

STRATEGIES AND BEST PRACTICES FOR EFFECTIVE COLLABORATION IN INTEGRATING SUSTAINABLE PRACTICES IN RENOVATION PROJECTS

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Abstract: In recent years, the construction industry has been closely focusing on integrating sustainable practices into renovation projects. The successful implementation of sustainable renovation practices is commonly interconnected with strong engagement among stakeholders. However, the implementation of sustainable renovation practices is still in its early stages in Sri Lanka; hence, integrated strategies are required for successful project completion. The research mainly focused on identifying the strategies and best practices that support strong collaboration when integrating sustainability into renovation projects. A qualitative approach was used, which included a literature review as well as semi-structured interviews with twelve construction professionals who had experience with renovation projects. Furthermore, the interview responses were analysed using manual content analysis, which expressed the importance of obtaining locally available materials, integrating waste management practices, promoting biophilic design, and implementing digital technologies like Building Information Modelling (BIM). Moreover, the research highlights the necessity of improving quality control systems, client education, skill development, and early stakeholder involvement. This study provides significant contributions to the body of knowledge on sustainable renovation in Sri Lanka and suggests practical implications for industry professionals and policymakers that support best practices while encouraging effective collaboration in integrating sustainability into renovation projects.

Keywords: *Best Practices, Renovation Projects, Sri Lanka, Strategies, Sustainability*

1. Introduction

Sustainable development is an integrated approach, which mainly focus on the quality of life while considering the long-term social, economic, and environmental benefits for both current and future generations (Ozili, 2022). Emas (2015) explains that the main goal of sustainable development is to create long-term balance between the economy and the environment, which can be achieved only when social, environmental, and economic factors are considered together in every stage of decision-making process. Furthermore, recognising local cultural concerns, improving governance capacity, and focussing more on life support systems are regarded as essential components in promoting sustainable development (Shi et al., 2019). The above approach has become increasingly necessary to many industries as a move to economic growth, environmental conservation, and social responsibility (Stock & Seliger, 2016). Subsequently, the construction industry negatively impacts the environment, which significantly necessitates a huge focus on sustainable development (Patil, 2012).

The construction sector plays an important role in global economic growth and contributes significantly to Gross Domestic Product (GDP) and employment opportunities (Ogunmakinde et al., 2022). Conversely, the construction industry is responsible for significant environmental problems such as high energy consumption, CO₂ emissions and waste generation (Ali et al., 2020). Energy performance regulations state that buildings contribute 20-25% of total life cycle greenhouse gas (GHG) emissions; this percentage can increase significantly for energy-efficient buildings, reaching 45-50%, and in extreme cases, exceeding 90% (Röck et al., 2020). The above environmental problems are expected to become more severe as urbanisation continues and demand for construction projects increases in future (Santamouris & Vasilakopoulou, 2021). Hence, the existing buildings typically require renovation to change their functionality, efficiency, and environmental impact due to their outdated structures, outdated technologies, and poor energy performance (Pombo et al., 2016).

Jensen et al. (2022) stated that fixing up buildings has become more important in various countries because structures are ageing and there is a need to minimise energy consumption and greenhouse gas emissions. These current problems highlight the essential need for long-term renovation measures (Jensen et al., 2022; Pombo et al., 2016; Vilches et al., 2017). Renovation is the process of improving existing buildings to increase their capability, efficiency and aesthetics (Ma et al., 2012). However, conventional renovation strategies fail to address all sustainability problems affecting the constructed surroundings (Akande et al., 2016).

Sustainable building renovation projects have received more attention in recent years due to high energy consumption in existing buildings (Jowkar et al., 2022). Moreover, the recent concept of sustainability includes environmental, economic and social issues, but often excludes structural safety, resulting in unsafe buildings, even though being more sustainable (Passoni et al., 2021). Therefore, renovation projects can significantly reduce environmental impact by using eco-friendly,

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sustainable materials while considering embodied energy when selecting components. Developing guidelines for sustainable renovation projects will be critical to addressing the environmental challenges facing the built environment while meeting the increasing need for higher building performance and occupant satisfaction (Nielsen et al., 2016). As building standards and environmental laws become more stringent, sustainable renovations must ensure compliance and future-proof buildings against expected legislative changes (Georgiadou, 2014). The integration of sustainable practices in renovation projects has become more important in managing environmental and resource-related challenges. However, the development of sustainable renovation in Sri Lanka is limited by the absence of specific policy guidelines and insufficient collaboration of stakeholders. The aim of this study is to identify strategies and industry best practices that allows efficient collaboration when integrating sustainability into renovation projects. The paper begins with an introduction to the topic, and then it provides a comprehensive literature review on sustainable practices in renovation projects. Next, the research method, comprising data collection and data analysis, is elaborated. The conclusion summarises the study and makes recommendations at the end.

2. Literature review

2.1. SUSTAINABILITY CONCEPT

Sustainability is designed to achieve an equilibrium of both the global environment and human civilisation (Yang & Zeng, 2020). Elkington (2018) stated that sustainability is a broad concept that focuses on achieving a balance between social, and environmental preservation, and economic growth. A developing comprehension of the relationships between these three areas has led to a change in its definition throughout time. According to the Report of the World Commission on Environment and Development (1987), which highlighted the significance of fulfilling existing demands without harming the ability of future generations to fulfil their requirements, sustainability was first largely focused on ecological elements (Redclift, 2005). However, the concept is currently extended to include wider social and economic aspects, highlighting the need to balance resource utilisation with economic growth and social equality (Purvis et al., 2019).

2.2. SUSTAINABILITY PRACTICES IN RENOVATION PROJECTS

Sustainable practices for renovation projects are becoming more essential while considering that buildings contribute a significant portion of Global Greenhouse Gas (GHG) emissions (Sabet & Easterbrook, 2016). Renovating existing structures, instead of deciding for demolition and new construction, is an effective way to reduce carbon emissions arising from the production, transportation, and installation of new materials (Zimmermann et al., 2023). To increase the effectiveness of sustainable renovation, LCA provides a comprehensive assessment of a building’s environmental impact from use of resources through end-of-life, helping project stakeholders minimize emissions at each stage (Zimmermann et al., 2023). Green building standards and tools for decision-making in renovation projects assist reduce greenhouse gas emissions by integrating construction practices with sustainable development goals and encouraging beneficial environmental and social outcomes (Sabet & Easterbrook, 2016). Table 1 illustrates the various sustainable practices used in the renovation projects.

