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Towards Establishing an International Sustainability Index for the Construction industry: A Literature Review

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ABSTRACT:
Sustainability aims to fulfil current generations' needs without compromising the quality of life for future generations. This is primarily achieved through saving the environment, enhancing society and prospering the economy; hence industries and nations embarked on employing sustainability indices to measure their sustainability performance.
This paper aims to explore and critically analyse the indices employed to measure sustainability performance in the construction industry and further to investigate their validity and reliability in measuring the sustainability performance during the various phases of the construction process. Literature review is employed to explore the various indices developed to measure the sustainability performance in general and in the construction industry in particular.
Research in sustainability indices has generally increased dramatically in the last decade. A number of indices were developed to quantitatively measure the sustainability performance of nations/industries. These, however, were criticised for being contradictive and misleading in some instances. Furthermore, indices developed to measure the sustainability performance in the construction industry, were to a large extent concerned with the finished buildings and their environmental impact. Little evidence, however, could be established for employing and integrating sustainability indices for the construction industry along the various phases from conception to completion.
The findings from this paper, will feed in to the second stage of this research to help establish a qualitative international sustainability index for the construction industry to ensure the sustainability of the construction process along the various phases of construction.

Conference Topic: Sustainable Buildings

Keywords: Construction Industry, Index, Sustainability,

1. INTRODUCTION

The construction industry plays a significant role towards achieving social and economic development at national and international levels. Socially, it constructs projects that fulfil the community needs and society requirements. In addition, it builds the infrastructure that enables these projects to perform their intended functions. Economically, the construction industry helps increase the gross domestic product (GDP), stimulate the development of other industries that depend on the construction industry as well as offers job opportunities. On the other hand, the construction industry has a negative impact on the environment. About 3 billion tonnes of raw materials and 40% of the total global economy are used in manufacturing construction materials worldwide. In addition, the construction industry is responsible for about 50% of the material resources taken from nature, 40% of energy consumption and 50% of total waste generated. Large amounts of energy are consumed during the procurement of materials, construction activities and operating artificial heating and cooling systems (Anink et al., 1996; Othman, 2007). The increasing recognition and the universal calls for sustainability have called for the construction industry to be more sustainable through constructing projects that save the environment, enhance the society and prosper the economy. For this reason industries and nations worldwide developed a number of indices to measure their sustainability performance.

2. Research Aim and Methodology

This paper aims to investigate and critically analyse the indices used to measure the performance of sustainability in the construction industry and further to study their validity and reliability in measuring the sustainability performance during the various phases of the construction process. A comprehensive literature review is carried out to achieve this aim. Literature review is used to (1) review the concept of sustainability, (2) investigate the environmental, social and economic dimensions of sustainability, (3) study sustainability and the construction Industry and (4) The Rationale of a Sustainability Index in Construction. Literature review resources depended on textbooks, professional journal and magazines, conference and seminar proceedings, dissertations and theses, organisations and government publications as well as Internet and related websites.

3. Sustainability Overview and Importance

There are more than 70 different definitions for sustainability (Pearce et al, 1989; Holmberg and Sandbrook, 1992) due to the different academic fields and disciplines that have their own definitions and approaches. However, all definitions agree that it is important to consider the future of the planet and there are many ways for humans to protect and enhance the Earth while satisfying the needs of various stakeholders (Boyko et al, 2006). The commonly used definition of sustainability is developed by the World Commission on Environment and Development (1987) which stated that sustainability is the 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. This definition calls for creating a balance between continuing in business and seeking profitability but not at the expense of the environment or society's needs (MaSC, 2002). Sustainability is focused on improving the environmental quality, enhancing social prosperity and improving economic performance (Addis and Talbot, 2001). The increasing recognition among leading scientists, the public and politicians that the planet's resources are consumed in ways that exceed its long-term capacity of use and this practice will undermine the vital life support system of the planet. This scenario emphasized that sustainability has its effects on both the local and global populace. Sustainability is considered as a global issue and it requires a global solution (Ugwu & Haupt, 2007). There is an increasing pressure on the need to achieve sustainability and the relevant authorities must formulate effective ways to achieve sustainability and to be implemented as a cornerstone for future policies (Kühtz, 2007). This is what that makes sustainability an important issue as being debated in large scale interests all over the world.

