Green roofs: Benefits &Uses

Prepared by:

Rebeen khasraw mustafa

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Abstract

In municipalities, constructions contribute large unused panels, particularly on their wall and roofs. These exterior surfaces commonly made from constituents that recorded as a reflector to the heat like concrete, glass, and bricks. Cover the outdoor surfaces with green flora could be a solution to numerous ecological, commercial and social difficulties, specifically in the urban zones. A assessment was focused of studies that stated and measured on the connection between characteristics of vegetation and their effect on building thermal performance, air and water pollution, and building energy effectual. A frequent of published researches were studied for their: (a) explanation depend on roof typologies and combinations; (b) historical progress periods; (c) observation the green system functions. These investigates cover to afford scholars with a assessment of conventional procedures to realize one of the inactive chilling approaches accepted in warm and cold temperatures. The skills offer a important influence to the field of supportable architecture, also to progress understanding of the progressive improvements of a green roof. Despite other new strategies of green system, this conventional and simple green roof has continued to contribute significantly to afford indoor thermal comfort.

Introduction

Rapid economic growth, many countries have been experiencing increased urbanization. Due to this amplified urban population, tall buildings and other new developments are made at the expense of green areas. This resulted in the shortage of greenery which in turn causes a decrease in canopy interception and transpiration within the urban area leading to an increased temperature and decreased air humidity [1]. These problems can be partially solved by altering buildings' rooftop properties. The introduction of plants and soil to the unutilized rooftop surfaces are often regarded as a valuable strategy to convert buildings more sustainable [2,3]. Green (vegetated, eco or living) roofs are basically roofs planted with vegetation on top of the growth medium (substrate). The concept was designed and developed to promote the growth of various forms of vegetation on the top of buildings and thereby provide aesthetical as well as environmental and economic benefits. Green roofs generally comprise of several components, including vegetation, substrate, filter fabric, drainage material, root barrier and insulation. The role played by each component is well defined in engineered green roof system and type of each green roof component depends on the geographic location [4].Green roofs are broadly classified into intensive, semi-intensive and extensive green roofs. Intensive green roofs are characterized with thick substrate layer (20–200 cm), wide variety of plants, high maintenance, high capital cost and greater weight. Due to increased soil depth, the plant selection can be more diverse including shrubs and small trees. Therefore, typically require high maintenance in the form of fertilizing, weeding and watering. On the other hand, extensive green roofs are characterized with thin substrate layer (less than 15 cm), low capital cost, low weight and minimal maintenance. Owing to the thin substrate layer, extensive roofs can accommodate only limited type of vegetation types including grasses, moss and few succulents. An extensive green roof system is commonly used in situations where no additional structural support is desired. Semi-intensive green roofs accommodate small herbaceous plants, ground covers, grasses and small shrubs due to moderately thick substrate layer. These roofs require frequent maintenance as well as sustain high capital costs. Of the three types, extensive green roofs are most common around the world due to building weight restrictions, costs and maintenance. Green roofs present numerous economic and social benefits in addition to more obvious environmental advantages such as storm–water management, decreased energy consumption of buildings, improved water and air quality, decreased noise pollution, extended roof life, reduced heat-island effect and increased green space in urban environments [1, 5, 6]. Many other benefits of green roofs are just as achievable, but thus far the green roofs generally are not optimized to meet those [7]. This is generally due to lack of research on different aspects of green roofs and premature introduction of products into the market. Thus, there is a great need for green roof research. The objectives of this review are to understand the current scenario in green roof research, provide suggestions to select different green roof components based on requirements and strategies to develop practical green roofs to meet consumer needs. In addition, this review also summarizes the benefits of green roofs as well as recent trends in green roof technology

