



## Advances of Green Roofs for Environment in Urban Areas

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### Abstract

In 21st century, the unplanned urbanization, global warming, lack of green space, and the human effects on the ecological balance in the nature influence the human life particularly in our cities. Additionally, the mentioned changes cause to decrease on other open-green spaces as well as the reduction of the natural places in the cities. That's the reason for ecological anxiety as well as the demand for recreational and roof areas in urban places. Establishing of the plant material on rooftops provides numerous ecological and economic benefits which might be summarized as following: improving of the microclimate and air quality, offering to a natural habitat, providing for additional space, increasing of water retention and noise protection, storm-water management, energy conservation, mitigation of the urban heat island effect, and increased longevity of roofing membranes, as well as providing a more aesthetically pleasing environment for life. This paper is a review of current knowledge regarding to the benefits of green roofs in urban areas that are so far from the nature and lack of green space.

**Keywords:** Urban Areas, Green-roof, Benefits of Green-roofs

### Introduction

Urban population has been increasing for several decades at an accelerated pace. In 2009, about half of the world's population (3.42 billion out of 6.83 billion) lived in urban area, and projections show this will increase to 68.7% by 2050 (World Urbanization Prospects and Revision, 2009).

This urbanization and population explosion in urban areas is continuously threatening the land available for urban green spaces (M'ikiugu et al., 2014). At the same time the case causes a decrease in per capita space and thereby a loss of per capita urban green space (James et al., 2009), which furthermore causes a decrease in daily exposure to more natural environments (Barton and Pretty, 2010) and many negative effects.

A city devoid of quantity and quality urban green spaces becomes a concrete jungle or a polluted city vulnerable to calamities, behavioral vices, and low livability index. Urban green spaces provide benefits to the city that helps mitigate these negative effects (De Ridder et al., 2004), and are valuable amenity-recreation venues, wildlife refuge and essential livable-city ingredients (Jim and Chen, 2003). Population explosion in urban areas is continuously threatening the land available for urban green spaces (M'ikiugu et al. 2012).

Green roofs which are a type of urban green spaces, are a technology that seeks to lessen

the impacts of urbanization on people and wildlife (Pearce and Walters 2012).

In the present paper, the literature was evaluated that are related with importance of green roofs and their supports on urban ecology which are getting far from nature and being an un-healthy environment due to the increasing of population.

### Green Roofs in Urban Green Spaces

Rapid urbanization has resulted in upgrading of interest in urban green space, and the ways in which this green space can benefit cities and their inhabitants have become key issues in urban planning (Sandström, 2002).

Urban green spaces are important natural and cultural entities of cities. They shoulder significant roles in sustainable urban development and urban ecology by virtue of multiple environmental, social, health and economic benefits (Chiesura, 2004; Zhou and Wang, 2011). Many studies have expounded the significant functions of urban green spaces in urban life (Yang et al. 2005; Alvey 2006; Sanesi et al. 2006; Uy and Nakagoshi, 2008; James et al. 2009, Tian et al. 2014).

Ecological restoration and green space development within cities, (such as green roofs and walls, wetlands, water gardens, green parking lots, permeable pavement, vegetative swales, and green ways) have become very important for a variety of

reasons (e.g., storm water control, air quality improvement, and human health support through the provision of recreational opportunities, heat island mitigation, biodiversity conservation, etc.)(Smetana and Crittendena, 2014).

Consequently, policy to encourage green roofs within developments has been established for a number of cities in Europe and USA (Carter and Fowler 2008; Pearce and Walters 2012; Peri et al. 2012).

#### **What is a green roof**

A green roof (also known as an eco-roof, planted roof, nature roof, living roof or roof greening system) is a living, vegetative system that contains a substrate (growing media) and a vegetation layer at its outermost surface. The design and construction between the roof structure and the growing media varies, but typically includes a geo-textile filter, drainage layer, root barrier and a waterproof membrane. Depending upon the vegetation layer, the growing media depth can vary from 20mm (for extensive systems utilising sedum mats) to 1500mm (for intensive systems containing large shrubs and trees) (Carroll 2010).

#### **The types of green roofs**

Modern green roofs can be classified as intensive and extensive systems depending on the plant species, construction materials, management and use (Spala et al, 2008; Berndtsson 2010; Jim and Tsang, 2011; Ascione et al. 2013):

Intensive green roofs have a thick layer of soil, require irrigation, and have high water retention and fertile conditions for plants. The depth of substrate is generally between 150mm and 1500mm and the vegetation used ranges from herbaceous plants, shrubs and grasses to larger plants and, in some cases, even trees. It can be said that intensive green roofs are comparable to open spaces at ground level and can be made use of by building residents. As a result of the size of the plants used, the depth of substrate and its high water retention; the weight of an intensive green roof is significantly higher than that of conventional roofs. Therefore, substantial reinforcement of an existing roof structure or the inclusion of additional building structural support is required. Intensive green roofs also require a large amount of maintenance, regular irrigation and applications of fertiliser.