3.2 Sustainability Dimensions

There are three dimensions of sustainability, namely environmental, social and economic dimensions see figure 1.

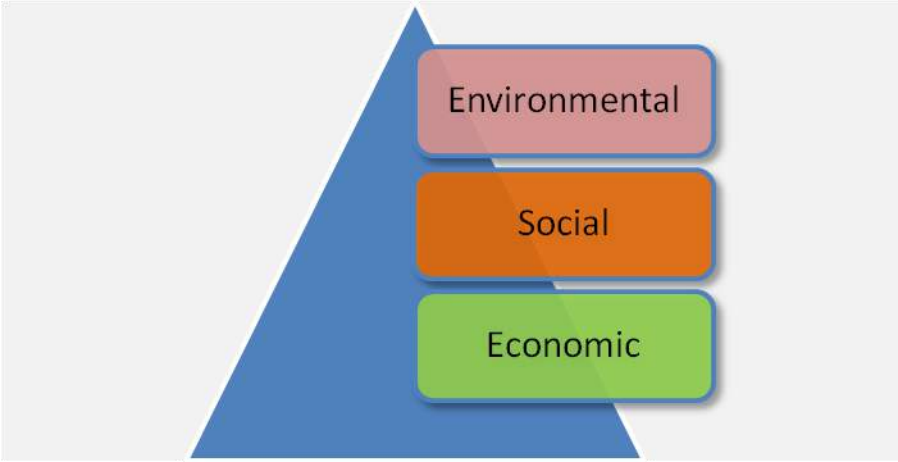

Figure 1: Dimensions of Sustainability

3.2.1 Environmental Dimension

Although the construction industry makes a vital contribution to the social and economic development of societies through providing building and infrastructure projects, it has major impacts on the environment. It is a very large consumer of non-renewable resources, a substantial source of waste, a polluter of air and water, and an important contributor to land dereliction (Friends of the Earth, 1995; Roodman and Lenssen, 1995). According to Anink et al (1996), the construction sector is responsible for 50% of the material resources taken from nature, 40% of energy consumption and 50% of total waste generated. This called for improving the construction industry to improve its performance to minimise the negative impact on the natural environment (Cole, 1999; Holmes and Hudson, 2000). This dimension focuses on:

- Reducing waste, effluent generation, emissions to environment.
- Reducing impact on human health.
- Using renewable raw materials.
- Eliminating toxic substances.

3.2.2 Social Dimension

Social sustainability looks at responding to the needs of people, providing high customer satisfaction and working closely with clients, suppliers, employees, and local communities (Cooper and Stewart, 2006). Sustainability plays a powerful role in the social level through

having the ability to provide access to good education, creating goodwill, improving community consultation and promoting interest in various fields. This dimension focuses on:

- International and national law.
- Workers health and safety.
- Urban planning and transport.
- Local and individual lifestyles and ethical consumerism.
- The relationship between human rights and human development.
- Corporate power and environmental justice.
- Global poverty and citizen action.
- Impacts on local communities and quality of life.
- Benefits to disadvantaged groups (e.g. disabled and low earners).

3.2.3 Economic Dimension

The economic aspect of sustainability focuses on the importance of stable economic growth. It means working within the capacity of the natural environment, adopting measures from fair and rewarding employment through to competitiveness and trade (OGC, 2007). This dimension aims to:

- Integrate ecological concerns with social and economic ones.
- Improve quality of life.
- Provide opportunities for local businesses.
- Increase market share due to an improved public image.
- Create new markets and opportunities for sales growth.
- Reduce cost through improving efficiency and reducing energy and raw material inputs.
- Create additional added value.

4. Sustainability and the Construction Industry

The concept of sustainability has become a cornerstone for the majority of construction developments and socio-economic activities in the built and natural environments. It is argued that in 1992, sustainability was mainly addressing the strategic level, whereas in 1994 the concept of sustainable construction was introduced at a tactical level in the building sector (Fernández-Sánchez and Rodríguez-López, 2010).