History of Roof Garden

Implanting flora at the building rooftop is an old system. The most famed ancient green roofs were the Hanging Gardens of Babylon built around 500 BC. In more current times, peoples tend to protection their rooftops with sod for the purpose of lagging from risky climates. Modern green roofs, consequently, might get their concept from ancient system; however technical advances have completed modern green roofs far more effective, practical and advantageous than their ancient counterparts [2]. In the early modern era, diverse continents kept the idea of the green roof alive, this concept was approximately adopted in numerous regions and cultures. In the mid of 1880s, the new technology brought the idea of a living roof on the top of the concrete roof, the first typical of this roof looked in the World Expo in Paris in 1867. The model has exemplified a green roof with waterproofing and drainage scheme, which consider the first design of an wide green roof [12]. During the 20th century, the inventor of modern architecture (Le Corbusier, Alvar Aalto, and Frank Lloyd), start to device the green roof and walls in their design to merge the natural with building. Their well-known designs are a clear sign of this concept (Villa Shodhan, Villa Mairea, and Millard House). Presents famed constructions designed with a green roof among the 1920s and 1930s. In the late of 20th century, the appearance of manufacturing era followed back the concept of green roof in Germany, after the invention of diverse gravel and sand with tar to produced non- inflammable water-resistant by H. Koch. With the aid of nature, the new materials developed the base system to herbaceous plants that grow on building's roof, later in the 1960s, both sand and gravel layers were extra with simple drainage system and new design of lightweight green roof [8]. The revolution and development of roof technology made German the first country in the world adopted the principle of green roof in the building followed by North Europe and North American and Finally a few countries in Asia as describes in figure 1.

Figure 1. Descriptive figure which demonstrated the different types of roof garden.

A. Green roofs at Monastery of La Tourette designed by Le Corbusier's.
B). Green gardens at the top of Rockefeller Centre in New York.
C). Roof garden at Villa Mairea designed by Alvar Aalto

Benefits of Roof Garden

Incorporating vegetation, growth medium and other landscape components on the rooftop of buildings offer several direct and indirect environmental benefits. These are summarized as below**:A-Storm water attenuation**: Green roofs are known to retain rainwater and delay peak flow, thus reducing flood risk [20, 21]. When rainwater gets in a green roof, a part of water will be imbibed by growing substrate or retained in the pore spaces. It can diffuse again into the atmosphere after the process of storing plants in the tissues of plants [22]. The remaining water passes through the filter fabric and then enters the drainage element. Due to the potential to store water between pores (in the case of granules) or compartments (in the case of drainage modules), water will be detained. After complete utilisation of drainage space, the overflow will drain. The retained water inside the green roof will evaporate or be used by plants and parts of it will transpire. It is the evaporated and transpired water that explains the runoff retention potential of green roofs. The type and thickness of the roof growth medium Green denote retention potential. Drainage element type and capacity for storage, vegetation type and coverage, pre-dry rain event volume and time, green roof slope. The growth medium plays a major role in water retention amongst the various factors.

Lightweight volcanic material is a major component of a green roof and has a significant role to retain moisture. Vijayaraghavan and Joshi [7A] conducted an exhaustive examination of substrate characteristics and identified delay in runoff generation from green roofs was mainly due to the high water holding capacity (WHC) of the growth medium. During their simulated green roof experiments, Graceson et al. [23] identified that higher WHC resulted in higher runoff retention.Plants play a significant and important role in reducing runoff, depending on each plant's ability to intercept water, water retention, and transpiration[22,24]. Speak et al. [25] indicated that average runoff retention of 65.7% can be achieved on an intensive green roof (University of Manchester campus), compared to 33.6% on an adjacent paved roof. Nagase and Dunnett [22] screened several vegetation species that are commonly used in extensive green roofs and identified a significant difference in the amount of water runoff between plant types. Weeds have an effective role in reducing runoff production, followed by weeds and sedum. The authors also suggested a higher degree of runoff control by using larger, larger diameters and larger plant species. There is a strong perception that runoff production from green rooftops with minimum water requirement is greater than from other plant species with higher transpiration rates than dry the substrates from precipitation events. [26,27]. However, Berghage et al. [28] identified that sedum species can rapidly transpire available water and can contribute up to 40% of a green roof's capacity to retain rainwater depending on the size and timing of rain events. The drainage element type allows for the storage of rainwater by green roofs. Plastic drainage modules, which collect water during dry periods in small compartments to supply the plants with water, have been used in recent years. Vijayaraghavan and Joshi [7A] utilized a commercial drainage element and the authors claimed the storage potential of the drainage module played a significant role in the reduction of runoff volume. Several studies correlated the capacity of green roofs to retain water with rainfall size, intensity and preceding dry times [1A, 29]. Villarreal and Bengtsson [30] the intensity of the main event and the slope of the green roof play a major role in storing water for the green roof. For a rainfall with an intensity of 0.4 mm/min, 62%, 43% and 39% of the total precipitation was retained in the green-roof having slopes of 2°, 8° and 14°, respectively. In figure 2 for rain intensity, 0.8 mm/min at slopes of 2°, 8° and 14°, the retentions were 54%, 30%, and 21%, respectively.

