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## **ANNEXURES**

## Annexure 1: Green Building Rating Systems

Table 2.2: Green Building Rating Systems

Source	Rating System	Established Year	Country	Sustainability Domains	Building Types Covered
Fowler and Rauch (2006); Say and Wood (2008); Nguyen (2011b)	BREEAM (Building Research Establishment Environmental Assessment Method)	1990	United Kingdom	<ul style="list-style-type: none"> <li>• Management (commissioning, monitoring, waste recycling, pollution minimization, materials minimization)</li> <li>• Health &amp; Wellbeing (adequate ventilation, humidification, lighting, thermal comfort)</li> <li>• Energy (sub-metering, efficiency and CO2 impact of systems)</li> <li>• Transport (emissions, alternate transport facilities)</li> <li>• Water (consumption reduction, metering, leak detection)</li> <li>• Materials (asbestos mitigation, recycling facilities, reuse of structures, facade or materials, use of crushed aggregate and sustainable timber)</li> <li>• Land Use (previously used land, use of remediated contaminated land)</li> <li>• Ecology (land with low ecological value or minimal change in value, maintaining major ecological systems on the land, minimization of biodiversity impacts)</li> <li>• Pollution (leak detection systems, on-site treatment, local or renewable energy sources, light pollution design, avoid use of ozone depleting and global warming substances)</li> </ul>	<ul style="list-style-type: none"> <li>• Courts</li> <li>• Homes</li> <li>• Industrial</li> <li>• Multi-residential</li> <li>• Prison</li> <li>• Offices</li> <li>• Retail</li> <li>• Schools</li> </ul>
	LEED (Leadership in Energy and	1998	United States	<ul style="list-style-type: none"> <li>• Sustainable Sites (construction related pollution prevention, site development</li> </ul>	<ul style="list-style-type: none"> <li>• Homes</li> </ul>

	Environmental Design)		<ul style="list-style-type: none"> <li>impacts, transportation alternatives, stormwater management, heat island effect, and light pollution)</li> <li>• Water Efficiency (landscaping water use reduction, indoor water use reduction, and wastewater strategies)</li> <li>• Energy and Atmosphere (commissioning, whole building energy performance optimization, refrigerant management, renewable energy use, and measurement and verification)</li> <li>• Materials and Resources (recycling collection locations, building reuse, construction waste management, and the purchase of regionally manufactured materials, materials with recycled content, rapidly renewable materials, salvaged materials, and sustainably forested wood products)</li> <li>• Indoor Environmental Quality (environmental tobacco smoke control, outdoor air delivery monitoring, increased ventilation, construction indoor air quality, low emitting materials use, source control, and controllability of thermal and lighting systems)</li> <li>• Innovation and Design Process (LEED® accredited professional, and innovative strategies for sustainable design)</li> </ul>	<ul style="list-style-type: none"> <li>• New commercial construction and major renovations</li> <li>• Existing building</li> <li>• Commercial interiors</li> <li>• Core and shell development</li> <li>• Neighbourhood development</li> <li>• Schools</li> <li>• Retail</li> <li>• Health care units</li> </ul>	
	CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)	2001	Japan	<ul style="list-style-type: none"> <li>• Indoor environment (noise and acoustics, thermal comfort, lighting and illumination, and air quality)</li> <li>• Quality of services (functionality and usability, amenities, durability and reliability, flexibility and adaptability)</li> </ul>	<ul style="list-style-type: none"> <li>• Pre-design</li> <li>• New Construction</li> <li>• Existing buildings</li> <li>• Renovation</li> </ul>

					<ul style="list-style-type: none"> <li>• Outdoor environment on site (preservation and creation of biotope, townscape and landscape, and outdoor amenities)</li> <li>• Energy (thermal load, use of natural energy, efficiency of systems, and efficient operations)</li> <li>• Resources and materials (water conservation, recycled materials, sustainably harvested timber, materials with low health risks,</li> <li>• Reuse and reusability, and avoidance of CFCs and halons)</li> <li>• Off-site environment (air pollution, noise and vibration, odor, sunlight, obstruction, light pollution, heat island effect, and local on local infrastructure)</li> </ul>	
Nguyen (2011b)	HK-BEAM (Hong Kong Building Environmental Assessment Method)	1996	Hong Kong	<ul style="list-style-type: none"> <li>• Site aspects (land use, site design appraisal, pollution during construction)</li> <li>• Materials aspects (building reuse, rapidly renewable materials, demolition waste)</li> <li>• Energy use (annual building energy use, embodied energy in building structural elements, air conditioning, appliances and lighting, testing and commissioning)</li> <li>• Water use (annual water use and monitoring effluent)</li> <li>• Indoor environmental quality (safety and security, indoor air quality and ventilation, thermal comfort, lighting, acoustics and noise, building amenities)</li> <li>• Innovation and performance enhancements, innovative techniques, performance enhancements)</li> </ul>	<ul style="list-style-type: none"> <li>• New Construction</li> <li>• Existing buildings</li> </ul>	
Fowler and Rauch (2006)	GBTool	1998	Canada	<ul style="list-style-type: none"> <li>• Energy consumption is assessed through total use of non-renewable energy (embodied and operational), electrical peak demand for operations, use of renewable energy, and commissioning.</li> </ul>	<ul style="list-style-type: none"> <li>• Tenant build out</li> <li>• Operations and maintenance applications</li> </ul>	

