CONCEPTUALISING THE BENEFITS OF GREEN ROOF TECHNOLOGY FOR COMMERCIAL REAL ESTATE OWNERS AND OCCUPIERS

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ABSTRACT

The benefits of Water Sensitive Urban Design (WSUD) are increasingly being recognised in terms of reduced flood risk, reduced cost of drainage, improved water quality, lower energy use and other, less tangible aspects, such as aesthetics and amenity. Multiple tools and evaluation techniques exist to estimate the costs and benefits of installations on a total level. These evaluations vary in accuracy and precision and many benefits are difficult to monetise. There are also distributional aspects of costs and benefits that will need to be considered in the ongoing dialogue to encourage appropriate installation of WSUD that have, thus far, rarely been explored in research. In particular, the perspective of the commercial real estate owner, investor or occupier has been neglected in favour of governmental and societal views. This can be understood within the wider context of urban design such as retention or infiltration installations in public spaces; in Central Business Districts (CBDs), however, the retrofitting of green roof technology is seen as one of the main contributors to WSUD and is largely in the hands of private companies. A conceptual model of the distribution of benefits from installing a green roof on an existing commercial building is presented that can inform the understanding of incentives and behaviours in the corporate real estate market. The results show that benefits accrue directly and indirectly to both owners and occupiers of commercial buildings with green roofs. However, many of the direct benefits are enjoyed by a much wider stakeholder group and these benefits will only be partly recognised as due to the investment in green roofs. Owners and occupiers of commercial buildings may also want to evaluate the indirect benefit accruing via their image of corporate social responsibility and, in addition the possibility of value uplift due to neighbourhood improvement.

Keywords:

Green Roof, Water Sensitive Urban Design, Cost benefit, commercial real estate, central business district, Sustainable Urban Drainage.

INTRODUCTION

In a world of rapidly expanding urbanisation, the increase in impermeable surfaces not only reduces water infiltration into the ground, but the corresponding decrease in vegetation means that other routes that rainwater would have taken prior to site development (such as transpiration by plants, and evaporation from leaf surfaces) are also lost (Burns *et al.*, 2012). This can lead to a more rapid build-up of flows and higher peaks, often overwhelming piped drainage systems and causing an increase in flood risk (CIRIA, 2009). It is, however, possible to restore catchment responses to a more natural state by implementing source controls, such as methods for infiltrating or retaining stormwater (Jumadar *et al.*, 2008). When integrated into the over-arching design philosophy known as water sensitive urban design (WSUD), such approaches can not only reduce flood risk but also offer 'ecosystem services' such as improved water quality and biodiversity (Ward *et al.*, 2012). Furthermore, wider social benefits can be generated, in that they provide:

*" ... a sensory manifestation of process for all to acknowledge and appreciate (tangible visual realities of how water sits and functions within a landscap*e)" (Ward *et al.*, 2012).

Where such multi-functionality can be derived there may also be concomitant multi-value benefits, which will be of heightened interest to policy-makers in times of economic constraint (Ashley and Nowell, 2010). Where local conditions permit, for example, the economic case for the retrofitting alternative drainage methods can be persuasive: a Scottish study compared the actual costs of construction and maintenance for retrofitting sustainable drainage solutions as opposed to traditional drainage systems (Duffy *et al.*, 2008). The results, in summary, were that:

" ... the capital costs ... were half that of conventional drainage. The annual average maintenance costs were 20-25 per cent lower ... and the whole-life maintenance costs ... within the catchment were half that of the conventional alternative." (Gordon-Walker et al., 2007).

