CONSOLIDATION OF WATER MANAGEMENT AND EFFICIENCY PARAMETERS FOR DEVELOPMENT OF GREEN BUILDING RATING SYSTEM

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ABSTRACT

Water generation and distribution involve activities that leads to energy consumptions in various ways. This leads to GHG emission which make it important for various sustainable development assessment. Hence it is important to develop some consolidated parameters to cover water in building life cycle assessment (LCA). Development of rating system involves the utilisation of some parameters and points allocation. These parameters and points allocation varies between countries and their rating systems. This study aim at reviewing water management and efficiency category and the extent of parameters and points allocation across some rating systems. The purpose of the review is to develop a consolidated parameters that will universally cover building life cycle assessment. Eleven rating scheme's categories, parameters and points allocation were reviewed. Specifically, water generation, distribution and usage was further elaborated for this study. The parameters were reviewed from the context of their, adaptability, preference, prevalence, relevance and measurability of parameter to suit the universal concept of sustainable building assessment. The review shows that the variations of the parameters and points distribution are based on social, economic and environmental need of the country. The highest parameters and points allocation signifies the need of efficient water generation, distribution and usage and lack of enough fresh water for daily activities. The lowest consideration is due to advancement in sustainable water generation, distribution and usage. The study consolidated the parameters in to nine parameters covering the strategies for reducing unnecessary water usage and other sourcing consequences. They also cover the approximate accounting of GHG emission from water consumption and its reduction. The study can be used by researcher, organisations and countries developing rating schemes. As the study harmonised parameters covered the entire sustainable building and greenhouse gas assessment in term of water generation, distribution and usage.

Keywords: Assessment, Consolidation, Parameters, Rating Tools, Sustainability, Water

INTRODUCTION

1. INTRODUCTION

Construction material production and other products require water and thus wastage of agricultural, industrial and building materials also lead to wastage of water. Also wastage of food, raw or cooked, clothes, paper or natural materials means considerable wastage of water. Wastage of water means energy waste and hence generally wastage means emission of greenhouse gases (GHG) (Soni, 2016; Usman, A. M. and Abdullah, K., 2018). It is evident that safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately one billion people still lack access to safe water and over 2.5 billion lack access to adequate sanitation (United Nation, 2008).

Lack of adequate access to safe drinking water made it mandatory for many countries to extract ground and river and lakes water treat, stored and transport and distributed it to towns and cities for various human consumption processes. This process involve the use of machineries and vehicles which consume energy and consequently leads to release GHG emission to the environment. Water management in sustainable development comprises of designing the building to have less water consumption and appropriate use of water during construction, development and operation processes.

Water efficiency consist of providing the building with appropriate fixture that improve or increase the overall water consumption efficiency. Carbon emissions from water use are associated with the energy used in generation and distribution of the water and from wastewater treatment processes. These emissions are classified under scope 2 and 3 of the GHG protocol guidelines, because they occur in utilities that supply water to institutions or treat the wastewater they discard and official and non-official vehicles. The water industry currently emits around 5 million metric tonnes of carbon dioxide equivalent (Mt CO_2e) per year due to the energy and process emissions for water and wastewater pumping and treatment (Arup and De Montfort University, 2012).

Building industries contribute to about 16% of freshwater consumption, hence greater emphasis was given to water efficiency and conservation in almost all the sustainable building rating schemes around the world. According to several researchers, more than hundred building sustainability evaluation tools were developed around the world. These tools focus on different areas of sustainable development and they are designed to suite the different types of building project and structures worldwide (Waidyasekara *et. al*, 2013). Among the initial phase of rating schemes developed were the Breeam developed in 1992, BEAM Hong Kong and LEED United state developed in 1996 while the Green Star Australia and CASBEE Japan developed in 2002 and the Green Mark Singapore. The most recent ones are the GBI Malaysia developed in 2009 and the GreenRE developed in 2013 (Usman, *et al*, 2018).

