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Feasibility Analysis of Converting Existing Low-Rise Office Buildings to Green Rated Buildings in Sri Lankan Context

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Abstract: Green buildings concept is gaining popularity all over the world as the sustainability and efficient energy management are becoming essential requirements during both construction and operational phases of buildings. Adaptation of green concepts, especially for new constructions, was started to practice by local designers and owners during the last few decades. However, conversion of existing buildings to Green buildings is still extremely rare in local context. Misconceptions relevant to conversion costs, lack of awareness relevant to the conversion methodologies and lack of knowledge on benefits of conversions would be probable reasons for this. Also, no previous studies on this matter are available in Sri Lankan context. Accordingly, this study was focused on assessing existing green features of a few selected existing low-rise office buildings (which were not originally designed as Green buildings) and analysing challenges, associated costs and benefits of converting these buildings to green rated buildings. A detailed study by selecting few existing buildings was carried out as per the Green rating assessment of Green Building Council of Sri Lanka (GBCSL). Based on the results of the study, it was found that Green scores under existing conditions of these buildings were very poor. Hence, a strategic approach to elevate these buildings to Green certified buildings was developed, while proposing an average unit rate for calculation of conversion costs that would be useful for estimations at the preliminary planning stage for this type of conversions.

Keywords: Green Building, Sustainability, Energy Efficiency

1. Introduction

The concept of 'Green Buildings' aims to increase the efficiency of utilizing resources such as energy, water, and materials in a building through its lifecycle (during both construction and operation), while reducing their impact on human health and the surrounding environment throughout their lifecycle. This is achieved through better design, construction, operation and maintenance. Therefore, green buildings are high-performance structures that meet certain standards for reducing natural resource consumption [1].

The green building concept is relatively new to Sri Lanka. However, it is rapidly expanding across different industries as the sustainability and the energy efficiency in every industry are becoming essential requirements under present context. The Green Building Council of Sri Lanka(GBCSL) came into existence with this development. Further, considering emerging challenges in the path of sustainable development, the government of Sri Lanka introduced a national program named 'Haritha (Green) Lanka' to achieve sustainable development in the country in 2009.

MAS Thurulie factory at Thulhiriya, National Data Centre of SLT Mobitel at Pitipana, Brandix Eco Centre, Seeduwa and Clearpoint Residencies at Rajagiriya are few eminent projects where it has achieved very high levels of Green ratings from local and international green rating systems.

However, incorporation of green features and obtaining green rating for existing buildings is still not very common practice as per records collected by authors in this regard. For example, as per data of GBCSL official web site(www.srilankagbc.org), only 9 buildings are listed under existing buildings that obtained green rating out of a full list of 32 buildings in the website. Factors like misconceptions on cost of the green construction, lack of awareness on tangible and intangible benefits of green construction, reluctance of adopting new concepts of higher managements would be probable reasons for this. This had been highlighted by Jayoda et al. [2] in their recent publication.

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There are numerous studies [3-14] that highlight the economic and social benefits of adopting a green approach in construction of buildings and some important findings of these studies are discussed below.
Romm [9] has carried out a study on improving productivity through energy-efficient design of buildings. According to eight case studies that had been considered in that study, 16% improvement in productivity of employees had been reported with newly remodelled facilities with energy efficient designs based on green building principles when compared with the productivity before remodelling. As per a study by Kats [10] on costs and financial benefit analysis of 33 Green Buildings (buildings having LEED certifications) over a 20-year study period has indicated that the total financial benefits of green buildings have exceeded average initial incremental investment(for adopting green features)by ten times on average. Specifically, energy savings alone surpass the average incremental costs associated adaptation of green concepts. A local study by Waidyasekara and Fernando [14] has also highlighted the significant increase of level of economic and social benefits by adopting green technologies in building construction. A study done by Weerasinghe and Ramachandra in 2018 [15] on economic sustainability of green buildings has shown financial justification for green building construction through a comparative analysis of selected Green and Non-Green buildings. Also, a study conducted by Weerasinghe and Ramachandra [16] on Green retrofitting of industrial manufacturing buildings has highlighted significant financial benefits of the green retrofitting by performing lifecycle financial analyses for such buildings.
However, any detailed study of assessing operational benefits and financial implications of converting existing low-rise buildings to green buildings have not been carried out in local context. Accordingly, this study focused on operational benefits analysis and financial implications assessment of converting existing low-rise buildings to green buildings. Hence, few existing low-rise office buildings, which were not originally designed considering any green rating, were selected and detailed analyses were performed for each case to upgrade such buildings to green rated buildings as per GBCSL rating system, while performing extensive cost analyses too for such conversions. The development of general cost guideline for conversion of non green rated buildings to green rated buildings was another objective of this study.

