World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:7, No:2, 2013

Evaluation of Green Roof System for Green Building Projects in Malaysia

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***Abstract*—**The implementations of green roof have been widely used in the developed countries such as Germany, United Kingdom, United States and Canada. Green roof have many benefits such as aesthetic and economic value, ecological gain which are optimization of storm water management, urban heat island mitigation and energy conservation. In term of pollution, green roof can control the air and noise pollution in urban cities. The application of green roof in Malaysian building has been studied with the previous work of green roof either in Malaysia or other Asian region as like Indonesia, Singapore, Thailand, Taiwan and several other countries that have similar climate and environment as in Malaysia. These technologies of adapting green roof have been compared to the Green Building Index (GBI) of Malaysian buildings. The study has concentrated on the technical aspect of green roof system having focused on i) waste & recyclable materials ii) types of plants and method of planting and iii) green roof as tool to reduce storm water runoff. The finding of these areas will be compared to the suitability in achieving good practice of the GBI in Malaysia. Results show that most of the method are based on the countries own climate and environment. This suggests that the method of using green roof must adhere to the tropical climate of Malaysia. Suggestion of this research will be viewed in term of the sustainability of the green roof. Further research can be developed to implement the best method and application in Malaysian climate especially in urban cities and township.

***Keywords*—**Green roofs, vegetation, plants, material, storm water.

I. Introduction

THE prominent need of environment sustainability has led to introduction of green technology in Malaysia. Malaysia governments have taken initiatives to develop the green environment and culture into the public and government sectors including private companies and NGOs. The prime objective of KementerianTenaga, TeknologiHijaudan Air (KeTTHA) is to enhance the green technology and environment [1]. Prior to this, the Association of consulting Engineers Malaysia (ACEM) together with PersatuanArkitek Malaysia (PAM) launched the Green Building Index (GBI) rating system [2], [3]. The main objective of GBI is to give certification to buildings for green status. It is also the rating tools evaluating and valuing the green standard of a building. These criteria of assessment include energy efficiency, water efficiency, sustainable and planning management, material and resources, indoor environmental quality and innovation.

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One of the criteria of the GBI rating assessment is the installation of green roof. This has led the emergence of green roof technology in Malaysia. The green roof or rooftop gardens had gained popularity in the North American and European countries. The difference of green roof system is that it implements by growing medium or plants on the roof of the building. Depending on whether it is extensive or intensive, the construction of the green roof is being completely or partially concealing with plants. The entity consists of soil and growing medium [4]. It is also known as eco-roof, living roof or vegetated roof.

Green roof is divided into two categories which are intensive and extensive roof. Intensive system have deep substrate consist of trees, big shrubs and many species of plants as in roof top garden and needs proper irrigation system. Maintenance is needed periodically with skilled labors. However, the latter has shallow substrate depth, with small plants and sedum and requires less maintenance [5], [6], [7]. There are researchers who classified another type of green roof as semi extensive. It is categorized as in between the intensive and extensive system, having covering 25% of the green roof area [5]. In some countries, green roof is sometimes referred as roof garden because of the garden like construction and scenery [8], [9].

The urge to implement green roof is important for the well being of next generation. Previous researchers have list out many benefits from research on green roof technologies in term of environmental, economics and aesthetics [11]. The current situation in Malaysia needs certain guidelines in implementing green roof, such as sustainable design, implementation and maintenance and utilizing roof spaces for green roofs. Also the obstacles of green roof have been reviewed [10], [11].

The differences of climate in temperate countries to tropical countries like Malaysia have caused problems in term of comparability [12]. The need to develop the Green Building Index (GBI) assessment is important, so that the local quality and standard will be at par with the international GBI of the relevant industries; e.g. GREENMARK (Singapore) LEEDS (U.S.A. and Canada), GREENSTAR (Australia) and BREEAM (UK). There is a need to compare with other developed countries, since each rating tool may be different in terms of climate and development status [12]. Besides that, the technology and method used in the green roof system by the developed countries were reviewed in order to suit to the Malaysian context. Therefore, the need to develop green roof guidelines is considerably important. This is done through evaluating of previous research on green roof in the aspects of climate, regulations, environment and public's perception [10].

