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Green roofs in temperate climate cities in Europe – An analysis of key decision factors

Thomas Brudermann[a], Tachaya Sangkakool[b,*]

[a] University of Graz, Institute of Systems Sciences, Innovation and Sustainability Research, Merangasse 18/1, 8010 Graz, Austria
[b] Prince of Songkla University, Faculty of Environmental Management, P.O. Box 50 Kor-Hong, Hatyai, Songkhla 90112, Thailand

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A B S T R A C T

This paper aims to identify and assess the main decision factors that are relevant for the diffusion of green roof technology in cities of temperate climate in Europe. A mixed design method was applied to identify relevant factors and to structure these along a Strengths, Weaknesses, Opportunities and Threats framework. The factors were subsequently assessed by a sample of green roof experts, using an Analytical Hierarchy Process. The results indicate that prospects for green roofs are in general rather bright, and that dissemination potential is substantial. Green roofs are particularly likely to benefit from climate change and respective counter-strategies, as they are seen as an adaptation and mitigation measure. However, current barriers to adoption need to be carefully considered. Especially the dilemmatic incentive structures, in that building owners bear most of the risks and potential disadvantages, while the public collectively benefits from green roof advantages, could be a major implementation barrier. Without supportive policies, green roofs are thus unlikely to move from niche to regime level in the near future.

1. Introduction

In recent decades and years, improved recognition of the benefits of green infrastructure has led to an increasing number of cities adopting policies in support of green roofs. German cities started to support green roofs as early as the 1970s (Berardi et al., 2014). For example, in Munich, all suitable flat roofs with a surface area of over 100 m^2 have to be 'greened'; the city of Esslingen subsidizes 50% of the costs for green roofs, and in Darmstadt, building owners receive up to € 5000 if they install a green roof (Getter and Rowe, 2006). In the city of Copenhagen, Denmark, green roofs are required for all newly constructed roofs with a pitch of less than 30° (Berardi et al., 2014). In the Austrian capital Vienna, financial support of € 8 – € 25 is granted per square meter of green roof, with an upper limit of € 2200 per project. During seven years of its existence (2003–2010), this policy has resulted in an additional 16,000 m^2 of green roofing (at a cost of € 150,000 of public funding[1]). Chen (2013) reviewed city policies in several Asian and American cities, and found policies and by-laws favoring green roofing in Singapore, Japan, Hong Kong, USA and Canada. Despite these developments, green roofs remain a niche technology and are, with a few exceptions, not yet widely dispersed in urban European areas.

Green roofs are in general classified into two major categories; intensive green roofs and extensive green roofs (Czemiel Berndtsson, 2010). Intensive green roofs are characterized by a rather high thickness of growing media; soil layers usually are thicker than 200 mm, with soil weights exceeding 300 kg/m^2 (Berardi et al., 2014). Such deep soil allows for the growing of relatively large plants, and thus provides greater planting flexibility. Roof top gardens and roof gardens require intensive green roofing (Bianchini and Hewage, 2012b; Kosareo and Ries, 2007). Basic maintenance of such roofs includes weeding, fertilizing, and watering of the plants (Czemiel Berndtsson, 2010).

Extensive green roofs, on the other hand, are limited to smaller plants such as sedums, small grasses, herbs, flowers and herbaceous plants (Berardi et al., 2014). The thickness of the growing medium is usually below 150 mm (Hakimdavar et al., 2014), with soil weights between 60 and 150 kg/m2 (Berardi et al., 2014). The construction of extensive green roofs is relatively simple; less effort is required in irrigation and maintenance (or may not be necessary at all). Due to their light weight and low level of maintenance, extensive green roofs are popular solutions in cities and are particularly appropriate for large scale rooftops (Hakimdavar et al., 2014; Jungels et al., 2013).

* Corresponding author.
E-mail addresses: Thomas.Brudermann@uni-graz.at (T. Brudermann), TachayaSangkakool@gmail.com (T. Sangkakool).

[1] According to information provided at www.nwrm.eu/case-study/green-roofs-vienna-austria (accessed April 6, 2016)