Environmental and sustainable development in relation to building gain a lot of concern over the last three decades and there has been an increase in the awareness recently. According to several researchers including Fenner and Ryce, (2011) and Waidyasekara, *et. al*, (2013), various building rating schemes make use of hierarchical criteria systems to evaluate the building with respect to the different aspect of sustainability. These aspects include energy, water, site development, material, waste and transportation among several other depending on the need of the stake holder of the country. These rating schemes are used to examine the performance or expected performance of the whole building and transformed the performance in to a tool that can be used to compare the building performance in relation to the environment. This research consider water management and efficiency as one of the basics in determining sustainability of environment in relation to building.

Green building is a type of building that consider certain concept that is an integrated approach that covers building architecture, engineering, landscaping/horticulture, maintenance and housekeeping for sustainable future. These concept includes sustainability criterion on site planning and design, site selection, water and energy sources, greenery of the environment, and the overall environmental quality among others. Hence, the concept revolves around conservation of energy, material, water, utilisation of waste materials and waste water to save depleting conventional resources for sustainable future development, simultaneously ensuring building internal comfort (Adegbile, 2013; Hedaoo and Khese, 2016; Soni, 2016).

Hence this study evaluate the importance of water conservation and efficiency in rating systems and tools through categories, parameters and points allocation consideration. The study finally consolidate the category's parameters in to a more suitable and appropriate parameters that fully covers the general concept of water management and efficiency category in sustainable building assessment.

2. METHODOLOGY

For the purpose of this research eleven SBRS are reviewed out of the several SBRS around the world. The summary of this SBRS and their corresponding rating tools and the rating scales are shown in Table 1.

Table 1; Summary of the Reviewed Rating Systems

SBRS	Country	Rating Tools	Categories	Certification Level
BREEAM	UK	5	10	5Star, 4Star, 3Star, 2Star, 1Star, Unclassified
Green Mark	Singapore	15	7	Platinum, Gold[PLUS], Gold, Certified
Green Star	Australia	4	9	Best Practice, Excellence, world Leadership
Green Star	New Zealand	4	9	
Green Star	South Africa	6	9	6Star, 5Star, 4Star, 3Star, 2Star, 1Star
BEAM	Hong Kong	3	7	Excellent, Very Good, Good, Satisfactory
India GBC	India	11	10	Platinum, Gold, Silver, Certified
LEED	United State	21	8	
GBI	Malaysia	17	6	
GreenRE	Malaysia	4	7	Platinum, Gold, Silver, Bronze
GreenShip	Indonesia	5	6	

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

Different number of tools were developed in the different rating schemes depending on the requirement of the stake holders in that country and national policy. Although all the rating tools aimed at single objective of assessing the sustainability of the building, it is difficult to specifically find similarity between the existing tools. Given the wide range of the rating tools, it is necessary to have a consistent evaluation of categories, parameters and availability across the schemes to ensure proper comparison across the rating schemes. The number of tools considered for the purpose of these study are shown in Table 2.

Table 2; Summary of Reviewed Rating Tools (RT) in the Rating Systems

SBRS	Reviewed RT	Reviewed Rating Tools
BREEAM	3 - Tools	Breeam's New Construction, In-Use and Refurbishment RT
Green Mark	4 - Tools	Green Mark's Residential New and Existing Building and Non-Residential New and Existing Buildings RT
Green Star A	3 - Tools	Green Star Australia's Design as Built, Building Performance and Interior Decoration RT
Green Star NZ	3 - Tools	Green Star New Zealand's Office, Industrial and Education Buildings RT
Green Star SA	3 - Tools	Green Star South Africa's Multi-Residential, Office and Public and Education Buildings RT

BEAM	3 - Tools	BEAM's Existing Selective and Comprehensive Building and New Buildings RT
India GBC	6 - Tools	Indian GBC's Existing, Owner Occupied New, tenant Occupied New, Green Residential Societies, Individual Residential Unit and Multi-Dwelling Residential Units Buildings RT
LEED US	6 - Tools	LEED's New Construction, Existing Building, Core and Shell, Hotel, Hospital, School Buildings RT
GBI	5 - Tools	GBI's Non Residential New and Existing, Residential, Industrial new and Existing Buildings RT
GreenRE	3 - Tools	GreenRE's Non Residential New and Existing Building and Residential Building and Landed Homes RT
GreenShip	4 - Tools	Green Ship's Non Residential New and Existing and Residential New and Existing Buildings RT

