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PERFORMANCE EVALUATION OF ENERGY CONSCIOUS BUILDING RATING AS A LEED -A REVIEW

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ABSTRACT
Today, there is a high level of demand for sustainable buildings. The most important decisions regarding a building's sustainable features are made during the design and preconstruction stages. Leadership in Energy and Environmental Design (LEED®) is the most widely adopted sustainable building rating system in the United States. For projects pursuing LEED certification, designers have to conduct in-depth sustainability analyses based on a building's form, materials, context, and mechanical–electrical–plumbing (MEP) systems. Since Building Information Modelling (BIM) allows for multi-disciplinary information to be superimposed within one model, it creates an opportunity to conduct these analyses accurately and efficiently as compared to the traditional methods. In this exploratory research, a case study was conducted on Salisbury University's Perdue School of Business building to demonstrate the use of BIM for sustainable design and the LEED certification process. First, a conceptual framework was developed to establish the relationship between BIM based sustainability analyses and the LEED certification process. Next, the framework was validated via this case study. The results of this study indicate that documentation supporting LEED credits may be directly or indirectly prepared using the results of BIM-based sustainability analyses software. This process could streamline the LEED certification process and save substantial time and resources which would otherwise be required using traditional methods.
KEYWORDS: LEED, Green Building

INTRODUCTION

Definition of Green Building:

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.

- ### What Makes a Building Green?

A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as protecting occupant health; improving employee productivity; using energy, water, and other resources more efficiently; and reducing the overall impact to the environment.

Green features of a green building

1. Minimal disturbance to landscapes and site condition
2. Use of non-toxic and recycled / recyclable material
3. Efficient use of water and water recycling

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4. Use of energy efficient and eco-friendly equipments
5. Use of renewable energy
6. Quality of indoor air quality for human safety and comfort
7. Effective controls and building management systems

- **Benefits of Green Buildings:**

A green building may cost more up front, but saves through lower operating costs over the life of the building. The green building approach applies a project life cycle cost analysis for determining the appropriate up-front expenditure. This analytical method calculates costs over the useful life of the asset.

These and other cost savings can only be fully realized when they are incorporated at the project's conceptual design phase with the assistance of an integrated team of professionals. The integrated systems approach ensures that the building is designed as one system rather than a collection of stand-alone systems.

Some benefits, such as improving occupant health, comfort, productivity, reducing pollution and landfill waste are not easily quantified. Consequently, they are not adequately considered in cost analysis. For this reason, consider setting aside a small portion of the building budget to cover differential costs associated with less tangible green building benefits or to cover the cost of researching and analyzing green building options.

- **Elements of Green Buildings**

Below is a sampling of green building practices.

1. **Siting**
   - Start by selecting a site well suited to take advantage of mass transit.
   - Protect and retain existing landscaping and natural features. Select plants that have low water and pesticide needs, and generate minimum plant trimmings. Use compost and mulches. This will save water and time.
   - Recycled content paving materials, furnishings, and mulches help close the recycling loop.
2. **Energy Efficiency**
   - Most buildings can reach energy efficiency levels far beyond California Title 24 standards, yet most only strive to meet the standard. It is reasonable to strive for 40 percent less energy than Title 24 standards. The following strategies contribute to this goal.
   - Passive design strategies can dramatically affect building energy performance. These measures include building shape and orientation, passive solar design, and the use of natural lighting.
   - Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well being.
   - Install high-efficiency lighting systems with advanced lighting controls. Include motion sensors tied to dimmable lighting controls. Task lighting reduces general overhead light levels.
   - Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures.
   - Minimize the electric loads from lighting, equipment, and appliances.
   - Consider alternative energy sources such as photovoltaic and fuel cells that are now available in new products and applications. Renewable energy sources provide a great symbol of emerging technologies for the future.
   - Computer modelling is an extremely useful tool in optimizing design of electrical and mechanical systems and the building shell.
3. **Materials Efficiency**
   - Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials that are being diverted from California's landfills, as mandated by the Integrated Waste Management Act.
   - Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets.