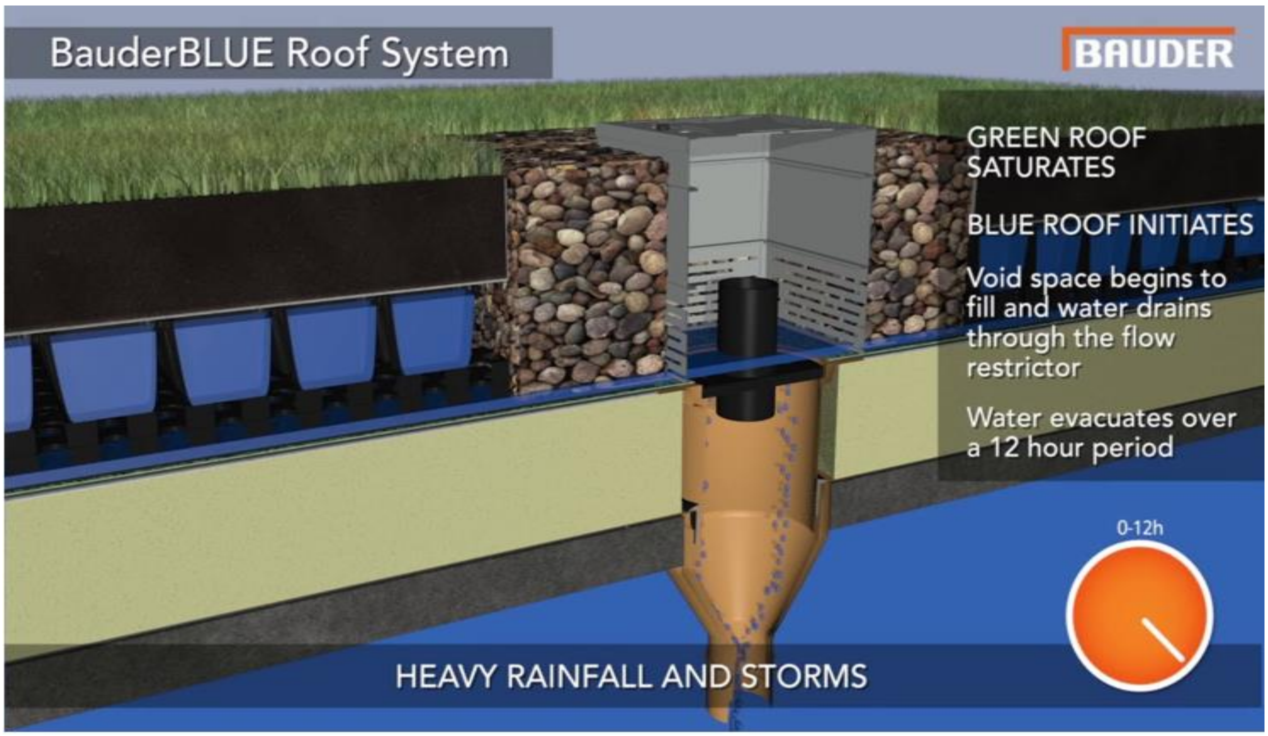

Figure 2. Showed rain water harvesting system.

