A fuzzy AHP model in evaluating interdependency of sustainable indicators and criteria- Case of India

A.Suchith Reddy[1*], P. Rathish Kumar[2], P. Anand Raj[3]
[1] *Research Scholar, Department of Civil Engineering, NIT Warangal, Warangal, India*
[2,3] *Professor, Department of Civil Engineering, NIT Warangal, Warangal, India*
** e-mail: asr.nitwarangal@gmail.com*

Introduction

The According to United Nations(UN), by the end of the year 2050, globally around 6.3 billion people are expected to live in the cities (Mahmoud, Zayed, & Fahmy, 2019) due to which the urban inhabitants increase rapidly with the huge requirement of infrastructural facilities for transportation, housing, health, and education. This unintended population growth will have to suffer from the availability of resources, energy, and pollution leading to environmental degradation. Today's cities energy consumption accounting to 70% of Greenhouse Gas emissions(GHG) (McCormick et al, 2013). Infrastructure buildings consume a huge quantity of natural resources and energy and produce hazardous waste along with pollution. To take control of the consumption (inputs) and emissions (outputs), it is necessary to implement and adopt the principles of sustainability. Based on the directions of UN Sustainable goals and principles, localized and specific indicators and criteria are essential in achieving sustainable construction(Reddy, Raj, & Kumar, 2018; Zhang, Zhan, Wang, & Li, 2019). The present study investigates the specific sustainable criteria with respect to Social, Environmental, Economic and Technological (SEET) indicators keeping in view the regional variations, culture, heritage, climatic, geographical, and regional context of developing countries like India. The objective of the study is to quantify the interdependency between indicators and criteria using Fuzzy Analytical Hierarchy Process (FAHP). The findings of the study simplify the decisions to be taken by the stakeholders in improving the sustainable performance of buildings and further facilitates in developing sustainable building assessment tool.

Research Methodology

The approach to evaluating the performance of the building can meet the design objective of the building. The scientific evidence proposes that the assessment of the significant performance of indicator can be performed by a consensus-based process which best suits the comprehensive analysis (Vyas, Jha, & Patel, 2019). The hierarchical model facilitates to provide a common platform for assessing the building in all disciplines of sustainability and also serves for the development of design and technical solution for achieving sustainability. Keeping in view, varied local and regional context, climate changes, construction procedures, topographical and cultural changes, the study identified four sustainable indicators Social, Environmental, Economic, and Technological and eight sustainable criteria including Water Efficiency (WE), Materials & Waste Management (MW), Human Well-being (HW), Energy Efficiency (EE), Sustainable Sites (SS), Social Welfare (SW), Transportation (T) and Management (M). Further, based on Content Analysis (CA) and Delhi Technique (DT) the criteria are refined and tailored to suit the Indian context. To evaluate the relative weights and quantify the interrelationship, a questionnaire survey was drawn out with 7-point Likert scale and experts from public and private organizations (including academicians, designers, architects, consultants, clients, contractors, and others) to analyze their significance towards sustainability. The data extracted was observed to be consistent using Cronbach's alpha coefficient for four dimensions of sustainability are found to be above 0.85. They are then processed, analyzed and interpreted using statistical techniques to extract the required information. This information is then analyzed using Fuzzy Analytical Hierarchy Process (FAHP)

a Multi-Criteria Decision-Making (MCDM) method to establish interrelationship among criteria and indicators.

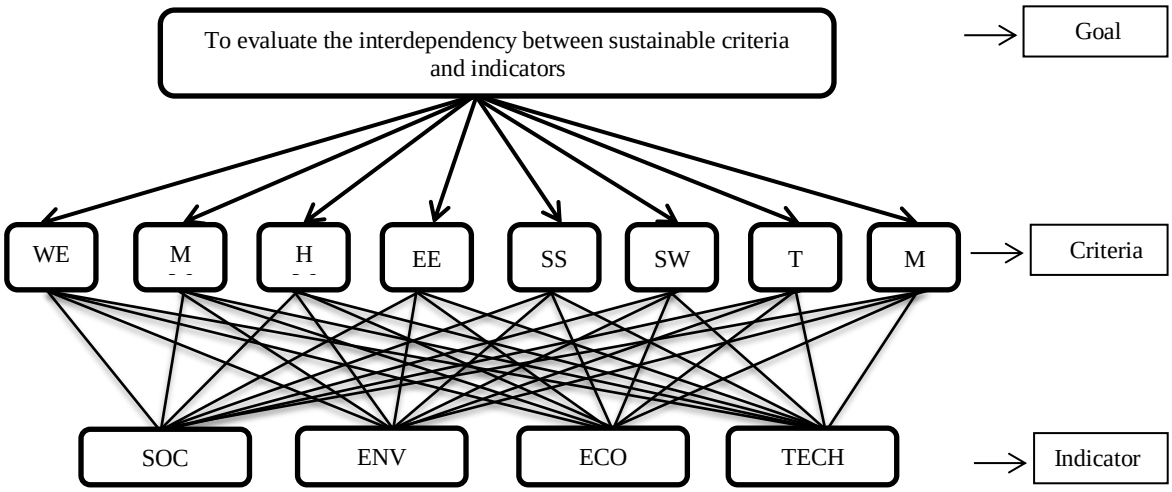

Fig.1 Hierarchy of the model to assess the interdependency of indicators and criteria

Results and Concluding Remarks

The study found that development of the nation involved with the adoption of sustainable principles in construction industry promotes the overall growth without disturbing the eco-system and avoids adverse impacts caused by the conventional principles and practices in India.

- The study brought out the significance of the proposed 'Technological' indicator and encouraged Quadra-Bottom Line approach in implementing and achieving sustainable construction. This facilitates to incorporate innovative ideas and then implement the concept of Reduce, Recycle and Reuse (3R's) into design principles. Among SEET indicators, Environmental indicator has secured the highest weight of 30.15% and Technological indicators of 28.52%.
- The normalized interdependency of Technological indicator has attained the highest weight of 28.40% prior to Environmental indicator of 27.01%, by this, the study derives the integration of Technological indicator with a triple-bottom-line approach to form quadra-bottom-line approach in achieving sustainable construction.
- The Material and Waste Management criterion has attained the highest relative weight and interdependency 13.96% and 15.56% respectively. Based on the interdependency, the criteria WE, MW, SS, and S are categorized under Social indicator, MW, EE, T, and M are categorized under Environmental aspect. Similarly, WE, HW, EE, and SS are grouped under Economic indicator and HW, SS, SW and M criteria are categorized under the Technological indicator.

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