2. Methodology

As already discussed, following four office buildings were selected for this study and basic details of sites are listed below:

- Site 1- 3 storey office building having total floor area of 5440 m^2
- Site 2 - 3 storey office building having total floor area of 2361 m^2
- Site 3 - 3 storey office building having total floor area of 1180 m^2
- Site 4 – 2 storey office building having total floor area of 1135 m^2

All these buildings are government office buildings in Northwestern province and photographs of above sites are presented in Figure 1.

Figure 1(a)- Site 1- 3 storey office building having a total floor area of 5440 m^2

Figure 1(b)- Site 2-3 storey office building having a total floor area of 2361m^2

Figure 1(c)- Site 3 -3 storey office building having a total floor area of 1180m^2

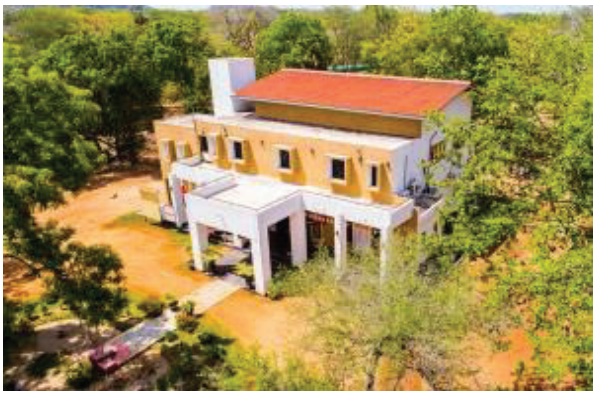

Figure 1(d)- Site 4 - 2 storey office building having a total floor area of 1135m^2

Figure 1 - Considered sites for the study

Table 1 presents basic information of sites considered for this study. At all sites, electricity is provided by Ceylon Electricity Board (CEB) and potable water is provided Water Supply and Drainage Board (NWSDB). In the case of Site 3 only, a solar panel system having nominal rated capacity of 3kW is available in parallel with CEB power supply. No rainwater harvesting scheme has been installed at any of these sites. It has reported a very high electricity demand for Site 1 as most of the internal areas of this building has been air-conditioned. Further, a large number of street and garden lights are available in this site.

According to rainfall data collected from Meteorological Department relevant to the closest weather monitoring station (Kurunegala), the lowest monthly rainfall reported for Sites 1, 2 and 3 are 75 mm. For Site 4, applicability of this rainfall data is highly questionable, and as per local records of the site, rainwater harvesting would not be effective there.

For the assessment of these buildings in green building perspective, Green^{SL} rating system developed by GBCSL was used. There are two separate Green rating systems published by GBCSL for assessment of new constructions and existing buildings. Since these are existing buildings, the Green^{SL} rating system Version 01, published for assessing existing buildings in 2013 (even though GBCSL is planning to issue a revised version in this regard it is not officially released yet), was used.

Table 1 - Basic information of sites

	Site 1	Site 2	Site 3	Site 4
Total land area (m^2)	3274	4046	1044	17740
Total floor area of building (m^2)	5444	2361	1176	1135
Total building footprint(m^2)	2070	900	430	855
Total landscaped area(m^2)	443 Internal roads, footpath in the site are paved by Premix	79 Interlock paved	207 Gravel and interlock paved	4283.5 Gravel and interlock paved
Total parking area(m^2)	759 Premix, Concrete and Gravel	294 Interlock paved	66 Interlock paved	100 Gravel
No of employees	700	180	204	75
Average potential electricity demand per month from grid (kWh)	13669	198	84	223
Average portable water demand per month (m^3)	553	118	120	120

As per this rating system, marks are assigned under eight (8) criteria during evaluation of a building. These eight criteria and number of points allocated for each criterion are listed in Table 2.

Table 2 - Numbers of points allocated for each criterion in Green^{SL} rating system

	Criteria	Total number of points allocated
1	Management	3
2	Sustainable site	21
3	Water efficiency	16
4	Energy & Atmosphere	26
5	Material and Resources	10
6	Indoor Environmental air quality	13
7	Innovation and Design Process	6
8	Social and Cultural awareness	4
	Total	100

According to the calculated total green score for a building, a final rating for the building is decided as per the criteria below:

Score of 40- 49 - Green^{SL} Certified rating
Score of 50- 59 - Green^{SL} Silver rating
Score of 60- 69 - Green^{SL} Gold rating
Score of above 70- Green^{SL} Platinum rating

As the initial step of the study, green scores of each building were calculated considering existing conditions and existing features of buildings.