There is a need to identify the method in implementing green roof system in particular, the technical aspect in choosing the waste and recyclable materials, plants technology selection and method for mitigating storm water runoff. The framework of this study intends to adapt the technology and method based on the following criteria as stated in the Malaysian GBI; i) method of using waste and recyclable material, ii) type of vegetation introduced and method of planting and iii) method of mitigating storm water.

II. Waste and Recyclable Material

The need to use waste and recyclable material is imminent to maintain the environment sustainability. The material is either used as growing media or different parts of layers in the construction of the green roof. The possibilities of using alternative waste and recyclable materials are important to address the environment issues as well as the economic point of view.

One example of material that needs to be replaced are polymers (low density polyethylene and polypropylene). The materials in green roof systems give lots of good to roof construction because of its weight and durability. However it is important to find other material to replace the material because the productions of these materials give bad effect to the environment [5]. Proficient green roof practitioners propose to introduce materials like plastics into the use of green roof because plastic is light in weight and good as water proofing element for the waterproof membrane. However, polyethylene and polypropylene can pollute the environment due to carbon emission during its manufacture. The issue is, almost all the layers of the green roof are made of polymer except for the growing medium. This shows that polymer is largely needed in the green roof construction and yet its usage has implication to the environment

There are certain guidelines by German Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) standards on these, which have been set up. The current use of substrate on green roof is the red bricks [13]. A research done by [7] making use of the wastes that is not wanted which normally uses disposed which include quarry fines, waste lay, paper ash and sewage sludge. All this substrate is integrated to a substance resulting in a substrate replaceable to red bricks at the same cost. It was found that all the waste from quarry fines, waste lay, paper ash and sewage sludge have properties that correspondently the same as red bricks which according to FLL standards is conforming to the level of quality.

One of the study done by [14] using LEED which is one of the many system for rating. It was tested in Columbia on a building to check on its result. A program model name mixed integer linear program (MILP) mend to give guidelines for those associated with building for an easier decision on the material for selection which include the material choices for roofing system. The system is an integration criterion of design, monetary budgeting and environment aspect of material in green buildings.

The use of rubber crumbs as drainage layers has many significant effects [15]. The test was done in a Mediterranean climate in Barcelona in a region called Lleida. The study shows that green roof using the material has slightly higher capacity to drain water, because rubber crumbs have lower bulk density. Further, it reduces the weight of the roof and low capacity of water retention. Importantly, the material does not affect the health of plants and their growing medium temperature at all. .

It was highly suggested to use recyclable material in roofing system because of its financial benefits [16]. The approach by these researchers was by applying Net Present Value (NPV) on green roof by measuring per unit of area of the roof. The NPV were tested on three different roofs which were intensive, extensive and extensive green roof installed with construction and demolition waste (C&D). Reuse of C&D material replacing polymers that are commonly used on roof result in achieving environment profits.

In order to achieve sustainability of building, [17] suggested that the need to dispose the growing medium of building components according to life cycle cost and analysis. The information on data of the roofing substrate is needed in order to treat the waste from the substrate.

Another natural material being embedded in the drainage and growing layer are Lapillus and Vulcaflor to create a coarse grain media for green roof [18]. Lapillus is the material that falls after a volcanic eruption while Vulcaflor is a natural volcanic material. The author applied simulation to test the flow of the saturated green roof adapting the porous coarse media.

Following are the summary of method applying recyclable and waste material on green roof system.