					<ul style="list-style-type: none"> <li>• Resource consumption is assessed through materials use (salvaged, recycled, bio-based and sustainably harvested, locally produced, designed for disassembly, re-use, or recycling) and water use for irrigation, building systems, and occupant use.</li> <li>• Environmental loadings include greenhouse gas emissions, other atmospheric emissions, solid wastes, stormwater, wastewater, site impacts, and other local and regional impacts.</li> <li>• Indoor environmental quality is assessed through indoor air quality, ventilation, temperature and relative humidity, daylight and illumination, and noise and acoustics.</li> <li>• Other criteria include selection of appropriate site (in terms of land use, brownfields, access to transportation and amenities), project planning, urban design (density, mixed uses, compatibility, native plantings, and wildlife corridors), building controls, flexibility and adaptability, maintenance of operating performance, and a few social and economic measures.</li> </ul>	
Say and Wood (2008); Nguyen (2011b)	Green Star	2003	Australia	<ul style="list-style-type: none"> <li>• Management (green star accredited professional, commissioning and tuning, adaptation and resilience, building information, commitment to performance, metering and monitoring, construction environmental management, operational waste)</li> <li>• Indoor Environment Quality (indoor air quality, acoustic comfort, lighting comfort, visual comfort, indoor pollutants, thermal comfort)</li> </ul>	<ul style="list-style-type: none"> <li>• Commercial office design and construction</li> <li>• Shopping centers</li> <li>• Healthcare facilities</li> <li>• Education facilities</li> <li>• Mixed use/multi-unit residential</li> <li>• Industrial</li> <li>• Public buildings</li> </ul>	

				<ul style="list-style-type: none"> <li>• Energy (greenhouse gas emissions, peak electricity demand reduction)</li> <li>• Transport (sustainable transport)</li> <li>• Water (potable water)</li> <li>• Materials (life cycle impacts, responsible building materials, sustainable products, construction and demolition waste)</li> <li>• Land Use &amp; Ecology (ecological value, sustainable sites, heat island effect)</li> <li>• Emissions (stormwater, light pollution, microbial control, refrigerant impacts)</li> <li>• Innovation</li> </ul>	
Fowler and Rauch (2006); Say and Wood (2008)	Green Globes	2005	Canada	<ul style="list-style-type: none"> <li>• Project Management (integrated design, environmental purchasing, commissioning, emergency response plan)</li> <li>• Site (site development area, reduce ecological impacts, enhancement of watershed features, site ecology improvement)</li> <li>• Energy (energy consumption, energy demand minimization, “right sized” energy-efficient systems, renewable sources of energy, energy-efficient transportation)</li> <li>• Water (flow and flush fixtures, water-conserving features, reduce off-site treatment of water)</li> <li>• Indoor Environment (effective ventilation systems, source control of indoor pollutants, lighting design and integration of lighting systems, thermal comfort, acoustic comfort)</li> <li>• Resource, Building Materials and Solid Waste (materials with low environmental impact, minimized consumption and depletion of material resources, re-use of existing structures, building durability, adaptability)</li> </ul>	<ul style="list-style-type: none"> <li>• New commercial building</li> <li>• Existing commercial buildings</li> <li>• Homes</li> </ul>

					and disassembly, and reduction, re-use and recycling of waste)	
Green Building Council of Sri Lanka (2015)	GREEN SL® Rating System	2010	Sri Lanka	<ul style="list-style-type: none"> <li>• Management (green building accredited professional, commissioning clauses, building tuning, optimizing occupant comfort and energy efficiency, building user's guide, building user's guide, environmental management, environmental management plan, environment management system (complying with ISO 14001))</li> <li>• Sustainable sites (erosion and sedimentation control, site selection, development density and community connectivity, brownfield redevelopment, alternative transportation, public transportation access, parking capacity, reduced site disturbances, protect or restore habitat, development footprint, stormwater design-quantity control, stormwater design-quantity control, heat island effect, non – roof, heat island effect, roof, light pollution reduction)</li> <li>• Water efficiency (water efficient landscaping, reduce potable water consumption, eliminate potable water consumption, water efficiency in air-conditioning system, innovative wastewater technologies, reduce potable water use or treat waste water, harvested rainwater, water use reductions)</li> <li>• Energy and atmosphere (fundamental building systems commissioning, minimum energy performance, CFC reduction in HVAC&amp;R equipment, optimize energy performance, renewable energy, additional commissioning, ozone depletion, measurement &amp; verifications, green power)</li> </ul>	<ul style="list-style-type: none"> <li>• Commercial,</li> <li>• Institutional buildings</li> <li>• High-rise residential buildings</li> </ul>	



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- Materials and resources (storage & collection of recyclables, building reuse: maintaining 50% of existing building structure and shell, maintaining 75% of existing building structure and shell, maintaining 75% of existing building structure and shell and 25% of non-shell areas, construction waste management: for 50% recycling, for 75% recycling, resource reuse: for at least 5% of the building, for at least 10% of the building, recycled content: for at least 10% of total value of materials, for at least 20% of total value of materials, local / regional materials: for a minimum of 20% usage, for a minimum of 50% usage, rapidly renewable materials, certified wood)
  - Indoor environmental quality (minimum IAQ performance, smoke (ETS) control, outdoor air delivery monitoring, increased ventilation, construction IAQ management plan before and after construction, low - emitting materials, paints and coatings, carpet systems, composite wood and agrifiber products, indoor chemical & pollutant source control, controllability of systems, lighting controls, comfort controls, thermal comfort: design, thermal comfort: verification, daylight & views)
  - Innovation and design process (innovation in design, exemplary performance)
  - Social and cultural awareness (archaeological sites & heritage buildings, social wellbeing, public health & safety, cultural identities)
-