In Portland, Oregon (US), a desk study on the cost-benefits of ecoroofs (also known as extensive green roofs, or vegetated roofs) identified a wide variety of watershed and human health benefits, as well as the avoidance of expenditure on public stormwater infrastructure (Bureau of Environmental Services - City of Portland, 2008). The potential immediate and long-term public economic benefits were calculated as:

"At year five, the benefit is $101,660, and at year 40 the benefit is $191,421. The ecoroof benefit is generated from reduced stormwater management system improvements and O & M costs, carbon reduction, improved air quality, and habitat creation."(Bureau of Environmental Services - City of Portland, 2008)

Retrofitting green roofs offers a key advantage over many of the other alternative drainage solutions, in that no additional land-take is required, whilst generating an array of benefits (Digman *et al.*, 2012). Unlike municipal drainage systems, however, the installation of green roofs on existing buildings can only be accomplished with the support of the owners and occupiers of suitable properties. New York City's policy-makers employ an incentive scheme (the Green Roof Tax Abatement program) to increase the uptake on private property (Bloomberg and Strickland, 2012). This approach was also used in the initial stages of Portland's 'Ecoroof program' from 2008 to 2012, with building owners and developers being offered an incentive of up to $5 per square foot for approved ecoroof projects (Environmental Services - City of Portland, 2011). Since 2005, the City of Chicago has made use of a fast-track permitting process for both new developments and retrofit applications that comply with a 'Green Permit Program' including green roof installation (Kasmierscak and Carter, 2010). The need for multi-stakeholder perspectives applies not only to the cost side of the equation, however, but also to those benefitting from such initiatives, ranging from occupants' reduced energy costs to mitigation of the urban heat island effect which benefits the wider community. This research, therefore, examines both the costs and benefits of green roof technology in the real estate context.

APPROACH

A systematic literature review protocol was designed, to identify the available information on the use of WSUD in reducing flood risk. Databases of both academic and industry sources were searched, using standardised parameters encompassing a wide range of subject terms, intervention types and outcome descriptors; the results were then filtered to identify those sources specific to the retrofitting of green roofs. It was found that the majority of flood mitigation studies utilised the 'extensive' type of green roof (150mm maximum substrate depth), typically using low-growing Sedum species. The intensive, or 'roof garden' method requires a greater depth of substrate for larger plant species; this type entails a greater structural loading, is unsuitable for roofs with a slope greater than 10^0 (Mentens *et al.*, 2006), and were not included in the study. This database was then interrogated to address the following research questions:

a. What is the evidence for the role of retrofitted green roofs in contributing to flood control in urban areas?
b. What environmental benefits accrue from retrofitting green roofs?
c. To which stakeholder group(s) does the array of benefits accrue?

The development of a conceptual framework to consider the distribution of direct and indirect benefits accruing to commercial property owners and investors was derived from the answers to these research questions as represented in the extant literature. The interrelationship between benefits and stakeholders was initially mapped on a grid matrix in order to identify the distribution of direct benefits across stakeholder groups. Then potential indirect benefits were added to the matrix for the central stakeholders of owners and occupiers of commercial properties.

From this grid matrix, stakeholders were grouped into four nested groups and a simplified representation of the flows of direct and indirect benefits was constructed. This conceptual model demonstrates not only the direct benefits to be evaluated but also the flows and sources of indirect benefits to the key acting stakeholder group.

The operationalisation and validity of the conceptual model is also considered in the light of the extant evidence on costs and benefits from the systematic review and wider Real Estate literature.

RESULTS

In this section the results of the literature review are followed by the development of the conceptual model from the perspective of the central acting stakeholders in retrofitting green roofs.

The benefits of green roofs in stormwater management and flood control

Green roofs consist of multiple layers, typically including an impermeable membrane; drainage layer (where needed); growing medium (substrate); and plant species appropriate to the conditions, particularly the local climate. They are designed to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows, but can have multiple additional benefits (Woods-Ballard *et al.*, 2007). In the context of retrofitting in a CBD, green roofs offer a major advantage over other WSUD options: by utilising extant surfaces, no additional land-take is required.

Green roofs can mitigate stormwater impacts in three ways: First, the onset of runoff is delayed, as water is absorbed by the substrate up to its available capacity; second, peak flows are attenuated, as the water thus stored reduces overall runoff volumes; and third, the stored water is eventually released over an extended period of time (via evapo-transpiration) (Mentens et al., 2006).