Thermal Benefits

Green roofs stay a striking selection for energy reserves in the building sector. They decrease building energy demand over the upgrading of thermal performance of constructions figure 3 [9, 31]. Schoolwork in Greece exposed that green roofs decrease the energy used for cooling between 2 % and 48 % depending on the area roofed by the green roof, with an indoor temperature decrease up to 4 K [32]. The development of thermal performance is essentially due to an increase in shading, better insulation, and higher thermal mass of the roof structure [9]. To be accurate, the thermal loads due to solar radiation and the air temperature are limited due to the presence of the flora layer. Moreover, the growing average gives extra insulation to the roof and the water content raises the thermal inertia of the structure. The ability of a green roof to progress thermal performance was also stated by Ekaterini and Dimitris [33]. According to their discovery, of the entire solar radiation rapt by the planted roofs, 27 % was reflected, 60 % was absorbed by the plants and the substrate medium, and 13 % was conducted into the substrate medium. Measurements since a green roof trial fixed on a five-storey commercial building in Singapore designated that a saving of 1–15 % in the annual energy consumption, 17–79 % in the space cooling load and 17–79 % in the peak space load could be achieved [34]. The authors similarly identified that maximum energy savings depend powerfully upon the plant species as well as the nature and depth of the growing medium. In winter, green roof act as insulators decreasing heat flow; but this advantage is frequently below discussion as some studies claimed green roof as a medium to save energy [35], others identified that green roof has no effect throughout winter [36] and some observed it as a reason of extra energy consumption [37]. Considering these provocative results, it is recommended to conduct more investigation on the effect of seasonal differences on the thermal performance of green roofs. Green roofs can also be observed as an applied implement to mitigate the urban heat island (UHI) effect i.e. to a reduction of ambient air temperature in urban areas. Several densely populated and intensely urbanised areas in the world suffer from UHI problems and the worst urban eco-environment [16]. Green roofs are tools that combat UHI and increase the albedo of urban areas [9, 38]. Berardi et al. [3] indicated that the albedo of green roofs ranges from 0.7 to 0.85, which is much advanced than the albedo (0.1–0.2) of bitumen, tar, and gravel roofs. In his review article, Santamouris [39] compared several mitigation technologies to minimalize the UHI effect and suggested that large-scale application of green roofs might decrease the ambient temperature from 0.3 to 3 °C.

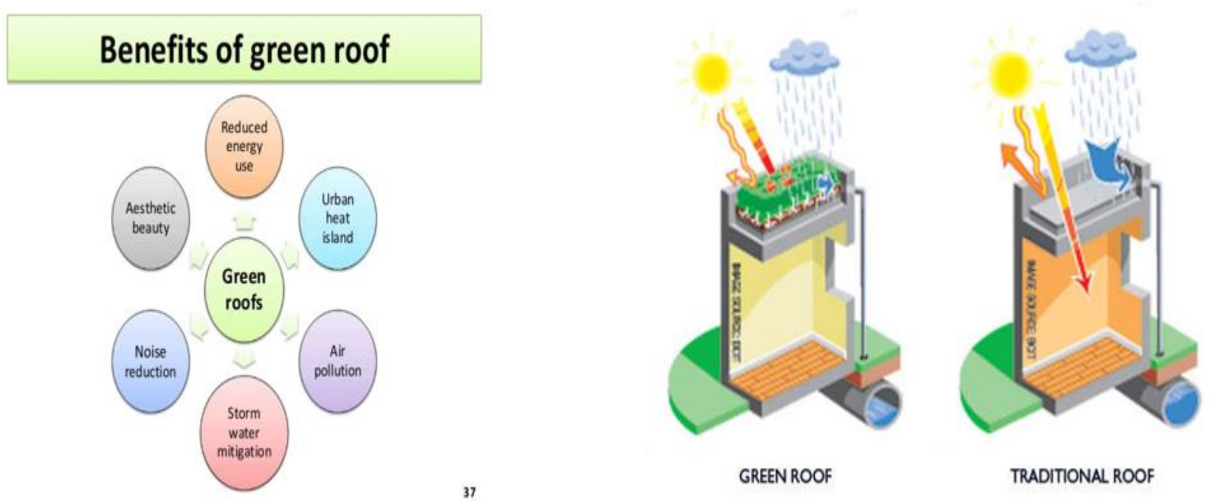

Figure 3. Descriptive figure which demonstrated the thermal benefit of roof garden.

