University of Birmingham
School of Mechanical Engineering

VALUE MANAGEMENT AND SUSTANABILITY IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

The construction industry has grown significantly in the past decade and its ability to produce sustainable projects successfully not only poses many challenges to construction companies but also has a major effect on the economic performance. The construction industry has also experienced an increase both in awareness and the importance of the sustainability phenomenon and in value management which has impacted positively in various areas of construction projects. The definition of a ‘successful’ construction project has developed beyond just profit for the construction company to include the extent to which sustainable value is delivered to satisfy the project objectives and stakeholders. The construction industry has been recognised as one of the largest industrial sectors in recent decades because of its major contribution to the economic growth of countries and its ability to satisfy mankind’s social need for shelter – but its adverse effect on the environment has also been noticeable.

This research project focuses on the development and improvement of existing methods of integrating the concept of sustainability into value management practice in the construction industry. An extensive literature review is carried out on the concept of sustainability and value management in terms of definition, approach, advantages and constraints to application. Then the current ways in which sustainable development is used in value management to deliver sustainable value construction projects is discussed. In the final phase of this research project a proposed improved model for integrating sustainability into the value management process is developed from the existing methods of integration.
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ABBREVIATIONS

CBA: Cost benefit analysis

CF: Carbon Footprint

CI: Construction Industry

CO$_2$: Carbon Dioxide

DEFRA: Department for Environment, Food and Rural Affairs

DFD: Data Flow Diagram

EE: Energy Efficiency

EA: Environment Agency (UK)

FA: Function Analysis

GHG: Green House Gas

LCA: Life Cycle Assessment

PM: Project Manager

SC: Sustainable Construction

VA: Value Analysis

VE: Value Engineering

VM: Value Management

VP: Value Planning
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1. INTRODUCTION

Resource efficiency and an environmentally friendly approach are not elements that have particularly characterised the construction industry (CI) over the past century; in fact, there are many concerns over the way the industry has performed and discussions on how it can dramatically reduce its environmental impact. Alarming figures catch the public eye and worry the authorities. For instance, it is the industry that generates the largest amount of greenhouse emissions (GHG). It also takes up 33% of the global energy consumption, because of its traditional construction techniques and inefficient use of the natural sources of energy in the whole process. Finally, its generated residuals are even more distressing; being 40% of the total volume of waste produced worldwide (United Nations Environment Programme, 2011).

All these figures clearly indicate that the CI is not sustainable with respect to environmental and economic factors, since the ecological remediation of its actions has to be paid sooner or later whatever the cost. However, it is also important to recognise how indispensable this particular industry is, and the huge contributions it has made to humankind. In spite of the inefficiencies and criticism of this area of engineering, there are several factors that triggered the present situation, which will be explained in the next chapter; among them are globalisation, land availability, urban settlement, and housing demand.

Another major consideration for this project is the current situation for the CI and how it has evolved over the past decade, particularly in the UK, where the Government together with the EU authorities have been alert to the scale of the problem and consequently several initiatives have been taken to impose and regulate the law over
this area. This dissertation considers two concepts (value management and sustainability) which could be used to effectively manage these CI problems, to reduce environmental, social and economic impacts.

Value management (VM) is studied in detail in chapter three; the challenges faced by the CI in present times are discussed and VM is presented as a potential solution to the problems of inefficiency demonstrated over the past decades. The technique was developed precisely to promote innovation to the industry, stimulating efficiency and value added in every stage of the construction and manufacturing process. It has been widely recognised for over 70 years, initially in the US and later adopted in the UK. Since then, VM has been widely recognised in many countries as a driver for many projects and it has been applied within many different sectors. VM was successfully introduced in the 1990s as an official field of further studies in the education system of the UK in the construction and engineering areas of study. The fundamental principle of VM is that a deep analysis in initial phase of a project should be undertaken to fully understand the implications and requirements of the client.

The recognition of the term ‘sustainability’ and its adoption into the CI indicates the promotion of environmental attitudes, emphasising resource efficiency, functionality and predominantly environmental conservation. This topic is covered in chapter four, which gives an overview of sustainability as a concept, and describes how the industry is adapting to this conservation wave and how this particular sector is committed to reduce its environmental impact.
CHAPTER ONE

1.1 Problem Statement

The application of VM within the CI is a result of the continuous evolution of the construction sector given the poor reputation gained as a result of construction failures across the world. The record of budget and time overruns has triggered the pursuit of efficiency of performance for this industrial sector. In addition to this, the CI’s environmental footprint has been a major contributor to the deterioration of the environment, ecosystems and species; its record of resource depletion and poor water resource management has made a significant contribution to global warming.

