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Abstract
The emergence of sustainable construction has been described as the largest innovation within the global construction industry at the end of last century. However, there are various concepts of sustainable construction and it is difficult to define the term in a simple uniform sentence. Basically, sustainable construction has four dimensions: environmental, social, economical and technical. While the literature establishes several diverse explanations of both ecological and technical principles, it often fails to consider economic concepts. From an economic point of view, sustainable construction is an unusual activity, which changes business patterns from a linear to a cyclic process. As the original stimulant, it is essential to detail the economic principles of sustainable construction and investigate their application in practice. This paper examines the concepts of sustainable construction and sets out the underlying economic principles and themes which apply to it. Furthermore, it highlights some economic challenges to sustainable construction: higher capital cost; lack of accurate cost information; unreliable long-term profits and invisible market value. Finally, it concludes that it is crucial to develop a green market in the built environment and a clear sustainable business strategy for construction companies who seek to implement sustainable construction.

Keywords
Sustainable Construction, Economic Principles, Challenges, Five Capitals Model and Long-term Benefits

1. Introduction

The pursuit of sustainable development brings the built environment and construction industry into sharp relief. The Habitat II Agenda stresses the fact that the construction industry is a major contributor to socio-economic development in most countries (CIB, 1999). Statistics show that the construction industry normally constitutes more than half of the total national capital investment, and represents as much as 10% of GNP in every country (CICA & UNEP, 2002). The building and construction industry makes a major contribution to the consumption of resource, for example, in the European Union buildings are responsible for more than 40% of total energy consumption and the construction sector is estimated to generate approximately 40% of all man-made waste (CIB, 1999). Since the first international conference on sustainable construction in USA, 1994, sustainable construction has become a major subject of policy, research and innovation, globally. However, because of the complexity of sustainability and the fragmentation of the construction industry, the level of implementation of sustainable construction practices is still low. Sustainable construction has been viewed as a government policy, which has been forced onto the industry, but with few economic incentives to stimulate its acceptance. In economic terms, the demand is low.

At a conceptual level, sustainable construction can be divided into four dimensions:

environmental, economical, social and technical. However, the economic and social concepts are more poorly defined than the environmental and technical concepts. This paper examines the concepts of sustainable construction, and introduces an Eco-economic theory that sets out the underlying economics principles and themes, which apply to the built environment. Furthermore, it outlines the challenges of sustainable construction and highlights the importance of its green market and a sustainable business strategy.

2. Concepts of Sustainable Construction

Sustainable construction was defined at the first international conference on sustainable construction, in Tampa, USA, 1994, as "the creation and responsible management of a healthy built environmental base on resources efficient and ecological principles" (Kibert, 1994). Later, Hill and Bowen (1997) divided the definition in four principles: social, economic, biophysical and technical.

- Social sustainability highlights improvement in the quality of human life, and the human living environment, which includes culture, health, education, and intergenerational equity.
- Economic sustainability includes the use of full-cost accounting methods and real-cost pricing to set the prices and tariffs of goods and services to achieve a more efficient use of resource.
- Biological sustainability includes the notion that sustainable construction needs to protect the natural environment rather than pollute it by encouraging the use of renewable resource and reducing the use of water, energy, materials and land at each stage of a project.
- Technical sustainability requires high performance, durability, quality and mixed use of a building.

Hill and Bowen's principles outline four themes of sustainable construction, but lacked a detailed discussion of each principle. They set out objectives, rather than guidelines for real practical activity. For examples, in the economic principles, full-cost accounting needs to consider the total cost rise in the business activity. It accounts for all initial, operating cost, environmental and social costs. This is almost impossible within current construction practice where there are time and finance limits. A new eco- economic principle is emerging, however, which identifies the differences between sustainable and conventional approaches.