## Annexure 2: Green Building Rating Systems used in Sri Lanka

**Table 2.4: LEED-BD+C: NC version 3.0 (2009)**

<b>Sustainable Sites</b>		<b>26 Possible Points</b>
Prereq 1	Construction Activity Pollution Prevention	Required
Credit 1	Site Selection	1
Credit 2	Development Density & Community Connectivity	5
Credit 3	Brownfield Redevelopment	1
Credit 4.1	Alternative Transportation, Public Transportation Access	6
Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
Credit 4.3	Alternative Transportation, Low Emitting & Fuel-Efficient Vehicles	3
Credit 4.4	Alternative Transportation, Parking Capacity	2
Credit 5.1	Site Development, Protect or Restore Habitat	1
Credit 5.2	Site Development, Maximize Open Space	1
Credit 6.1	Stormwater Design, Quantity Control	1
Credit 6.2	Stormwater Design, Quality Control	1
Credit 7.1	Heat Island Effect, Non-Roof	1
Credit 7.2	Heat Island Effect, Roof	1
Credit 8	Light Pollution Reduction	1
<b>Water Efficiency</b>		<b>10 Possible Points</b>
Prereq 1	Water Use Reduction	Required
Credit 1	Water Efficient Landscaping	2-4
Credit 2	Innovative Wastewater Technologies	2
Credit 3	Water Use Reduction	2-4
<b>Energy &amp; Atmosphere</b>		<b>35 Possible Points</b>
Prereq 1	Fundamental Commissioning of Building Energy Systems	Required
Prereq 2	Minimum Energy Performance	Required
Prereq 3	Fundamental Refrigerant Management	Required
Credit 1	Optimize Energy Performance	1-19
Credit 2	On-Site Renewable Energy	1-7
Credit 3	Enhanced Commissioning	2
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement & Verification	3
Credit 6	Green Power	2
<b>Materials &amp; Resources</b>		<b>14 Possible Points</b>
Prereq 1	Storage & Collection of Recyclables	Required
Credit 1.1	Building Reuse, Maintain Existing Walls, Floors & Roof	1-3
Credit 1.2	Building Reuse, Maintain Interior Non-Structural Elements	1
Credit 2	Construction Waste Management	1-2
Credit 3	Materials Reuse	1-2
Credit 4	Recycled Content	1-2
Credit 5	Regional Materials	1-2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	1

<b>Indoor Environmental Quality</b>		<b>15 Possible Points</b>
Prereq 1	Minimum IAQ Performance	Required
Prereq 2	Environmental Tobacco Smoke (ETS) Control	Required
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2	Increased Ventilation	1
Credit 3.1	Construction IAQ Management Plan, During Construction	1
Credit 3.2	Construction IAQ Management Plan, Before Occupancy	1
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	1
Credit 4.2	Low-Emitting Materials, Paints & Coatings	1
Credit 4.3	Low-Emitting Materials, Flooring Systems	1
Credit 4.4	Low-Emitting Materials, Composite Wood & Agrifiber Products	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 6.1	Controllability of Systems, Lighting	1
Credit 6.2	Controllability of Systems, Thermal Comfort	1
Credit 7.1	Thermal Comfort, Design	1
Credit 7.2	Thermal Comfort, Verification	1
Credit 8.1	Daylight & Views, Daylight	1
Credit 8.2	Daylight & Views, Views	1
<b>Innovation in Design</b>		<b>6 Possible Points</b>
Credit 1	Innovation in Design	1-5
Credit 2	LEED Accredited Professional	1
<b>Regional Priority</b>		<b>4 Possible Points</b>
Credit 1	Regional Priority	1-4

Source: (USGBC, 2009)

Project Totals 110 Possible Points

- Certified 40–49 points
- Silver 50–59 points
- Gold 60–79 points
- Platinum 80 points and above

**Table 2.5: GREENSL® Rating System**

<b>Management</b>		<b>4 Possible Points</b>
Prerequisite 1	Green Building Accredited Professional	Required
Prerequisite 2	Commissioning Clauses	Required
Credit 1.1	Building Tuning	
Credit 1.1.1	Optimizing occupant comfort and energy efficiency	1
Credit 1.2	Building User's Guide	
Credit 1.2.1	Building User's Guide	1
Credit 1.3	Environmental Management	
Credit 1.3.1	Environmental Management Plan	1
Credit 1.3.2	Environment Management System (Complying with ISO 14001)	1

<b>Sustainable Sites</b>		<b>25 Possible Points</b>
Prerequisite 1	Erosion and Sedimentation Control	Required
Credit 2.1	Site Selection	5
Credit 2.2	Development Density and Community Connectivity	4
Credit 2.3	Brownfield Redevelopment	1
Credit 2.4	Alternative Transportation	
Credit 2.4.1	Public Transportation Access	2
Credit 2.4.2	Parking Capacity	1
Credit 2.5	Reduced Site Disturbances	
Credit 2.5.1	Protect or Restore Habitat	2
Credit 2.5.2	Development Footprint	2
Credit 2.6	Stormwater Design, Quantity Control - I	3
Credit 2.7	Stormwater Design, Quantity Control - II	2
Credit 2.8	Heat Island Effect, Non – Roof	1
Credit 2.9	Heat Island Effect, Roof	1
Credit 2.10	Light Pollution Reduction	1
<b>Water Efficiency</b>		<b>14 Possible Points</b>
Credit 3.1	Water Efficient Landscaping	
Credit 3.1.1	Reduce Potable Water Consumption	2
Credit 3.1.2	Eliminate Potable Water Consumption	2
Credit 3.2	Water Efficiency in Air-conditioning System	1
Credit 3.3	Innovative Wastewater Technologies	
Credit 3.3.1	Reduce Potable Water Use or Treat Waste water	2
Credit 3.3.2	Harvested Rainwater	3
Credit 3.4	Water Use Reductions	1-4
<b>Energy &amp; Atmosphere</b>		<b>21 Possible Points</b>
Prerequisite 1	Fundamental Building Systems Commissioning	Required
Prerequisite 2	Minimum Energy Performance	Required
Prerequisite 3	CFC Reduction in HVAC&R Equipment	Required
Credit 4.1	Optimize Energy Performance	1-10
Credit 4.2	Renewable Energy	7
Credit 4.3	Additional Commissioning	1
Credit 4.4	Ozone Depletion	1
Credit 4.5	Measurement & Verifications	1
Credit 4.6	Green Power	1
<b>Materials &amp; Resources</b>		<b>21 Possible Points</b>
Prerequisite 1	Storage & Collection of Recyclables	Required
Credit 5.1	Building Reuse	
Credit 5.1.1	Maintaining 50% of Existing Building Structure and Shell	1
Credit 5.1.2	Maintaining 75% of Existing Building Structure and Shell	2
Credit 5.1.3	Maintaining 75% of Existing Building Structure and Shell and 25% of Non-shell Areas	3
Credit 5.2	Construction Waste Management	
Credit 5.2.1	For 50% Recycling	1
Credit 5.2.2	For 75% Recycling	2
Credit 5.3	Resource Reuse	
Credit 5.3.1	For at least 5% of the Building	1
Credit 5.3.2	For at least 10% of the Building	2
Credit 5.4	Recycled Content	

