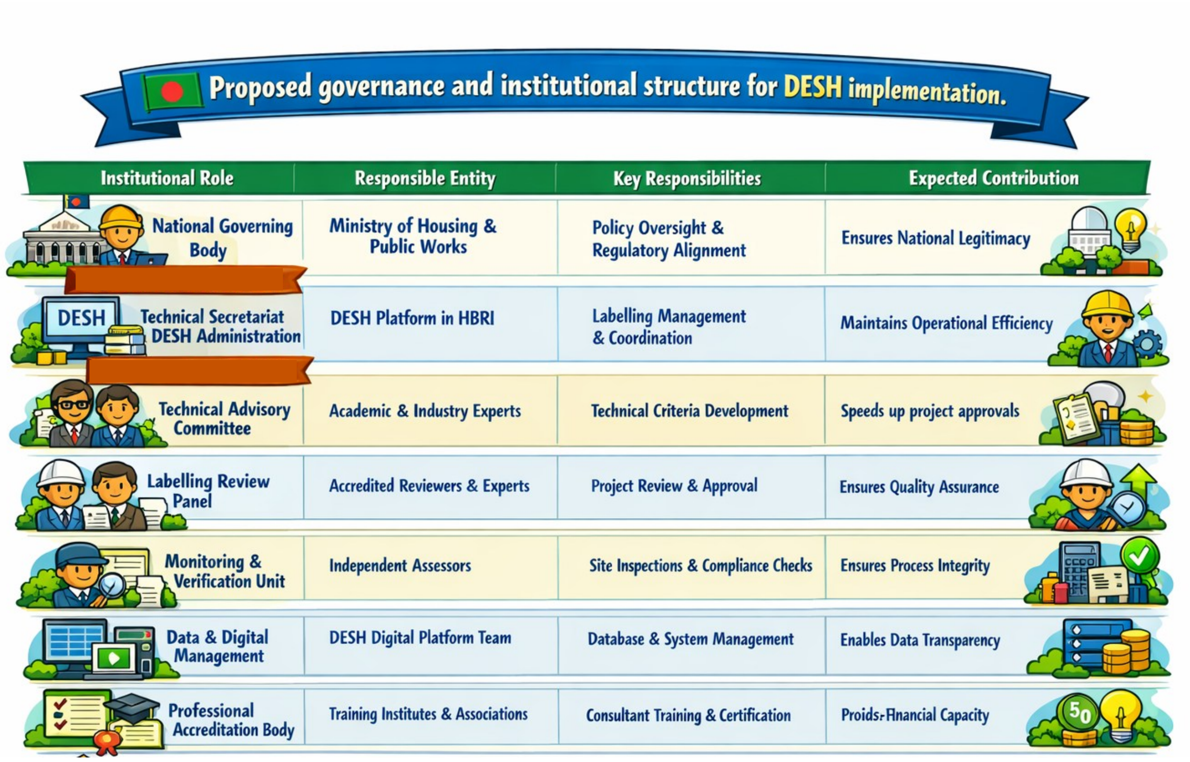


Figure 22. Summary of governance and institutional structure for DESH implementation.

18.2 Reviewer Accreditation

To maintain the credibility of the assessment process, DESH requires qualified professionals to participate in project evaluation and verification. Accredited DESH Professionals must complete approved DESH training programs and demonstrate adequate technical knowledge of sustainable building design, environmental assessment, and performance evaluation methodologies. Reviewers are expected to possess relevant professional experience in architecture, engineering, environmental management, or sustainability consulting. Accredited professionals are required to participate in continuing professional development (CPD) programs to maintain their qualifications and stay informed about evolving standards, technologies, and regulatory requirements. To ensure impartiality, reviewers must declare any potential conflicts of interest and avoid participating in assessments where they have professional or financial relationships with project teams.

18.3 Quality Assurance Protocols

The DESH system incorporates multiple quality assurance mechanisms to ensure the reliability and accuracy of project assessments. All project submissions must follow standardized documentation templates and calculation formats prescribed by the platform. The labeling process involves a multi-level review structure, typically consisting of an initial design-based technical review, an independent quality assurance verification, and final labeling confirmation by the designated review panel. During the construction phase and prior to final labeling, on-site verification procedures may be conducted to confirm that the implemented design measures correspond with the submitted documentation. In addition, the digital platform may incorporate automated validation checks to identify incomplete submissions, calculation inconsistencies, or missing documentation, thereby improving the efficiency and transparency of the review process.

18.4 Integrity and Transparency

Maintaining institutional integrity and transparency is a core principle of the DESH framework. All reviewers, committee members, and involved professionals are required to submit conflict-of-interest declarations to prevent bias in the evaluation process. Labeling decisions, review comments, and supporting documentation are recorded on the digital platform to maintain a clear, traceable audit trail. The system also includes a formal appeals and re-evaluation mechanism, allowing project applicants to request reconsideration of labeling outcomes where additional evidence or clarifications are provided. Public transparency may be further enhanced through an official registry of labeled projects accessible through the DESH platform.

18.5 Continuous Improvement

To remain relevant and effective, the DESH system incorporates mechanisms for continuous improvement and periodic review of its assessment criteria and operational procedures. Updates to labeling benchmarks and performance thresholds will be undertaken regularly to reflect technological advancements, emerging sustainability practices, and national development priorities. The system may also utilize operational performance data, simulation models, and life-cycle assessment methodologies to refine evaluation methods and improve the accuracy of sustainability performance indicators. Continuous alignment with national regulatory frameworks, particularly the BNBC, and adherence to international best practices ensure that DESH remains both locally relevant and globally comparable. Through these mechanisms, the platform aims to support the long-term development of sustainable, low-carbon buildings in Bangladesh.

18.6 Practical Initiatives to Strengthen Credibility

To ensure effective implementation and practical applicability of the DESH web-based building labeling platform, several practical initiatives should be integrated into the system. These initiatives aim to generate reliable performance data, support evidence-based design decisions, and enhance accessibility of technical resources for project teams. By incorporating applied research, pilot testing, and digital data repositories, the DESH platform can facilitate informed decision-making and strengthen the overall credibility of the sustainability assessment process.

One important initiative is conducting evidence-based analyses of the life-cycle environmental impacts of commonly used building materials in the local construction industry. Materials such as concrete, bricks or eco-blocks, glass, steel, and aluminum should be assessed through LCA studies to determine their embodied carbon, energy consumption, durability, and environmental impacts throughout production, transportation, use, and end-of-life stages. These analyses will help establish localized benchmarks and enable accurate evaluation of material sustainability within the DESH framework.

Another key component is the application of energy modeling and building performance simulation for selected pilot projects. Using building simulation tools, designers and assessors can evaluate energy demand, thermal comfort, daylight performance, and carbon emissions during the design stage. Pilot projects can serve as demonstration cases to validate the DESH system's performance indicators and provide empirical evidence to support future refinements to the labeling criteria. Such modeling approaches help bridge the gap between theoretical sustainability strategies and actual building performance.

The DESH platform should also develop a centralized digital database containing standard technical values for building appliances and systems. This database may include typical performance parameters for lighting systems, air-conditioning equipment, ventilation systems, water fixtures, and renewable energy technologies commonly available in the local market. By integrating these reference values into the web-based tool, users will be able to access reliable data for project assessment and documentation preparation quickly. This feature will improve user convenience, reduce calculation inconsistencies, and support accurate performance evaluations.

In addition, the system will encourage data collection from completed projects to establish a national performance benchmark database. Operational data related to energy consumption, water use, indoor environmental quality, and maintenance performance can be compiled and analyzed to improve the reliability of sustainability indicators. Over time, such data-driven insights will allow DESH to refine its performance benchmarks and align them more closely with real building operation conditions in Bangladesh.

Together, these practical initiatives help transform the DESH labeling system from a purely evaluative framework into a knowledge-driven platform that supports research, capacity building, and evidence-based sustainable building design.

19 User Roles, Responsibilities and Access Control

The DESH web-based building assessment platform operates through a clearly defined, role-based access control system to ensure transparency, accountability, and integrity throughout the evaluation and certification process (Figure 23). Each user category is assigned specific responsibilities aligned with their functional role, while strict limitations are imposed to prevent conflicts of interest and unauthorized data manipulation. Figure 23 shows user roles, responsibilities, and the access control network of DESH.

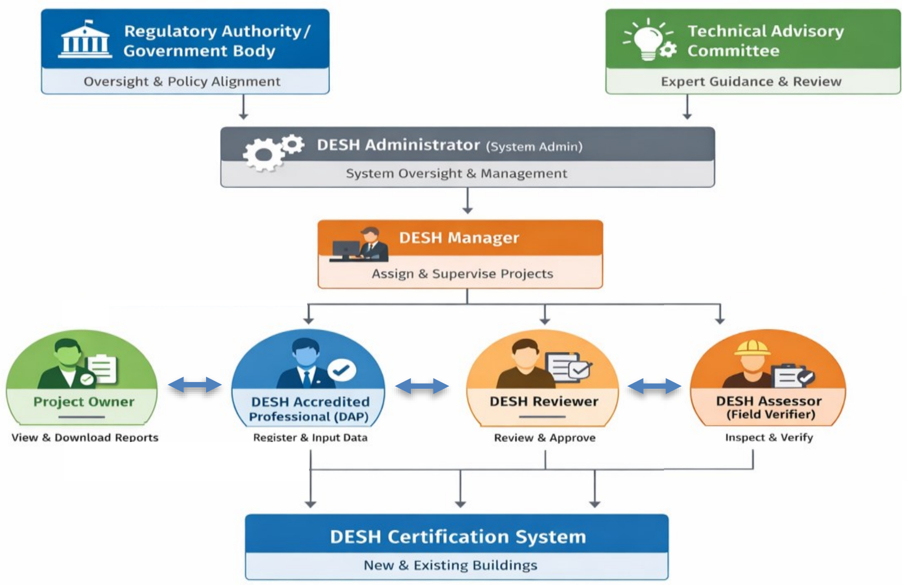


Figure 23. User roles, responsibilities, and access control network

At the project level, the Project Owner is granted read-only access to performance dashboards and certification outputs, and can communicate instructions to the DESH Professional, who serves as the primary technical operator of the system. All fees and payments (registration and labeling) will be processed through the Project Owner's account. The DESH Professional is responsible for project registration, data input, documentation upload, and coordination with reviewers, but is restricted from accessing confidential reviewer or assessor assignments and from influencing approval decisions.

The technical evaluation process is conducted independently by the DESH Reviewer, who verifies submitted information, performs compliance checks, and issues approval or rejection decisions. To maintain impartiality, reviewers are prohibited from modifying the original data or engaging in field verification. Complementing this role, the DESH Assessor undertakes on-site inspections and validation, responds to reviewer-flagged issues through evidence-based reporting, and remains restricted from altering submitted data or reviewer judgments.

Oversight and workflow coordination are managed by the DESH Manager, who assigns projects to reviewers and assessors, monitors progress, and generates consolidated reports, without interfering in technical evaluation outcomes. System-level control is maintained by the DESH Administrator, who manages platform architecture, user roles, and data integrity, ensuring secure and auditable system operations while remaining excluded from influencing certification decisions without formal authorization.

At the strategic level, the DESH Technical Advisory Committee provides expert input on methodology, benchmarks, and dispute resolution, supporting continuous system improvement without engaging in routine project operations. The DESH Steering Committee operates at the policy level, ensuring alignment with national regulations, endorsing certifications, and facilitating integration with incentive and compliance frameworks.

Table 14 provides details on user roles, responsibilities, and access controls in DESH. This structured separation of roles ensures a robust governance mechanism where data input, technical review, field verification, system management, and policy oversight remain independent yet coordinated, thereby enhancing the credibility, transparency, and reliability of the DESH certification system.

Table 14. Details of the user roles, responsibilities, and access controls in DESH.

User Role	Permitted Actions (Do)	Restrictions (Do Not)
Project Owner	Pay registration and labeling fees; view project data and performance DESH board; download up-to-date progress and certification reports; provide comments/instructions only visible to DESH Professional where required.	Modify or alter any submitted data, calculations, or assessment inputs.
DESH Professional	Register projects and create Project Owner(s) accounts (with User Name and Password); input and update project data; upload documentation; respond to reviewer comments; monitor project progress; download reports.	Access confidential information related to the assignments of reviewers or assessors; override verification or approval decisions.
DESH Reviewer	Access assigned projects; review submitted data and documentation; verify compliance through structured checks (tick/marking system); provide comments and request clarifications; approve or reject submissions; download project reports.	Modify original input data; access identity or confidential information of assignment of DESH Assessors; perform field verification roles.
DESH Assessor	Access assigned projects for site verification; review reviewer comments and flagged issues; conduct field inspections; upload verification reports, photographic evidence, and findings; provide responses to queries.	Modify submitted project data or reviewer decisions; access full reviewer evaluation records beyond the assigned scope.
DESH Manager	Create and manage accounts for DESH Reviewers and Assessors; assign projects to DESH Reviewers and Assessors; oversee workflow and progress; monitor system performance; generate and download consolidated reports across projects.	Modify project input data or interfere with technical evaluation outcomes; override independent review decisions without due process.

User Role	Permitted Actions (Do)	Restrictions (Do Not)
DESH Administrator (System Admin)	Create and manage accounts for DESH Managers; Manage and maintain the overall platform architecture; configure system settings; manage user roles and permissions; perform system updates and implement security controls; and access and modify data as needed for system integrity and audit purposes.	Intervene in technical assessment outcomes without formal authorization; compromise data integrity or bypass audit protocols.
DESH Technical Advisory Committee	Provide expert guidance on methodology, benchmarks, and complex cases; review disputed assessments; support continuous improvement of the system.	Engage in routine project-level data handling or direct system operations.
DESH Steering Committee	Oversee policy alignment; endorse certifications; integrate DESH outcomes with national regulations, incentives, and compliance frameworks.	Engage in day-to-day system operations or individual project assessments.

20 Comprehensive Framework Summary

The DESH framework integrates procedural, technical, financial, and institutional components into a comprehensive building sustainability assessment system (Table 15). By combining structured labeling processes, standardized documentation protocols, incentive mechanisms, and performance-based evaluation, the framework aims to support the adoption of environmentally responsible building practices in Bangladesh. The structure reflects principles adopted in an internationally recognized system, while adapting the operational model to local regulatory, climatic, and economic conditions.

Table 15. Comprehensive framework summary for the DESH building labeling system.

Framework Component	Key Elements	Description	Responsible Entity	Expected Outcome
System Registration	Project registration and ID allocation	Project applicants submit basic project information, pay registration fees, and obtain a unique project ID within the DESH digital platform.	DESH Administration Unit	Formal entry of projects into the labeling system
Pre-Assessment Guidance	Optional advisory workshop and preliminary review	Early consultation helps project teams understand labeling targets, required documentation, and sustainability strategies	DESH Technical Secretariat and Accredited Consultants	Improved project preparedness and realistic labeling planning
Documentation and Compliance Protocols	Standardized templates, calculation methods, and verification procedures	All project submissions follow standardized documentation formats, regulatory compliance requirements, and verification	DESH Technical Secretariat	Transparent and consistent project evaluation

Framework Component	Key Elements	Description	Responsible Entity	Expected Outcome
		protocols		
Labeling Fee Structure	Registration fees, area-based labeling fees, and verification charges	Fees are scaled based on building type and gross floor area to ensure equitable participation across project sizes	DESH Administration Unit	Financial sustainability of the labeling system
Design Phase Assessment	Evaluation of design documentation and sustainability strategies to assign a provisional label	Reviewers assess design drawings, calculations, and compliance with sustainability criteria before construction.	DESH Review Panel	Provisional credit approvals and early performance validation
Construction Phase Verification	Site inspections and documentation review	Construction practices and installed systems are verified through audits, documentation review, and DESH assessors.	Independent Verifiers and DESH Monitoring Unit	Ensures that approved design strategies are implemented correctly

Framework Component	Key Elements	Description	Responsible Entity	Expected Outcome
Commissioning and Performance Verification	Testing and operational performance validation	Building systems are tested to confirm operational efficiency, energy performance, and environmental quality standards.	Commissioning Agents and DESH Verification Team	Confirmation of building system performance and readiness for labeling
Final Labeling Review	Assessment of as-built documentation and performance evidence	Final evaluation confirms compliance with DESH requirements and determines the labeling status achieved	DESH Labeling Review Panel	Official DESH labeling issuance
Labelling Status	Labeled, Brown Leaf Orange Leaf Yellow Leaf Green Leaf	Projects receive labeling based on accumulated performance points and percentage score thresholds.	DESH Governing Authority	Recognition of different statuses of sustainability achievement
Incentive Mechanisms	Financial, regulatory, and recognition-based incentives	Includes soft loans, FAR incentives, tax reductions, fast-track approvals, and public recognition for labeled projects	Government agencies, municipalities, and financial institutions	Encourages voluntary adoption of sustainable building practices

Framework Component	Key Elements	Description	Responsible Entity	Expected Outcome
Relabelling and Monitoring	Periodic performance reassessment (each year)	Existing buildings may undergo relabelling based on operational performance monitoring and updated assessments.	DESH Monitoring and Verification Unit	Maintains long-term sustainability performance of labeled buildings

Figure 24. Comprehensive framework summary for the DESH building labeling system.

Figure 24 presents a comprehensive summary of the DESH web-based building labeling system. It consolidates the key components of the proposed framework, e.g., process stages, documentation, labeling status, incentives, and fees, into a single structured table suitable for a guideline document.

21 Roadmap and Tasks

The development and deployment of the national sustainable assessment system are envisioned as a phased process. Initial efforts focus on conceptualization, benchmarking, and the development of a functional demonstration platform that communicates the system's logic and potential. Subsequent phases involve testing and refinement through academic studios, pilot projects, and institutional collaborations, followed by scaling for broader national adoption. The current project phase aims to deliver a demonstrable prototype by mid-year, providing a tangible foundation for further development and stakeholder engagement.

To ensure the effective development and widespread adoption of the DESH web-based building labeling tool in Bangladesh, a structured set of tasks should be implemented through collaboration among government agencies, academic institutions, industry partners, and civil society organizations (Table 15). These tasks are intended to establish a national framework for sustainable building assessment, promote capacity development, and support the transition to low-carbon, resource-efficient buildings.

Stakeholder consultations indicate that institutional collaboration is essential for the successful implementation of DESH. Academic institutions, particularly engineering and technical universities, can provide research support, technical expertise, and training programs, while government organizations responsible for building development and regulation can integrate DESH into policy and planning frameworks. In Bangladesh, agencies involved in the design and construction of public buildings, such as the Department of Architecture, under the Ministry of Housing and Public Works, Bangladesh, can play a significant role in demonstrating sustainable design practices through government projects. Collaboration with research institutions will help overcome manpower limitations in government agencies by supporting technical studies, performance simulations, and sustainability assessments.