3. Five Capitals Model

Before identifying the economic principles of sustainable construction, it is necessary to understand some fundamental concepts of eco-economics. This section establishes the concept of a five capitals model and analyses the differences between the model and conventional wealth methods. The five capitals model builds upon the idea of capital, which is fundamental to Eco-economics. The five capital components include natural capital (or environmental capital), human capital, social capital, manufactured capital and financial capital (or credit capital) (Addis and Talbot, 2001; Gilman, 1992).

- Natural Capital: includes the environment, landscape, species, diversity, natural resources and materials.
- Human capital: includes people, health, skill, knowledge, and motivation.
- Social capital: includes family, community, trade unions, security, and culture

- Manufactured capital: includes tools, machines, buildings, and infrastructure.
- Financial capital: includes money, shares, bonds and banknotes.

Gilman (1992) compared the five capitals model and conventional wealth method (see figure 1). He found that the traditional factors involved in economic activity include: land, labour and manufactured capital. The conventional method is a linear process, which assumed that the natural resources are unlimited, labour "aids manufactured capital, converts land (as raw materials) into goods & services". Then all goods and services are consumed by individuals or family groups to produce utility or welfare. This type of method only considers the output, not input and the creation of a consumer society.

<< Insert Figure 1: Two Views of Economic Reality (adopted from Gilman, 1992) about here >>

The sustainable method is different; it is intended to be a more realistic model of economic activity. It expands the three factors into five capital components. Environmental capital expands the concept of land to include all natural systems such as the atmosphere, biological systems, and even the sun. Human capital expands beyond labour to include quality as well as quantity. Social capital includes all the culture, community, etc. and credit capital includes money and debts, etc. As the lower diagram shows, all of the five capital components are blended together, in support of some human activity. Human activity includes not only an economic dimension, but also social and environmental dimensions. A new addition, time is another limited resource that must be allocated amongst various alternative activities. In this diagram, the natural system is cyclic, with all natural resources being recycled. Further, the heart of the sustainable method is human quality: the goal of all human activities. Compared with the conventional method, the sustainable approach is a cyclic process, which is more complex and at the same time more realistic. The sustainable approach takes into account both inputs and outputs, and considers the human quality of life, not only utility and welfare.

4. Economic Principles of Sustainable Construction

The sustainable approach is a cyclic process; which consider both input and output factors, efficiently integrating all five capital components into the human activity in order to create the best quality of life. Sustainable construction, therefore, should have the same characteristics; the economic principles of sustainable construction are outlined below:

- Value for money
- Maximum output with minimum input
- Integration of short term return and long term benefits
- Stakeholder partnerships
- Human quality of life: from asset to services

Value for money is a technical term commonly incorporated into one of the UK's popular procurement systems, the Private Finance Initiative. Value for money means the efficient use of financial capital. This does not mean the reduction of the initial cost to the minimum, but rather considering all costs during the facility's lifetime, by reducing the whole life cost to a minimum level. Best value for money is the optimum combination of whole life costs and benefits (PFP, 1995). Another factor impacting on value for money is risk transfer. All project risks must be carefully measured, reduced or transfered at the minimum level in order to achieve the best value for money.

The second principle refers to the utilisation of the minimum input to produce the maximum output. In building and construction projects, this requires not only achieving the best quality and performance of the building, but the consideration of efficient raw materials. Here we need to apply the "3R" principles: reuse, recycle and renewal. All construction activities, which include planning, designing, constructing and operating, need to use materials, energy and water efficiently.

Third, both the developer and the contractor need to judge the balance between short-term returns and long-term benefits. The short-term return is important, but not essential, research found that the long term expensive is five times of the initial cost (Johnson, 2000). Furthermore, the potential long-term rewards are significant when the productivity, social and environmental benefits are considered.

Partnership between stakeholders is fundamental for a sustainable construction approach. They can bring significant benefits by improving the quality and timeliness of completion, while reducing costs (Latham, 1994). All people involved in building and construction projects need to work together; the integration of the demand and supply chain is crucial.