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- Reuse and recycle construction and demolition materials. For example, using inert demolition materials as a base course for a parking lot keeps materials out of landfills and costs less.
- Require plans for managing materials through deconstruction, demolition, and construction.
- Design with adequate space to facilitate recycling collection and to incorporate a solid waste management program that prevents waste generation.

4. **Water Efficiency**
   - Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other non potable water for site irrigation.
   - Minimize wastewater by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures.
   - Use recirculation systems for centralized hot water distribution.
   - Install point-of-use hot water heating systems for more distant locations.
   - Use a water budget approach that schedules irrigation using the California Irrigation Management Information System data for landscaping.
   - Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas.
   - Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.
5. **Occupant Health and Safety**

Recent studies reveal that buildings with good overall environmental quality can reduce the rate of respiratory disease, allergy, asthma, sick building symptoms, and enhance worker performance. The potential financial benefits of improving indoor environments exceed costs by a factor of 8 and 14.

Choose construction materials and interior finish products with zero or low emissions to improve indoor air quality. Many building materials and cleaning/maintenance products emit toxic gases, such as volatile organic compounds (VOC) and formaldehyde. These gases can have a detrimental impact on occupants' health and productivity.

Provide adequate ventilation and a high-efficiency, in-duct filtration system. Heating and cooling systems that ensure adequate ventilation and proper filtration can have a dramatic and positive impact on indoor air quality.

Prevent indoor microbial contamination through selection of materials resistant to microbial growth, provide effective drainage from the roof and surrounding landscape, install adequate ventilation in bathrooms, allow proper drainage of air-conditioning coils, and design other building systems to control humidity.

- ## Building Operation and Maintenance

Green building measures cannot achieve their goals unless they work as intended. Building commissioning includes testing and adjusting the mechanical, electrical, and plumbing systems to ensure that all equipment meets design criteria. It also includes instructing the staff on the operation and maintenance of equipment.

Over time, building performance can be assured through measurement, adjustment, and upgrading. Proper maintenance ensures that a building continues to perform as designed and commissioned.

- ## Advantages

1. **Environmental benefits of green building:**
   - Enhance and protect biodiversity and ecosystems
   - Improve air and water quality
   - Reduce waste streams
   - Conserve and restore natural resources
2. **Economic benefits of green building:**
   - Reduce operating costs
   - Improve occupant productivity
   - Enhance asset value and profits
   - Optimize life-cycle economic performance
3. **Social benefits of green building**:
   - Enhance occupant health and comfort
   - Improve indoor air quality
   - Minimize strain on local utility infrastructure

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- Improve overall quality of life

- **Disadvantages:**

1. Location: Since these buildings depend on sun for energy, they need to be located in position that will have the best sun exposure which may demand placing them opposite to other neighborhood homes.
2. Availability: The materials to build such buildings can be hard to find especially in urban areas where preserving the environment is not the people's first option. So shipping these materials can then cost a lot than a standard building.
3. No air cooling features: These buildings run on heat to generate power, so they are not designed for hot areas as they do not have any ventilation systems, so air conditioners will be required which will make these buildings anything but Eco-friendly.
4. Increased cost is the first point of concern: If you don't have the adequate capital, it can be difficult to carry out such a project. Nevertheless, you can save significant amount of money and resources in general in the long run.
5. Quality of the indoor air: If a contractor uses the wrong kind of recycled materials that formerly in the past contained chemicals, it can be harmful for people who inhale them.
6. Lack of materials: In some cases, it can be hard to find the materials or even if you do find them, it can be very expensive or tough to transfer them to the project's locations.

- **What Is To Be Done?**

Essential to an effective green building policy that delivers energy efficiency is by using simple, standardized and better energy performance materials throughout the construction in all phases of building design and operation. Thus, to have green Building concept, some or all of the following steps need to be followed.