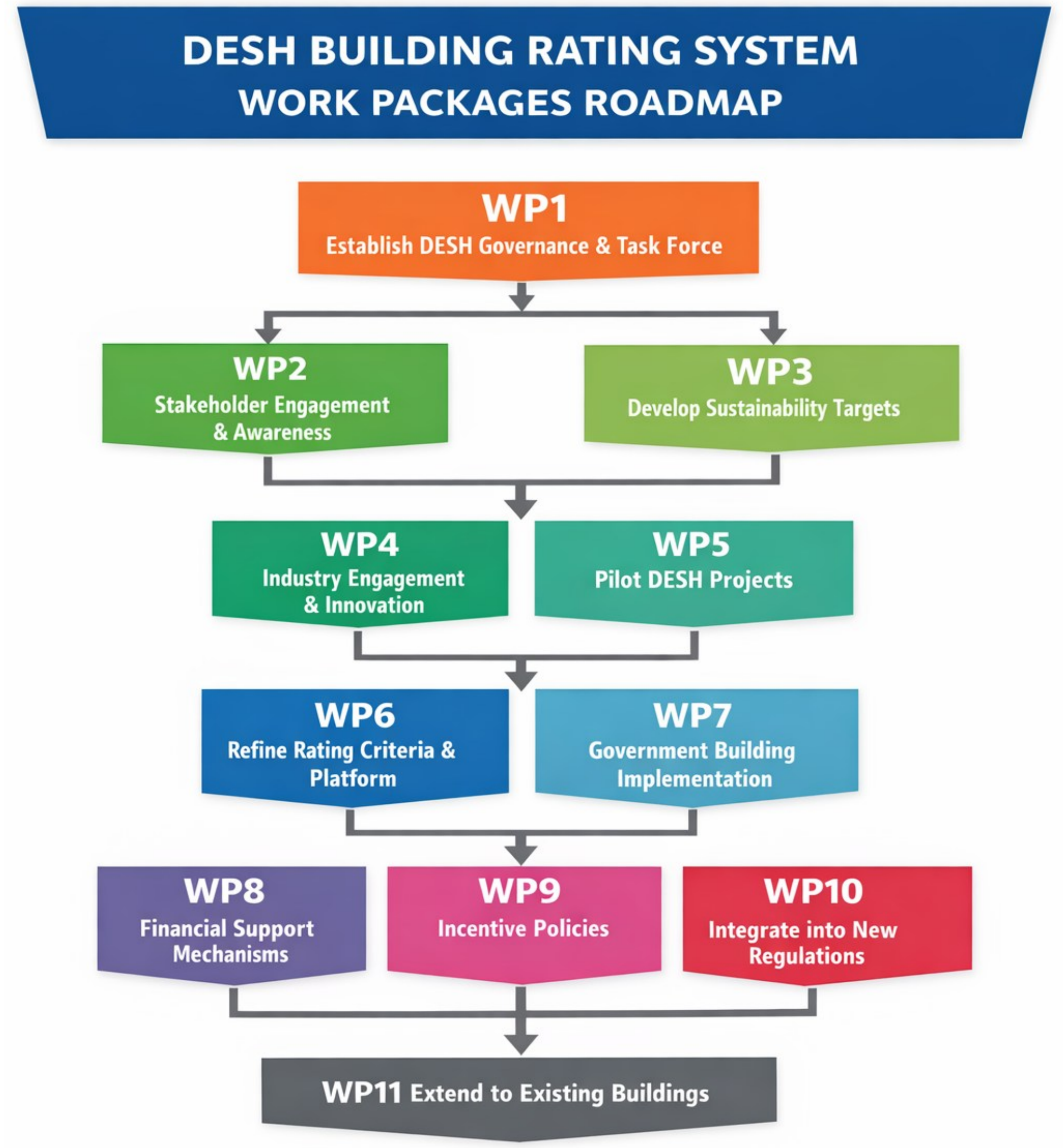


Figure 25. Roadmap and tasks for implementation of the DESH framework.

Community involvement and awareness building are also important initial steps in promoting sustainable construction practices. Many stakeholders still associate the concept of green buildings primarily with vegetation on roofs or facades. Awareness programs should clarify that sustainable buildings involve comprehensive strategies, including energy efficiency, water conservation, resource management, and improved indoor environmental quality. Outreach activities may include public campaigns, training workshops for architects and engineers, media programs, and engagement with local communities and small- and medium-scale enterprises involved in the construction sector.

Another important task is developing locally relevant sustainability performance targets. These targets should be based on existing national standards and policies, including the BNBC, energy efficiency initiatives, and environmental regulations, and should also reference international best practices in sustainable building assessment. Primary targets may include rainwater harvesting, greywater reuse, efficient water fixtures, waste segregation, improved thermal performance, and reduced operational energy demand. These targets should be developed through consultation with professionals, industry experts, and regulatory authorities to ensure that they are both achievable and contextually appropriate.

To demonstrate the feasibility of the DESH framework, pilot projects should be implemented and monitored. Selected buildings can be designed and constructed in accordance with DESH criteria, and their operational performance can be evaluated through post-occupancy monitoring. These pilot projects will provide valuable real-world data to refine the labeling system, verify performance indicators, and demonstrate the benefits of sustainable design to policymakers and developers.

In parallel, digital tools and software systems should be developed to support the DESH assessment process. A web-based platform will allow project teams to submit documentation, calculate performance indicators, and track labeling progress. The platform may also integrate energy simulation tools, material databases, and reference benchmarks to facilitate objective evaluation of building performance across different project types and climatic conditions.

Finally, to encourage industry participation, policy support mechanisms such as incentives, subsidies, and financing opportunities should be introduced. These may include tax benefits, access to green financing, priority permitting processes, or recognition programs for developers and building owners who achieve a higher status of DESH labeling. Over time, sustainability assessment and energy performance labeling may gradually become mandatory for new buildings and be extended to existing buildings through renovation and retrofit programs. Figure 8 shows the roadmap and tasks for implementing the DESH framework.

22 Work Packages

To translate the recommended tasks into actionable steps, the implementation strategy for the DESH platform can be organized into a series of Work Packages (WPs). These work packages represent coordinated activities carried out by a national task force composed of government organizations, academic institutions, industry representatives, and development partners. Each work package focuses on a specific aspect of system development, pilot implementation, or policy integration.

22.1 WP1: Establishment of the DESH Governance and Task Force

This work package focuses on establishing the institutional framework required for the development and operation of the DESH system. A national task force should be formed to coordinate research activities, policy development, and implementation processes. The task force may include representatives from universities, government agencies, professional institutions, and relevant industry organizations to ensure a multidisciplinary and collaborative approach.

To ensure consistency with national policy frameworks, the nomenclature, governance roles, and coordination mechanisms may follow the structure outlined in the 'Bangladesh Climate Action Roadmap for the Buildings and Construction Sector' developed under the Ministry of Housing and Public Works (MoHPW, 2024) (Appendix D). Aligning the institutional framework with these national and international initiatives will help ensure coherence with Bangladesh's climate commitments and sustainable development priorities.

Outputs

• Establishment of the DESH governing body and task force: nearly Zero Emission Communities Research Board (neZECoRBo: নিজে করব); and nearly Zero Emission Communities Renovation Union (neZECoRUn: নিজে করুন)

• Formation of an executive board and technical advisory committee

22.2 WP2: Stakeholder Engagement and Awareness

This work package aims to raise awareness of sustainable building practices among stakeholders, including architects, engineers, developers, policymakers, and the general public. Activities may include workshops, training programs, media campaigns, and outreach initiatives across different regions of the country.

Outputs

• Public awareness campaigns on sustainable buildings

• Training programs for professionals and industry stakeholders

22.3 WP3: Development of DESH Sustainability Targets

This work package involves reviewing national and international sustainability standards and defining measurable performance targets suitable for Bangladesh. These targets will serve as the basis for the DESH labeling criteria and assessment methodology.

Outputs

• Version 1 of the DESH sustainability assessment framework

• Defined benchmarks for energy, water, materials, and environmental performance

22.4 WP4: Industry Engagement and Innovation Promotion

Under this work package, developers, manufacturers, and construction companies will be encouraged to adopt innovative sustainable technologies and design strategies that exceed minimum performance targets. Voluntary recognition programs and industry partnerships may be developed.

Outputs

• Guidelines for advanced sustainable building practices
• Framework for voluntary sustainability recognition programs

22.5 WP5: Pilot DESH Projects

This work package involves implementing demonstration projects that meet DESH sustainability criteria. These projects will serve as case studies to test the labeling methodology and evaluate the real-world performance of sustainable building strategies.

Outputs

• Demonstration DESH-labelled buildings: nearly Zero Emission Communities (neZECom: নিজে কম) Building; and nearly Zero Emission Communities Renovation and Adaptation (neZECoRA: নিজে করা)
• Development of evaluation tools for building performance

22.6 WP6: Refinement of Labeling Criteria and System Development

Following the evaluation of pilot projects, the DESH labeling criteria and benchmarks will be refined. The labeling system may be transformed into a performance-based labeling framework supported by a web-based assessment platform.

Outputs

- Version 2 of the DESH sustainability standard
- Development of the DESH digital assessment platform

22.7 WP7: Implementation in Government Buildings

This work package promotes the adoption of DESH criteria in public sector building projects to demonstrate leadership in sustainable development. Government buildings can serve as early adopters and examples of best practice.

Outputs

- Sustainable design guidelines for government buildings
- Demonstration projects across multiple regions

22.8 WP8: Development of Financial Support Mechanisms

This work package focuses on identifying financial strategies to support sustainable construction, including subsidies, grants, and climate finance initiatives for projects that meet DESH performance criteria.

Outputs

- Policy proposals for financial incentives and subsidies
- Framework for climate finance integration

22.9 WP9: Incentive Policies for Sustainable Buildings

This work package aims to encourage private-sector investment in sustainable buildings through supportive policy measures, such as tax incentives, green financing schemes, and regulatory benefits.

Outputs

• Policy framework for sustainable building incentives

• Recommendations for financial and regulatory support mechanisms

22.10 WP10: Integration with New Building Regulations

This work package explores pathways to integrate DESH sustainability criteria into national building regulations for new construction projects. This may include mandatory performance standards and sustainability labeling requirements.

Outputs

• Policy recommendations for integrating DESH into building regulations

• Guidelines for sustainable building design in different contexts

22.11 WP11: Extension to Existing Buildings

The final work package focuses on developing sustainability assessment and retrofit guidelines for existing buildings. Labeling programs may be introduced to encourage building owners to improve the performance of older buildings.

Outputs

• DESH retrofit guidelines for existing buildings: Addition, Modification and Retrofitting DESH (AMaR DESH: আমার দেশ)

• Framework for building energy performance labeling

Together, these tasks and work packages provide a structured implementation roadmap for the DESH web-based building labeling system, ensuring that the platform evolves through research, pilot testing, stakeholder engagement, and policy integration to support sustainable development in Bangladesh's built environment.

23 Conclusions

This study establishes a clear and urgent need for a nationally integrated, context-responsive sustainable building assessment system for Bangladesh. The benchmarking of global, regional, and national frameworks confirms that, while international systems offer strong technical foundations and methodological rigor, they do not fully address the country's climatic conditions, development priorities, and socio-economic realities. At the same time, existing national initiatives remain fragmented and limited in scope, reinforcing the necessity for a unified, performance-based framework that aligns global best practices with local needs.

The proposed DESH (Design for Environment and Sustainable Habitats) framework addresses this gap by introducing a holistic, emissions-governed, and digitally enabled assessment system tailored to Bangladesh. It advances a methodological shift from conventional additive certification approaches toward a preventive and diagnostic logic, in which buildings are understood as dynamic systems and performance is continuously evaluated throughout their life cycle. By integrating embodied and operational carbon, location-sensitive assessment, and circular economy principles, DESH establishes a robust foundation for decarbonization and climate resilience. Its strategic focus on residential buildings further ensures that early implementation delivers maximum national impact.

DESH is designed not only as a certification tool but also as a dynamic decision-support platform that enables real-time performance evaluation, continuous improvement, and evidence-based design. The integration of simulation, BIM, and geospatial data enhances analytical accuracy while maintaining accessibility for practitioners. Through its structured yet flexible framework, DESH supports the transition toward healthy, resource-efficient, and nearly Zero Emission Communities (neZECom) that reflect both environmental priorities and social well-being.

Importantly, the framework is strongly aligned with Bangladesh's national policies and international climate commitments, including long-term decarbonization targets and resilience strategies. It complements existing regulatory instruments, particularly the BNBC (2020), by moving beyond compliance toward measurable performance improvement. With appropriate institutional support, stakeholder engagement, capacity building and policy incentives, DESH has the potential to drive market transformation, strengthen governance and mainstream sustainable building practices across the country.

In conclusion, DESH represents a transformative step toward establishing a credible, scalable and nationally relevant sustainable building assessment system. Its successful implementation can significantly reduce carbon emissions, enhance climate resilience, improve occupant health and support Bangladesh's broader sustainable development and climate goals.

Bibliography

1. Building Assessment & Carbon Tools

Builders for Climate Action. (n.d.). *Material Carbon Emissions (MCE) calculator guide*. MassCEC. https://www.masscec.com/sites/default/files/documents/TDDC%20Att%20C%20-%20Builders%20for%20Climate%20Action%20Tool%20Guidebook.pdf

Circular Ecology. (n.d.). *Embodied carbon assessment*. https://circularecology.com/embodied-carbon.html

Global Green Growth Institute. (n.d.). *Building Emission Assessment Tool (BEAT)* [Software]. https://beat-alcbt.gggi.org/

Global Green Growth Institute. (n.d.). *BEAT: Building Emission Assessment Tool brochure*. https://alcbt.gggi.org/beat-building-emission-assessment-tool-brochure/

KBOB. (n.d.). *Ökobilanzdaten im Baubereich [Life Cycle Assessment data in the construction sector]*. https://www.kbob.admin.ch/de/oekobilanzdaten-im-baubereich

NABERS. (n.d.). *Estimate your rating: NABERS calculators*. https://www.nabers.gov.au/our-calculators/estimate-your-rating

One Click LCA. (n.d.). *Life cycle stages*. https://help.oneclicklca.com/en/articles/275901-life-cycle-stages

Royal Institution of Chartered Surveyors (RICS). (2023). *Whole life carbon assessment for the built environment* (2nd ed.). https://www.rics.org/content/dam/ricsglobal/documents/standards/Whole_life_carbon_assessment_PS_Sept23.pdf

Sustainable and Renewable Energy Development Authority (SREDA). (n.d.). *Net energy metering calculator*. https://nemcalc.sreda.gov.bd/

2. Policy, Standards & National Roadmaps

Bangladesh National Building Code (BNBC). (2020). *Bangladesh National Building Code 2020*. Housing and Building Research Institute (HBRI), Ministry of Housing and Public Works.

Climate Reality Project. (n.d.). *How the climate crisis is impacting Bangladesh*. https://www.climaterealityproject.org/blog/how-climate-crisis-impacting-bangladesh

GlobalABC. (2025). *Bangladesh climate action roadmap for buildings and construction sector*. https://globalabc.org/sites/default/files/2025-09/Bangladesh%20Roadmap%20fa%202025.pdf

Government of Bangladesh. (2024). *Bangladesh National Air Quality Management Plan 2024-2030*. Ministry of Environment, Forest and Climate Change.

SREDA. (2023). *Energy Efficiency and Conservation Master Plan up to 2030*. Ministry of Power, Energy and Mineral Resources. https://sreda.gov.bd/

UNFCCC. (2025). *Bangladesh's third nationally determined contribution (NDC 3.0)*. https://unfccc.int/sites/default/files/2025-09/Bangladesh%20Third%20Nationally%20Determined%20Contribution%20%28NDC%203.0%29.pdf

World Bank. (2021). *Bangladesh country environmental analysis*. World Bank Group. https://openknowledge.worldbank.org/handle/10986/36315

3. Green Building Rating Systems & Manuals

CIM. (n.d.). *BREEAM vs. LEED: Understanding key differences in green building certifications*. https://www.cim.io/blog/breeam-vs-leed-understanding-key-differences-in-green-building-certifications

GRIHA Council. (2022). *GRIHA version 2019: The sustainable habitat handbook*. The Energy and Resources Institute (TERI).

Institute for Building Environment and Energy Conservation (IBEC). (2021). *CASBEE for buildings (New construction) technical manual*. Japan Sustainable Building Consortium.

International Finance Corporation. (2022). *EDGE certification system: Technical guide*. World Bank Group. https://edgebuildings.com/technical-guide/

Sri Lanka Green Building Council. (2021). *GREENSL® rating system for the built environment*. https://www.srilankagbc.org/

U.S. Green Building Council. (2023). *LEED v4.1 building design and construction reference guide*. USGBC.

World Green Building Council. (n.d.). *The business case for green building: A review of the costs and benefits*. https://worldgbc.org/article/the-business-case-for-green-building-a-review-of-the-costs-and-benefits-for-developers-investors-and-occupants/

4. GIS, BIM & Data Architecture

Esri. (n.d.). *BIM and GIS integration: Models & maps working together*. https://www.esri.com/en-us/industries/aec/overview/gis-and-bim

LGED GIS Portal. (n.d.). *Published maps*. LGED Bangladesh. https://gis.lged.gov.bd/Map/Public/published-map

Meta AI. (n.d.). *Canopy height maps dataset*. https://ai.meta.com/ai-for-good/datasets/canopy-height-maps

Pineview Labs. (n.d.). *Build a geospatial data platform on AWS with Nomad and open-source services*. https://labs.pineview.io/build-a-geospatial-data-platform-on-aws-with-nomad-and-open-source-services/

Zhang, L., et al. (2022). A data schema for exchanging information between urban building energy models and urban microclimate models. *Journal of Building Performance Simulation*. https://www.tandfonline.com/doi/full/10.1080/19401493.2022.214229

[5](5)

5. Simulation Software & Technical Documentation

BSCS Science Learning. (n.d.). *Green building design studio v2* [Interactive simulation]. https://interactives.bscs.org/BIG/green-building-design-studio-v2/#designscreen

EnergyPlus. (n.d.). *EnergyPlus EpJSON input schema documentation*. https://energyplus.readthedocs.io/en/latest/schema.html

Ladybug Tools. (n.d.). *Ladybug Tools home page*. https://www.ladybug.tools/

Marsh, A. (n.d.). *3D Sun-Path* [Web application]. https://andrewmarsh.com/apps/staging/sunpath3d.html

National Renewable Energy Laboratory (NREL). (n.d.). *PVWatts calculator*. https://pvwatts.nrel.gov/

Solemma. (n.d.). *ClimateStudio*. https://www.solemma.com/climatestudio

U.S. Department of Energy. (2018). *SBIR-2018: CAD-integrated web-based building performance simulation platform*. https://www.energy.gov/eere/buildings/sbir-2018-cad-integrated-web-based-building-performance-simulation-platform

6. Academic Research & Case Studies

Ahmed, S., & Hossain, M. (2018). Climate-responsive architectural strategies for tropical regions: Implications for energy-efficient building design in South Asia. *Journal of Building Engineering*, 18, 101–112. https://doi.org/10.1016/j.jobe.2018.03.006

Alam, M., Hossain, M. A., & Rahman, M. M. (2019). Barriers to the adoption of green building practices in developing countries: Evidence from Bangladesh. *Sustainable Cities and Society*, 52, 101864. https://doi.org/10.1016/j.scs.2019.101864

Hossain, M. S., et al. (2022). *Impact of urbanization on urban heat island intensity in major districts of Bangladesh*. ResearchGate. https://www.researchgate.net/publication/357555810

Röck, M., et al. (2022). Life cycle assessment of embodied carbon in buildings: Background, approaches and advancements. *Buildings*, 12(11), 1944. https://www.mdpi.com/2075-5309/12/11/1944

Sarker, S., et al. (2023). Life cycle assessment and circular building design in South Asian countries. *Buildings*, 13(12), 3045. https://www.mdpi.com/2075-5309/13/12/3045

Zheng, Z., et al. (2025). Comparative assessment of LEED, BREEAM, and WELL. *Energies*, 18(16), 4322. https://www.mdpi.com/1996-1073/18/16/4322

7. News, Media & Disaster Reports

BBC News. (2013, May 3). *Bangladesh factory collapse toll passes 1,000*. https://www.bbc.com/news/world-asia-22476774

Clean Clothes Campaign. (2021). *Rana Plaza: 8 years on*. https://cleanclothes.org/campaigns/past/rana-plaza
Hoskins, T. E. (2015, June 22). Reliving the Rana Plaza factory collapse: A history of cities in 50 buildings, day 22. *The Guardian*. https://www.theguardian.com/cities/2015/jun/22/rana-plaza-factory-collapse-history-cities-50-buildings
Mirdha, R. U. (2018, September 23). Green garment factory owners are left frustrated. *The Daily Star*. https://www.thedailystar.net/business/news/green-garment-factory-owners-left-frustrated-1637248

Appendices

Appendix A

HBRI Building – Extended Part Information for Energy Model

- Approximately, how many people work in each room of the building shown in the PDF drawings? How long do they work there every day (roughly)? How many computers and lights roughly in each room? Any other equipment in any of the rooms, please mention it.

