GREEN ROOFS AS URBAN ANTIDOTE: A REVIEW ON AESTHETIC, ENVIRONMENTAL, ECONOMIC AND SOCIAL BENEFITS

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ABSTRACT

Vegetated façade so called as green roof is actually an old and traditional system is rediscovered and implemented to address and ameliorate deleterious impacts on our urban environment. This paper reviews the evidence for the varied benefits of green roof as urban antidote in reducing the energy required for the maintenance of interior climates, increase sound insulation, fire resistance, increase in the life span of the roof, provide small-scale green open space, wildlife niche creation, air quality improvement and reduction of UHI effects. In addition, green roofs could also improve storm water attenuation, increase the aesthetic value of a building façade and provide visual relief from the city hustle bustle.

1. INTRODUCTION

Sustainable design is the philosophy of a design that could eliminate negative environmental impact through a sensitive design. It is integrated design processes which highlight certain technologies for efficiency improvement. Green roof is one of the approaches in a sustainable design whereby the function of structure and nature are interrelated to sustain the environment (Köhler, 2001). Recently, there are many terms representing this type of rooftop greenery, Ecoroof, Bioroof, Living roof, Brown roof and also Green Roof Infrastructure. However, whichever term is used, the concept is still the same. Green roof is in simple terms, roof bearing vegetation that may take many different forms. Some are mats of uniform vegetation and thickness covering a large expanse of flat or sloping roof (Cantor, 2008).

However, the biggest problem with designing green roof is to convince the professional in built and design industries that the technology is a good idea. This kind of sustainable technology is available to be implemented in tropical climate countries and Singapore is the pioneer of green roof development. In Korea, the government started subsidizing green roofs program since 2002 after seeing the potentials of rooftops as green spaces in Seoul compared to the limited ground open spaces to be developed as urban park, neighbourhood parks, children's playgrounds, and pocket parks (Tong, M.Ahn, 2011). While in tropical Malaysia, the prospect of green development towards sustainable development and environmental preservation looks promising and bright to be implemented rigorously. (Chua and Oh, 2011).

2. MATERIALS AND METHOD

A comprehensive literature review was done based on green roof history, types, plant materials and its benefits towards the environment, economy and social factors. The resources of the study are fundamental, sourcing from journals and articles which are mostly drawn from between the years 2001 until 2011, to ensure the most updated data on green roofs. Papers were selected and examined to identify the range of green roofs benefits within research concern and factors that attribute to the environment, economy and also social factors. The factors are then discussed based on current scenario and existing literatures. The reviews will later determine the research gaps to be undertaken for future research.

3. HISTORY OF GREEN ROOF

Green roof as vegetated façade was a long tradition technology. It started with the ancient garden which are; the Ziggurats of Ancient Mesopotamia (4^{th} Millenium-600 B.C.); Hanging Gardens of Babylon; and Villa of the Mysterious, Pompeii. It was then followed by the Middle Ages and the Renaissance Garden; Mont-Saint-Michel, France; Palazzo Piccolomini, Pienza, Italy; Tower of the Guinigis, Lucca, Italy; Medici Roof Garden, Careggi, Italy. Then, it was used by the Scandinavians for thermal insulation during winter. Later, the development of green roof continued to evolve all over the world from 1600 to 1875 (Köhler, 2001; Oberndorfer, 2007; Osmundson, 1999).

Germany is one of the pioneers in green roof development. Since the 1880s, there was unintentional innovation of green roofs development due to rapid urbanization and construction industrialization in Berlin. The apartment block known as "rental barracks" (Mietskasernen) was actually built to house the city's increasing population of workers became the origins of inexpensive tar which was highly flammable where if one coal spark ignites a fire, it could destroy the whole city blocks at a time (McDonough, 2005).

Due to the safety problem, H.Koch, a German roofer developed a roofing technique to make the roof less combustible but still an economical alternative by covering the tar with a layer of sand and gravel. The technique became popular and was constructed throughout Berlin. The layer of sand and gravel which are fire-and weather-proofing became a growing medium for plants when plants eventually covered the roof surfaces. That is the origin of naturally-occurring plant palettes as those used in modern green roofs today. It also indicated early green roofs were employed as fire retardant structures (Köhler, 2005).

Later in the 1960s, scientists began to research the unusual vegetation growing on some of Berlin's pre-war roofs leading to the rediscovery of Koch's green roofs. Often called the father of modern green roofs, Reinhard Bornkamm, a researcher from Free University of Berlin, began to study the vegetation ecology of Koch's roof. He then built the first modern large-scale green roof project in Berlin on a building at the Free University where he combined extensive and intensive technologies but unfortunately it was dismantled due to lack of funding for its upkeep.