Green roofs have been found to be highly suitable stormwater controls for retrofitting in dense urban areas (Voyde *et al.*, 2010). As roofs can account for 40-50% of impermeable surface area in urban areas, they present a major opportunity to decrease run off (Stovin, 2010). Regional climatic conditions are a key variable, however: vegetated roofs in a sub-tropical Mediterranean climate (for example, Fioretti *et al.*, 2010) will perform differently from those in a temperate maritime climate such as the UK. A test plot on a roof in Sheffield (UK), for instance, was found to have an average volume retention of 34%, and an average peak reduction of 57% compared with the total rainfall; it was suggested that such a roof could reduce the annual runoff in many parts of the country by 300mm as compared with conventional roofing (Stovin, 2010). Assessing the performance of green roof technology is a complex issue, however, being dependent on a combination of factors including the characteristics of the roof itself (such as slope, species mix, substrate type) and those of the weather (particularly rainfall intensity and the antecedent moisture conditions): the height of vegetation, for example, was shown to have an impact on run off detention up to a factor of 2, with taller plants having more absorption (Nagase and Dunnett, 2012). Rose and Lamond (2013) note that reported performance, in terms of the annual percentage of stormwater controlled, ranged from 42-90% of annual rainfall; average retention during storm events varied from 30-100%, however, with some runoff being inevitable in extreme events.

Other environmental benefits of green roofs

Urban stormwater not only poses a flood risk but can also have a negative impact on receiving water (Wong, 2000). Foul water contamination can occur (from combined sewer systems, for example), whilst other pollutants (sediments, oils, fuels and toxic metals) can be washed from surfaces into urban waterways (Gordon-Walker et al., 2007). The retrofitting of green roofs (among other WSUD devices) can reduce the risks of such pollution and stream degradation (Carter and Rasmussen, 2006); green roofs, however, can also offer a range of additional environmental benefits. These include thermal insulation of properties, leading to reduced carbon emissions (Fioretti *et al.*, 2010; Bastien *et al.*, 2011); mitigation of urban heat island effect and improved air quality (Bureau of Environmental Services - City of Portland, 2008); improved biodiversity (for example, Livingroofs.org, 2005); and carbon sequestration (Getter and Rowe, 2009).

Other benefits and technical aspects of green roof retrofit

Green roofs have the potential to extend the useful life of roofing materials, by protecting them from the aging effects of exposures to the atmosphere, weather and pollutants: for example green roofs have been found to aid protection of waterproofing materials from solar damage, which can result in financial savings in terms of reduced maintenance costs (Wilkinson and Reed, 2009). In addition green roofs have been said to provide acoustic damping (Arthur and Wright, 2005), amenity benefit (Buccola and Spolek, 2011), aesthetic improvement (Elstein *et al*., 2008), and reduced heating and cooling costs (Vila *et al*., 2012)

Not all buildings are suitable for retrofitting green roofs, with key considerations including the structural strength of the building, the degree of pitch (which affects runoff dynamics), and the avoidance of overshadowing (which could inhibit vegetation growth) (Wilkinson and Reed, 2009). Assessment of the suitability of buildings for retrofitting green roofs must include the strength of the building structure intended to take the load. The use of lightweight materials in the substrate may be beneficial in such contexts: for example, 'crumb rubber' from recycled tyres (Ristvey *et al.*, 2010; Vila *et al.*, 2012); or specially treated waste expanded polystyrene foam (a material otherwise destined for land fill) (Compton, 2006).

