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Cost–benefit analysis for green façades and living wall systems

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ABSTRACT

Vertical greening systems can be used as a mean to improve the environmental conditions of dense urban areas. Several researches have proved the environmental benefits of green envelopes. It is still not clear if vertical greening systems are economically sustainable, differently several Life Cycle Cost Analysis and Cost–Benefit Analysis determined economic costs and benefits of green roofs. This paper presents a Cost–Benefit Analysis of different vertical greening systems – green façades and living wall systems – considering personal and social benefits and costs over their life cycle. Installation, maintenance, and disposal costs of each analysed system are compared with the related private and social benefits (increase of real estate value, savings for heating and air conditioning, cladding longevity, air quality improvement, etc.), determining three indicators: the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Pay Back Period (PBP). The CBA demonstrated that some of the vertical greening systems analysed are economically sustainable. Economic incentives (tax reduction) could reduce personal initial cost allowing a wider diffusion of greening systems to reduce environmental issues in dense urban areas, such as urban heat island phenomenon and air pollution.

1. Introduction

1.1. Background

Greening the building envelope can be an opportunity to restore the environmental quality of dense urban areas by combining nature and built areas [1]. In general terms the main benefits connected to a green building envelope regard environmental practices, economics, and social aspects, as the greenhouse gases output reduction, climate change adaptation, air quality and indoor and outdoor comfort conditions improvement, urban wildlife (biodiversity), etc.; these benefits concern several fields, which are all related and operate on a scale range; some only work if a large surface in the same area is greened and their benefits are only apparent at a neighbourhood or city scale, others operate directly on the building scale [2–5].

Greening horizontal surfaces with intensive and extensive green roofs are widespread especially in the northern part of Europe and several studies investigate their economic benefits [6–9]. Wong et al. [8] compare the cost of traditional roof solutions with green roof solutions. Bianchini and Hewage [9] perform a probabilistic analysis to estimate personal and social NPV and pay back period of green roofs. Claus and Rousseau [10] perform a private and a social CBA for green roofs.

Vertical greening systems can be classified into façade greenings and living walls systems according to their growing method [2,3].

Green façades are based on the use of climbers attached directly to the building surface, as in traditional architecture, or supported by cables or trellis. In the case of an indirect greening system, where cables or meshes support vegetation, many materials can be used as a support for climbing plants such as steel (coated steel, stainless steel, galvanized steel), different types of wood, plastic or aluminium. Indirect greening systems can be combined with planter boxes at different heights of the façade. In this case the system requires nutrients and a watering system, if the rooting space is not sufficient. If nutrients and a watering system are needed, it can be defined as a living wall system [2,3].

Living wall systems (LWS), also known as green walls and vertical gardens, are constructed through the use of modular panels, each of which contains its own soil or other artificial growing mediums, for example foam, felt, perlite and mineral wool, based on hydroponic culture, using balanced nutrient solutions to provide to the whole or part of the plant food and water requirements [2].

1.2. Aim of the study

This paper provides a Cost–Benefits Analysis (CBA) and compares different vertical greening systems – green façade and living wall system – considering personal and social benefits and costs

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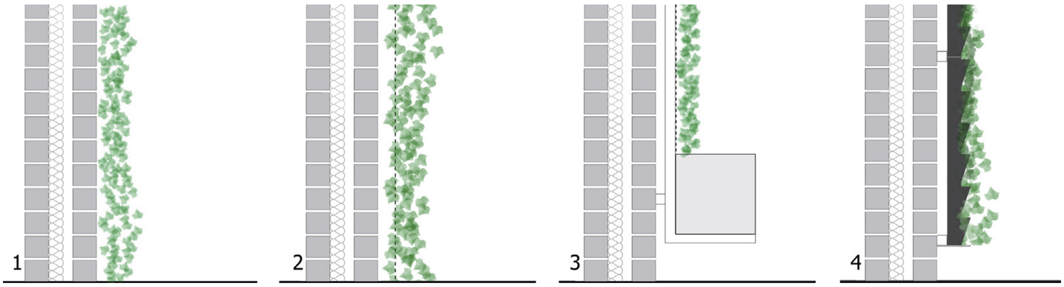

Fig. 1. The vertical greening systems analysed applied on a double brick wall with air cavity and mineral wool: 1. Direct green façade, 2. Indirect green façade, 3. Indirect green façade combined with planter boxes, 4. Living wall system.

over their life cycle. The aim is to evaluate the economic sustainability of different types of vertical greening systems, through three indicators: the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Pay Back Period (PBP). The presented CBA includes the calculation of initial costs (installation), maintenance costs, disposal costs, economic benefits related to the increase of rent income (due to the increase of property value), building envelope longevity and energy demand reduction for heating and air conditioning. With respect to the social economic benefits, positive environmental effects of vertical greening systems have been considered in terms of costs savings for the society (assumptions made for the calculation of some benefits are based on an extensive literature review).