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

The important of water in the building industries from building construction to building operation cannot be over emphasize hence every rating scheme around the world made water efficiency and conservation the basis for assessing the sustainability of all types of buildings. As shown in Table 3, all the rating tools in all the rating schemes consider water and allocate considerable number of parameters and points. The terminology used for describing categories varies across the rating schemes as described in (Usman, *et al*, 2018; Usman and Abdullah, 2018a). For water in SBRS, the terminologies as well as total number of parameters and points allocation for SBRS and water category in the reviewed rating tool are shown in the following Table 3.

Table 3; Various Terminologies for Water Category in Rating Systems

SBRS	**Terminology**	**Parameters in SBRS**	**Parameters In WME**	**Points In SBRS**	**Points In WME**
BREEAM	Water	57	5	171	15
Green Mark	Water Efficiency	39	5	230	18
Green Star A	Water	29	1	118	10
Green Star NZ	Water	54	4	146	12
Green Star SA	Water	66	12	155	15
BEAM	Water Use	83	6	229	32
India GBC	Sustainable Water Practices	57	6	154	20
LEED US	Water Efficiency	56	5	110	11
GBI	Water Efficiency	46	4	100	11
GreenRE	Water Efficiency	35	7	212	18
GreenShip	Water Conservation	46	11	98	18

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017; Usman, *et al*, 2018)

3. WATER MANAGEMENT AND EFFICIENCY

Water management and efficiency (WME) category as it is named in this study is the category in the reviewed rating systems. It is a category that consider efficient water consumption during construction and operation. It encourages proper fitting for efficient water distribution for various activities and component in the building. It also encourage abiding by efficient and effective policies to conserve water in the community. The magnitude of weight given to this category varied according to their impact on the social, environmental and economic issues of the country. Each of the rating scheme allocate different number of parameters as well as number of points in the different rating tools. Tables 4 shows the different average number of parameters allocated by the rating schemes to the reviewed rating tools. The parameters allocation analysis in this research are divided in to two viz.

1. Parameters allocated in the water management efficiency categories of each of the rating tool in the rating schemes. These parameters can only be found in the water efficiency category.
2. Parameters allocated in other categories of the rating tool which are fully related to water management and efficiency.

The consideration of both will provide a total coverage of water consumption and its efficiency during the entire building life cycle. Hence Table 4 out lined all the criteria above. These parameters covers the entire parameters allocated in water category as well as other categories of the ratings systems.