Evidence on costs and benefits

The evidence base for estimating the direct benefits of green roofs is a rapidly developing field. Studies that have evaluated some of benefits and related them to installation costs include academic studies and practical city wide assessments of retrofitting plans. For example retrofitting green roofs can reduce the need to improve traditional piped drainage systems and in Portland, Oregon (USA) it was calculated that the ‘Ecoroof’ programme had the potential to save the public purse $60 million (Bureau of Environmental Services - City of Portland, 2008). Similarly individual property owners also benefit, with reduced energy bills for heating and cooling (owing to the insulating properties of such roofs) (Bamfield, 2005; Bastien *et al.*, 2011). In Portland it was estimated that, over the expected 40 year life of a green roof, the benefit to an individual property owner was $43,500 (in reduced energy bills for heating and cooling) (Bureau of Environmental Services - City of Portland, 2008).

There are also direct benefits to the broader stakeholder community which are less easily monetised: green roofs can add to biodiversity/wildlife habitat (Livingroofs.org, 2005; Vila *et al.*, 2012); improve air quality (Stovin et al., 2012); and can help to attenuate the urban heat island effect (Vila *et al.*, 2012; Stovin *et al.*, 2012). Getter and Rowe (2009) assessed the carbon sequestration ability of green roofs: an average of 375 g C m^{-2} was achieved and thereby contributing to the acknowledged need to reduce global greenhouse gas emissions.

The cost-benefit equation is also influenced by design aspects: Jia *et al.* (2012), in modelling potential improvements to the Beijing Olympic Village, found the optimal solution (maximising the flood control benefit whilst minimising cost) was to modify existing green roofs by doubling the soil depth (from 0.3 to 0.6m).

Typically omitted from the literature relating to WSUD, however, is the issue of indirect benefits that may accrue to commercial property owners and investors as a result of benefitting the community, reducing flood risk and creating a “greener” or more sustainable commercial building. Empirical evidence for the economic value of greening buildings to owners and occupiers in the real estate literature is mixed (Sayce *et al.*, 2010). However theoretical models of the impact of sustainability claims for commercial buildings hinge on lower utility costs, reputational effects, the form of commercial leases, the demand for green property, health and wellbeing of the buildings occupants, and the views of the investment market (Rapson *et al.*, 2007). Evidence for the impact of creating improved amenity and neighbourhood effects by greening in business districts is also sparse and contradictory (CABE Space, 2006; Sinnett *et al.*, 2011).

Development of the conceptual model

Two key outputs of the literature review were a list of the perceived benefits of installing green roof technology and an associated list of stakeholder groups that could potentially reap these benefits. The benefits have been described in the previous section. The list of beneficiaries includes the owners, investors and occupiers of the building to be retrofitted; customers of the businesses occupying the building to be retrofitted, owners, occupiers, investors and customers of the other buildings in the vicinity that are at risk from surface water runoff; other local residents, businesses and employees and customers thereof that may benefit from non flood related local environmental impacts; Water companies and their customers and/or municipalities and their ratepayers that benefit from reduced drainage and water processing; Local and national taxpayers and their representatives that benefit from reduced damage costs; wider society that benefits from mitigation and broader environmental enhancements. However, given that the cost of the installation of a roof is likely to be incurred by the owner or occupier of the building (unless specific incentive schemes exist) the understanding of the distribution of the benefits across stakeholder groups is highly relevant to understanding the motivation of owners and occupiers of commercial buildings towards retrofitting green roofs.

Table 1 shows in more detail where the main stakeholder groups derived from the literature may potentially gain from the installation of a green roof by owners or occupiers of a building in the CBD. The building owner/investor and building occupier are those with direct interest in the building being considered for retrofit: the other stakeholders are affected by the decision of these two central actors to install or not to install a green roof. The list of benefits is also drawn from studies in the literature that demonstrate evidence that this benefit exists and extends to property stakeholders. However it is difficult to apportion shares of the benefits accruing through evidence in published sources, furthermore the majority of these benefits are based on physical aspects of the environment that can be measured. Benefits can also be classified into direct and indirect. An example of a direct benefit is the reduction of run-off leading to reduced flood risk for building occupiers and occupiers of surrounding buildings. An example of an indirect benefit is the potential uplift in value (rental or capital) of a commercial property due to the improved aspect of a building through the amenity of a green roof.

