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Assessment of the Gains and Benefits of Green Roofs in Different Climates

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Abstract

Different geographical locations and different climates provide different benefits to adding a green roof. The research question is whether a green roof's purpose and efficacy is affected by different climates, or even same climates but different geographical locations. The independent variables that must be considered are climate and location, which are relevant from the standpoint of policies that drive adoption. The method is a literature analysis/meta-analysis in which similar studies are compared/contrasted with respect to their findings. The outcome is a determination of (a) whether there are differences; and (b) possible factors influencing those differences. The impact will be to (a) understand the factors influencing policy planning, and (b) develop policies to encourage the diffusion of this technology in locations and contexts where it will be most effective.

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Keywords: Green roofs; climate; GDP

1. Introduction

The adoption of green roofs or living roofs is a growing trend since the 1960s. After gaining popularity in Europe, most of the world is now familiar with this green infrastructure as part of the sustainable design of a building. Green roofs are part of the green infrastructure which uses vegetation, soil, and natural processes to

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manage water and create healthier urban environments [1]. Such roofs are of particular interest due to the following reasons:

- Storm water management.
- Urban heat island effect.
- Summer cooling/winter heating.
- Roof membrane longevity improvement.
- Noise reduction.
- Providing wildlife habitat and natural biodiversity enhancement.
- Amenity value, aesthetics and marketing.

1.1. Green Roofs

Green roofs can be constructed in almost every climate with different functional emphases. In wet urban areas, the main focus is on stormwater management. The city of Chicago realized by 2004 that they could not manage the city's stormwater runoff on their own which is why they asked for the cooperation of private developers to add sustainable features to the design of buildings, including green roofs [2]. Another potential benefit of this technology is its ability to moderate heat gain in urban environments. New York City, for example, is characterized by an annual average difference of temperature of 2.5 °C between urban and rural sites [3]. A study of New York City's heat effect found that increasing land cover and green roofs lowered the citywide surface urban air temperature by 0.4°C on average and 0.7°C at 3:00 pm when the greatest temperature reductions tend to occur [4]. Green roofs also offer thermal benefits with regard to moderating temperatures inside buildings on which they are installed. For instance, a study conducted on the thermal properties of green roofs in the Loutraki region of Greece showed that: a) the measured temperature inside the building with the green roof was less than the one measured inside the building with a traditional roof, b) heat insulation performance of green roofs is considerable for buildings with little to no insulation, and c) the estimated heating and cooling loads are lower in the building with green roofs regardless of insulation [5].

From those examples, it seems like a trend emerges as to the primary uses of green roofs: in Chicago, green roofs are being encouraged to manage stormwater, in New York, to alleviate urban heat island effect, and, in Greece, to provide better thermal comfort inside a building. Since these cities have different relative climates, climatic conditions could offer one explanation for the justification to the function of a green roof, i.e., in rainy climates, a green roof is used to reduce stormwater runoff while in hotter climates, green roofs are mainly constructed to provide thermal comfort and energy reductions in a building.

This paper compares the uses of green roofs in different parts of the globe with similar climates to determine the potential influence of climate on green roofs.

1.2. Climate

Merriam-Webster defines climate as being the "the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity, and precipitation" [6]. Weather is further defined as "the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness" [7]. Therefore, typical weather patterns of geographical areas are associated as having the same climate based on observed weather over the course of several years. Several climatic regions around the world are identified mainly by the precipitation and temperature information as reported in Table 1. Studies included in the meta-analysis conducted in this paper have been selected and compared based on the climate where the green roof was studied.

Table 1 . Classification of climate according to the Köppen-Geiger map [8]

Climate	Precipitation	Temperature
Equatorial	Desert	Hot arid
Arid	Steppe	Cold arid
Warm temperate	Fully humid	Hot summer
Snow	Summer dry	Warm summer