# INFLUENCE OF VERTICAL GREENERIES TO SCORE POINTS IN GREEN RATING SYSTEMS FOR MULTI-STORIED BUILDINGS IN SRI LANKAN CONTEXT

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**Abstract** - Green rating systems have become more significant factor to enhance green construction practice and saving energy of a building. Vertical greens and its influence on green rating systems to score more points, is the key concern of this research. Especially the vertical greenery component which gives more benefits to the facility by make use of natural processes such as temperature control, Indoor air quality and lighting of a building as previous studies have proven. It will significantly influence green rating systems to score more points to reach higher ratings.

This research compare three most commonly used green rating systems in Sri Lanka and how those influenced by the vertical greenery to reach high scores. Three Green Rating Systems, namely, GreenSL® Rating System for Built Environment, GM ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) and LEED V4 for Building Design and Construction are evident to be mostly used rating tools in Sri Lanka. Considerable percentage of points can be obtained with the positive effects of the vertical green façades, both direct and indirect methods, with above three rating systems, especially in energy saving, greenery, air quality aspects.

Application of comprehensive vertical greenery will result in significant difference between in and out temperature of a room and help to increase the thermal comfort and some other aspects too. Mainly this improvement can score more points in all three rating systems in varying degrees. GM ENRB: 2017 score card related to aspects in concern shows reasonably high possibility of scoring more points compared to and Green SL and LEED rating tools. Among latter two tools least potential is with LEED, which seems assessing more indirect influences with respect to technical aspects concerned in the study.

**Keywords** - Vertical greenery; Energy consumption; Thermal comfort; Rating systems

## I. INTRODUCTION

Presently different types of rating systems were introduced to measure sustainability in the constructions. Further, the different types of green assessment systems were introduced by different countries and organizations considering different aspects and conditions etc. This paper aims to find out the influence of vertical greenery to score points in green rating systems. The specific objectives are: 1) select key benefits (direct and indirect) of vertical greenery through literature, 2) discover how likely to score more points directly and indirectly due to the effects of vertical greenery 3) identify the weightage adopted in vertical greenery aspects to score points in green rating systems; 4) evaluate vastly achievable green score containing green rating system, by comparing GreenSL® Rating System for Built Environment, GM ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) and LEED V4 for Building Design and Construction, scoring more points in vertical greenery aspect in Sri Lankan context.

The term "green" emphasis, environmentally friendly practices ranging from building design to final site landscaping. In a local research it has been found that, "Through the preliminary survey, it has been identified the general benefits of vertical greening such as air quality improvement and its velocity changes, ecological aspects and its attractive appearance, protection against driving rain and sun radiation, sound absorption and noise reduction, social impact, cost effectiveness and energy saving. And there are risks of vertical greening such as moisture problems, damage and deterioration, maintenance."(N.M, 2012)

Studies have shown that vertical greenery systems are able to reduce thermal heat transfer by several Celsius degrees into the building which in turn reduces energy consumption for air conditioning. Presently this green features are included in green tools and rating systems and are in the process of familiarizing and test run in Sri Lankan context.

## II. SIGNIFICANT OF THE RESEARCH

Since studies have shown that mainly vertical greenery systems are able to reduce thermal heat transfer into the building which in turn reduces energy consumption for air conditioning and giving many more other benefits such as increasing green cover/area of a building, shading effect, increasing indoor air quality, aesthetic appearance of a building, etc. This paper contains a general analysis of direct and indirect influence of vertical greening systems (plants or vegetation against a façade) and their behaviour with positive effects to score points in commonly using three Green Rating systems in Sri Lanka as GreenSL® Rating System for Built Environment, GM ENRB: 2017 (BCA Green Mark for Existing Non Residential Buildings) and LEED V4 for Building Design and Construction to score more under vertical greenery aspect in Sri Lankan context

## III. LITRATURE SURVEY

In the literature survey, initial intension was to define the vertical greenery and discuss direct & indirect positive effects of vertical greenery. The benefits those can be gained due to the effect of the vertical greenery are mainly; thermal effectiveness and reduction of energy consumption for air conditioning. Vertical green gives thermal comfort to the building. "Vertical vegetation, in addition to green roofs, can cool buildings in tropical and subtropical climates through their impact on shading the building, adding to exterior wall insulation, evaporating moisture from the growing substrate and transpiring moisture from leaf surfaces"(Wong, 2010).

