BSRI (Building Sustainability Rating Index) for Building Construction

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Abstract

Sustainability has been defined by various institutions as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". This is a soft qualitative definition. It has also been defined as "taming the exponential growth of resource consumption and emissions generation while maintaining an exponential growth in affluence growth". This is a quantitative definition. This paper provides a building sustainability rating system (BSRI) to assess sustainability impacts using both prescriptive (qualitative) assessment tools as well as performance (quantitative) rating tools of resource consumption and emissions generation. BSRI is easy to apply and focuses on macro (strategic design mission, vision and objectives) as well as micro (tactical) levels of the building stakeholder's sustainability perspectives. The criteria and indices in BSRI are defined in order to reduce ambiguity, confusion and misunderstanding and create a standard for future integration of sustainability (GREEN) with BIM and LEAN platforms. The BSRI platform allows for adaptation and growth in knowledge of the sustainability issues such as embedded energy protocols, through the use of Bayesian Equations.

Key Words: Sustainability Assessments, Weighted Point system, Bayesian Equations, Resource consumption.

Introduction

This paper is limited by time and resource constraints to the building sector of the construction industry. The inspiration of this paper comes from the Construction Industry Institute project titled Project Definition Rating Index (PDRI) which was used by the author extensively in construction with positive results.

There is a growing concern among building construction stakeholders on how to improve construction practices to minimize their detrimental effects on the natural environment (Cole, 1999; Holmes and Hudson, 2000). The environmental impact of construction, green buildings, designing for recycling, waste reduction, dematerialization, de-construction and eco-labeling of building materials are some initiatives, among others, that have captured the attention of building professionals across the world (Johnson, 1993; Cole, 1998; Crawley and Aho, 1999).

Definition of Sustainability

The Report of the World Commission on Environment and Development (WCED), concerned about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development, stated that sustainable development implies meeting the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). This definition of sustainability by WCED was adopted by the United Nations World Commission on Environment and Development, (United Nations, 1987) and the US Environmental Protection Agency “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (US EPA, 2008): “Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the (Vitrubious) classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.”

The Pentagon has declared the topic of sustainability as a top national security issue because of social implications with global and national repercusions. The Pentagon has created a Sustainable Design & Constructability Guide, where sustainable design includes not only environmental considerations, but takes into account how the environment integrates with cost, schedule, operations, maintenance, and worker/employee considerations (Pentagon, 2004). According to Zimmermann et al. (2005), sustainability is defined as a state in which a stable social order underpinned by a suitable economic framework can prevail in the long term without overtaxing the earth’s overall ecological capacilty. Accordingly, provisions need to be made for quantifying the contribution required from various areas of human activity to achieve a sustainable society.

The above definitions of sustainability are soft, qualitative, prescriptive and have engendered our current system of sustainability assessment tools.

On the other hand, Fernandez-Solis (2009) defines sustainablity as the taming of unstainable exponetialoids of resource consumption and emissisions generations while maintaining an exponential growth of affluence that matches the exponetial growth of population for the next generations. This definition of sustainability requires hard performance metrics that measure opposing vectorial forces, (Garcia Bacca's definition of exponentialoid) in a rating tool that also takes into consideration the soft qualitative dimensions.

Sustainability Systems

Two systems have emerged in from the second millennia: A building sustainability that is based on prescriptive assessments using focus groups, structured interviews, qualitative analysis and a building performance rating tool using hard metrics.

Building performance, as evidenced by the building commissioning movement, is now a major concern of professionals in the building industry (Crawley and Aho, 1999) and environmental building performance assessment has emerged as a major issue in sustainable construction (Cole, 1998; Cooper, 1999; Holmes and Hudson, 2000). According to Cole (1998), the definition of building performance varies according to the different interests of parties involved in building development. For instance, a building owner may wish the building to perform well from a financial point-of-view, whereas the occupants may be more concerned about indoor air quality, comfort, and health and safety issues. Using a single method to assess a building's environmental performance and to satisfy all needs of users is no easy task.

Therefore, an ideal environmental building assessment will include a correct and complete set of requirements of the different parties involved in the development. The phrase "built environment" refers to the man-made surroundings that provide the setting for human activity, ranging from large-scale civic surroundings to personal places. The built environment has a profound effect on our natural environment, economy, health, and productivity. Green building has been defined as the practice of increasing the efficiency with which buildings use resources — energy, water, and materials — while reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal: the complete building life cycle.