Integrating VM and sustainability into a single approach becomes a necessity for the CI if it is to enhance the conservation of the environment (as well as gain other benefits associated with VM). Although sustainability and VM are separate areas, they have become linked together as a result of continuous pressure from international organisations and governments to implement policies and regulations that mitigate the existing problems affecting the welfare of the planet.

Existing models of sustainability into VM have considered many aspects in terms of resource management, efficiency and value added factors over the initial requirement of the stakeholders; these aspects limit decision making and, together with the budget, limit the course of a project. As a consequence, the main driver turns out to be the economical factor; environmental factors remain overlooked. The proposed model will contribute a defined method which can be applied at the initial phase of a project, particularly at workshop phases, where sustainability aspects should influence the participants and members of the project.
CHAPTER ONE

1.2 Research Questions

This dissertation aims to address the following questions based on the understanding of the problem statement.

1. What is value management?
2. What is the meaning of the term ‘sustainability’ in the CI?
3. What are the main problems that impact on the sustainability of the planet?
4. Are there any existing methods for measuring the impact of sustainability?
5. Can VM process be used to improve sustainability in construction?
6. How can sustainable projects be enhanced through VM techniques?
7. Are there any barriers to the integration of sustainability into the VM process?
2. BACKGROUND RESEARCH INTO THE CONSTRUCTION INDUSTRY

2.1 Challenges facing the Construction Industry

The CI over the past century has provided solutions for a series of problems affecting the masses. However, the biggest challenge of the CI nowadays is to safeguard natural resources, adding new measures to develop the industry to a new dimension of efficiency. The accelerated use of natural resources is outpacing the capacity of the Earth to regenerate those resources. According to Gardiner and Theobald (2012), there are two alternatives to this concern: “the cutting down our use of natural resources does not mean we need lower our standard of living, we just need to use natural resources more wisely”. The challenges that the CI is facing at the moment have been mentioned, but in addition many aspects affecting most countries and larger cities have been identified: globalisation, urban settlement, land availability, population growth and green building.

2.1.1 Globalisation

According to (Lo & Marcotullio, 2001) the term ‘globalisation’ is frequently associated with trade and aspects of economics, but the context has a wide connotation including migration flows, media, culture and technology. The economic development of a country involves technological advances, trading of goods, services, information, among other significant aspects. From the CI point of view, globalisation has contributed positively in many respects. For example, the flow of information, knowledge, technology and expertise is vastly increased in and between different countries as if there were no borders; so too is the dissemination of new techniques and the search for and implementation of new materials, contributing to the evolution
of traditional methods of construction, increasing the efficiency of the use of natural resources. On the other hand, globalisation has also unleashed some inconveniences, such as the perception of living standards: the demand for infrastructure, transport, jobs, services, food, and water has increased significantly. Urban settlements are another concern; more and more people are moving to urban areas and this phenomenon contributes to the degradation of the environment and high levels of pollution.

Figure 1 illustrates the amount of CO2 emissions in tonnes equivalent per capita in relation to GDP per capita based on purchasing power parity (PPP) in US Dollars. The direct relation between higher incomes and higher levels of emissions points out US, Canada and Australia as the major contributors of CO2 in the entire planet, whereas the wealthy cities with the larger GDP and emissions are New York, London and Paris.

Figure 1: Carbon emission and income for selected countries and cities
(Source: United Nations Environment Programme, 2011)
2.1.2 Urban settlement

Through the ages the geographical location of certain cities has given them economic advantages when it comes to trading, particularly those with access to the sea or rivers where the concentration of economic activities has boosted the development of entire nations over the past centuries. Nevertheless, there are also cities well known as industrial or manufacturing centres due to the concentration of specific industries allocated in certain areas where the availability of materials, resources, land and adequate conditions converge to make these regions appropriate for manufacturing and production activities, for instance agricultural, livestock, fishing, food, textile and mining.