Response: In each floor approximate average number of users is 5-6 nos per floor(occasionally it can be 50-60 in total numbers for the 2nd floor conference room)

- When the air conditioner is turned on, usually? At what time of the year or at what outdoor air temperature is the air conditioner turned on? What temperature is set in the air conditioner when it is turned on? If possible, please provide the capacity of each AC (1 ton, 1.5 ton or 2 ton)

Response: No air conditioning on the ground floor; the 2nd-floor air conditioning turns on occasionally during daytime meetings for 2-3 hours in the summer season. The 1st-floor AC runs for 2-3 hours on average during summer. With all the floors featuring cross-ventilation and ceiling fans, the need for AC is minimal. The average capacity of AC is 2.5 to 3 tons, and all are inverters with an average temperature of 25-26 degrees Celsius.

- When the fan is turned on, usually? At what time of the year or at what outdoor air temperature is the fan turned on?

Response: The fan usually turned on during peak hours in high summer. Like from 10 am-4 pm at an outdoor temperature of 30 to 40 degrees Celsius.

- Are the windows opened when the outdoor temperature is mild? Are the windows always closed? Please provide any information about what outdoor air temperature usually causes windows to be opened and closed

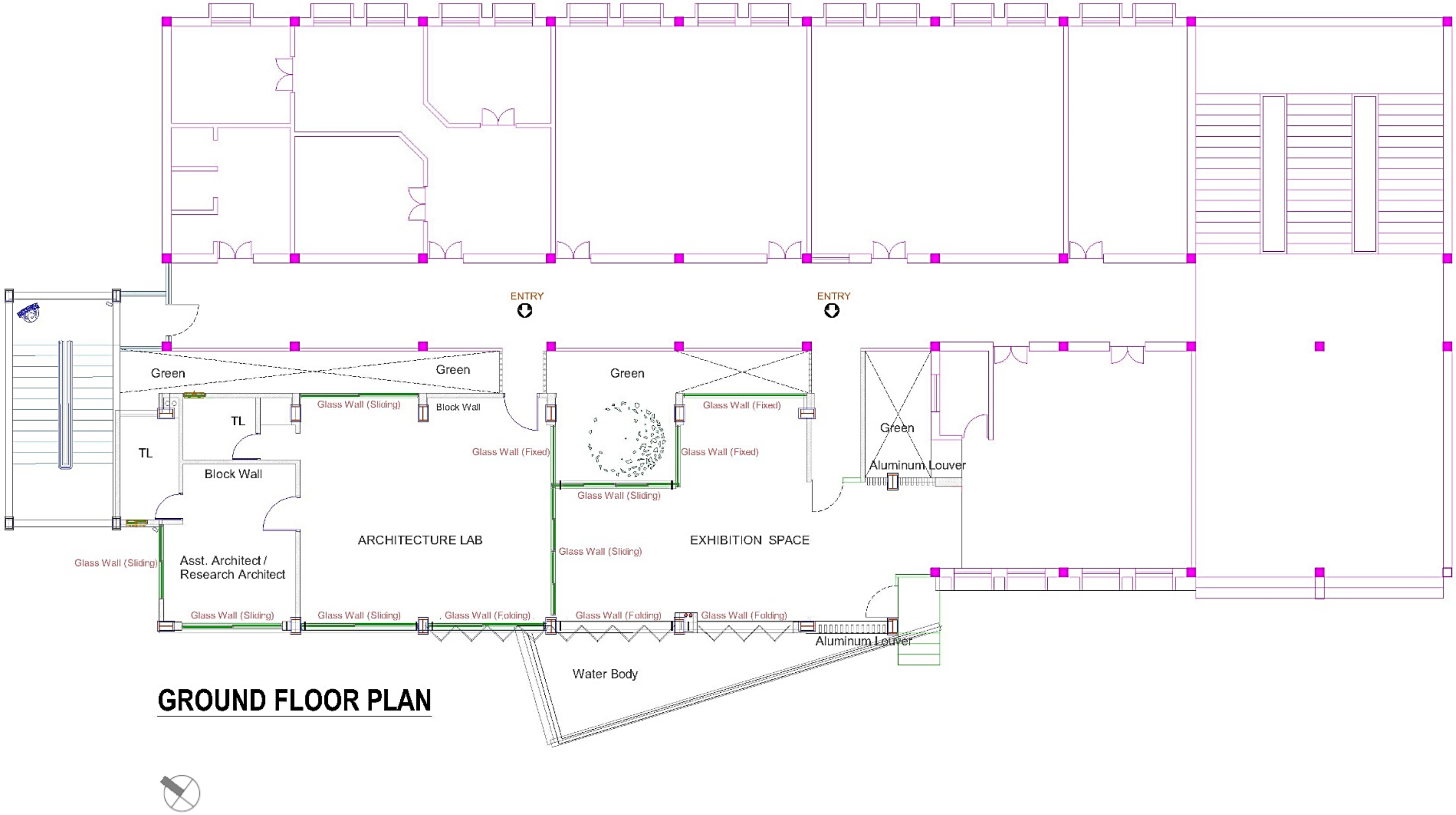
Response: The windows are usually open at outdoor temperatures above 27–28 degrees Celsius for cross ventilation. It's usually closed after 3 pm.

- Total electricity consumption in this building for one year. This will be used for model validation purposes.

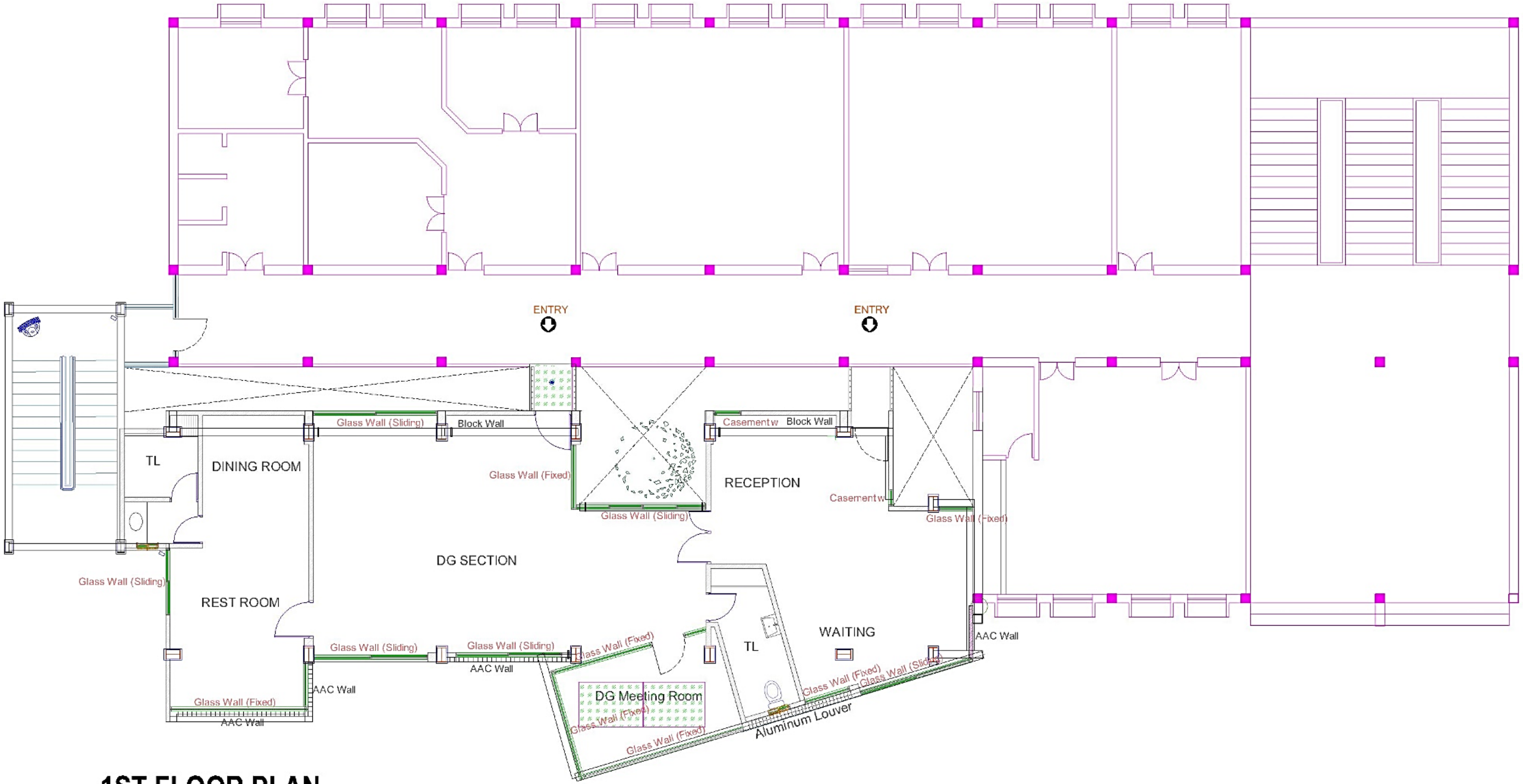
Response: Unknown, as it is integrated with all the existing buildings in the office, but the roof solar is 2kw on the grid. Also, the faucets and water appliances are low-flush, and there is an 800-gallon rainwater-harvesting tank on the roof.

- In the floor plan, please highlight the materials of each wall, floor, roof, window and door. I have some information about the materials used. But it does not say which wall is made of which material. If all external walls are made of the same material, please specify whether they are AAC walls or others. Also, please provide the materials used for internal walls.

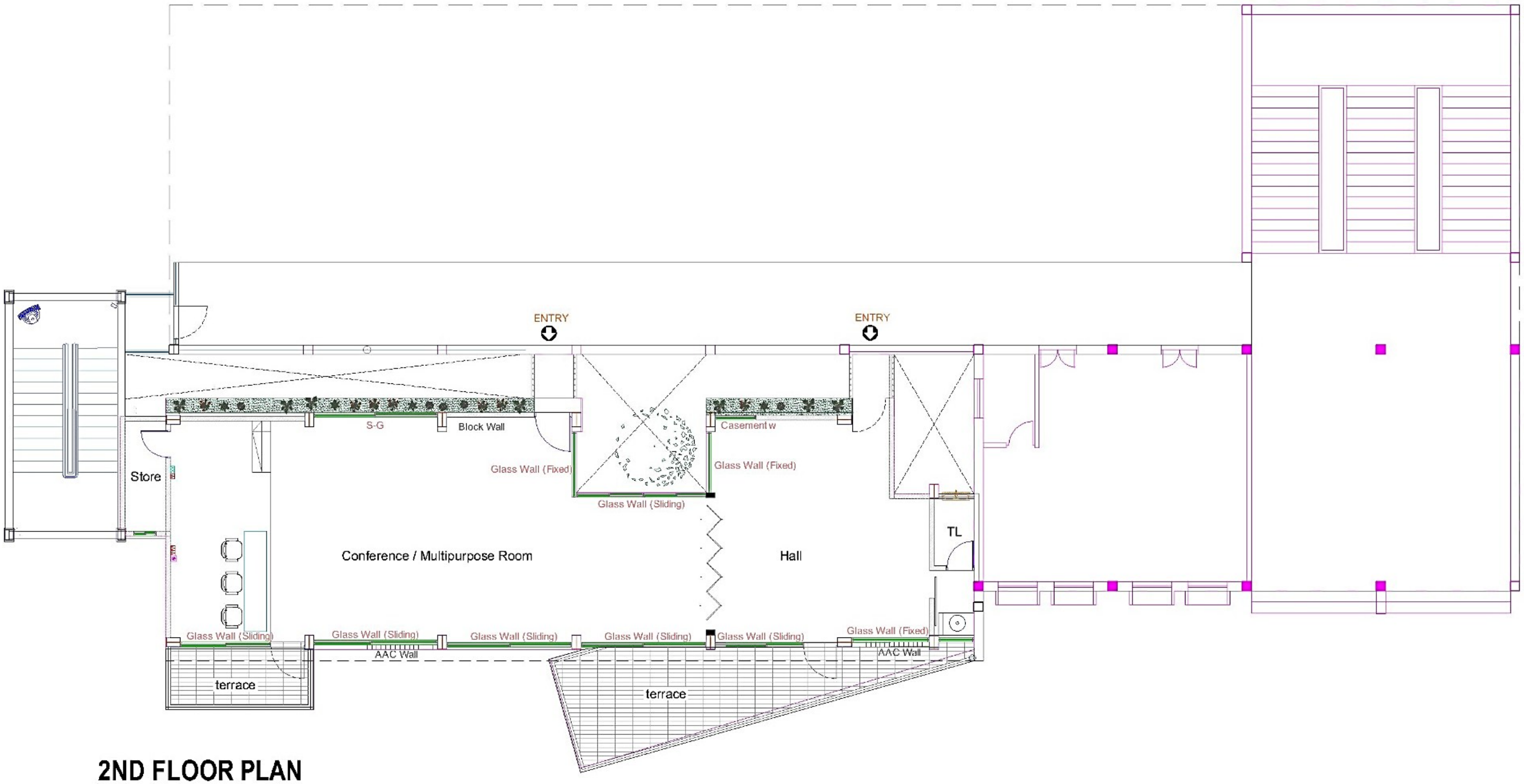
Response:



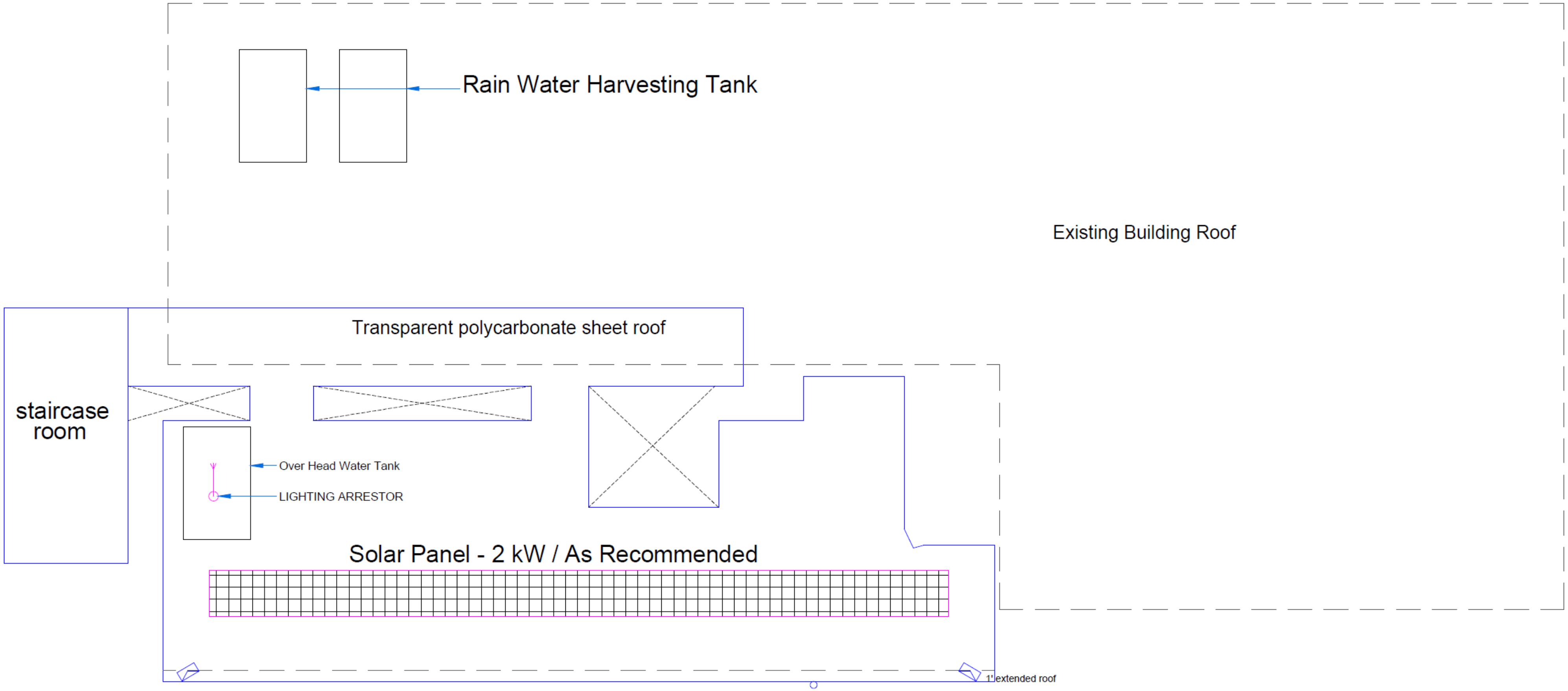
GROUND FLOOR PLAN



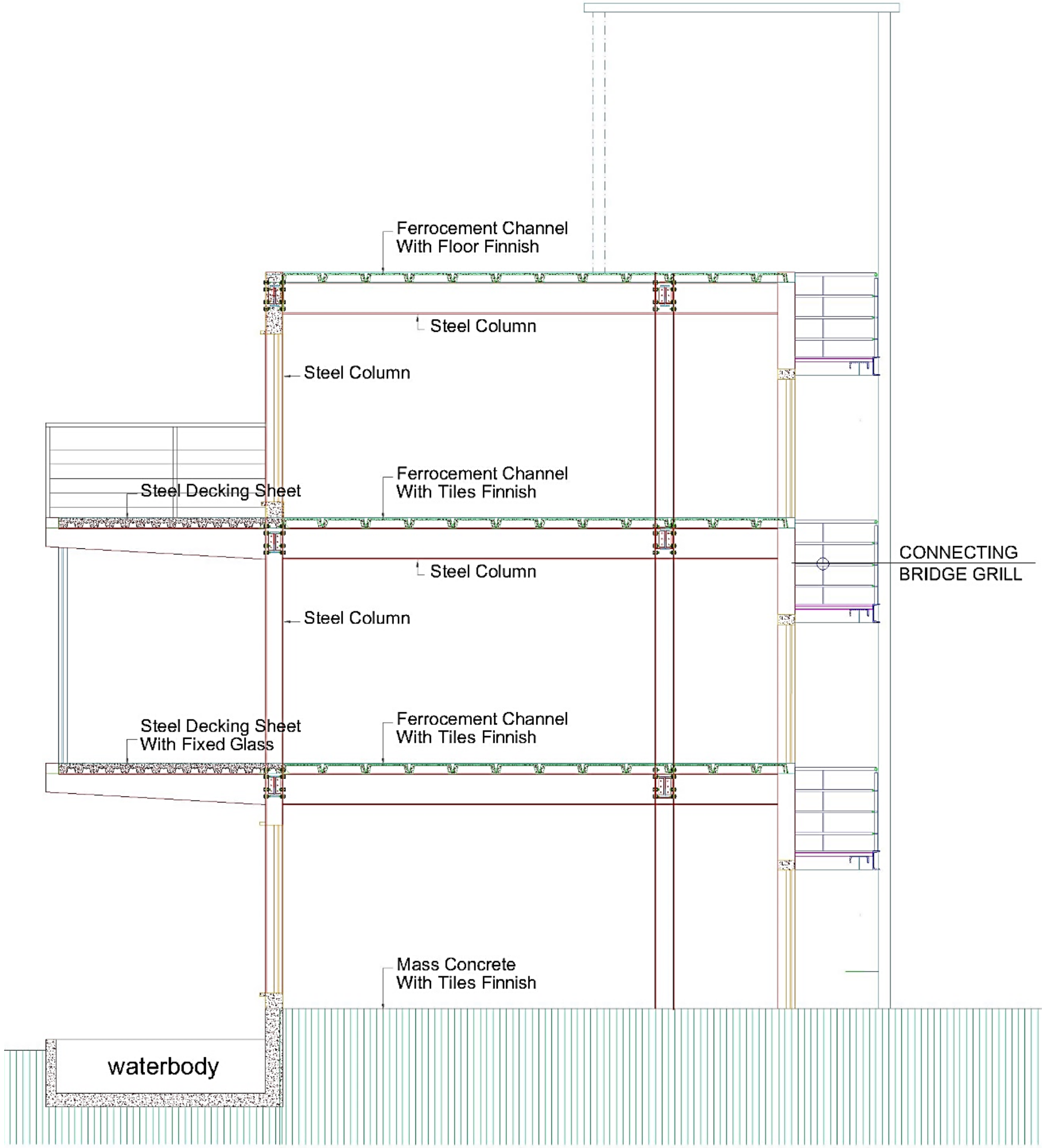
1ST FLOOR PLAN



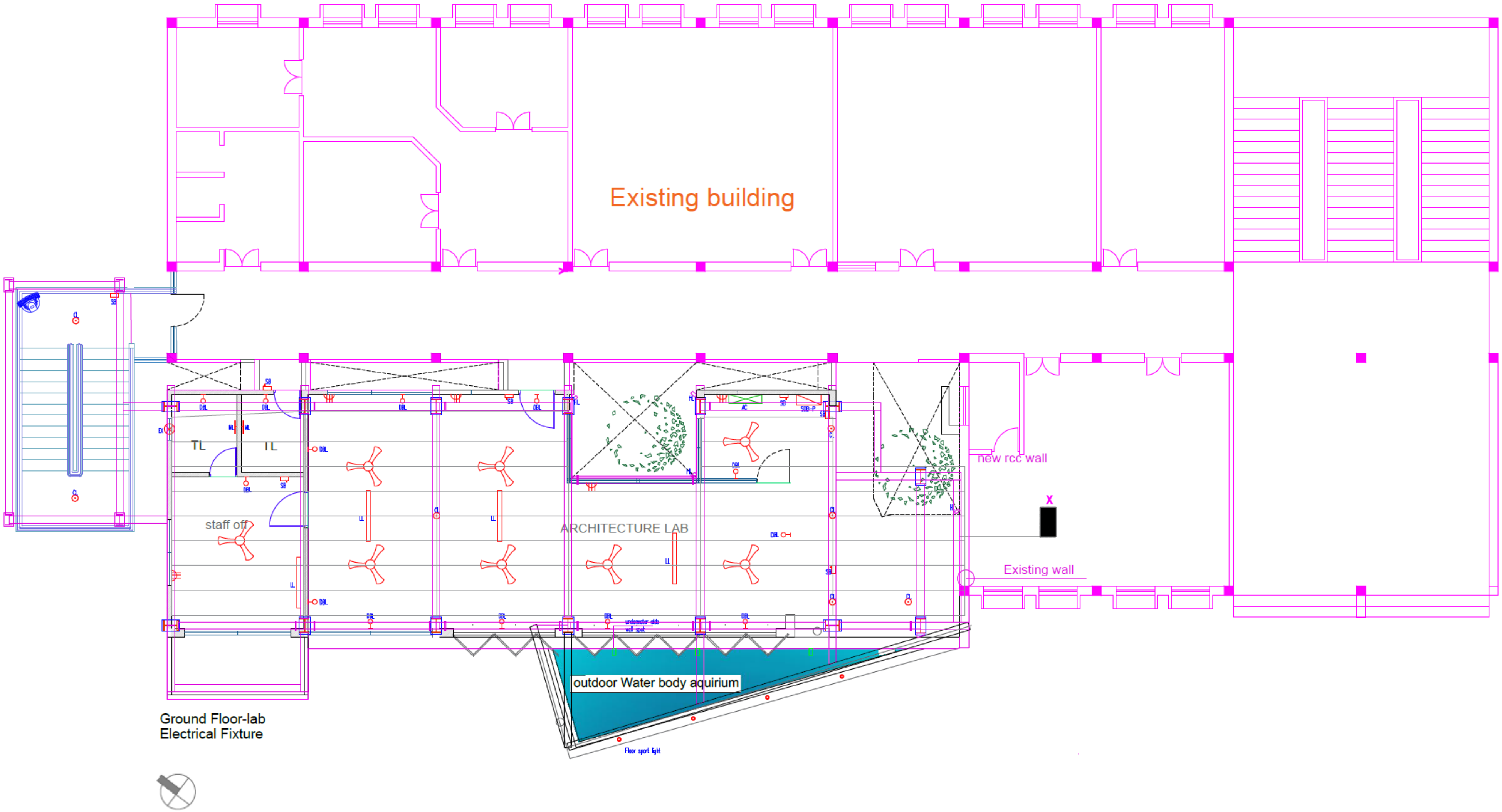
2ND FLOOR PLAN



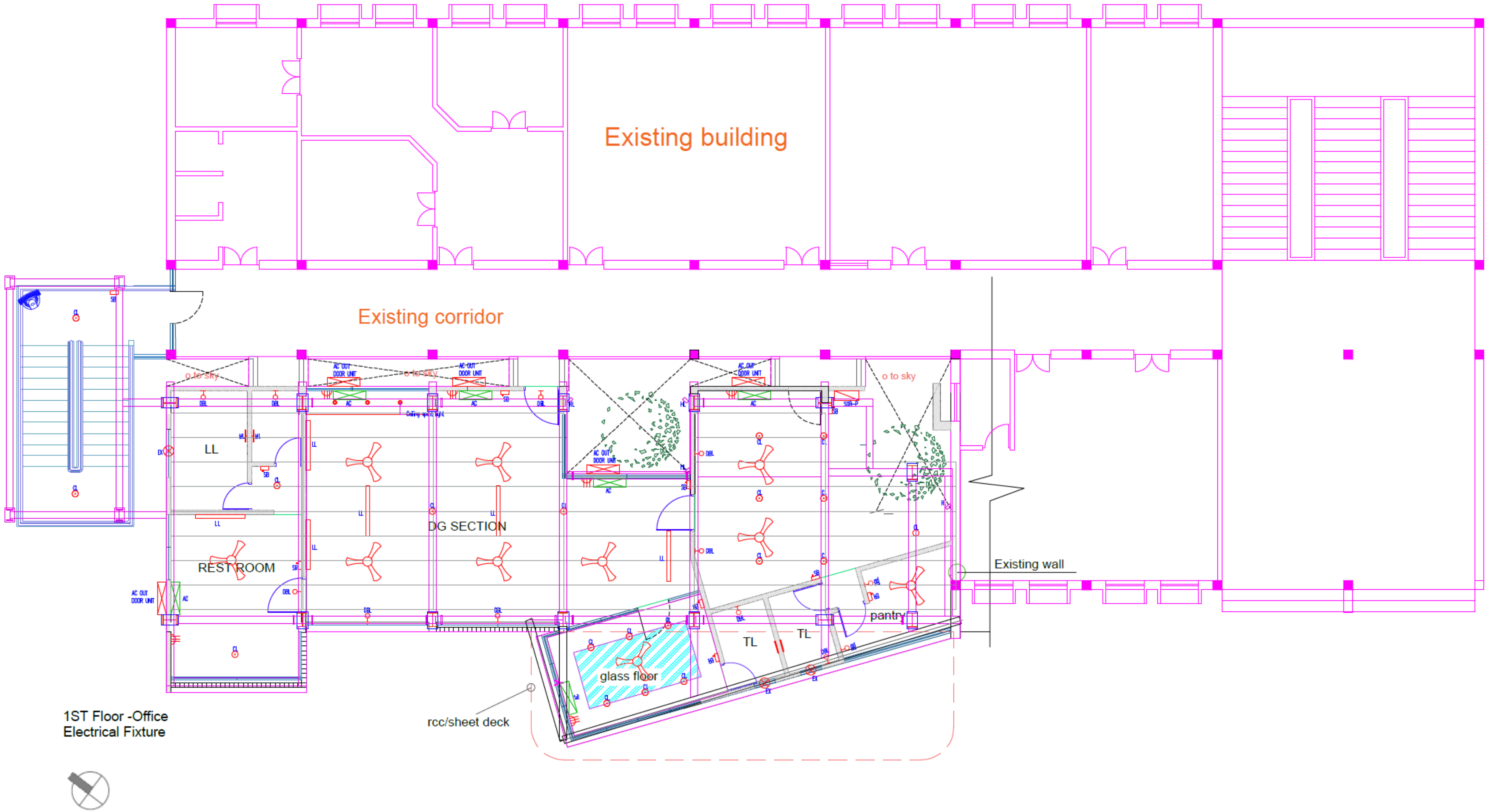
ROOF FLOOR PLAN


Ferrocement Channel
With Floor Finnish
Steel Column
Steel Column
Steel Decking Sheet
Ferrocement Channel
With Tiles Finnish
CONNECTING
BRIDGE GRILL
Steel Column
Steel Column
Steel Decking Sheet
With Fixed Glass
Ferrocement Channel
With Tiles Finnish
Mass Concrete
With Tiles Finnish
waterbody

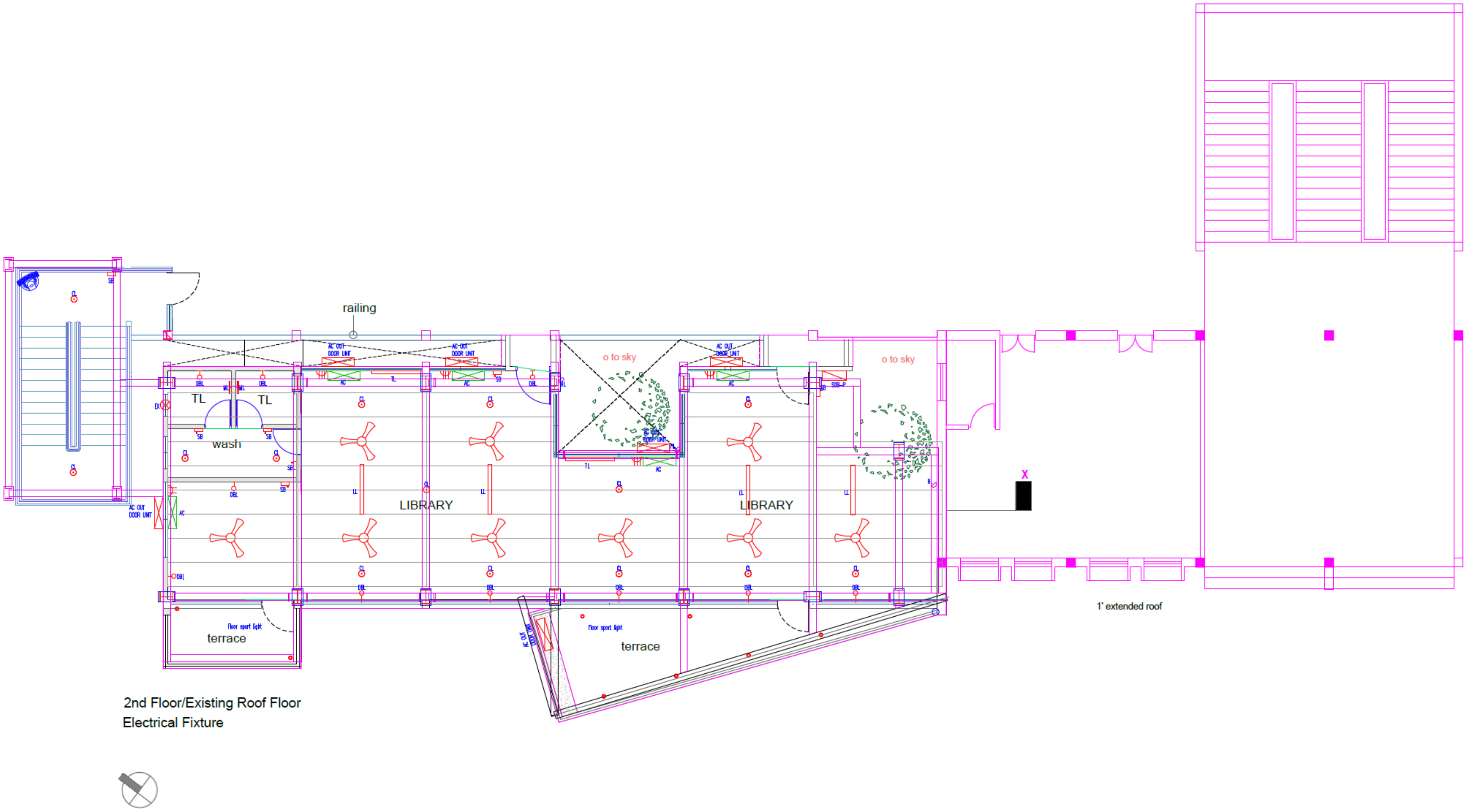
SECTION: Y-Y



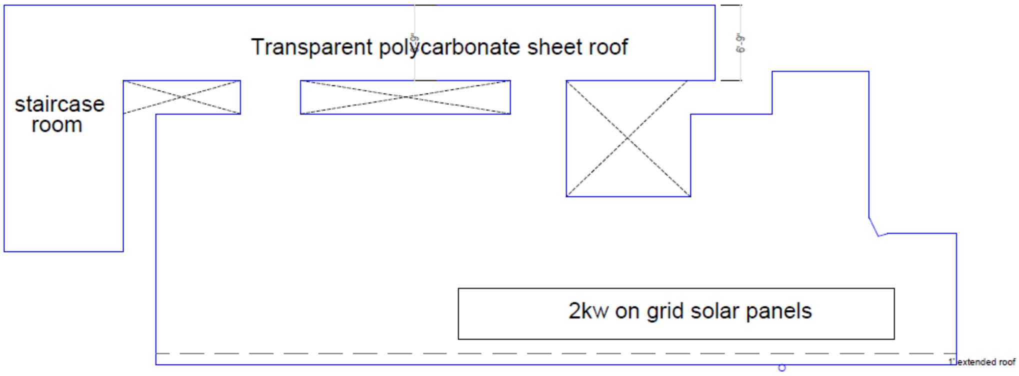
Ground Floor-lab
Electrical Fixture



1ST Floor -Office
Electrical Fixture



2nd Floor/Existing Roof Floor
Electrical Fixture



Roof plan

ELECTRICAL LEGEND & INSTRUCTION

SYMBOLS	NOTE	DESCRIPTION	TOP HEIGHT
	SDB	SUB DISTRIBUTION BOARD.	7'-0" FROM FFL
	SB	SWITCH BOARD.	52" FROM FFL
	L DBL	WALL MOUNTED SINGLE/DOUBLE BRACKET LIGHT.	8'-0" FROM FFL
	CL	CYLINDER DECORATED LED DIMMABLE PENDANT LIGHT 4 INCH CYLINDERS LED PENDANT DOWNLIGHT FOR LIGHTING PROJECT	AT CEILING
	ECL	EMERGENCY CEILING LIGHT.	AT CEILING
	ETL	EMERGENCY TUBE LIGHT.	8'-0" FROM FFL
	LL	4 FOOT LED LINEAR FIXTURE, 40 WATT, 120-277V, CCT SELECTABLE, BLACK OR WHITE FINISH	8'-0" FROM FFL
	F	CEILING FAN.	AT CEILING
	ML	TUBE LIGHT 2'	TOP OF MIRROR
	CH	CHANDELIER LIGHT.	AT CEILING
	A/C	DP SWITCH	52" FROM FFL
	P	5A-2PIN SOCKET	12" FROM FFL
	BB	BROADBAND CONNECTION	12" FROM FFL
	D	DISH ANTINA OUTLET	4'2" FROM FFL
	IC	INTERCOM OUTLET	52" FROM FFL
	CB	CALLING BELL	8'-0" FROM FFL
	BP	BELL PUSH	52" FROM FFL
	GL	GARDEN LIGHT	AS PER GARDENING SITUATION.
	SL	SECURITY LIGHT POINT	AS PER CHOICE
	BL	BOUNDARY LIGHT	AS PER BOUNDARY DESIGN
	WM	WASHING MACHINE POINT	3'-9" FROM FFL
	KH	KITCHEN HOOD POINT	5'-8" FROM FFL
	PL	PENDENT LIGHT	
	LPL	LED PANNEL LIGHT	
	DC	DOME CAMERA	AT CEILING
	UW S	UNDERWATER SPOT	AT UNDERWATER SIDE WALL
	HL	Halogen Light	

CABLE SCHEDULING:

1. SB TO LIGHT,FAN&EXHAUST FAN,2PIN = 1.5rm BYA.+1Sq mm Ecc
2. SDB TO SB,3PIN = 2.5rm BYA,+1Sq mm Ecc [1.5 rm for Earthling]
3. SDB TO AC = 4rm BYA,+2.5Sq mm Ecc [2.5 re for Earthling]
4. DB TO SDB = 10rm BYA,+6sq mm Ecc [4 rm for Earthling]
5. AJB TO DISH = 6RG
6. TJB TO TEL = 2PAIR
7. IJB TO INTCOM = 2PAIR
8. IJB TO INTERNET = CAT6

PVC PIPE SCHEDULING:

1. SB TO LIGHT,FAN&EXHAUST FAN,2PIN = 3/4" PVC PIPE
2. SDB TO SB,3PIN = 1" PVC PIPE
3. SDB TO AC = 1"PVC PIPE
4. DB TO SDB = 1" PVC PIPE
5. AJB TO DISH = 3/4" PVC PIPE
6. TJB TO TEL = 3/4" PVC PIPE
7. IJB TO INTCOM = 3/4" PVC PIPE
8. IJB TO INTERNET = 3/4" PVC PIPE

BASIC INSTRUCTION:

1. ALL THE SWITCH BOARD TOP SHOULD BE 4'-6" HEIGHT FROM FLOOR.
2. ALL THE SOCKET BOTTOM SHOULD BE 9" HEIGHT FROM FLOOR.
3. ALL THE SDB BOARD BOTTOM SHOULD BE 6'-6"HEIGHT FROM FLOOR.
4. AT ALL A/C & OTHERS SOCKET SHOULD HAVE A 3-PIN SOCKET (15A & 13A).
5. ALL LIGHT POINT HEIGHT SHOULD BE BELOW 18" FROM FINISHED CALLING LEVEL.

GENERATOR CONNECTION (BACK-UP POLICY):

CONSIDERING 100% BACK-UP OF ACTUAL LOAD.

- Provide exact construction layers of wall, floor, ceilings, roofs, windows and doors. For example, the external walls may be made of plaster or AAC. If you look at it from the outside of the wall, the sequence of construction could be Plaster>AAC Block> Plaster.

