# Introduction

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'Sustainability' encapsulates environmental issues relating to the protection of the earth's natural systems and the conservation of essential natural resources. The concept of sustainability emerged as a major consideration in 1987 when Gro Harlem Brundtland, then Prime Minister of Norway, defined it as meeting our own needs without impairing the ability of others to meet their needs, incorporating the principles of intra- and inter-generational equity [1].

Sustainability has many dimensions: ecological, economic, social, cultural and others, with each having specific implications for the built environment. For example, the economic dimension of sustainability is concerned with generating a maximum flow of income while at least maintaining the stock of assets (or capital) which yield these benefits [2]. In the context of the built environment the economic dimension implies minimising the resource inputs into the construction process as well as minimising the resource inputs required for operating and maintaining the infrastructure, while still achieving the desired functionality requirements.

It is the ecological dimension, however, that this special issue is focused on. The ecological dimension is concerned with ensuring that the earth's naturally existing physical, chemical and biological systems are not jeopardised. In the context of the built environment, the ecological dimension requires that:

- critical natural resources should be conserved
- waste and pollution should be minimised
- the natural environment should not be disturbed.

A key problem here is determining where the system boundary starts and stops. The system boundary is where inputs and outputs are determined to be irrelevant. For example, disturbances to the natural environment that are associated with the building procurement process may occur within or remote from the building site, or perhaps even in another country, which complicates environmental management [3-5]. From an economic standpoint, however, the system boundary issue is rarely relevant because the costs of upstream requirements are rolled into the price of a product.

Other requirements for ecological sustainability in the built environment include:

- preserving the integrity and functionality of constructed facilities under changing environmental conditions
- preserving the health and productivity of users of constructed facilities
- the development of environmental awareness for built environment practitioners.

Present day efforts to effect sustainability concepts in built environment projects can be traced back to the oil crises of the 1970s, the period when public concern with the nature and quality of the environment is generally acknowledged to have started. In 1972, the United Nations Conference on the Human Environment was held, paving the way for the establishment of the United Nations Environment Programme. Around this time several books were also published, drawing attention to the fragility of the earth's ecosystems and the finite nature of its resources. A prime example of such books is the best seller *The Limits to Growth* [6].

More recently, the International Panel on Climate Change [7] has confirmed earlier expectations that human activities, particularly consumption of fossil fuels, are having a negative effect on the global environment. In specific situations, such as the recent California energy crisis of January, 2001, government, industry and the public resolve to reduce reliance on fossil fuels is often rehardened with some effect. Supply-side efficiency is now regarded as insufficient without innovative demand-side conservation of resources.

Examples of the environmental implications of construction activities abound. Aspects of construction projects in which significant potentially negative environmental effects have been identified include: construction materials, construction energy usage, construction waste and indoor air pollution. For example, French [8] estimated that about 50,000 people in the UK and two million people in the USA would die from diseases related to asbestos (a building material) in the 30-year period after 1986. Similarly, some constituents of commonly used paints such as lead, benzene and formaldehyde have been identified as health hazards.

In the recent past, there has been a growing awareness within the building and construction industries of the implication of sustainability for the construction industry itself. For example, it has been forecasted that the UK will face a shortfall of coarse aggregates, estimated at 40 million tonnes by the year 2010 [9]. Following from the increased level of awareness, attention is increasingly being paid to the need to be environmentally responsible and minimise negative environmental impacts that may arise from the implementation of project activities and the operation of facilities [10].

Several countries have introduced stringent energy-related building regulations and have stepped up research efforts on energy-efficient and pollution-reducing technologies. Life cycle costing of certain categories of buildings at the building design approval stage has also become a statutory requirement in several countries. Life cycle energy and life cycle environmental assessments are still voluntary in almost all countries, yet being identified as an 'environmental-conscious' organisation now appears to have commercial advantages, and may be required for organisational survival [11].

The built environment occupies a particularly significant position in sustaining and improving the quality of life, by virtue of its role in producing the infrastructure (for example, roads, bridges, buildings) required for meeting growing human needs for food, transportation, energy and shelter. A great challenge for researchers and practitioners is the development of products, systems, methodologies and organisational arrangements that can be used to respond to the challenges of sustainability. Despite efforts made thus far to address sustainability-related issues in the built environment, there have been only limited achievements. Thus, there is a need for more construction-related research on environmental issues, especially as buildings become more efficient.

