COMPARATIVE STUDY OF GREEN BUILDING RATING SYSTEMS: IN TERMS OF WATER EFFICIENCY AND CONSERVATION

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ABSTRACT

The construction industry puts a great effort on achieving sustainable development. This is because in the construction industry a lot of natural resources are being consumed. Water is one of the most important natural resources for the development of all economic activities taking place to care for the environment and quality of life in the society. Therefore, availability and management of water resources is essential for a long term sustainability of any country. At present, many environmental assessment tools or green building rating systems developed and accepted by many countries. Simply, green building rating systems provide best standards and assist to fulfil green building practices. Each rating system addressed key sustainable parameters: energy, water, site, indoor environmental quality and materials in order to build sustainable environment.

Since freshwater scarcity has become a global issue, this paper aims to investigate how and in what strategies water efficiency and conservation is discussed in the existing green building rating systems. Primarily, literature review and documentary review were used as the main research method. The eleven green building rating systems which are designed for new construction were considered and were analysed to compare in terms of the key requirements/strategies and credits awarded for water efficiency and conservation in the rating systems. It was found that in terms of water, intention of each rating system is to reduce potable water consumption compared to the benchmark buildings. It further address in many directions to conserve and monitor water throughout the project life cycle. However, few rating systems have only addressed water conservation and water pollution during the construction phase. Furthermore, the paper enables to analyse the priority given for the water efficiency compared to other sustainable parameters.

Keywords: *Construction Industry; Green Rating Systems; Sustainable Development; Water Efficiency and Conservation.*

1. INTRODUCTION

The concern for environment and sustainable development is being increased in world wide. From this dimension, there has been a rapid development in the number of environmental or green building assessment methods, tools, and certificates especially under the popular buzz words 'sustainability' and 'green'. Boonstra and Pettersen (2003) emphasized the requirement of environmental assessment methods which respond to environmental issues and define sustainable levels. According to Hiete *et al.*, (2011), various building rating systems make use of hierarchical criteria systems to evaluate the buildings with respect to the different aspects of sustainability. Fowler and Rauch (2006) explained that sustainable building rating systems are used to examine the performance or expected performance of a 'whole building' and translate performance assessment into a tool that can be used to compare the building performance of other buildings or a performance standard. As stated by Gowri (2004), green building design challenges to go beyond the typical building code requirements to improve overall building performance and minimize life-cycle environmental impact and cost. Cole *et al,* (n.d.) mentioned that motivates change in the construction industry and market transformation by attaching a label of environmental performance that increases the real market value of buildings improving

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environmental qualities. Moreover, Sev (2009a) recognized, building environmental assessment tools have become widespread in recent years and attracted the construction sector and public awareness in sustainability. Therefore, at present, construction industry is one of the industries talk more on sustainable and environmental performance. Thus, use of environmental tools to measure project performance becomes a compulsory item in industry stakeholders' project agenda.

As revealed in literature, environmental assessment systems or tools (Boonstra and Pettersen, 2003; Cole et al.,n.d), building environmental assessment tools (Sev, 2009a; Wallhegan, 2013); sustainable building assessment systems (Fowler and Rauch, 2006; Gibberd, 2005), green building rating systems (Gowri,2004), building performance assessment methodologies (Sinou and Kyvelou,2006),and green building assessment tools (Ali and Nsairat,2009) are some of the common terms used by the researchers to explain rating systems which developed to measure or evaluate performance of projects under sustainable development. Although each gives similar meaning, this research is focused buildings rather than environment and also rating systems rather than assessment, therefore, the term 'green building rating system' (GBRS) is referred in this paper. The purpose of this paper is to compare and contrast the green building rating systems achieving the following objectives.