On the other hand, the centralisation of economic activity in some important cities is the result of the conglomeration of company’s headquarters and financial centres based in ‘global cities’, where people are attracted to move because of high income expectancies and wealth. According to the World Urbanisation Prospect Report (United Nations, 2014), the percentage of the human population living in urban areas is currently 54%, and it is expected that this figure will increase by 12 % within the next 36 years, as shown in Figure 2. These figures also flag up other significant problems for the inhabitants of urban spaces; the lack of access to basic services, the demand for energy, high pollution levels and poverty in general create inadequate living conditions, and in addition there are problems caused by the imminent environmental impact induced by the increasingly high population density (National Geographic, 2014).
Rural areas are persistently under the threat of being absorbed by urban areas, due to the increasingly high expansion of the big cities horizontally. Developing countries have faced for decades constant problems of land invasions from a sector of the society with lack of access to housing and opportunities, usually settling on the outskirts of the perimeter of large cities, surviving in deplorable conditions due to the lack of access to basic services, for instance of water supply, electricity and sewerage. Developed countries such as the US face the opposite problem, due to a large amount of land availability. The consequence is the excessive use of land (Raup, 2007). Nevertheless, the case of the large cities is still the same, where the access to housing for people is substantially high, and only few sectors of the society are able to afford to live in there.
2.1.3 Land Availability and Population Growth

One consequence of the increasingly high levels of population growth in the world, which is measured by the fertility rates in countries like India and China where the population exceeds one billion of people, is the availability of land. This becomes a concern to the world authorities due to the environmental impacts of urban areas. Over the past few decades it has become more and more common for rural areas to become part of urban areas due to the expansion of the big cities, particularly in countries such as the US where economic development was virtually sustained, but land availability and excessive use of space was overlooked (Raup, 2007).

The influence on the current birth rate of the world population is also a matter of concern for the world’s future. Countries such as India and Nigeria are both experiencing an exponential increase of population: it is expected that their population numbers will surpass 1.5 billion and nearly one billion, respectively. The consequence of the increasingly high levels of population growth in the world, which is measured by the fertility rates in countries like India and China where the population exceeds one billion, the availability of land becomes a concern to the world authorities due to the environmental impact that implies living in urban areas. The demand for housing infrastructure is also exponentially growing, another challenge for the construction sector.

2.1.4 Green Building

The main goal of green building is to provide an alternative method of building to minimise the environmental footprint by efficiently using the natural resources employed and reducing waste, pollution and degradation of the environment. The main effects of the built environment are depicted in Table 1.
To achieve this goal, new environmentally friendly materials throughout a systematic Life Cycle Assessment (LCA), and the optimal use of the sources of energy to maintain, operate, renovate and deconstruct are incorporated. “This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building” (U.S. Environmental Protection Agency, 2012). Applying the concept of green building results in numerous benefits – final environmental, economic and social aspects – as described in Figure 3.

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Table 1: Impacts of the built environment (Source: U.S. Environmental Protection Agency, 2012)
Figure 3: Benefits of green building

- **Environmental**
  - Look after the ecosystems and species
  - Improve water and air quality
  - Reduce of waste

- **Economical**
  - Reduce unnecessary operating costs
  - Expand the market of green products and services
  - Add more value to the final users, improving productivity
  - Optimise Life-cycle economic performance

- **Social**
  - Promote comfort and health to final users
  - Promotes new aesthetic designs
  - Improve overall quality of life
3. **VALUE MANAGEMENT**

Value management (VM) is a potent tool used in the CI to achieve the best value for money by effectively managing the challenges that might occur within the project. VM process should not be mistaken as budget saving or reduction exercises. Cost reduction exercises ultimately focus on gaining the lowest possible overall cost for a project, even if this mean a compromise in value (Norton, 1992). However, in construction projects a certain amount of unnecessary cost is inevitable during the life cycle due to project complexity, delays and uncertainty.

3.1 **The nature of value**

In order to understand the concept of VM, it is essential to establish what ‘value’ is. De Marle (1992) stated that value is often wrongly assumed to be a property of goods or services, a concept which has its origin in prehistoric Greek philosophy. According to SAVE (2007) value is “a fair return or equivalent in goods, services or money for something exchanged”. Value can also be described as “the equivalence of an item expressed in objective or subjective unit of currency, effort, exchange or a comparative scale that reflect the desire to obtain or retain the item. Whether in monetary or non-monetary units the measurements of objective or subjective measures are often translated into a monetary value as a meaningful means of expression” (Kelly and Male 2001). Dallas and Clackworthy (2010) define value as the ratio of satisfaction of needs (monetary or non-monetary benefits) to resources used (money, material, time, and energy).

There are four different types of value: used value (need), esteem value (want), exchange value (worth), cost value (cost). Value is expressed as “satisfaction of need/resources used; however, in construction resources used is in terms of the whole
CHAPTER THREE

Life cost of a project and therefore value is represented as satisfaction of needs/whole life cost” (Beardsall, 2005). In conclusion, value is expressed as a ratio of two variables; function and resources (cost). Therefore value can be defined as highest function (benefits) to total cost ratio of project and can be represented mathematically as:

\[
Value = \frac{Function \ (F)}{Cost \ (C)}
\]

From the equation above, value depends on the level of function and resources used. Figure 4 illustrates the relationship between the elements of value.

