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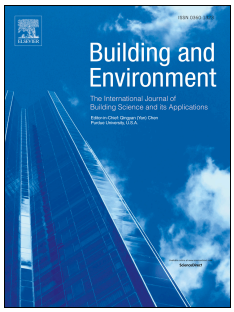

Evaluating the economic sustainability of a vertical greening system: A Cost-Benefit Analysis of a pilot project in mediterranean area

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Evaluating the economic sustainability of a vertical greening system: a Cost-Benefit Analysis of a pilot project in Mediterranean area

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Abstract
The growing diffusion of vertical green systems has led to the development of new systems and technological solutions which can improve the quality of urban environments. The present research evaluates the economic sustainability of a vertical greening system (VGS) installed on an office building in Genoa (Italy) through a Cost-Benefit Analysis (CBA). The benefits deriving from the installation of VGS are compared with the costs. The economic benefits considered are related to the economic effects of energy savings (for air conditioning), with values deriving from field studies and monitoring activities, biomass production, estimated according to the material produced by annual maintenance works (pruning), and property value. The latter is estimated thanks to the involvement, by means of a specific survey, of real estate agents working in the city of Genoa. Results show that a VGS can be economically sustainable when a tax reduction on installation costs is considered; in this case, the Net Present Value and the Internal Rate of Return are positive and the Pay Back Period is lower than the life span of VGS. A relevant contribution is also determined by the energy saving for building summer conditioning due to the reduction of the external air temperature. A Monte Carlo simulation allows verifying the reliability of the results obtained for the economically sustainable scenarios. A Sensitivity Analysis on the main variables underlines the relevance of the design phase in order to optimize the choice of materials and technological solutions reducing installation and maintenance costs.

Keywords: Cost-Benefit Analysis, Vertical Green System; Living Wall System; Economic Sustainability.

1. Introduction

By 2020 it is estimated that almost 80% of EU citizens will be living in cities [1], and their quality of life will be directly influenced by the state of the urban environment. Vegetation can significantly improve the environmental quality of dense urban areas by reducing the Urban Heat Island (UHI) effect [2], [3], improving air quality [4], [5] and energy performance of buildings [6], [7], [8], reducing crime [9], producing health benefits [10], [11], managing storm-water [12], and fostering biodiversity [13], [14], contributing to the achievement of several European environmental objectives (as the 7th Environmental Action Programme). According to the European Commission [15]–[17], nature-based solutions can provide "environmental, social and economic benefits and help build resilience" [18]. Today, addressing economic, environmental and social sustainability is mandatory, as highlighted by the international community (e.g. Brazil 2012 Conference on Sustainable Development). Several urban environmental and ecological issues can also be effectively reduced by vegetation [19]. Greening cities can contribute to curb the negative effects of climate change related hazards, including storm surges, extreme precipitation, and floods [17], [19].
Most of vertical greening systems are characterized by a large range of individual benefits, which can be evaluated in economic terms, e.g. energy savings for summer cooling and the increase of the durability of some building components, like plaster façade [20]. Other economic benefits include the increase of real estate value, thanks to the improvement of the aesthetic quality of building and the internal comforts for residential (due to the lower sound level environments) [21]. Social benefits of green envelopes include the increase of environmental quality nearby dense urban areas, led by greenhouse gases output reduction, heat island phenomena reduction, better air quality, indoor and outdoor comfort conditions improvement, urban wildlife (biodiversity) [13]. Previous researches demonstrate that vertical greening systems can be