- Identify green building rating systems and key environmental parameters
- Compare the rating systems reflecting values and priorities of key environmental parameters
- Discuss importance of water as a sustainable material
- Analyse key requirements and credits awarded for water efficiency and conservation in green rating systems
- Discuss credential given for water handling and monitoring during construction phase in GBRS

2. BACKGROUND TO THE RESEARCH

2.1. INTRODUCTION TO GREEN CONCEPT AND GREEN RATING SYSTEMS

Green building concept has become a flagship of sustainable development in this century that takes the responsibility for balancing long-term economic, environmental and social health (Ando *et al.*, 2005 cited in Ali and al Nsairat, 2009). Numerous benefits of green buildings were identified by many researchers. For example green buildings are energy efficient, water conserving, durable and non-toxic and high recycled content materials (Ali and al Nsairat, 2009); increases occupant productivity, enhances marketability , reduce operating cost (Fowler and Rauch, 2006); longer lifespan, reduced replacement and operation cost (Davis Langdon, 2007). Moreover, Sev (2009a) stated green building optimises efficiencies in resource management and operational performance; and minimises risks, which threaten the human health and environment'.

As stated by Fowler and Rauch (2006), there is hundreds of building evaluation tools that focus on different areas of sustainable development and are designed for different types of projects world-wide. These tools include life cycle assessment, life cycle costing, energy systems design, performance evaluation, productivity analysis, indoor environmental quality assessments, operations and maintenance optimization, whole building design and operations tools, and more. Ali and Nsairat Al (2009) divided these assessment tools into two groups. First group includes criteria based system such as BREEAM (Building Research Establishment's Environmental Assessment Method), LEED (Leadership in Environmental and Energy Design), GBTool, Green Star. The second group includes life cycle assessment (LCA) methodology. As Ali and Nsairat Al (2009) stated, since late 1990s methods for environmental assessment of building based on LCA have been developed for the building sector and also as stated by Cole *et al.*, (n.d), the field of building environmental assessment has matured remarkably quickly since the introduction of BREEAM in 1990. The BREEAM is the world's longest established environmental assessment method for the UK building industry as the benchmark for assessing the environmental performance. The primary aim is to mitigate the life cycle impacts of new buildings on the environment in a robust and cost effective manner (BREEAM, 2011). In the meantime, LEED is the most popular and widely used green building assessment tool for

buildings. It was first introduced in 1998 in the US (USGBC, 2013). As Gowri (2004) mentioned, later many rating systems were developed based on the original international rating systems such as LEED and BREEAM, or integrating few other rating systems. BREEAM Canada, BREEAM Greenleaf, LEED India are examples of such efforts. As stated by Boonstra and Pettersen (2003), the latest tools address environmental issues not only during particular design stages but also in building operation. It is true, because the main objective of many green assessment systems is promote and integrate whole building design while reducing environmental impact and recognising the environmental leadership. Simply, each rating system designed to reflect the different phases in the building life cycle. Moreover, Green Star South Africa identified green rating system as a common language and standard method of measurement for green buildings (GBCSA, 2010).

2.2. IMPORTANCE OF WATER IN SUSTAINABLE DEVELOPMENT

As described by Sev (2009b), the relationship between sustainable development and the construction industry has become clear, since construction is of high economic significance and has strong environmental and social impacts. Moreover, Sev (2009b) mentioned while traditional design and construction activities focus on cost, performance and quality issues, sustainable design and construction adds the issues of minimization of resource consumption, environmental degradation and healthy and comfortable built environment. As stated by Dalton and John (2008), sustainability issues need to be addressed at the development level as a whole. The report of David Langdon (2007) explained that rapid change in priorities in the construction industry in Europe, North America, Asia and Australia with sustainability and the issues of global warming and resource conservation quickly are becoming high priority subjects. Furthermore, Fawcett *et al.* (2012) mentioned an objective of sustainability is to avoid or minimise any damaging future consequences from current consumption and investment activities. Therefore, many green building assessments discussed and identified protection and conservation of water as one of the fundamental principles concern for sustainable construction. As mentioned by Guggemos and Horvath (2006), construction industry is one of the largest users of water along with energy and material resources. Moreover, many studies (Economist, 2008; OECD, 2008) predicted that water is a scarce resource for many parts of the world and availability of potable water is inadequate and shrinking (ABB review, 2011) and volume of potable water use for construction activities are high (Green roads TM manual V1.5). McComack *et al.* (2007) mentioned that while an enormous amount of water is used to operate buildings, a considerable amount of water is also used for extraction, production, manufacturing, delivery of materials to site and the actual on-site construction process. The report of David Langdon (2007) explained that, a waterless future ultimately means cost increases; desalination, recycled water, third pipes, grey water, black water, water tanks etc. Thus, all these facts prove the importance of addressing water in sustainable development.