TABLE I
Summary of Method for using Recyclable and Waste Material

Author(s)	Methods	Findings
Molineux et al. (2009) [7]	Uses quarry fines, waste lay, paper ash and sewage sludge in substrate of green roof	All the waste having same properties corresponding to red bricks
Castro-Lacouture et al., (2009) [14]	Used Mixed Integer Linear Program (MILP) for guidelines to select material for building including roofing system	Able to select best material in term of design, monetary and environmental aspect of green building
Cabeza et al., (2012) [15]	Used rubber crumbs as drainage layers	The rubber crumb have higher capacity to drain water
Hewage and Bianchini, (2012) [16]	Applying Net Present Value (NPV) on green roof by measuring per unit of area of the roof	The ability of the construction and demolition waste was profitable to the environment
Peri et al, (2012) [17]	Suggested that the need to dispose the growing medium of building components according to life cycle cost and analysis.	The information on data of the roofing substrate is needed in order to treat the waste from the substrate should able to achieve sustainability.
Palla et al., (2009) [18]	Natural material being embedded in the drainage and growing layer are	The method able to restore water in the green roof media by process of

	Lapillus and Vulcaflor to create a coarse grain media for green roof. Applied simulation to test the flow of saturated media.	evapotranspiration and filtration.

III. Vegetation and Plants Method

The need to determine the type of plants and method of planting is essential in constructing green roof. There have been many research and studies in plants composition and planting method adapted mostly in the developed country, the like the United States of America, Germany and Sweden.

Depending on specific climate and surrounding, the suitability of plant species for green roof in specific countries should be determined through rigorous. This opinion is also agreed in the works of [19], [20] and [21]. The right plant selection helps maintaining the sustainability of green roof. Perhaps, the longevity of the system is able to sustain to a certain period with low maintenance. It can be explained through the method of technology of designing and techniques used in the planting. Again, [19] states the importance of plant selection in particular habitat but not limited to only particular species. Thus, more research can be done on the potential of plant species such as herbs, vegetables and other crops for the green roof system. It is seen that green roof must be able to interact positively with the ecosystem elements such as small animals, insects and between the plants and vegetation themselves. The main concern of adapting different type of plants are most importantly among media, soil and type of plants involved in different climate such as temperate, tropical, dry, polar and highland climates.

However, design, availability of installation material and maintenance budget can be the main issue in plant selection. For instance, in the four season climate during the summer time, many species will not turn "green" as expected as the like of native prairie grasses, while perennials will look brownish in color [22]. This can turn to fire hazard which should be a concern in certain climate where there is low humidity. The design of these extensive roofs must have either irrigation or substrate that is deeper than normally found on extensive roof. [23] Tested on nine sedum species plants in two season, spring and autumn with different substrate depth. From the study, when planted during spring, most of the plants survive better compared to autumn. This study was done in Michigan, USA.

Rowe [24] had provided several considerations for finding out the suitability of species for green roof. Author concludes that the types of plant suitability must be evaluated in term of management and maintenance practices of different locations and climatic regions. Review of [25] indicates his experiment on runoff quantity from 100mm growing medium in trays combined with forbs and grasses and also bare substrate. His finding shows that vegetation covered on the roofs have no relationship with the types of vegetation and the ability to mitigate the storm water runoff.

Once [26] had done test on green roof growth medium by embedding furnace bottom ash (FBA). Kamtchaticum, Spurium, Sexangulare were the sedum types used in the test. Black (EPDM) and white (TPO) membrane were compared with the green roof. Even though the vegetation covering the roof was considered as poor, the results showed that the roof saves energy more than the two roofs. Compared to the black roof, is the green roof is 10 degree cooler and 20 degree cooler than the roof without greenery.

The needs to diversify the plant type to enhance the biodiversity of green roof have been proposed by [20]. The biodiversity ecosystem can be achieved when the integration plants such as grasses, forbs and succulents will resulted as the most optimized in the test. Results of this plant selection will benefit in energy and monetary savings, reductions in greenhouse emissions and also betterment of the urban climates. Another study done by [27] which uses many different aspect of plants species which are in term of spans of life, origins, forms of growth, height and time of flowering. All are in the form of dry and stress nutrients habitats. It was intended to test the cause of the depth of substrates on plant survival on green roof. They found out that at depth of 200mm, the productivity, species richness and diversity was to be the optimum level than 100mm depth substrates. Studies have shown that by using the natural nearby soil and vegetation is most suitable because it can adapt to local weather and nearby environment. It is the most suitable for the region endangered species and habitats. This was includes varying the substrate thickness of the soils [28],[29].

