AN APPRAISAL OF CO-BENEFITS OF GREEN BUILDING; CHALLENGES IN CREATING CRISIS-ADAPTIVE BUILT ENVIRONMENT

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Abstract

As the world moves achieving sustainable built environment, the concept of green building has emerged as one of the most important trends in the construction sector around the world. Buildings that are sustainable, use less energy and less water, save money while preserving natural resources. As a result of growing interest in the topic on a global scale, the development of sustainable buildings has recently appeared as an emerging trend in Sri Lanka. According to the findings of several studies, the initial expenditure required for the construction of sustainable buildings is considerably more than that of conventional buildings. Adopting a green concept for the construction of buildings, in a state of crisis like Sri Lanka needs to understand the advantages and difficulties that may arise in the process. In the face of the current crisis in Sri Lanka.
This study is conducted to examine the co-benefits that can be obtained from the concept of green buildings and the methods used in creating such buildings that are adaptive to prevailing crisis. A questionnaire survey is deployed to accumulate primary data, and the statistical approach of the relative importance index was utilized in the analysis of data. According to the findings, green buildings offer numerous environmental co-benefits, economic co-benefits, and social co-benefits, creating energy efficient, and crisis-adaptive built environment. Further the study reveals the relative significance level of each building element within the context of sustainable built- environment, and barriers in the construction industry in its achievement.

Keywords: Co-Benefits; Construction industry; crisis- adaptive built environment; Sustainability

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Introduction

The concept of Green Building, an insufficient rate of long-term feasibility takes arisen from a lack of knowledge and accurate interpretations of numerous sectors and elements. Green building is still a large and vital necessity in infrastructure development. Hence, only a modest proportion of the country's buildings has gone with the concept of green building. One of the fundamental causes is a lack of awareness and sufficient abilities concerning green building concepts among industrial and economic specialists. On the other hand, many individuals are cautious to put the green thought into reality since the investment would not pay off.

As a significant exporter, Sri Lanka has various sectors dedicated to this goal. However, given Sri Lanka's current crisis situation, energy-related issues have had a substantial impact on the economy. Due to the energy crisis, Sri Lanka's economy has come to a halt, as there is inadequate electricity to run these businesses properly. As a result, despite the crisis, the industries created under the green concept in Sri Lanka continue to operate. This case study shows how the green-minded industries benefited from the crisis. Factory workers were chosen for this study because they consume a lot of energy and employ a large number of people. The co-benefits of the green concept in tackling the country's energy issues, as well as its contribution to Sri Lanka's growth, will be investigated. It is less likely that the Green Building concept was widely accepted. It expects to make the public aware of the socio-economic co-benefits of the concept linked to the incurred expenses of the concept. Applying the green concept to a developing country like Sri Lanka will result in minimal co-benefits for the people of the country. Thus, the significance of this research is in "how the concept of green building effects co-benefits of embracing a green building construction notion in crisis" and in providing solutions to the above-mentioned difficulties in the national framework.

Therefore, the preliminary objective of this study was to investigate the co-benefits of adopting a green concept in Sri Lanka in terms of economic, social, and environmental factors in developing a crisis-adaptive built environment. The study's objectives were formed to identify the concept of green buildings and the costs and co-benefits associated with green construction, to identify the green building approaches in the Sri Lankan construction industry, and to discover the most co-beneficial components in terms of economical, environmental, and social aspects, as well as the time required to achieve each co-benefit while constructing green buildings. Understanding the barriers to green building development, as described in the study following, will make it simpler to find solutions to encourage the green building industry. 1st step: Determine the predominance of Green Buildings. 2nd step: Determine the challenges and co-benefits of Green Building development. 3rd step: Analyze the difficulties and co-benefits. 4th step: Introduce a structure to decrease difficulties and raise co-benefits. Based on the information presented above, a study will be done to discover the co-benefits of the green concept.

Theoretical Basis

The concept of green building

Concerns have been raised regarding how to enhance construction techniques in order to lessen their negative environmental implications (Cole, 2000; Pahwa). According to Chan et al. (2009), when comparing Asian nations, buildings in Hong Kong use nearly 89% of the nation's electricity and approximately half of all energy. The term "responsibility" refers to the act of determining whether or not a person is responsible for his or her own actions (Chan, 2009). Green building, sometimes known as "sustainable construction," is gaining popularity as the environmental benefits of construction become more apparent (Kibert, 2007). Green buildings are described as "Healthy facilities developed and erected in a source of energy manner, embracing new environmental principles" (Kibert, 2007).

Accepting long-term economic, environmental, and social responsibility has become a symbol of long-term economic, environmental, and social well-being in the twenty-first century (Nsairat, 2009). Green construction, according to Cole (2000), aims to reduce resource use and environmental effect far beyond conventional practice while ensuring appropriate interior environmental quality (Cole, 2000). The premise is that by continuously improving the environmental implementation of individual structures, the building industry may attain environmental sustainability by lowering resource consumption and environmental loadings (Cole, 2005).