3. RESEARCH METHOD

The materials compiled in this document through literature review and information available in internet are taken directly from the rating system websites. Although, the search identified several rating systems, but due to inconsistency of evaluation criteria, and for want of authorization to download, some rating systems could not be considered for the analysis though they are well- known in the construction industry. For example Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) Japan; Green Globes-Canada; GBTool are some of them. Moreover, while selecting rating systems, screening criteria such as relevance, measurable, applicability and availability (Fowler and Rauch, 2006) were considered. The interpretations of the terms used are as follows. ‘Relevance- does the rating system provide a “whole building evaluation” or individual design feature?; ‘Measurable-‘does the rating system use measurable characteristics?’; Applicability- does the rating system designed for new construction and non-domestic?’ and Availability- Is the latest version of rating system easily available? After screening all the aspects, the sample consisted with the eleven green rating systems covering Asia, Europe, North America,

Australia and South Africa as shown in Table 1. Furthermore, Table 1 gives reference for the document referred for the analysis, number of category (water, energy, site.) and certification level (Benchmarks) considered under each GBRS.

Table 1: Summary of Green Building Rating Systems

No.	Green Rating Systems	Country	Document considered	*Nr. of category	Certification Level
1	BREEAM	UK	NC 2011 SD5073	8	Pass, Good, Very good, Excellent
2	LEED	US	NC-2009	7	Certified, Silver, Gold ,Platinum
3	HK- BEAM	Hong Kong	2004 V4/04	6	Bronze, Silver, Gold ,Platinum
4	Green Star-AUS	Australia	2011 Office v3	9	Best Practice, Australian Excellence, World Leadership
5	BCA Green Mark	Singapore	NRB/V4.1/2013	5	Certified, Gold , Gold Plus, Platinum
6	GRIHA	India	2010 Volume 1	4**	1 Star, 2 Star, 3 Star, 4 Star, 5 Star
7	Green Star -SA	South Africa	2008 Office v1	9	Best Practice, South African Excellence, World Leadership
8	GBI	Malaysia	NC 2009 version 1	6	Certified, Silver, Gold ,Platinum
9	Green Star -NZ	New Zealand	Office 2009	9	Good Practice, Best Practice, NZ Practice, World Excellence
10	GreenSL	Sir Lanka	2010 Version 1	8	Certified, Silver, Gold ,Platinum
11	Pearl -BRS	Abu- Dhabi	2010 Version 1.0	7	1 Pearl, 2 Pearl, 3 Pearl, 4 Pearl, 5 Pearl

* Nr. of category counted including innovation category

** In GRIHA (Green Rating for Integrated Habitat Assessment) 34 criteria discussed under 4 main categories.

4. ANALYSIS OF KEY ENVIRONMENTAL PARAMETERS IN GREEN RATING SYSTEMS

Green rating systems cover number of environmental and social parameters that assess phases in a building life cycle. As stated by Gowri (2004), terminologies, structure of rating systems, relative importance of the environmental categories, and documentation requirements for certification are differed from one given to another rating system. This is because each country is launching indicators/parameters for its own market even though there are some similarities. In general, Site, Water, Energy, Materials and Indoor Environment are the five main environmental categories focus in GBRS addressing building design and life cycle performance (Gowri, 2004). Apart from that section like management, social & cultural awareness, pollution, transport could be seen within the rating systems. It is pertinent to note that in all the GBRS, there is a provision for 'Innovation Design' and allocated few credits for it. The BREEAM has given the maximum credit for Innovation. As mentioned by Gowri (2004), each category has number of prerequisites and all the projects must meet all the prerequisites to qualify for certification because prerequisites are critical since no credits points allocated towards the overall score but must be met irrespective of meeting other credit requirements.