Credit 5.4.1	For at least 10% of Total Value of Materials	1
Credit 5.4.2	For at least 20% of Total Value of Materials	1
Credit 5.5	Local / Regional Materials	
Credit 5.5.1	For a Minimum of 20% Usage	1
Credit 5.5.2	For a Minimum of 50% Usage	3
Credit 5.6	Rapidly Renewable Materials	1
Credit 5.7	Certified Wood	1
<b>Indoor Environmental Quality</b>		<b>21 Possible Points</b>
Prerequisite 1	Minimum IAQ Performance	Required
Prerequisite 2	Smoke (ETS) Control	Required
Credit 6.1	Outdoor Air Delivery Monitoring	1
Credit 6.2	Increased Ventilation	1
Credit 6.3	Construction IAQ Management Plan	
Credit 6.3.1	Construction IAQ Management Plan Before and After Construction	1
Credit 6.4	Low - Emitting Materials	
Credit 6.4.1	Paints and Coatings	1
Credit 6.4.2	Carpet Systems	1
Credit 6.4.3	Composite Wood and Agrifiber Products	1
Credit 6.5	Indoor Chemical & Pollutant Source Control	1
Credit 6.6	Controllability of Systems	
Credit 6.6.1	Lighting Controls	1
Credit 6.6.2	Comfort Controls	1
Credit 6.7	Thermal Comfort, Design	1
Credit 6.8	Thermal Comfort, Verification	1
Credit 6.9	Daylight & Views	
Credit 6.9.1	Daylight	1
Credit 6.9.2	Views	1
<b>Innovation &amp; Design Process</b>		<b>4 Possible Points</b>
Credit 7.1	Innovation in Design	
Credit 7.1.1	Innovation in Design	1-2
Credit 7.1.2	Exemplary Performance	1-2
<b>Social &amp; Cultural Awareness</b>		<b>3 Possible Points</b>
Prerequisite 1	Archaeological Sites & Heritage Buildings	Required
Credit 8.1	Social Wellbeing, Public Health & Safety	1-2
Credit 8.2	Cultural Identities	1-2

Source: (GBCSL, 2015)

- Certified 40–49 points
- Silver 50–59 points
- Gold 60–69 points
- Platinum 70 points and above

### Annexure 3: Sustainability Domains and Criteria, Green Building Strategies and Technologies and Construction Cost Impact

**Table 2.9: Sustainability Domains and Criteria, Green Building Strategies and Technologies and Construction Cost Impact**

Domain	Criteria	Green Building Strategies and Technologies	Construction Cost Comparing to Conventional Counterparts	LCC Impact (Yes/No)	LCC Elements	Factors Influencing
Sustainable Sites	Construction activity pollution prevention	Erosion and sedimentation control plan (strategies)	No construction or soft cost impact or minimal added cost	No Only construction	A very small reduction from overall construction cost by reducing clean-up and corrective action	
	Site selection	Avoiding non-compliant sites	No construction or soft costs Possible costs, where appropriate sites are available at an added cost	No Only construction	Choice of location can affect feasibility and cost of sustainable design measures. Overall project cost	
	Development density & community connectivity	Construct or renovate a building in a previously developed site with pedestrian access between the building and services	Significant cost impact <sup>1</sup> when increasing density by development of multi-story buildings and structured parking in urban sites	No	Tax incentives and property cost savings at construction	Rural or suburban buildings
			Significant cost impact to smaller rural or suburban buildings (single story buildings with surface parking) to increase the density of the project	No		

Brownfield redevelopment	Hazardous materials removal or encapsulation during demolition or renovation	Significant cost impact	No	Additional soft cost for design, testing and monitoring	
	Encapsulation of contaminated soils or remediation of contaminated soils using chemical additives	Significant cost impact	No		
Alternative transportation— Public transportation access	Bring bus lines to the site	No construction or soft costs	No	Reduced parking and reducing cost	
	Shuttle buses to transport staff and patients from the project site to bus or train stops		Yes	Fuel	
Alternative Transportation— Bicycle Storage and Changing Rooms	Installation of adequate bicycle racks and shower/changing facilities	Minimal construction or soft cost	Yes	Cleaning, utilities, services and fabric maintenance, sign and demarcation Reduced parking	
Alternative Transportation— Low-Emitting and Fuel-efficient Vehicles	Parking for low-emitting and fuel-efficient vehicles	Minimal construction cost impact	Yes	Cleaning, sign and demarcation, fabric maintenance	
	Refuelling stations or electric refuelling stations	Minimal construction and soft cost	Yes	Cleaning, sign and demarcation, maintenance of equipment	
	Low-emitting and fuel-efficient vehicles	Low cost impact	Yes	Fuel, emission test	
	Low-emitting or fuel-efficient vehicle-sharing program	No cost impact	No		
Alternative Transportation— Parking Capacity	Sharing parking facilities with adjacent buildings minimize parking lot/garage size	Minimal construction cost	Yes	Cleaning, sign and demarcation, fabric maintenance	
Site Development— Protect or restore Habitat	Minimize disruption to existing ecosystems and design the building to minimize its footprint	Significant or prohibitive cost, where parking is underground or in a structure to provide space for natural habitat Relatively small soft cost	Yes	Cleaning Native or adopted plants require minimal or no irrigation do not require active maintenance such as mowing or chemical inputs and fertilizers	Parking is underground or in a structure to provide space for
	Stacking the building programme tuck under parking and sharing parking facilities native or adopted plants				
	Landscape Parking spaces with green roof	Low cost impact			