Air Pollution

The green roof system is a general method that could assistance to mitigate air pollution in urban environments. Urban air often covers raised levels of pollutants that are harmful to human health and the environment [52]. Among numerous mitigation technologies, the capacity of plants to clean the air is considered a practical and environmentally benign technique [8]. Overall, plants mitigate air pollution through direct and indirect practices, i.e. directly consume gaseous pollutants through their stomata or indirectly by adapting microclimates [53]. The indirect processes such as reducing indoor temperature which in turn decrease the air-conditioning energy usage and following the emission of pollutants from power plants along with the potential of vegetation to minimize UHI were covered in previous sections. Yang et al. [53] counted a total of 1675 kg of air pollutants was removed by 19.8 ha of green roofs in one year with O3 accounting for 52% of the total, NO2 (27 %), PM10 (14 %), and SO2 (7 %). On the other hand, Johnson and Newton [54] assessed that 2000 m2 of uncut grass on a green roof can eliminate up to 4000 kg of particulate matter. Rowe [8] further added that one square meter of a green roof could balance the annual particulate matter emissions of one car. It is also worth noting that the potential of green roofs to minimise CO2 concentration was studied by Li et al. [55]. The authors recognized that the performance of the green roof was associated with the condition of the plants, the position of the green roof and the ambient airflow condition. More precisely, on a sunny day, a green roof may lower the CO2 concentration in the near region by as much as 2%. Planting trees in urban areas have been shown to provide better benefits in the mitigation of air pollution [56, 57]. However, considering the limited available space in urban areas, it is difficult to develop urban forest. Due to the above fact, it is a general conclusion that concentrated green roofs are more favourable in terms of minimizing air pollution than widespread roofs, owing to the opportunity of installing small trees and shrubs [2, 58].

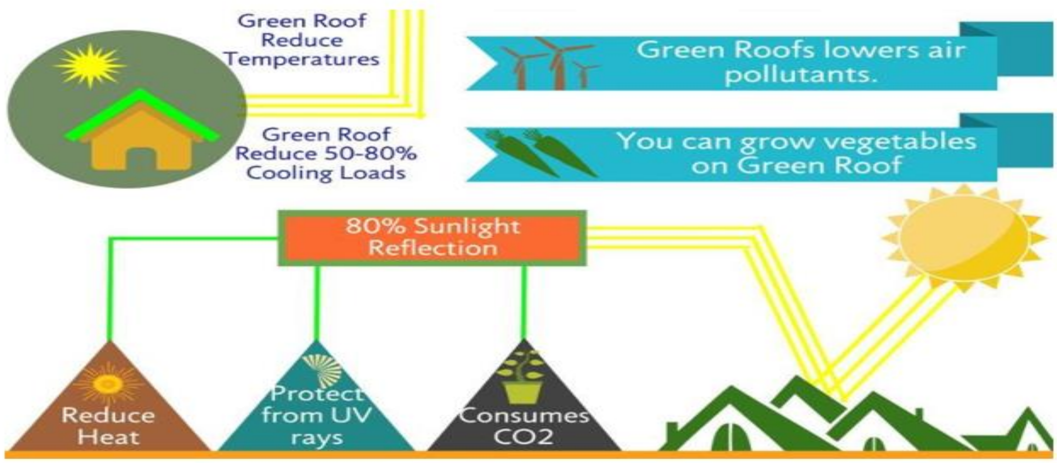

Figure 4. Descriptive figure which explained the decreasing of air pollution with roof garden.

Noise Reduction

Green roofs are limits constructed among outdoor and indoor environments, due to their components and characteristics General, it reduces road noise pollution in urban areas [48,49].Green roofing can decrease sound in a building, if increased roof components, provide increased insulation for the roof system and by absorbing sound waves that are deflected above the roofs explained in figure 5 [50] Study on green roofs of diverse depths of the sub-substrate, water content and plant types, The loss of the trans-implanted surfaces was greater than the loss of the non-implanted reference surfaces, according to the results indicated, with ratios reaching 10 and 20 dB in the low and the medium. Frequency bands, correspondingly Van Renterghem and Botteldooren [48].The total efficiency of spacious green roofs (15-20 cm) while increasing the thickness of intensive green roofs (greater than 20 cm) does not produce more and positive effects on performance Green roofs in sound insulation are clearer and good at low altitude buildings because an increasing layer must develop an actual absorbent surface exposed to the direct urban sound field [8].