However, Bornkamm's students continue his research in the 1980s and they were surprised when they found fifty of Koch's historic green roofs. After more than seventy years and two World Wars, the roofs still remained waterproof through the entire life of the building. Normally, waterproofing membrane of modern green roof is replaced every 10 to 15 years, but Koch's technique is able to keep the roof waterproof for a long period. Since then, many of German's scientist and business community interested in these discoveries started to research more about green roof technology. Unfortunately, most of the papers are written in German (Mentens, 2005). Mean while, in the Asian region, green roof development was only implemented in 1914, when the store of Mitsukoshi department built one of the first roof gardens in Tokyo. The Mitsukoshi roof was designed with a traditional Japanese garden. However, the original garden was damaged in 1923 during the Kanto earthquake but it was later rebuilt. In 1936, Asakura Sculpture Museum, which is the oldest extended roof garden was built when private roof and terrace gardens became famous, and roof space was used for plantings by organizations. The roof garden was designed by Fumio Asakura, the founder of Japanese modern sculpture.

The interest in modern green roof technology grew since 1939 in Tokyo due to the urban heat island effect caused by World War II. Today, the Japanese government is following Tokyo's lead on green roof legislation. All new construction either houses or office buildings in urban areas should have at least twenty percent green of their rooftops. In 2005, the law goes into effect (McDonough, 2005). However, the development of green roof has not been implemented widely in Asia if compared to the western countries due to a lack of comprehensive research on how to suit the technology with our local climate especially in terms of the selection of suitable substrate and vegetation to be planted on the roof without incurring a high cost budget to build and maintain. Hence it created a need for more justification on the plants growing media and use of native species including the cost analysis for further research.

3.1 Types of Green Roof

Nowadays, green roofs are designed for multi types of buildings known for their deep substrates and various plants use for intensive green roof while the shallower substrates for extensive green roof. Intensive green roof is quite similar with the conventional ground-level gardens and they are usually built concurrently with the building construction and require substantial investment in plant care (Bass and Coffman, 2007). Extensive green roof is strictly limited in its plants selection and functional purposes, therefore it requires less maintenance (Dunnett and Kingsbury, 2004). The development of extensive green roofs are usually implemented on the existing building's rooftop.

Table 1 : General Advantages of Different Green Roof Types

Source: Green Roofs in Sustainable Landscape Design, Cantor, Steven L., foreword by Steven Peck, 2008, page 29.

Extensive	Semi-Intensive	Intensive
Lightweight	Combines best features of extensive and intensive	Greater diversity of plants
Suitable for large areas	Utilizes areas with greater loading capacity	Best insulation properties and storm water management
Low maintenance costs and no irrigation required	Greater coverage at less cost than intensive	Greater range of design
May be suitable for retrofit projects	Average maintenance	Often accessible
Lower capital costs	Greater plant diversity than extensive	Greater variety of human uses

Easier to replace	Greater opportunities for aesthetic design than extensive.	Greater biodiversity potential
Suitable for sloped and flat roof	Suitable for flat roof	Suitable for flat roof

3.2. Aesthetic

Today, a roof is no more the last part of the building's facade anymore. The development of green roofs on the roof top transformed the physical and visual aesthetic of the barren concrete structure into a living and breathing green space (Cantor, 2008; Grant, 2006). Green roofs help to soften the artificial urban landscape and provide visual relief from the concretized environment for urban citizen through providing relaxation and restoration ambience in the city (Hartig et al., 1991). Apart from that, it also enhances architectural designs to create iconic landmarks in the city.

3.3 Environmental Benefits

Urbanism caused the deleterious impact on our environment. Therefore, green roofs is a system that helps in reducing the UHI effect-decrease smog episodes, problems related with stress and lower the consumption of energy used by the building's occupants (Liu, 2009). Implementing extensive green roof will reduced 60% of heat gain compare to bare roof in temperate climate (Ismail, 2010). However the percentage of heat reduced is depend on the size of roof area and also the type of building (high rise or low rise building). Greater size of roof area determine the greater size of green roof, therefore greater amount of heat will be reduce in the building. Commonly, extensive green roof is more effective in reducing the heat if compared with intensive and semi-intensive green roofs.

