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Environmental benefits of green infrastructure techniques and applications

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Abstract

Green areas are very important to the ecoystem and to the people who live around them. However, many of these areas have been degraded by human behaviour towards the environment. There are three steps involved in solving these problems; the first is to stop the abuse, the second is the restoration phase, and, finally, monitoring and maintenance are required. The main aim of this paper is to develop the means to restore our buildings and their surrounding areas by using green infrastructure techniques in general and green roofs specifically. Green infrastructure refers to the natural and engineered systems that act as a living infrastructure; it integrates natural vegetation and soils into the community's fabric through a variety of techniques, approaches, technologies and practices. The importance of green infrastructure goes beyond the restoration of buildings and their surrounding spaces and extends to social, economic and environmental integrity.

The methodology includes a literature review and analyzed examples of applications of the green roof method. The research concludes with some recommendations regarding the use of green infrastructure generally, and, having shown their positive impact, of green roofs specifically.
Keywords: sustainable architecture, vertical and horizontal gardens, recycling and reuse, green buildings and socio-economic impact.

1 Introduction

The loss of natural areas has repercussions beyond the problems of water, air, energy, damage to communities and the disappearance of rare species. That is why investing in green infrastructure makes economic sense and is a strategic approach

to land conservation that is critical to the success of smart growth initiatives. Green infrastructure will help reconnect existing natural areas and improve the overall ecological performance of the locality.

2 Green infrastructure

Different references offer different definitions of the term 'green infrastructure'; Ref. [1] states that "Green infrastructure means different things to different people depending on the context in which it is used." Meanwhile, in the *Towards a Green Infrastructure for Europe* workshop, held in Brussels in March 2009, one of the definitions used was "Planning/strategic approaches that maintain ecological functions at the landscape scale in combination with multifunctional land uses".

3 Green infrastructure vs. grey infrastructure

All communities need both types of infrastructure, and planners must find ways of incorporating both types.

Table 1: Comparison between green and grey infrastructure [2].

	Grey infrastructure	Green infrastructure
Definition	Refers to technical interconnected structures that support a society, such as: roads, railways, water supply, sewers, power grids and telecommunication.	It is an interconnected network of green space that conserves ecosystem values and functions and provides associated benefits to society.
Cost	Large investment is needed to provide services.	Nature can provide services for free.
Care	Does not necessarily care for the ecosystem.	The main aim of green infrastructure is to care for the ecosystem.

4 Types of green infrastructure

There are five areas of green infrastructure: habitat, community, climate, energy and water. Each has its benefits and strategies, each can benefit from green infrastructure in different ways and there are various strategies to ensure this.

4.1 Habitat

According to [4], increased vegetation helps to support biodiversity and provide a valuable habitat for a variety of flora and fauna.

Figure 1: The change from grey infrastructure techniques to green infrastructure techniques [3].

4.2 Community

This has many benefits attached to it: benefits regarding social interaction, inclusion and cohesion.

4.3 Climate

Infrastructure can provide climate change mitigation and adaptation in a variety of ways [4].

4.4 Energy

There are many ways in which green infrastructure can save energy: through urban heat islands, the way in which energy is used, climate change (the green areas make the climate cooler and, as a result, helps to decrease air condition use) and water/energy nexus [5].

4.5 Water

There are many water types: drinking water, ground water, lakes, oceans, beaches, rivers and streams, storm water, waste water, and wetlands. All these resources need to be treated and protected. According to [4], green infrastructure techniques help to control the quality of water.

This paper will focus on the study of green roofs.

Table 2: Green infrastructure techniques and their benefits.

Green infrastructure techniques	Slower rate of runoff	Infiltration	Retention	Detention	Water quality control
Green roof	●		●	●	●
Downspouts' disconnection	●	●			
Rain barrel			●		
Permeable pavement	●	●			●
Vegetated swale	●	●		●	●
Rain garden	●	●	●	●	●
Infiltration trench		●			●
Urban forests	●		●		●
Restored wetlands	●	●	●	●	●

5 Green roof

"*A vegetated landscape built up from a series of layers that are installed on a roof surface as 'loose laid' or modular (that is, installed layer by layer on the roof or as pre-prepared layers in trays*)" [6].