- Plan each office / home's orientation to the sun to harness energy and shield it from heat i.e. Proper Building Orientation and Landscape and emphasis on natural light.
- High efficiency insulated glass windows can reduce requirements of energy during the operation or use of Building. Thus it will emit minimum carbon dioxide CO_2.
- Minimize Cement / concrete consumption through innovative architecture and Structural Design for optimum use of cement.
- Maximum use of waste Pozzolonic materiel like fly ash in Concrete Mixture along with Cement.
- Non – toxic paints should be used on the walls. These use water rather than petroleum based solvents and do not emit smog producing pollutants. This will improve Indoor Air Quality.
- Use Sewage treatment and recycle the waste water from bathroom and Kitchen.
- Organic waste, both solid and liquid, produce a large quantity of Methane which is 23 times stronger than CO_2 as green house gases (GHG). Such organic waste must be processed to tap gas which can be used as cooking gas or fuel.
- Provide Rainwater Harvesting systems on the roof of Building to collect water, which can be used to flush Toilets or for general wash or recharge the ground.
- Use Solar Panels to heat bath water and generate little electricity for use when there are power cuts instead of using Invertors.
- Install simple Wind turbines on the roof, which can be used to generate electricity for use when there is no power.
- A rain garden can help reduce storm water runoff.
- Use Drip Irrigation to water the plants or Native landscaping around building. This requires less water for irrigation and maintenance.

Government or Municipal corporations should provide enough incentives like tax rebates or tax breaks for green buildings during approvals.

Government should make basic green norms – like gray water recycling and rainwater harvesting compulsory for all new buildings in all 5,161 cities, towns and urban agglomerations in the country.

- **Objectives of Green Building**

The common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

1. Efficiently using energy, water and other resources.

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2. Protecting occupant health and improving employee productivity.
3. Reducing waste, pollution and environment impact.

- **Goals of Green Building**

The following are the goals of a green building. Select the site so that the building can use maximum natural resources.

1. To design the building in such a way that it should use the resources efficiently
2. To use energy efficiently
3. To use water efficiently
4. To use materials efficiently
5. To improve indoor environmental quality
6. To optimize operation and maintenance
7. To reduce waste from the building.

REVIEW OF RESEARCH PAPER

Binh K. Nguyen, Hasim Altan, (2011), The paper presents the comparative review of five prominent sustainable rating systems namely BREEAM, LEED, CASBEE, GREEN STAR and HK-BEAM. The review process adopts a system of criteria which encompasses all features of sustainable rating tools. The main goal of the study is to consider all aspects of the systems in order to find out the best one(s). The study provides a deep insight into sustainable rating tools and can be a recommendation and reference for users when choosing between rating systems.

Mohammed S. Imbabi, Collette Carrigan & Sean Mc Kenna, (2012), The cement industry faces a number of challenges that include depleting fossil fuel reserves, scarcity of raw materials, perpetually increasing demand for cements and concretes, growing environmental concerns linked to climate change and an ailing world economy. Every tonne of Ordinary Portland Cement (OPC) that is produced releases on average a similar amount of CO2 into the atmosphere, or in total roughly 6% of all man-made carbon emissions. Improved production methods and formulations that reduce or eliminate CO2 emissions from the cement manufacturing process are thus high on the agenda. Emission reduction is also needed to counter the impacts on product cost of new regulations, green taxes and escalating fuel prices. In this regard, locally available minerals, recycled materials and (industry, agriculture and domestic) waste may be suitable for blending with OPC as substitute, or in some cases replacement, binders. Fly ash, Blast furnace slag and silica fumes are three well known examples of cement replacement materials that are in use today that, like OPC, have been documented and validated both in laboratory tests and in practice. The first is a by-product of coal combustion, the second of iron smelting and the third of electric arc furnace production of elemental silicon or ferro silicon alloys. This paper presents a concise review of the current state-of-the-art and standards underpinning the production and use of OPC-based cements and concretes. It outlines some of the emerging green alternatives and the benefits they offer. Many of these alternatives rely on technological advances that include energy-efficient, low carbon production methods, novel cement formulations, geopolymers, carbon negative cements and novel concrete products. Finally, the economics of cement production and the trends in the UK, US and the Gulf Cooperation Council (GCC) Region are presented, to help guide and inform future developments in cement production based on maximizing the value of carbon reduction.