Table 4. Parameters and Points Allocated to Water Category in Rating Systems

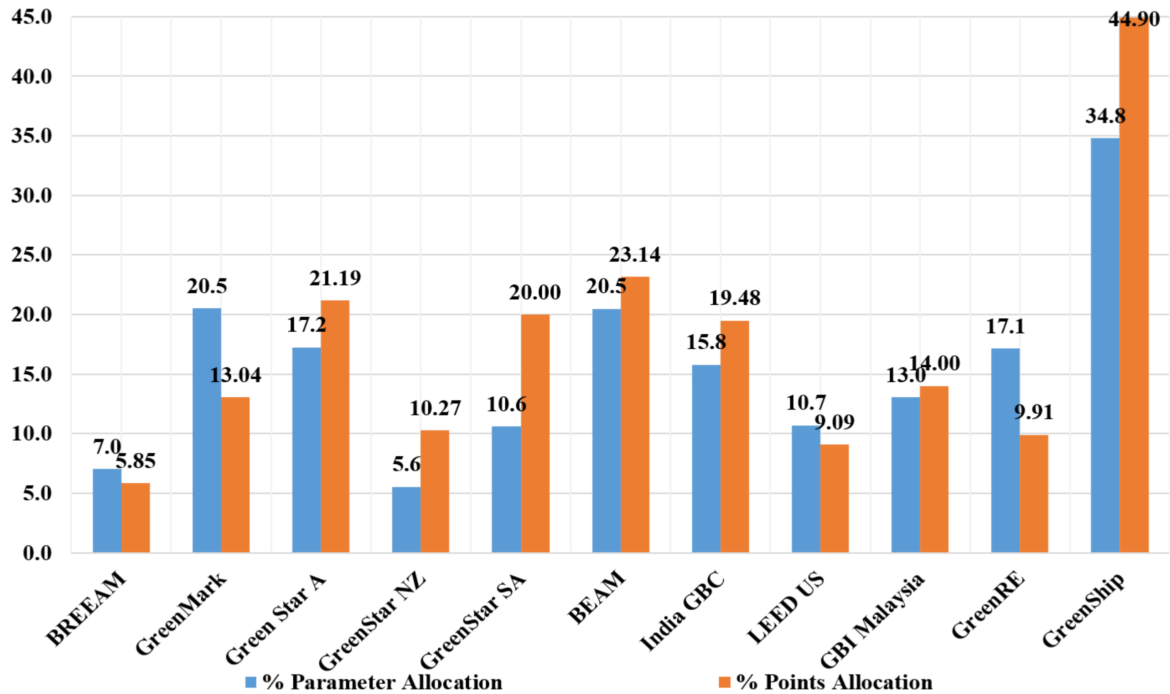
Breeam	**Points**	**BEAM HK**	**Points**
Water consumption	5	Water Efficient Devices	7
Water monitoring	1	Water Use for Irrigation	2
Water leak detection and Prevention	3	Cooling Tower Water	3
Water efficient equipment.	1	Water Recycling	3
Total	**10.0**	Water Saving Performance	6

Green Mark	**Points**	Quality Building Fresh Water	3
Water Monitoring	3	Water Metering	2
Water Efficient Fittings	9	Water Audit	3
Alternative Water Sources	3	Enhancement	2
Water Efficiency Improvement Plans	2	Twin Tank System	2
Irrigation System and Landscaping	3	Water Efficient Flushing System	3
Cooling Towers	2	Quality Building Flushing Water	4
Common Area/water Tank washing	7	Water Conservation Plan	3
Water Usage and Leak Detection	2	Fresh Water Plumbing System	6
Total	**30**	Water Leakage monitoring	2
Green Star SA	**Points**	Promotional Programme	2
Occupant Amenity Water	5	Innovative Technique	2
Water Sub-Metering	3	**Total**	**53**
Landscape Irrigation	3	**Indian GBC**	**Points**
Heat Rejection Water	4	Rain Water Harvesting	5
Potable Water Efficient Appliances	2	Landscape Areas	3
Pool, Spa Fauna Water Efficiency	2	Water Sub Metering	3
Potable Water	12	Water Efficient Fixtures	5
Total	**31**	Onsite STP	3
Green Star NZ	**Points**	Automatic Water Controllers	1
Potable Water	10	Waste Water Treatment	5
WAT-2 Water Meters	2	Turf Area	4
Storm-water Management	3	Management of Irrigation System	1
Total	**15**	**Total**	**30**
USA LEED	**Points**	**Green Star A**	**Points**
Outdoor Water Use Reduction	0	Potable Water	9
Indoor Water Use Reduction	0	Fire Protection Testing Water	2
Building-Level Water Metering	0	Storm Water management	2
Outdoor Water Use Reduction	2	Potable Water	10
Indoor Water Use Reduction	6	Metering and Monitoring	2
Cooling Tower Water Use	2	**Total**	**25**
Total	**10**		
GBI Malaysia	**Points**	**GreenShip**	**Points**
Rainwater Harvesting	3	Water Metering	1
Water Recycling	2	Water Calculation	0
Water Efficient - Irrigation/Landscaping	2	Water Saving Fixtures	3
Water Reduction	2	Fresh Water Efficiency	8
Metering & Leak Detection System	2	Water Use Reduction	8
Water Efficient Fittings	3	Rain Water Harvesting	3
Total	**14**	Deep Well Reduction	2
GreenRE	**Points**	Water Saving Irrigation	2
Water Efficient Fittings	10	Water Efficient Landscaping	2
Water Usage Monitoring/Leak Detection	2	Waste Water Management	3
Irrigation System and Landscaping	3	Water Recycling	4
Water Consumption of Cooling Tower	2	Alternative Water Resources	2
Alternative Water Sources	3	Water Tap Efficiency	2
Water Efficiency Improvement Plans	1	Water Monitoring & Control	2
Total	**21**	**Total**	**42**