Finally, as the five capitals model showed, sustainable construction is an unusual business pattern, which changes from a linear process to a cyclic process. Traditionally, project success depends upon three factors: time, cost and quality. It did not consider the external environmental or the end user. The spirit of function is the asset, not services; however, the heart of sustainability is the human quality of life. The function of a building or infrastructure is to provide healthy and comfortable built environment for the occupier(s). Sustainable construction, therefore, requires an understanding of the occupiers.

5. Challenges

Currently, sustainable construction faces some economic challenges. The primary barrier to the introduction of sustainable construction is the client's widely held belief that sustainable construction will cost more and attracted a higher risk (Johnson, 2000; Landman, 1999). They believe that the initial cost will increase, while using new technologies, green materials, and extra design. This results, therefore, not only in higher capital cost but also in the lack of reliable accurate cost information. The second barrier is the client's cost advisor. Ballett and Howard (2000) found that the UK's quantity surveyors overestimated the cost of more energy efficient and environmental friendly buildings by between 5 and 15%. This misperception by cost advisors hinders the implementation of sustainable construction. Third, the long-term benefits are unreliable, most traditional construction methods only consider a short-term period, after that, all of the benefits may not be received by the builder/developer/owner. But the long term benefits from sustainable construction, taking into account whole life cost savings, are not attractive to developers or construction companies. The last primary barrier is the invisible market value. The green market has not developed yet, and the traditional market does not accept the new type of construction method. Moreover, sustainable construction is a kind of process, which hardly presents value sensitivity in the short-term. Smith et al (1998) state that developers are encouraged to think of short-term profits rather than the long-term consequences of their actions because the financial systems actually discourage long-term investment through the practice of discounting.

6. Green Market and Business Strategy

After describing the economic principles and examining the challenges of sustainable

construction, the next question is whether or not sustainable construction positively contributes to business performance and organisation effectiveness (Heerwagen, 2000). This depends on two factors: the development of a green market and the implementation of a sustainable business strategy. The resulting changes in the marketplace would be dramatic. The green market would encourage more environmental protective materials, new technologies, the use of green labels, and the development of an e-procurement system for the market in order to reduce the consumption of energy and labour resources. Furthermore, the green market would educate more customers to understand the benefits of sustainable construction and the development of further green buildings. Finally, a market approach can smooth the transition to greener buildings and reassure agents, investors and occupiers that both short-term and long-term risks are being effectively managed (Bordass, 2000). The second factor is that construction companies, seeking to implement sustainable construction, should have a sustainable business strategy. Bogensätter (2000) presents three possible strategies of sustainable construction. They are:

- Intelligent design with less resources and less costs,
- Low tech with low energy consumption and low maintenance costs
- Planning for tomorrow with less cost for tomorrow Both 'intelligent design' and 'planning for tomorrow' enables the achievement of the maximum environment performance, but require a relatively high initial expenditure, and the use of many types of high-technical methods and materials. The 'Low-tech' strategy is deemed to be the easiest solution to apply in practice (Bogensätter, 2000).

7. Conclusion

Sustainable construction, as a new construction process, which is increasing bettered understood and applied. It has environmental, social, economic and technical dimensions. The five capitals model illustrates the economic principles of sustainability. It integrates the five capitals into the human activity in order to achieve the best human quality of life. Sustainability changes the traditional linear approach to a cyclic process. The economic principles of sustainable construction include value for money; maximum output with minimum input; integration of short-term return and long-term benefits; stakeholder partnerships and human quality of life. However, sustainable construction currently faces some economic challenges. These are higher capital cost, lack of accurate cost information, unreliable long-term benefits and an invisible market value. There are two factors, which influence the level of implementation of sustainable construction. For the supplier and the purchaser, a sustainable business strategy is required and for the external environment, a matured green market is emerging.

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Figure 1: Two Views of Economic Reality (adopted from Gilman, 1992)