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MULTI-CRITERIA ASSESSMENT FOR ENVIRONMENTAL SUSTAINABILITY OF BUILDINGS

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Thesis submitted in partial fulfilment of the requirements for the degree Doctor of Philosophy

Department of Civil Engineering

University of Moratuwa

Sri Lanka

University of Moratuwa



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SRMSR CHANDRATILAKE

A thesis submitted in partial fulfilment of the requirements of the University of Moratuwa for
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DECEMBER 2015

DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any materials previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where acknowledgement is made in the text.

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ABSTRACT

In the last couple of decades there has arisen a crowded toolbox of quantitative methods used to assess construction sustainability. The evolution of the assessment systems shows the interest in quantifying sustainability with a range of very specific indicators. The majority of the existing sustainability assessment methods for buildings evaluate performance of buildings for a selected set of domains, with a lot of commonality.

This study focuses on the building sector and as the first step relevant domains were identified through comprehensive analysis of available assessment systems. Site, energy efficiency, water efficiency, material, indoor environmental quality and waste and pollution are the identified domain for the study. Secondly, aspects of (criteria for) the selected domains were identified and the relative importance of the domains and aspects was established by an expert survey. Thirdly the overall domain weights were compared with those assigned by other rating systems, originating from different countries to find the correlation which can demonstrate the influence of national contexts for relative weights in rating systems.

The fourth step is to analyse the applicability of continuous functions to assess the sustainability in contrast to step functions to facilitate 'assessment' rather 'rating' of buildings. Fourth aspect of this research is to establish the dependencies and influences between indicator scores within domains. The matrix representation was used to handle these direct and indirect influences. Finally the research focused on optimisation techniques that can be used to handle tradeoffs between indicator scores and to arrive at acceptable indicator combinations with optimised environmental sustainable scores for a given building.

It was found that in the building hierarchy the "system" level is the most important, having over fifty percent of overall weight. In the building lifecycle, the "operation" stage is the most important phase. There is also strong coupling between the operation stage and system level. Good correlation was found between national statistics and the weights, demonstrating that national contexts influence the relative weights in rating systems. The outcome of the dependency evaluation shows that there are considerable dependencies between indicator scores. It was found that the proposed optimisation technique is truly useful to arrive at planning strategies that yield high environmental sustainability scores for buildings while accounting for negative dependencies.

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ABBREVIATIONS

AHP	Analytic Hierarchy Process
CCM	Common Carbon Metric
CED	Cumulative Energy Demand
LEED	Leadership in Energy and Environmental Design
EPD	Environmental Product Declarations
ERA	Environmental Risk Assessment
GBC	Green Building Council
GHG	Green House Gas
IOA	Input Output Analysis
LCA	Life Cycle Analysis
LCC	Life Cycle Cost
LC-ZEB	Life Cycle Zero Energy Buildings
MFA	Material Flow Accounting
SDI	Sustainable Development Indicators
TQA	Total Quality Assessment
ZEB	Zero Energy Buildings

PUBLICATIONS

Journal Publications

- Chandratilake, S. R. and Dias, W. P. S. (2014). Ratio based indicators and continuous score functions for better assessment of building sustainability. *Energy*, 83, 137-143
- Chandratilake, S. R. and Dias, W.P.S. (2013). Sustainability rating systems for buildings: Comparisons and correlations, *Energy*, 59, 22-28.

Conference Papers

- Chandratilake, S. R, Dias, W. P. S.(2012). *Relative importance of lifecycle and hierarchy stages for sustainability of buildings*. Paper presented at the ICSECM Conference, (135-143), Peradeniya, Sri Lanka. December 2012.
- Chandratilake, S. R, Dias, W. P. S. (2009). *Object oriented model for sustainability of buildings*. Paper presented at the IABSE Symposium, (178-182), Bangkok, August 2009.