Then, the green rating for each building was identified separately. None of the above buildings were able to achieve at least Green certified ratings and very poor green scores were reported (Details of these scores are presented under Results and Discussion). Secondly, possible improvements/modifications that can be incorporated to these buildings to achieve at least Green Certified rating was extensively studied individually. Identification of these improvements/modifications were done considering factors like initial costs for proposed modifications/improvements, level of disturbances to existing functions and operations of the building, structural concerns of the building, existing climatic conditions in the area, etc. Once, proposed modifications/improvements are identified, high-level implementation proposals for modifications/improvements were developed individually for the selected cases and cost estimations for proposed changes were developed individually. According to the calculated costs and green ratings of individual cases, development of general cost guidelines was planned.

3. Result and Discussion

3.1 Green scores under existing conditions

Calculated Green scores as per Green^{SL} rating system for the buildings considered under existing conditions are presented in Table 3.According to the results presented in Table 3, the highest green score of 25 has been reported for Site 3 and the lowest green score of 13 was reported in Sites 1 and 2. The presence of solar panel system, the implementation of effective solid waste management system and the presence of sustainability site requirements (presence of high level perviousness in the surrounding garden due to availability of unpaved land and usage of interlocking blocks for all roads and footpaths, and availability of tree canopy for the parking area) have earned relatively higher marks for Energy and Atmosphere, Material & Resources and Sustainable site criteria at Site 3.

Table 3 - Green scores as per Green^{SL} rating system for buildings considered under existing conditions

	Criteria	Score of Site 1	Score of Site 2	Score of Site 3	Score of Site 4
1	Management	0	0	0	0
2	Sustainable site	3	4	7	7
3	Water efficiency	1	1	1	0
4	Energy & Atmosphere	1	0	9	0
5	Material & Resources	5	5	5	5
6	Indoor Environmental air quality	3	3	3	3
7	Innovation & Design Process	0	0	0	0
8	Social & Cultural awareness	0	0	0	0
	Total	**13**	**13**	**25**	**15**

Hence, it has a comparatively high Greenscore as given in Table 3. However, nonexistence of solar panel systems and availability of impervious gardens (in case of Sites1 and 2) have contributed for the very low Green scores for other three sites. In summary, all four sites are having low Green scores and none of the sites is having at least Green certified rating under Green^{SL} rating system.

Accordingly, as already mentioned, detailed studies were individually conducted for each site to identify strategies to elevate each building to Green Certified level.

3.2 Improvements of Site1 to upgrade to Green certified level

Since the conversion of these buildings to Green Certified buildings should be planned under the minimum cost and the minimum disturbances to present operations at sites, it was focused on five (5) criteria to improve the Green score. The five (5) criteria that were identified in this regard were Management, Sustainable site, Water efficiency, Energy and Atmosphere and Indoor environmental quality. Firstly, under Management, the development of building user's guide and environmental management plan were proposed. With the introduction of the building user's guide and management plan, it would be able to claim four (4) marks under Management. The lowest cost was reported for this criterion (refer Table

4) as it only involves preparation of guides and manuals.

Under Sustainable site criteria, it was planned to increase the score from 3 to 12. Accordingly, introduction of dedicated parking for low emitting and fuel-efficient vehicles, maintaining exact parking capacity at site according to local authority guidelines, introduction of storm water design (quantity and quality control) by changing present tarred area to pervious interlocking block paved area and reduction heat island effect of roof by application of certified solar reflective paint were proposed.

As it can observed in Figure 2, presently most of the parking areas and internal roads are having premixed surfaces.

Figure 2 - Premixed parking areas of the Site 1

The aim of introducing these changes is claiming of 9 additional points.

Under water efficiency, it was planned to claim 5 additional points. Measuring of water usage of building subsystems, introduction of rainwater harvesting system to utilize collected rainwater for toilet flushing and changing of existing plumbing fixtures to high-efficiency fixtures were proposed in this regard. As per the calculation performed based on roof area of buildings and average minimal monthly rainfall data for the area, it was able to achieve minimum of 50% reduction of potable water consumption for toilet flushing at this site through rainwater harvesting. According to the cost calculations done to estimate additional costs involved for transition of this building to Green certified building, the second highest percentage cost (31.1%) from total conversion cost was reported under water efficiency criterion (refer Table 4). The structural changes and necessary construction that would have to be introduced for collection and storing of rainwater, necessity of introducing new plumbing network to separately distribute potable and harvested rainwater (propose to use for toilet flushing and gardening) and higher prices of high-efficiency fixtures were main reasons for this considerably high cost.