In accordance with the aim of this research to examine the benefits of retrofitting from the perspective of commercial property owners and occupiers, table 1 emphasises the indirect benefit flows from the perspective of these two stakeholders.

Table 1. Matrix of benefits and beneficiaries from investment in green roof technology

* = beneficiary *? Potential beneficiary depending on remit of stakeholder ?? Indirect beneficiary if able to charge higher rents due to neighbourhood improvements	Building owner/ investor	Building occupier	Those locally at risk from flooding	Local population	Water companies and their customers	Local/national taxpayers	Global benefit / climate mitigation
Peak flow retention	*	*	*		*?	*?	
Runoff water quality improvement	??	*?			*?	*?	*
Carbon and nitrogen sequestration							*
Insulation - reduced heating and cooling	??	*					*
Aesthetic improvement	??	*	*	*			
Reduce Urban Heat Island	??	*	*	*		*	
Acoustic damping		*					
Extended life of roof membrane	*?	*?					
Biodiversity enhancement	??	*	*	*			
Lower maintenance costs	*	*					
Amenity Benefit	??	*	*	*			
Reduced cost of drainage	*?	*	*?	*?	*	*?	
Air quality	??	*	*	*			
Reduced stream degradation	*?	*?	*?	*?	*?	*?	
Reduced land take for runoff reduction vs other methods	* If runoff reduction required						

In commercial property terms there are reputational and operational factors that also affect the value to owners and occupiers of a commercial site as discussed above. There is, therefore a feedback from the perceived wider benefits accruing to all stakeholders into the value of a building both for owners and occupiers that is hard to measure and even harder to predict. This feedback value may not be related to the scale of measurable impacts or their distribution among stakeholders as the value judgements made by other stakeholders often relate to perceived rather than actual benefits. For example if the installation of a green roof is seen as socially responsible because it reduces the urban heat island then the benefit of corporate social responsibility is felt by the occupier or owner regardless of the performance of the actual roof in this respect. Green roofs have the advantage of high visibility such that the immediate neighbours can clearly see the pro-environmental behaviour, even more evident than the display of an improved EPC. This leads to the development of a conceptual model for the value of green roof installation to owners and occupiers of commercial buildings with feedback effects into the company operational profit and building value. This conceptual model is shown in figure 1.

Assigning precise quantities to the range of benefits enjoyed by every stakeholder in the conceptual model is problematic in the short term as the evidence base to make impact estimates is not sufficiently well developed. It has been demonstrated above that in some instances the cost of a green roof installation could be offset over time by measureable direct benefits such as reduced heating and cooling. However, the additional value of energy efficiency may not be sufficient incentive to move towards retrofitting a green roof. Indeed, other energy efficiency measures may be taken that could be just as effective and less costly. Equally, it is unlikely that the cost of a green roof can be justified by the reduction in flood risk to the individual property on which it is installed. This research suggests that the business case for retrofit of green roofs will rely on the consideration of multiple direct benefits and may also depend on recognising feedback from wider societal and ecological beneficiaries. While the conceptual and theoretical arguments exist, the lack of quantitative studies that link property value and company profitability directly to pro-environmental behaviour and reputation is a barrier to such recognition. There is a need to apply approaches that can foster understanding of the indirect benefits of retrofitting green roofs in order to evaluate whether they can drive appropriate adaptation or not.