Table 1: Sustainable Practices in Renovation Projects

Sustainable Construction Practices	References
Sustainable Material Utilisation	[1], [2], [4], [6], [7]
Waste Management	[3], [8]
Biophilic Design	[5], [9], [10]
Value management	[11], [12], [13]
Building Information Modelling (BIM)	[14], [15]
1 - (Doddy et al., 2024), 2 - (J. Liu et al., 2020), 3 - (Yu et al., 2021), 4 - (Antoniou et al., 2022), 5 - (Sharifi & Sabernejad, 2016), 6 - (Lopes et al., 2024), 7 - (Almeida et al., 2016), 8 - (Spišáková et al., 2021), 9 - (Nitu et al., 2022), 10 - (Cacique & Ou, 2022), 11 - (B. J. Ekanayake et al., 2018), 12 - (Isa et al., 2019), 13 - (Kamari et al., 2019), 14 - (Lu et al., 2017), 15 - (Hammond et al., 2014)	

2.2.1 Overview of Sustainable Building Materials

The environmental impacts from the construction industry are consider the sustainable building materials which are designed to reduce environmental degradation while maintaining their structural integrity (Doddy et al., 2024). Material selection is an essential component of sustainability in renovation, including the whole lifespan of a building and analysing its long-term consequences on social, economic, and environmental issues (J. Liu et al., 2020). The usage of sustainable materials in the renovation projects mainly improves the energy efficiency, insulation and airtightness in the building (Antoniou et al., 2022). The adoption of circular business model concepts can significantly improve sustainable value creation in the building sector while prioritising material reuse (Nussholz et al., 2020). Moreover, implementing circular economy concepts into the renovation projects is important for obtaining the benefits from the sustainable materials to control the environmental impact and physical stability (Lopes et al., 2024). Additionally, the financial challenges of utilising sustainable materials, including the initial costs and long-term savings, must be carefully evaluated to promote better adoption among stakeholders (Almeida et al., 2016).

2.2.2 Waste Generation During Renovation Projects

Construction and demolition waste and hazardous waste are the primary categories of waste generated during renovation activities (Lemańska & Sagan, 2019). According to Lemańska and Sagan (2019), construction and demolition waste consisting of materials including concrete, bricks, asphalt, steel, wood, glass, and ceramics are usually reused or recycled for the sustainable waste management practices. Improper handling of hazardous waste during renovation projects, including volatile organic compounds, asbestos, and lead, mainly causes major health and environmental hazards (Qu et al., 2023).

Construction and demolition wastes are among the fastest-growing kinds of waste as an outcome of worldwide economic expansion and urbanisation (Mihai, 2019). Construction and demolition waste includes the excessive inappropriate materials which are created during the renovation activities, including concrete, wood, metals, masonry, and other construction materials (Liu et al., 2022). Renovation projects generate hazardous waste, which creates huge amount of environmental and health risks due to its toxicity, which requires careful management and regulatory compliance for public health and the environmental protection (Ardiana et al., 2022). Hazardous waste in renovation projects includes items like plywood, heavy metals, paints, solvents, and some types of sealants (Qu et al., 2023). Project managers should assess the resources before starting any work to identify any possibly hazardous items (Wu et al., 2021). A better waste management strategy that specifies the safe handling, storage, and disposal of hazardous wastes can be developed using this approach (Wu et al., 2021).

2.2.3 Biophilic Design Approach for Renovation Projects

Biophilic design integrates the natural elements into architectural contexts for establishing a connection between humans and nature while improving sustainability (Sharifi & Sabernejad, 2016). In the context of renovation projects, the above method is particularly important for improving environmental performance and fulfils the rising need for better living surroundings (Nitu et al., 2022). Natural light, ventilation, and natural materials are some of the examples of biophilic concepts which lower energy use and improve indoor environmental quality (Cacique & Ou, 2022). Biophilic design provides practical methods to improve the functioning and durability of renovated structures, in addition to aesthetics (Nitu et al., 2022). The above approach offers effectiveness to improve mental health, productivity, and overall quality of life for residents while addressing energy efficiency and carbon reduction in renovation projects (Sharifi & Sabernejad, 2016). Therefore, in renovating projects, biophilic design is a complete approach that achieves a balance between ecological sustainability and human-centered design (Nitu et al., 2022).

2.2.4 Value Management

Value management (VM) is an important sustainable practice in the renovation projects for resource efficiency while maintaining value for money through accurate evaluation and cost control (B. Ekanayake et al., 2018). VM overcomes specific challenges in renovation projects, such as unforeseen building conditions, by improving functionality without compromising quality or performance (Isa et al., 2019). In Sri Lanka, a hotel renovation project which used VM resulted in a 5.06% cost reduction and an 8.31% decrease in operating and maintenance expenses, stating the significance of integrating the VM in early stages of the project to minimise time and cost overruns (Ekanayake et al., 2018). Sustainable renovation frameworks prioritise energy efficiency, life-cycle cost management, and occupant satisfaction with the goal to develop functional and cultural changes, which lead to more resilient and efficient building performance (Kamari et al., 2019).

2.2.5 Building Information Modelling

Building Information Modelling (BIM) is a technology which supports sustainability in renovation projects with its integrative and analytical skills, which helps architects and engineers to adopt sustainable design principles through comprehensive simulations (Lu et al., 2017). Furthermore, BIM's ability to monitor the lighting, ventilation, and emissions in the building can be helpful for the decision-making process to obtain the green building certifications like LEED and improve projects to satisfy demanding environmental criteria (Hammond et al., 2014). Renovating existing structures with BIM can save energy consumption, greenhouse gas emissions and improve cost-efficiency by efficient utilisation of resources (Hammond et al., 2014). For example, project teams can use BIM to simulate the multiple situations to determine effective renovation techniques, such as changing building orientation or utilising daylight to minimise energy consumption (Lu et al., 2017).