Costs and benefits of green buildings

Sustainable building construction is gaining popularity owing to its ability to lessen building environmental effect. While the environment is frequently the major focus of sustainable building design, there are various co-benefits that can improve the quality of life for building occupants and communities. The studies on the co-benefits of sustainable building construction, with an emphasis on energy, water, waste reduction, health, and economic benefits.

Energy Benefits: Building energy use accounts for a significant portion of global greenhouse gas emissions. By the use of energy-efficient technology, passive solar architecture, and renewable energy sources, sustainable building construction may significantly reduce energy usage. According to Azar and green (2016), energy-efficient buildings may reduce electricity use by up to 90%. Lower energy costs arise from energy savings, which may be major cost reductions for building owners and tenants.

Water Benefits: Water scarcity is an increasing issue all over the globe, and sustainable building construction may help to reduce water usage significantly. Water-saving fixtures, rainwater harvesting, and graywater systems can all assist in reducing building water utilization. Green roofs and rainwater collecting systems, according to Kleerekoper et al. (2015), can minimize stormwater runoff and enhance water quality in metropolitan settings. Water conservation methods can also assist in establishing owners and tenants preserve money on their water costs.

Waste Reduction: Waste reduction is prioritized in sustainable building construction through the use of recycled or reused resources and the optimization of building material utilization. Colantonio et al. (2017) discovered that sustainable building construction may minimize waste creation by up to 80%, saving building owners and contractor’s cost. Trash reduction also contributes to preserve the environment by reducing the quantity of waste delivered to landfills.

Health Benefits: There are various health advantages to sustainable building construction for building occupants, including enhanced indoor air quality, access to natural light, and green spaces. According to Shove et al. (2015), sustainable building design can enhance tenants' mental and physical health. Access to green areas and natural light has been demonstrated in other research to reduce stress, improve cognitive function, and boost productivity.

Economic Benefits: Building owners and occupants can profit financially from sustainable building construction. Saving energy and water can result in reduced utility costs, while reducing trash creation can result in lower waste disposal costs. According to Kibert (2016), because of the rising demand for sustainable buildings, sustainable building development can result in long-term cost savings as well as higher property value.

Sustainable building construction provides a variety of co-benefits in addition to environmental sustainability. Energy, water, and waste reduction, as well as health and economic advantages, are among the co-benefits. The material examined in this study shows that sustainable building design may significantly improve building occupants' quality of life while encouraging long-term economic advantages. As a result, as a vital approach for attaining a sustainable built environment, sustainable building construction should be addressed.

Green building approaches in Sri Lanka

In today's Sri Lanka, the concept of green construction is somewhat worrying. People desire to employ more energy-efficient structures. As a result, the industry is quickly expanding (Lanka, 2010). Sri Lanka has started to reform its construction industry by embracing green building principles. The Sri Lankan Green Building Council was founded in response to a developing tendency in the built environment to adopt greener construction approaches (Lanka, 2010). The Sri Lankan government announced the Haritha (Green) Lanka public initiative to promote sustainable development while taking current and upcoming concerns into account. The MAS holdings firm Pvt. Ltd. is one of the most imaginative and forward-thinking instances. In 2010, the Thurulie factory in Thulhiriya was awarded the Globe Medal for Sustainability Revolution (Construction, 2009).

Furthermore, the United States Green Building Council has awarded it LEED Platinum accreditation (Leadership in Energy and Environmental Design), making it the world's first LEED Platinum new construction factory (MAS Holdings Ltd, 2010). Aside from that, there are a few structures in Sri Lanka that have been designated as green buildings such as, the Institute of Technology University of Moratuwa, Aliya Resorts & Spa in Sigiriya, Brandix eco-center in Seeduwa, and MAS Thurulie plant in Thulhiriya. In 2010, the Green Building Council introduced a new construction grading system called GREENSL®, which is quite comparable to LEED, to give green certification (council, n.d.).

Impacts on Green Building construction & operation

The most frequently criticized aspect of the process is the cost of environmentally friendly building construction. A more considerable price tag is connected with photovoltaics, sophisticated appliances, and cutting-edge technology. Most green buildings save construction costs by 20% to 25% while generating ten times the revenue throughout the life of the building. Green buildings, according to research, cut a building's operating expenses by 30% to 40% when compared to conventional constructions (Construction, 2009). Buildings are made of cement, sand, steel, stones, bricks, and finishing materials. These account for around 20% of the greenhouse gases emitted by a structure over its lifetime. Wherever possible, green buildings employ non-toxic, reusable, and recyclable materials. Locally produced commodities are better since they reduce the amount of fuel used to transport materials. Additionally, preference should give to recyclable materials. Materials having a higher excellent reprocessed content should be utilized to limit the exemplified energy of structures, thereby lowering the environmental effect related with the origin and processing of energy-intensive materials. Green building materials include ecology blocks, recycled stone, recycled metal, recycled concrete, rubbish, wood, rice husk ash, compressed earth blocks, baked Earth, foundry sand, and waste disposal from construction projects.