Jian Zuo, Zhen-YuZhao, (2013) Green building is one of measures been put forward to mitigate significant impacts of the building stock on the environment, society and economy. However, there is lack of a systematic review of this large number of studies that is critical for the future endeavor .The last decades have witnessed rapid growing number of studies on green building. This paper reports a critical review of the existing body of knowledge of researches related to green building. The common research the sand methodology was identified. These common themes are the definition and scope of green building; quantification of benefits of green buildings compared to conventional buildings; and various approaches to achieve green buildings. It is found that the existing studies played predominately focus on then environmental aspect of green building. Other dimensions of sustainability of green building, especially the social sustainability are largely over looked. Future research opportunities were identified such as effect so climatic conditions on the effectiveness of green building assessment tools, validation of real performance of green buildings, unique demand so specific population, and future proofing.

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Joseph Iwaro & Abrahams Mwasha (2013), Sustainable design is a design approach put in place to promote the environmental quality and the quality of building indoor environment by reducing negative impacts on building and the natural environment. Also, it is a design philosophy that seeks to incorporate sustainable development concept in terms of initiatives and values into sustainable building envelope design. However, the problem remains as to what constitutes sustainable development concept required for sustainable envelope design. Therefore, this paper is aimed at examining the role of sustainable development concept in sustainable envelope design by investigating the impacts of sustainable envelope design on building sustainability using Integrated Performance Model. This was validated by comparing the energy efficiency performance from selected case studies of buildings with sustainable development concept and building envelope without sustainable development concept. It is expected that the incorporation of sustainable development concept in terms of initiatives and values will enhance the energy performance of building envelopment development and bring about building sustainability.

Ahmed Rashwan, Osama Farag & Wael Seddik Moustafa, 2013, The energy consumption in Egypt has increased sharply in the past few years, and ultra-energy efficient technologies are desperately needed for the national energy policy. This paper discusses and explores the possibilities offered by the use of nanomaterial technology which integrates with building envelope to improve the Energy efficiency and reduce energy consumption in buildings by the use of energy simulation software. The current study was aimed at testing the thermal performance of the Nano Thermal Model (NTM) and measuring heat-Transfer Rate, especially the quantity of Heat gain/loss through fabric, compared to conventional building envelope materials (baseline model) under typical Egypt-Aswan weather conditions. The results indicate the use of nanomaterials can improve the thermal performance of a building in hot dry climate like Egypt that especially needed cooling loads during the summer months. It also shows that the nanomaterials integrated with the envelope of the future building will achieve the lowest scientifically and empirically recorded values of heat transition in the field of construction. This lowest rates of the fabric heat transfer through the envelope is up to 72% when comparing the performance of the wholly Nano Thermal Model to the traditional model improved.

S.C. Chan, A.I. Che-Ani b & N.L. Nik Ibrahim, "2013 Natural ventilation is believed to be capable of enhancing indoor air quality through proper passive designs. However, most modern buildings today still depend heavily on artificial ventilation for their daily operations. The current study aims to identify the extent of passive designs that correlate to the thermal comfort satisfaction levels and user expectation on utilization. Feedbacks from respondents in selected primary school offices were collected and analyzed. Pearson's or the Product-Moment Correlation Coefficient analysis was used to justify the extent of correlation between the key parameters. The key parameters involved consisted of both physical and non-physical factors which influence human responses to the changes in the surrounding environment. The findings of this study indicate that the paired comparison between passive design, satisfaction levels, and estimation from the occupants have weak correlations, and thus, this means that the applicability of passive design should be further integrate with other influencing parameters in order to intensify the application of natural ventilation in office buildings in the near future.

Francesca Bottalicoa, Gherardo Chiricia, et.al., 2016, We investigated the potential performance of air pollution removal by the green infrastructures and urban forests in the city of Florence, central Italy, with a focus on the two most detrimental pollutants for human health: particulate (PM10) and ozone (O3). The spatial distribution of green infrastructures was mapped using remote sensing data. A spatial modeling approach using vegetation indices, Leaf Area Index, and local pollution concentration data was applied to estimate PM10 and O3 removal. The results are discussed to highlight the role and potential of green infrastructures and urban forests in improving air quality in Southern European cities.