	Site Development— Maximize open space	Pedestrian oriented hardscape and limited hardscape, vegetated roof areas, wetlands or naturally designed ponds, tuck-under parking and sharing parking facilities with neighbours	Minimal to significant cost impact for urban sites, green roofs  Rural zero to minimal cost	Yes	Cleaning, landscaping	
	Stormwater design— Quantity control	Detention through swales	Minimal cost impact	No		
		Infiltration of stormwater via vegetated roofs, and paving Reuse stormwater for non-portable uses such as landscape irrigation toilet and urinal flushing and custodial use	Significant cost impact	Yes	Landscaping	
		Detention and retention through ponds, surge chambers or tanks	Significant cost impact	Yes	Cleaning	
		Rainwater harvesting	Significant cost impact	Yes	Cleaning, repairs and replacements	
	Stormwater design— Quality control	Constructed wetlands, vegetated filters and open channels to treat stormwater runoff, and reuse the water for irrigation, toilet and urinal flushing	Significant cost impact	Yes	Water quality testing, cleaning, Services maintenance	
	Heat island effect non-roof	Shade from native or adapted trees and large shrubs, vegetated trellises	Minimal cost impact	No		
		Shade from structures covered by solar panels	Significant cost impact	Yes	Maintenance of the solar panels	
		White asphalt or by providing open grid paving or gravel at parking stalls, leaving only the aisles asphalt Light coloured surface	Minimal or no cost impact	No		High end technologies
		Changing the colour of concrete paving	Low cost impact			
		Shade from architectural devices or structures that reflect solar (photovoltaic cells)	Low cost impact	Yes	Repairs and replacements, cleaning	
		Vegetated roof previous pavement, grid pavers, rains gardens, vegetated swales, rainwater recycling, infiltration				
	Heat island Effect— Roof	High emissivity roof	Low cost impact <sup>3</sup>	Yes	Repairs and replacement	Roofing material with solar reflectance index



		Green roof	Significant cost impact	Yes	Landscaping	
	Light pollution reduction	Full cut-off luminaires, low-reflectance surfaces and low-angle spotlights Manual or occupant sensing device	Minimal cost impact	Yes	Maintenance cost of lighting, electricity cost	Vegetated roofs high albedo roofs
Water Efficiency	Water efficient landscaping	Native, drought tolerant plants	Minimal cost impact	No		
		Drip irrigation or automated controls with moisture sensors and municipally provided reclaimed water for irrigation	Minimal cost impact	Yes	Repairs and replacements	
		Rainwater harvesting	Significant cost impact	Yes	Cleaning, repairs and replacements	
	Innovative wastewater technologies	HVAC condensate or cooling tower waste water for irrigation (non-chemical cooling tower systems)	Minimal cost impact	Yes	Cleaning, treating and minor repairs and replacements	
		Low-flow and waterless flush fixtures	Low cost impact	Yes	Repairs and replacements	
		Gray water treatment	Significant cost impact	Yes	Repairs and replacements	
		Sewage water treatment	Significant cost impact	Yes	Repairs and replacements	
Water use reduction	Low flow fixtures for lavatories and showers, motion sensor operated devices, reduced flush or dual flush toilets, and waterless or reduced flush urinals	Low cost impact	Yes	Repairs and replacements		
Energy and atmosphere	Fundamental commissioning of building energy systems	Engage a Commissioning Authority and adopt a commissioning plan	Significant cost impact	No		
	Minimum energy performance	Whole building energy simulation, prescriptive compliance path: ASHRAE advanced energy design guide, prescriptive compliance path: advanced buildings™ core performance™ guide	If energy efficiency is not addressed early the costs can become significant	Yes	Energy cost	
	Fundamental refrigerant management	Zero use of chlorofluorocarbon (CFC)-based refrigerants	No cost impact	Yes	Replacement cost	
	Optimize energy performance	Whole building energy simulation, prescriptive compliance path: ASHRAE	Significant cost impact	Yes	Energy cost	

		advanced energy design guide, prescriptive compliance path: advanced buildings™ core performance™ guide			
	Onsite renewable energy	Solar, wind, geothermal, biomass, large hydro power, low-impact hydro, biogas and municipal solid waste	Significant cost impact	Yes	Maintenance, repair and replacement
	Enhanced commissioning	Engage a Commissioning Authority and adopt a commissioning plan early in project design phase	Significant cost impact	No	
	Enhanced refrigerant management	Select HVAC & R equipment with reduced refrigerant charge and increased equipment life	Low cost impact	Yes	
		Maintain equipment to prevent leakage of refrigerant to the atmosphere	Low cost impact	Yes	
		Utilize fire suppression systems that do not contain HCFCs or Halons	Low cost impact	Yes	
	Measurement and verification	Energy metering and sub metering	Significant cost impact	Yes	
	Green Power	Solar, wind, geothermal, biomass, biogas and low impact hydropower	Significant cost impact	Yes	
Material and Resources	Storage and collection of recyclables	Designate an area for recyclable collection and storage that is appropriately sized and located in a convenient area	Minimal or no cost impact	No	
	Building Reuse	Reusing existing, previously-occupied building structures, envelopes and elements	Do not necessarily add cost to a project,	Yes	
		Reusing existing building structures, envelopes and interior non-structural elements	it is the impact of the cost of achieving other necessary points	Yes	
Construction waste management	Designate a specific area on the construction site for segregated or comingled collection of recyclable materials to divert from disposal in landfills and incineration facilities	Minimal cost impact: in areas where construction waste management is widely used Significant cost impact: in areas with contractors unfamiliar with construction waste management	Yes		Contractors unfamiliar with construction waste management