Sustainable construction is defined as the contribution of construction to sustainable development, which includes profitability, competitively, greater customer satisfaction, protecting the environment, and efficient use of energy etc. (Pitt *et al*., 2009). Buildings, however, are criticised for being a demand-led commodity, hence, constructed with shorter life expectancy and being dominated by mechanical, electrical, and electronic equipments (Bon and Hutchinson, 2000). This perception of property as a commodity, however, is claimed to have been changing to emphasise sustainability related characteristics and performance aspects as important determinants of a property's worth and market (Lorenz *et al*., 2007).

Attempts made to introduce sustainability in the construction industry, have been reportedly confronted with the challenge for achieving profitability and competitiveness. This is to a large extent attributed to the tendency among clients and policymakers to perceive sustainability as primarily concerned with adding on expensive elements such as PV panels or geothermal heat pumps etc. (Edum-Fotwe and Price, 2008). This may arguable be true when sustainability features are 'tacked onto otherwise fairly conventional designs (Bordass, 2000).

For sustainable development to be effectively attained, it is argued that the social, economic, as well as the environmental aspects need to be appropriately addressed (Fotwe and Price, 2008). Nevertheless, while the issues for exploring environmental sustainability are argued to be well known and 'rehearsed'; the social and economic aspects of developments are said to be less 'appreciated; suggesting sustainability trade-offs (Edum-Fotwe and Price, 2008; Lombera and Aprea, 2010; BREEAM, 2010). This conventional understanding of sustainable development, based on the three pillars model is criticised for being flawed as it implies that trade-offs can always be made between environmental, social, and economic dimensions of sustainability (Adams, 2006). Hence, the translation of objectives and policies into procedures and principles of operation is perceived crucial to ensure the successful implementation of sustainability (Standing and Jackson, 2007; Pitt *et al*., 2009).

Form a cost perspective, it is anticipated that cost savings can be optimised when sustainability measures are incorporated and addressed at the conceptual design phase using an integrated design team. This is particularly important in order to ensure that the project is designed as 'one system' rather then a 'collection of stand-alone components' (Edum-Fotwe and Price, 2008; Reed and Gordon, 2000) – Figure 2. Further economic benefits of sustainable buildings have

been identified to include reduced operating costs, reduced waste, reduced liability, enhanced productivity and learning, reduced social costs (Edum-Fotwe and Price, 2008).

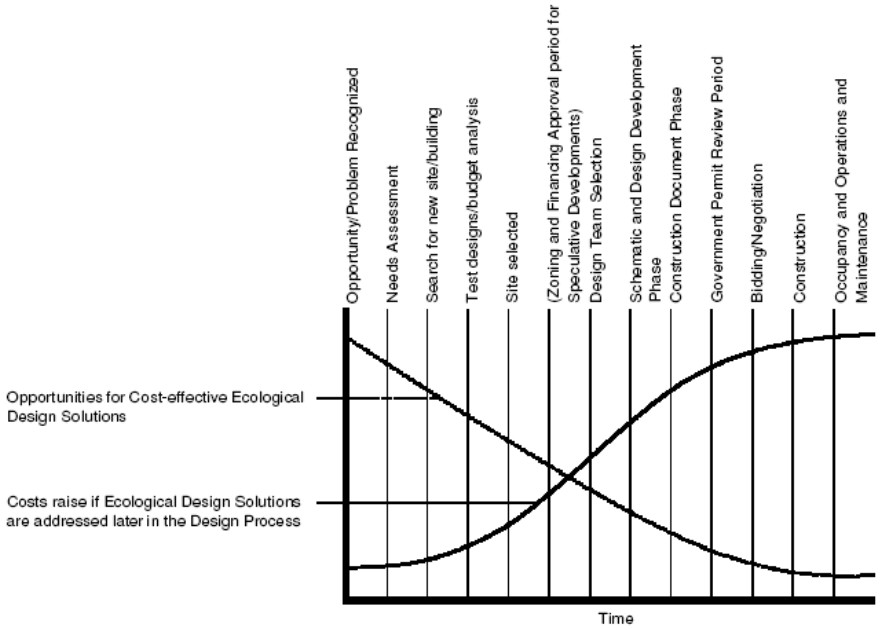

Figure 2: Relationship of cost and ecological design in a typical development scenario

