# The development of a multi-criteria approach for the measurement of sustainable performance for built projects and facilities

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## CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that this thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Signature of Candidate

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# ABSTRACT

It has long been recognised that environmental matters are important to the survival of the construction industry. Yet, in general, the construction industry continues to degrade the environment, exploiting resources and generating waste, and is reluctant to change its conventional practices to incorporate environmental matters as part of the decision-making process.

Building development involves complex decisions and the increased significance of external effects has further complicated the situation. Cost benefit analysis (CBA) is one of the conventional tools used widely by public and private sectors when appraising projects. It sets out to measure and compare the total costs and benefits of different projects that are competing for scarce resources in monetary terms. However, there are growing concerns that the values of environmental goods and services are often ignored or underestimated in the CBA approach which has led to the overuse and depletion of environmental assets. Consequently, CBA's usefulness and relevance in this respect is increasingly controversial.

Project development is not just concerned with financial return, but is also conscious of the long-term impacts on living standards for both present and future generations. Sustainable development is an important issue in project decision-making and environmental effects need to be incorporated into the evaluation process. A multi-dimensional evaluation approach attracts increasing attention around the world as the way to incorporate environmental issues in the decision-making process. This approach uses the conventional market approach to monetarise economic aspects of a development, whilst using a non-monetary approach to evaluate the environmental matters.

The purpose of this thesis is to critically examine the impact of construction activities on the environment and methods of quantifying environmental matters. This thesis also evaluates the principal sustainable development determinants for modelling, and evaluating long-term environmental performance of buildings during the project appraisal stage. Projects can be assessed using an index system that combines the principal determinants of sustainable development.

The four criteria as identified in this research are financial return, energy consumption, external benefits and environmental impact. The derived sustainability index combines the four identified attributes into a single decision-making tool. The attributes are each expressed in units that are best suited to their quantitative assessment. The development of a sustainability index is a way of combining economic and environmental criteria into the decision-making framework.

The sustainability index has also been developed into computer software called SINDEX to be used as a benchmarking tool to aid design and the sustainability assessment of projects. SINDEX is a sustainability modelling tool used to calculate and benchmark sustainable performance of proposed buildings, new and existing facilities.

Conventional project appraisal techniques measure net social gain to select a project, whilst the sustainability index measures the relative ranking of projects from a sustainable development view. Buildings have a long life, so any improvement in appraisal techniques for choosing the best option amongst the alternatives will significantly reduce their future environmental impact. As such, a methodology that embraces various criteria in relation to project development is crucial in this respect. The development of a sustainability index is a way to combine multiple criteria measured using different units. Using the sustainability index will greatly assist the construction industry to realise sustainable development goals, and thereby make a positive contribution to identifying optimum design solutions.