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A Conceptual Framework for Implementing Sustainability in the Building Sector

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Abstract—*This paper presents a conceptual framework aimed at implementing sustainability principles in the building industry. The proposed framework based on the sustainable triple bottom line principle, includes resource conservation, cost efficiency and design for human adaptation. Following a thorough literature review, each principle involving strategies and methods to be applied during the life cycle of building projects is explained and a few case studies are presented for clarity on the methods. The framework will allow design teams to have an appropriate balance between economic, social and environmental issues, changing the way construction practitioners think about the information they use when assessing building projects, thereby facilitating the sustainability of building industry.*

Keywords: *sustainable building; conceptual framework; resource conservation; cost efficiency; human adaptation.*

1. Introduction

The building industry is a vital element of any economy but has a significant impact on the environment. By virtue of its size, construction is one of the largest users of energy, material resources, and water, and it is a formidable polluter. In response to these impacts, there is growing consensus among organizations committed to environmental performance targets that appropriate strategies and actions are needed to make building activities more sustainable [1–3]. With respect to such significant influence of the building industry, the sustainable building approach has a high potential to make a valuable contribution to sustainable development. Sustainability is a broad and complex concept, which has grown to be one of the major issues in the building industry. The idea of sustainability involves enhancing the quality of life, thus allowing people to live in a healthy environment, with improved social, economic and environmental conditions [4]. A sustainable project is designed, built, renovated, operated or reused in an ecological and resource efficient manner [5]. It should meet a number of certain objectives: resource and energy efficiency; CO2 and GHG emissions reduction; pollution prevention; mitigation of noise; improved indoor air quality; harmonization with the environment [6]. An ideal project should be inexpensive to build, last forever with modest maintenance, but return completely to the earth when abandoned [7].

Building industry practitioners have begun to pay attention to controlling and correcting the environmental damage due to their activities. Architects, designers, engineers and others involved in the building process have a unique opportunity to reduce environmental impact through the implementation of sustainability objectives at the design development stage of a building project. While current sustainability initiatives, strategies and processes focus on wider global aspirations and strategic objectives, they are noticeably weak in addressing micro-level (project specific level) integrated decision-making [8]. Paradoxically, it is precisely at the micro-levels that sustainability objectives have to be translated into concrete practical actions, by using a holistic approach to facilitate decision making. Although new technologies such as Building Research Establishment Environmental Assessment Method (BREEAM), Building for Environmental and Economic Sustainability (BEES), Leadership in Energy and Environmental Design (LEED) *etc*., are constantly being developed and updated to complement current practices in creating sustainable structures, the common objective is that buildings are designed to reduce the overall impact of the built environment on human health and the natural environment.

This paper therefore compliments existing research in the field of sustainability by reporting the development a conceptual framework for implementing sustainability objectives at the project-specific level in the building industry from a life-cycle perspective. The framework contributes to the industry and sustainability research by demonstrating the scale of the issues involved, beginning with an assessment of the environmental challenges the industry faces. It puts forward strategies and methods to mitigate the environmental impacts of construction activities, thereby facilitating the sustainability of building projects.

2. Sustainable Building Principles

It is estimated that by 2056, global economic activity will have increased fivefold, global population will have increased by over 50%, global energy consumption will have increased nearly threefold, and global manufacturing activity will have increased at least threefold [9,10]. Globally, the building sector is arguably one of the most resource-intensive

industries. Compared with other industries, the building industry rapidly growing world energy use and the use of finite fossil fuel resources has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts—ozone layer depletion, carbon dioxide emissions, global warming, climate change [10]. Building material production consumes energy, the construction phase consumes energy, and operating a completed building consumes energy for heating, lighting, power and ventilation. In addition to energy consumption, the building industry is considered as a major contributor to environmental pollution [11–14], a major consumption of raw materials, with 3 billion tons consume annually or 40% of global use [13,15–18] and produces an enormous amount of waste [19,20]. The principal issues associated with the key sustainable building themes has been mapped out and collated in the Table 1.

Table 1: Sustainable building issues.

Title	Key Theme	Principal Issues
Economic sustainability	**1.0 Maintenance of high and stable levels of local economic growth and employment**	Improved productivity; Consistent profit growth; Employee satisfaction; Supplier satisfaction; Client satisfaction Minimizing defects; Shorter and more predictable completion time; Lower cost projects with increased cost predictability; Delivering services that provide best value to clients and focus on developing client business
	1.1 Improved project delivery	
	1.2 Increased profitability & productivity	
Environmental sustainability	**2.0 Effective protection of the environment**	Minimizing polluting emissions; Preventing nuisance from noise and dust by good site and depot management; Waste minimization and elimination; Preventing pollution incidents and breaches of environmental requirements; Habitat creation and environmental improvement; Protection of sensitive ecosystems through good construction practices and supervision; Green transport plan for sites and business activities
	2.1 Avoiding pollution	
	2.2 Protecting and enhancing biodiversity	
	2.3 Transport planning	
	3.0 Prudent use of natural resources	Energy efficient at depots and sites; Reduced energy consumption in business activities; Design for whole-life costs; Use of local supplies and materials with low embodied energy; Lean design and construction avoiding waste; Use of recycled/sustainability sourced products Water and Waste minimization and management
	3.1 Improved energy efficiency	
	3.2 Efficient use of resources	
Social sustainability	**4.0 Social progress which recognizes the needs of everyone**	Provision of effective training and appraisals; Equitable terms and conditions; Provision of equal opportunities; Health, safety and conducive working environment; Maintaining morale and employee satisfaction; Participation in decision-making; Minimizing local nuisance and disruption; Minimizing traffic disruptions and delays; Building effective channels of communication; Contributing to the local economy through local employment and procurement; Delivering services that enhance the local environment; Building long-term relationships with clients; Building long-term relationships with local suppliers; Corporate citizenship; Delivering services that provide best value to clients and focus on developing client business
	4.1 Respect for staff	
	4.2 Working with local communities and road users	
	4.3 Partnership working	