3. Research Methodology

A qualitative approach was selected to obtain clear and detailed insights from industry professionals on current sustainable practices and collaborative processes in building renovation projects. Twelve professionals, including quantity surveyors, engineers, architects, and project managers with both consultant and contractor, participated in semi-structured interviews to gather comprehensive information. Purposive and snowball sampling methods were used to select participants, providing significant knowledge of sustainability and renovation. Participant background, concepts of sustainability in renovation, current sustainable practices, and strategies for better integration were all covered in the interview guideline. Only five sustainable practices were selected for data analysis since each of them was broadly discussed in the literature and confirmed by experts during interviews to be directly applicable to Sri Lankan renovation projects. Manual content analysis was used to examine the data. Table 2 provides a summary of participant profiles.

Table 2: Participant Profiles

Expert Code	Type of the Organization	Profession	Industry Experience	Work Experience in Renovation Projects	
				No. of Projects	Type of Projects
R1	Contractor	Quantity Surveyor	10 Years	2 Projects	Hotels, Commercial
R2	Consultant	Quantity Surveyor	27 Years	5 Projects	Commercial
R3	Contractor	Civil Engineer	8 Years	4 Projects	Residential
R4	Consultant	Chartered Architect	24 Years	22 Projects	Personal housing, Apartment, Commercial, Institutional, Banks, Military
R5	Contractor	Quantity Surveyor	5 Years	4 Projects	Hotel, commercial
R6	Contractor	Quantity Surveyor	5 Years	13 Projects	MEP Projects
R7	Contractor	Civil Engineer	13 Years	11 Projects	Infrastructure, Resort
R8	Contractor	Civil Engineer	9 Years	4 Projects	Mall, Road
R9	Contractor	Civil Engineer	8 Years	4 Projects	Warehouses, Utility Spaces
R10	Consultant	Chartered Civil Engineer	13 Years	5 Projects	Historical, Clinics
R11	Consultant	Chartered Architect	7 Years	12 Projects	Residential, Cafes, Clinics, Hotels
R12	Consultant	Chartered Architect	29 Years	52 Projects	Apartments, Banks, Factories, Showrooms, Hotels, Temples

4. Data Analysis

4.1. EXISTING SUSTAINABLE PRACTICES IN RENOVATION PROJECTS IN SRI LANKA

Table 3 discusses the existing sustainable practices in renovation projects from various perspectives.

Table 3: Existing Sustainable Practices and Respondent-Based Suggestions

Subcategory	Key Findings / Practices	Respondent References
Material Selection		
Use of Renewable / Natural Materials	<ul style="list-style-type: none"> - Adoption of renewable, locally available, and natural materials. - Use of locally sourced wood and bamboo to reduce transport emissions and support local industries. - Use of timber, clay tiles, and earth-based materials with low embodied energy. 	R1, R2, R5, R12
Use of Recycled / Reclaimed Materials	<ul style="list-style-type: none"> - Reuse of old clay tiles, wooden rafters, antique doors/windows, brass items, steel materials to minimise virgin material use and waste. - Use of reclaimed wood, recycled steel, and crushed concrete for pavements. - Application of recycled tiles for flooring. - Use of recycled steel, glass sheets, and recycled aggregates in renovation works. 	R2, R3, R4, R9
Use of Biodegradable Materials	<ul style="list-style-type: none"> - Use of mud-based paints and earth-based plasters as alternatives to synthetic paints. - Use of coconut leaves and bamboo for roofing to reduce environmental impact. - Use of biodegradable coatings such as mud plastering for resorts. 	R4, R11, R12
Use of Industrial By-products / Innovative Renewable Inputs	<ul style="list-style-type: none"> - Use of aerated cement blocks (by-products of coal power plants) for sustainable construction (Centara Resort). - Some projects lack renewable material usage, relying only on solar energy (e.g., Robinson Club Maldives). 	R7
Waste Management		
Material Recovery & Reuse	<ul style="list-style-type: none"> - Careful dismantling of roof purlins, rafters, sheets, doors, and windows for reuse. - Demolition waste repurposed for temporary landfills. - Reuse of bricks and other structural components wherever possible (limitations acknowledged). - Evaluating necessity of demolition before proceeding to avoid unnecessary waste generation. 	R10, R5, R12