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

The coverage and consolidation will help the researchers and organisations in developing a new rating systems. Figure 1 show the percentage parameter and points allocation for all the WME related parameters. It can be seen that GreenShip give highest priority as fresh water generation and its distribution is major problem in Indonesian sustainable built environment. This is followed by BEAM, Green Star A, Green Mark. This clearly show the variation of parameters and point's allocation depend on the individual need of a country.

Figure 1, Percentage Average Number of Parameters and Points Allocation



(BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

3.1 KEY WME PARAMETERS

From Table 4 and Figure 1, the summary of the key parameter are derived as shown in the following Table 5 and 6. The summary describe the parameters consideration by each of the rating systems and its corresponding points allocations. Table 5 shown frequency of appearance of the parameters and their average points allocation for all the rating schemes. These parameters appears across the entire rating systems categories in the rating tools.

Table 5; Frequency of Appearance of Parameters and their Average Points Allocation

S/No	Key Parameters (KWME)	Frequency	Average
1	Water Metering and Monitoring	10	3
2	Water Efficient Fittings & Equipment	8	5
3	Alternative Water Sources	3	3
4	Potable Water	4	8
5	Water Efficiency Improvement policy	4	4
6	Irrigation System and Landscaping	8	3
7	Water Consumption Reduction	4	6
8	Cooling Towers/Heat Rejection	5	3
9	Water Saving Performance	1	6
10	Common Area/water Tank washing	2	5
11	Water Recycling	4	5
12	Fresh Water Plumbing System	1	6
13	Fire Protection Testing Water	2	2
14	Water Efficient Flushing System	2	3
15	Water Usage and Leak Detection	3	2
16	Storm water Control	7	3

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

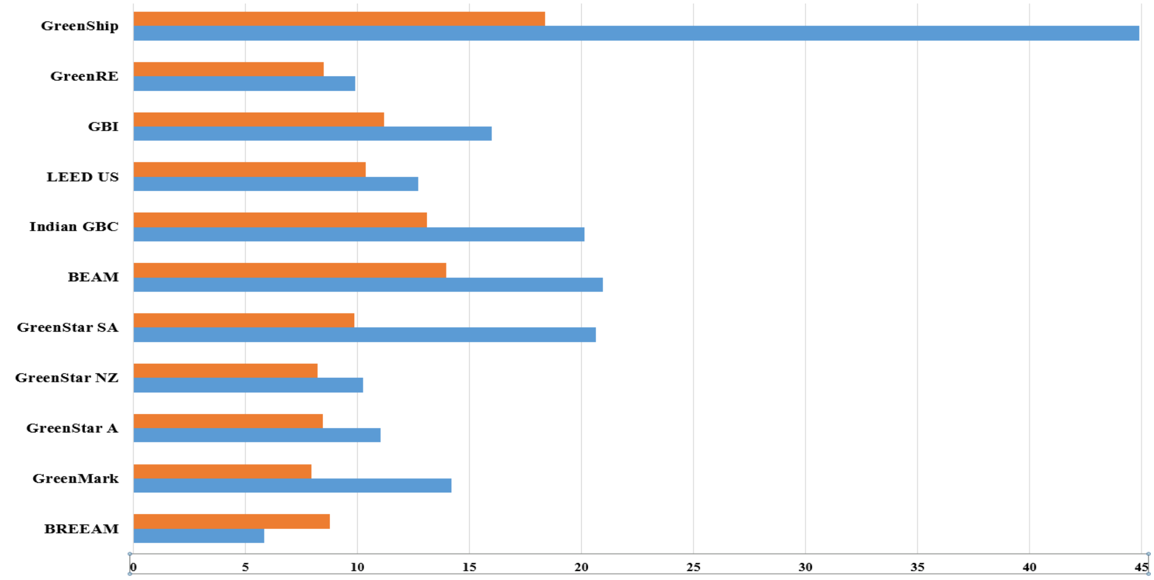
Table 6; Points Allocation Matrix against WME Parameters