Building designers and occupants have long been concerned about building performance (Cooper, 1999, Kohler, 1999, Finnveden and Moberg, 2005). Considerable work has gone into developing systems to measure a building's environmental performance over its life. They have been developed to evaluate how successful any development is with regards to balancing energy, environment and ecology, taking into account both the social and technological aspects of projects (Clements-Croome, 2004). Separate indicators, or benchmarks based on a single criterion, have been created to monitor specific aspects of environmental building performance such as air quality and indoor comfort. However, these benchmarks serve to emphasize the need for a comprehensive assessment tool to provide a thorough evaluation of building performance against a broad spectrum of environmental criteria.

The Building Research Establishment Environmental Assessment Method (BREEAM) in 1990 was the first environmental building assessment method and it remains the most widely used (Larsson, 1998). The Building Research Establishment developed the system in collaboration with private developers in the UK, and it was launched as a credit award system for new office buildings. In BREEAM practice, a certificate of the assessment result is awarded to the individual building based on a single rating scheme of fair, good, very good or excellent. The purpose of this system is to set a list of environmental criteria against which building performances are checked and evaluated. This assessment can be carried out as early as the initial stages of a project. The results of the investigation can be fed into the design development stage of buildings; changes can then be made to satisfy pre-designed criteria (Johnson, 1993). Since 1990, the BREEAM system has been constantly updated and extended to include assessment of such buildings as existing offices, supermarkets, new homes and light industrial buildings (Yates and Baldwin, 1994).

Crawley and Aho (1999) suggest that the system successfully alerts building owners and professionals to the importance of environmental issues in construction. BREEAM has made an impact worldwide, with Canada, Australia, Hong Kong and other countries using the BREEAM methodology in developing their own environmental building assessment methods. Following the launch of BREEAM in the UK, other assessment methods have been developed around the world to undertake environmental building assessment. Table 1 summarizes various environmental building assessment methods used in different countries.

Most environmental building assessment tools cover the building level and are based on some form of life-cycle assessment database (Seo et al., 2006). The industry uses two categories of tools: assessment tools and rating tools. Assessment tools provide qualitative performance indicators for design alternatives, while rating tools determine the performance level of a building in graphic (stars) or quantitative systems. Furthermore, these tools are created and maintained by government or private agencies. EMGB, NABERS and BASIX are operated by the government while the others (such as LEED) have a private, voluntary and contractual origin and are for guidance only. They essentially aim to show those involved in the building process the potential for improvement. Most building evaluation methods are concerned with a single criterion such as energy use, indoor comfort or air quality, to indicate the overall performance of a building (Cooper, 1999; Kohler, 1999). As environmental issues become more urgent, more comprehensive building assessment methods are required to assess building performance across a broader range of environmental considerations.

An environmental building assessment method reflects the significance of sustainability in the context of building design and subsequent on-site construction work. The primary role of an environmental building assessment method is to provide a comprehensive assessment of the environmental characteristics of a building (Cole, 1999) using a common and verifiable set of criteria and targets for building owners and designers to achieve higher environmental standards. It also enhances the environmental awareness of building practices and lays down a foundation for the building industry to move towards environmental protection and achieving the goal of sustainability. It provides a way of structuring environmental information, an objective assessment of building performance, and a measure of progress toward sustainability.

Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. There is now clear evidence that humanity is living unsustainably by consuming the Earth's limited natural resources more rapidly than they are being replaced by nature. During ancient times, humanity constructed houses using natural resources without interfering with nature, and finally giving back to nature in the same format. As technology advanced, we started to mutate natural resources to construct buildings, which has resulted in a highly unsustainable grid pattern. This grid is causing serious harm to the concept of sustainability and needs to be changed in order to save resources for future generations.

Literature Review

Before moving forward to the sustainability assessment system and its development, it is important to first discuss the complexity of the construction industry and its systemic nature. According to Fernández-Solís (2007), a world view of the construction industry with its complexity provides a more realistic platform from where we can identify the elements that historically have influenced industrial change, thus avoiding the attraction and bias of reductionist models. He further states that the complexity of the building construction industry needs to be better understood so that the mechanisms and forces that create change in the industry can be discerned (Fernández-Solís, 2007).