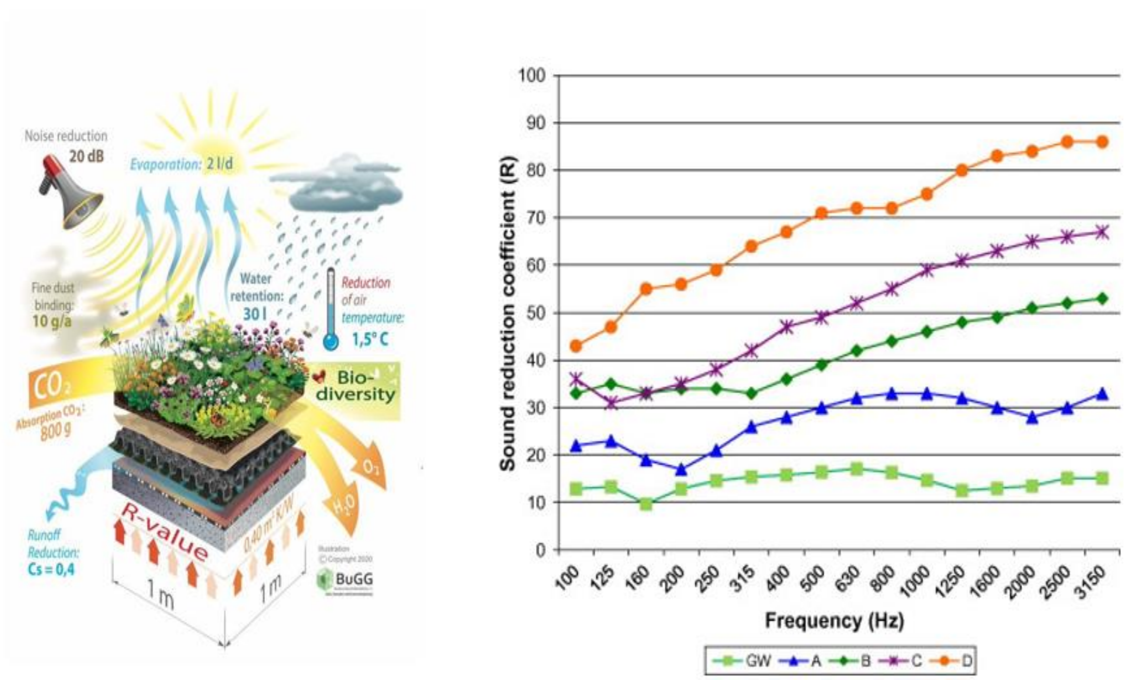

Figure 5. Demonstrated the noise reduction in roof garden design.