![Figure 4: Variations of function and costs (Source: Male et.al., 1998)]

3.2 Concept of Value Management

VM was developed in the “manufacturing sector of North America as value thinking in the late 1940s when the shortage of strategic materials forced General Electric Company (GEC)” to consider alternative methods to perform the same functions at a lower cost (Dallas, 2006; Norton and McElligott, 1995). It immediately became apparent that the alternative methods generated equal or improved quality at a lower budget, leading to VA being defined as “an organised approach to providing the necessary function at lowest cost” (Kelly and Male, 2002). Value engineering (VE) was initially employed in the United States CI by the General Services Administration in the 1960s and was later introduced into UK manufacturing. This led to the establishment of the Value Engineering Association now known as the Institute of Value Management (IVM) (Kelly and Male, 2002).
The following terminologies are used to describe a methodical approach of function evaluation of a project to ensure effective delivery of its objectives: value planning (VP), value analysis (VA), value engineering (VE) and value management (VM). The term VE is utilised during the detailed design, construction and operation stages. Kelly et al. (2004) define VE as a subset of the VM process, where the emphasis is on improving value in the design and construction stages of the technical project.

*Figure 5: Relationship between VM and VE (Source: Hayden and Parsloe, 1996)*

VM is an umbrella term used for the overall philosophy and application of value studies at any strategic phase of a project, which includes; VP, VA and VE (Pasquire and Maruo, 2001). Kelly et al. (2004) stated that VM describes the framework for optimising the value of a project for its stakeholders from the project conceptual stage to the operational stage. Value management is a “systems oriented and multi-disciplinary team approach, project life cycle oriented, a proven function oriented management technique; on the other hand VM is not a design review or a cheapening process, and nor is it a requirement done on all design, quality control, cost reduction exercises or standardisation exercises” (De Leeuw, 2001). VM does not have any universally accepted definition. VM is a “systematic, multi-disciplinary effort directed toward analysing the functions of projects for the purpose of achieving the best value at the lowest overall life cycle project cost” (Norton and McElligot, 1995). Table 2 shows other definitions of VM by various authors.
Norton and McElligott (1995) recommend that VM study should be implemented in construction project cases such as expensive and complex design programme projects, unique projects with new or advanced material and technology, projects with repetitive cost and projects with limited budget and time. VM should not be limited to these specific cases but can used in all projects at any stage where necessary to achieve optimum value and benefits for the project.
CHAPTER THREE

3.3 The Benefits of Value Management

The benefits of VM can be categorised as client-related, cost-related and project-related. The VM study serves as an analytical tool during the project design brief (Yu et al., 2005). Both the stakeholders and design team effectively learn about the client requirements and the functional requirements of the design. The cost-related advantages are considered as a result of the enhancement of design value. Norton and McElligott (1995) believe that “VM process can cut the total cost of a project by 10%, whilst only costing 1% of the total project cost to carry out, therefore generating a savings ratio of 10:1”. Project-related benefits arise from the fact that the VM process ensures a common understanding between all those involved, resulting in the management of the project being considerably smoother.

3.4 Disadvantages of Value Management

Some project clients may see VM as a critique of their ideas by the VM professional, resulting in negative attitudes and resistance to implementation of VM recommendations (Norton and McElligott, 1995; Ellis et al., 2005). Fong (1999) argues that whilst VM has grown in popularity, there is still a absence of understanding of the principles of the process amongst some clients and construction professionals. This lack of knowledge can be responsible for opposition to its use, and in the case where the VM process is implemented it may not produce significant benefits compared to the resources used in the process. Another common problem relates to the timing of VM implementation. Ellis et al. (2005) contend that applying VM at later phase often manifests as a budget reduction exercise instead of preserving or enhancing value. This perception that VM is frequently viewed and applied by some organisations strategically as a cost cutting exercise is shared by Hayles et al. (2010).
3.5 Value management process (job plan)

A successful VM process requires: careful consideration when structuring and the use of a job plan. The job plan is as “a logical and sequential approach to problem solving”, (H M Treasury, 1996). This involves identification and evaluation of a range of options that are separated into its integral steps and then used as a basis of VM. VM is a systematic approach which consists of three generic phases:

1. The orientation and diagnostic phase
2. The workshop phase
3. The implementation phase.

3.5.1 The orientation and diagnostic phase

The orientation and diagnostic phase (pre-workshop phase) philosophy is derived from the definition of both words. Orientation is defined as resolving the relative position of something and diagnostic known as aiding to assess. One of the main objectives at this stage is to, ensure all parties involved are kept well-coordinated and the availability of information is sufficient and ready for use later within the workshop phase (Norton and McElligott, 1995). This stage consists of reviewing documents and discussions that are carried out between value manager(s), clients and stakeholders. This helps to understand value problems and brainstorm solutions. Kelly et al. (2006) states, the decisions quality is determined by the value of information gathered.