There were also other approaches by employing dynamic ecosystems and diversity of species. Firstly, finding shows the importance of distinguishing different species' capability to survive on green roof and its function of services the green roof itself. Secondly, the importance of selecting the right species because it is not confirms when diversity will improve the function of the green roof. Lastly was to test the different species under different environment for its specific contributions [30]. The work of [31] is evidenced that by increasing the diversity of green roof may enhance the habitat value. The study was done to test the performance of dry land and wetland species for the green roof. Result indicates that the performance of monoculture dry land and the mixture of dry land and wet land performed the best. Followed by monoculture of wet land and mixture of wetland species performed the poorest in term of roof cooling and storm water retention.

A study was carried out to search for the effect of water on 4 types of growth forms namely succulents, woody creeping shrubs, herbaceous dicots and grasses [32]. This is referring to watering capacity issue. The total of 14 numbers of plants species was used in the experiment. Succulents were found to be the best and survived in the dry conditions. S. acre and S. spurium (most common in green roof) had survived the drought test and Sedum×rubrotinctum even can withstand without water for 2 years as proven in the work of [33]. Table 2 summarises the results on types of plants used for green roof system.

For a country as Malaysia that have tropical climate, a study of plant selection had been done by [34] Family name of

certain species that can survive in tropical climate has been identified. Crassulaceae, Portulaceae and Neoregelia are the family of species that are indentified that can grow in tropical Malaysia climate. It was conclude that by selecting the right plants for the planting technology enables developers and the people at large to benefits from budget wise and maintenance.

In another Malaysian study, Ismail et al [35] use different type of plants to evaluate the thermal performance of typical Malaysian house. The plants were arrowhead plants (syngoniumpodophyllum), sweet potato (ipomoea batatas), cardinal creeper (ipomoeahorsfalliae/jasminumsambac), and beach morning glory (ipomoea pes-caprae). The selection of these plants because the ability to withstand high temperature and able to uptake high amount of carbon dioxide. The application of the green roof give promising result to the indoor and outdoor air temperature which was lower compared to both the black bare roof and white roof.

Following are the summary of type of plants and vegetation methods on green roof system.