Literature survey emphasis, a general introduction of vertical greening systems and its behaviour in relation to enhance thermal comfort with reduction of the energy consumption for air conditioning in buildings. "Increased air temperature can be expected to be particularly problematic in urban areas, where temperatures already tend to be a few degrees warmer than the surrounding countryside. This difference in temperature between urban and rural areas has been called the 'urban heat island effect'(Badrulzaman Jaafar, 2011). Other than the the aesthetical value, a green envelope can improve the urban environment conditions and the living conditions of the inhabitants. As mentioned above unstable and increasing energy prices, concern over environmental impact and occupant health and comfort are the drivers of green buildings today (Honeywell). A green envelope can intercept the radiation and thus reduce the warming up of hard surfaces; great quantities of solar radiation are adsorbed for the growth of plants and their biological functions(Krusche, 1982).

Vertical vegetation can cool buildings in tropical and subtropical climates through their impact on shading the building, adding to exterior wall insulation, evaporating moisture from the growing substrate and transpiring moisture from leaf surfaces(Wong, 2010). Few parameters may affect the amount of the vertical vegetation's improvement in energy performance aspect. Some examples are choice of vegetation, growing medium, and extent of wall coverage, water availability, geometry and direction, thickness of the vegetation, type of façade etc. A study conducted in Germany by (Bartfelder, 1987) shows a temperature reduction at the green façade in a range of 2-6 °C compared to the bare wall.

As per results obtained by a metropolitan scale survey in Tokyo suggests, temperature reduction by 5-8°C at facade wall surface (Shibuya K, 2007). A study conducted in Germany (Bartfelder, 1987) shows a temperature reduction at the green façade in a range of 2-6°C compared to the bare wall. Greenery also reduces the cooling loads through better insulation and shading. According to Dunnett (Dunnett, 2004) every decrease of the internal building temperature with 0.5°C may reduce the electricity use

with 8% for air-conditioning. And it is estimated (Akabari, 2001) that 5-10% of the current demand of cities is used to cool buildings and the electricity demand is increased for increment of every 1°C.

Another study in Singapore (Wong N.H., 2009) with vertical greening types shows a maximum reduction of 11.6°C. As (Eumorfopoulou, 2009) states a cover vegetation kept a daily room temperature 2°C cooler on average. And Alexander suggests that the surrounding air temperature can be decreased by a maximum of 8.4°C in an urban canyon in humid Hong Kong on a hottest day of the month(Alexandri, 2006). As per a local case study "minimum of 17.5% of electricity use for air conditioning can be reduced by obtaining a 3.50C of temperature reduction" (Peiris1, 2014) "Vertical green vegetation can be adopted as a counter measure of reduction of indoor temperature and reduction of energy consumption for air conditioning in Sri Lankan context" (Peiris1, 2014). The studies of Cheng (C.Y. Cheng, 2010) living wall modular panels reduced the daily cooling load by 1.45kWh and internal surface temperature by 2°C.

Benefits of vertical greenery according to study of Chiang and Tan (Chiang and Tan, 2009) are presented in Table 01.

**Table 2. Benefits of vertical greenery**

| Category | Benefits |
|---|---|
| Aesthetic | • Greener skyline as part of city branding.<br>• Visual relief from urban environment.<br>• Enhance architectural designs; create iconic landmarks in the city.<br>• Screen and isolate views.<br>• Enhancing public spaces. |
| Environment | • Reduction of the Urban Heat Island effect and regulating of the microclimate.<br>• Improving the air quality by absorption of pollution and dust as well as reducing the greenhouse effect by $CO_2$ absorption.<br>• Enhancement of biodiversity through addition of natural habitats within the city.<br>• Vertical green affect to reduce direct sunlight coming to the building, improve air quality, provide insulation, protect the wall against driving rain.<br>• Improving rain water retention.<br>• Therapeutic effects of plants and landscape.<br>• Increase the green coverage of a city. |
| Economic | • Reduction of cooling loads through better insulation and shading.<br>• Improving acoustic insulation.<br>• Increasing property values.<br>• Protection of building facade |

LEED predominantly evaluates environmental factors including Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, and Indoor Environment Quality categories (Dat Tien Doan a, Ali Ghaffarianhoseini a, Nicola Naismith a, Tongrui Zhang a, 8 July 2017). As some studies shown (Lizawati Abdullah, Norhaslina Jumadi, Roshdi Sabu, Huraizah Arshad, Faza Fayza Mohd Fawzy, 2015) 61 % for energy efficiency, 22% environmental protec¬tion , 4% for Indoor environmental quality and 4% green features and innovations, have been weighted in BCA Green Mark rating system.

## IV. IMPLEMENTED PROCESS

During this study, GreenSL® Rating System for Built Environment, GM ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) and LEED V4 for Building Design and Construction to score more in vertical greenery aspect in Sri Lankan context were analyzed in detail. The rationale to select these rating systems is based on considering GM ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) and LEED V4 for Building Design and Construction, well-known leading ones alongside GreenSL® Rating System for Built Environment, which in comparison is a relatively

new system that has recently released its latest version and Sri Lanka has subsequently seen a significant increase in the number of registered green buildings. This research has been carried out as a literature based work. Positives impacts of vertical greenery has been found out and compared with the areas which can be adopted to gain more points in each rating system to find out what would be the most possible scoring (points) rating system in Sri Lankan context, with the use of vertical greenery.