Response: 4 materials: AAC, double-glazed window at front side/single-glazed at back, sand cement solid block, ACP panel at outer beam level as envelope/

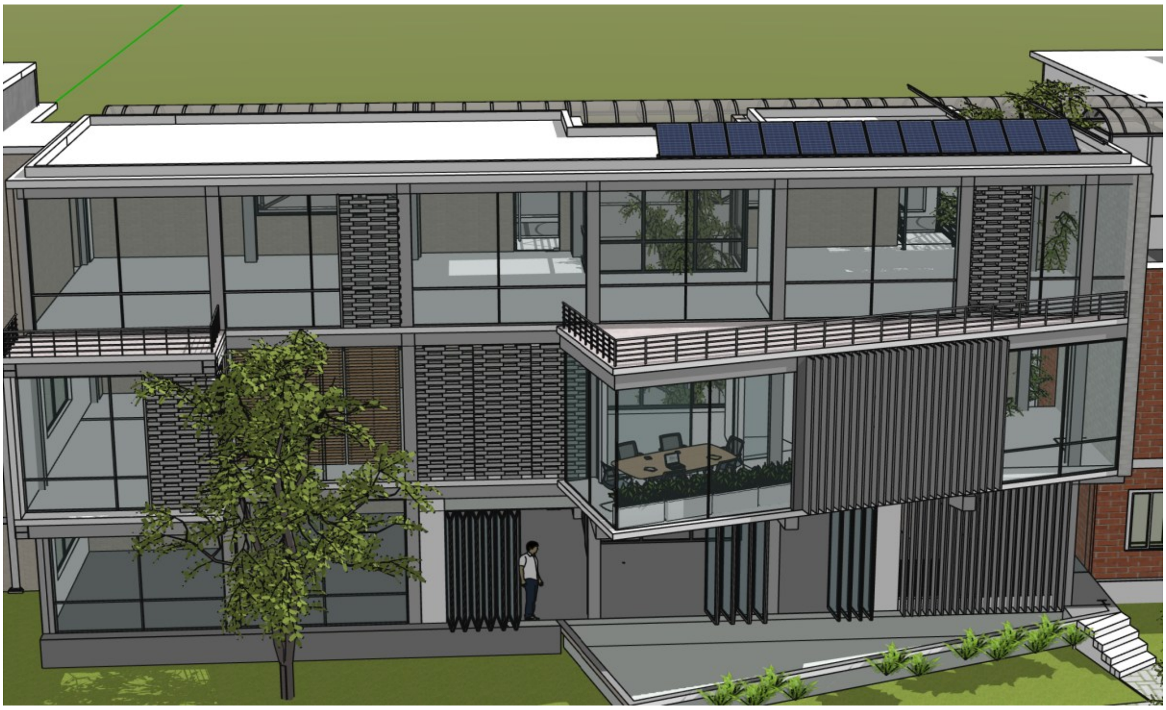
2a: Exterior wall layer: For glass- EDF EURO FRAME WITH POWDER COAT PAINT> DOUBLE GLAZED WINDOW 6MM TEMPERED GLASS +6MM VOID+ 6MM TEMPERED GLASS

2b: Exterior+ Interior wall layer: AAC SCREENING: WEATHER COAT ACRYLIC PAINT WITH NO PLASTER > AAC BLOCK> INTERIOR ACRYLIC PLASTIC PAINT WITH NO PLASTER

2c: Exterior+ Interior wall layer: EXPOSED SOLID SAND CEMENT BLOCK WITH WATER REPELLENT (NO PLASTER) >SOLID BLOCK>INTERIOR ACRYLIC PLASTIC PAINT

2d : Aluminium composite panel(acp) at outer exposed steel beam. Layer: ACP>STEEL FRAME

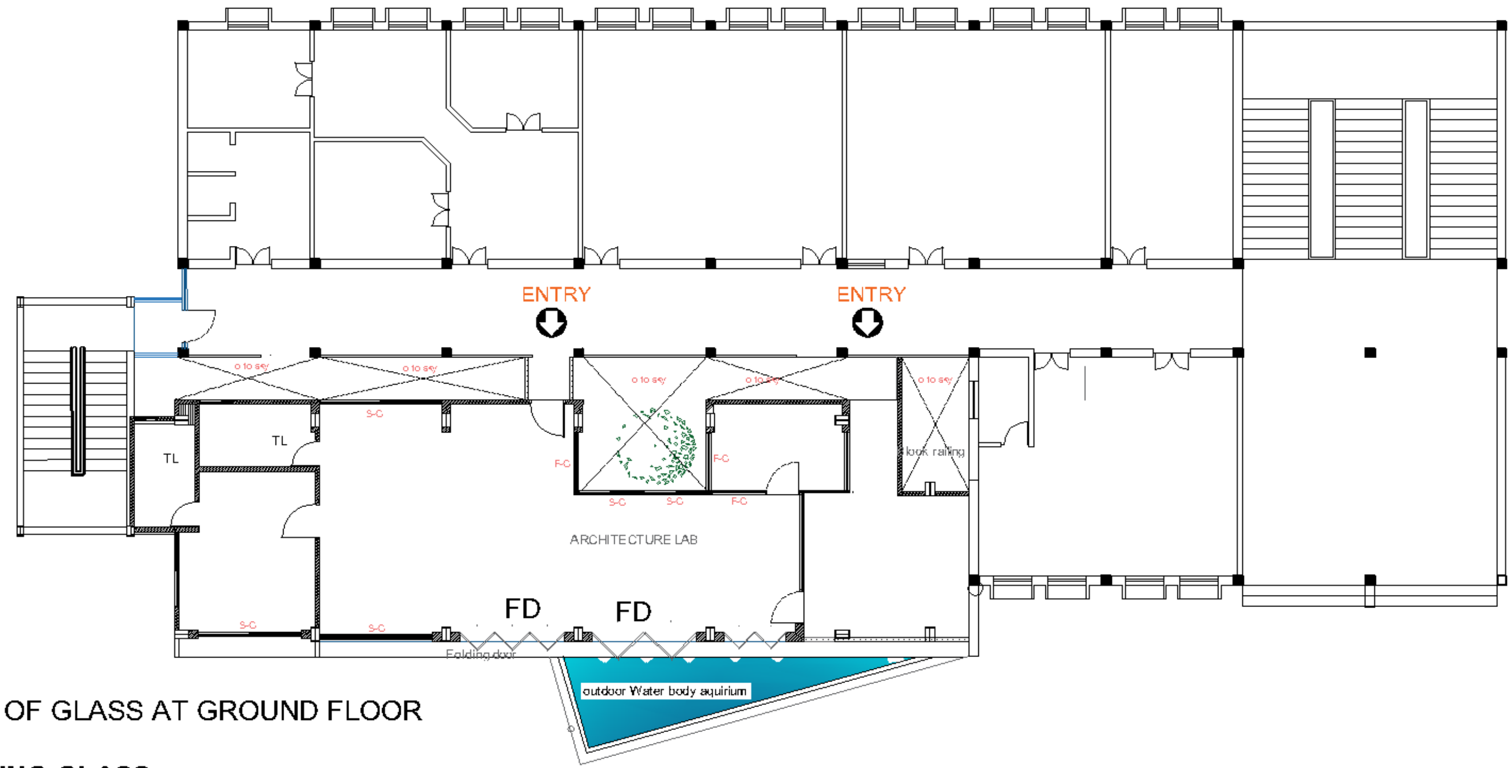
- In the image below, I can see some external walls with holes. Is it really like that? Does it mean that there is always natural ventilation?



Response: All exterior walls are fully operable, including those beside the AAC screening at the front. Except for the marked portion, which is fixed

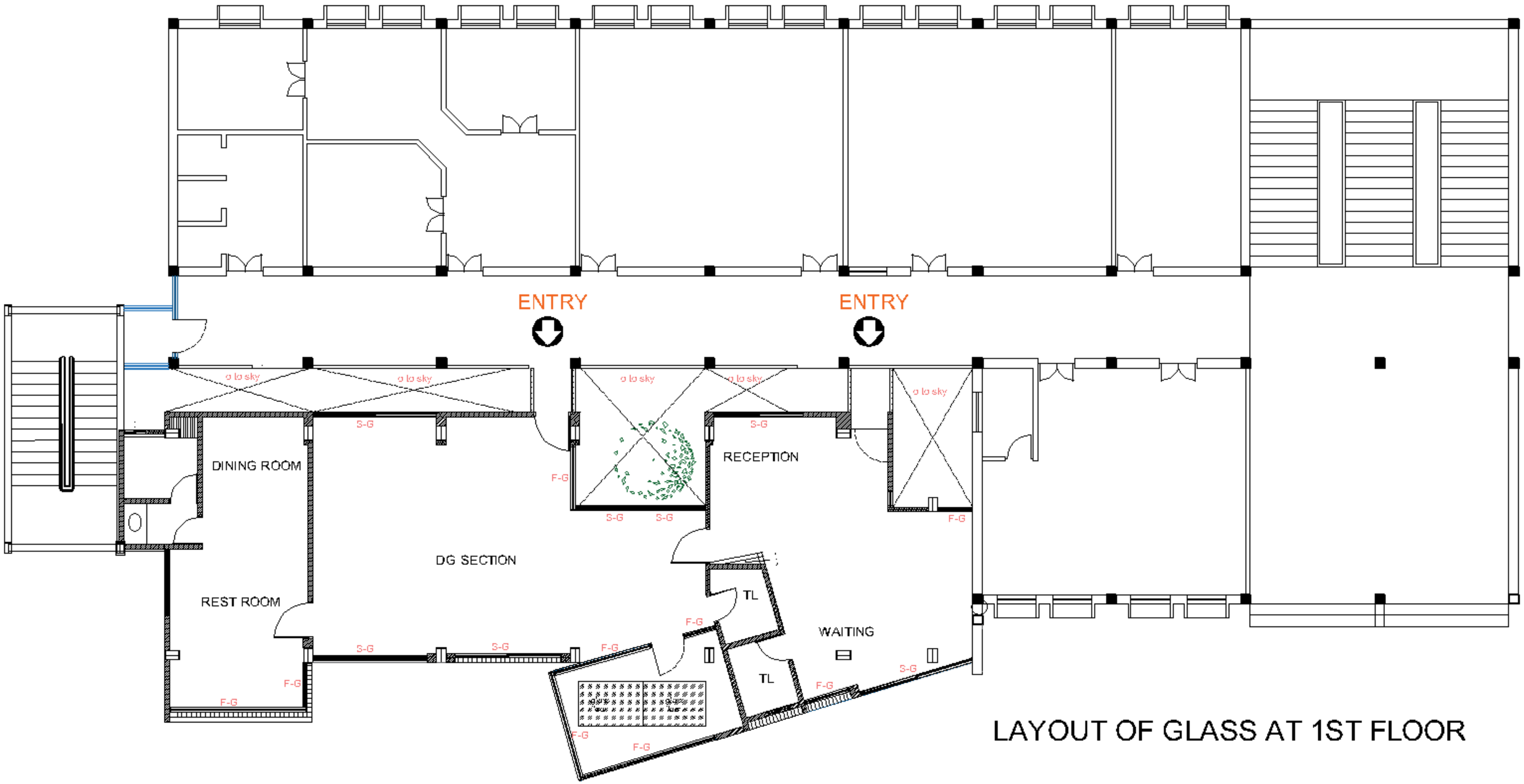
- Please indicate in the drawing which glass walls are sliding and which glass walls are folding?

Response:



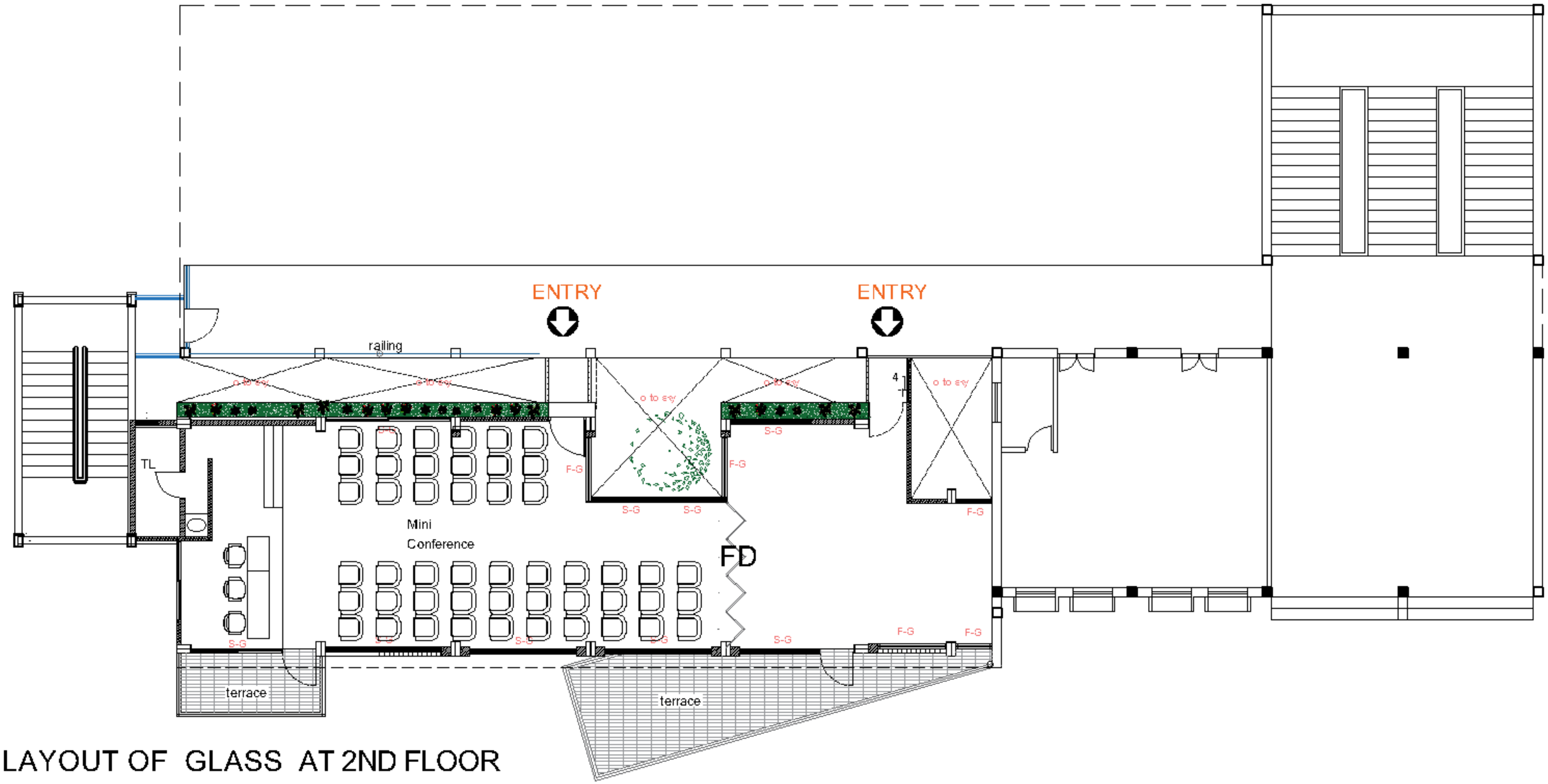
LAYOUT OF GLASS AT GROUND FLOOR

SG-SLIDING GLASS
FG- FIXED GLASS
FD-FOLDING GLASS



LAYOUT OF GLASS AT 1ST FLOOR

SG-SLIDING GLASS
FG- FIXED GLASS
FD-FOLDING GLASS



LAYOUT OF GLASS AT 2ND FLOOR

SG-SLIDING GLASS
FG- FIXED GLASS
FD-FOLDING GLASS

Appendix B

Typical Residential Building Operational Settings for Energy Simulation

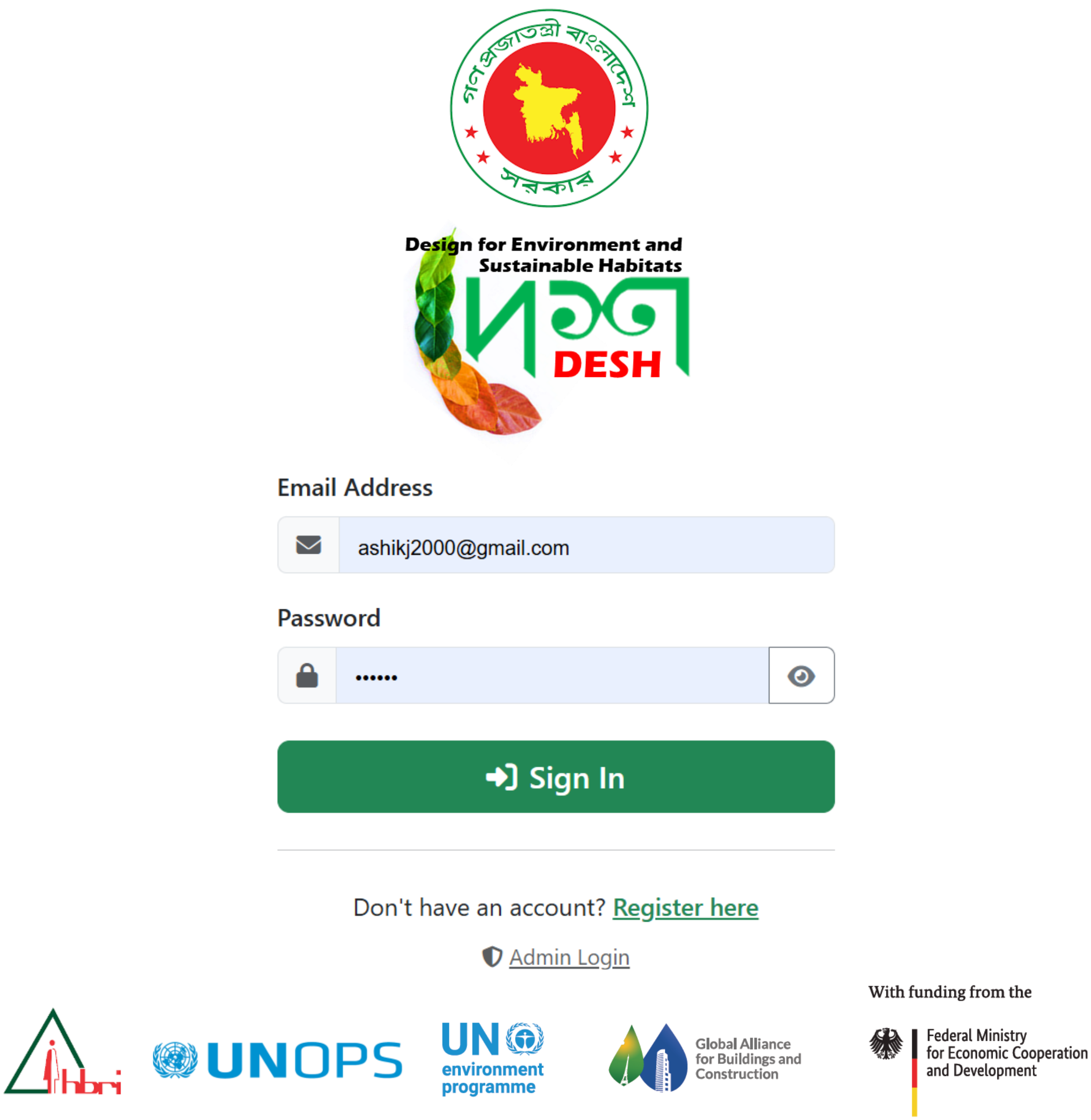
Parameters	Settings	
Weather data	The weather data will be collected from the EPW weather database (https://www.ladybug.tools/epwmap/).	
Standard and references for zone settings	Light power density 11-30 W/m²	Mechanical and Electrical Equipment for Buildings by Grondzik et al., 2019/ BNBC/ASHRAE/IES Standard 90.1-2022
	Equipment power density 8-14 W/m²	Mechanical and Electrical Equipment for Buildings by Grondzik et al., 2019.
	Occupancy density 0.03-0.1 ppl/m²	AHSRAE/Emarat Nirmal Bidhimala
	Site EUI for multifamily housing: 188 kWh/m²	U.S. National Median EUI by Building Type, Department of Energy, USA (EPA, 2016).
Building material data	Exterior wall	Material: Plaster with off-white paint surface / U-value = 0.75 W/m²·K
	Exterior floor	Material: Tiled (beige) / U-value = 0.75 W/m²·K
	Window	Material: Atlantica (Clear), Transmittance: 0.68 / U-value = 2.69 W/m²·K, SHGC = 0.405
	Window frame	Material: Grey aluminium (Glossy) Reflectance:43.33, Specular:2.69, Diffuse: 40.38, Roughness:0.01
	Interior wall	Material: inorganic paint (off-white) Reflectance:0.75, Specular: 0.35, Diffuse: 0.75, Roughness:0.05
	Interior ceiling (adiabatic)	Material: inorganic paint (white) Reflectance:0.85, Specular:0.1, Diffuse: 0.7, Roughness:0.05
	Interior floor (adiabatic)	Material: tiled (beige) Reflectance:0.50, Specular:0.1, Diffuse: 0.3, Roughness:0.01.
	Shading	Material: inorganic paint (off-white) Reflectance:0.75, Specular:0.35, Diffuse: 0.75, Roughness:0.05

Parameters		Settings
Internal loads	People	Occupant density: 0.15 people/m² Activity schedule: 120 W/person
	Metabolic rate	1.2 met
	Lighting	12 W/m²
	Equipment	8 W/m²
	Colling load	100 W/m²
	Ceiling fan energy	1000 Pa
	Infiltration rate (Per area of façade)	Infiltration 0.5 ARCH / Hourly air exchange 0.9 ARCH / Buoyancy-driven flow: on
	Humidity set	Indoor mean minimum RH 80%, Outdoor mean minimum RH 20%
	Natural ventilation	On
	Mechanical ventilation	Off
HVAC systems	Temperature set	Outdoor mean maximum temperature (T_{max}) 26°C / Indoor mean maximum temperature (T_{max}) 30.6°C
	HVAC system	Ideal air load system
	Cooling set point	28° C
	Heating load	Off

Appendix C

Content for Labeling System

Design for Environment and Sustainable Habitats (DESH-দেশ)