Sustainable building approach is considered as a way for the building industry to move towards achieving sustainable development taking into account environmental, socio and economic issues, as shown in Table 1. It is also a way to portray the industry's responsibility towards protecting the environment [3,17,21,22]. The practice of sustainable building refers to various methods in the process of implementing

building projects that involve less harm to the environment—*i.e.*, prevention of waste production [23], increased reuse of waste in the production of building material—*i.e.*, waste management [24,25], beneficial to the society, and profitable to the company [26–29]. Hill and Bowen [30] state that sustainable building starts at the planning stage of a building and continues throughout its life to its eventual deconstruction and recycling of resources to reduce the waste stream associated with demolition. The authors then describe sustainable building as consisting of four principles: social, economic, biophysical and technical. Amongst the published work relating to the principles of sustainable building are collated in Table 2.

Table 2. Principles of sustainable development.

Authors	Proposed principles for sustainable building
Halliday [1]	*Economy:* Good project management is a vital overarching aspect in delivering sustainable projects, both in the short and long term. *Using Resources Effectively:* Buildings should not use a disproportionate amount of resources, including money, energy, water, materials and land during construction, use or disposal. *Supporting Communities:* Projects should clearly identify and seek to meet the real needs, requirements and aspirations of communities and stakeholders while involving them in key decisions. *Creating Healthy Environments:* Projects should enhance living, leisure and work environments; and not endanger the health of the builders, users, or others, through exposure to pollutants or other toxic materials. *Enhancing biodiversity:* Projects should not use materials from threatened species or environments and should seek to improve natural habitats where possible through appropriate planting and water use and avoidance of chemicals. *Minimising pollution:* Projects should create minimum dependence on polluting materials, treatments, fuels, management practices, energy and transport.
DETR [32]	Profitability and competitiveness, customers and clients satisfaction and best value, respect and treat stakeholders fairly, enhance and protect the natural environment, and minimise impact on energy consumption and natural resources.
Hill and Bowen [30]	*Social pillar:* improve the quality of life, provision for social self-determination and cultural diversity, protect and promote human health through a healthy and safe working environment and *etc*. *Economic pillar:* ensure financial affordability, employment creation, adopt full-cost accounting, enhance competitiveness, sustainable supply chain management. *Biophysical pillar:* waste management, prudent use of the four generic construction resources (water, energy, material and land), avoid environmental pollution and *etc*. *Technical pillar:* construct durable, functional, quality structure *etc*. These four principles are contained within a set of over-arching, process-oriented principles (e.g., prior impact assessment of activities).

3. Sustainable Implementation: A Framework of Strategies and Methods

In order to achieve a sustainable future in the building industry, Asif *et al*. [38] suggest adoption of multi-disciplinary approach covering a number of features such as: energy saving, improved use of materials, material waste minimization, pollution and emissions control *etc*. There are many ways in which the current nature of building activity can be controlled and improved to make it less environmentally damaging, without reducing the useful output of building activities. To create a competitive advantage using environment-friendly construction practices, the whole life-cycle of buildings should, therefore, be the context under which these practices are carried out. A review of literature has identified three general objectives which should shape the framework for implementing sustainable building design and construction (Figure 1), while keeping in mind the principles of sustainability issues (social, environmental and economic) identified previously. These objectives are:

1. Resource conservation
2. Cost efficiency and
3. Design for Human adaptation

4. Conclusions

Sustainable building is considered as a way for the building industry to move towards protecting the environment. The promotion of sustainable building practices is to pursue a balance among economic, social, and environmental performance in implementing construction projects. If we accept this, the link between sustainable development and construction becomes clear; construction is of high economic significance and has strong environmental and social impacts. With the growing awareness on environmental protection, this issue has gained wider attention from construction practitioners worldwide. Implementing sustainable building construction practices has been advocated as a way forward in fostering economic advancement in the building industry while minimizing impact on the environment. In order to reduce these detrimental impacts of construction on the environment and to achieve sustainability in the industry, three principles emerge: resource efficiency, cost efficiency and design for human adaptation. They form framework for integrating sustainability principles into construction projects right from the conceptual stage.

The framework has considerable potential to accelerate the understanding and implementation of sustainability in building construction. It provides a brief overview of sustainability principles, strategies and methods, and emphasizes the need for an integrated and holistic approach for implementing sustainability in building projects. It is intended to provide a general framework for improving the quality and comparability of methods for assessing the environmental performance of buildings. It identifies and describes issues to be taken into account when using methods for the assessment of environmental performance for new or existing building properties in the design, construction, operation, refurbishment and deconstruction stages. It is not an assessment system in itself but is intended to be used in conjunction with, and complimentary to existing assessment systems such as BREEAM, BEES, LEED, *etc*.

The sustainability requirements are to a greater or lesser extent interrelated. The challenge for designers is to bring together these different sustainability requirements in innovative ways. The new design approach must recognize the impacts of every design choice on the natural and cultural resources of the local, regional and global environments. These sustainability requirements will be applicable throughout the different stages of the building life cycle, from its design, during its useful life, up until management of the building waste in the demolition stage. This framework lays the groundwork for the development of a decision support tool to help improve the decision making process in implementing sustainability in building projects. The full decision support tool will be described in the model currently being developed for use in the UK building industry.

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