After reviewing each system, it was identified many rating systems were given more credits for the 'Energy section' (Please Refer Figure 1). In BCA Green Mark Singapore, out of 190 credits, 116 credits assigned for energy category and in order to achieve green mark award, minimum 30 points required to fulfil from the energy section (BCA, 2013). In HK-BEAM (Hong Kong - Building Environmental Assessment Method), even allocated more credits for energy, in order to qualify for the overall grade it is necessary to obtain a minimum % of credits from Indoor Environmental Quality (IEQ) (HK-BEAM, 2004). This explains number of criteria used and structure may vary strongly between the systems. Figure 1 provides the overall picture of credits distribution among the key parameters and weightage (%) only shown for the main key environmental parameters in the order of Sustainable Sites, Water, Energy, IEQ and Materials. In addition, Green Star - Australia rating system allocated significant credits for Transport (C-11) and Emission (C-19) aspects. The BREEAM allocated for 9 credits for transport, 7 credits for waste and 13 credits for pollution aspects

respectively. In addition, 10 credits allocated for the 'Innovation work' in the BREEAM. In Pearl-BRS assigned 43 points for the precious water including storm water which represents 23.9% from the total.

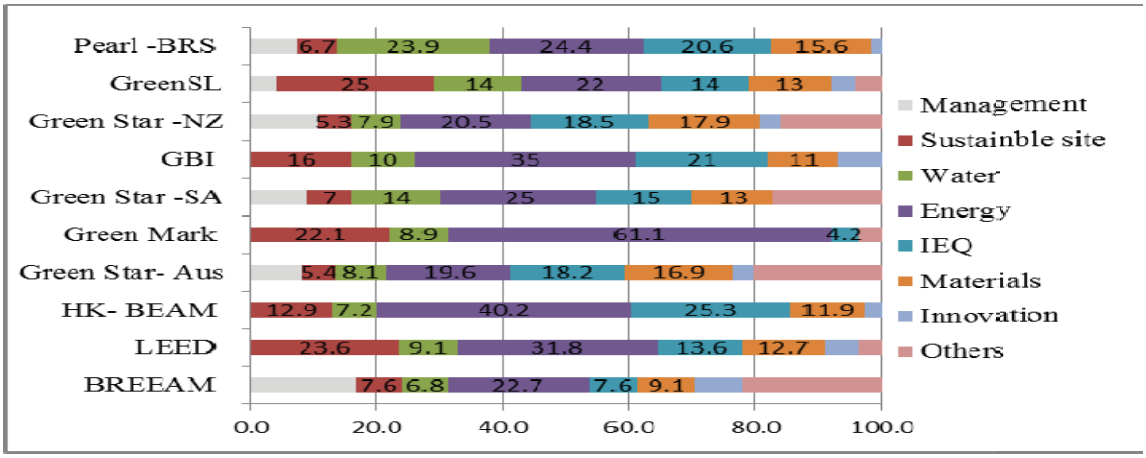

Figure 1: Analysis of Key Parameters Identified by Green Building Rating Systems

5. KEY REQUIREMENTS AND CREDITS AWARDED FOR 'WATER' IN GREEN RATING SYSTEMS

Table 2: Water Requirements Identified by Green Building Rating Systems

NO	*REQUIREMENTS*	*DESCRIPTION*
1	Reduce building water use	Reduce potable water consumption in the building through the use of water efficient components (using efficient fixtures like low-flow fixtures and appliances, etc.)
2	Water efficient plumbing fixtures and fittings	To reduce potable water & unregulated water consumption by encouraging specification of water efficient equipment
3	Water efficient landscaping / irrigation	Intent is to limit or eliminate the use of potable water for landscape irrigation and to minimize the load on the municipal water supply and depletion of groundwater resources
4	Water recycle and reuse inclu**d**ing rainwater	Encourage rainwater harvesting and recycling of grey water in order to reduce freshwater consumption
5	Water monitoring, leak detection & prevention	Reduce wastage of freshwater through monitoring, reduce the impact of water leak and allow for auditing of water use
6	Water Quality	Intent is to ensure that quality of potable water delivered to building users is satisfactory and meet the water quality norms as prescribed in the standards for various applications
7	Innovative waste water technologies	To reduce wastewater generation and potable water demand while increasing the local aquifer recharge
8	Innovative water transmission	To limit the use of non-renewable energy for water transmission
9	Efficient discharge to foul sewers	Reduce volumes of sewage discharge from buildings
10	Water efficiency in air conditioning (Heat rejection water)	To limit or eliminate the use of potable water for air conditioning make-up while using of condense water for irrigation
11	Water Consumption for fire systems	To limit or eliminate the use of potable water for fire systems by promoting the use of recycled water and/or alternatives
12	Efficient water use during construction	Minimize the use of potable water during con truction