Barriers to Sri Lankan green building construction

Numerous academics have identified various impediments to green building development and implementation challenges in a variety of countries (Arif M, 2009; Ashuri,2010). One of the key challenges related with green buildings, citing Geelani et al. (2012), is the larger initial cost. According to Jayalath (2010), the cost of green building construction has grown by 20 to 25% in Sri Lanka. According to the Holcim Foundation for Sustainable Construction, the initial construction cost of the Thurulie green factory building in Sri Lanka is 30% greater than the cost of a conventional factory building (Geelani, 2012; Jayalath, 2010). The fact that the bulk of the co-benefits of green buildings can be achieved over time with a short payback period removes this economic barrier to green buildings (Kats, n.d.).

Abidin et al. (2012), on the other hand, claimed that government measures and standards may result in the compression of construction projects aimed at improved environmental protection (Abidin, 2012). Though there are enough environmental regulations and policies in place, there is no specific guideline or policy in Sri Lanka that focuses on green building methods. Another impediment is the failure of the government to enforce current regulations and policies. Hewage (2011). There are prevalent misunderstandings among the public that green buildings are significantly more expensive than regular buildings and are quite difficult to get by middle or lower-class people (Azizi, 2015). Given the information mentioned above, the impediments to Sri Lankan green building construction can be divided into financial, regulatory, social, knowledge/skills, and industrial divisions.

Research Methodology

The study collected and analyzed data on the co-benefits of sustainable building development using a mixed-method methodology. To begin, a study of the literature on the co-benefits of sustainable building construction was done to identify and analyze existing studies. This analysis was used to discover a set of co-benefits as well as the normal timeframe for achieving each benefit. To collect information, a questionnaire survey was used. The results of the questionnaire retested experts' perceptions of the amount of co-benefit and the period of achievement of each co-benefit revealed through the literature study. In addition, interviews with experts in the field on the green concept and its associated benefits were conducted. The questionnaire findings were used to retest experts' perceptions of the rate of co-benefit and the time needed to achieve each co-benefit found in the literature review.

The case studies give information regarding the implementation of the Green Building Concept. The case studies aid in acquiring information like the technology they have used, green materials, and orientation methodologies on applying green concepts in the country.

The Relative Importance Index (*RII*) was used to analyze the level of co-benefit, and the method was used to analyze the period of achievement. The level of co-benefit was assessed using a five-point Likert scale ranging from "not at all" (1) to "very high" (5).

Table 1: Scale for a period of achievement

Level of achievement		
1-no idea	2- Short Term	3- long Term

No idea - The timeframe of accomplishment is unknown to the respondents.
Short Term – Period following the construction of less than two years
Long- Term - Time after construction of more than two years

A study is also carried out to establish how long it takes to obtain the co-benefits of green-concept buildings.

Research findings & Analysis

This section presents the research study's findings and an assessment and explanation of those findings. In addition to the data collection method, interviews were done with the following individuals: four architects, three engineers, and two quantity surveyors.110 people completed the questionnaire out of 120, which is 91.6 %. The number of projects completed by respondents was used to assess their knowledge and experience.