Green roofs could also reduce storm water runoff (Weiler and Scholz, 2009). This happens because water runoff is held by the vegetation and soil before it directly hit the ground. However the amount of storm water reduction is based on the types of plants used and also the growing media depth. The deepest soil layer will reduce a lot of storm water runoff compared to a shallower one. This indirectly improves rainwater retention to help drains cope with severe downpour and finally reduce flash flood (Cantor, 2008). On the other hand, green roofs could enhance biodiversity in the city by providing additional natural habitats for flora and fauna (Chrisman, 2005). Green roofs provide the niche for invertebrate, various insects, including beetles, ants, bugs, flies, bees, spiders and leafhoppers (Coffman and Davis, 2005). Green roofs can also become a nest for birds and native avian communities (Baumann, 2006).

The other benefit of green roof is it can treat polluted air that could harm human health (Mayer, 1999). In urban areas, vegetation is a significant contributor to the reduction of air pollutants (Akbari et al., 2001; Nowak, 2006; Rosenfeld et al., 1998; Scott et al., 1998). The vegetations on green roofs will trap many particulates that would otherwise contaminate the air or be inhaled by human or animals (Cantor, 2008).

3.4 Economy Benefits

Green roofs development is a long term investment whereby its installation may need a certain amount of budget. This is due to a significant cost barrier between green and conventional roofs (Wong et al., 2003). However, it is undoubted that green roofs help in increasing the land line properties of the building in the future. The marketability of green roof in branding the building as a green building will definitely give a tremendous impact to private enterprise, universities and cities in attracting citizen and tourist to visit the buildings (Oberndorfer et al., 2007).

Some thought that green roofs can damage the roof structure. However, through cost benefits analyses, it shows that green roofs will improve the longevity of roof life span. The vegetation and waterproof membrane of green roofs will stabilize the temperature of the roof and extend its life by more than 20 years (USEPA, 2000). In Berlin, Porche and Köhler (2003) found some green roofs in Berlin lasted 90 years without having a major damage to it. In Singapore, green roofs reduce cooling load by 10% of the usual building with a conventional roof (Wong et al., 2003). The reduction of heat and temperature will lead to a reduction of air conditioning cost to keep the internal part of the building cooler.

Apart from that, green roofs also could be an economical kitchen garden where vegetables and fruits are planted on the roof. Apart from saving money, an agriculture green roof also helps in saving time to go shopping in the market when the owner just need to pluck them whenever they want to. This kind of approach could enhance the citizen to utilize the open space on top of their roof and learn to appreciate nature as well. Furthermore, rooftop farm lowers the carbon footprint caused by trucks used to transport food into the city. However, there is still a lot of research to be done to prove whether it is an efficient process for growing plants on rooftop (Rowe, 2010).

3.5 Social Benefits

People in urban area rarely express their emotion regarding the loss of green space (Weiler and Scholz, 2009). They only realize the need of green space when it becomes very limited in numbers and scale. There are a lack of research being done on small-scale green areas that are close to where people live and work if compared with the research on urban parks. Based on research done by Kaplan and Kaplan (1989) and Godbey et al. (1992) on the use of urban parks verifies that the majority of users are visitors on foot. These findings strongly prove the earlier research done by Alexander et al. in 1977, that people will visit urban park if the journey only take them three to five minutes walk from their home or office. That is the duration for people to visit green space if it is just on top of their roof. The use and role of roof gardens in the pattern of urban living will work best when they are a direct established relationship between the space and the people who live and work around it (Rogers and Urban Task Force, 1999). Green roofs could provide a natural refuge area for urban citizen to renew themselves spiritually as most of their lives are spent in urban areas for urban tasks (Miller, 1986). Rooftop gardens offer usable spaces (Willmert, 2000). When humans view green plants and nature, it has beneficial health effects as well as improved health and worker productivity. Employees with a view of nature were less stressed, had lower blood pressure, reported fewer illnesses, and experienced greater job satisfaction (Cooper-Marcus and Barnes, 1999; Kaplan et al., 1988; Ulrich, 1984).

Green roofs will promote sense of ownership, fosters community interaction and also bring greenery ever closer to building occupants. From the survey done in Singapore, 80% of the citizen voted for more roof gardens to be implemented in the city. There are varied reasons influencing the survey results which are recreational purposes, and also beautifying the city ambience through greenery and nature element (Yuen and Wong, 2005).

CONCLUSION

Green roofs installation benefits are varied in terms of its aesthetic values, improving the environment, economy and social among the urban citizen. The contribution of green roof practice reveals great opportunity in mitigating the impact of urbanism in the urban area. It is an urban antidote that will increase the performance of a healthy living ambience in the city. However, a lot of research still needs to be done in Asian countries on green roofs installation system including the types of substrates and appropriate plant selection relating to region climate. This is because, most of the previous research on green roofs are focused on temperate climate. Thus, this study could provide an understanding on the varied benefits and importance of green roofs development especially in urban city planning.

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