Waste Management Systems / Treatment	<ul style="list-style-type: none"> - Use of wastewater treatment plants, septic tanks, soakage pits, compost pits for organic waste. - Implementation of rainwater harvesting systems contributing to sustainable waste and resource management. 	R4
Waste Segregation & Recycling	<ul style="list-style-type: none"> - Segregation of construction and demolition waste to identify recyclable components. - Use of Reduce–Reuse–Recycle (3R) approach to minimise environmental impact. 	R2, R6, R8
Challenges & Limitations	<ul style="list-style-type: none"> - Lack of waste audits; most waste is dumped without proper tracking or recovery systems. - Waste management processes not followed consistently; demolition waste sometimes used for backfilling without formal strategies. 	R7, R9
Biophilic Design		
Natural Ventilation Strategies	<ul style="list-style-type: none"> - Use of cross ventilation and stack ventilation. - Large openings to optimise wind flow. - Natural ventilation widely used in hotels/resorts to reduce air-conditioning demand. - Integration of ventilation strategies to minimise energy usage. 	R3, R4, R6, R7, R12
Maximising Natural Lighting	<ul style="list-style-type: none"> - Designing to capture more daylight. - Aligning building orientation with sun path to enhance indoor lighting. - Reducing reliance on artificial lighting. 	R4, R12
Use of Natural Elements & Water Features	<ul style="list-style-type: none"> - Incorporation of fountains, ponds, aquariums, and rain gardens to enhance interior environmental quality and biophilic experience. 	R3
Climate-Responsive Design	<ul style="list-style-type: none"> - Aligning design with wind direction and sun path to support passive cooling and lighting strategies. 	R4
Application Context (Hotels/Resorts)	<ul style="list-style-type: none"> - Many hotels designed as open-air spaces with strong natural ventilation. - Resorts rely on passive ventilation rather than mechanical systems. 	R5, R7
Limitations / Constraints	<ul style="list-style-type: none"> - Adoption of biophilic design in some renovation projects is limited due to structural constraints of existing buildings. 	R10
Value Management		
Cost Optimisation Through Material Selection	<ul style="list-style-type: none"> - Contractors propose alternative materials and design options to reduce costs without compromising quality. - Use of low-cost finishes such as cement floors. - Selection of affordable yet aesthetic materials like glass cladding, composite aluminium panels, and wallpapers. 	R4, R5, R12
Economic Feasibility Assessments	<ul style="list-style-type: none"> - Application of feasibility studies before implementing renovation work. - Cost estimation and return on investment (ROI) analysis used for decision-making. 	R10
Balancing Cost & Sustainability	<ul style="list-style-type: none"> - Emphasis on integrating sustainable materials and systems while keeping projects economically feasible. - Need to balance environmental benefits with project budgets. 	R6
Energy & Resource Efficiency Measures	<ul style="list-style-type: none"> - Incorporating energy-efficient lighting systems. - Installing water-saving fixtures to reduce operational costs and environmental impact. 	R2
Structural Improvements for Cost Efficiency	<ul style="list-style-type: none"> - Transition from solid precast piles to spun piles to reduce material cost and improve structural efficiency. 	R7
Selective Application of Value Management	<ul style="list-style-type: none"> - Value management practices not uniformly applied; implementation depends on project scope and client requirements. 	R11
Building Information Modelling (BIM)		
Benefits of BIM	<ul style="list-style-type: none"> - Enhances design efficiency and accuracy. - Reduces construction waste through improved planning. - Optimises energy performance and supports sustainable design. - Facilitates predetermination of spaces and better understanding of construction techniques during design and construction. 	R2, R4, R6
Use of BIM Software	<ul style="list-style-type: none"> - Use of Revit, Civil 3D, Lumion, and AutoCAD for modelling, design visualisation, and coordination. 	R3
Challenges in Renovation Projects adopting BIM	<ul style="list-style-type: none"> - Limited adoption in Sri Lanka due to lack of existing as-built drawings. - Complexity of modelling around existing services makes BIM application challenging. - BIM not widely used in certain renovation contexts due to practical implementation barriers. 	R5, R10

4.2. STRATEGIES TO IMPROVE THE INTEGRATING SUSTAINABILITY IN RENOVATION PROJECTS

The strategies recommended by the respondents to improve the integration of the sustainability practices in renovation projects are listed in Table 4 and some of the strategies are further elaborated based on the interview findings.

Table 4: Strategies to Improve Sustainable Practices Integration

Strategies	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
Proper material sourcing and selection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Maintain good communication with suppliers	✓											
Use locally available sustainable materials	✓	✓	✓	✓	✓	✓		✓				
Educate clients on lifecycle cost savings	✓	✓	✓		✓		✓	✓	✓		✓	✓
Government incentives for sustainable materials		✓								✓		
Quality control for reused materials				✓	✓					✓		
Designing waste management processes	✓	✓	✓		✓		✓			✓	✓	✓
Designated waste disposal areas	✓											
Conduct waste audits before demolition		✓	✓		✓							
Introduce waste segregation protocols		✓					✓					
Collaborate with recycling companies		✓			✓							
Design green roofs, vertical gardens, natural ventilation	✓		✓	✓	✓					✓		✓
Use technology and digital Tools		✓	✓		✓	✓		✓		✓	✓	
Use digital tools for waste tracking and auditing		✓	✓									
Training and skill development	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Provide training on BIM and digital tools		✓	✓		✓	✓		✓	✓	✓	✓	
Encourage collaboration among stakeholders	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Conduct feasibility assessments and cost-benefit analyses		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.2.1 Sourcing Sustainable Materials

R1 emphasised "Good communication with suppliers are must for the procurement of sustainable materials more easily for use in renovation projects". Moreover, R3 pointed out the main difficulty of high upfront costs and limited local availability of sustainable materials. However, R3 suggested "Sourcing of local materials can lower both prices and environmental effect". In addition, R3 mentioned that "Educating clients on lifecycle cost savings can help them understand that sustainable materials; while explaining them about the initial cost and the way it leads to long-term savings due to their durability and energy efficiency." Furthermore, R4 focused that "Adopting locally available materials helps lower the environmental impact through reducing transportation emissions and improving the local economy". Similarly, R4 said that "The flexibility in optional designs for cost savings allows for the modification of the renovation project to available resources, implementing that sustainability without harm for the purpose of aesthetics or functionality." R5 emphasised the importance of locally available and reused materials to achieve sustainability. Additionally, R5 suggested explaining to clients the benefits of utilising materials such as reclaimed wood that can considerably reduce the impact on the environment. Additionally, R6 suggested "Promoting increased local material production to improve the availability of sustainable materials." The above method is mainly planned to make sure that local markets provide the need for sustainable materials, which reduces dependence on imported materials, which can have a greater carbon footprint. However, R7 also recognised "Importing alternatives when local supply is insufficient", mentioning that sometimes local materials may not be sufficient for specific renovation projects." In such instances, the need is important to carefully choose alternative materials that are sustainable and locally available in other areas.