Elie Azar, Christina Nikolopoulou & Sokratis Papadopoulos, 2016 Sustainable building performance requires the integration of various metrics such as energy consumption, thermal comfort levels, occupants' wellbeing, and productivity. Despite their interdependence, these metrics have been mostly evaluated independently, overlooking potential tradeoffs that can occur between them (e.g., energy conservation efforts and thermal comfort). In addition, human-related factors such as occupants' energy consumption behaviors, schedules, and movements between buildings cannot be captured using current commercial building modeling tools. Consequently, simulating the performance of a group of buildings such as in a campus, neighborhood, or city remains very challenging. In this paper, a comprehensive agent-based modeling (ABM) framework is

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developed to: (1) model an urban area with several buildings along with the movements and actions of people within the environment; (2) calculate key performance metrics such as indoor/outdoor thermal comfort and energy consumption levels; and (3) test and propose strategies to optimize sustainable building operation. This study illustrates the multidisciplinary approach needed to capture various dimensions of sustainable building performance. The framework is then applied to a green campus environment, identifying an energy management strategy that can reduce energy consumption by 19% without compromising occupants' comfort and wellbeing.

Parisa Pakzad & Paul Osmond, 2016 An urban ecosystem is a dynamic system. Therefore, regular monitoring through the use of measurable indicators will enable an assessment of performance and effectiveness. This paper presents a conceptual framework to facilitate the development of an inclusive model for the sustainability assessment of green infrastructure. The framework focuses on key interactions between human health, ecosystem services and ecosystem health. This study reviews existing models for assessing green infrastructure performance and evaluates these models via a range of selection criteria proposed by the authors based on literature review and interviews with stakeholders. This enables derivation of a novel conceptual framework that identifies and brings together the criteria and key indicators. This integrated framework may then be applied to develop a composite indicator-based assessment model to measure and monitor performance of green infrastructure projects and support future studies.

Amany Ragheba, Hisham El-Shimy & Ghada Ragheb, 2016, In recent years, sustainability concept has become the common interest of numerous disciplines. The reason for this popularity is to perform the sustainable development. The Concept of Green Architecture, also known as "sustainable architecture" or "green building," is the theory, science and style of buildings designed and constructed in accordance with environmentally friendly principles. Green architecture strives to minimize the number of resources consumed in the building's construction, use and operation, as well as curtailing the harm done to the environment through the emission, pollution and waste of its components. To design, construct, operate and maintain buildings energy, water and new materials are utilized as well as amounts of waste causing negative effects to health and environment is generated. In order to limit these effects and design environmentally sound and resource efficient buildings; "green building systems" must be introduced, clarified, understood and practiced. This paper aims at highlighting these difficult and complex issues of sustainability which encompass the scope of almost every aspect of human life.

Sara Ursic, Roko Misetic & Anka Misetic, 2016, The authors have focused on the second home phenomenon that is developing in the most attractive areas. It irretrievably distorts the quality of space with numerous consequences for the local settlements. The analyses has shown that the Croatian urban planning documents (as regulatory mechanisms) neither sufficiently recognize nor do they control the development of second home and its huge influence on sustainable development. Consequently we have identified many ecological as well as social problems in the coastal settlements: inadequate planning of infrastructure and facilities, illegal and substandard building, aesthetically questionable constructions and divided communities.

Pervez Hameed Shaikh & Nursyarizal Bin Mohd. Nor, et.al. 2016, Malaysia is located in Southeast Asia near the equator within the typical tropical climatic zone. The efficient use of energy is vital due to the dependency on fossil resources that are being exhausted, which ultimately cause CO2 emissions. Economic development and population growth are deemed to affect the growing energy demand in the country. Therefore, sustainability, energy security, and climate change are crucial challenges for the power sector in Malaysia. The aforementioned issues can be tackled with energy efficient measures in the building sector. Buildings in Malaysia consume 14.3% of the overall energy and 53% of only electrical energy is being consumed in residential and commercial sectors. Therefore, energy efficiency in buildings is crucial in order to reduce the energy use and improve the local environmental sustainability. This paper discusses a review on the building energy scenario, the policy perspectives, building energy efficiency programs along with landmark buildings and their characteristics. Besides, the potential of renewable energy resources in buildings and various prospective issues and challenges faced by the country have also been discussed. The significant review content thus benefits researchers, scientists and practitioners for a better understanding on energy efficiency and the sustainable measures that have been so far taken. The review also puts forward some actions to promote building energy efficiency and conservation.