## V. DATA ANALYSIS

### *A. Direct and indirect impacts of vertical green as per literature survey*

- Aesthetic appearance
- Lighting and shading effect
- Screen and isolate views.
- Indoor temperature reduction/indoor thermal comfort
- Reduction of the Urban Heat Island effect and regulating of the microclimate.
- Improve indoor air quality
- Increase indoor Oxygen level
- Enhancement of biodiversity through addition of natural habitats within the city.
- Protection against driving rain
- Sound absorption and noise reduction
- Save considerable amount of energy using for air conditioning of the building
- Therapeutic effects of plants and landscape.
- Increase the green coverage of a city.
- Protection against Sun radiation
- Increase urban greening
- Exterior wall insulation
- Improving rain water retention.
- Improving acoustic insulation.
- Increasing property values.
- Protection of building façade

### *B. ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings)*

The Building and Construction Authority (BCA) Green Mark scheme is a green building rating system introduced for the tropical climate. This has been launched in 2005. BCA Green Mark sets parameters and establishes indicators to guide the design, construction and operation of buildings towards increased energy effectiveness and enhanced environment performances. (BCA) Green Mark for Existing Non-Residential Buildings, GM ENRB: 2017, is the 4th edition and Green Mark aims to derive sustainability outcomes and enable to develop a high quality and environmentally sustainable built environment for current and future generations to come. Criteria have structured into five sections, and total points awarding was 165. Possible ratings are as follows;

| | |
|---|---|
| Green Mark Platinum | 70 and above |
| Green Mark Gold PLUS | 60 to < 70 |
| Green Mark Gold | > 50 to < 60 |
| Green Mark Certified | Compliance with all pre-requisite requirements |

### *C. LEED V4 for Building Design and Construction*

LEED is a voluntary standard developed by USGBC (US Green Building Council). It was first launched in 1998 with a pilot version (LEED 1.0) LEED is considered as the most widely adopted rating scheme based on the number of countries, For this research LEED V4 Building Design and Construction 2018 has been selected. LEED evaluates environmental factors including Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, and Indoor Environment Quality categories. Whole of the building's lifecycle could be evaluated based on the criteria from Building Design and Construction, Interior Design and Construction, Building Operations and Maintenance, Neighborhood Development manuals. LEED has total points of 124.

### *D. GreenSL® Rating System for Built Environment*

The GREENSL® Rating System of Green Building Council Sri Lanka (GBCSL) was launched in 2010 in Sri Lanka. Prerequisites and credits in the GREENSL® Rating System for Built Environment address eight domains;

- Management (MN)
- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (EQ)
- Innovation and Design Process (ID)
- Social and Cultural Awareness (SC)

Total score of GREENSL® Rating System is 100 points and the Certifications from the GREENSL® Rating System for Built Environment will be awarded according to the following range;

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

***E. Comparison of rating systems and points that can be scored against positive effects of vertical greenery.***

**Table 03. Comparison of rating systems against points that can be scored with vertical greenery**

| GM ENRB: 2017 BCA Green Mark scheme for existing non-residential buildings | EED v4 for Building Design and Construction | GREENSL® Rating System |
|---|---|---|
| Greenery Provision (GnP) (2.5 Points) | Sustainables sites (SS)On-Site restoration (01–02 points) | Optimizing occupant comfort And Energy Efficiency (01 Point) |
| Vertical Greenery Applicable greenery areas on building façade (01 Point) | Nonroof and Roof (02 points) | Heat Island Effect, Non–Roof (01 Point) |
| Façade Performance Applicable to all air conditioned buildings (02 Points) | Energy and atmosphere Whole Building Energy Simulation (09 Points) | Optimize Energy Performance (01-10 Points) |
| Air Conditioning System Operating Efficiency Unitary Air-conditioner (08 Points) | Building envelope, opaque: roofs, walls, floors, slabs,doors etc (01 point) | Ozone Depletion (01 Point) |
| Air Distribution System (04 Points) | Green power and carbon offsets (01 point) | Outdoor Air Delivery Monitoring (01 Point) |
| Natural Ventilation (01 Point) | Carbon Dioxide Monitoring (01-02 points) | |
| Energy Efficiency Practices And Features (02 Points) | Thermal comfort (01 point) | Optimizing occupant comfort and Energy Efficiency (01 point) |
| Thermal Comfort (01 Point) | | Heat Island Effect, Non–Roof (01 point) |
| Temperature Contro (0.5 Point) | | Optimize Energy Performance (01-10 points) |
| Indoor Air Quality (IAQ) Management (02 Points) | | Ozone Depletion (01 point) |
| Outdoor Air Control (01 Point) | | Green Power (01 point) |