4.2.2 Government Support

R2 discussed the need to "Advocate for government subsidies or incentives for renewable materials". Government support can make sustainable materials more financially feasible for contractors and clients, subsequently improving their application. Moreover, R2 highlighted that "The incentives may be provided in the way of reductions in taxes, subsidies, or reduced import charges on sustainable goods, making them more accessible and cheaper." Similarly, R8 suggested that

"Promoting the lifecycle cost benefits of sustainable materials by educating stakeholders on the long-term savings that can be made through energy-efficient and durable materials", consultants and contractors can assist clients in seeing over the initial costs and making better choices about their renovation projects. R9 emphasised that "Government involvement is more significant to develop better regulations that would assist in generating a more sustainable construction sector". Consequently, government regulations can regulate the usage of sustainable materials and encourage contractors to support sustainable practices. R10 suggested that "Cost-benefit analyses must be implemented for the financial advantages of utilising recycled and renewable materials." Therefore, according to the respondents, contractors and consultants can resolve concerns about higher initial costs and help clients understand the long-term financial and environmental benefits of sustainability.

4.2.3 Integrating Waste Management Practices

R1 stated that "We set up designated areas for waste disposal to handle renovation waste appropriately in the simplest way; otherwise, the situation will get messy and difficult to maintain in case of lacking a suitable system." On the other hand, R2 suggested, "Using digital tools to track waste and doing regular waste audits helps us manage waste effectively. Once we have data, we can make better choices about minimising and reusing waste." Furthermore, R2 stated, "When we establish waste segregation protocols at the start of a project, recycling becomes significantly more effective." Similarly, R3 pointed out, "It's difficult to manage and quantify waste effectively, so digital tracking technologies actually help us make better decisions." Moreover, R3 highlighted that "Training workers to perform waste audits is a must to achieve our sustainability targets; without sufficient training, workers don't always know how to handle various kinds of waste products." R5 responded, "Before we destroy anything, we undertake waste audits to see what materials might be recovered and recycled. This way, we save resources and money at the same time." Additionally, R5 pointed out, "We aim to recycle as much as possible, especially wood, tiles, and metal, because it makes a major impact in reducing waste." However, R7 mentioned, "If we include structured waste segregation systems from the design process itself, it'll be much easier to manage waste efficiently."

4.2.4 Promoting Biophilic Design

R1 mentioned "We use green roofs and vertical gardens to improve air quality and greenery in our renovation projects." Furthermore, R3 stated, "Biophilic design makes interior environments healthier by including natural features like plants and high ventilation." In an instance, R3 pointed out, "We choose low-maintenance green features so that clients don't have to worry about constant upkeep, and if it's too complicated to maintain, people won't use it." Moreover, R3 stated that when we show clients the return on investment for biophilic design, they are willing to adopt it with its long-term benefits, and many clients have poor knowledge about how better air quality and natural lighting reduce energy costs. R4 mentioned that they include internal courtyards, roof terraces, and sunshades in their designs to improve sustainability, which makes a huge difference in long-term energy efficiency. Similarly, R8 underlined, "Bringing in natural elements like plants, lighting, and water features significantly improves indoor air quality and the overall impression of an environment, and people will feel more comfortable in environments that interact with nature."

4.2.5 Implementing Building Information Modelling (BIM)

R3 mentioned, "It is important to implement BIM step by step, starting with smaller projects because stakeholders can experience its benefits without feeling overloaded. If we push it too quickly, they disagree with the change." Similarly, R5 explained, "We must concern of keeping records for everything digitally so that future renovations have all the essential sustainability data for the implementation of BIM and also having accurate records makes decision-making easier." Furthermore, R5 noted that providing proper training for the contractors to work on BIM in a proper way is compulsory to get the maximum advantage in renovation projects. Likewise, R6 pointed out, "BIM plays an important role in maintaining the efficiency of the projects and sustainability and also it helps to plan material utilisation to reduces waste." Additionally, R11 said, "BIM is a game-changer for minimising expenses in the long term since it helps us optimise materials and reduce waste and if we use it appropriately, we may reduce many unnecessary costs."

4.2.6 Providing Training and Skill Development

R1 recommended, "Providing proper training of workers on sustainable construction methods is significant because, without proper knowledge, they might not follow the right practices." Similarly, R2 stated, "Focusing on hands-on training sessions helps workers to see how to implement sustainable practices in real scenarios." Moreover, R3 highlighted, "Training shouldn't be for one time. We should provide regular training to inform the workers on new sustainable processes and materials." Furthermore, R4 added, "Providing proper training to workers, site managers, and even clients help smoothen the transition to sustainable renovation." On the other hand, R5 pointed out, "Many workers are not familiar with sustainable building practices. Hence, promoting training programmes is a must to introduce those sustainable practices for renovations gradually." Likewise, R7 noticed, "Some clients also need training, specifically for handling sustainable materials and maintenance." Similarly, R9 remarked, "There should be more financial support for training programmes because many companies hesitate to invest in worker training."

4.2.7 Enhance Quality Control Systems

R4 stated "We used to apply wood preservatives to increase the lifespan of those reused materials and maintain their

quality." Similarly, R5 mentioned, "Proper quality inspections are necessary before reusing materials to confirm they meet the required standards." Moreover, R6 noticed, "We conduct regular inspections during the renovation process to help make sure all sustainable materials are performing as expected." Likewise, R7 added, "Checking the durability of reused materials before installation is a key part of our quality control process."

On the other hand, R8 pointed out, "Some contractors ignore quality control while using recycled materials, which can lead to problems in the structures." However, R9 responded, "If we set high standards for quality assurance, reused materials can be as effective as new ones." Furthermore, R10 stated that "Pre-ordering materials improves their availability of sustainable materials and allows us enough time to check their quality before starting the project."

4.2.8 Client Education

R3 indicated, "We always make an effort to explain to clients that sustainable materials may have a higher upfront cost, but they save money in the long run through lower maintenance and energy efficiency." Similarly, R5 mentioned "Many clients refuse to use reused materials, so we take the time to show them the benefits and real examples of successful projects." Moreover, R7 noted, "Clients need to understand the long-term cost advantages of sustainability, so we always provide simple cost comparisons to help them make informed decisions about the sustainability." Likewise, R8 stated "We make sure to advise stakeholders about both the financial and environmental benefits of adopting sustainable renovation practices."