As discussed in previous sections 'Water' is one of the key environmental parameters identified in green building rating systems. The purpose of this section is to analyse, how and what extent green rating systems address the water element in order to sustain water resources for the future generation. It was identified that intent of each green rating system is to reduce or eliminate the use of potable water for many purposes during the project lifecycle. Some GBRS included prerequisites for water section, LEED and Pearl BRS are examples for such. All the requirements (sub- sections) identified under water section in each rating system summarised into twelve headings as shown in Table 2. In addition, Table 2 provides the brief description to explain the commitment expect from each requirement. It is important to note, the storm water management did not consider for the analysis. From the sample, Pearl BRS Abu-Dhabi is the only rating system addressed storm water management under the water section. All other GBRS addressed storm water management under the sustainable site or management sections. Table 3 provides the matrix which shows credits distribution against the water requirements addressed by each GBRS.

Table 3: Matrix for Credits Distribution against Water Requirements and GBRS

	Water requirements and credits distributions in GBRS	**BREEAM-UK**	**LEED -US**	**BEAM - Hong Kong**	**Green Star- Australia**	**Green Mark- Singapore**	**GRIHA - India**	**Green Star- South Africa**	**GBI- Malaysia**	**Green Star- New Zealand**	**GreenSL - Sri Lanka**	**Pearl BRS-Abu Dhabi**
1	Reduce building water use	5		3	5		2	5		7	4	19
2	Water efficient plumbing fixtures and fittings	1	4	2		10			2			
3	Water efficient landscaping /irrigation		4	1	1	3	3	3	2	1	4	8
4	Water recycle and reuse including rainwater			3			5		4			
5	Water monitoring, leak detection & prevention	3		2	1	2		2	2	2		4
6	Water Quality			2			2					
7	Innovative waste water technologies		2				2				4	
8	Innovative water transmission										1	
9	Efficient discharge to foul sewers			1								
10	Water efficiency in air conditioning				4	2		4		2	1	8
11	Water Consumption for fire systems				1			1				
12	Efficient water use during construction						1					
	Total Points allocated for water section	**9**	**10**	**14**	**12**	**17**	**15**	**15**	**10**	**12**	**14**	**39**
	Total Points including innovation and bonus	**132**	**110**	**194**	**148**	**190**	**104**	**107**	**100**	**151**	**100**	**180**
	(%) from total	**6.8**	**9.1**	**7.2**	**8.1**	**8.9**	**14.4**	**14.0**	**10.0**	**7.9**	**14.0**	**21.7**

According to Table 3, many GBRS allocated range of 10-15 credits for the water section. The maximum points allocated in the Pearl BRS Abu-Dhabi rating system which is 39 points out of 180 (21.7%). Although, altogether twelve requirements identified about the water category, it is apparent that few requirements/strategies only addressed in each rating system. As shown in Table 3, GRIHA (Green Rating for Integrated Habitat Assessment) India and BEAM-Hong Kong are the only rating systems addressed more than six requirements relevant to water efficiency and conservation. However, it was observed that many such requirements are covered through different headings in other systems. For example in Green SL even there is no separate requirement for water recycling and rainwater harvesting, it is addressed under the requirement of innovative waste water technologies. In addition, recording and monitoring potable water consumption during construction, water pollution during the

construction and water quality are addressed under Management, Sustainable Sites, and Health & Well-being categories in BREEAM, HK-BEAM and Green Star – Australia rating systems. Moreover, Figure 2 clearly illustrated the weightage (%) given for water category. Out of eleven GBRS, Pearl Abu-Dhabi, GRIHA- India, GreenSL, Green Star- SA and GBI- Malaysia came to the top five ranks. Less weightage was given in the BREEAM which was 6.8%. Although, Australia is considered as a water crisis country, comparatively less priority has been given for water section.