The orientation and diagnostic phase involves conduction of preliminary studies that help identify: objectives of the study, project concerns, background information, hidden agendas, assumptions, constraints, available participants, stakeholder engagement and the entire scope of the study. This involves a series of interviews and briefings of the stakeholders involved. At this stage, the value manager is able, with
the consent of the client, to create a workshop agenda and analyse the different stakeholders required to attend. The duration of this stage is commonly between five to ten working days; it may differ depending on the type and complexity of the project. A summary of the activities involved are shown in Table 3.

Table 3: Activities involved in the orientation and diagnostic phase of VM

<table>
<thead>
<tr>
<th>Activities</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Identify stakeholders</td>
<td>The stakeholders mapping and analysis techniques is carried out to identify the stakeholders involved in the project and their key objectives.</td>
</tr>
<tr>
<td>2 Collect information</td>
<td>Collection of information process is done to ensure the availability of the required data. According to Hammersley (2002) data can be collected pre-workshop meetings, interviews and questionnaires</td>
</tr>
<tr>
<td>3 Identify the project objectives and constraints</td>
<td>This enables the value manager(s) to set the project purpose, time, budget and quality limitations through document analysis and interviews.</td>
</tr>
<tr>
<td>4 Determine the workshop scope and agenda</td>
<td>This should be carried out in order to highlight the workshop duration and the techniques to be used.</td>
</tr>
<tr>
<td>5 Pre-workshop meeting</td>
<td>This conducted with key stakeholders to discuss and agree on the objectives, scope and constraints. Pre-meeting enable the workshop participants to come reassured and well prepared.</td>
</tr>
</tbody>
</table>
3.5.2 VM Workshops

The VM workshop plans the activities required to successfully apply VM techniques. It is a systematic process consisting of a single or several of workshops where stakeholders aim to accomplish greater value from the project. VM workshops also differ in their duration that is from a short series and a single workshop to an extended sequence with various workshops and other activities. This depends on a number of factors such as:

1. Project complexity
2. Project size
3. The stage of project development
4. Estimated costs of the project

The workshop outlines specific steps required in order to effectively analyse project to generate several alternatives to address the stakeholders' objectives, requirements and expectations. During this phase the multi-disciplinary team is required and led by a value manager to carry out the workshop agenda. The workshop phase is structured around the job plan which consists of six job plan phases, as listed below.

**Information phase:** This brings all members of the team to a similar level of knowledge and provides a comprehensive understanding of the most significant aspects of the project. Important questions to be answered are: “What is it? What does it do? What must it do? What must it cost? What is the value performance of the primary function?” (Stocks and Singh, 1999). Some techniques utilised at this phase include brainstorming, stakeholder analysis, project driver analysis and client value system analysis.

**Function analysis:** The function analysis (FA) is the factor that distinguishes between VM processes and from other management styles. The FA technique helps in
the identification of what parts of the system and the system as a whole must do. “A clear understanding of what must be done allows for easy identification of waste, preventable costs and also considers alternative methods that perform the same functions leading to an increase in value” (DWH, 2005). There are several methods of carrying out FA, these include: function logic diagrams, objective hierarchy, task FAST, and function breakdown structure. (Connaughton and Green, 1996)

Creativity phase: this stage is vital for VM. It is primarily targeted at persuading participants to openly suggest alternative solutions through brainstorming and lateral thinking. This helps improve knowledge transfer and encourage the creation of new knowledge.

Evaluation Phase: ideas generated during the creativity phase are evaluated and prioritised for their feasibility against the set objectives to identify suitable ideas for development. Evaluation phase Techniques include decision matrices, and SWOT analysis.

Development phase: The ideas that best satisfy social, economic, environmental and financial objectives are then chosen for further development into an action plan with the aid of tools such as Life Cycle Assessment (LCA).