5. Sustainability Indicators in Construction

Indicators are measures which enable information on complex phenomenon to be simplified, the main functions of which include quantification, simplification, and communication (Fernández-Sánchez and Rodríguez-López, 2010; Lombera *et al*., 2010). According to Strange and Bayley (2008), indicators may be qualitative and/or quantitative measures; which are used to signal and pre-warn against a particular condition to allow decision to be taken. There are several attempts to measure the extent to which the construction industry was sustainable; e.g. BREEAM (UK), LEED (US), NABERS (Australia), FTSE4 Good Index, Morley Fund Management's Sustainable Matrix etc. (Pitt *et al*., 2009). Further indicators included Design Quality Indicators (DQI), M4I key performance indicators, and housing quality indicators (Edum-Fotwe and Price, 2008).

The majority of attempts to implement sustainable development in construction, however, are criticised for using sets of objectives that are "dissociated" from the description of the sector; and consequently resulted in a trivial number of interrelated metrics (Kohler, 2006). Furthermore, the indicators were criticised for only measuring the 'measurable', and

consequently were not sensitive to context, and hence lacking proper frameworks (Edum-Fotwe and Price, 2008; Kohler, 2006).

According to Barrera-Roldán and Saldívar-Valdés (2002), criteria for selecting indicators should be based on a logical framework of 'action-response' relationship between the economy, society, and environment; should identify 'what' is being measured, and is expected to further allow comparisons to be made. In this context, sustainability indicator could be perceived as a means for meeting sustainability targets; as well as controlling and monitoring the progress over time (Fernández-Sánchez and Rodríguez-López, 2010).

Currently, there are more than 70 tools based on sustainability indicator systems for evaluating building projects. These are criticised for their uncertainty and subjectivity; and predominately assessing the environmental aspects of buildings (Fernández-Sánchez and Rodríguez-López, 2010). Halliday (2008), however, argued that 'cost' is the primary aspect of discussion on sustainable building; claiming that sustainability proponents have committed few resources (if any) to the proof from which real benefits in the sustainability tri-polar could follow. Hence, making it difficult to determine whether it really costs more to build in a genuinely sustainable manner (Halliday, 2008; Cole, 2000). Furthermore, in the case where additional costs were recorded, the samples were relatively small and may be limited to one case study; which makes the results questionable. In the UK for example, it was reported that energy efficient and environmentally friendly buildings cost between 5-15% more to build from the outset, however, this assumption was not backed up by any empirical results (Bartlett and Howard, 2000). This notion was inline with the criticism noted by Edum-Fotwe and Price (2008) that the results of buildings studied did not reveal whether the additional costs marked were the result of good design or a poor one.

Many beneficial features of sustainable construction are argued to have little or no additional capital cost; and yet could deliver cost benefits. This may be achieved through transferring expenditure to design time rather than committing resources to mechanical services equipments, which arguably take an increasingly large amount of the cost of buildings (Halliday, 2008). In this context, e.g. high insulation levels, and passive moisture management is expected to cost more elementally, nevertheless require minimal heating and ventilation systems. Hence, resulting in both capital as well as running cost benefits (Halliday, 2008).

6. The Rationale of a Sustainability Index in Construction

The measurement of sustainable development is perceived as an essential prerequisite for promoting a sustainable society. Nevertheless, despite the considerable attention devoted to sustainable development indicators (SDI); newly developed SDI sets have always been experiencing difficulty in gaining wide acceptance (Mitchell, 1996). Furthermore, sustainability indicators in general have been criticised for failing to fulfil fundamental scientific requirements; which consequently could mislead sustainability on a policy level (Böhringer and Jochem, 2007; Mitchell, 1996). In addition, it is argued that normalisation and weighting of indicators are generally associated with subjective judgements without systematically assessing critical assumptions (Lombera and Aprea, 2010).

It is envisaged that in order to allow successful measurement of sustainable development, it is essential to first place the identification of operational indicators that provide manageable units of information on economic, environmental, and social conditions (Böhringer and Jochem, 2007). In the same context, it is imperative to first agree on the SD definition and the associated interpretation, to identify 'who' these indicators are intended for, and 'who' will act on the information these indicators convey. Furthermore, SDIs are advised to be accompanied by a target value identifying desirable conditions and threshold values identifying problem, and critical levels (Mitchell, 1996).