Second, after considering construction complexity, one should consider the aspect of resource consumption in the industry. In recent years, there has been increasing pressure on all the entities involved in the construction industry to preserve the global environment by reducing energy and material consumption in order to achieve effective sustainable development. According to Yokoyama (2005), in order to reduce resource consumption, we must concentrate on resource consumption of the building in the construction stage and energy resource consumption in the operation stage. However, if the purpose is to save energy or reduce CO2 emission, we must concentrate on energy resource consumption in the operation stage. Furthermore, Yokoyama states that in order to improve resource productivity of buildings, it is crucial to design low resource consumption buildings.

Currently, buildings account for 40% of primary energy use, 72% energy consumption, 39% of CO_2 emissions, and 13% of potable water consumption in the United States (USGBC, 2008). Building construction and their planned locations significantly affect the majority of our consumption of resources. A growing association of devoted professionals is trying to advocate and practice in supplementary sustainable approaches.

The literature review indicates that the task of understanding and translating strategic sustainability objectives into concrete action at the project level has become quite challenging for construction professionals (Viitaniemi & Haapio, 2007). The process has been exacerbated by the multi-dimensional perspectives of sustainability, such as economy, society, and environment, combined with a lack of structured methodology and information at various levels. Also, while discussing environmental issues in the building sector, the use of terms is not well established. This inconsistent use of terms may cause confusion and misunderstandings (Viitaniemi & Haapio, 2007). Over the past few years, the increased concern over the deterioration of our environment has motivated the development of various sustainability assessment systems across the globe. Although most of them are based on the concept of life cycle assessment, they have basically focused on the evaluation of environmental performance during building operation (Cole, 2000). The limited attention given to the onsite construction impacts is a consequence of the perceived relatively lower significance of construction impacts, compared with the lifecycle impacts associated with building design and management.

The environmental assessment methods all have limitations that may hamper their future usefulness and effectiveness (Ding & K.C., 2007). According to Ding (2007), current assessment methods do not adequately and readily consider environmental effects in a single tool and therefore do not assist in the overall assessment of sustainable development. Also the inflexibility, complexity and lack of consideration of a weighting system are still major obstacles to the acceptance of sustainability assessment methods. Use of a sustainability index should simplify the measurement of sustainability, therefore making a significant contribution to the identification of optimum design solutions and facility operations (Ding & K.C., 2007).

Cole (2000) argues that the environmental building assessment methods contribute significantly to an understanding of the relationship between buildings and the environment. But the interaction within the building and the grid still remains largely unknown.

In several countries, “rating” schemes have been introduced, which do provide additional information for assessing energy-efficiency compared to an arch-type building. These schemes have a variety of objectives, forming either part of the requirements for building=planning code compliance or part of a scheme to market energy-efficient environmentally responsible buildings (Soebarto, 2001). Despite claims to the contrary, most assessment programs are not design-orientated. They are constructed to give endorsement to a completed design rather than to assist the designer during the design process (Soebarto, 2001).

According to Howard (2005), considerable progress has been made in recent years in the evolution of environmental assessment methods and in promoting their use by the industry. The future evolution of existing sustainability assessment methods for buildings is likely to include:

1. Continuing refinement of the metrics and methods of assessing the sustainability of buildings, which is likely to include:
    - Improved methodology to provide a level playing field and publicly available data for the use of Life Cycle Assessment (LCA in buildings.
    - Improved tools to make the complexity of LCA accessible and practical for designers, operators and owners of buildings.
    - Improved performance based metrics, underpinned by better research for a broader range of sustainability measures in existing assessment and certification systems.
2. Steady progress in the market uptake of these methods and transformation of the building and real estate industries.
3. Steady growth in the achievements, activity, growth and influence of Green Building Councils internationally.

Hence, in the future, the rating systems devevloped should ideally assist designers during the design process, they should be clear with definitions of indicators in order to avoid confusion, and they should be developed with the help of trend analysis or equivalent to remove future ineffectiveness.

Methodology

The objective of this research is to develop a rating system which will satisfy present as well as future requirements of sustainability. The most significant problem facing anyone who attempts to study the future is how to sift effectively through the myriad of information sources and pull put those trends worthy of future study and tracking. Researchers use a number of techniques to think about and sketch out future opportunities. Trend analysis is one technique that offers reliable outputs. Trend analysis is nothing but collecting and analyzing local, regional or global conditions. Researchers can develop forecasts of future conditions through simple exploration of collected data (Wallace, 2005). BSRI is intended to assess the sustainability of new building construction right, from the design stage to operational stages, as defined system boundaries.