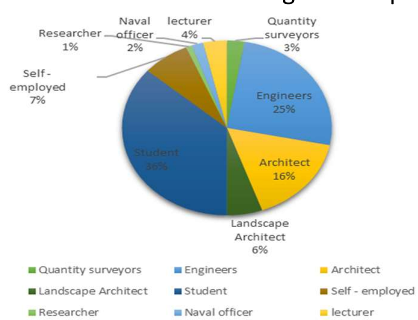

Figure 1: current occupation concept Source: author

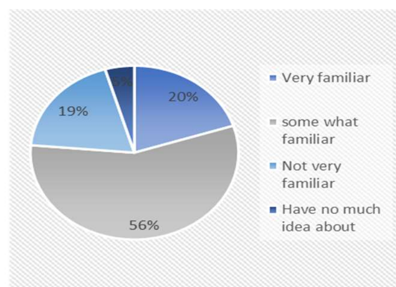

Figure 2: The comprehension of the green building Source: author

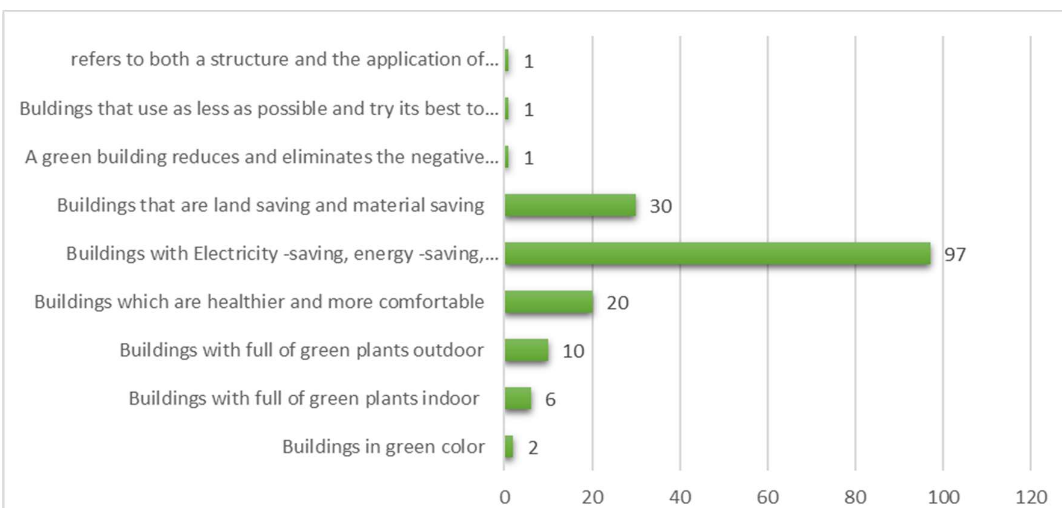

Figure 3: knowledge of the concept of becoming green
Source: author

In the new building and is better suited to Sri Lanka. As seen in the graph below, individuals in the building industry a have high awareness of the Green Building Concept. Many individuals in Sri Lanka have just a rudimentary understanding of the "green concept." It is possible to re-propagate the green concept in Sri Lanka if one has a thorough understanding of the fundamentals of the concept. Only a few individuals do not have a thorough comprehension of the green idea. With the help of this idea, it is feasible to discover a solution to Sri Lanka's energy dilemma and further popularize it in the nation by providing people with explicit knowledge of the outcomes of the experiment.

Constructed green buildings in Sri Lanka

I.A factory

They have been identified by calculating the annual data of the factory 2020 -2021,

- energy costs were reduced by 40%

It is possible to replace air conditioners with a low-energy "evaporative cooling" technology, which alone saves around 65 % of use. Light consumption is kept to a bare minimum by relying heavily on natural light to illuminate the workspace, and individual sewing machines are equipped with LED Task lighting. Solar panels provide ten percent of the plant's total electricity.

- 56 % reduction in water consumption

Drainage systems, such as rain collection tanks, collect water for non-drinking uses like flushing toilets and landscapes.

- 92% waste recycling

Everything that goes down the drain is processed on-site by an anaerobic digestion sewage treatment plant, and the biogas produced as a byproduct of this will utilize in the kitchen.

- Reduced absenteeism

Green roofs with high solar reflectance and vegetation-grown green roofs keep the inside of buildings more relaxed. Relaxation stations, picnic spots, and a holistic center are just some of the rewards available to staff.

II.B bank

They have been identified by calculating the annual data of the Bank Reduce energy costs by 30% and 56% reduction in potable water.

III.C factory

They have been identified by calculating the annual data of the factory,

- Energy cost reduction by 50%

A new screw-type chiller unit provides energy–efficient air conditioning for the entire factory. Square ducts were converted to round ducts to reduce distribution loss in air conditioning. Sophisticated new LED used as task lights provides light to the sewing machines.

- 60% reduction in water consumption

A series of measures exist to reduce water consumption through recycling. Direct rainwater is recycled for all uses except for drinking. A tertiary filtration system and a disinfection process allow the used water to be recycled again for toilet flushing and gardening.

- 95% waste recycling

The factory has a solid waste disposal system by recycling or reusing the solid waste it uses. Canteen waste is being composed and contributes to biogas generation. Reduced absenteeism with improvement health standard to 2% An advanced intelligent building management system controls relative humidity and carbon dioxide levels to improve comfort levels for workers. The green areas in the gardens have been increased.

Calculating the number of luminaries require for an area of a green building

By reorganizing and selecting luminaries for the region, a green building's energy consumption from luminaries is further lower. The Utilization Factor approach may compute the number of luminaires required for a particular area. First, the area's Room Index (K) must be determined.

$$K = \frac{L x W}{(L+W) x H_m} \qquad (1)$$

Where L= length of room
W= width of room
H_m = height of luminaries above working plane

$$N = \frac{(E x L x W)}{(NL x \Phi x MF x UF x LLD)} \qquad (2)$$

Where E= Required illuminance (Lux level)
N= Number of Luminaries
NL= Number of lamps in each luminaire
Φ= Lamp flux
MF= Maintenance Factor
UF= Utilization Factor
LLD= Lamp Lumen Deterioration Factor

Analysis of Economic Co-benefits

The RII computes the economic co-benefits, and the results are shown following table.