Presentation phase: a draft of the developed idea is presented to the value manager for further discussion with the stakeholders. A final report is then presented to describe the main issues that need to be improved, and acceptance and approval of an action plan for implementation.

3.5.3 The implementation phase

Often referred as the ‘Achilles heel’, the implementation phase is the stage where VM commonly fails. This is due to poor implementation of the action plans. In order to limit this, implementation meetings involving the same participants who attended the
workshop phase plus senior management representatives should be put in place following the completion of all the above phases in the VM workshop (and at any other opportune time). This allows participants to report on their element of the action plan. Any mismatches within the workshop report are resolved, funding and planning documentation are developed.

![Value study process flow diagram](image)

**Figure 6: Value study process flow diagram (Source: SAVE International 2006)**

### 3.6 Value Management Timing

“VM has been carried out successfully within different sectors, across many activities and at different organisational levels” (Dallas and Clackworthy, 2010). VM should be used during the investment life cycle and its decisions by carrying out formal studies at decision stages. To achieve successful VM, the value manager must identify the intervention point within the project life cycle in order to apply appropriate techniques for the workshop.
Male et al. (1998) derives that VM process implemented at these four opportunity points can yield maximum effect on any construction project during its life cycle

1. Pre-briefing study to produce strategic brief through pre workshop meeting to ensure the most suitable solution for project and also to gain a unified agreement from the stakeholders about the project’s main objectives

2. Project brief through “articulating the strategic brief into performance specification and design and construction terms” (Mlybari, 2011)

3. Concept design study to review the project brief and enhance the concept design

4. Detailed design study to perfect the design through project function evaluation

Figure 7 shows the timing and cost to implement Value management at different phase of a project. There are three graphs; cost reduction, resistance to change, cost to change. The cost reduction potential of a project reduces as the project gets into the late phase, while the resistance to change and cost to change increase during the project. From the figure the opportunity point for VM application would be at the interception point at the construction phase to gain maximum value for the project

Figure 7: Timing and potential saving through VM (Source: BRE: Building research establishment, 2000)
3.7 Value Management Team

No specific number of team members is recommended for VM, but only a range. “VM team sizes can vary between 5 and 30 members depending on factors such as size, technology, nature and complexity of the project” (Kelly et al., 2004). A huge VM team can be problematic due to: poor communication among members, conflict between members, difficulty gaining consensus on ideas, and delays in reaching decisions. In order to solve this problem, a large VM team should be divided into sub-teams of five to seven members; also having more than one value manager to coordinate the VM study is highly advantageous. It is recognised that VM requires an appropriate team to be selected at an appropriate time for each intervention point by the value manager(s) in conjunction with the client. However it is important to ensure there is a suitable mix of skills that can address the value issues.
4. SUSTAINABILITY

4.1 Sustainability through the Ages

Sustainability is an inherent process of the Mother Nature, implicitly regulating the life cycle of every single element on the planet. According to Robertson (2014), this process involves the planet as a whole, including resources, different ecosystems, and inhabitant species, particularly humans, playing a key role in maintaining its equilibrium. The industrial revolution in the late eighteenth century and the continuous pursuit for sources of energy led to the discovery of different fuels, coal being the main source of energy in the early nineteenth century. Oil, gas and other fossil fuels, with an exponential efficiency compared with traditional coal, still power several industries, particularly transport. Other natural resources such as water, wood, soil, charcoal and several minerals have been largely exploited throughout modern history. After the usage of such resources, the tangible outcome is industrial waste, pollution and therefore the depletion of natural resources (Hawken, et al., 2013).

4.2 Approaches Worldwide

Sustainability nowadays has been openly recognised by societies in general, and is a hot topic for the authorities worldwide. However, this concept is not often treated as a priority by the governments, particularly in western countries, where the balance falls on the economy side rather than the sustainability side (Shared Planet, 2013).

Figure 8 compares the amount of material extraction in billions of tonnes and the GDP in trillions of USD dollars over the past century, reflecting the growing demand for the natural resources in the global market. It clearly indicates the contribution of natural resources to economic growth; essentially the more resources extracted the higher increase of GDP.
Moreover, the actual levels of power utilisation are another challenge for scientists nowadays. Countries such as Sweden and Denmark are aware of the severity of the energy waste, revealing that traditional uses for energy are only 40% and 50% efficient. They believe that figures can be improved by implementing change “at all levels of society, from agriculture, business, transport, buildings to single households” (The official Website of Denmark, 2014).