Although green roofs offer many advantages for building developers, owners and users, they also benefit the wider environment through their positive impact on sustainability, biodiversity and the attenuation of storm water. Moreover, green roofs improve the quality of life for the building users, whilst providing a payback for the environment, and they can have wide ranging long-term financial benefits [7].

6 Types of green roofs

Green roofs have traditionally been categorised as extensive or intensive. Extensive green roofs are lightweight with a shallow layer of growing substrate, less than 200 mm deep, requiring minimal maintenance. They generally have lower water requirements and use small, low-growing plant species, particularly succulents (Figures 2 and 3).

Figure 2: Extensive green roof [6].

Figure 3: Extensive green roof on a building [6].

'Eco-roofs' or 'brown roofs' are terms used to describe these extensive green roofs. Biodiverse green roofs are designed and planted to increase local plant diversity and provide habitat for wildlife (Figure 4) [6].

Figure 4: Eco-roofs [6].

However, intensive green roofs are generally heavier, with a deeper layer of growing substrate, supporting a wider variety of plant types (Figure 5). As they can support a heavier weight, they are readily accessed by people. More irrigation and greater maintenance are required than for extensive roofs. Intensive green roofs are highly engineered landscapes, often built directly on structures with considerable weight load capacity [6].

Figure 5: Intensive roof [8].

7 Benefits of green roofs

The benefits of green roofs include: an improvement in air quality, help in mitigating the urban heat island effect, reduction in storm water runoff, improvement to building insulation and an increase in green space and biodiversity in urban centres [9].

The benefits of green roofs can be categorized as: public benefits, private benefits and design-specific benefits [10].

Firstly, public benefits include: waste diversion, storm water management, new amenity spaces and moderation of the urban heat island effect [10]. The benefits associated with private benefits include: energy efficiency, increased roofing membrane durability, fire retardation, reduction of electromagnetic radiation, noise reduction and marketing [10]. Finally, increased biodiversity, improved health and well-being, urban agriculture and educational opportunities are seen as design-specific benefits [10].

Table 3: Matrix of roof type vs. potential environmental benefit [10].

Roof Type	Potential Benefit					
	Climate Change	Building Energy Balance	UHIE	SUDS	Biodiversity	Amenity
Intensive	✓✓	✓✓	✓✓✓	✓✓✓	✓	✓✓✓ (visual)
Extensive – mat-based <40mm	✓	✓	✓	✓	✓	✓ (visual)
Extensive – substrate-based >75mm	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓ (visual)
Recreation	✓ *	✓ *	-	-	-	✓✓✓ (sports/play)

* These advantages are only realised on recreation roofs if vegetation, introduced in the form of planters and cool roof technology, are also utilised.

8 Examples of green roofs

The paper will discuss two examples: Burnley Biodiversity Green Roof and North Harringay Junior School, Haringey Green Roof.

8.1 Burnley biodiversity green roof

The project is located on an existing building with heritage considerations at Burnley Campus, The University of Melbourne. With an area of 49m², this green roof is situated above ground floor offices on a concrete roof deck with a one-degree slope (Figure 6) [6].

"A 400 mm wide unplanted perimeter zone keeps the area around the edge of the roof clear. Aluminium edge restraints separate vegetated and non-vegetated areas of the roof. Scoria aggregate was installed in the non-vegetated areas of the green roof" [11].

Although there is no irrigation system on the biodiversity roof, it is watered from time to time by hand-held hoses during hot weather or prolonged periods without rain [11].

This project was completed in February 2013 at a cost of $13,390, with an estimated cost saving of $2,000 [11]. Although the biodiversity features Victorian grassland plant species, a range of landscaping materials and a small ephemeral pond [6], the maintenance only takes about one hour per month.

Nine months after planting, results and observations were as follows: the vegetation was still quite sparse, although likely to fill in, particularly as the grasses self-sow over time. Plants were being grazed by possums living in a pair of Italian cypress trees that were growing inside the building. The trees were removed during 2013 because possum nesting and grazing caused irreparable damage to the trees' canopies, although the rooftop plants recovered well over spring [1].