	Materials reuse	Incorporate salvaged materials into such as beams and posts, flooring, paneling, doors and frames, cabinetry and furniture, brick, and decorative items	Minimal or no construction cost impact Significant cost impact for compliance	Yes	Compliance
	Recycled content	Use recycled content materials	Minimal or no construction cost impact Significant cost impact for compliance	Yes	
	Regional materials	Use locally sourced materials	Difficult to assess what the cost implications might be	Yes	
	Rapidly renewable materials	Use rapidly renewable materials such as bamboo, wool, cotton insulation, agrifiber, linoleum, wheat board, strawboard and cork	Minimal or no construction cost impact Significant cost impact for compliance	Yes	
	Certified wood	Install FSC–certified wood products	Minimal cost impact for buildings using certified wood only in finished carpentry Significant cost impact for buildings requiring large quantities of dimensional softwood or sheet goods	Yes	
Indoor Environmental Quality (IEQ)	Minimum IAQ performance	Design mechanical or natural ventilation systems to meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE standard	No cost impact	Yes	HVAC
	Environmental Tobacco Smoke control	Prohibit smoking in buildings	No cost impact	No	
		Locate any exterior designated smoking areas or effectively control the ventilation air in smoking rooms	Significant cost impact		

Outdoor air delivery monitoring	Install CO <sub>2</sub> and airflow measurement equipment and feed the information to the HVAC system to trigger alarms	Minimal cost impact	Yes	CO <sub>2</sub> air flow measurement equipment Gas meter readings
Increased ventilation	For mechanically ventilated spaces: use heat recovery  For naturally ventilated spaces: design airflow paths, estimate external driving pressures and select types of ventilation devices	Low cost impact		
Construction IAQ management plan—during construction	Control pollutant sources and interrupt contamination pathways, sequence the installation of materials to avoid contamination of absorptive materials, such as insulation, carpeting, ceiling tile and gypsum wallboard and avoid using permanently installed air handlers for temporary heating/cooling during construction	Minimal cost impact, in areas where construction IAQ management is widely used Significant cost impact, in areas with contractors unfamiliar with construction IAQ management	No	
Construction IAQ management plan—before occupancy	Perform a building flush-out or test the air contaminant levels in the building prior to occupancy	Minimal cost impact	No	
Low-emitting materials—adhesives and sealants	Use low-VOC materials for adhesives and sealants	Minimal cost impact	Yes	
Low-emitting materials—paints and coatings	Use low-VOC paints and coatings	Minimal cost impact	Yes	
Low-emitting materials—flooring systems	Select products that are either certified under the Green Label Plus program or for which testing has been done by qualified independent laboratories	Minimal cost impact	Yes	
Low-emitting materials—composite wood and agrifiber products	Specify wood and agrifiber products that contain no added urea-formaldehyde resins and laminating adhesives for field and shop-applied assemblies that contain no added urea-formaldehyde resins	Cost can be vary widely depending on the product selected and market conditions	Yes	Market conditions

Indoor chemical and pollutant source control	Design facility cleaning and maintenance areas with isolated exhaust systems for contaminants, install permanent architectural entryway systems and high-level filtration systems in air handling units	Low cost impact, unless the building has multiple entries	Yes	
Controllability of systems—lighting	Design the building with occupant controls for lighting	Costs can range from minimal to significant	Yes	
Controllability of systems—thermal comfort	Design the building and systems with comfort controls to allow adjustments to suit occupancy rate using operable windows and mechanical systems	Low cost impact, unless areas are under the control of the single occupants	Yes	
Thermal comfort—design	Establish comfort criteria according to ASHRAE 55-2004 that support the desired quality and occupant satisfaction with building performance	No cost impact	No	
Thermal comfort—verification	Design monitoring and corrective action systems	Moderate cost impact	Yes	
Daylight and views—daylight	Maximize interior day lighting using building orientation, shallow floor plates, increased building perimeter, exterior and interior permanent shading devices, high-performance, glazing, and high-ceiling reflectance values, automatic photocell-based controls	Costs can range from minimal to significant	Yes	High end technologies
Daylight and views—views	Maximize day lighting and view using lower partitions, interior shading devices, interior glazing and automatic photocell-based controls	Costs are minimal to moderate	Yes	

Source: (Kats, 2010; Langdon, 2007; Matthiessen & Morris, 2007)

## Annexure 4: Breakdown of Running Cost Elements

Table 3.1: Breakdown of Running Cost Elements

	Running costs Elements	Definition
<b>Running costs</b>		
<b>Operation</b>		
	Utilities	
	Electricity	Electricity consumption
	Water rates	Water consumption
	Fuel oil	Fuel charges
	Effluent & drainage charges	Effluent and drainage removal by authorities
	Administrative costs	
	Security	Technicians, housekeeping personnel, in house and outsource O&M staff
	Service attendants	Property management contract
	Waste disposal	Security personnel
	Property management	Waste disposal to the responsible authorities
	Sundries	
	Taxes	Tax and other overheads
	Insurance	Property insurance
<b>Maintenance</b>		
	Services	
	Heating & Ventilation	
	Air conditioning & Ventilation	Chillers, AHU, FCU, VRV, VAV, cooling towers, valves, pumps, emission units, thermal insulation, controllers, grills, fans, and filters, diffusers, ductwork, pipework, air curtains, air extract systems, fume extracts, dust collection units, rotating ventilators, roof-mounted ventilation units
	Lifts & Escalators	Lifts, firefighting lifts, escalators,