Extensive green roofs have a thin layer of substrate (20mm to 200mm), require little or no irrigation, and have low water retention and nutrient poor conditions for plants. The thin growing medium can consist of recycled materials. Extensive green roofs are less costly to install than

intensive green roofs and are also cheaper to maintain. Generally they are planted with, or colonized by, mosses, succulents, wild flowers and grasses that are able to survive on the shallow low-nutrient substrates.

#### **The benefits of green roofs**

There are numerous social and private benefits provided by intensive and extensive green roof systems (Benvenuti 2014; Berardi et al. 2014; Carter and Fowler 2008; Getter and Bradley 2006; Jim and Hongming 2010, Mentens et al. 2006; Rowe 2011; Tomalty and Komorowski 2010; Oberndorfer et al. 2014).

The benefits of green roofs may be summarized under three groups:

##### **1. Ecological Benefits of a Green Roof**

###### *Stormwater Management*

Moderation of Urban Heat Island Effect

Improved Air Quality

Increased Biodiversity

Noise Reduction

Reduction of Electromagnetic Radiation

###### *Waste Diversion*

##### **2. Economical Benefits of a Green Roof**

###### *Energy Efficiency*

Increases Water Retention

*Increased Roofing Membrane Durability*

###### *Fire Retardation*

Urban Agriculture

Local Job Creation

Marketing

##### **3. Other Public Benefits**

Aesthetic Improvement

New Amenity Spaces

Improved Health and Well-Being

Educational Opportunities

##### **1. Ecological Benefits of A Green Roof**

Ecological benefits of the green roofs could be explained as in the following lines:

**a. Stormwater Management**(Villarreal and Bengtsson 2005; Carter and Rasmussen 2006; Mentens et al. 2006; Getter et al. 2007)

-With green roofs, water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation.

-In summer, depending on the plants and depth of growing medium, green roofs retain 70-90% of the precipitation that falls on them; in winter they retain between 25-40%. For example, a grass roof with a 4-20 cm (1.6 - 7.9 inches) layer of growing medium can hold 10-15 cm (3.9 - 5.9 inches) of water.

-Green roofs not only retain rainwater, but also moderate the temperature of the water and act

as natural filters for any of the water that happens to run off.

-Green roofs reduce the amount of stormwater runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

**b.Moderation of Urban Heat Island Effect**(Kumar and Kaushik 2005; Jim and Hongming 2010; Jim2012)

-Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool cities during hot summer months and reduce the Urban Heat Island effect. The light absorbed by vegetation would otherwise be converted into heat energy.

-Urban Heat Island is also mitigated by the covering some of the hottest surfaces in the urban environment – black rooftops.

-Green roofs can also help reduce the distribution of dust and particulate matter throughout the city, as well as the production of smog. This can play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with warmer summers.

**c.Improved Air Quality** (Peck et al. 1999;Firth and Gedge 2005; Clark 2005; Yang et al. 2008; Currie and Bass 2008; Clark et al. 2008)

-The plants on green roofs can capture airborne pollutants and atmospheric deposition.

-They can also filter noxious gases.

-The temperature moderating effects of green roofs can reduce demand on power plants, and potentially decrease the amount of CO<sub>2</sub> and other polluting by-products being released into the air.

**d.Increased Biodiversity**(Grant et al. 2003; Clemants et al. 2006; Deutsch et al 2007; Surhone et al. 2010; Carroll2010; Pearce and Walters 2012)

-Green roofs can sustain a variety of plants and invertebrates, and provide a habitat for various bird species. By acting as a stepping stone habitat for migrating species they can link species together that would otherwise be fragmented.

-Increasing biodiversity can positively affect three realms:

1.Ecosystem: Diverse ecosystems are better able to maintain high levels of productivity during periods of environmental variation than those with fewer species

2.Economic: Stabilized ecosystems ensure the delivery of ecological goods (e.g. food, construction materials, and medicinal plants) and services (e.g. maintain hydrological cycles, cleanse water and air, and store and cycle nutrients)

3.Social: Visual and environmental diversity can have positive impacts on community and psychological well-being

**e.Noise Reduction** (Connellya and Hodgson 2013; Getter and Rowe 2006; Peck et al. 1999; Van Renterghem and Botteldooren 2009; Veisten et al. 2012)

Green roofs have excellent noise attenuation, especially for low frequency sounds. An extensive green roof can reduce sound from outside by 40 decibels, while an intensive one can reduce sound by 46-50 decibels

**f.Reduction of Electromagnetic Radiation**(Herman 2003; Minke 2013)

The risk posed by electromagnetic radiation (from wireless devices and mobile communication) to human health is still a question for debate. Nevertheless, green roofs are capable of reducing electromagnetic radiation penetration by 99.4%

A green roof of 16 cm substrate and wild grasses reduces the radiation in the range of 2 Gigahertz, in which most cellular (mobil) phones are working, by 24 decibels, which corresponds to 99 %. In combination with a 24 cm thick mud brick dome a reduction of 99,999 % is reached.