Key Parameters (KWME)	BREEAM	Green Mark	Green Star A	Green Star NZ	Green Star SA	BEAM	Indian GBC	LEED US	GBI	GreenRE	GreenShip
Water Metering and Monitoring	1	3	--	2	3	5	7	1	2	2	3

Water Efficient Fittings & Equipment	1	9	--	--	2	7	5	--	3	10	3
Alternative Water Sources	--	3	--	--	--	--	--	--	--	3	2
Potable Water	--	--	9	10	12	--	--	--	--	--	1
Water Efficiency Improvement policy	--	2	--	---	--	12	--	--	--	2	10
Irrigation System and Landscaping	--	3	--	--	3	2	4	2	2	3	4
Water Consumption Reduction	5	--	--	--	--	--	--	6	2	--	10
Cooling Towers/Heat Rejection	--	2	--	--	4	3	--	2	--	2	--
Water Saving Performance	--	--	--	--	--	6	--	--	--	--	--
Common Area/water Tank washing	--	7	--	--	2	--	--	--	--	--	--
Water Recycling	--	--	--	--	--	3	7	--	2	--	7
Fresh Water Plumbing System	--	--	--	--	--	6	--	--	--	--	--
Fire Protection Testing Water	--	--	2	--	1	--	--	--	--	--	--
Water Efficient Flushing System	--	--	--	--	--	3	3	--	--	--	--
Water Usage and Leak Detection	3	2	--	--	--	2	--	--	--	--	--
Storm water Control	--	3	2	3	--	--	5	3	5	--	3
Frequency	4	9	3	3	7	11	6	5	6	6	10
Total	10	33	13	15	27	45	31	14	16	21	44
Average	3	4	4	5	4	4	5	3	3	4	4
Credit Allocated By SBRS	10	30	11	12	32	53	30	11	14	21	44
Total Credits Allocated to SBRS	171	230	118	146	155	229	154	110	100	212	98

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

Figure 2; Variation of Percentage Points Allocation to WME Category and WME Parameters



	BREEAM	GreenMark	GreenStar A	GreenStar NZ	GreenStar SA	BEAM	Indian GBC	LEED US	GBI	GreenRE	GreenShip
%WME-C Points	9	8	8	8	10	14	13	10	11	8	18
%KWME-P Points	6	14	11	10	21	21	20	13	16	10	45

Source: (BEAM Plus, 2017; Breeam, 2017; GBI, 2017; GNZ, 2016; Green Mark, 2017; Green Star, 2017; Green Star SA, 2014; GreenRE, 2017; Indian GBC, 2017; LEED, 2017)

Figure 2 was plotted to describe the variation of overall point allocated to the parameters in the WME category and points allocated to parameters related to WME in the entire rating schemes. This is because there are some parameters that are fully related to WME category which are considered in other categories. These parameters includes rain or storm water management which appear in the environmental protection category in the Green Mark Non-residential new building and Emissions category in Green Star A's Performance rating tool and NZ's Industrial and offices rating tools respectively. Metering and monitoring which considered in the Management category of the Green Star Australia Performance rating tool etc. Also some parameters appear in some other rating tools and did not appear in the other which increase the number of parameters when takin the average number of parameters considered for sustainable built environment.

4. PARAMETERS CONSOLIDATION

From Tables 4, 5 and 6 and Figure 2, is can be seen that all the parameters move towards covering the sustainable water consumption and utilisation even though they have different numbers and points allocation. Hence all the rating tools have same objective. It is also evident that some parameters are more important than others as the matrix of parameters with point's allocation frequency shows some parameters are considered more frequent than others. For this regards the following are the most important consolidated parameters for efficient assessment of sustainability of built environment in terms of water management and conservation and their description. The following are considered during design, construction and operation.