The sustainability measurements noted in literature were mainly used to evaluate existing buildings (new and/or refurbished) – (e.g. BREEAM, 2010). Apart from one attempt to make sustainability one of the management areas to drive construction projects towards sustainable construction practices (Khalfan, 2006); no application of sustainability practices across the construction supply chain was evident in literature. In this context, sustainability was mapped across the construction process protocol phases (PP, 2000); in order to set out a framework to drive sustainability along the construction process (Khalfan, 2006). While, this may be an encouraging attempt; it is too generic, and hence, making it difficult for 'users' to apprehend during the actual implementation of sustainability management and consequently any associated assessment to be carried out. In addition, it does not specify who or when exactly these activities should take place, and how these are inter-linked with other activities within the process protocol. Furthermore, Khalfan (2006) argued that indicators would vary from project to project; this however, would prevent comparisons and benchmarking to take place on an industry wide of policy level.

In order to address the short comings noted in the current sustainability indices in general, and in the construction industry in particular, with particular emphasis on the ease of understanding and use, this paper attempted to first identify and map the main issues across the construction process. Using a qualitative approach - content analysis, this paper, teased out the main sustainability issues raised in extant literature, and categorised these in light of the tri-polar of sustainability: economic profitability, environmental responsibility, and social awareness (Figure 3).

- At the economic profitability level, projects and built facilities have to be delivered on time, defect free and materials used in an efficient way to reduce waste and rework. In addition, life cycle cost of materials, equipment and technology required has to be considered through selecting durable, maintainable, repairable, controllable and recyclable elements. Furthermore, investors and stakeholders concerns have to be considered throughout the different stages of the project life cycle to produce products that meet their expectations and fulfil their needs. Finally, economic profitability of projects could be improved through research & development to overcome shortcomings and learn from feedback and learned lessons.

- At the environmental responsibility, designers and construction professionals are required to consider water treatment, efficient use of resources and energy consumption, reducing pollution generated from their projects as well as saving soil and biodiversity.

- Towards raising social awareness, designers and construction professionals, have to involve clients and end-users in the design decision making process, take precautions in their design and project execution to reduce crime and vandalism, information technologies have to be utilised to facilitate communications amongst different project stakeholders. Society improvement in terms of education, training, security, accessibility, safe working conditions and supply chain management have to be considered during design and construction.