Contribution of green roofs to CO_2 sequestration

The climate of Earth has altered in the past 1,300 years due to small differences in Earth's orbit that alter the quantity of solar energy the planet takes. However, the current warming tendency particularly worried scientists for the reason that it is arranged at an extraordinary rate and is suspected to be sequester 55,252 tons of carbon, the amount equal to the emissions from about 10,000 mid-sized sport utility vehicle (SUV) or trucks. The reduction of ambient CO_2 concentration near green roofs is substantial. Li et al. (2010) studied the effect of green roofs on ambient CO_2 concentration to estimate the benefit of urban greening figure 6. CO_2 concentrations above a 4 m×4 m green roof and a bare control roof were monitored. Data showed that on a characteristic sunny day with light wind, the CO2 concentration above the green roof was 4.3 mg/m3 lower than at the control roof throughout the day time before 4 PM and slightly higher during the night time. To further estimate the influence of green roofs on ambient CO2 concentration, the author also measured the CO2 of the green roof in a chamber to hypothesis an absorption/emission velocity curve. Using this CO2 absorption/emission velocity curve, the author modelled the green roof effects in an urban area with a species transport module from commercial computational fluid dynamics software. Imitation outcomes showed that CO2 concentration around the green roof fell markedly. Depending on the total of wind facilitating the mixing, the decrease of CO2 concentration in the green roof locality stretched up to 9.3 %. The application of green roofs could yield a long term economic payback (Niu et al. 2010). Hong et al. (2012) and Kim et al. (2012) noted that the forest reduction rate in metropolitan areas was extremely high, and the area of forests was well below the World Health Organization's minimal standard. Hong considered green roofs as the optimum alternative to increase urban forests to control temperature and absorb CO2. The study used EnergyPlus that considered both economic and environmental effects to evaluate the benefits of adding green roofs to some educational facilities in Seoul, South Korea. There were 16 scenarios established by combining green roofs, external insulation, exterior blinds, double glazing, and LED light improvements. The study correlated energy consumption with CO2 equivalents. The rate of plant CO2 equivalent reduction was estimated by plant absorption rate. Then the results of the life cycle CO2 analyses with these various scenarios were converted to certified emission reductions (CERs) carbon credits and dollar values ($4.49/ton of CO2 equivalent). Life cycle cost analyses showed that when considering only the initial expense, the conventional roof system was superior to the green roof systems. However, when considering the environmental value, the results revealed that a green roof system could induce up to 33.8 % savings in terms of combined cost reduction and environmental values.

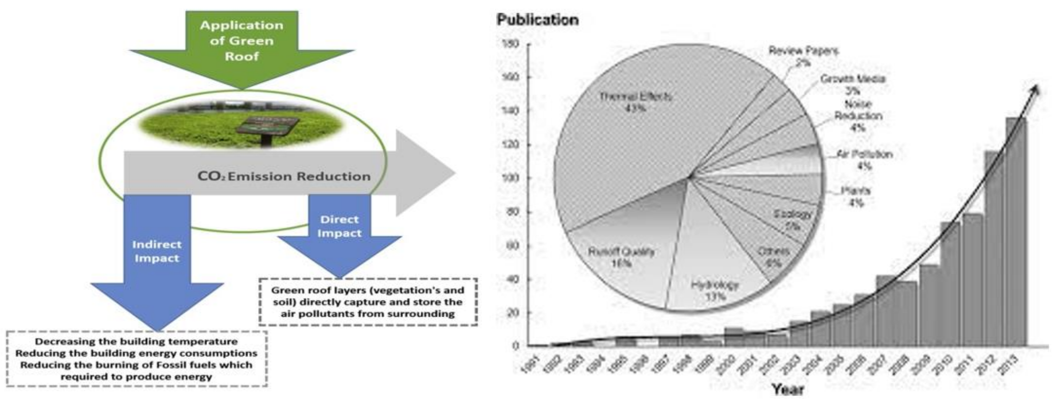

Figure 6. Descriptive figure which demonstrated the green roofs to CO2 sequestration.

Other benefits

Green roofs can also be observed as a tool to improve the aesthetic appeal of any building. Associated with bland and utterly boring flat roofs, green roofs are additionally enjoyable to experience or view from other buildings. Green roofs also aid to restore the biodiversity that has been lost due to urban development. Green roofs offer a safe place for birds, insect and other plants to grow. Green roofs protect the roof membrane from extreme heat, wind and ultraviolet radiation. Due to the presence of vegetation and a thick substrate layer, the daily expansion and contraction of the roofing membrane can be avoided. A study in Toronto by Liu and Baskaran [59] assessed that the membrane temperature on a green roof reached only 25 °C, while that of a convention roof increased to 70 °C.

Conclusion

Subsequently, besides the discussion of this article, the green roof plays a key role in reducing the temperature, absorbing sound, reducing noise, environmental pollution and carbon dioxide, and has a main role to save rainwater and reprocessed again oxygen production, and building sustainable invention.

Recommendation

The most important point for as the advantages of the green roof, it is desirable to use the green roof in new buildings and a new designs system, mainly these buildings with a small land area or in this building that does not have an area or green spaces on the ground floor because it has a major role in terms of aesthetic and social, producing a healthy environment and protecting the building from All the environmental and climatic factors and influences around it and build a sustainable building.

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