The government of Denmark is a good example of conscious vision of welfare for future generations, taking actions over the current situation and improving outdated techniques, particularly in the construction sector. For instance, traditional practices of construction have been taken to a new dimension in remodelling, construction and energy use by reducing the consumption of the amount of materials, energy use for lighting and heating. This new approach has changed the way of harnessing natural energy from Earth. According to the World Energy Council (2013), figures recorded over the past twenty years has permitted the analysis of the pattern of growth using indicators from population growth, different sources of energy production, CO₂
emissions and GDP in two main periods of time, 1993 and 2011. Both groups of data have been analysed to predict the near future in 2020, as shown in Table 4.

Table 4: Key Indicators for 1993, 2011 and 2020

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World Population, billion</td>
<td>5.5</td>
<td>7</td>
<td>8.1</td>
<td>27%</td>
</tr>
<tr>
<td>GDP, trillion USD</td>
<td>25</td>
<td>70</td>
<td>65</td>
<td>180%</td>
</tr>
<tr>
<td>TPES, Mtoe</td>
<td>9532</td>
<td>14092</td>
<td>17208</td>
<td>48%</td>
</tr>
<tr>
<td>Coal, Mt</td>
<td>4474</td>
<td>7520</td>
<td>10106</td>
<td>88%</td>
</tr>
<tr>
<td>Oil, Mt</td>
<td>3179</td>
<td>3973</td>
<td>4594</td>
<td>25%</td>
</tr>
<tr>
<td>Natural Gas, bcm</td>
<td>2176</td>
<td>3510</td>
<td>4049</td>
<td>62%</td>
</tr>
<tr>
<td>Nuclear, TWh</td>
<td>2106</td>
<td>2386</td>
<td>3761</td>
<td>13%</td>
</tr>
<tr>
<td>Hydropower, TWh</td>
<td>2286</td>
<td>3229</td>
<td>3826</td>
<td>29%</td>
</tr>
<tr>
<td>Biomass, Mtoe</td>
<td>1036</td>
<td>1277</td>
<td>1323</td>
<td>23%</td>
</tr>
<tr>
<td>Other renewables*, TWh</td>
<td>44</td>
<td>515</td>
<td>1999</td>
<td>n/a</td>
</tr>
<tr>
<td>Total Electricity production/year, TWh</td>
<td>12607</td>
<td>22202</td>
<td>23000</td>
<td>78%</td>
</tr>
<tr>
<td>Electricity production/year, MWh per capita</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>52%</td>
</tr>
<tr>
<td>Total CO₂ emissions/year, GtCO₂</td>
<td>21</td>
<td>30</td>
<td>42</td>
<td>44%</td>
</tr>
<tr>
<td>CO₂ emissions/year, tonne CO₂ per capita</td>
<td>4</td>
<td>4</td>
<td>n/a</td>
<td>11%</td>
</tr>
<tr>
<td>Energy intensity, koe/2005USD</td>
<td>0.24</td>
<td>0.19</td>
<td>n/a</td>
<td>-21%</td>
</tr>
</tbody>
</table>

Despite the fact that energy sources are not unlimited, accelerated growth has allowed industries to develop mass-production systems, essentially by extracting, processing and using resources indiscriminately up to the present day. This consumption of resources, the unmeasurable amount of waste, extinction of species, population growth and the environmental repercussions for future generations have triggered the recognition of sustainability as a matter of concern for the governments who are empowered to look after Mother Nature, imposing law and protecting the ecosystems, elements, resources and species inhabiting the planet (Robertson, 2014).
The resulting figures are indicators of the environmental impact and more importantly of the course followed by countries; most of them are increasingly following economic welfare rather than paying attention to environmental issues. In 1973, with the global energy crisis, better known as the Oil Crisis, the world faced for the first time the consequences of a whole system relying on petroleum collapsing. The International Energy Agency (IEA) was founded primarily to regulate oil price fluctuations and potential disruptions in the regular supply of petroleum (Coyle and Simmons, 2014). In addition the agency deals with recommendations on policies and suggestions for the development of new technologies and clean energy sources, but this is the political side of the organisation and not its real purpose.

The first time collective concern was promoted was by the United Nations (1987), which recognised the current problem and forthcoming consequences for the planet in the long term. The figures show a general unsustainable growth and usually these alarming figures are not given the weight they deserve. The demand of energy in the world is predicted to increase at a slightly lower rate; however, total emissions have doubled since 1993. To meet such demands, clean, efficient and sustainable sources of energy are the solution for the future, and indeed “there are more energy resources in the world today than ever before” (World Energy Council, 2013). Nevertheless, the situation is of concern the general public. GDP has increased dramatically by 180%: if compared the energy indicators and CO₂ emissions, shows a moderate increase there too, but not enough to preserve the environment.
4.3 Carbon Footprint

Over the past few decades, the concept of the carbon footprint (CF) has increased its popularity across the world. International organisations, governments and private companies have carried out CF studies and calculations to evaluate the impact of carbon emissions released to the atmosphere and the effect of such emissions to an existing problem known as climate change.