4.1 WATER METERING AND MONITORING:

This parameters take care of the control and monitoring of water consumption in the building. The input for assessment of these parameter include drawing and the layout should clearly indicate all the basic water fittings as well as the control devices for the building. This parameter can be assessed and the points scored by providing the building with water monitoring and metering devices. These devices must be capable of providing the building water monthly and yearly consumption profile. The building must also have isolation devices for isolation the building segment in case of maintenance or over howling.

4.2 WATER CONSUMPTION REDUCTION

This parameters take care of the water consumption reduction through comparing the design and operational water consumption. This parameter can be assessed by providing the assessor with the reports, drawing and the layout should clearly indicate the water consumption components and the measurement and control devices for the building and the trend of water reduction.

4.3 ALTERNATIVE WATER SOURCES

This parameter encourage the use of alternative water sources such as rain water harvesting. It involve providing the building with rain water harvesting provision such as proper harvesting provision of the structure, storage tank and proper distribution system etc. The assessment of these parameter involve providing the assessor with drawing and reports that describe the building feasibility study. The readiness of the structure must be provided during the construction phase. While the adoption of the rain water harvesting must be provided after the construction and must be of use during operation.

4.4 WATER EFFICIENT FITTINGS AND EQUIPMENT

This parameter consider most efficient plumbing system in the building to promote efficient water distribution throughout the building. This parameter can be assessed by providing details of the fittings and equipment with their specification and certification. The fitting must be of good quality and comply with the countries standard. They must also provide designated water flow and pressure for efficient water distribution.

4.5 EFFICIENT COOLING SYSTEM AND WATER CYCLE

This parameters make sure that efficient cooling systems and the efficient water cycle for the cooling system are applied to the building to reduce the overall energy consumption from cooling. The assessment of this parameter involve a detailed report and calculations for proper selection of efficient cooling and water cycle systems.

4.6 IRRIGATION AND LANDSCAPING

This parameter encourage the use of efficient grasses and water ring systems for landscapes which involve native and adaptive grasses and trees and efficient landscape watering provision. It can be assessed through provision of proper report and adoption of the requirement for the parameter.

4.7 WATER EFFICIENCY IMPROVEMENT POLICY

This parameter consider the local and international sustainable development laws and policies to full make the building sustainable in relation to the environment. It can be assessed by abiding by these local and international law stated in the assessment process and tool.

4.8 GHG EMISSION ESTIMATION

This parameter encourage the accounting of GHG emission in the form of carbon footprint of the building. The assessment of this parameter occur during construction and operation. This parameter deals with the activities during construction and operation that consumed water as it is clear that water consumption mean GHG emission.

The components of this parameter consider water consumption from various segment of building construction and operation. The segment during construction include but not limited to site preparation, construction project and road, parking space and landscaping water consumption. The total consumption together with the emission factor for the country or region gives the total emission in the form of carbon footprint. Likewise for the operation, the water consumption from various section in the building. This together with emission factors gives the carbon for the building.

Assessment of the parameters for construction phase involve assessing the total carbon footprint per total project cost. While for operational phase involve assessing the total carbon footprint per floor area of the building. Further sub parameters is computed to account for the carbon footprint reduction during the periods of operation of the building.

4.9 GREENHOUSE GAS EMISION REDUCTION

This parameter assesses the GHG emission reduction from a specified bench mark period to the year of assessment. The percentage reduction determines the extent of building performance in reducing the building impact on the environment. It is assessed by computing the yearly carbon footprint of the building in terms of water consumption and compare it with subsequent years.

5. DISCUSSION

From Table 5 and 6, the frequency of consideration of the parameters by the rating systems varies with the BEAM, GreenShip and the Green Mark having the highest parameters consideration of 11, 10 and 9 respectively (Breeam, 2017; Green Mark, 2017; GreenShip, 2016). The minimum consideration is 3 which is the average parameters in the Green Star Australia and New Zealand (GNZ, 2016; Green Star, 2017). These shows that, the WME was given the appropriate concern by each of the rating systems.