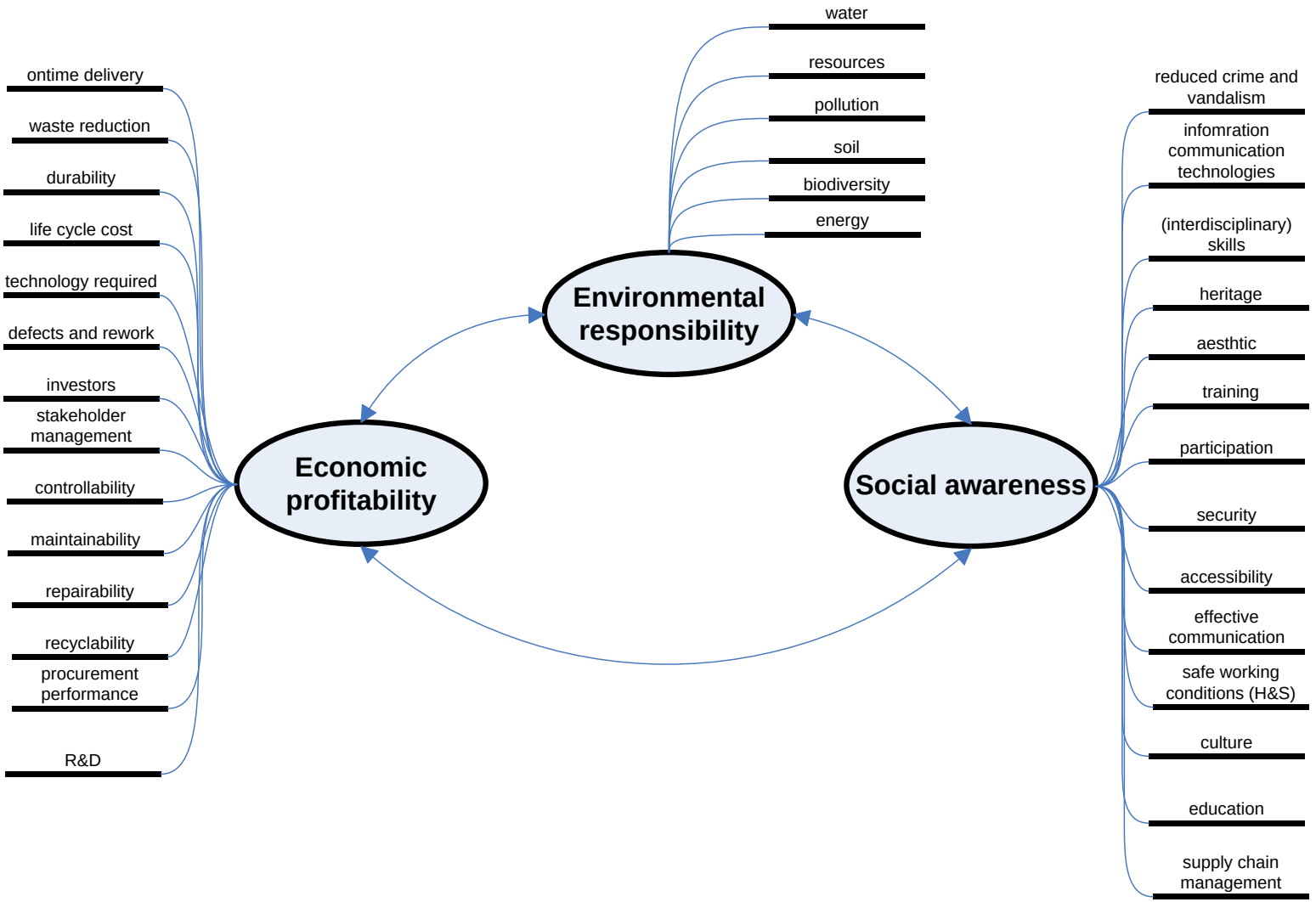

Figure 3: Qualitative data - the construction industry sustainability tri-polar

Further categorisation of sustainability measures across the various construction phases, however, is needed to help set measures across the different phases. Hence, further mapping was carried out to help guide measuring sustainability along the various stages of construction: inception, design, construction, operation, and the demolition phase (Figure 4):

- During the inception phase, three main strategies are needed to ensure that the project is sustainable. These include sustainability policy statement, procurement policy, and management policy.
- The design need to address issues such as simplicity, energy conservation, air quality, flexibility/adaptability, design for recycling, passive design etc. (Figure 4).
- During the construction phase, it is imperative to minimise disturbance, ensure safety awareness, eradicate offensive behaviour, minimised defects and rework, and eventually deliver on time.
- The operation/occupancy phase, require for example efficient operation and management procedures, handover training need to take place, environmental performance and occupant satisfaction need to be measured and assessed accordingly. This should also take into consideration issues such as the reduction of crime and vandalism, accessibility, and after sale support.
- Last but not least, demolition and recycling need to ensure the efficient reuse of resources, and minimisation and constructive use of waste,

The categories identified in Figure 4, were concluded from extant literature and are by no means exhaustive; further research is expected to quantitatively conclude and prioritise a set of industry wide indicators.