With the objective of claiming 8 points by introducing on-site renewable energy system, it proposed to install a 9kW solar panel system which would be equivalent to the 10% of total average energy consumption of this building (as per Green^{SL} guidelines). The percentage cost for this is high as 36% (it is the highest reported percentage cost) of total cost for conversion of this building to Green certified building. The considerably high energy consumption of this building (due to the availability of Air-conditioned environment for most part of the building and usage of considerable number of street and garden lights)is the main reason for the relatively high conversion cost for Energy and Atmosphere in this site.

Under Indoor environmental quality criterion, it was proposed to introduce permanent CO_2 monitoring systems, Green Cleaning Program and Indoor Integrated Pest Management system with the intention of claiming 4 additional points for this site.

The breakdown of points that are additionally claimed by these proposed modifications and involved cost for proposed modifications are presented in Table 4. According to Table 4, the revised Green score is 42 and total additional cost for proposed modifications is Rs. 24,740,000.00

Table 4 - Revised Green Score of Site1 with associated additional costs

Criteria	Init. Score	Revised Score	Addit. Cost (Million LKR)
Management	0	4	0.50
Sustainable site	3	12	7.12
Water efficiency	1	6	7.70
Energy & Atmosphere	1	8	8.9
Material and Resources	5	5	-
Indoor Environmental air quality	3	7	0.52
Innovation and Design Process	0	0	-
Social and Cultural awareness	0	0	-
Total	**13**	42	24.74

3.3 Improvements of Site 2 to upgrade to Green certified level

Changes/improvements to upgrade this building too was developed under the same strategy.

Under Management, the development of building user's guide and environmental management plan were proposed to obtain 4 additional marks as in Site 1.

Under Sustainable site criteria, it was planned to increase the score from 4 to 12. Accordingly, introduction of dedicated parking for low emitting and fuel-efficient vehicles, maintaining exact parking capacity at site according to local authority guidelines and reduction heat island effect of the roof by application of certified solar reflective paint were proposed to claim additional points. The changing of paving was not required at this site as pervious interlocking paving was available at the site. However, it had to reduce the excessive paved area by introducing natural landscaped features for the part of the paved area as per requirements Green^{SL} guidelines.

Water efficiency aspect was addressed by the same approach adopted in Site 1. As per the existing roof arrangement of this building (as shown in Figure 3) and the load carrying capacity of the slab immediately below the roof, it cannot install typical polyethylene tanks to store collected rainwater at this site.

Figure 3 - A photograph of building at Site 2 at Roof level

Hence, a special reinforced concrete water tank was proposed to suit for the site condition. Accordingly, a relatively high cost was reported for conversion activities relevant to water efficiencies for this site. Hence, the highest percentage cost of 52.7% out total additional cost for transition to Green certified level was reported for this criterion in this site.

Under Energy and Atmosphere, additional 8 points were claimed with the proposal of introducing solar panel system. Due to low energy consumption at this site due to minimal air-conditioned areas, the cost associated for solar panel installation is relatively low when compared with Site 1.

Four (4) additional points were claimed under Indoor Environmental air quality criterion using the same approach adopted at Site 1.

The breakdown of points additionally claimed by these proposed modifications and involved cost for proposed modifications are presented in Table 5.

Table 5 - Revised Green Score of Site 2 with associated additional costs

Criterion	Init. Score	Revised Score	Addit. Cost (Million LKR)
Management	0	4	0.50
Sustainable site	4	12	2.98
Water efficiency	1	8	5.27
Energy & Atmosphere	0	8	0.84
Material and Resources	5	5	-
Indoor Environmental air quality	3	7	0.42
Innovation and Design Process	0	0	-
Social and Cultural awareness	0	0	-
Total	**13**	44	10.01

3.4 Improvements of Site 3 to upgrade to Green certified level

An almost similar approach to Site 2 was adopted for this site as well to upgrade the building to Green certified building. However, since this site was already having a Solar panel system, no additional cost was associated with Energy and atmosphere criterion as it can be observed in Table 6.It was not able to propose installation of a roof level water tank at this site to store harvested rainwater due to the roofing arrangement at the site. Hence, a separate reinforced concrete water tank structure was proposed under rainwater harvesting system for this site. Accordingly, considerably high percentage additional cost (63.6%) was reported under Water efficiency criterion in this case.