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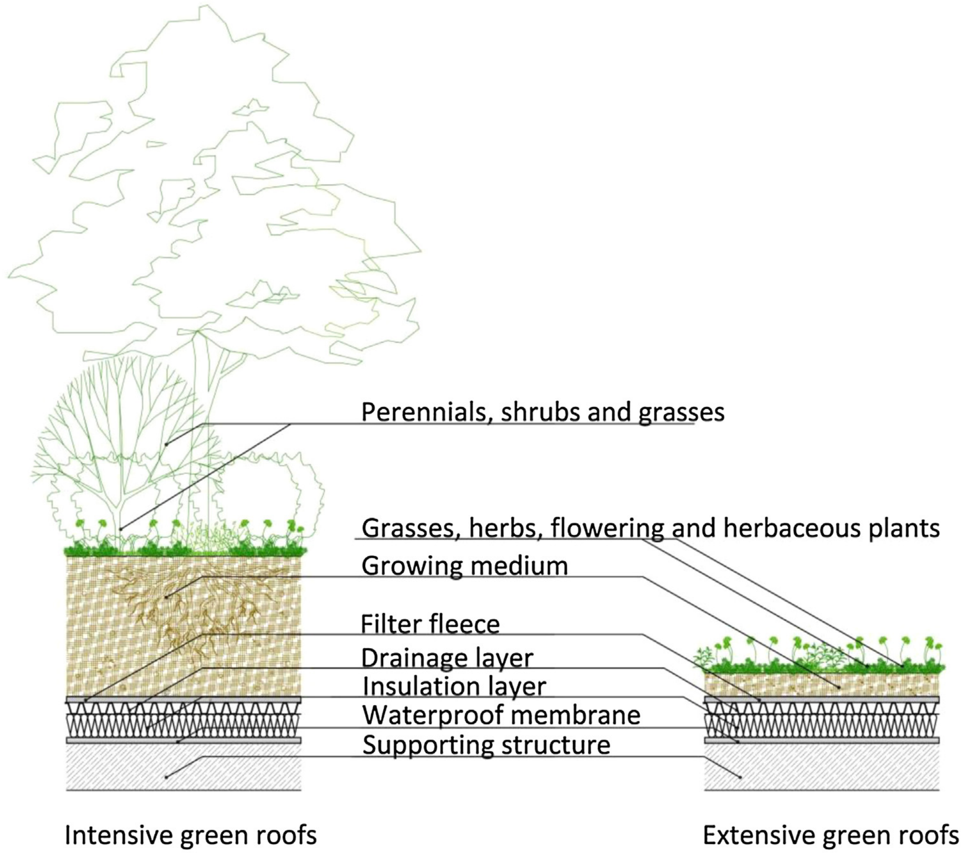

Fig. 1. Intensive versus extensive green roofs.

Fig. 1 illustrates the general idea and the differences between extensive and intensive green roofs.

Green roofs are generally known to be an environmentally friendly product and an elementary component of sustainable construction (Bianchini and Hewage, 2012b). It has been shown that green roofs have a positive environmental performance in the long-term (Bianchini and Hewage, 2012a) as emissions generated during component manufacturing are offset 13–32 years after installation. There is still some criticism, however, concerning the nature of the materials used.[2] Despite this, green roofs still promise to be a suitable technology in the domain of climate change adaptation and mitigation. Green roofs can also be financially attractive. In particular, extensive green roofs are considered to be a low risk investment since they can entail payback periods below 10 years (Bianchini and Hewage, 2012b).

The aim of this paper is the identification and assessment of the main factors that are relevant for the diffusion of green roof technology in temperate climate cities, especially in Central and Northern Europe. The aim is to identify the general factors needed for green roof diffusion, i.e. the technical details of different roof types are not the point of focus. Factors are identified on the basis of reviews of the scientific literature and qualitative interviews with experts. These are then assessed based on the quantitative judgments provided by a sample of experts.

The remainder of the paper is structured as follows. Section 2 deals with the methodological approach employed and the study design. Section 3 describes the results of a systematic analysis of green roof strengths, weaknesses, opportunities and threats (SWOT analysis), together with subsequent quantification of these factors using an Analytical Hierarchy Process (AHP). In Section 4, the results are discussed and possible strategies for green roof diffusion are developed. Section 5 completes the paper with a short conclusion.

2. Method

Our study was implemented in a four stage study design and is based on a mixed method approach. In a first step, the possible decision factors were identified by undertaking a literature search on green roofs in Scopus.[3] In a second step, semi-structured interviews were conducted with 15 green roof experts in Austria. The sample included experts from diverse fields – architects, planners, academics and city representatives, as well as adopters. Some of the participants were able to view the issues from different perspectives (e.g. architectural and academic). This was to ensure that a broad set of factors related to implementation/adoption of green roofs would be included as well, as the existing scientific literature tends to focus on technical and economic aspects, but does not pay a lot of attention to (other) adoption challenges and barriers. The interviews were analyzed by means of qualitative content analysis as proposed by Mayring (2014), using the open access software QCAmap. In a third step, the factors identified were structured in terms of their respective strengths, weaknesses, opportunities

[2] Bianchini & Hewage analyzed emissions of NO_2, SO_2, O_3 and PM_{10}. Due to the additional negative impacts of the low density polyethylene and polypropylene used in green roof layering, they call for the exploration of materials that can replace the current use of polymers to enhance overall sustainability of green roofs.

[3] A Scopus search for "green roofs" and related keywords returns more than 1500 papers. The literature review therefore was limited to frequently cited articles in peer-reviewed journals; usefulness of papers was furthermore judged on the basis of the paper's abstracts. As a result, 40 papers were considered in this step.