TABLE II
SUMMARY OF THE TYPE OF PLANTS AND VEGETATION METHOD ON GREEN ROOF SYSTEM

Author(s)	Methods	Findings	Plants selection
Getter and Rowe (2007) [23]	tested on nine sedum species plants in two season, spring and autumn with different substrate depth	When planted during spring, most of the plants survive better compared to autumn.	Nine species of sedum-Sedum Cauticola, S. floriferum, S. sexangulare and many more
Rowe (2011) [24]	Uses many type of species to test the suitability on green roofs	Management and maintenance practice must be view at location and climate	Need to use plants in various climate and locations to promote biodiversity
Dunnett et al. (2008) [25]	Did an experiment to check on runoff quantity from 100mm growing medium in trays combined with forbs and grasses and also bare substrate.	Found out that it is no correlation between green roofs and different vegetation covers.	Grasses and forbs Grass- F.ovina, k.macrantha, H. pretense, Briza media Forbs-L. hispidus, succisapratensis, campanula rotundifolia, viola riviniana
Once et al. (2012) [26]	Use furnace bottom ash as medium in the green roof	Compared to the black roof (EPDM) green roof is 10 degree cooler and 20 degree cooler than the white (TPO) covering roof.	Three sedum types (kamtchaticum, spurium, sexangulare).
Dunnett et al. (2008).[27]	uses many different aspect of plants species intended to test the cause of the depth of substrates on plant survival on green roof	At depth of 200mm, the productivity, species richness and diversity was to be the optimum level than 100mm depth substrates	Fifteen herbaceous perennial of herbs and grasses
Brenneisen, (2006), Lee et al, (2010). [28][29]	Thicknesses of the substrates were varied. Also use the region nearby soils	using the nearby soil and vegetation is most suitable because it can adapt to local weather and nearby environment.	Plants type include of geophytes and succulent
Cook-Patton and Bauerle (2012) [30]	employing dynamic ecosystems and diversity of species	Conclude that it need to test the different species under different environment for its specific contributions	Suggest to vary species from different groups (e.g. succulent, grasses and legumes)
MacIvor et al(2011) [31]	test the performance of dry land and wetland species for the green roof	wet land and mixture of wetland species perform the poorest in term of roof cooling and storm water retention	Dry land species: Sibbaldiopsistridentate, Danthoniaspicata (L.), EmpetrumnigrumL. Wet land: Kalmia polifolia, ScirpuscespitosusL., Vacciniummacrocarpon
Lundholm and Wolf (2008) [32]	study to find out the effect of water on 4 types of growth forms namely succulents, woody creeping shrubs, herbaceous dicots and grasses	Succulents were found to be the best and survived the dry conditions. S. acre and S. spurium (most common in green roof) had survived the drought test	14 species- succulents, herbaceous dicots, grasses and shrubs
Johari et al(2011) [34]	Review on types of plants and planting schemes to developed sustainable green roof system	Identified 3 family names of plants that can survive in Malaysian tropical climate	Crassulaceae, Portulaceae and Neoregelia are the family of species that are indentified
Ismail et al(2011) [35]	Uses different type of plants to evaluate the thermal performance of typical Malaysian house	Green roof resulted in lower out and indoor air temperature than black and white roof	Arrowhead plants (s. podophyllum), sweet potato (i. batatas), cardinal creeper (i.horsfalliae/j. sambac), and beach morning glory(i.pes-caprae).

IV. STORM WATER RUNOFF

Storm water runoff is considered as the most popular and main concern of green roof [36], [37]. Uncontrollable storm water runoff will result in diminishing environment including water stream, river and lakes. It carries contaminants such as pesticides, chemical substances, heavy metals and other substances, which will pollute the environment [36]. So, the importance of green roof to mitigate the storm water runoff by water retention from plants in green roof is considered very important in urban development to sustain and preserve the nature.

Green roof gives very good indication as a method for managing storm water in urban and developed areas [38].

From the many benefits of the green roof shows that it reduces volume of flood, the flood peak, extending the beginning of flood time and also expanding the flood peak duration. A study by [36] found that by using slopes on surface of green roof demonstrate effect on runoff retention quantities. The result shows the higher the slope, the lower amount of water retention. However it was demonstrate on Midwestern United States climate and cannot be having the same conclusion on other climate.

A pilot test under repeatable rain simulations were done by [21] on many species of plants in United States climate. Many of them are sedum type, which include Rupestre Angelina, and Hispanicum. Other species are red clover (Trifoliumpratense), and white clover (Trifoliumrepens) also included were ryegrass (Loliummultiflorum) and Big-leaf Periwinkle(Vinca major). All the plants were planted in 2' x 2' trays with the same soil at different depth of 5cm and 14 cm. The objective was to determine how storm water would react on each plant type to different soil depth and root zone development. Result of the experiment shows that under same conditions, T. Pratense species had the most optimized average detention of water compared to other plants.

Many experiments found ways to adapt green roof technology in term of the suitable adapted vegetation and drainage layers. According to Sheng [2] the method of adapting integrated sustainable roof design (ISRD) by merging green roof system, photovoltaic thermal power and rain harvesting system. The author discovers the technique of integrating the solar panel of photovoltaic thermal (BiPVT) to green roof through the ISRD. The system can be changed based on specific needs of the weather and situation such as rainy days and draught. The problem is that the different rating tool of Green building system (GBI), which indirectly encouraged the use of BiPVT rather than green roofs.