On the other hand, R9 pointed out, "Most of the clients only consider the initial costs and never consider the long-term savings, so we have to carefully present the complete perspective." However, R10 stated, "If we show them clear case studies and financial benefits, they usually become more open to sustainable solutions." Furthermore, R11 mentioned "We conduct awareness sessions and provide easy-to-understand guides so that clients can actively participate in making sustainable choices for their renovation projects." In addition, R12 pointed out, "We also highlight alternative ventilation strategies and other energy-saving techniques to help clients reduce operational costs after the renovation."

4.3. BEST PRACTICES FOR EFFECTIVE COLLABORATION IN INTEGRATING SUSTAINABLE PRACTICES IN RENOVATION PROJECTS

Renovation projects provide a unique opportunity for integrating sustainability into already-existing structures as the construction industry moves towards a sustainable and more environmentally conscious future. However, effective integration of sustainable practices in such projects mainly depends on the collaboration of key stakeholders, especially consultants and contractors. Based on the data received from the interviews, few practical guidelines were suggested below for the purpose of improving successful collaboration for meeting sustainability goals in renovation projects. Based on the data received from the interviews, several practical guidelines were suggested for improving collaboration in achieving sustainability goals in renovation projects.

4.3.1 Better Communication from the Initial Phase

The early involvement of stakeholders is important for the success of sustainable renovation projects. R4 stated, "Early discussions help align client goals with sustainability targets." Similarly, R7 mentioned, "When we are involved early, we can plan material reuse and waste reduction more effectively." The research indicates that when sustainability-related discussions begin during the conceptual and design phases, consultants are better positioned to recommend energy-efficient designs and materials. Similarly, contractors can prepare for on-site implementation strategies that support these early decisions.

4.3.2 Clearly Define Responsibilities

The analysis highlights the roles that are overlap with the stakeholders and work uncertainty as important difficulties to the successful integration of sustainability. R3 noted, "When responsibilities are clearly defined, duplication and delays can be avoided." R6 added, "Proper task allocation ensures smooth coordination during renovation." For example, consultants should focus on lifecycle cost of the project and selecting sustainable materials and contractors should focus on sustainable construction methods and on-site waste management. Well-structured project guidelines that explain major responsibilities of stakeholders can effectively minimise the delays and increase accountability. This systematic method is important for managing the complexities of renovation projects, as adapting existing structures requires specific coordination.

4.3.3 Educate the Clients

Client awareness was accepted in the study as an important success part for sustainable renovation. R5 mentioned, "Explaining the long-term cost benefits helps clients accept sustainable materials." R11 highlighted, "When we show real project examples, clients become more confident about sustainable design decisions." Consultants and contractors can take significant roles in providing data-backed ideas and case studies to clients, showing how sustainability relates with their economic and environmental goals. It additionally develops trust and helps smoother decision-making processes.

4.3.4 Integrate Sustainability into Contracts

Contracts of the projects which includes sustainability provisions gives formal commitment from all stakeholders. R5 noted, "Embedding sustainability KPIs in contracts ensures ongoing monitoring and compliance." According to the research, one of the most successful strategies for achieving acceptance of sustainable practices is to implement them within the contract terms. It could

contain important criteria on material procurement, energy performance targets, waste management strategies, and post-construction sustainability assessments. Contracts that involve these features improve willingness and determined responsibility.

4.3.5 Conduct Training and Knowledge Sharing Programs

A lack of knowledge about sustainable renovation techniques is highlighted from the data analysis as an ongoing challenge while integrating the sustainability in renovation projects. R6 emphasized, "Regular workshops help stakeholders adopt innovative methods and sustainable materials." Knowledge-sharing workshops can also help in fill the gaps between theory and practice, supporting the adoption of locally sourced sustainable materials and innovative technology. When consultants and contractors share their skills, it provides a collaborative learning environment that supports greater sustainability goals.

4.3.6 Advocate for Policy and Incentives

Adaptation of sustainable renovation techniques has been limited by financial and legal constraints, according to consultants and contractor's responses. R7 stated, "Government subsidies and incentives motivate clients to adopt sustainable solutions." When contractors and consultants all together support and advocate for sustainable laws and incentive programmes, the construction industry benefits from a more supportive infrastructure that promotes innovation and long-term investment in sustainable practices.

4.3.7 Implement Monitoring and Evaluation

Ongoing monitoring and evaluation methods plays a significant role in the evaluating process in the success of sustainable strategies throughout the project. R8 mentioned, "post-implementation reviews allow stakeholders to identify improvements and replicate successful practices." These assessments should not only cover environmental indicators but also include social and economic factors. Consultants can develop monitoring frameworks, while contractors gather on-site performance data. Regular review provides ongoing progress, modification, and transparency in delivering on sustainability goals.

5. Conclusions and way forward

This study examines the strategies and best practices for improving effective collaboration while integrating sustainable practices into renovation projects in Sri Lanka. The findings show that while sustainability is becoming a common thing in the construction industry, its application in renovation projects is still insufficient. The study identified several strategies for effective integration of sustainable practices in renovation projects, including prioritising the use of sustainable materials, adopting biophilic design, implementing digital technologies for better coordination, and managing waste in an organised manner. Moreover, the study also highlighted the significance of training, client education, and quality control as supporting aspects for collaboration effectiveness. These findings revealed an increasing awareness about the sustainable renovation projects, which need not just technical solutions but also strong stakeholder collaboration for effective integration. Sustainable renovation is becoming increasingly popular, but implementation remains restricted by challenges including a limited budget, lack of materials, and regulatory gaps. Furthermore, the research findings offer best practices for consultants, contractors, and policymakers to enhance the implementation of sustainable renovation projects. Future research could explore the long-term impact of policy changes and the use of new technology to improve sustainable renovation.