Per ISO/TS 21931-1, the assessment method shall involve following elements:

1. Intended use of the system
2. Definition of the system boundaries
3. Statement of assumption
4. Structured list of issues
5. Means of quantifying the environmental performance of the building
6. Sources of information
7. Evaluation and interpretation
8. Reporting the results and communication format

The proposed methodology for the development of BSRI consists of the following important concepts:

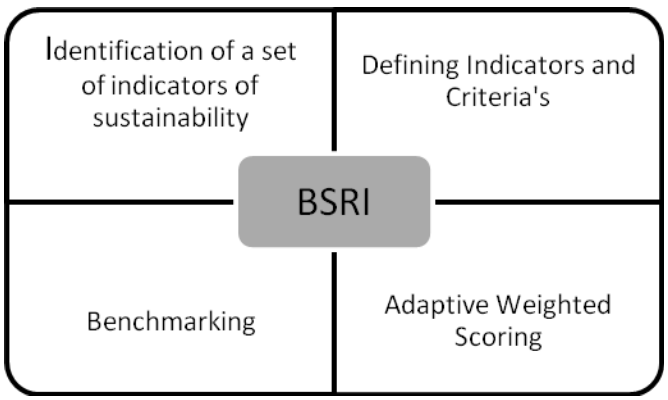

Figure 1: Important concepts in the methodology of BSRI

Indicators

An actor in the field of building construction needs tools and systems to improve sustainability practices. These tools are based on sustainability indicators and criteria. According to Haapio (2007), indicators are measures which can show the direction of change while criteria are characteristics that are considered important and by which success or failure is judged.

Indicators provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They help to measure and calibrate progress toward sustainable development goals. They can provide an early warning, sounding the alarm in time to prevent economic, social and environmental damage.

According to ISO (2006), when developing and selecting indicators, the starting point should be the identification of the main users and user needs. Sustainability indicators for construction works are needed by a number of interested parties in the building and construction sectors, for decision-making by:

- Investors and owners of the project
- Occupants of the building
- Planners, designers and developers of the project

- Contractors
- Facility managers
- Public entities

There are three main types of sustainability indicators:

1. Environmental Indicators: An environmental indicator addresses the environmental aspect of building construction in terms of either loading or impact. Environmental loading is related to the use of resources and its subsequent impacts on the environment.
2. Economic Indicators: These indicators are related to the economic flows in the building's life cycle.
3. Social Indicators: These indicators demonstrate building interaction, through issues related to sustainability at the community level. The deciding factors in this segment are building occupants, community, public entities, etc.

One salient feature of BSRI is its easy to use index with well defined list of indicators. The BSRI research team will conduct a survey with a combination of structured interviews with industry professionals, academicians and policy makers in the Green building industry. This process will help the team to establish a clear set of definitions with appropriate weights from professionals. The following chart shows some of the key sustainability indicators:

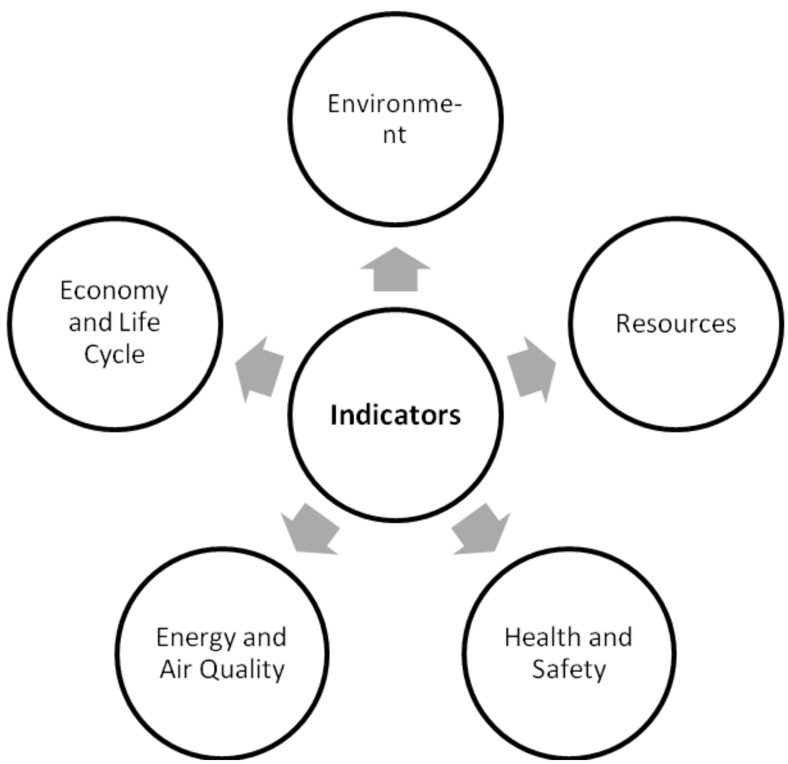

Figure 2: key sustainability indicators

Filters

A filter is a tool designed to pass certain criteria while blocking others. The filters in this research will be designed to remove certain indicators that do not affect resource consumption in the construction process.

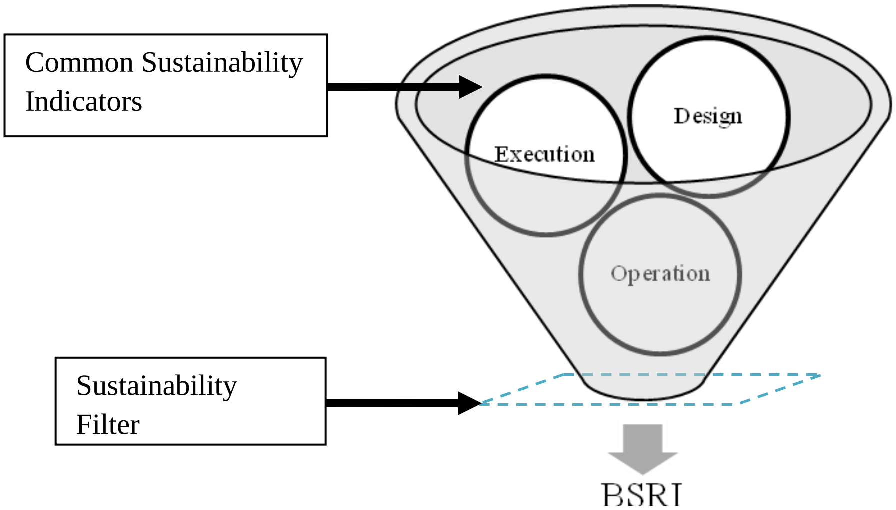

Figure 3: Sustainability filters

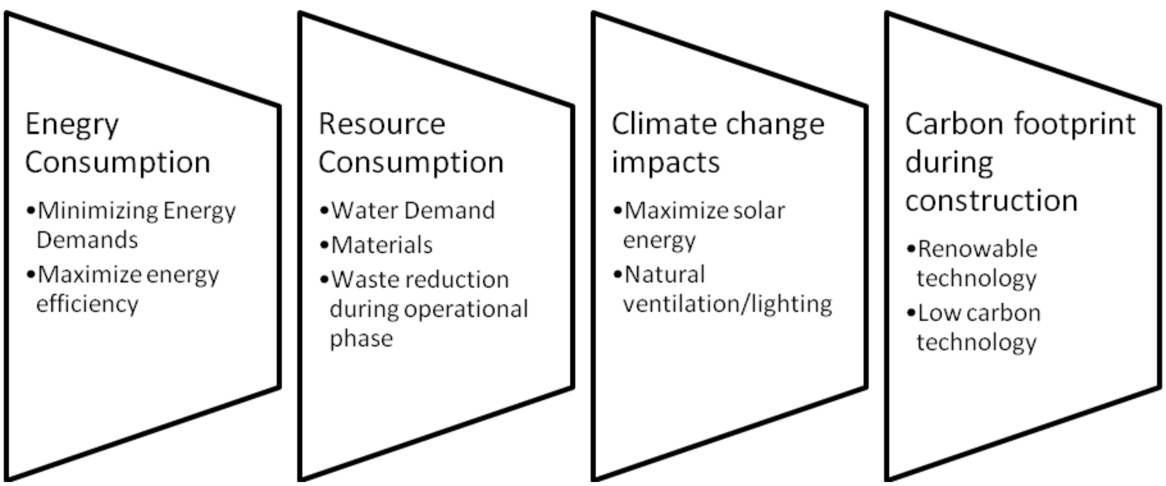

Figure 4: key sustainability indicators

After reviewing the published literature and following the above stated aspects, the research will move ahead with developing a matrix comprised of various activities that affects the sustainability of buildings the most (Prototype). This list will be then sent to stakeholders, such as owners, contractors, and sustainability certifying professionals, as well as to academicians, for their review. They will be asked to rate each activity from 0-5 (0=does not affect sustainability, 5= affects sustainability the most)