Sl. No	Categories and Sub-categories	Max Points
1	**Climate Adaptation and Resilience**	**16**
1.1	Climate Sensitivity	8
1.2	Resilient Structure	8
2	**Site Sustainability and Planning**	**12**
2.1	Topsoil Preservation	2
2.2	Green Cover	2
2.3	Site Facilities	2
2.4	Dust Control	2
2.5	Site Safety	2
2.6	Environmental Impact	2
3	**Materials and Resources**	**34**
3.1	Construction Materials	8
3.2	Reused/Recycled Construction Materials	4
3.3	Construction Material Durability	2
3.4	Construction Materials Wastage	4
3.5	Low-Emission Construction Materials	2
3.6	Interior Finishes and Materials	4
3.7	Reused/ Recycled Interior Materials	4
3.8	Interior Material Durability	2
3.9	Interior Materials Wastage	2
3.1	Low-VOC Interior Materials	2
4	**Water and Waste Management**	**30**
4.1	Construction Water Use	8
4.2	Construction Water Sourced from Surface	2
4.3	Construction Water Sourced from Rain	2
4.4	Operational Water Use	8
4.5	Operational Water Sourced from Surface	2
4.6	Operational Water Sourced from Rain	2
4.7	Water Heating	2
4.7	Waste Management	4
5	**Energy Conservation and Environmental Quality**	**24**
5.1	Interior Lighting	4
5.2	Exterior Lighting	4
5.3	Indoor Cooling	4
5.4	Room Heating	2
5.5	Ventilation	4
5.6	Indoor Air Humidity	2
5.7	Exhaust Systems	2
5.8	Acoustics Performance	2
6	**Energy Efficiency and Renewable Energy**	**24**
6.1	Energy-Saving Equipment	8

Sl. No	Categories and Sub-categories	Max Points
6.2	Energy-Saving Cooking	8
6.3	Renewable Energy	8
7	**Lifestyle, Social, Health and Safety**	**10**
7.1	Transportation and Lifestyle	2
7.2	Occupant satisfaction	2
7.3	Fire Safety	2
7.4	Gender Responsiveness	2
7.5	Universal Design	2
	Total	**150**

1 Climate Adaptation and Resilience

1.1 Climate Sensitivity

Contextual Justification for Bangladesh	Bangladesh is highly vulnerable to the impacts of climate change, including flooding, cyclones, extreme heat, and salinity intrusion. Integrating climate-responsive design ensures long-term durability, occupant safety and reduced lifecycle costs, particularly in resource-constrained and high-risk environments.
Compliance Requirements	Ensure affordable, climate-resilient design that identifies and addresses Bangladesh-specific climate risks, where relevant, including the following. (1) Flooding and waterlogging (2) Cyclones and high wind loads (3) Extreme heat and thermal stress (4) Salinity and corrosion (particularly in coastal regions) (5) Landslides and erosion (in hilly areas) (6) Heavy rainfall and monsoon intensity (7) Fluctuating water tables and drought
Objectively Measured Criteria	Presence and adequacy of design strategies that respond to the identified climate risks, demonstrated through drawings, estimates, calculations and design documentation.
Measurement Unit / Criteria	Percentage (%) of relevant climate risks adequately addressed through design measures.
Point Distributions	**8 pts:** ≥ 80% of relevant risks are comprehensively addressed **0 pt:** ≤ 40% of relevant risks are addressed, or no clear strategy is provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Climate risk assessment and response note (site-specific). • Complete set of design and working drawings showing mitigation measures (e.g., plinth height, structural detailing, shading, material selection). **Verification after Construction (Before Occupancy)** • As-built drawings reflecting implemented climate-responsive features. • Site verification report and photographic evidence. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Performance review report (e.g., flood performance, thermal comfort feedback, material durability observations).

1.2 Resilient Structure

Contextual Justification for Bangladesh	Bangladesh lies within moderate to high seismic risk zones. Inadequate soil investigation and poor structural detailing significantly increase vulnerability to earthquake damage. Ensuring appropriate geotechnical investigation and earthquake-resistant structural design is critical for life safety, disaster resilience and long-term structural performance.
Compliance Requirements	Conduct detailed geotechnical soil investigations and design the foundation and structural system appropriately, ensuring compliance with HBRI guidelines. (1) Digital Survey (2) Soil investigation (3) Seismic zoning requirements (4) Appropriate load combinations (5) Ductile detailing and structural design provisions (6) Drainage planning
Objectively Measured Criteria	Verified geotechnical investigation and structural design calculations demonstrating compliance with seismic and soil-related requirements.
Measurement Unit / Criteria	Percentage (%) of required compliance elements adequately addressed
Point Distributions	**8 pts:** ≥ 80% of required elements addressed **0 pt:** ≤ 40% of required elements addressed or missing critical components (e.g., no soil investigation)
Required Documentation	**Prediction before Construction (Planning Stage)** • Geotechnical investigation report (e.g., soil test, bore log, and recommendations). • Structural design calculations and analysis reports (including seismic design basis). • Structural drawings indicating compliance with HBRI requirements. • Method Statement for a comprehensive strategy to enhance the construction's service life, structural longevity and durability. **Verification after Construction (Before Occupancy)** • Structural completion certificate from a qualified engineer/authority. • As-built structural drawings reflecting actual construction. • Site verification report. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Structural inspection and maintenance record (e.g., visual inspection and settlement/crack monitoring if required).

2 Site Sustainability and Planning

2.1 Topsoil Preservation

Contextual Justification for Bangladesh	Rapid urban development in Bangladesh often results in the permanent loss of fertile topsoil. Preserving topsoil is essential for maintaining soil carbon, supporting biodiversity and enhancing on-site water retention and landscaping quality.
Compliance Requirements	Strip and preserve fertile topsoil (typically 75–150 mm depth) prior to excavation. Store it safely to prevent contamination or erosion and reuse it on-site for landscaping, green areas or land restoration.
Objectively Measured Criteria	Measured area (or volume) of topsoil stripped, preserved and reused as a percentage of the total site area requiring excavation.
Measurement Unit / Criteria	Percentage (%) of topsoil preserved and reused
Point Distributions	**2 pts:** ≥ 80% of topsoil preserved and reused **0 pt:** ≤ 40% of topsoil preserved and reused or no proper preservation measures
Required Documentation	**Prediction before Construction (Planning Stage)** • Topsoil stripping, storage and reuse plan. • Method statement indicating depth, handling and protection measures. **Verification after Construction (Before Occupancy)** • Photographic evidence of topsoil stockpiling and reuse. • Landscaping completion report indicating use of preserved topsoil. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Landscape maintenance confirmation report (including condition of planted areas).

2.2 Green Cover

Contextual Justification for Bangladesh	Plants and trees play a critical role in reducing urban heat stress in Bangladesh's tropical climate. Green cover helps maintain the microclimate, provides shading, reduces the urban heat island effect, enhances stormwater management and acts as a carbon sink.
Compliance Requirements	Provide and/or preserve vegetation across the site, including ground-level landscaping, vertical greenery (façade) and roof-level planting (green roofs), where applicable.
Objectively Measured Criteria	Ratio of total vegetated/plantation area (e.g., ground, façade and roof) to the total built-up floor area.
Measurement Unit / Criteria	Percentage (%) of plantation area relative to total built-up floor area
Point Distributions	**2 pts:** ≥ 10% **0 pt:** ≤ 5% or no meaningful plantation provision
Required Documentation	**Before Construction (Design Stage)** • Landscape design drawings and report (including planting strategy, species selection and area calculations). • Roof and façade greening details (if applicable). **Verification after Construction (Before Occupancy)** • Post-construction plantation/tree inventory. • Photographic verification of implemented green areas (e.g., ground, façade and roof). **Confirmation after One Year of Occupancy (and periodically thereafter)** • Survival and maintenance report of planted vegetation (including replacement, if required).

2.3 Site Facilities

Contextual Justification for Bangladesh	Informal labour conditions are common in Bangladesh's construction sector, often lacking basic welfare and safety provisions. Ensuring adequate worker facilities promotes social sustainability, improves occupational health and safety and enhances overall construction quality and productivity.
Compliance Requirements	Provide the following minimum facilities at the construction site. (1) Shaded rest area (2) Safe drinking water (3) Sanitation/toilet facilities (4) First aid provision (5) Temporary site office (6) Secure storage/lockers for workers (7) Personal Protective Equipment (PPE) (8) Safety signage and instructions
Objectively Measured Criteria	Site inspection checklist verifying the presence and adequacy of the required facilities as a percentage of the total listed items.
Measurement Unit / Criteria	Percentage (%) of required facilities provided
Point Distributions	**2 pts:** ≥ 80% of required facilities are provided **0 pt:** ≤ 40% of required facilities are provided
Required Documentation	**Before Construction (Design / Planning Stage)** • Site layout plan showing the location and allocation of the worker welfare facilities. • Construction health and safety plan (including PPE and emergency provisions). **Verification after Construction (Before Occupancy)** • Site audit photographs showing installed facilities. • Completed compliance checklist verified by supervising authority. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

2.4 Dust Control

Contextual Justification for Bangladesh	Dust pollution is a major urban health concern in Bangladesh, particularly in dense construction areas. Effective dust control reduces air pollution, protects worker and public health, and minimizes environmental nuisance.
Compliance Requirements	Provide and implement the following dust control measures at the construction site. (1) Dust barriers (2) Enclosures (where applicable) (3) Covered storage of materials (4) Covered transport of loose materials (5) Water spraying/suppression system
Objectively Measured Criteria	Site inspection checklist verifying the presence and effective implementation of the required dust control measures as a percentage of the total listed items.
Measurement Unit / Criteria	Percentage (%) of required dust control measures implemented
Point Distributions	**2 pts:** ≥ 80% of required measures are implemented **0 pt:** ≤ 40% of required measures are implemented or ineffective control
Required Documentation	**Before Construction (Design / Planning Stage)** • Site layout plan showing locations of dust control measures. • Dust control method statement (including frequency of water spraying and transport management). **Verification after Construction (Before Occupancy)** • Site logbook documenting implementation (e.g., spraying frequency and transport control). • Photographic evidence of barriers, enclosures, covered storage, and transport. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

2.5 Site Safety

Contextual Justification for Bangladesh	Construction activities in Bangladesh often take place adjacent to public spaces and pedestrian areas, sometimes without adequate safety measures. Effective site fencing and safety signage are essential to protect the public, prevent unauthorized access and reduce accidents.
Compliance Requirements	Provide continuous site fencing/hoarding along the construction site boundary and install appropriate safety signposts (e.g., warning signs, restricted access and hazard notices) throughout the construction period.
Objectively Measured Criteria	Ratio of the total length of installed site fencing (with appropriate safety signage) to the total perimeter of the construction site.
Measurement Unit / Criteria	Percentage (%) of site perimeter adequately fenced and provided with safety signage.
Point Distributions	**2 pts:** 100% of site perimeter fenced with appropriate safety signage **0 pt:** ≤ 50% of site perimeter fenced or inadequate safety measures
Required Documentation	**Before Construction (Design / Planning Stage)** • Site layout plan showing location and extent of fencing/hoarding and signposts. • Samples or list of safety signage content (e.g., texts, symbols and language). **Verification after Construction (Before Occupancy)** • Completion photographs showing installed fencing and signage around the site perimeter. • Site verification checklist. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

2.6 Environmental Impact

Contextual Justification for Bangladesh	Dense urban neighborhoods in Bangladesh require strong and well-managed measures to minimize environmental impacts during construction. Effective control of air, water, soil and ecosystem disturbances is essential for protecting communities and promoting environmental sustainability.
Compliance Requirements	Identify and implement measures to minimize environmental impacts on the following. (1) Air (e.g., dust and emissions) (2) Water (e.g., runoff and contamination) (3) Soil (e.g., erosion and contamination) (4) Ecosystems (e.g., vegetation and habitat disturbance)
Objectively Measured Criteria	Number and adequacy of environmental impact mitigation measures implemented across the four categories (e.g., air, water, soil and ecosystems), expressed as a percentage of total required categories.
Measurement Unit / Criteria	Percentage (%) of environmental impact categories adequately addressed
Point Distributions	**2 pts:** ≥ 50% of categories are addressed with effective measures **0 pt:** ≤ 50% of categories are addressed, or no structured measures provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Environmental Management Plan (EMP) covering air, water, soil and ecosystem protection measures. • Defined roles, responsibilities and approval chain for implementation. • Environmental performance indicators (KPIs) and monitoring mechanisms. **Verification after Construction (Before Occupancy)** • Completed site logbook documenting implementation of measures. • Complaints register (if any) and corrective actions taken. • Periodic environmental monitoring reports. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Updated or final environmental performance summary (for projects with extended construction or phased completion).

3 Materials and Resources

3.1 Construction Materials

Contextual Justification for Bangladesh	Reinforced concrete dominates construction in Bangladesh, resulting in high embodied carbon from cement-intensive practices. The proposed thresholds encourage realistic reductions through optimized structural design, use of alternative blocks, recycled steel and local material sourcing. Lower embodied carbon reflects efficient design, reduced cement intensity, and responsible material selection.
Compliance Requirements	Calculate and reduce total embodied carbon emissions generated during the construction phase from primary construction materials (e.g., cement, bricks/blocks, steel, aggregates, and exterior finishes), in accordance with life-cycle assessment (LCA) boundaries.
Objectively Measured Criteria	Total embodied carbon intensity ($kgCO_2e/m^2$) of the floor/built-up area, calculated using HBRI-approved LCA tools and Bangladesh-relevant emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of floor/built-up area ($kgCO_2e/m^2$)
Point Distributions	**8 pts:** $\leq$ 350 $kgCO_2e/m^2$ **0 pt:** $\geq$ 550 $kgCO_2e/m^2$
Required Documentation	**Prediction before Construction (Planning Stage)** • Preliminary Bill of Quantities (BOQ). • Material specifications and assumptions (including sourcing and recycled content). • Calculations using HBRI-approved LCA methodology, system boundaries and emission factors used. **Verification after Construction (Before Occupancy)** • Final BOQ and as-built material quantities. • As-built working drawings. • Updated and verified the LCA calculation report reflecting actual construction. **Confirmation after One Year of Occupancy (and periodically thereafter)** • BOQ and material quantities for any renovation, replacement or amendment works. • Updated LCA calculation report reflecting additional embodied carbon impacts.

3.2 Reused/Recycled Construction Materials

Contextual Justification for Bangladesh	Bangladesh faces resource constraints and increasing pressure on raw material extraction. Promoting the reuse and recycling of construction materials supports circular construction practices, reduces embodied carbon and minimizes environmental impacts associated with material production and disposal.
Compliance Requirements	Use a higher proportion of reused and/or recycled content in primary construction materials (e.g., steel, aggregates, bricks/blocks) compared to virgin materials during construction.
Objectively Measured Criteria	Percentage (%) of reused and/or recycled content in primary construction materials, calculated by mass relative to the total mass of primary materials used.
Measurement Unit / Criteria	Percentage (%) by mass of reused/recycled materials
Point Distributions	**4 pts:** ≥ 30% reused/recycled content **0 pt:** ≤ 15% reused/recycled content
Required Documentation	**Prediction before Construction (Planning Stage)** • Material sourcing plan identifying reused/recycled materials. • Supplier declarations and certifications indicating recycled content. **Verification after Construction (Before Occupancy)** • Delivery challans and procurement records. • As-built material summary (mass-based). • As-built working drawings (if relevant to material verification). **Confirmation after One Year of Occupancy (and periodically thereafter)** • Material quantities and records for any renovation or amendment works (if undertaken).

3.3 Construction Material Durability

Contextual Justification for Bangladesh	Encourages the use of durable construction materials suitable for humid, flood-prone and saline environments. Using long-lasting materials reduces the need for frequent replacements, thereby minimizing repeated embodied carbon impacts and promoting sustainable construction practices throughout the structure's lifecycle.
Compliance Requirements	Use durable primary construction materials with documented replacement cycles exceeding a 50-year reference service life. Compliance should be based on verified data from authoritative sources such as the HBRI.
Objectively Measured Criteria	Measured volume of primary construction materials that meet the durability criteria (≥ 50-year service life) as listed by HBRI. Materials must be resilient to environmental conditions common in Bangladesh, including high humidity, flooding and salinity.
Measurement Unit / Criteria	Percentage (%) of primary construction materials meeting the durability standard.
Point Distributions	**2 points:** ≥ 80% of construction materials meet durability criteria **0 points:** ≤ 60% of construction materials meet durability criteria
Required Documentation	**Prediction before Construction (Planning Stage)** • Durability specifications of primary construction materials. • Structural design life statement indicating expected service life. **Verification after Construction (Before Occupancy)** • Delivery challans confirming the supplied materials. • As-built material summary. • As-built working drawings showing materials installed. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Maintenance and asset management plan. • Maintenance records documenting inspections, repairs, and replacements

3.4 Construction Materials Wastage

Contextual Justification for Bangladesh	Typical construction material wastage in Bangladesh ranges from 8–15%. Establishing thresholds encourages best practices in material handling. Reducing waste directly lowers embodied carbon and contributes to resource efficiency and sustainability in construction.
Compliance Requirements	Minimize material waste during construction by effectively planning, handling and monitoring primary construction materials.
Objectively Measured Criteria	Percentage of primary materials effectively used versus wasted during construction, measured by mass. This evaluates how efficiently materials are handled and applied on-site.
Measurement Unit / Criteria	Percentage (%) of material wastage relative to total material used.
Point Distributions	**4 points:** ≤ 5% wastage **0 points:** ≥ 10% wastage
Required Documentation	**Prediction before Construction (Planning Stage)** • Construction waste management plan detailing prevention, segregation and reuse strategies. **Verification and Confirmation after Construction (Before Occupancy)** • Waste logs recording materials wasted and reused. • Disposal receipts for materials sent to landfill or recycling. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

3.5 Low-Emission Construction Materials

Contextual Justification for Bangladesh	Prioritizes health and durability as co-benefits rather than trade-offs. Encourages integrating carbon-reduction strategies with occupant health and safety by limiting hazardous substances and emissions from construction materials.
Compliance Requirements	Primary materials and associated products (e.g., additives, coatings and sealants) must meet HBRI limits for hazardous substances and emissions. Compliance must ensure that indoor environmental quality (IEQ) is not compromised.
Objectively Measured Criteria	Total number of materials used that meet HBRI health and emission criteria, including both primary construction materials and associated products.
Measurement Unit / Criteria	Percentage (%) of materials meeting health and emission standards.
Point Distributions	**2 points:** ≥ 75% of materials meet criteria **0 points:** ≤ 50% of materials meet criteria
Required Documentation	**Prediction before Construction (Planning Stage)** • Product data sheets. • Third-party test certificates confirming compliance with HBRI standards. **Verification after Construction (Before Occupancy)** • As-built compliance summary detailing installed materials and their conformity. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Indoor Air Quality (IAQ) spot check reports to ensure ongoing compliance and occupant safety.

3.6 Interior Finishes and Materials

Contextual Justification for Bangladesh	Encourages the use of durable, locally sourced and low-carbon interior finishes. Interior finishes are often replaced frequently and can be carbon-intensive; using low-carbon alternatives reduces lifecycle embodied carbon and promotes sustainability.
Compliance Requirements	Select and use low-carbon interior finishes to minimize total embodied carbon across their full life cycle, from production to installation and maintenance.
Objectively Measured Criteria	Embodied carbon intensity of interior finishes, calculated using HBRI-approved Life Cycle Assessment (LCA) tools and Bangladesh-relevant emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter ($kgCO_2e/m^2$) of interior finish surfaces.
Point Distributions	**8 points:** $\leq$ 80 $kgCO_2e/m^2$ **0 points:** $\geq$ 150 $kgCO_2e/m^2$
Required Documentation	**Prediction before Construction (Planning Stage)** • Interior material specifications. • Bill of Quantities (BOQ). • Preliminary LCA calculation report estimating embodied carbon. **Verification after Construction (Before Occupancy)** • As-built finishes schedule. • Updated BOQ reflecting actual materials. • Final LCA calculation report based on installed quantities. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Records of renovation or amendments (if any). • Updated BOQ. • Updated LCA calculation report to account for changes in finishes.