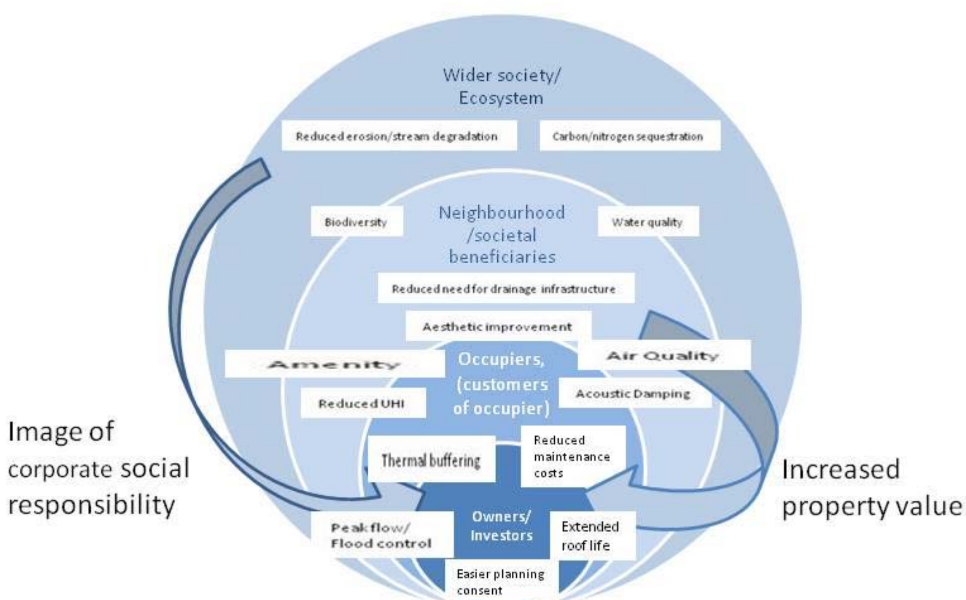

Figure 1. Conceptual model of distributed benefits of green roof technology from the perspective of owners and occupiers of commercial buildings.

DISCUSSION AND CONCLUSIONS

The proposal of a conceptual model for the benefits of retrofitting green roof technology for owners and occupiers of commercial buildings in CBDs is a novel departure from current literature that focuses on the wider societal perspective of reducing flood risk for a district. This research addresses a crucial gap in the implementation strategy of water sensitive urban design, in recognising that the actors most central in enhancing the take up of green roofs may be commercial enterprises or investors that remain to be convinced of the business case for green roofing.

Furthermore, it is critical in this evaluation to consider the full range of benefits accruing from green roof installation, not limited to the flood or water quality issues normally paramount in the cost benefit analysis for local government or environmental agencies.

This research has scoped the associated literature very widely and identified a broad list of actual and perceived benefits from green roofs. The systematic review also identified key stakeholders and beneficiaries of green roof benefits and their proximity to the central actors. Green roofs are seen to have a small potential positive contribution to climate mitigation, but most of the benefits of green roof technology are more direct and relate to quality enhancements in the local environment with the potential to lead to neighbourhood improvement. However, the quantification of the scale and scope of these benefits in CBDs is argued to be in its infancy, therefore further research is needed to fully operationalise the conceptual model with respect to direct benefits of green roofs.

In the context of commercial property it is also important to examine potential indirect benefits of green roofs. Increased operational efficiency within an improved building may boost the utility of the premises for commercial tenants, whilst occupiers of "green" commercial buildings may also benefit from reputational enhancement. Owners and investors could therefore benefit from higher yields from a more attractive commercial environment. Furthermore, the aspect of socially responsible investment could be considered as a reputational gain for these stakeholders. The research suggests that this is not dependant on actual delivery of the technology against perceived benefits, but is based on awareness of green roofs as an ecological good. Therefore this benefit is both locally specific (dependant on cultural norms in the customer base) and neighbourhood and market specific (dependant on the pool of property investors and owners with a vested stake in the business district). The goals and priorities of these stakeholders will have an impact on the willingness to retrofit green roofs.

This insight, together with the lack of monetised benefit data for many of the wider benefits of green roof retrofit, suggests that the complete operationalisation of the proposed conceptual model through robust cost benefit analysis is some way off. Therefore, in discussion of the business case for green roofs in the short term, it may be helpful to consider methodology that allows for the statement and balance of multiple goals, not all of them quantifiable or monetised. Further research is also warranted in order to strengthen the evidence base relating to the actual performance of green roofs in delivering the perceived benefits across the stakeholder groups and their feedback in terms of enhanced property value.

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