Electric power & lighting		
	Lighting	Light fittings, conduits and cable trunking, lighting switches, lighting control equipment
	HV Generation, transmission & distribution	HV transformer, HV switchgear, HV cables and wiring, bus bar trunking, standby generator,
	Lightning conductors	Earthing and bonding cables, components, surge protection
	Lamp Replacement	Internal, external lamps/luminaires replacement
	Power	General LV power, Extra LV power supply, DC installations, LV switchgear, UPS, cables and wirings
Telecommunication & data		
Plumbing & internal drainage		
	Cold water Service	CW distribution pipe lines, valves, water saving devices, taps, pumps, expansion vessels, water storage tanks and cisterns,
	Sanitary fittings	Tap and outlet, WCs, shower basins, urinals, cisterns, sinks, bidets, shower unit, towel trails, hand dryers, paper towel dispensers
Fire detection & protection system		
Other M&E Services		
	Refrigeration equipment	Refrigeration plant and equipment
	Fire alarms	Manual and automatic fire alarms
	Emergency lighting	Emergency lamps and battery replacement
	Built in fittings	Mirrors, curtains, wall hangings, storage racks, shelves, blinds, shutters,
	CCTV Camera	Camera, recorders, monitors, controllers
	Loose appliances	Damaged mechanical and electrical appliances such as computers, laptops, processors, printers, scanners etc.
Decoration		
	Internal Decoration	Paintings and decorating internal elements
	External Decoration	Paintings and decorating external elements
Fabric		
External Wall		
	Walls	External enclosing walls
	Windows	Windows and openings in external walls for ventilation and light

	Glazing	Glazing in external enclosing walls; façade,
	Doors	Doors and openings in external enclosing walls; entrance doors, door frames, door linings, door sets
Internal Finishes		
	Floor Finishes	Non-structural screeds, in-situ floor finishes, tiled floor finishes, woodblock
	Wall finishes	In-situ coatings applied to walls, sprayed monolithic coatings to columns and walls, plasterboard, ceramic wall tiling,
	Ceilings	Linings, plaster in-situ, sprayed coatings
Roof Structures		
	Covering Flats	Roof cladding, roof ventilation tiles, photovoltaic devices, thermal insulation, surface treatments to roof coverings, paving tiles, paving slabs
	Covering Pitched	Roof decks and slabs, trusses, purlins, rafters, binders, hangers, hip and valley rafters, ridge boards, wall plates,
	Gutters and rain water pipes	Gutters, including fittings, gutter outlets, balloons and gratings, roof drainage pipe work, rainwater heads, painting and anti-corrosion treatments to gutters
Other structural Items		
	Floors staircase & Steps	Floor steps, handrails, springer board, repair of worn or damaged nosing
	Internal walls & Partitions	Internal walls and fixed partitions: walls from cubicles
	Internal glazing & windows	Internal glass work, window frames
	Internal Doors	Doors, hatches, shutters and grills and other openings in internal walls and partitions
Fitting & Fixtures		
	Vandalism	Deliberate destruction or damage to the fitting and fixtures
	Built in furniture	Counters, desks, benches, worktops, chairs, bathroom furniture
	Key issues	Access controls, magnetic locks, electrified locksets, standalone locksets, electric strikes, key and exit switches, exit devices
	Ironmongery	Ironmongery to fittings, doors, windows, cubical,
	Signs	Directional signboards, notice boards, sign writing, nameplates
Cleaning		
	Internal / External Surface	Regular cleaning of the building
	Windows cleaning	Removing stains and deposits from windows



External works		
	Roads pavement	Replacement and refurbishment of paving, paths
	Repairs and decoration	Minor building external works
	Landscaping	Seeding, turfing, planting, and irrigation
	Grounds maintenance	Trimming, blowing, spreading manure, compost and fertiliser
	Pest control services	Spraying and fogging
	Drains	Outlets, gutters, pipes, down pipes
Repairs and replacement of minor components/ small areas		Reactive maintenance activities of minor components
Maintenance management		Planned, reactive, proactive maintenance management, maintenance contractor's

## **Annexure 5: Interview Guidelines**

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### **Impact of Sustainability Criteria on the LCC of Green Buildings in Sri Lanka**

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Dear Sir/ Madam,

#### **Interview Guideline for Dissertation – MSc by Research Degree**

I am A.S. Weerasinghe a postgraduate student of Faculty of Graduate Studies, University of Moratuwa following MSc by Research Degree. In fulfilment of this degree, the students are required to study as a full-time research student and produce a report on their interesting area of knowledge. The focus of my research is to assess the impact of sustainable features on the LCC of green buildings in Sri Lanka. Specifically, the research intends to identify and analyze the LCC and economic benefits contributing through the sustainable features; sustainable sites, water efficiency, energy and atmosphere, material and resources and indoor environmental quality of green buildings.

This interview guideline will be distributed to the professionals of the organization such as Facilities Managers and Engineers who are engaged with the initial green building project or currently engage with the green building activities. The confidentiality of the organization as well as the participants will be maintained throughout the research and the identities of the participants will not be revealed in this report or in any other document or event relating to this study. I hereby certify that the information collected from this interview will be used only for fulfilling the research aim. I would be grateful if you could participate in this interview.

Thank you.