3.7 Reused/ Recycled Interior Materials

Contextual Justification for Bangladesh	Encourages adaptive reuse and circular interior strategies, which are common in incremental development practices. Higher rates of material reuse and recycling directly reduce embodied carbon and lessen the demand for virgin material extraction. This approach prioritizes prevention over offsetting.
Compliance Requirements	Maximize the use of reused and recycled interior materials relative to total interior materials while minimizing reliance on virgin materials.
Objectively Measured Criteria	Cost proportion of reused and recycled interior materials relative to the total cost of interior materials. This reflects both the financial and environmental commitment to circularity.
Measurement Unit / Criteria	Percentage (%) of reused/recycled materials by cost compared to total interior material cost.
Point Distributions	**4 points:** ≥ 40% reused/recycled materials **0 points:** ≤ 20% reused/recycled materials
Required Documentation	**Prediction before Construction (Planning Stage)** • Interior sourcing plan indicating the intended proportion of reused/recycled materials. **Verification after Construction (Before Occupancy)** • Delivery records confirming the quantity and type of materials used. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Records of renovation or amendments (if any), indicating reuse/recycling of materials.

3.8 Interior Material Durability

Contextual Justification for Bangladesh	Considers user behavior and the full lifecycle impacts of interior finishes, aspects often overlooked in rating systems. Frequent replacement of interior materials increases both lifecycle emissions and long-term costs. Prioritizing durable materials reduces environmental impact and operational expenses.
Compliance Requirements	Use interior finished materials with a documented replacement frequency exceeding a 15-year reference service life, based on verified product data.
Objectively Measured Criteria	Number of interior materials listed by HBRI that meet the durability criteria of a ≥ 15-year reference service life.
Measurement Unit / Criteria	Percentage (%) of interior materials meeting durability criteria.
Point Distributions	**2 points:** ≥ 80% of materials meet durability criteria **0 points:** ≤ 40% of materials meet durability criteria
Required Documentation	**Prediction before Construction (Planning Stage)** • Product durability data and specifications. **Verification after Construction (Before Occupancy)** • Delivery records confirming installed materials. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Maintenance and replacement plan. • Records of any replacements performed during occupancy.

3.9 Interior Materials Wastage

Contextual Justification for Bangladesh	Interior works often generate disproportionate amounts of waste. Encouraging modular construction, prefabrication and skilled workmanship can significantly reduce material wastage and improve efficiency.
Compliance Requirements	Minimize interior material waste generation during fit-out works through planning, material optimization and proper execution practices.
Objectively Measured Criteria	Proportion of interior material waste generated during fit-out works compared to total interior material used, measured by mass.
Measurement Unit / Criteria	Percentage (%) of material waste relative to total interior materials used.
Point Distributions	**4 points:** ≤ 5% waste **0 points:** ≥ 10% waste
Required Documentation	**Prediction before Construction (Planning Stage)** • Interior waste minimization plan detailing strategies for modular use, prefabrication and material handling. **Verification and Confirmation after Construction (Before Occupancy)** • Waste logs recording quantity and type of material waste generated. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

3.10 Low-VOC Interior Materials

Contextual Justification for Bangladesh	Supports the Healthy Building Design Concept by improving indoor air quality and occupant health. Ensures that interior finishes comply with low- or zero-VOC limits and exclude harmful substances such as formaldehyde.
Compliance Requirements	Minimize indoor concentrations of volatile organic compounds (VOCs), formaldehyde and CO_2 by using HBRI-compliant interior finishes and proper ventilation strategies.
Objectively Measured Criteria	Percentage of interior surface area covered with finishes that meet VOC, formaldehyde and other indoor air quality (IAQ) limits, relative to total interior surface area.
Measurement Unit / Criteria	Percentage (%) of compliant surface area versus total interior surface area.
Point Distributions	**2 points:** ≥ 80% compliant surface area **0 points:** ≤ 40% compliant surface area
Required Documentation	**Prediction before Construction (Planning Stage)** • VOC certificates and product datasheets. • IAQ testing plan. **Verification after Construction (Before Occupancy)** • As-built compliance report- Laboratory IAQ test reports. **Confirmation after One Year of Occupancy (and periodically thereafter)** • IAQ spot check reports to ensure ongoing occupant safety.

4 Water and Waste Management

4.1 Construction Water Use

Contextual Justification for Bangladesh	Construction water is often inefficiently used, leading to resource waste. Encourages efficient water use practices during curing, cleaning and dust suppression, as well as reuse strategies where possible.
Compliance Requirements	Minimize total construction water use for curing, cleaning and dust suppression while maintaining quality standards.
Objectively Measured Criteria	Construction water intensity is defined as the total construction water used per unit floor/built-up area.
Measurement Unit / Criteria	Cubic meters per square meter (m^3/m^2) of floor/built-up area.
Point Distributions	**8 points:** $\leq 0.40\ m^3/m^2$ **0 points:** $\geq 0.70\ m^3/m^2$
Required Documentation	**Prediction before Construction (Planning Stage)** • Construction water management plan, including reuse and efficiency strategies. **Verification and Confirmation after Construction (Before Occupancy)** • Site water logs documenting water consumption. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

4.2 Construction Water Sourced from Surface

Contextual Justification for Bangladesh	Municipal water is scarce and often requires costly treatment. Encourages the use of surface water sources during construction to reduce dependence on municipal supply and associated costs.
Compliance Requirements	Maximize the use of surface water for construction activities, including curing, cleaning and dust suppression, wherever feasible.
Objectively Measured Criteria	Percentage of volume of the total construction water supplied from surface water sources compared to the total water used (including municipal supply).
Measurement Unit / Criteria	Percentage (%) of volume of the construction water from surface sources.
Point Distributions	**2 points:** ≥ 80% of construction water from surface sources **0 points:** ≤ 40% construction water from surface sources
Required Documentation	**Prediction before Construction (Planning Stage)** • Water sourcing plan specifying intended surface water use. • Distance and accessibility of surface water collection points from the construction site. **Verification after Construction (Before Occupancy)** • Metered records of surface water usage. • Records of electricity consumption for pump operations (if applicable). **Confirmation after One Year of Occupancy (and periodically thereafter)** • Not applicable.

4.3 Construction Water Sourced from Rain

Contextual Justification for Bangladesh	Municipal water is scarce and requires costly treatment. Encourages the use of rainwater during construction, particularly in the monsoon season, to reduce reliance on municipal water and lower costs.
Compliance Requirements	Maximize the use of rainwater for construction activities, including curing, cleaning and dust suppression, during the monsoon period.
Objectively Measured Criteria	Percentage of volume of the total construction water supplied from rainwater compared to the total water used (including municipal supply).
Measurement Unit / Criteria	Percentage (%) of volume of the construction water from rainwater.
Point Distributions	**2 points:** ≥ 80% of construction water is from rainwater **0 points:** ≤ 40% of construction water is from rainwater
Required Documentation	**Prediction before Construction (Planning Stage)** • Size and capacity of rainwater reservoir. **Verification after Construction (Before Occupancy)** • Metered records of rainwater used. • Records of electricity consumption for pump operations (if applicable). **Each Year after Occupancy** • Not applicable.

4.4 Operational Water Use

Contextual Justification for Bangladesh	Water scarcity is increasing in urban areas, highlighting the need for efficient water use. Encourages adoption of norms and practices that reduce water consumption across different building functions.
Compliance Requirements	Minimize water consumption across domestic, cleaning, landscaping and cooling uses through efficient fixtures, systems and behavior-based strategies.
Objectively Measured Criteria	Annual per capita water consumption for different uses, calculated as total water consumption divided by the number of occupants.
Measurement Unit / Criteria	Litres per person per day (LPD).
Point Distributions	**8 points:** ≤ 100 LPD **0 points:** ≥ 135 LPD
Required Documentation	**Prediction before Construction (Planning Stage)** • Fixture specifications and schedules. • Initial LPD calculation. **Verification after Construction (Before Occupancy)** • System commissioning reports. • Updated LPD calculation reflecting installed systems. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Water bills. • Occupancy data for calculating per capita water consumption.

4.5 Operational Water Sourced from Surface

Contextual Justification for Bangladesh	Addresses groundwater depletion and urban water stress. Encourages the use of alternative water sources to enhance long-term water resilience and reduce dependence on municipal supply.
Compliance Requirements	Maximize the use of alternative water sources (e.g., surface water) to meet operational water demand, minimizing reliance on municipal water.
Objectively Measured Criteria	Percentage of volume of the total operational water supplied from surface water compared to total operational water demand.
Measurement Unit / Criteria	Percentage (%) of volume of the total operational water from surface sources.
Point Distributions	**2 points:** ≥ 50% of operational water from surface sources **0 points:** ≤ 25% of operational water from surface sources
Required Documentation	**Prediction before Construction (Planning Stage)** • Water system design. • Distance and accessibility of surface water collection points. **Verification after Construction (Before Occupancy)** • Confirmation of metering setup. • Electricity consumption estimate for pump operations. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Metered consumption records showing the proportion of water supplied from surface sources. • Electricity consumption for pump operations.

4.6 Operational Water Sourced from Rain

Contextual Justification for Bangladesh	Addresses groundwater depletion and urban water stress. Encourages the use of rainwater as an alternative water source to enhance long-term water resilience and reduce dependence on municipal supply.
Compliance Requirements	Maximize the use of rainwater for operational purposes, minimizing reliance on municipal water.
Objectively Measured Criteria	Percentage of volume of the total operational water supplied from rainwater compared to total operational water demand.
Measurement Unit / Criteria	Percentage (%) of volume of the total operational water from rainwater sources.
Point Distributions	**2 points:** ≥ 50% of operational water from rainwater **0 points:** ≤ 25% of operational water from rainwater
Required Documentation	**Prediction before Construction (Planning Stage)** • Water system design. • Size and capacity of rainwater reservoir. **Verification after Construction (Before Occupancy)** • Confirmation of metering setup for rainwater use. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Metered consumption records showing the proportion of water supplied from rainwater.

4.7 Water Heating

Contextual Justification for Bangladesh	Water heating demand is minimal in Bangladesh's hot-humid climate. This criterion discourages unnecessary mechanical water heating and promotes energy-efficient living.
Compliance Requirements	Minimize annual heating-related carbon emissions while ensuring compliance with BNBC (2020) standards.
Objectively Measured Criteria	Annual carbon emissions associated with water heating, calculated to meet BNBC standards by occupancy type.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of floor/built-up area per year [$kgCO_2e/(m^2\cdot year)$]
Point Distributions	**2 points:** ≤ 3 $kgCO_2e/(m^2\cdot year)$ **0 points:** ≥ 8 $kgCO_2e/(m^2\cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • Heating system design calculations. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for water heating systems. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills. • Metered water heating energy data.

4.8 Waste Management

Contextual Justification for Bangladesh	Waste generation from construction, demolition and building operations is a growing environmental and social challenge in Bangladesh. Landfills are limited and often located near vulnerable communities. Promoting zero-waste operations, source separation, recycling and reuse reduces environmental pollution, embodied carbon and resource depletion, while creating local green jobs and materials markets. Including infrastructure and operational planning early ensures long-term success in minimizing waste.
Compliance Requirements	Provide dedicated areas for the collection and storage of the following. (1) Recyclables and salvage (2) Organics and food waste (3) Paper and cardboard (4) Glass (5) Plastics (6) Metals (7) Manufacturer take-back storage (8) Hazardous waste (9) Excavated soil (10) Land-clearing debris
Objectively Measured Criteria	Site inspection checklist verifying the presence and adequacy of the required storage as a percentage of the total listed items.
Measurement Unit / Criteria	Percentage (%) of required storage provided
Point Distributions	**4 pts:** ≥ 80% of the required storage is provided **0 pt:** ≤ 40% of the required storage is provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Design and detail drawings showing dedicated storage areas for the collection of each catagories. • Construction and Demolation (C&D) materials management plan. • Maintenance manuals and resources to facilitate building occupants and operators achieving high-performance waste prevention and recycling goals. • Operational procedures and tenant guidelines for waste material handlings. **Verification after Construction (Before Occupancy)** • Waste tracking logs showing total generation, disposal and diversion (by weight or volume). • Third-party verification reports for diverted materials. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Documentation of salvage, recycling and take-back programs. • Waste collection bills.

5 Energy Conservation and Environmental Quality

5.1 Interior Lighting

Contextual Justification for Bangladesh	Lighting efficiency is a low-hanging opportunity in Bangladesh's buildings. Encourages daylight-responsive design and use of LED and energy saving fixtures to reduce energy use while maintaining visual comfort.
Compliance Requirements	Minimize lighting power density (LPD) while ensuring standard interior lighting levels are met per BNBC guidelines.
Objectively Measured Criteria	Annual carbon emissions associated with interior lighting, calculated to meet both LPD and lighting level requirements.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of floor/built-up area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**4 points:** ≤ 10 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 20 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • Lighting system design calculations, including LPD and control strategies. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for lighting systems. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills. • Metered lighting energy data.

5.2 Exterior Lighting

Contextual Justification for Bangladesh	Exterior lighting often runs for long hours in Bangladesh. Encourages the use of lighting zoning, control systems and solar-powered exterior lighting to reduce energy consumption while maintaining safety and visual comfort.
Compliance Requirements	Minimize exterior lighting power density (LPD) while maintaining standard exterior lighting levels as per BNBC (2020) guidelines.
Objectively Measured Criteria	Annual carbon emissions associated with exterior lighting, calculated to meet both LPD and lighting level requirements.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**2 points:** $\leq 4\ kgCO_2e/(m^2 \cdot year)$ **0 points:** $\geq 10\ kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • Exterior lighting system design calculations, including LPD and control strategies. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for exterior lighting systems. **Each Year after Occupancy** • Utility bills. • Metered exterior lighting energy data.

5.3 Indoor Cooling

Contextual Justification for Bangladesh	Cooling is a major contributor to operational emissions in hot-humid climates such as Bangladesh. Evaluating realistic cooling demand ensures strategies reduce energy use while maintaining occupant comfort.
Compliance Requirements	Minimize annual cooling-related carbon emissions while meeting BNBC (2020) comfort standards for the relevant occupancy type.
Objectively Measured Criteria	Annual carbon emissions associated with cooling, calculated to meet BNBC comfort standards.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter served area per year [($kgCO_2e/(m^2 \cdot year)$)]
Point Distributions	**4 points:** $\leq 15\ kgCO_2e/(m^2 \cdot year)$ **0 points:** $\geq 30\ kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • Cooling system design calculations. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for cooling systems. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills. • Metered cooling energy data.

5.4 Room Heating

Contextual Justification for Bangladesh	Heating demand is minimal in Bangladesh's hot-humid climate. This criterion discourages unnecessary mechanical room heating and promotes energy-efficient building design.
Compliance Requirements	Minimize annual heating-related carbon emissions while ensuring compliance with BNBC (2020) comfort standards.
Objectively Measured Criteria	Annual carbon emissions associated with heating, calculated to meet BNBC comfort standards by occupancy type.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of served area per year [$kgCO_2e/(m^2 \cdot year)$]
Point Distributions	**4 points:** ≤ 3 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 8 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • Heating system design calculations. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for heating systems. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills. • Metered heating energy data.

5.5 Ventilation

Contextual Justification for Bangladesh	Appropriate ventilation is critical in Bangladesh's hot, humid climate to maintain indoor air quality, prevent mold and moisture-related problems and ensure occupant comfort and health. User-adjustable systems and demand-based ventilation help balance comfort with energy efficiency.
Compliance Requirements	Provide standard ventilation to circulation areas, living spaces and rooms with prolonged occupancy to reduce CO_2 accumulation, humidity, odors and pollutant concentrations, ensuring compliance with BNBC (2020) comfort standards.
Objectively Measured Criteria	Annual ventilation-related carbon emissions, calculated using HBRI emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**4 points:** ≤ 2 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 5 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Ventilation system design drawings. • PHPP ventilation sheet or equivalent simulation. • Humidity and airflow calculations. • Draught mitigation plans. **Verification after Construction (Before Occupancy)** • Commissioning reports of the ventilation system. • Airflow measurements for rooms with prolonged occupancy and circulation spaces. • Verification of user controls and adjustability. • Noise and draught assessment report. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Annual airflow measurements • Indoor relative humidity logs • Occupant feedback on thermal comfort, noise and draughts.

5.6 Indoor Air Humidity

Contextual Justification for Bangladesh	Indoor humidity, thermal comfort and moisture protection are critical in Bangladesh due to its hot-humid climate and high rainfall. Excessively high or low humidity can cause mold, structural damage and discomfort. Maintaining standard heating, cooling and dehumidification ensures occupant health and comfort, as well as the long-term durability of building components. Hygrothermal performance is especially important for buildings with interior insulation, flat roofs, or moisture-sensitive assemblies.
Compliance Requirements	Ensure indoor air humidity meets standard comfort criteria and supports a healthy indoor environment, as per BNBC (2020).
Objectively Measured Criteria	Annual indoor air humidity-related carbon emissions, calculated using HBRI emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**4 points:** ≤ 2 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 5 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • PHPP ventilation and humidity sheets or equivalent simulations. • Hygrothermal simulations for critical components. • Design documentation for heating, cooling, dehumidification and draught mitigation. **Verification after Construction (Before Occupancy)** • Commissioning reports confirming HVAC performance. • Indoor temperature and humidity measurements. • Draught assessments. • Expert reports for moisture-prone assemblies (if applicable). **Confirmation after One Year of Occupancy (and periodically thereafter)** • Indoor temperature and humidity logs. • Occupant thermal comfort surveys (PMV/PPD). • Maintenance records for humidity control.

5.7 Exhaust Systems

Contextual Justification for Bangladesh	Inadequate ventilation is a major contributor to unhealthy indoor environments in Bangladesh, causing high humidity, mold growth and poor indoor air quality (IAQ). Effective exhaust systems mitigate these issues.
Compliance Requirements	Provide dedicated natural/mechanical/hybrid exhaust systems with outdoor discharge for kitchens, toilets and wet zones to ensure standard air circulation and a healthy indoor environment as per BNBC (2020).
Objectively Measured Criteria	Annual exhaust-related carbon emissions, calculated using HBRI emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**4 points:** ≤ 2 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 5 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Mechanical drawings specifying exhaust system layout and capacity. **Verification after Construction (Before Occupancy)** • Commissioning reports confirming installation and operational performance. **Confirmation after One Year of Occupancy (and periodically thereafter)** • IAQ spot check reports to verify ongoing performance.

5.8 Acoustics Performance

Contextual Justification for Bangladesh	Urban living in Bangladesh is exposed to excessive outdoor noise from traffic, generators, construction and mixed land use. Acoustic performance critically affects occupant comfort, productivity, health and energy use. Without appropriate acoustic design, strategies such as cross-ventilation and open-plan offices become less effective, increasing energy consumption and reducing indoor environmental quality. Effective acoustic design ensures speech privacy and noise control, reducing reliance on mechanical cooling in noisy urban contexts.
Compliance Requirements	Ensure compliance with BNBC (2020) space-appropriate acoustic performance criteria, including background noise levels, external and internal sound insulation, reverberation control, speech privacy and intelligibility, where applicable.
Objectively Measured Criteria	Annual acoustic performance-related carbon emissions, calculated using HBRI emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**4 points:** ≤ 2 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 5 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction and Simulation before Construction** • Acoustic design report. • Space-specific acoustic performance targets. • Acoustic simulations/calculations. • Drawings showing treatments, insulation, glazing and layouts. **Verification after Construction (Before Occupancy)** • As-built drawings showing installed materials. • Product datasheets for insulation, glazing and absorptive finishes. • Installation verification report (spot checks). **Confirmation after One Year of Occupancy (and periodically thereafter)** • On-site acoustic measurements and test reports. • Post-Occupancy Evaluation feedback on acoustic comfort.

6 Energy Efficiency and Renewable Energy

6.1 Energy-Saving Equipment

Contextual Justification for Bangladesh	Household and facility appliances can significantly contribute to operational carbon emissions. Promotes the use of energy-efficient appliances and occupant behavior strategies to reduce overall emissions.
Compliance Requirements	Minimize annual appliance-related carbon emissions through the selection of efficient equipment and effective usage practices.
Objectively Measured Criteria	Annual carbon emissions associated with appliances and equipment used other than comfort and cooking purposes, calculated based on energy use and emission factors.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of floor/built-up served areas per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**8 points:** ≤ 20 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 35 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Energy model and simulation results. • System design calculations. • Equipment schedule with efficiency ratings. **Verification after Construction (Before Occupancy)** • Calibrated energy model. • Commissioning reports for appliances and equipment. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills. • Metered appliance energy data.