6. References

- Akande, O. K., Odeleye, D., Coday, A., & JimenezBescos, C. (2016). Performance evaluation of operational energy use in refurbishment, reuse, and conservation of heritage buildings for optimum sustainability. *Frontiers of Architectural Research*, 5(3), 371–382. <https://doi.org/10.1016/j.foar.2016.06.002>
- Ali, K. A., Ahmad, M. I., & Yusup, Y. (2020). Issues, impacts, and mitigations of carbon dioxide emissions in the building sector. *Sustainability (Switzerland)*, 12(18). <https://doi.org/10.3390/SU12187427>
- Almeida, M., Mateus, R., Ferreira, M., & Rodrigues, A. (2016). Life-cycle costs and impacts on energy-related building renovation assessments. *International Journal of Sustainable Building Technology and Urban Development*, 7(3–4), 206–213. <https://doi.org/10.1080/2093761X.2017.1302837>
- Antoniou, F., Demertzidou, F., Mentzelou, P., & Konstantinidis, D. (2022). Energy upgrading of buildings in Greece with eco-materials: An investigation of public awareness. *IOP Conference Series: Earth and Environmental Science*, 1123(1). <https://doi.org/10.1088/1755-1315/1123/1/012033>
- Ardiana, N., Suryawan, I. W. K., Ridhosari, B., & Mutiara Sari, M. (2022). Hazardous waste generation and composition from electric train activities. *IJCA (Indonesian Journal of Chemical Analysis)*, 5(1), 62–67. <https://doi.org/10.20885/ijca.vol5.iss1.art7>
- Cacique, M., & Ou, S. J. (2022). Biophilic design as a strategy for accomplishing the idea of healthy, sustainable, and resilient environments. *Sustainability (Switzerland)*, 14(9). <https://doi.org/10.3390/su14095605>
- Doddy, P., Ardana, H., Arini, R. E., & Priyana, Y. (2024). Analysis of the effect of the use of environmentally friendly building materials on the stability of tall building structures in Jakarta. In *West Science Interdisciplinary Studies* (Vol. 02, Issue 04).
- Ekanayake, B. J., Sandanayake, Y., & Ramachandra, T. (2018). *Application of value management to refurbishment projects: A Sri Lankan case study*.
- Ekanayake, B., Sandanayake, Y. G., & Ramachandra, T. (2018). Application of value management to refurbishment Projects: A Sri Lankan case study. In C. Gorse & C. J. Neilson (Eds.), *Proceeding of the 34th Annual ARCOM Conference* (pp. 607–616). Association of Researchers in Construction Management. Retrieved from <https://www.researchgate.net/publication/327751577>
- Elkington, J. (2018). *25 years ago I coined the phrase "triple bottom line." here's why it's time to rethink It*. <https://jeremy.earth/wp-content/uploads/2020/01/csr-elkington-25-years-ago-i-coined-the-phrase-e2809ctriple-bottom-line.e2809d-hereu2019s-why-itu2019s-time-to-rethink-it.pdf>