Such research should typically span the entire building life cycle, and include such activities as: the extraction of raw materials, manufacture, transportation and storage of construction materials, planning, design and construction of buildings, operation and maintenance of buildings, demolition, recycling and, ultimately, final disposal of waste. The authors recommend the development of a balance of settlement-, country- and world-wide solutions to lowering environmental impacts from the built environment, rather than optimising for a single building, region or country.

Examples of specific areas in which concerted research efforts are required are the:

- development of building materials and products with high recycled content
- development of alternative sources of energy for building product manufacture
- design, development and implementation of waste minimisation strategies and techniques for the entire building life cycle
- design of building layout and fixtures that are suited to the physiological, psychological and social needs of the users
- design of organisational systems that will enable project teams to respond to sustainability-related issues
- development of more reliable methods for assessing environmental impact.

Invariably, however, success in the implementation of sustainability in the built environment depends on the extent to which the concept of sustainability is integrated into the daily activities of construction industry practitioners [12]. It is only when sustainability-related issues become part of the culture of the industry that barriers to its implementation can be overcome, and positive contributions made to protect the environment.

In the first paper of this special issue, Ries presents an environmental impact assessment method implemented in a computational tool for the environmental evaluation of building designs. The method is an extension of a traditional material-focused life cycle analysis, also known as life cycle assessment (LCA), and is based on a spatial allocation for emissions and resource usage.

Lombardi and Brandon posit that the new agenda of sustainability requires a change in both emphasis and the criteria through which sustainability is evaluated in planning and design. It requires the adoption of a suitable framework which enables decision makers (designers, planners, local authorities) to understand the problems implied in a decision. Their paper seeks to illustrate the relevance of the framework developed on the basis of a multi-modal system approach for understanding and evaluating sustainability in the built environment. The developed framework enables different levels of information and structures all relevant issues in an ordered manner.

The terms 'sustainable architecture', 'green building' and 'ecological design' have emerged as environmentally friendly modes of design, construction and operation geared towards producing healthy, enduring communities. Zachariah *et al*. consolidate the current foci of sustainable architecture through a review of several projects and institutional guidelines that are geared towards achieving sustainability in the built environment. They present a contemporary checklist of desirable design strategies and building practices for a green building. Consideration is given to attempts to ranking the importance of these strategies.

Pearce and Vanegas argue that there is no consensus on how comprehensively and uniformly to define the concept of sustainability, as it pertains to the built environment. They further argue that there is no consensus on what aspects of the built environment should be considered in evaluating the sustainability of a built facility. Considering this, Pearce and Vanegas evaluate the sustainability literature, and systematically identify the parameters of both the built environment and the concept of sustainability. In doing so, they provide set of parameters that can be used in future research to begin uniformly and comprehensively to define sustainability as it applies to built facilities.

One of the ongoing challenges in the quest to make our built environment more sustainable is defining what sustainability means in terms understandable to – and measurable by – built environment decision makers. Pearce and Vanegas, in a second paper, present an approach for developing a comprehensive and exhaustive definition of sustainability for the built environment. Their paper uses systems thinking to define characteristics and critical constraints of both the earth as a whole and the built environment in particular.

Griffith states that management systems implemented by contractors are paramount to encouraging sustainable built environments. Evolving from developments in the manufacturing industries, a number of forward-looking contracting organisations are at the forefront of establishing Integrated Management Systems (IMS) within the UK. IMS can provide a framework for sustainable construction through the effective management of quality, safety and, in particular, environmental impact. Based upon empirical and primary research data, this paper examines the concept and principles of IMS, their potential application and contribution to sustainable built environments and the issues that they raise for the future management of the construction processes.

Being one of the fastest growing cities in sub-Saharan Africa, Gaborone City, Botswana, is experiencing a considerable amount of development. Evidence from a study undertaken by Ssegawa demonstrates that the construction of infrastructure and facilities has had a negative impact on the environment. Several stakeholders in the construction industry have been interviewed to evaluate their awareness and ascertain their views on the issue, in the context of any existing laws and regulations relating to the built environment. Ssegawa proposes some recommendations for achieving more sustainable construction practices.