William O'Brien & Isabella Gaetani, et.al., 2017, Existing building performance metrics cover a wide variety of domains including energy performance, equipment performance, electric lighting, indoor environmental quality, capital and operating costs, and environmental impact. They facilitate building benchmarking and yield actionable insights at all phases of the building life-cycle. Yet, the occupant domain e one of the most significant with respect to building performance e is relatively immature with regards to performance metrics. This paper provides guidance, examples, and critical discussion for developing and applying occupant-centric building performance metrics. First, an approach is proposed for developing and evaluating the suitability of such metrics. Then, using samples of data from real and simulated buildings, this paper proposes metrics that are appropriate for quantifying occupants' impact on buildings. These metrics provide an indication of building performance from an occupant-building interaction perspective, serving a purpose much like traditional building performance metrics. They also force professionals to consider occupants through a new lens because people are the real recipient of the measures and services provided by buildings.

Zeev Stossel, Meidad Kissinger & Avinoam Meir, 2017 Advancing urban sustainability requires an implementation of various measures such as environmental policy, behavioral change, and technological developments, which have to be taken at various spatial scales. However, choosing the right measures demands considering their potential contribution in reducing the environmental impact and advancing urban sustainability. In recent years, some attempts to assess the contribution of implementing various measures have been advanced by various researchers focusing on different components of urban environmental interactions. While these studies make a significant contribution towards the understanding of the impact of various measures taken for a specific environmental issue, they mostly ignore the diversity and complexity of the urban interface with the environment at different spatial scales, as well as the ecological economics perspective, which approaches the city as a system. This paper uses the UBSI index published recently in this journal, to evaluate the urban biophysical sustainability of the city of Tel Aviv-Jaffa (Israel) in 2014. Based on this data, future scenarios are developed, which examine the potential contribution of various policy measures and different technological processes to the city's sustainability. This examination is conducted while considering population growth and changes of consumption patterns as they are expected to occur until 2030.

Manuel Carlos Felgueirasa, Florinda F. Martinsb & Nídia S. Caetanoac, 2017 Energy consumption in buildings is responsible for an important share of global consumed energy. The current electric energy paradigm carries important consequences both at economic and environmental levels. The so called Zero Energy Buildings' strategy provides some guidelines in order to achieve better results in buildings energy demand. This scenario is a highly multidisciplinary engineering issue, and poses several challenges at the higher education level, that is taught in separate areas. This paper presents some higher education teaching limitations to address new technological challenges in new buildings design.

CONCLUSION

An urban ecosystem is a dynamic system. Therefore, regular monitoring through the use of measurable indicators will enable an assessment of performance and effectiveness. This paper presents a conceptual framework to facilitate the development of an inclusive model for the sustainability assessment of green infrastructure. The framework focuses on key interactions between human health, ecosystem services and ecosystem health. This study reviews existing models for assessing green infrastructure performance and evaluates these models via a range of selection criteria proposed by the authors based on literature review and interviews with stakeholders. This enables derivation of a novel conceptual framework that identifies and brings together the criteria and key indicators. This integrated framework may then be applied to develop a composite indicator-based assessment model to measure and monitor performance of green infrastructure projects and support future studies.

Energy consumption in buildings is responsible for an important share of global consumed energy. The current electric energy paradigm carries important consequences both at economic and environmental levels. The so called Zero Energy Buildings strategy provides some guidelines in order to achieve better results in buildings energy demand. This scenario is a highly multidisciplinary engineering issue, and poses several challenges at the higher education level, that is taught in separate areas.

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