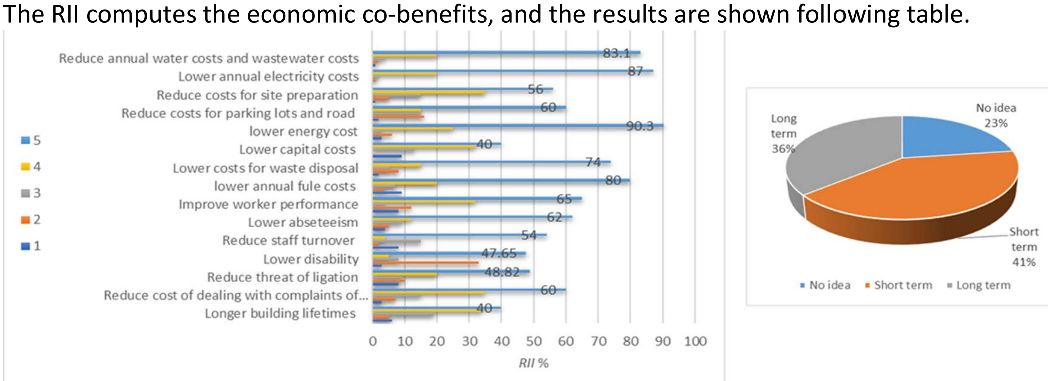

Figure4: level of economic co-benefits/ Period of achievement
Source: author

The *RII* is used to calculate the economic benefits, and the results are given in Figure 4. The most beneficial economic component of implementing a green concept for building development in Sri Lanka, according to the majority of respondents (RII-90.30 percent), is lower energy expenses. According to the respondents, lower annual electricity expenses, lower annual water, and wastewater costs, lower annual fuel prices, and lower annual waste disposal costs were the following top four economic benefits. The model calculated how long it would take to realize economic co-benefits. The conclusions of the expert's opinions on the time necessary to achieve economic co-benefits are revealed in Figure 4. Most of the financial co-benefits are long-term, with the majority being accessible two years after the building is built.

Analysis of social co-benefits

The degree of social benefits was calculated using RII and the findings show in Figure 5. The respondents highlighted 'Preservation of water resources for future generations (RII-86.47 %) as the most valuable societal component in implementing a green concept for building development in Sri Lanka. The top four social benefits aspects are expanding the market for ethically preferred goods, reducing adverse health consequences, improving occupant contentment and comfort, and increasing mobility alternatives for workers. wastewater treatment facilities had the most negligible societal co-benefit.

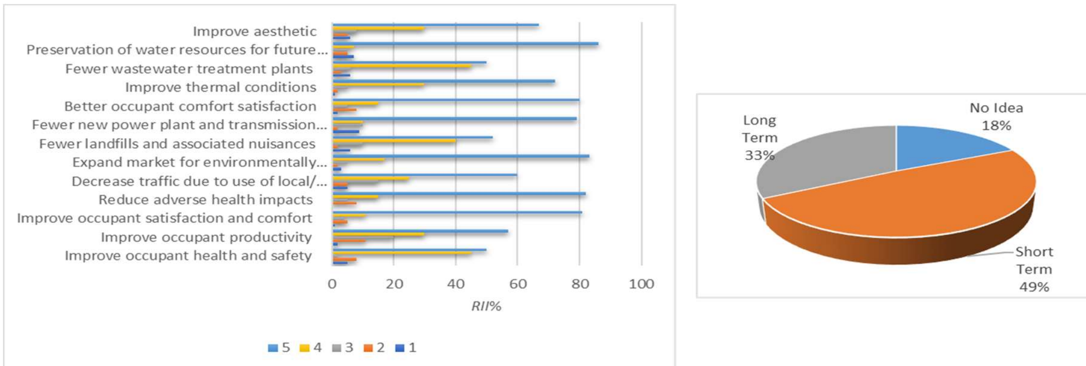

Figure 5: level of social co-benefits
Source: author

Figure 5 shows that many social benefits are short-term, accounting for 49% of total social benefits. In other words, this is equal to half of the social co-benefits, and respondents identified 33% of the benefits as long-term achievements.

Analysis of Environmental Co-benefit

RII was used to analyze the level of environmental co-benefits, and the findings are revealed in Figure 6. As per survey participants, reduced potable water consumption (RII-90.5%) is the most favorable environmental element in applying a green concept for building construction in Sri Lanka. Out of nineteen, the top four environmental attributes were: better air quality inside the factory, decreased energy usage, lower fossil fuel use, and natural resource conservation.