Table 6 - Revised Green Score of Site 3 with associated additional costs

Criterion	Init. Score	Revised Score	Addit. Cost (Million LKR)
Management	0	4	0.50
Sustainable site	7	12	0.77
Water efficiency	1	4	2.86
Energy & Atmosphere	9	9	-
Material and Resources	5	5	-
Indoor Environmental air quality	3	7	0.37
Innovation and Design Process	0	0	-
Social and Cultural awareness	0	0	-
Total	**25**	40	4.50

Table 7 - Revised Green Score of Site 3 with associated additional costs

Criterion	Init. Score	Revised Score	Addit. Cost (Million LKR)
Management	0	4	0.50
Sustainable site	7	12	1.04
Water efficiency	0	4	0.92
Energy & Atmosphere	0	8	0.84
Material and Resources	5	5	-
Indoor Environmental air quality	3	7	0.52
Innovation and Design Process	0	0	-
Social and Cultural awareness	0	0	-
Total	**15**	40	3.82

3.5 Improvements at Site 4 to upgrade to Green certified level

Green scores and additional costs involved in upgrading Site 4 is presented in Table 7. The major difference in this site was comparatively lower scoring under water efficiency. The main reason for this was inability to collect enough water through rainwater harvesting at the site due to climatic condition of the site as already discussed. However, implementation of other possible measures such as Measuring of water usage of building subsystems and changing of existing plumbing fixtures to high-efficiency fixtures were proposed for this site as well to claim maximum possible marks under Water efficiency. The highest percentage (27.2%) out of total conversion cost in this case was reported under Sustainable site criterion as it can be observed in Table 6.

3.6 Common challenges observed when proposing changes/alterations to achieve higher Green scores

Common challenges observed to achieve higher green scores are discussed below.

1. The main common challenge that was noted was difficulties of introducing rainwater collection and installing rainwater collection tanks at an appropriate location due to existing designs. For example, for Site 1 and Site 3, new water tank structures had to be proposed to place rainwater harvesting tanks to achieve required head for the water supply after collection rain water. However, in other sites, it was able place rainwater harvesting tanks within existing buildings with necessary modifications.
2. It had to propose a separate water supply network to supply collected rainwater for toilet flushing and irrigation requirements as presently water for both drinking and other requirements were supplied under single common systems at all sites. For this alteration, a considerable cost was involved at each site. However, it became essential to introduce these alterations at each site as it was decided to use rainwater without special purification or treatment for toilet flushing and irrigation due to large cost involved for the purification and treatment to convert rain water to potable water.

3. Non availability of sufficient rainwater due to the climatic conditions at certain sites may also become a concern as in Site 4.

4. Presence of roofs with steep slopes, reinforced concrete roof slabs etc. may also become concerned when planning of solar panel installations. However, it was able to propose solar panels for all sites considered in this study as all considered buildings were having roofs with appropriate roof angle and adequate roof areas to harvest required amount of solar energy at each site.

3.7 Unit area cost calculation for sites

With the objective of identifying general cost guideline for this type of green conversions for conventional low-rise office buildings to Green certified buildings, unit area cost calculation was performed for all sites and was tabulated in Table 8.

Table 8 - Associated costs and revised Green ratings of all considered sites

Site	Final Green Score	Initial Green Score	Associated cost for conversion Rs. Million	Total build. area (m^2)	Unit area cost for conversion Rs./m^2
Site 1	42	13	24.74	5445	4544
Site 2	44	13	10.01	2361	4240
Site 3	45	25	4.50	1176	3827
Site 4	40	15	3.82	1135	3365

As can be observed in Table 8, the highest unit area cost for conversion was noted in site 1. The fairly high cost involved for solar panel installation to cater for at least 10% of energy demand in this site (due to large air conditioning volumes and large number of street and garden lights) was noted as the main reason for this highest unit area cost. The lowest unit area cost was reported for Site 4.Relatively lower cost for water efficiency criterion at that site (as already mentioned, rainwater harvesting was not proposed for this site due to minimal average rainfall at the site) would be the main reason for the minimum unit area cost for green conversion at that site. However, for standardisation of results, a revised unit area cost for that site was further calculated considering installation rainwater harvesting system in the site as well. According to that revised proposal, the unit area cost was found as Rs.4854 per m^2 with an improved Green score of 42 (see Table 9). Also, for Site3, a revised unit area cost was calculated while adding cost for installation of solar panels(even though it is already available) to standardize the unit costs. Accordingly, the revised unit rate for Site 3 was found as Rs.4533 per m^2.