The frequency of appearance of the parameters in a rating scheme also varies as others appears more frequent than others. The appearance ranges from fresh water plumbing systems and water saving performance parameters which appears only in the BEAM rating scheme with appreciable point's allocation of 6points (BEAM Plus, 2017). The highest appearance was recorded for water metering and monitoring which appear in all the rating schemes except the Green Star Australia (Green Star, 2017). This parameters is followed in significance by water efficient fitting and equipment and irrigation and landscaping. These first parameter was considered in all except the Green Star A and NZ and Lead US while the second was considered in all except the BREEAM and Green Star A and NZ. From Table 5, in order to have an efficient assessment process without repetition of parameters harmonisation between the summarised parameters is needed.

It is evident that consideration of category and/or parameters depends on the country's needs. Some countries have problem of energy fuel source hence more parameters in the energy category will be considered to enable efficient energy generation and distribution. Others have problems of fresh water hence their tools and schemes will give high priority to water efficiency category as well as it parameters such countries include those countries by the sea (island) and in the desert (Dry land).

The study consolidate the parameters in to ten parameters to cover the building life cycle assessment. Certain factors were considered during the selection of the consolidated parameters. The design and construction aspect was covered in the seven of the parameters. These parameters discussed the strategies to avert the consequences of built environment on the climate change. These stage of assessment occurs during design and construction but have the major impact during operation of the building. Another two cover the GHG emission estimation and reduction over the period of operation. These parameters discussed and assessed the estimation of the GHG emission associated with building construction and operation. The emission is estimated from the carbon footprint of water consumption major material consumed and secondary material produced during construction. The other is the net avoided emission from waste generated during construction and building operation. They also estimate emission reduction over a certain period of operation. The last one assess the building in term of abiding by the national policy and standards of the country.

6. CONCLUSION

Water scarcity and its importance for various human activities mandate the necessity of generation of portable water from fresh, river, waste and sea water treatment, reserving and transporting. The water treatment, storing and transporting and distribution it to towns and cities for various human consumption processes involve the use of machineries and vehicles which consume energy from utilities and burning fossil fuel and consequently leads to release GHG emission to the atmosphere which degrades the environment. These makes water management and efficiency important for various sustainable development assessment. Water management and efficiency category was found to be among the most important category as it is considered in all the rating systems with appreciable parameters and points allocation. Also the study show that the distribution of parameters and points in the WME depends on the need of the country of which the rating scheme is developed.

The highest parameters and points allocated by the GreenShip and Green Star SA signifies the need of efficient water generation and distribution in the community as well as the building. While in Green Mark and BEAM is due to lack of enough fresh water for daily activities as well as building construction. According to several references specifying lack of enough raw material (Fresh water, coal, petroleum products etc.) and the excessive importation of such and its impact on the sustainable development of Singapore and Hong Kong. As they are small Island or combination of smaller islands. The lowest in the BREEAM, Green Star NZ and LEED was as a result of advancement in sustainable water generation and distribution in the respective countries. The others though they have high water need due to their population but have less non-revenue water hence high efficient distribution and usage system.

The variation of parameters and points in the water category defines the uniqueness of need of the countries and the environments. For researchers, organisation and/or countries developing rating systems, the study harmonised the parameters for their input and reference. This division dives the category in to water metering and monitoring, water consumption reduction, alternative water sources and overall water consumption. Others are water efficient fittings and equipment, efficient cooling system and water cycle, irrigation and landscaping and water efficiency improvement policy. This parameters covered the entire sustainable built environment life cycle assessment in term of water generation, distribution and usage.

To complete the assessment of building life cycles sustainability, GHG emission associated with building water consumption during construction phase and operation was considered. The carbon footprint per project cost and total floor area defines the building impact on the environment. The consolidated parameters covers the complete building life cycle in terms of water management and efficiency assessment. They can be useful to researchers, organisations and governments in developing a new sustainable building assessment tool. It can also be important in estimating the quantity of GHG emission in the form of carbon footprint of the building. This is useful in determining the GHG emission of a community, town or country as a whole.

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