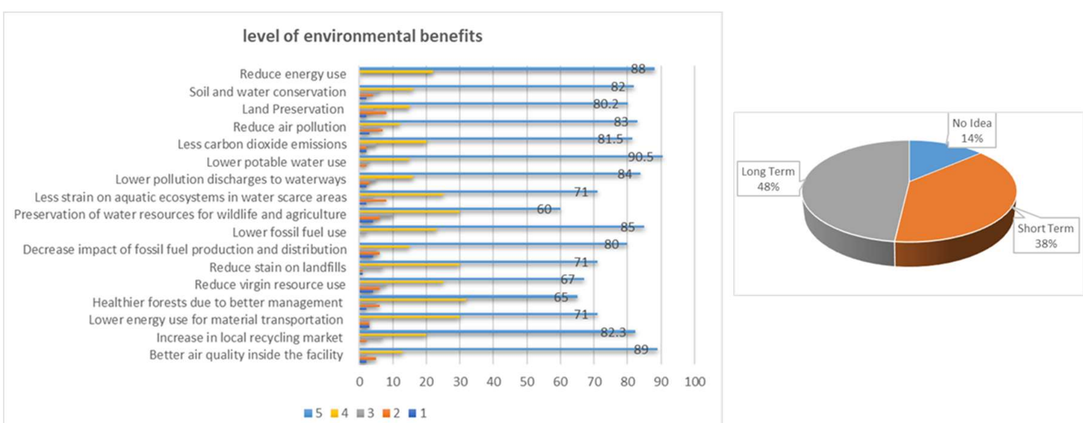

Figure 6: level of Environmental co-benefits
Source: author

According to Figure 6 long- term and short-term benefits account for 48% and 38% of total co-benefits, respectively. However, 14% of those interviewed had no idea how long it takes in Sri Lanka to achieve environmental co-benefits when developing green structures.

Sustainable co benefits of green building implementation

The dense population density and economic activity in urban areas have improved the relationship between cities and the environment. Cities have a crucial role in addressing environmental and health challenges, which are also important for future sustainable development. It has also been argued that with suitable rules and measures, urban development settings might yield enormous ecological profits. As a result, the environmental obstacles to green building merit consideration in several aspects of urban development settings. Natural ventilation and energy performance are two problems for green building design since they are significant components that represent the quality of the design. Natural ventilation is an important component that reflects the quality of the design, but it becomes an obstruction throughout the green building design process.

Table 02: Sustainable co benefits of green building implementation
source: Author

Sustainable Indicator	Key Findings/co Benefits Related to Green Buildings
Environmental co benefits	• High overall energy performance, water conservation and reduction of CO2 emissions. Sustainable green buildings can reduce energy consumption by up to 40% to reduce CO2 emissions. • The waste recycling rate in green buildings can reach more than 90%, which can significantly reduce environmental pollution. • Use of low-carbon materials (such as timber) has been shown to minimize life cycle carbon emissions. • Contribute to urban biodiversity enhancement and ecosystem conservation through optimal land use strategies in sustainable development.
Economic co benefits	• Significant economic savings can be achieved through improved life cycle cost (LCC) methods • Investments on green buildings can be effective through long-term electricity cost savings
Social benefits	• Construction companies can enhance corporate reputation and attract potential investors easily • Improved asset value due to perceived high user satisfaction and social performance benefits
Health and safety co benefits	• Achieve higher levels of indoor environmental quality (IEQ), improve health of residents and increase user satisfaction • Residents are more emotionally stable than those who live in traditional buildings. • Residents have 6% higher sleep quality than those in non-certified buildings. • Green building applications can control indoor air pollutants during the COVID-19 pandemic, inhibit the growth of pathogenic bacteria and ensure water safety to avoid cross-contamination

Some green building projects are designed in accordance with standard regulations but are unreasonable design, which might result in higher energy consumption than non-LEED buildings.

Green building practice in Sri Lanka: positive and negative aspects

The majority of respondents stated that green buildings give several co-benefits to the organization, its employees, and the entire society that outweigh the initial cost and help the organization achieve its goals. Financial co-benefits include low operational costs, low energy bills, profit maximization, low staff incentive costs, low compensation for employee health issues, and inexpensive advertising costs. Human resource benefits such as effective employee health, safety, and satisfaction, self-motivated employees, and attracting, encouraging, and retaining the best employees were also highlighted. These, on the other hand, increase employee productivity and product quality. Furthermore, the findings indicate that the notion of the green building adds value to the structure and its product. Other than it though, acquire a competitive advantage in the market and improve the market worth of the organization and the product. Finally, this helps to boost customer happiness, goodwill, and the organization's image, which opens the door to new market prospects. From the perspective of the employees, it offers a comfortable environment within the workstations and protects the employees' health and safety.

Sri Lanka is a third-world country with a difficult economic state, and the majority of construction projects within the country rely on foreign funds provided by funding organizations or other countries. According to the empirical information acquired from interviews, even though numerous co-benefits outweigh the initial cost, many enterprises, particularly in the private sector, are short of resources and are reluctant to accept the risk of investment in green initiatives. Furthermore, several respondents emphasized that the green building council in Sri Lanka plays an important role in assisting organizations to ensure sustainable growth for future generations in order to overcome some of the difficulties mentioned.