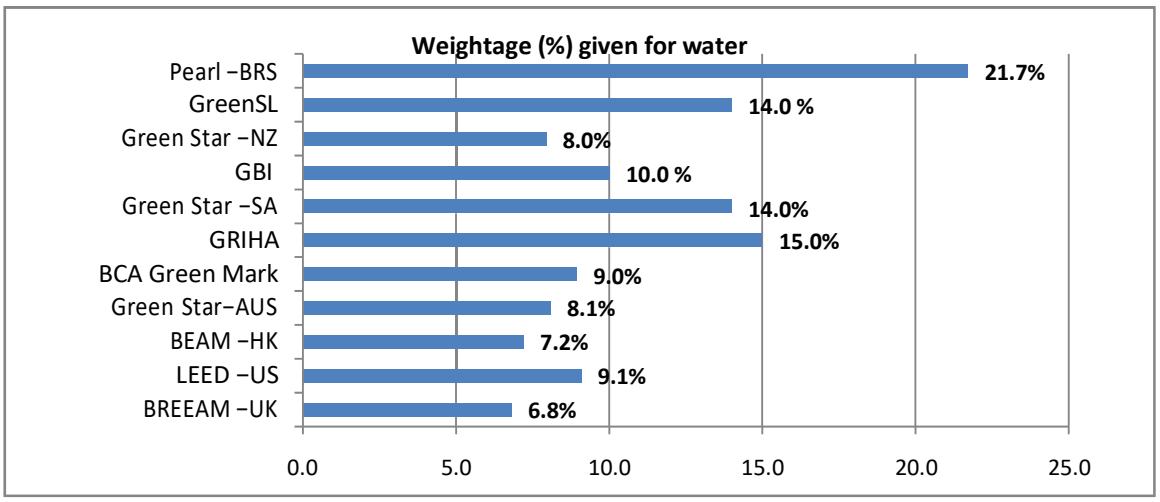

Figure 2: Weightage Given for Water Category by GBRS

Table 4: Highest Category and Priority given for Water

Rating System	Prority Level given for water	Highest Priority category
BREEAM –UK	8out of 10	Energy
LEED –US	5 out of 7	Energy
HK– BEAM	5 out of 6	Energy
Green Star–AUS	5 out of 9	Energy
Green Mark	3 out of 5	Energy
GRIHA –India		Energy
GBI –Malaysia	5 out of 6	Energy
Green Star –NZ	6 out of 9	Energy
GreenSL	3 out of 8	Sustainable Site
Pearl –BRS	2 out of 7	Energy

Table 4 summarises the highest category and priority level given for the 'water category' by each green rating assessment system. Except GreenSL rating systems, 'energy category' received the highest ranked according to the credits allocation. It shows the priority level given for water differs from rating system to system. Pearl- BRS was given the second place while Green Mark and GreenSL giving the third place for the water section. BREEAM has given the least priority level compared to other GBRS. As stated by Gowri (2004), though energy efficiency is a major component of designing a green building, several other basic sustainability requirements need to be met before claiming the additional credits for energy efficiency. At present water is identified as a global issue and therefore water shallalso to be received a greater priority.

6. CREDENTIAL GIVEN FOR WATER DURING THE CONSTRUCTION PHASE IN GREEN RATINGS

Water is one of the most important natural resources for the development of all economic activities, taking place to care for the environment and quality of life in the society. Therefore, availability and management of water resources is essential for a long term sustainability of any country. After reviewing the green rating assessment systems it was identified that intention of all the rating systems is to reduce the potable water consumption. Moreover, each rating system identified the strategies/requirements for the efficiency use of potable water throughout the building lifecycle as discussed in Section 5.0. It was identified that the requirements, points or credits distribution and priority order are unique to a specific country. Moreover, during the analysis it was found that except few, many GBRS have not addressed the use of potable water in an efficient manner during the construction stage although rating systems designed to measure whole-life performance of a building project. Among the sample; LEED, HK-BEAM, Green Mark, Green Star, GBI, GreenSL and Pearl BRS are belong to the above category. BREEAM-UK and GRIHA- India are two rating systems which addressed and allocated credits for the monitoring and handling potable water consumptions during the construction phase, from the sample selected. In the BREEAM, one credit was allocated for recording and monitoring potable water consumption during the construction under 'Management' section. GRIHA – India is the only rating system specifically addressed separate criteria for the water conservation during the construction phase. Basically, purpose is to minimize the use of potable water during construction and encourage alternative methods which consume less water. For example, use materials such as pre-mixed concrete for preventing loss during mixing or use recycled treated water and control the waste of curing water (EARI, 2010). Importantly, one credit has been allocated for the water pollution during the construction in HK-BEAM rating system. As mentioned earlier, water is a changeable resource for Abu-Dhabi (ADUPC, 2010), Therefore, Pearl BRS has given more weightage to 'precious water'. However, controlling potable water during the construction was not acknowledged in Pearl rating system though large amount of mega scale building and civil construction projects involve and even though, water supply completely depends on desalinated water for construction work.