| GM ENRB: 2017 BCA Green Mark scheme for existing non-residential buildings | EED v4 for Building Design and Construction | GREENSL® Rating System |
|---|---|---|
| Demand Control Ventilation (02 Points) | | Resource Reuse (01 point) |
| Biophilic Features (01 Point) | | For at least 10% of Total Value of Materials (01 point) |
| Advanced green (01 Point) | | Thermal Comfort, Design (01 point) |
| Thermal Comfort with Elevated Air Speed (01 Point) | | |
| **Points 40** | **Points 18** | **Points 17** |

Total points that can be scored from above three rating systems against positive effects of vertical greenery as follows;

**Table 04. Percentage & points scoring form each rating system against the vertical greenery**

| | Points | Percentage of total points |
|---|---|---|
| GM ENRB: 2017 BCA Green Mark scheme for existing non-residential buildings. | 40 | 24.2% |
| LEED v4 for Building Design and Construction | 18 | 14% |
| GREENSL® Rating System | 17 | 17% |

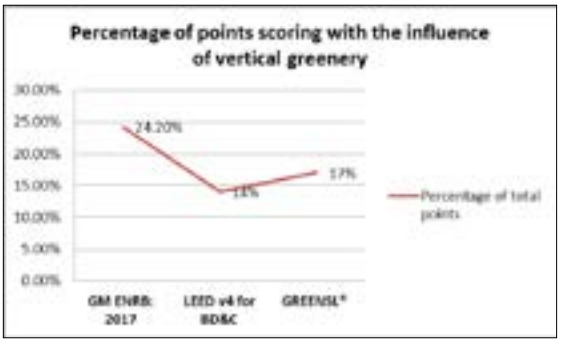


*Figure 1. Percentage of points scoring with the influence of vertical greenery*

## VI. RESULTS AND OUTCOME

### *A. Discussion*

According to the literature survey, to reduce a single degree of Celsius of room temperature, using a split air conditioner, requires almost 5% of its total energy consumption per day (considered as the minimum possible energy reduction). As per literature 3.50C maximum inside temperature reduction is possible with green façade, which can reduce 17.5 % of electricity use for air conditioning (split air conditioner).

The prime result of vertical greenery layer in multi-stored buildings is the thermal comfort. The conclusions from the research are as follows;

- According to the referred literature minimum of 17.5% of electricity use for air conditioning can be reduced by obtaining a $3.5^0$C of temperature reduction.
- Vertical green can be adopted as a counter measure for reduction of indoor temperature and reduction of energy consumption for air conditioning in Sri Lankan context.
- Green facades and green vegetated walls can improve the environment and air quality in cities which are having less green coverage.

- Regarding the heating, less heat accumulation occurs in the case of a vertical green vegetated surface, it is therefore a wise choice to apply greened surfaces especially in warmer climates.
- Among the three selected rating systems, ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) is the most possible point scoring rating system with the use of direct & indirect effects of vertical greenery (with a considerable percentage up to 24.2% from total points).
- Least potential is to score more points in LEED with the use of vertical greenery, since the tool is more advanced and area of interest is covered in many indirect aspects.
- GreenSL® Rating System for Built Environment has some similarities with, ENRB :2017 (BCA Green Mark for Existing Non Residential Buildings) since both green tools are assessing closely similar climatic conditions.

**Recommendations**

From this research, it has been found that, the use of vertical greenery systems on multi-stored buildings can support to improve its thermal comfort mainly and various other green aspects and those impacts support to score more points in rating systems. Further, comparatively high percentage of points can be scored from regional tools. Hence, regional tools give more similar results, it is recommended to use regional tools having similar context or background for local assessment requirements.

Since, it has been observed that a significant percentage of points can be scored with the effects of vertical greenery from rating systems, it is recommended to introduce separate section/sub aspects in rating systems including appropriate criteria to evaluate/identify/quantify positive impacts related to vertical greenery.

**Recommendations for Further Researches**

- Evaluation of effectiveness of horizontal greenery to score points in rating systems related to Sri Lankan context.
- Improving Local Green Rating tools comparing with leading rating systems in the world.
- Thermal effectiveness of the plants used in horizontal and vertical greening systems in relation to Sri Lankan context.
- Thermal effectiveness of the greenery systems related to climatic conditions in Sri Lanka.
- Appliances of green wall systems in different aspects for different building types.

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