Relationship between roof criteria, runoff, rainfall and different time scale (e.g. annual, seasonal and stormy) were studied by observation and experimentation [9]. Four different roof systems were examined which were non greened roof, gravel covered, intensive and extensive. The result shows that the issue of water retention in winter time was less than in summer. The approach was introduced to the city of Brussels. Further suggestion was that green roof needs to be integrate with run off reduction mechanism such as storage reservoirs [9] and also rainwater harvest system [2].

Method applied by Rowe [37] that use three methods used to measure storm water retention; roof with gravel ballast, typical roof without vegetation and extensive roof [37]. Similar experiment also shows that good storm water retention is correlated to roof slope and depth of media. The result further shows that the traditional roof with gravel ballast has less performance than roof with vegetation. It was suggested that to maximize rainfall retention, the issues of substrate depth and slope of roof must be taken into consideration.

Applying modular extensive green roof system by evaluating the storm water runoff had been done by [39]. Water quality also being investigated in term of its nutrients quality and dissolved metals. The roof was founded to precipitate 34% more than expected. It was proven the green roofs as an effective tool to reduce storm water runoff and bring the pollutant substances from the roof to minimal level.

Schroll[40] monitored 3 design of roofing in the winter climate in Oregon, Northwest pacific of United States: impervious design roof, medium design roof and extensive green roof. They also test the irrigation for maintaining the vegetation under dry and waterless season. Implication from the result is that the cold and extreme condition of winter are challenging for the storm water achievement. Suggestion to optimize the performance is to select the correct plants that suit the regional climate and environment.

The method of applying an extensive green roof system using test bed that incorporate sedum based type of vegetation in 80mm substrate layer [41]. The objective was to evaluate the storm water runoff using regression and process based modeling tools. The mean and median retention for all storms was found to be 70% to 91% per event which suggest that the when at peak rainfall events green roof is a good way to mitigate the storm water.

For small rain events, [42] used a simulation model using HYDRUS -1D on a modular green roof block. The simulation was able to predict accurately storm runoff in a small rain event. It shows that at growth media of 10cm it acquire complete retention of run off at 2.0 cm in depth. For larger rainfall, this simulation tends to over predict.

Investigation of water runoff from actual and simulated rain had been conducted on four different rooftop assemblies [43]. The objective was to investigate the effect of green roof as sink or source of metal and chemical contaminants. It was found that light metals were found in the runoff Mg, K, Ca and Na. Other nutrients also were present which are nitrate $NO_3^-$and phosphatePO_4^{3-}. It was proposed to use material that is environmental friendly on the roof construction.

Following are the summary of method implementing storm water management.

TABLE III
SUMMARY OF METHODS IMPLEMENTING STORM WATER RUNOFF

Author(s)	Methods	Findings
Getter et al (2007) [36]	Using slopes on surface of green roof demonstrate effect on runoff retention quantities.	The result shows the higher the slope, the lower amount of water retention
Spolek and Buccola (2011) [21]	A pilot test under repeatable rain simulations on many species of plants in United States climate	under same conditions, T. pratense species has the most optimized average detention of water comparing with other plants
Sheng et. al, (2011) [2]	the method of adapting integrated sustainable roof design(ISRD) by merging green roof system, photovoltaic thermal power and rain harvesting system	Different rating of Green building system which indirectly encouraged the use of BiPVT rather than green roofs.
Hermy et al., (2006) [9]	Four different roof were examined which are non greened roof, gravel covered, intensive and extensive	The finding was that winter had better water retention than summer