#### ***Section 1- Background Information***

*The information relates to the organization and respondents (Please write the answer on the given space or tick the relevant category)*

1. Please specify the type(s) of industrial manufacturing which your organization involved in

- I. Apparel Industry
- II. Chemical and allied Industry
- III. Electronic and Electrical Equipment Industry
- IV. Metal Industry
- V. Food and Kindred Industry
- VI. Furniture and Fixtures Industry
- VII. Industry and Commercial Machinery Industry
- VIII. Pharmaceuticals
- IX. Leather Industry
- X. Lumber and Wood Industry
- XI. Paper and Allied Industry
- XII. Petroleum Refining and Related Industry
- XIII. Printing, Packaging, and Allied Industry
- XIV. Rubber and Miscellaneous Plastic Industry
- XV. Stone, Clay, Glass, and Concrete Industry
- XVI. Tobacco Industry
- XVII. Transportation Equipment Industry

2. Designation of the Respondent.....

3. Years of Experience

- 1-10  11-20  21-30  More than 30

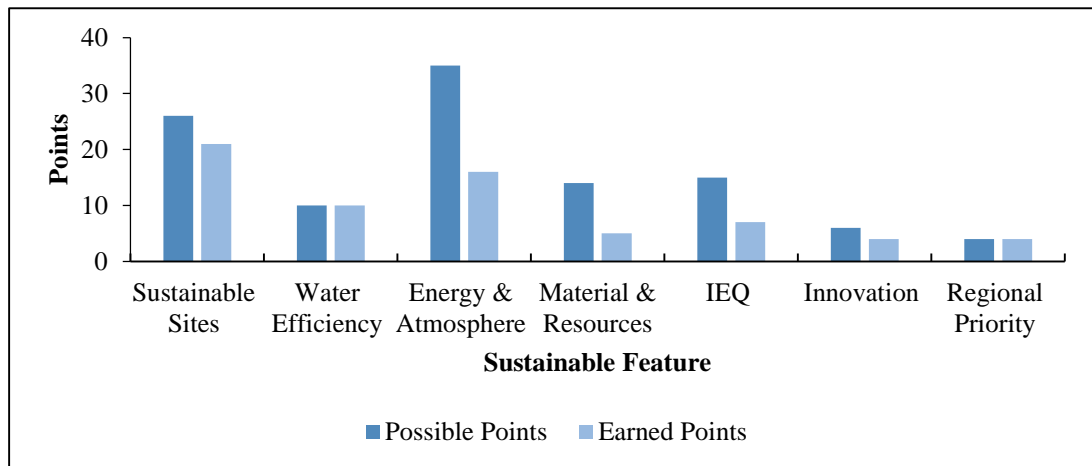
4. Did you involve at the construction stage of this project?

- Yes  No

***Section 2 – Reasons of Level of Achievement of Sustainable Features***

*This section collects the data on reasons of level of sustainability achievement of green building projects in Sri Lanka. A graph which illustrates the level of achievement of*

each sustainable feature according to LEED BD+C: New Construction (v3 -2009) was developed and given in the below. The participants have freedom to explain the reasons referring to the below graph.



**Figure 1: Level of Achievement of Sustainable Features: LEED BD+C: New Construction (v3 - 2009)**

5. What are the sustainable criteria that could be easily achieved under each sustainability feature?
6. In your opinion, the level of achievement for above criteria is high or low?
7. Please explain the reasons for the higher achievement of sustainability criteria mentioned in the question 05.
8. What are the sustainable criteria that could be difficult or very difficult to achieve under each sustainability feature?
9. In your opinion, the level of achievement for above criteria is high or low?
10. Please explain the reasons for the lack of achievement of sustainability criteria mentioned in the question 07.
11. In your opinion, would it be possible to achieve the identified number of points for each sustainable feature using the criteria mentioned in the question 05?
12. If not, what kind of strategies we should take to increase the level of achievement of sustainable features of green buildings?

**THANK YOU!!!!**

Feature	Sustainable Criteria (SC)	Initial Cost of SC > Initial Cost of Conventional Counterparts (Yes/No)	Increase Cost of Construction (LKR)	LCC Impact (Yes/No)	O&M Cost Elements	O&M Cost (LKR)
SS	<input checked="" type="checkbox"/> Construction activity pollution prevention					
	Site selection					
	Development density & community connectivity					
	Brownfield redevelopment					
	Alternative transportation—Public transportation access					
	Alternative Transportation—Bicycle Storage and Changing Rooms					
	Alternative Transportation—Low-Emitting and Fuel-efficient Vehicles					
	Alternative Transportation—Parking Capacity					
	Site Development—Protect or restore Habitat					
	Site Development—Maximize open space					
	Storm water design—Quantity control					
	Storm water design—Quality control					
	Heat island Effect—Non-Roof					
	Heat island Effect—Roof					
Light pollution reduction						
WE	<input checked="" type="checkbox"/> Water use reduction					
	Water efficient landscaping					
	Innovative wastewater technologies					

	Water use reduction					
EA	<input checked="" type="checkbox"/> Fundamental commissioning of building energy systems					
	<input checked="" type="checkbox"/> Minimum energy performance					
	<input checked="" type="checkbox"/> Fundamental refrigerant management					
	Optimize energy performance					
	Onsite renewable energy					
	Enhanced commissioning					
	Enhanced refrigerant management					
	Measurement and verification					
	Green Power					
MR	<input checked="" type="checkbox"/> Storage and collection of recyclables					
	Building reuse—Maintain existing walls, floors and roof					
	Building reuse—Maintain existing interior non-structural elements					
	Construction waste management					
	Materials reuse					
	Recycled content					
	Regional materials					
	Rapidly renewable materials					
	Certified wood					
IEQ	<input checked="" type="checkbox"/> Minimum IAQ performance					
	<input checked="" type="checkbox"/> Environmental Tobacco Smoke control					
	Outdoor air delivery monitoring					
	Increased ventilation					
	Construction IAQ management plan—during construction					
	Construction IAQ management plan—before occupancy					

Low-emitting materials— adhesives and sealants					
Low-emitting materials—paints and coatings					
Low-emitting materials— flooring systems					
Low-emitting materials— composite wood and agrifiber products					
Indoor chemical and pollutant source control					
Controllability of systems— lighting					
Controllability of systems— thermal comfort					
Thermal comfort—design					
Thermal comfort—verification					
Daylight and views—daylight					
Daylight and views—views					