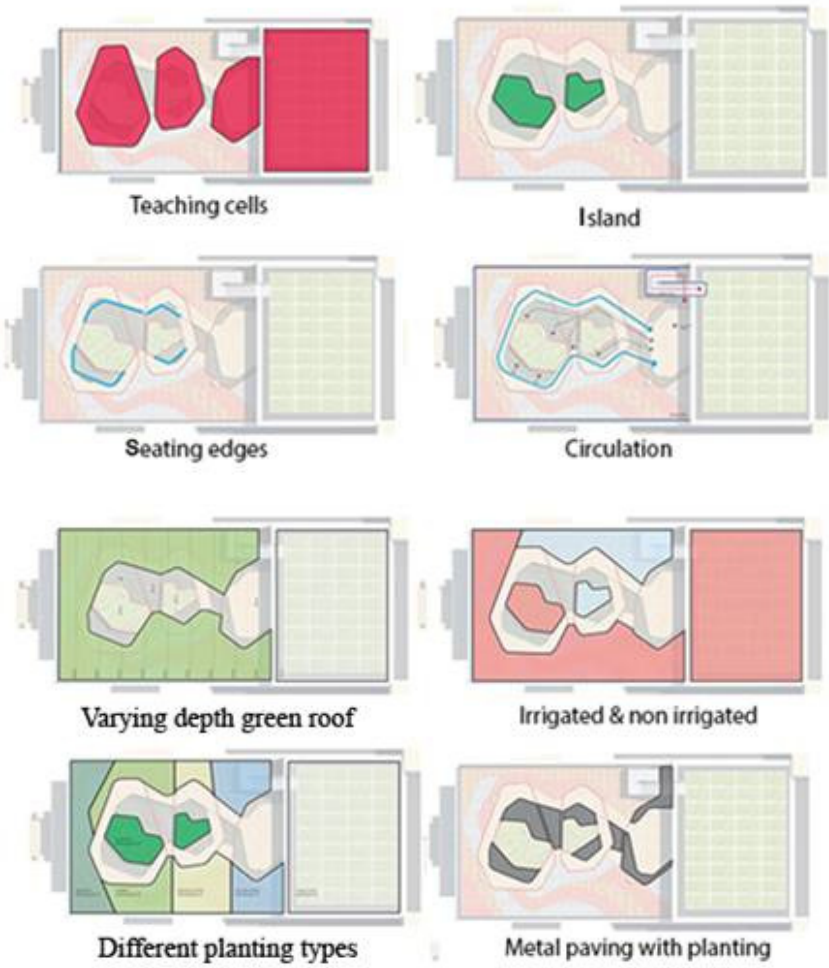

Figure 6: Burnley biodiversity green roof features [12].

8.2 North Harringay Junior School, Haringey green roof

The second green roof is located at North Harringay Junior School, London. This project, with an area of 190m², was completed in 2005 at a cost of $24,000 [6]. The benefits have arisen from turning an unused roof area into a valued teaching and recreational amenity for the school. Regular workshops are also held for pupils and parents. All materials come from sustainable recycled resources [13].

The roof garden comprises Derbigum and ZinCo green roof layers: SSM45 moisture mat, FD25 drainage layer with SF filter sheet attached and Zincolit substrate, mixed in with local top soil (Figure 7) [10].

It contains a tropical bed, a native English bed and vegetable beds. It also includes a wormery to make compost [13]. Maintenance is required every eight weeks after planting [14].

The end result of this project was to return an unused area of the school's footprint to a really useful teaching and recreational amenity for both the school and the local community [6].

Figure 7: North Harringay Junior School, Haringey, Green Roof [15].

9 Conclusion and recommendations

This paper has discussed the meaning of green infrastructure as a theory and the importance of using it to restore our environment. It lists the types of green infrastructure techniques and the different benefits of each, before going on to discuss different examples of green roofs as a way to apply green infrastructure techniques to every building, regardless of its usage.

The examples show that you can change the nature of school roofs by making them green roofs, which students and teachers can use for different activities, saving biodiversity and energy, by reducing the thermal gain of ceilings.

From the previous studies, the recommendation is to apply green infrastructure to our cities by changing the concept of traditional roofs and introducing green roofs. These have many benefits such as improving the quality of life, helping to create more recreational spaces for new activities and socializing, solving the problems of socio-economic impact, reducing thermal gain by ceilings and increasing the number of green spaces, which helps to improve the outdoor air quality and produce energy.

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