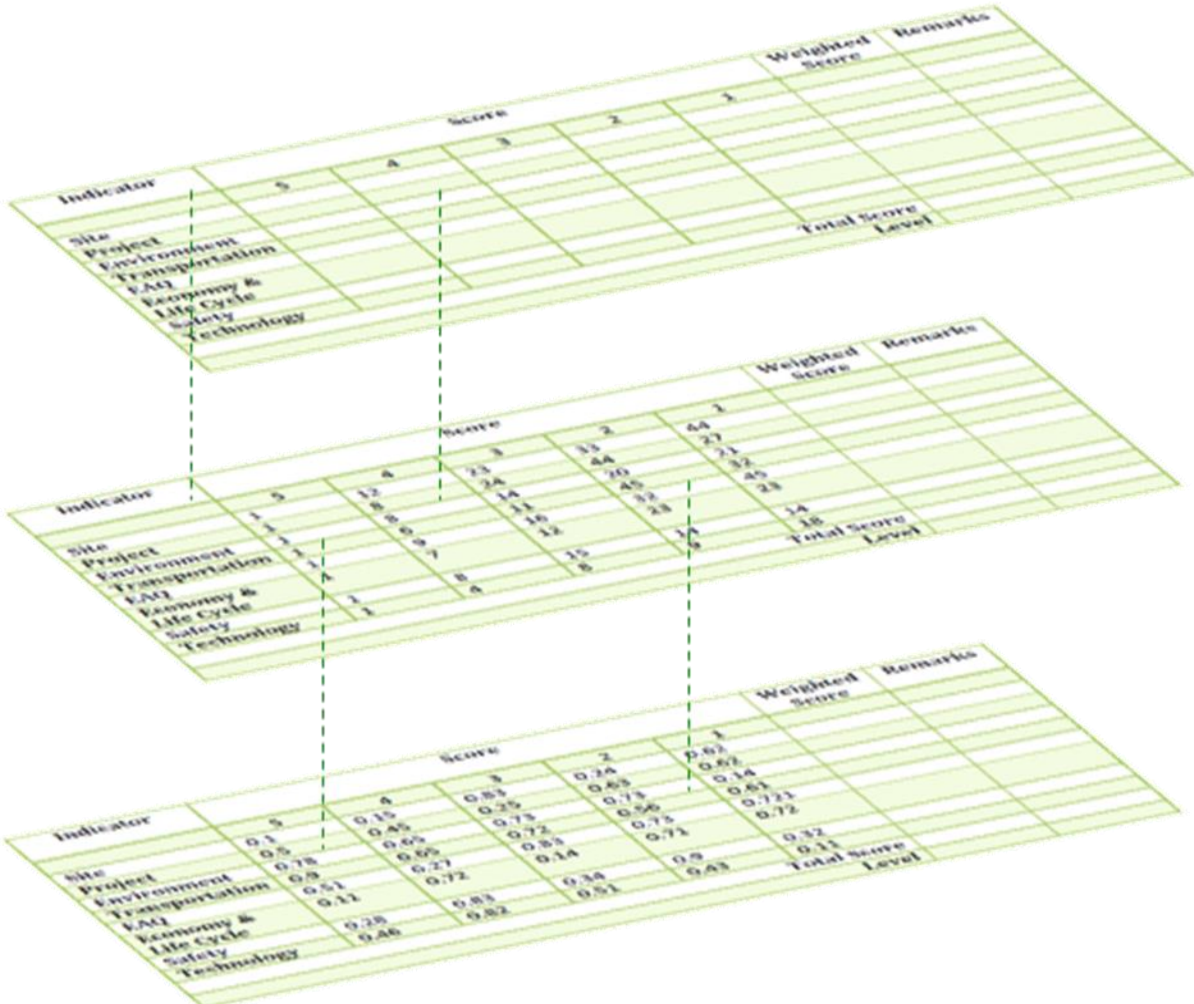

Figure 5: Graphical model of proposed rating system.