Rowe et al. (2005) [37]	using three different roof system to measure the storm water retention using roof with gravel ballast, typical roof without vegetation and extensive roof	Traditional roof with gravel ballast is less performed than roof with vegetation. Suggestion to maximize rainfall retention, the issues of substrate depth and slope of roof must be taken into consideration.
Gregoire et al. (2011) [39]	Applying modular extensive green roof system by evaluating the storm water runoff	roof was founded to precipitate 34% more than expected
Schroll et al. (2011) [40]	Monitored 3 design of roofing in the winter climate. The weather was dry and extremely cold	cold and extreme condition of winter are challenging for the storm water achievement
Stovin et al. (2012) [41]	Applying an extensive green roof system using test bed that incorporate sedum based type of vegetation in 80mm substrate layer. Evaluate the storm water runoff using regression and process based modeling tools	The mean and median retention for all storms was found to be 70% to 91% per event
Hilten et al. (2008) [42]	used a simulation model using HYDRUS -1D on a modular green roof block	Predict accurately storm runoff in a small rain event. It shows that at growth media of 10cm it acquire complete retention of run off at 2.0 cm in depth
Balasubramaniam et al. (2012) [43]	Investigate water runoff from actual and simulated rain on four different rooftop assemblies. To investigate the effect of green roof as sink or source of metal and chemical contaminants	Found that light metals were found in the runoff Mg, K, Ca and Na. Other nutrients also were present which are nitrate NO_3^- and phosphate PO_4^{3-}

V. Framework Study

The construction of the framework had described the three technical aspects of green roof designed found in the developed countries.; e.g. United States of America, Canada, Germany, Japan and plenty more. The use of waste and recyclable material, types of vegetation and planting method and also the method of reducing storm water runoff. The results are directed to the findings practiced in the developed countries, which may not all applicable to the Malaysian context.

From the three aspects of focused in this paper, storm water management method had been reviewed the most, basically because of the importance and needs to implement it. The urgent need to apply the green roof to mitigate the storm water is seem extremely necessary for highly rainy cities like Kuala Lumpur and the Klang Valley. The rapid growth of urban areas and the vast destruction of green areas had been roaring in the twenty first century. This had led to more and more impervious surface which can lead to massive impact to urban planning. One of it is the flash flood which is major threat to the development of the city of Kuala Lumpur [44]. Moreover the Klang valley region is being affected by the south west Monsoon from the Malacca straits that can carry heavy rain which eventually bring flash flood to affected areas [45]. By having green roof therefore will help to overcome the problem even though by a slight margin in its contribution. The need to identify the correct and most suitable and applicable method of mitigating storm water is duly crucial at this stage of time.

The methods mostly applied are simulation and modeling [21], [42], adjusting composition of green roof and compare with test roof [9], [36], [37], [40], [43]. Also using modular [39] and test bed [41] has proven to be efficient to reduce storm water runoff. Another method by [2] proposing integrated sustainable roof design (ISRD). This integrated system is a promising design that can combine all three systems into one. The green roof system, rain harvesting system and photovoltaic thermal power generation combine into this integrated system. Further research can be done in order to test the feasibility design and function of this integrated design.

VI. Conclusion

The awareness from the Malaysian society towards implementing green is still at very low level. The importance of the system had been proven by many expert and practitioners. Whole parties have to take initiatives to enhance the practice of the green roof system. The correct method of choosing the recyclable and waste material, plants and vegetation and also the method to mitigate the storm water runoff. Every aspect of the green roof system must be address including the law and regulation, design techniques and installation. Also must be taken into consideration are the maintenance, monetary, and life cycle analysis of the roof.

Therefore, the need to find out the most efficient and optimum method in these aspect of GBI assessment is important. The rating tools stated in the reviews are based on temperate climate, where mostly having four seasons climate, namely summer, autumn, winter and spring. Certainly this may not be totally applicable to our environment. Thus, findings suggest that further research on green roof system at the tropical climate is crucial. Perhaps, more study on countries having the same climate and environment as Malaysia should be taken into. These include the country's regulation, social and culture factors in building and roofs design techniques.

Acknowledgment

The authors wish to thank Ministry of Science and Technology Malaysia (MOSTI) under the FRGS grant no FRGS/1/2012/STWN01/UIAM/02/1 for the funding of this research.

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