**g.Waste Diversion**

Green roofs can contribute to landfill diversion by:

-Prolonging the life of waterproofing membranes, reducing associated waste

-The use of recycled materials in the growing medium

-Prolonging the service life of heating, ventilation, and HVAC systems through decreased use

**2. The Economical Benefits of a Green Roof**

**a.Energy Efficiency** (Okel, A. 2010; Teemusk and Mander 2010; Jim CY.2012)

The greater insulation offered by green roofs can reduce the amount of energy needed to moderate the temperature of a building, as roofs are the sight of the greatest heat loss in the winter and the hottest temperatures in the summer.

For example, research published by the National Research Council of Canada found that an extensive green roof reduced the daily energy demand for air conditioning in the summer by over 75% (Liu 2003).

**b.Increases Water Retention** (Stovin 2010; Mentens et al. 2006; Carter and Jackson 2007)

A green roof can reduce water run-off by 50–90 %; any remaining water flows from the roof with a delay. Outlets, pipes and drains can be reduced in capacity, thereby saving construction costs. Sewer costs can be reduced in some areas.

#### **c. Increased Roofing Membrane Durability**

The presence of a green roof decreases the exposure of waterproofing membranes to large temperature fluctuations, that can cause micro-tearing, and ultraviolet radiation.

#### **d. Fire Retardation**

Green roofs have a much lower burning heat load (the heat generated when a substance burns) than do conventional roofs (Köehler 2004).

#### **e. Urban Agriculture (Whittinghill and Rowe 2011)**

-Using green roofs as the site for an urban agriculture project can reduce a community's urban footprint through the creation of a local food system.

-These projects can serve as a source of community empowerment, give increased feelings of self-reliance, and improve levels of nutrition.

#### **f. Local Job Creation**

-The growth of green roof and wall market gives new job opportunities related to manufacturing, plant growth, design, installation, and maintenance.

-American Rivers suggests that a USD \$10B investment could create 190,000 jobs by building 48.5 billion-square-feet of green roof area, or just one percent of the United States' roof space in every community over 50,000 in population.

-There is significant potential for new growth in dense urban areas that were previously unusable.

#### **g. Marketing**

-Green roofs can increase a building's marketability. They are an easily identifiable symbol of the green building movement and can act as an incentive to those interested in the multiple benefits offered by green roofs.

*-Green roofs, as part of the green building movement, have been identified as facilitating (Wilson 2005):*

- Sales
- Lease outs
- Increased property value due to increased efficiency
- Easier employee recruiting
- Lower employee and tenant turnover

### **3. Other Public Benefits**

#### **a. Aesthetic Improvement**

*Urban greening has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity.*

#### **b. New Amenity Spaces**

Green roofs help to reach the principles of smart growth and positively affect the urban environment by increasing amenity and green space and reducing community resistance to infill projects. Green roofs can serve a number of functions and uses, including:

- Community gardens (e.g. local food production or co-ops)
- Commercial space (e.g. display areas and restaurant terraces)
- Recreational space (e.g. lawn bowling and children's playgrounds)

#### **c. Improved Health and Well-Being**

-The reduced pollution and increased water quality that green roofs bring can decrease demands for health care

-Green roofs can serve as community hubs, increasing social cohesion, sense of community, and public safety.

#### **d. Educational Opportunities**

Green roofs on educational facilities can provide an easily accessible sight to teach students and visitors about biology, green roof technology, and the benefits of green roofs.

### **Result**

Urbanization and industrialization improve our material lives and comfort; however, they also induce many problems to human beings, such as global warming, industrial waste, and air pollution. Apart from the adverse global impacts, they affect regional urban areas more seriously and obviously where industrial activities and heavy use of synthetic construction material are commonly observed. As a result, the natural environment and ecology are tremendously affected and have lost necessary balance.

In the light of the growing environmental problems of modern times, the key concepts of landscape ecology, ecosystem sustainability and biodiversity have become increasingly important.

Green roofing has become increasingly popular in cities because it creates additional green spaces and ecological spaces that bring some nature in the concrete and steel jungle. Green roofs are shown to be a potentially valuable tool for increased sustainability in highly developed urban areas.

Finding ways to repair the damaged environment in the urban landscape is difficult. The more tools that urban planners, landscape designers, policy makers, and engineers have in their proverbial toolbox, the more flexibility they will have to determine what practices may work best given the constraints of the local landscape. Design ecosystems, like green roofs, fit well with jurisdictions that see the built environment as ripe with opportunities for management.

Local administrations, urban planners and environment designers have to study about the applicable projects that are related to make far the urban from ecological problems and the policy makers should support them with laws. People are also be awareness by the training activities.

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