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Developing key sustainability indicators for assessing green infrastructure performance

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Abstract

In recent years, integrated networks of green spaces at city scale, or "green infrastructure" (GI), are seen increasingly as fundamental to the delivery of ecosystem services for human and environmental health. A range of models that assess the performance of specific aspects and elements related to GI have been developed in response. However, there is no model that is comprehensive and integrative across all types of GI and ecosystem services. This paper aims to suggest a set of potential indicators that facilitate the development of an inclusive model for the sustainability assessment of GI performance.

This research is based on the findings from a previous study conducted by the authors that identified definitions, types and conceptual framework of GI as well as thirty performance indicators through reviewing literature and incorporating results from semi-structured interviews involving twenty-one selected Australian representative experts. This analysis was combined with input from 373 national and international stakeholders through an online questionnaire to establish an integrated framework by weighting, screening and aggregating selected indicators. This framework comprises a reduced set of sixteen potential indicators based on experts' perspectives which represent the key interactions between human health, ecosystem services and ecosystem health across four dimensions (ecological, economic, socio-cultural and health). Future research will involve testing this proposed framework and providing a platform for decision-makers to test various scenarios based on the base case and existing conditions to provide an early warning of changes in the sustainability levels in the urban environment.

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Keywords: green infrastructure; sustainabile development; performance indicators; ecosystem services, human health, ecosystem health.

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1. Introduction

It is crucial to assess and monitor the sustainability level of built and natural environments as a result of accelerated urbanisation and global land alteration, transformation and fragmentation by humans. Accordingly, many approaches to sustainability-oriented frameworks at the project and policy level have been developed by considering the social, economic and ecological dimensions individually, and then attempting to assess and integrate these findings. The major challenges for sustainability assessment are related to the need to identify both science-based and policy-based indicators, which are able to justify a boundary between what contributes to a sustainable development and what does not. In this context, green infrastructure is identified as an alternative nature-based and cost-effective infrastructure solution for improving the sustainability of urban development [1-6]. GI is defined as an integrated network of natural and semi-natural areas and features which deliver a variety of benefits to humans and ecosystems [2, 7]. In this study, understanding the environmental performance of GI as well as the social and economic benefits has motivated the development of an indicator-based framework for assessing the sustainability performance of GI projects. To initiate the research, semi-structured interviews were conducted with 21 Australian representative experts. Results revealed nine key concepts that cover GI performance that were consistent across all interviews [8].

These nine concepts were taken as the basis to establish the assessment framework and identify suitable GI performance indicators:

1. Climate change adaptation and mitigation;
2. Human health and well-being;
3. Healthy ecosystem;
4. Biodiversity;
5. Economic benefits;
6. Alignment with political issues and city strategies;
7. An active travel network;
8. Water management;
9. Food production.

Most of the common sustainability and environmental frameworks for selecting indicators were developed based on the causal network (CN) method [9] such as pressure-state-response (PSR), force-state-response (DSR) and force-pressure-state-impact-response (DPSIR). By reviewing the literature and the results from the semi-structured interviews, Pakzad and Osmond [10] proposed a set of 30 GI performance indicators based on DPSIR. This indicator set focuses on the key interactions between human health, ecosystem services and ecosystem health, which is in line with proposed frameworks by other scholars [1, 4, 11, 12]. This framework helps to clarify the complex relationship between cause and effect variables, to understand the issues that change the performance of GI and to identify potential solutions [10]. However, a quantitative approach was required to verify and validate the findings that resulted from the qualitative research phase (semi-structured interviews) and to test the conceptual framework and the 30 GI performance indicators proposed in the previous study.

2. Methodology

2.1. Target Population

The questionnaire was emailed to 1387 individuals, who were selected because they were national and international experts in the field of built environment and/or sustainability. Out of the potential 1387 respondents, 1152 had valid email addresses. The information issued to the respondents included a URL link to an online questionnaire. This information was also distributed to the mailing lists of participant organizations, which were identified in the first round of semi-structured interviews. Additionally, the questionnaire invitation was distributed on the news web page of representative organizations such as Australian Institute of Landscape Architects, Australian Institute of Architects, Low Carbon Living CRC, Infrastructure Sustainability Council of Australia, Australian Sustainable Built Environment Council and the United Habitat. In statistical terms, the population size in