After receiving the reviews, the next step in this research will be to reorganize the matrix as per the review results and furnish it for the sustainability assessment stage.

In the assessment stage, we will select 3 sets, each with 3 ongoing building construction projects for assessment purposes, as follows:

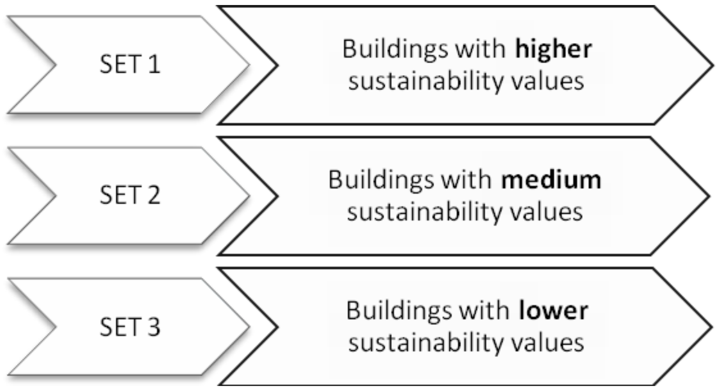

Figure 6: Project sets for BSRI

BSRI will be applied with these three sets and the results will be prepared for the next stage, which is the validation stage. Validation of the BSRI will be carried out through workshops and surveys. In those, the BSRI results will be reviewed and analyzed by industry experts.

It is very important to set benchmarks during the development of any system. Benchmarks will be set for each activity with an evaluation of its impact on the building's sustainability. Benchmarking will define limits for each level, as well as give us the standard for the type of building. The following table shows conceptual project benchmarking for BSRI:

Project Benchmarking

SR NO.	PROJECT	TYPE	LOCATION	BSRI SCORE
1	Reed Arena Expansion	Sports Complex	College Station, TX	650
2	Agriculture Program State Headquarters	Educational	Oklahoma City, OK	890
3	Interdisciplinary Life Sciences Building	Educational	Milwaukee, WI	750
4	New Campus Housing	Residential	College Station, TX	530
5	Mitchell Buildings	Commercial	Austin, TX	320

Benchmark

Minimum 100
Maximum 1000

Figure 7: Proposed project benchmarking system for BSRI

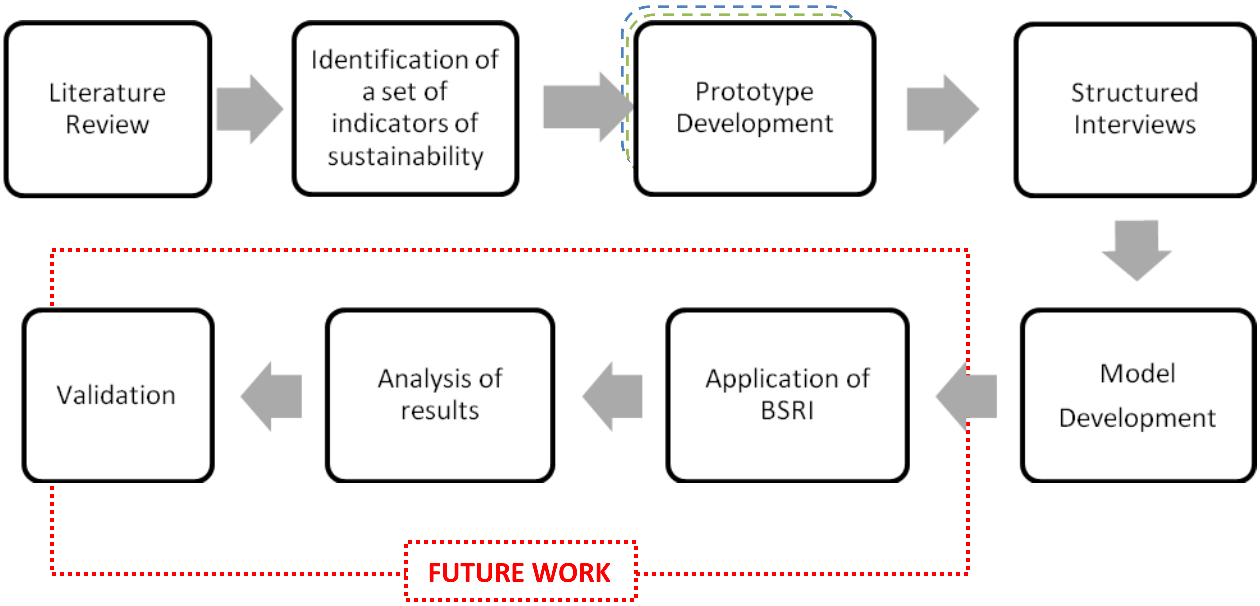

Figure 8: Proposed methodology for BSRI

Significance of proposed study

This research aims to deliver a building sustainability rating system which will be:

- Easy to apply and focused on macro as well as micro levels of building construction.
- Focused on owner's sustainability perspective.
- Composed of well-defined criteria and indicators in order to reduce confusion and misunderstandings.
- An adaptive weighted scoring system.
- An open system.

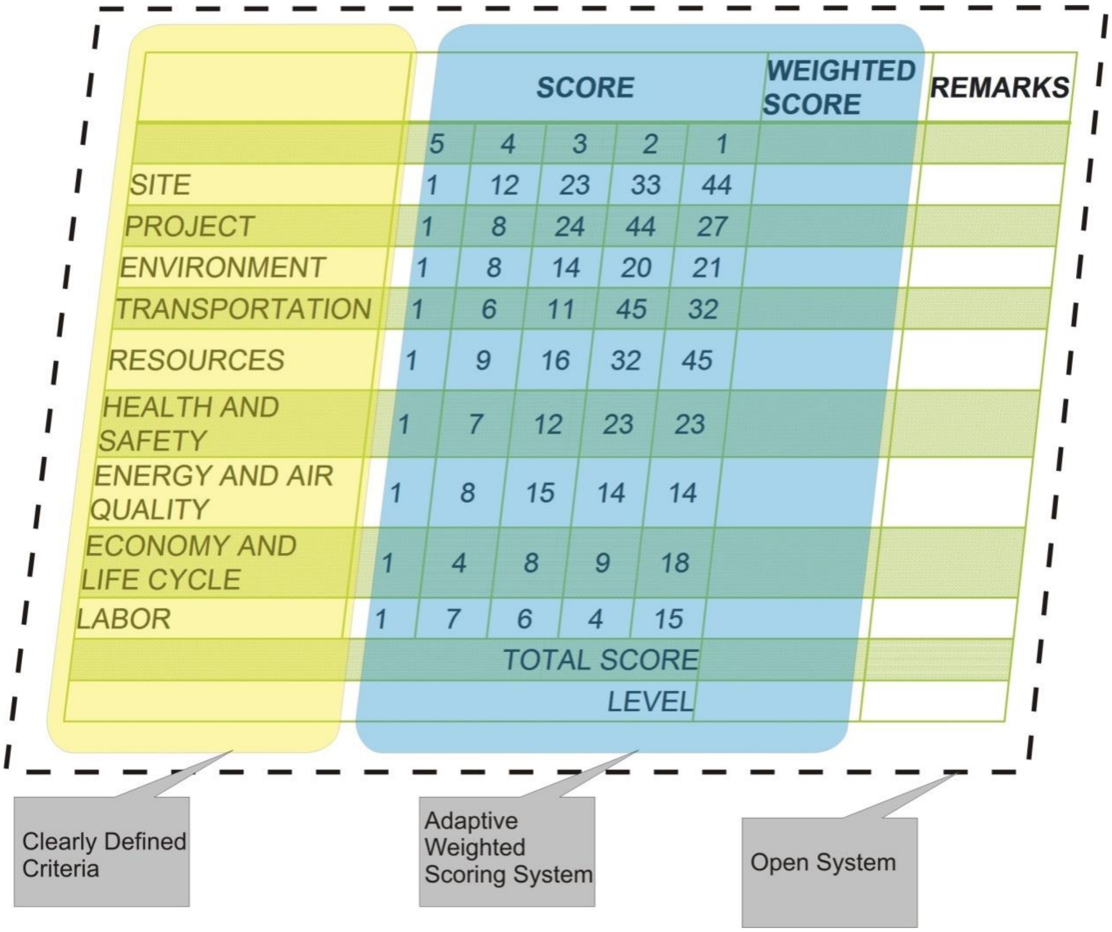

Figure 9: BSRI system demo

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