Table 03: Co-Benefits in which the RII is higher than 80% with their period of achievement
source: Author

Area	Co-Benefits	*RII* (%)	Rank	Period of achievement
Economical	Lower energy costs	90.3	2	Short term
	Lower annual electricity costs	87	5	Long term
	Reduce annual water costs and wastewater costs	83.1	10	Long term
	Lower annual fuel costs	80		Long term
Social	Preservation of water resources for future generations	86	6	Long term
	Expand the market for environmentally preferable products	83.2	9	Long term
	Reduce adverse health impacts	82.1	13	Long term
	Improve occupant satisfaction and comfort	81	16	Short term
	Better occupant comfort satisfaction	80	19	Short term
Environmental	Lower potable water use	90.5	1	Long term
	Better air quality inside the facility	89	3	Short term
	Reduce energy use	88	4	Long term
	Lower fossil fuel use	85	7	Long term
	Lower pollution discharges to waterways	84	8	Long term
	Reduce air pollution	83	11	Short term
	Soil and water conservation	82	14	No idea
	Less carbon dioxide emissions	81.5	15	Short term
	Increase in the local recycling market	82.3	12	Long term
	Land preservation	80.2	17	No idea
	Decrease the impact of fossil fuel production and distribution	80.1	18	Long term

Table 1 summarizes all the benefits for which the RII value is greater than 80% and indicated the period of achievement of each benefit whether long-term, short-term or no- idea. When considering the total number of environmental benefits, 63% of the benefits have exceeded the margin of 80% of the RII value in the level of benefit. In social benefits, 43% of benefits have exceeded 80% RII value in the level of benefit. Even though, there are nineteen economic benefits identified, only four benefits among them were ranked more than 80% RII value which was almost equal to 21% of the total.

Table 04: Challenges of green building implementation.
source: Author

Challenges of green building implementation.	
Aspects	**Key Findings**
Environmental challenges	Air temperature, relative humidity, air velocity and average radiation temperature are difficult to control in green building design. Green buildings designed according to the standard provisions with poor design issues may lead to higher overall energy consumption than non-LEED buildings.
Economic challenges	Higher initial costs are as a barrier to the widespread adaptation of green buildings in the construction industry. The construction costs of green buildings with different LEED certification levels, such as silver, gold, and platinum, are 0.23%, 1.21%, and 6.62% higher than those of conventional buildings.Additional costs of sustainable green buildings, such as LEED certification and design costs contributing to low construction profitability
Social-cultural challenges	Lack of awareness and overall sustainability knowledge and minimum understanding of long-term benefits among contractors and owners. Collaboration among all participants and stakeholders in the green building scale-up process is ineffective and lacks public participation.
Technological challenges	The integration of new tools such as Building Information Modeling (BIM) technology in green building projects is not widespread. Application of different software by different companies can result in deviations in information transmission, resulting in communication problems between different design departments. Lack of key technologies, such as energy efficiency research in green buildings.

Table 05: Checklist for implementing the green building concept in new construction in Sri Lanka
source: Author

Green Building Guide Checklist				
Reference	Standard Construction	Light Green Construction (25%)	Medium Green Construction (50%)	Dark Green Construction (90%)
1. DEVELOPING YOUR GREEN TEAM				
An Assembling the team	No green team assembled	In-Designer green team assembled	designer professional, engineer, contractor/supplier team assembled	design professional, engineer, contractor/supplier team, stakeholders assembled, plus the design process is integrated
Using Green Building Checklists	No checklist is used	Checklist used as a general guide	A Checklist is used in conjunction with a certified green building program	Higher points/rating is sought for the project through a certified green building program
2. SITE SELECTION CRITERIA				
Location	Very little consideration for proximity to community services	Close to community services	Infill site, close to community services, close to alternative transportation	Infill/reclaimed/Brownfield site, close to community services, close to alternative transportation, bicycle and pedestrian linkages
Solar Access	No consideration	Some solar access	Good solar access	Excellent solar access
Infrastructure	Cost consideration only	Cost and resources considered	Cost, resources and infill opportunities considered	Cost, resource, infill, and density is considered
3. SITE DESIGN AND LANDSCAPING				
Site Protection	No site protection	Protect natural areas of the site	Protect natural areas of the site, save and reuse all topsoil from site	Protect natural areas of the site, save and re-use all topsoil from the site, and develop landscape and site preservation plans to address the above items.
Water Efficient Landscaping	Default landscape planning using non-native plants	Intentional landscape plan using climate-appropriate plants	Intentional landscape plan using climate appropriate plants and low-water use irrigation practices	Intentional landscape plan using xeric native plants, low water use irrigation practices, soil amendments and bedding mulch, and turf alternatives
4. MATERIAL RESOURCE EFFICIENCY: BUILDING ENVELOPE DESIGN				