Langford *et al*. present an evaluation tool for assessing the durability, adaptability and energy conservation of existing buildings and new building designs. The paper examines the issues that were the basis for developing the metrics and the application of the tool in the evaluation of selected higher education buildings and a new community hospital. The paper explains how the tool can be used in building design and building management.

Clarke and O'Rourke build on the findings of a survey of construction waste carried out by APT Environmental in June, 1999, in the Greater Nottingham area. They incorporate a review of current recycled material producers and investigate the potential and current use of inert and non-inert construction waste arisings. The materials have been categorised under the Environment Agency's classification system. From this, the current market for all recycled construction materials is established.

Moore *et al*. consider the value of indigenous materials in developing nations and provide an overview of current approaches to encouraging their sustainable use. Moore *et al*. state that a significant factor in the failure of traditional building materials to become widely established in the developing world is identified as being a lack of appropriate codes and standards. The relevance of using existing tests for the on-site selection of suitable earth-based brick construction materials is examined. Issues relevant to the further development of a materials performance database are discussed in the context of achieving a design aid.

The contemporary interpretation of sustainable building reflects a process in which a global, consensual and technocratic vision of environmental change has tended to dominate the debate. According to Farmer and Guy, the example of natural ventilation serves to highlight this process. They suggest an alternative understanding, and present natural ventilation as a social expression of contrasting and often contradictory environmental values. Through an analysis of competing discourses around natural ventilation, they emphasis the interplay of distinct design logic and the contested nature of environmental innovation.

Hill *et al*. outline the concept of sustainable development and its application, within the context of emerging policies and legislation in South Africa. They discuss the transition to sustainability for each of the five stages in the life cycle of the built environment: urban planning, project design, building materials manufacture, construction and maintenance and management. Environmental, economic and social sustainability are examined for all five stages of the building life cycle.

Zawdie and Lee state that technological learning is crucial for mitigating the environmental impact of production, but is constrained by poor management and policies. Analysis of technical efficiency trends in the Ethiopian manufacturing industry shows scant evidence of technological learning, and confirms the hypothesis that industrialisation in developing countries correlates positively with environmental neglect. The results also suggest that there is significant scope for improving technical efficiency.

Questions concerning the capability of the earth to support such a large population have arisen. Efforts are underway to find solutions in several aspects of the building process, including the selection and specification of materials. Kien and Ofori used a mailed questionnaire survey to study the awareness level of architects in Singapore regarding the environmental impacts of materials and the actions they are taking to protect the environment.

Littlewood and Geens discuss the UK government's recent reduction in its projection for new homes to be built by 2016. They present two distinct approaches by residential developers to improve the design of new homes, illustrated with four example projects. One project attempts to recreate village life, whilst the other three projects demonstrate energy efficiency. These four projects highlight an increasing pattern by residential developers to employ external consultants. This and proposed amendments to building regulations could mean an opening for a new professional partnership to secure commissions in the new homes sector.

When design or operating an industrial plant, it is insufficient to consider only the economic viability of the facility. White examines current sustainability awareness levels and presents a case study that incorporates sustainability principles in the design of an effluent treatment plant for a textile manufacturer. The likely design of the treatment system (electro-flotation followed by filtration) will do more than just meet regulatory requirements, it will maximise the possible reuse of water and so minimise environmental impact of the facility.

The renewal of ancient neighbourhoods is a worldwide problem with different cultural, technological, economic and organisational implications. In the 1980s and 1990s an interesting organisational approach to the problem was developed in Italy with the establishment of the 'Neighbourhood Laboratory'. The Laboratory lets owners have their properties incrementally renovated by local craftsmen by using the services of engineering and construction firms. In the final paper of this special issue, Costantino describes the organisational structure of the laboratory and its possible contribution to sustainability.

## Summary

The papers presented in this special issue have addressed a number of salient points that need to be considered if we are to produce sustainable built environments. However, much more research is needed with respect to how we can effectively utilise technology to design, produce and manage ecologically sustainable built environments.

The Guest Editors were overwhelmed by the number of papers submitted for possible publication in this special issue. At least two referees reviewed each paper, in a 'double blind' process. The Guest Editors would like to express their gratitude to the 31 referees who reviewed papers for this special issue. In addition, we would like to acknowledge the assistance provided by Dr Mohamed Dorgham, the Editor-in-Chief of the *International Journal of Environmental Management and Technology.*

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