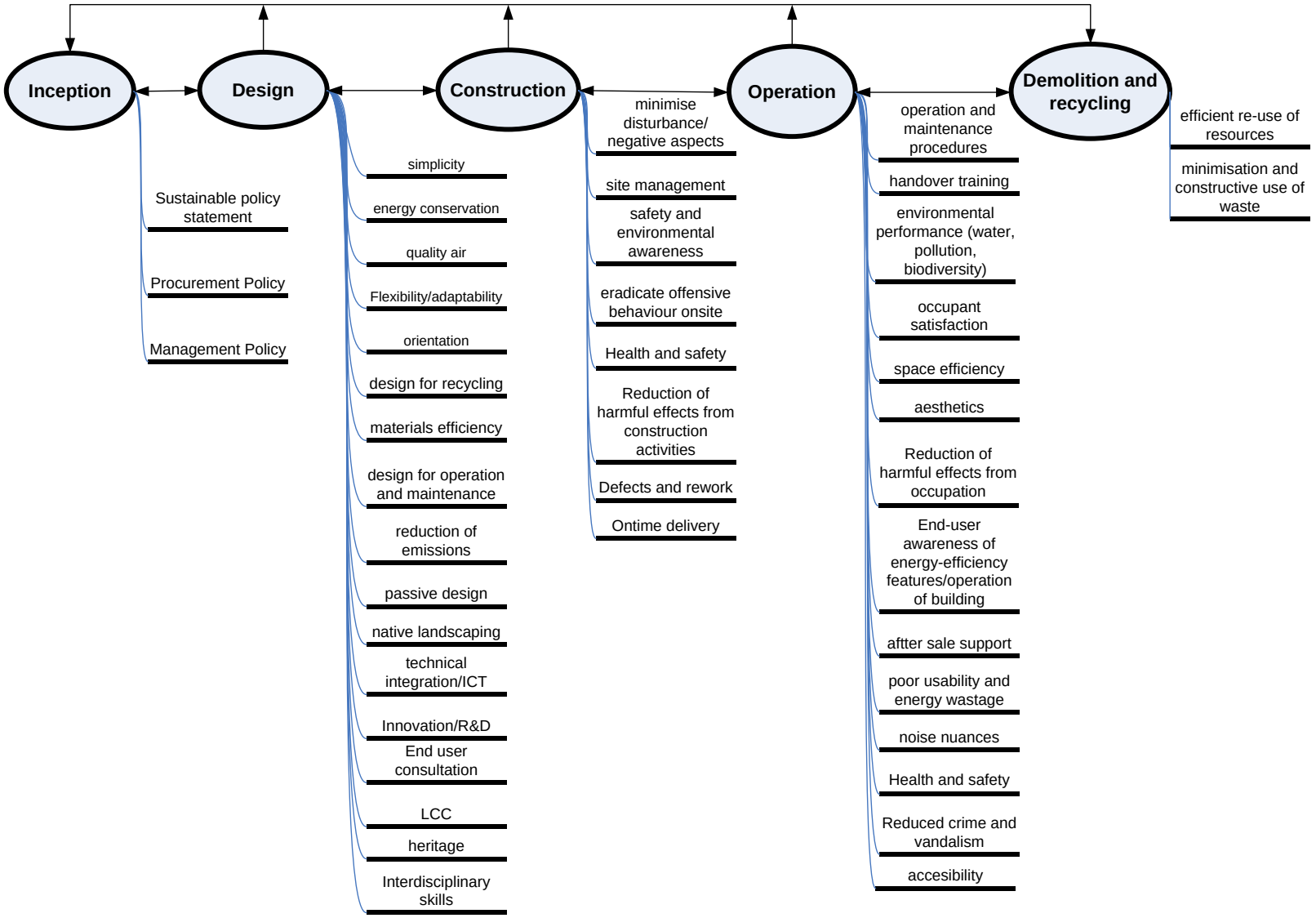

Figure 4: Breakdown of sustainability issues across the construction phases

7. Conclusions and Recommendations

In spite of the vital contribution of the construction industry towards achieving sustainable development objectives at both national and international levels, the construction industry is not only a very large consumer of non-renewable resources and energy, it is also a substantial source of waste, carbon emission and pollution as well as land dereliction and ecological destruction. The increasing recognition and the universal calls for sustainability called for the construction industry to more sustainable.

The implementation of sustainability within the construction industry, however, has been faced by challenges with regards to feasibility and practicality. This is exacerbated by the lack of proper indicators and measurements. While there are a set of indicators to measure the sustainable development within the construction industry, these mainly targeted existing buildings, with no clear evidence about embracing sustainability practices across the whole construction supply chain from inception to demolition. This paper employed a qualitative approach, content analysis, to tease out the sustainability nuances across the different phases of construction. Further research is expected to quantitatively conclude and prioritise a set of potential industry wide indicators to help measure and benchmark sustainable practices across the construction industry.

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