1.3. *Costs of vertical greening systems*

During the past four or five years the variety of products available on the market for vertical green envelopes has increased rapidly; it is possible to approximate the costs needed to install some of the systems described above in Europe [11]. The cost of a simple disposition of climbing plants at the base of the façade (direct greening system) is around 30–45 €/m^2 for grown climbing plants. In the case of indirect greening system (grown climbing plants + supporting material) the cost range is 40–75 €/m^2. When planter boxes are combined with supporting systems the costs significantly vary according to the material used (from 100 to 150 €/m^2, for a system made of plastic, up to 800 €/m^2 for a system made of zinc-coated steel). Also in the case of living wall system (pre-vegetated panels) the costs can significantly vary: from 400 to 1200 €/m^2 depending on system conception and material used. A wide range has been given; this is because the costs depend on the façade surface and height, location, connections, etc. [11]. It is clear that the living wall systems are much more expensive than the direct and indirect greening systems, this is due to the maintenance needed (nutrients and watering system), the materials involved, and the design complexity; on the other hand it can be mentioned that living wall systems increase the variety of plants engaged as they don't make use exclusively of climbing plants and offer much more creative and aesthetical potential [12].

1.4. *Benefits of vertical greening systems*

Vertical greening systems provide a large range of personal and social benefits. Personal benefits on a single envelope scale of green façades and living wall systems are mainly related to the energy savings for heating and air-conditioning, improvement of real estate value (or rent), and durability of façades.

Studies demonstrate that a vertical green layer can contribute to the building envelope performances by creating an extra stagnant air layer which has an insulating effect [13] and reduces the energy demand for air-conditioning up to 40–60% in Mediterranean climate [14,15].

The economic effects generated by the presence of vegetation on property values have been investigated in several studies. Peck et al. [16] assumed that a green wall would yield the same property increase as a "good tree cover" and they estimate a value increase interval for a property of 6–15% with a midpoint of 10.5%. Des Rosiers et al. [17] have estimated that hedges or green walls

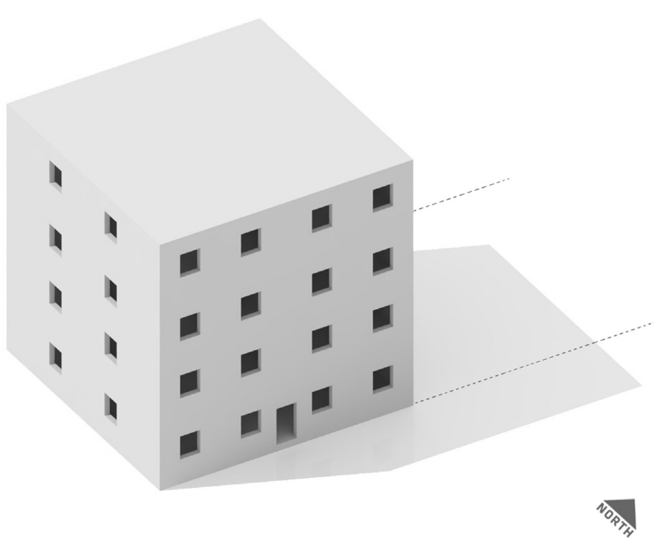

Fig. 2. Scheme of the building used for the analysis (no green situation).

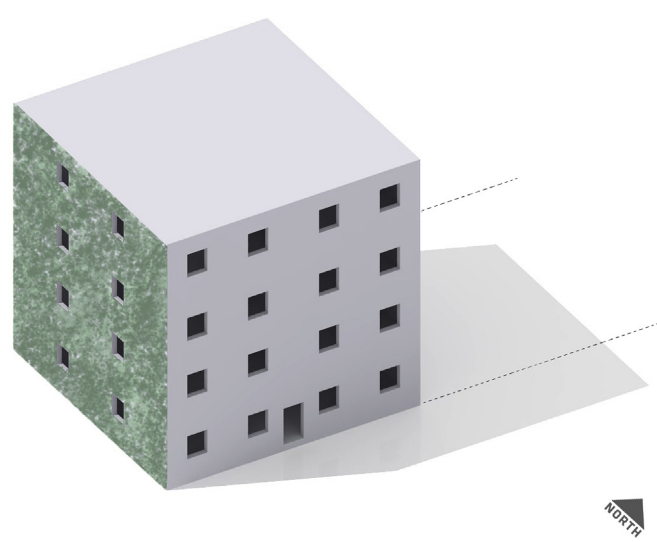

Fig. 3. Green south façade of the building used for the analysis.