Orientation	No solar orientation	Solar orientation within 45 degrees of due south	Solar orientation within 30 degrees of due south	Solar orientation within 20 degrees of due south
Passive Solar Heating	No consideration for passive solar or window placement	Proper window placement, sizing, and shading	Proper window placement, sizing and shading, introduction of low cost mass	Proper window placement, sizing and shading, introduction of higher cost mass, and increased solar glazing area
Passive Solar Cooling	No consideration for passive cooling	Strategic placement of vented windows, use of overhangs to reduce unwanted heat gain	Strategic placement of vented windows, use of overhangs, use of ENERGY STAR fans, and use other architectural shade structures	Strategic placement of vented windows, use of overhangs, use of ENERGY STAR and whole house fans, use of other architectural shade structures and strategic placement of landscaping for shading
Space Efficiency	Default space efficiency planning	intentional space efficiency planning	Intentional space efficiency planning, elimination of hallways	Intentional space efficiency planning, elimination of hallways, designing loft spaces, incorporation of multi-function flex space, and using built-ins
5. ENERGY EFFICIENCY				
Lighting	Standard lighting with incandescent bulbs, not designed for natural daylighting or southern orientation	Good daylighting, standard fixtures with 30 percent of hard-wired fixtures having compact florescent bulbs (CFLs)	Better daylighting, 60 percent of hard wired fixtures Energy Star rated with CFLs, including ceiling fans, recessed ceiling lights in unconditioned cavities only, simple lighting controls	Advanced daylighting, including the use of clearstory or tubular skylights, all fixtures Energy Star rated with 90 percent CFLs and LED bulbs, no recessed ceiling lights, advanced lighting controls, whole house fan properly insulated
6. WASTE MANAGEMENT				
Recycling	No recycling program	Establish a basic construction waste management plan to recycle	Establish coordinated construction waste management plan with contractors and provide bins	Establish coordinated construction waste management plan with all contractors and suppliers and provide bins and other storage areas for collection

A green building provides various environmental, economic, and social co-benefits to building owners and users. With the rapid growth of the construction industry, there is an important need to promote the use of green building concepts in Sri Lanka.

Conclusions

The study's primary focus was on identifying the co-benefits of green buildings in the local context. The study was done based on the perceptions of experts working in green construction projects, and data was collected through a questionnaire survey, site visits, and interviews. The findings revealed that the majority of the co-benefits in each category are achievable in the Sri Lankan setting, however, the magnitude of those co-benefits may fluctuate. According to the professionals' point of view, many co-benefits might be realized in the long term, where it takes more than two years after construction, and a significant number of short-term co-benefits were identified by the respondents in social economically and environmentally. Still, few structures in Sri Lanka have adopted the green concept, and many specialists have stated that they have no idea when some co-benefits listed under economic, social, and environmental aspects will be realized. The survey discovered the following significant barriers to sustainable construction: a lack of incentives (government support), a higher preliminary cost, a lack of credible research on the co-benefits of green building, a lack of public awareness, and employee resistance to changing from conventional to green practices lack of solid data on the co-benefits of green building, Furthermore, the findings of this research will aid practitioners involved in green building projects in Sri Lanka in adopting the most appropriate green construction methods, resulting in increased economic, social, and environmental co-benefits. the study emphasizes the co-benefits of using a green building concept. It suggests that the government's engagement in this innovative notion was the most significant barrier to recognizing the green building concept. As a result, according to the recommendations, the notion of green building might be adapted to the Sri Lankan context, so boosting the country's long-term sustainability.

The support of government is essential in promoting green building in the construction industry. The government can influence the construction industry through a variety of approaches. The regulatory and incentive instruments can be considered to promote green building. The government's best approach is to provide incentive packages to the construction industry that encourage them to practice sustainability in their projects. To encourage the green building concept, for contractors and investors interested to work and invest in Sri Lanka, the government must offer appropriate incentives and infrastructural facilities. Public awareness programs should be implemented to promote and spread the concept nationwide. The Green Building Council Sri Lanka can significantly promote the Green Building Concept to the general public, schools, and universities.

Based on the previously mentioned impediments to green construction and the present development of green building, various directions and specific methods for future green building improvement are offered. Green building construction technologies should be advanced in order to satisfy future market demand. Developers should invest more in crucial technology research and development. To strengthen the commercialization and market penetration capacity of new technologies, the government should increase its support for technical research and communication. Additionally, innovative technology must be marketed by utilizing an effective platform for demonstration and promotion. Property developers are the key stakeholders in green building development, deciding whether or not to use green technology, commodities, and projects. Increasing stakeholder awareness is co beneficial to the green building development process. The goal of most developers is to make a profit. Even designing green buildings is a plan to obtain not only profit, but also the future reputation and social position of the company. Yet, obtaining future honor without compromising present payment collection is a must, particularly for small-scale construction enterprises.

Additionally, during the Community Awareness programs, the consultants must encourage and inform society about the co-benefits that endure and investors gain during and after the project through Life Cycle Costing. Despite the initial cost being high, there are numerous economic, social, and environmental co-benefits to green building projects. Construction-related Senior Professionally Qualified representatives must participate in the initial and strategic planning stages of critical decisions. Due to a lack of awareness, private sector companies and individuals are unlikely to risk investing in and assisting with Green Building projects. Moreover, with the assistance of Non-Governmental Organizations and Social Networks, construction youth (fresh blood) can conduct awareness campaigns about converting traditional buildings to green. The incentive programs might serve as a powerful internal motivator to increase the popularity of green development. Therefore, legislation is a critical component in promoting green building. Local economic growth, weather circumstances, regional resources, and construction level should all be taken into account while developing and improving green building standards. Future research should compare the performance of green buildings in different countries across numerous categories. Notwithstanding the hurdles associated with green building implementation, green building has the potential to significantly cut energy consumption and the greenhouse effect.

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