Table 9 -Standardized costs and revised Green ratings of all considered sites

Site	Final Green Score	Initial Green Score	Associated cost for conversion Rs. Million	Total build. area (m^2)	Unit area cost for conversi on Rs./m^2
Site 1	42	13	27.74	5445	4554
Site 2	44	13	10.01	2361	4240
Site 3	45	25	4.50	1176	4533
Site 4	40	15	3.82	1135	4854

After this standardization, a minimum variation unit area cost was found among all sites. Accordingly, an average unit area cost for conversion of ordinary office building to a Green certified building as per Green[SL] rating system was calculated and it was found as Rs.4545 as per present market prices of Sri Lanka. It would be possible to use this value for budgeting purposes with reasonable accuracy, when it requires to prepare an estimate to upgrade existing low rise office building to a Green certified building in future projects.

3.8 Benefit analysis of conversion to Green certified buildings

According to proposed changes at sites, tangible benefits such as saving of electricity costs and saving of cost for non-drinking water can be identified. Such savings of individual sites are tabulated in Table 10. No savings in non-drinkable water was calculated for Site 4 as effective rainwater harvesting cannot be achieved at that site. In case of other sites, percentage savings in non-drinkable water were calculated based on actual monthly weather data and water consumption records of each site.

Table 10 -Percentage savings of electricity and non drinkable water

Site	Average percentage saving in non-drinkable water (%)	Percentage saving in electricity cost (%)
Site 1	63	11
Site 2	83	39
Site 3	63	100
Site 4	-	35

Also, considerable amounts of electricity cost savings were also reported at each site. The highest percentage saving of 100% was reported in Site 3. Low electricity demand at that site would be the reason for reporting highest percentage saving at that site. Due to the very high electricity of Site 1, the lowest percentage saving of electricity was reported at that site.

In addition to these tangible benefits, intangible benefits such as improvement of quality of working environment for building users (due to the introduction of processes under Indoor Environmental air quality criterion, actions taken to minimise heat island effects, etc.) can be expected. Minimizing of rainwater runoffs to facilitate flood controlling and upgradation of outdoor environment for much greener environment are other intangible benefits that were identified when upgrading these buildings to Green certified buildings.

4. Conclusion

As already discussed, this study was focused on operational benefit analysis and financial implication assessment of converting existing low-rise buildings to green buildings. As the initial step, a review of green ratings was carried out on selected ordinary low-rise buildings. According to results of the study, extremely poor Green ratings for all sites were reported. The highset score was reported for Site 3and even that score was 25. This clearly indicates the lack of attention paid on incorporating Green concepts in construction of buildings even in recent past. This further indicates poor energy management, ineffective and inefficient utilization of scared resources like water, and environmental unfriendly building management practices of these buildings.

Accordingly, possibilities of upgrading these sites to Green rated condition as per GBCSL rating system was studied in detail. As per the result of analysis performed in this regard relevant to selected sites, it was noted that the claiming of required additional marks can be achieved with a fair effort and reasonable cost under criterion of Management, Sustainable site, Water efficiency, Energy and Atmosphere and Indoor environmental quality in general. In financial perspective, it was found that average per area upgrading cost to elevate this type of site to Green certified level would be Rs.4545 per m^2 (Rs.422 per sqft). This is a comparatively very low cost when one considers the tangible and intangible benefits received by users and owners of buildings. Further, this rate would be possible to be used for estimation purposes when upgrading this type of building to a Green certified building, where such data is lacking in the local context.

Further, it was found that incorporation of certain green features like rainwater harvesting would not always be possible and effective due to climatic conditions of certain sites. Also, implementation of rainwater harvesting systems was found as the main challenging and costly task in conversion of an ordinary existing building to a Green rated building. Shape and slope of roofs, difficulties of placing rainwater collection tanks and difficulties of introducing new plumbing system for distribution of collected rainwater are some critical factors that affect the implementation of rainwater harvesting in this type of existing buildings.

However, as per results of this study, necessity and possibility of upgrading existing general office buildings in the country to at least to Green rated status was clearly identified and further research on this subject area is highly recommended to convert existing buildings to Green buildings in an effective and efficient way.

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