6.2 Energy-Saving Cooking

Contextual Justification for Bangladesh	Cooking energy use is a significant contributor to energy demand, indoor air pollution and carbon emissions in Bangladesh. Inefficient gas stoves, biomass and electric resistance cooking increase emissions and health risks.
Compliance Requirements	Minimize annual carbon emissions from cooking through energy-efficient LPG burners, induction cooktops, improved biomass cookstoves and behavior-based efficiency improvements, which lower fuel demand and improve indoor air quality.
Objectively Measured Criteria	Annual cooking-related carbon emissions, calculated using HBRI emission factors for gas, electricity, LPG or biomass.
Measurement Unit / Criteria	Kilograms of CO_2 equivalent per square meter of floor/built-up served area per year [$kgCO_2e/(m^2 \cdot year)$].
Point Distributions	**8 points:** ≤ 15 $kgCO_2e/(m^2 \cdot year)$ **0 points:** ≥ 30 $kgCO_2e/(m^2 \cdot year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Cooking energy strategy and assumptions. • Kitchen layout and ventilation design. • Cooking appliance schedule with efficiency ratings (e.g., high-efficiency). • LPG burners, induction cooktops, improved biomass cookstoves. **Verification after Construction (Before Occupancy)** • As-installed cooking appliance list. • Commissioning confirmation of gas/electric connections and safety checks. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Utility bills (gas/electricity). • Metered or estimated cooking energy use. • Occupant cooking practice report.

6.3 Renewable Energy

Contextual Justification for Bangladesh	Bangladesh has high solar energy potential and supports net-metering policies. Promoting on-site renewable energy reduces grid dependence, lowers emissions and enhances energy resilience.
Compliance Requirements	Maximize the contribution of renewable energy sources (e.g., solar PV) to meet total building energy demands.
Objectively Measured Criteria	Ratio of annual energy supplied from renewable sources compared to total electricity demand, calculated using HBRI-approved tools.
Measurement Unit / Criteria	Percentage (%) of total energy supplied from renewable sources.
Point Distributions	**8 points:** ≥ 30% of total energy from renewables **0 points:** ≤ 10% of total energy from renewables
Required Documentation	**Prediction before Construction (Planning Stage)** • Renewable energy system design. • Single-line diagram (SLD) showing integration with the building electrical system. **Verification after Construction (Before Occupancy)** • Commissioning reports. • Net-metering approval documentation. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Renewable generation and export/import meter data.

7 Lifestyle, Social, Health and Safety

7.1 Transportation and Lifestyle

Contextual Justification for Bangladesh	Location strongly influences lifestyle-related emissions. Encourages transit-oriented and mixed-use development. Proximity of the site to public transport in high-density cities (e.g., Dhaka, Chattogram and other divisional cities) significantly reduces transport emissions and reliance on private vehicles.	
Compliance Requirements	Reduce transport-related emissions by ensuring that sites are within 1,000 m walking distance of public transport stops (e.g., tempu, bus, BRT, MRT, rail, and water transport).	
Objectively Measured Criteria	**Walking Distance** GIS-measured walking distance from the construction site to the nearest public transport stops.	**Transport Emissions** Annual occupant transportation emissions normalized by floor area.
Measurement Unit / Criteria	Meter (m) – walking distance to public transport.	Kilograms of CO_2 equivalent per square meter per year [$kgCO_2e/(m^2·year)$].
Point Distributions	**2 pts:** ≤ 500 m **0 pts:** ≥ 1000 m	**2 pts:** ≤ 10 $kgCO_2e/(m^2·year)$ **0 pts:** ≥ 20 $kgCO_2e/(m^2·year)$
Required Documentation	**Prediction before Construction (Planning Stage)** • Site location map with distances to public transport stops. • GIS-based walking distance analysis. **Verification after Construction (Before Occupancy)** • As-built site location confirmation. • Final pedestrian route measurement. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Occupancy declaration. • Occupant travel report, including distance and cost.	

7.2 Occupant satisfaction

Contextual Justification for Bangladesh	Occupant satisfaction is critical for facilities' performance, productivity and well-being. In Bangladesh, high temperatures, humidity and dense urban contexts can impact comfort. Ensuring operable windows and user control over lighting, shading and thermal systems allows occupants to adapt the environment to their personal preferences, increasing satisfaction and reducing complaints. Exemptions are allowed only when justified and do not significantly impair occupant comfort (e.g., interior rooms and security concerns).
Compliance Requirements	Provide the following facilities. (1) Visual access to outdoors must be maintained for occupant well-being. (2) All rooms with prolonged occupancy must have operable windows (exemptions require justification for security or specific design needs). (3) Occupants must have individual control over lighting in workspaces (manual lighting controls must take priority over automated systems). (4) Shading elements must be manually operable by building occupants (manual shading overrides are required for automated systems). (5) Thermal controls must be separate for every individual usage unit (high humidity necessitates localized control over air movement systems). (6) Provision for fans should support natural ventilation strategies. (7) Control systems must be intuitive and accessible to all users. (8) Building exemptions are not significantly reduceing overall occupant comfort.
Objectively Measured Criteria	Building inspection checklist verifying the presence and adequacy of the required facilities as a percentage of the total listed items.
Measurement Unit / Criteria	Percentage (%) of required facilities provided
Point Distributions	**2 pts:** ≥ 80% of required facilities are provided **0 pt:** ≤ 40% of the required facilities are provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Room and HVAC design drawings. • Lighting and shading control plans. • HVAC system specifications. **Verification after Construction (Before Occupancy)** • As-built drawings showing operable windows, lighting and shading controls, and unit-level HVAC controls. • Commissioning reports confirming HVAC performance.

	Confirmation after One Year of Occupancy (and periodically thereafter) • Occupant satisfaction surveys. • Post-Occupancy Evaluation (POE) reports. • Maintenance logs of operable windows, lighting, shading and HVAC controls.

7.3 Fire Safety

Contextual Justification for Bangladesh	Frequent fire incidents in Bangladesh highlight the need for strict compliance with fire safety standards. Ensuring life safety is non-negotiable in all construction types.
Compliance Requirements	Achieve operational fire safety with the following. (1) Fire Safety Plan (FSP) approved by the Fire Safety and Civil Defense (FSCD) department. (2) Approach road to the facility is wide enough for a fire tender. (3) Have an alternate emergency fire escape in place. (4) Emergency exits are free of obstacles. (5) Have an Evacuation Plan in place in case of an Emergency. (6) Fire blanket available in the kitchen. (7) Have adequate fire extinguishers at appropriate places. (8) Have smoke detectors in the required rooms. (9) Fire alarms installed where applicable. (10) Have an emergency contact list posted at visible locations, including the Police station, FSCD control room, the nearest Fire Station, WASA, and DESCO/DPDC. (11) Users practice a fire safety drill with other once every six months.
Objectively Measured Criteria	Building inspection checklist verifying the presence and adequacy of the required facilities as a percentage of the total listed items.
Measurement Unit / Criteria	Percentage (%) of required facilities provided
Point Distributions	**2 pts:** $\geq$ 80% of required facilities are provided **0 pt:** $\leq$ 40% of the required facilities are provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Fire safety plan showing the relevant facilities as listed above. • NOC from relevant authorities. **Verification after Construction (Before Occupancy)** • As-built drawings. • Clearance certificates from the fire department. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Fire drill records. • Renewal and inspection documents for fire safety systems.

7.4 Gender Responsiveness

Contextual Justification for Bangladesh	Women's safety and accessibility are critical urban issues in Bangladesh. Ensuring social inclusion, safety and security in building design supports equitable access for all occupants.
Compliance Requirements	Provide safe, inclusive, gender-responsive access by ensuring the following. (1) Adequate lighting in common areas (2) Secure entry and exit points (3) Visible circulation paths (4) Where relevant, separate and secure sanitation facilities
Objectively Measured Criteria	Number of safety and accessibility facilities provided, verified using the HBRI checklist.
Measurement Unit / Criteria	Percentage (%) of applicable facilities that have been implemented.
Point Distributions	**2 points:** ≥ 80% of facilities provided **0 points:** ≤ 40% of facilities provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Design note highlighting gender-responsive measures. • Layout plans showing lighting, circulation and sanitation provisions. **Verification after Construction (Before Occupancy)** • As-built verification report confirming implementation. **Confirmation after One Year of Occupancy (and periodically thereafter)** • Post-occupancy walkthrough report documenting safety and accessibility performance.

7.5 Universal Design

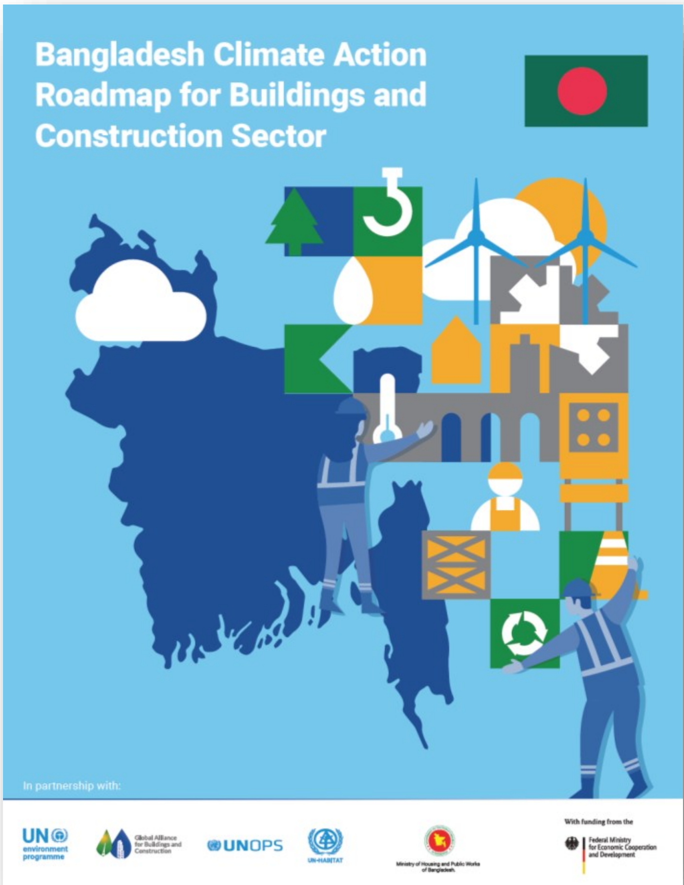
Contextual Justification for Bangladesh	An aging population and accessibility gaps are growing concerns in Bangladesh. Providing inclusive design ensures long-term usability and equitable access for different occupants, including people with reduced mobility.
Compliance Requirements	Ensure universal access by providing the following. (1) Step-free entry (2) Ramps with maximum slope 1:12 (3) Handrails on both sides of ramps and stairs (4) Non-slip surfaces (5) Door clear width ≥ 900 mm (6) Accessible toilets (7) Lift access where applicable
Objectively Measured Criteria	Number of universal access facilities provided.
Measurement Unit / Criteria	Percentage (%) of applicable universal access facilities implemented.
Point Distributions	**2 points:** ≥ 80% of facilities provided **0 points:** ≤ 40% of facilities provided
Required Documentation	**Prediction before Construction (Planning Stage)** • Universal access drawings. • Checklist of accessibility requirements. **Verification after Construction (Before Occupancy)** • As-built photos and measurements. **Confirmation after One Year of Occupancy (and periodically thereafter)** • User feedback report on accessibility and usability.

Appendix D

Project Concepts for Implementation

Source Document: MoHPW (2024) ***"Bangladesh Climate Action Roadmap for the Buildings and Construction Sector,"*** *developed under the Ministry of Housing and Public Works under the collective effort of the GlobalABC led by UNEP under the project titled* ***"Transforming the Built Environment through Sustainable Materials"****, funded by the German Ministry for Economic Development and Cooperation (BMZ), and implemented in partnership with UNOPS and UN-Habitat.*

Project concepts for implementation: 88-91 Pages



PROJECT TITLE	Objective
7. nearly Zero Emission Communities Research Institute (neZECoRI) [The Bengali meaning of 'neZECoRI' is 'do it by myself'] Development of an institutional framework dedicated to providing support and guidance for sustainable design and construction initiatives. The institute will comprise relevant experts and stakeholders from government, academia, professional bodies, industry and NGOs. It will engage in partnerships and community outreach.	All objectives. **Link to national and global agendas** EECMP 2030, SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 16, SDG 17.
Enabling environment recommendations	**Institutions**
– Responsible for promoting, regulating, and overseeing sustainable practices. – Enhance Inter-Agency Coordination. – Provide training for architects, engineers, and contractors. – Implement Monitoring and Evaluation Frameworks. – Develop Comprehensive Policies and Regulations. – Secure Funding and Develop Financial Incentives.	MoHPW. **Potential funding sources** Financial institutions (BB), NBR, MoF, RAJUK, MoPEMR and international donors (e.g., BMZ and World Bank).
Expected outputs and impacts	**Capital/upfront costs**
– Coordinated approach in implementing sustainability measures and support to the construction industry.	**Moderate**
Supporting actions	**Operational costs**
– Demonstration Projects on Zero Energy Buildings with life-cycle cost analyses. – Energy Labeling System for Zero Operational Carbon Sites and New Building Design and Construction.	**Medium** **Implementation time** **Low**

PROJECT TITLE	Objective
8. nearly Zero Emission Communities (neZECom) [The Bengali meaning of 'neZECom' is 'Reduce self-need'] Construction of showcase projects for Zero Emission Buildings, incorporating life-cycle cost analyses. Initiate the design of all new government buildings as part of the Zero Emission implementation project in suburban and rural areas to showcase the feasibility and benefits of low-carbon construction.	All objectives. **Link to national and global agendas** National Housing Policy 2016, EECMP 2030, Detailed Area Plan (DAP 2022-2035), SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 15, SDG 17.
Enabling environment recommendations	**Institutions**
– Establish Design, Construction, and Supervision Teams. – Develop Design, Validation, and Post-Occupancy Evaluation Tools. – Secure Funding and Investment for Zero-Energy Projects. – Mandate Updated Energy Standards for New Buildings.	DoA and nearly Zero Emission Communities Research Institute (neZECoRI) **Potential funding sources** GoB, international donors (e.g., BMZ and World Bank).
Expected outputs and impacts	**Capital/upfront costs**
– Demonstrations and installations of pilot projects, including at least one government building/ school in each district, with a life-cycle cost analysis.	**High**
Supporting actions	**Operational costs**
– Energy Labeling System for Zero Operational Carbon Sites and New Building Design and Construction.	**Low** **Implementation time** **Moderate**

PROJECT TITLE	Objective
9. Design for Environment and Sustainable Habitations (DESH) [The Bengali meaning of 'DESH' is 'country', as reflected in the last part of the country's name, BANGLA-DESH] Establishment of an energy labeling system for Zero Operational Carbon sites and Zero Emissions Building design and construction. The objectives of DESH are: to ensure that the **Design** concept is appropriate to the local context; to eliminate **Environmental** impact over the life cycle; to ensure **Sustainability** for future generations; and to minimize energy demands throughout the life cycle of **Habitation** development.	All objectives.
	Link to national and global agendas
	BNBC, BEER, ARCH, LEED, EDGE, nZEB, SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 15, SDG 17.
Enabling environment recommendations	**Institutions**
– Set Primary Targets Based on Existing Standards. – Encourage and Support Developers to exceed minimum standards. – Update and Transfer Standards to a Performance-Based Rating System. – Allow upgrading of labels by incorporating additional renewable features or reducing energy demands. – Determine subsidy amounts based on achieved energy and carbon efficiency levels compared to pilot projects.	nearly Zero Emission Communities Research Institute (neZECoRI)
	Potential funding sources
	Financial Institutions (BB), NBR, MoF, RAJUK, MoPEMR and international donors (e.g., BMZ and the World Bank).
Expected outputs and impacts	**Capital/upfront costs**
– Mandatory labeling of all existing buildings. [GREEN Leaf: 100 – 80 %; YELLOW Leaf: 79 – 60 %; ORANGE Leaf: 59 – 40 %; BROWN Leaf: below 40%]	**Moderate**
Supporting actions	**Operational costs**
– Demonstration Projects on Zero Energy Buildings with life-cycle cost analyses.	**Moderate**
	Implementation time
	Moderate

PROJECT TITLE	Objective
10. nearly Zero Emission Communities Renovation Body (neZECoRBo) [The Bengali meaning of 'neZECoRBo' is 'I will do it myself'] Establishment of a body dedicated to providing support and guidance for sustainable renovation and material reuse efforts initiatives under neZECoRI.	All objectives.
	Link to national and global agendas
	EECMP 2030, SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 16, SDG 17.
Enabling environment recommendations	**Institutions**
– Foster Partnerships with International Organizations. – Involve local communities in decision-making processes. – Train building managers and maintenance personnel. – Enhance Regulations. – Provide Training. – Implement Penalties for Non-Compliance.	nearly Zero Emission Communities Research Institute (neZECoRI)
	Potential funding sources
	Financial Institutions (BB), NBR, MoF, RAJUK, MoPEMR and international donors (e.g., BMZ and the World Bank).
Expected outputs and impacts	**Capital/upfront costs**
– A unified approach and leadership in implementing sustainable renovation practices across the country.	**Low**
Supporting actions	**Operational costs**
– Demonstration Projects for Existing Buildings. – Energy Labeling System for Existing Buildings.	**Low**
	Implementation time
	Low

PROJECT TITLE	Objective
11. nearly Zero Emission Communities Renovation and Adaptation (neZECoRA) [The Bengali meaning of 'neZECoRA' is 'do it myself'] Implementation of pilot projects focused on sustainable renovation and adaptation towards Zero Emissions Buildings as part of neZECom.	All objectives. **Link to national and global agendas** National Housing Policy 2016; DAP 2022-2035, SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 15, SDG 17.
Enabling environment recommendations – Promote the retrofitting and renovation of existing buildings supported by the government to increase housing availability. – Develop comprehensive building management and maintenance plans. – Regular energy audits and retrofits. – Upgrade current structures to make them more habitable, energy-efficient, and resilient. – Promote Community Management and Maintenance. – Provide Financial Incentives for Homeowners.	**Institutions** nearly Zero Emission Communities Research Institute (neZECoRI) **Potential funding sources** Financial Institutions (BB), NBR, MoF, RAJUK, MoPEMR and international donors (e.g., BMZ and the World Bank).
Expected outputs and impacts – Retrofitting of existing buildings to include essential low-energy and accessibility features.	**Capital/upfront costs** **High**
Supporting actions – Energy Labeling System for Existing Buildings.	**Operational costs** **Low** **Implementation time** **Moderate**

PROJECT TITLE

12. Addition, Modification and Retrofitting DESH (AMaR DESH)
[The Bengali meaning of 'AMaR DESH' is 'my country']

Development of a comprehensive energy labeling system to assess and improve the performance of existing buildings towards Zero Emissions.

Enabling environment recommendations

- Conduct Post-Occupancy Energy Evaluation and Energy Audits.
- Provide Financial Incentives and Subsidies.
- Partner with Appliance Manufacturers.
- Promote the use of renewable energy.

Expected outputs and impacts

- Mandatory labeling of all existing buildings. [GREEN Leaf: 100 – 80 %; YELLOW Leaf: 79 – 60 %; ORANGE Leaf: 59 – 40 %; BROWN Leaf: below 40%]

Supporting actions

- Demonstration Projects for Existing Buildings.

Objective

All objectives.

Link to national and global agendas

BNBC, BEER, ARCH, LEED, EDGE, nZEB, SDG 3, SDG 6, SDG 7, SDG 9, SDG 11, SDG 12, SDG 13, SDG 15, and SDG 17.

Institutions

nearly Zero Emission Communities Research Institute (neZECoRI)

Potential funding sources

Financial Institutions (BB), NBR, MoF, RAJUK, MoPEMR and international donors (e.g., BMZ and the World Bank).

Capital/upfront costs

Moderate

Operational costs

Moderate

Implementation time

Low