- Emas, R. (2015). *The concept of sustainable development: Definition and defining principles*. <https://doi.org/https://doi.org/10.13140/RG.2.2.34980.22404>
- Georgiadou, M. C. (2014). Future-proofed energy design approaches for achieving low-energy homes: Enhancing the code for sustainable homes. *Buildings*, 4(3), 488–519. <https://doi.org/10.3390/buildings4030488>
- Hammond, R., Nawari, N. O., Walters, B., Hammond, R. S., Nawari, N. O., & Asce, M. (2014). *BIM in sustainable design: Strategies for retrofitting/renovation*. <https://doi.org/https://doi.org/10.1061/9780784413616.244>
- Isa, N. M., Kamaruzzaman, S. N., & Mohamed, O. (2019). A preliminary survey on facilities management functions in value management process in the construction stage. In *Journal of Design and Built Environment* (Vol. 19, Issue 2). <https://doi.org/https://ejournal.um.edu.my/index.php/jdbe/article/view/19645>
- Jensen, P. A., Thuvander, L., Femenias, P., & Visscher, H. (2022). Sustainable building renovation—strategies and processes. In *Construction Management and Economics* (Vol. 40, Issue 3, pp. 157–160). Routledge. <https://doi.org/10.1080/01446193.2022.2045717>
- Jowkar, M., Temeljotov-Salaj, A., Lindkvist, C. M., & Støre-Valen, M. (2022). Sustainable building renovation in residential buildings: Barriers and potential motivations in Norwegian culture. *Construction Management and Economics*, 40(3), 161–172. <https://doi.org/10.1080/01446193.2022.2027485>
- Kamari, A., Jensen, S. R., Corrao, R., & Kirkegaard, P. H. (2019). A holistic multi-methodology for sustainable renovation. *International Journal of Strategic Property Management*, 23(1), 50–64. <https://doi.org/10.3846/ijspm.2019.6375>
- Lemańska, J. J., & Sagan, J. (2019). Non-destructive testing methods as a main tool supporting effective waste management in construction processes. *Archives of Civil Engineering*, 65(4).
- Liu, H., Guo, R., Tian, J., Sun, H., Wang, Y., Li, H., & Yao, L. (2022). Quantifying the carbon reduction potential of recycling construction waste based on life cycle assessment: A case of Jiangsu province. *International Journal of Environmental Research and Public Health*, 19(19). <https://doi.org/10.3390/ijerph191912628>
- Liu, J., Bengtsson, B., Bohman, H., & Pauli, K. S. (2020). A system model and an innovation approach toward sustainable housing renovation. *Sustainability (Switzerland)*, 12(3), 1–16. <https://doi.org/10.3390/su12031130>
- Lopes, L., Penazzato, L., Reis, D. C., Almeida, M., Oliveira, D. V., & Lourenço, P. B. (2024). A holistic modular solution for energy and seismic renovation of buildings based on 3D-printed thermoplastic materials. *Sustainability (Switzerland)*, 16(5). <https://doi.org/10.3390/su16052166>
- Lu, Y., Wu, Z., Chang, R., & Li, Y. (2017). Building Information Modeling (BIM) for green buildings: A critical review and future directions. *Automation in Construction*, 83, 134–148. <https://doi.org/10.1016/j.autcon.2017.08.024>
- Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. In *Energy and Buildings* (Vol. 55, pp. 889–902). <https://doi.org/10.1016/j.enbuild.2012.08.018>
- Mihai, F. C. (2019). Construction and demolition waste in romania: The route from illegal dumping to building materials. *Sustainability (Switzerland)*, 11(11). <https://doi.org/10.3390/su11113179>
- Nielsen, A. N., Jensen, R. L., Larsen, T. S., & Nissen, S. B. (2016). Early stage decision support for sustainable building renovation - A review. In *Building and Environment* (Vol. 103, pp. 165–181). Elsevier Ltd. <https://doi.org/10.1016/j.buildenv.2016.04.009>
- Nitu, M. A., Gocer, O., Wijesooriya, N., Vijapur, D., & Candido, C. (2022). A biophilic design approach for improved energy performance in retrofitting residential projects. *Sustainability (Switzerland)*, 14(7). <https://doi.org/10.3390/su14073776>
- Nussholz, J. L. K., Rasmussen, F. N., Whalen, K., & Plepys, A. (2020). Material reuse in buildings: Implications of a circular business model for sustainable value creation. *Journal of Cleaner Production*, 245. <https://doi.org/10.1016/j.jclepro.2019.118546>
- Ogunmakinde, O. E., Egbelakin, T., & Sher, W. (2022). Contributions of the circular economy to the UN sustainable development goals through sustainable construction. *Resources, Conservation and Recycling*, 178. <https://doi.org/10.1016/j.resconrec.2021.106023>
- Ozili, P. K. (2022). Sustainability and sustainable development research around the world. *Managing Global Transitions*, 20(3). <https://doi.org/10.26493/1854-6935.20.259-293>
- Passoni, C., Marini, A., Belleri, A., & Menna, C. (2021). Redefining the concept of sustainable renovation of buildings: State of the art and an LCT-based design framework. *Sustainable Cities and Society*, 64. <https://doi.org/10.1016/j.scs.2020.102519>
- Patil, Y. D. (2012). *Sustainable development and construction Industry*. <http://ssrn.com/abstract=2004957>
- Pombo, O., Rivela, B., & Neila, J. (2016). The challenge of sustainable building renovation: Assessment of current criteria and future outlook. In *Journal of Cleaner Production* (Vol. 123, pp. 88–100). Elsevier Ltd. <https://doi.org/10.1016/j.jclepro.2015.06.137>
- Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: in search of conceptual origins. *Sustainability Science*, 14, 681–695. <https://doi.org/10.1017/S0376892900011449>
- Qu, P., Zhao, D., Yan, M., Liu, D., Zhang, R., Li, S., Pei, L., Yan, H., Zeng, L., & Dang, S. (2023). Maternal exposure to housing renovation during the periconceptional period and the risk of offspring with isolated congenital heart disease: a case-control study. *Environmental Health: A Global Access Science Source*, 22(1). <https://doi.org/10.1186/s12940-023-00990-z>
- Redclift, M. (2005). Sustainable development (1987-2005): An oxymoron comes of age. *Sustainable Development*, 13(4), 212–227. <https://doi.org/10.1002/sd.281>
- Report of the World Commission on Environment and Development*. (1987).
- Röck, M., Saade, M. R. M., Balouktsi, M., Rasmussen, F. N., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., & Passer, A. (2020). Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. *Applied Energy*, 258. <https://doi.org/10.1016/j.apenergy.2019.114107>
- Sabet, M., & Easterbrook, S. (2016). *Homeowners as engaged participants: Determining information needs to maximize the environmental benefit of green renovations*.
- Santamouris, M., & Vasilakopoulou, K. (2021). Present and future energy consumption of buildings: Challenges and opportunities towards decarbonisation. In *e-Prime - Advances in Electrical Engineering, Electronics and Energy* (Vol. 1). Elsevier Ltd. <https://doi.org/10.1016/j.prime.2021.100002>
- Sharifi, M., & Sabernejad, J. (2016). Investigation of biophilic architecture patterns and prioritizing them in design performance in order to realize sustainable development goals. *European Online Journal of Natural and Social Sciences*, 5(3), 325–337. Retrieved from www.european-science.com <http://www.european-science.com>
- Shi, L., Han, L., Yang, F., & Gao, L. (2019). The evolution of sustainable development theory: Types, goals, and research prospects. *Sustainability (Switzerland)*, 11(24). <https://doi.org/10.3390/su11247158>

- Spišáková, M., Mésároš, P., & Mandičák, T. (2021). Construction waste audit in the framework of sustainable waste management in construction projects: case study. *Buildings*, 11(2), 1–16. <https://doi.org/10.3390/buildings11020061>
- Stock, T., & Seliger, G. (2016). Opportunities of sustainable manufacturing in industry 4.0s. *Procedia CIRP*, 40, 536–541. <https://doi.org/10.1016/j.procir.2016.01.129>
- Vilches, A., Garcia-Martinez, A., & Sanchez-Montañes, B. (2017). Life cycle assessment (LCA) of building refurbishment: A literature review. *Energy and Buildings*, 135, 286–301. <https://doi.org/10.1016/j.enbuild.2016.11.042>
- Wu, P. Y., Mjörnell, K., Mangold, M., Sandels, C., & Johansson, T. (2021). A data-driven approach to assess the risk of encountering hazardous materials in the building stock based on environmental inventories. *Sustainability (Switzerland)*, 13(14). <https://doi.org/10.3390/su13147836>
- Yang, J., & Zeng, Y. (2020). Sustainability: Design, making, and technologies. *Journal of Integrated Design and Process Science*, 24(2), 1–3. <https://doi.org/10.3233/JID200021>
- Yu, A. T. W., Wong, I., & Mok, K. S. H. (2021). Effectiveness and barriers of Pre-refurbishment Auditing for refurbishment and renovation waste management. *Environmental Challenges*, 5. <https://doi.org/10.1016/j.envc.2021.100231>
- Zimmermann, R. K., Barjot, Z., Rasmussen, F. N., Malmqvist, T., Kuittinen, M., & Birgisdottir, H. (2023). GHG emissions from building renovation versus new-build: Incentives from assessment methods. *Buildings and Cities*, 4(1), 274–291. <https://doi.org/10.5334/bc.325>