As stated by Waidyasekara *et al.,* (2012) lack of understanding of how water is used and how water is wasted are major challenges faced by the industry and there is no best practices evolved about water used for the construction sites and it is rarely addressed. There is therefore, it is important to address water handling and monitoring during the construction phase and cannot be ignored because water is an inevitable natural resource used in the construction industry. As stated by Utraja (2010), quality and quantity of water also has greater effect on the strength of mortar and concrete used for construction work. Although, Ali and Nsairat Al (2009) defined rating system as a management tool that organize and structure environmental concerns during the design, construction and operation phases, still many ratings systems need to be improved and extended to the construction phase. In terms of water efficiency and conservation, existing rating systems fairly address benchmarks and performance indicators for the building operation phase. However, none of them address any benchmarks for activities during the construction phase. This supports the statement mentioned in the BREEAM technical manual (2011), 'at present data from construction sites do not generally exist in enough detail to set benchmarks and targets, BREEAM therefore does not set any requirements in terms of specific targets for reducing energy, water and transport consumption resulting from the construction process.' The similar pattern could be observed from other rating systems as well. However, Waidyasekara et al., (2012) emphasised the importance of addressing water pollution and damage to the environment due to construction activities and necessity of implement rules and regulations towards water monitoring and handling in construction sites. Since many researchers have already identified the entire world is facing water crisis in very near future, individual green rating systems have a big role with sustaining potable water for the future generation addressing not only during the operation phase but also during the construction phase as well.

7. CONCLUSIONS

Construction industry is more responsible and has huge impact on creating a sustainable built environment. At present, construction industry is attracted and attached with labels of environmental tools which are designed to promote and integrate whole building design while reducing environmental impacts. Simply the rating systems act as a standard method of measurement for green buildings. It is noted, protection and conservation of water is one of the fundamental principles concerned in the sustainable development because at present water is a scarce resource and considered as a global issue.

This paper attempted to simplify how and in what strategies water efficiency and conservation is addressed in the existing green building rating systems. From the comparison of the eleven GBRS, it was found out there exist the different importance level, structure, and credits allocation between each system. Except GreenSL, all other rating systems were given the highest rank to 'Energy' because still energy is a global issue. Based upon the detailed analysis, the paper draws the following conclusions with respect to the water section addressed in the rating systems. It was found that in terms of water, intention of each rating system is to reduce potable water consumption compared to the benchmark buildings and addressed many directions to conserve and monitor water throughout the project life cycle. According to the rating system, requirements or strategies, credits allocation, and the project phase have been addressed in different manner. Water category was given the highest weightage by Pearl BRS-Abu Dhabi (21.7%) and the least weightage given in the BREEAM which is 6.8%. Requirements addressed by all GBRS grouped into twelve factors. Most of the GBRS have addressed few requirements /strategies stated in Table 3. It is pertinent to note that all the rating systems have well addressed water conservation methods during the in-use phase. However, credential given for the construction phase is directly addressed by only few rating systems like GRIHA and BREEAM. In general, all systems allocates more credits for limit or eliminate the use of potable water for landscaping and irrigation purposes, water recycling and water efficacy in HVAC. It further, each rating system encourages rainwater harvesting, and use of grey water, and condense water as an alternative source to reduce potable water consumption.

Finally, based on the findings, the paper suggests green building rating systems need to be reviewed and revised in terms of water efficiency and conservation with reference to the construction phase through establishing new benchmarks.

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