Several authors have suggested different definitions of CF, from different points of view. For instance, Connect4Climate (2010) proposed a simple explanation which suggests that CF refers to the mass of cumulated CO2 emissions, in other words “is a shorthand to describe the best estimate that we can get of the full climate change impact of something”. Figure 9 shows the impact of industrial activity, construction, transport, consumption patterns, lifestyle, among a wide variety of other activities that generate negative effects on climate change.
Figure 9: Global CO2 and non-CO2 greenhouse gas footprint for different consumption categories and users. (Hertwich & Peters, 2009)
On the other hand, Weidman and Minx (2007) are not satisfied about what in fact CF means and how it is used in present times. The initial intention of CF was to quantify accurate values and figures of certain chemical emissions and gases emanated to the atmosphere, including sophisticated LCA. However, it was not even clear what exactly was defined as a chemical threat for the environment and the way it should be quantified in terms of global impact or within the country of origin. Ambiguities like this have cast doubts on the reliability of the data provided by organisations and their lack of commitment to tackle an existing problem.

The role of organisations is not clear in terms of figuring out the environmental impact of their activities and how to counter with a short or long term plan to reduce them, which is the aim of the CF approach. Furthermore, companies nowadays use this information for commercial purposes rather than to minimise environmental impact. Despite its limitations and drawbacks, CF analysis can be utilised as a powerful tool to display key information with multiple variables related each other. With the right data and relevant information, the output can result in actions being taken that favour the environment. An example of relevant data can be seen in Figure 10 which compares and illustrates different types of variables such as CO$_2$ emissions in tonnes and different communities, matched with transport and energy, in a single chart.
As mentioned in previous chapters, the contribution made by the CI is remarkable in terms of achievements for mankind. However, the price of such achievements has been the continuous depletion of natural resources and non-renewable sources of energy. “Environmental impacts occur at every stage of the construction cycle: siting, production and supply of building materials and equipment, on-site construction, operation and demolition” (United Nations Environment Programme, 1994). The substantial consumption of non-renewable resources such as fresh water, minerals, wood and energy are clearly contributing to global warming and therefore to climate change, affecting every inhabitant in the world. The most significant environmental threats are analysed in six main aspects in the following paragraphs.
4.4.1 Biodiversity

Biological diversity is an essential element for a vigorous ecosystem. However, research carried out by the UK Green Building Council (2009) found that 39% of habitats in the UK and 27% of species are considered to be in decline, presenting a picture of accelerated deterioration. The impact generated by building activities on species is shown in Figure 11, which indicates the overall percentage of threat as a consequence of the consumption of natural resources for diverse purposes, among them building.

Figure 11: Species under threat globally: percentage of species assessed so far that are threatened (Source: The IUCN Red List of Threatened Species, 2014)

4.4.2 Climate Change

Efforts to minimise the impacts of building on climate change are still poor. Green building is an innovative alternative to minimise the effect, as described in chapter two. However, old and existing housing and office infrastructure demand high levels of energy; the direct consequence is the production of more energy to satisfy those demands, and consequently the intangible result is global warming. “The long lifespan of our buildings means that they are particularly at risk from, especially considering 87% of existing buildings will still be standing in 2050” (UK Green Building Council, 2014).
Figure 12 illustrates three measurements of the increase of temperatures recorded over around 150 years. The trend shows an increase of 1°C which in terms of global temperature results in severe impacts reflected in several kinds of natural phenomena such as floods, ice melting, high sudden extreme high and low temperatures, drought, and erosion.

4.4.3 Energy and Carbon

Global energy consumption demand trends show a dramatic waste and consumption of energy in its diverse forms. “Our built environment is vital in the fight against climate change as about 45% of CO$_2$ emissions in the UK come from energy used in our homes and buildings” (UK Green Building Council, 2014). The global built environment across the world currently accounts for between 40% and 50% of the total consumption of natural resources, 20% of total fresh water consumption and between 30% and 40% of energy consumption, consequently generating nearly one third of global CO$_2$ worldwide emissions. The levels of CO$_2$ emissions from different
sources are predicted to increase significantly with the current rates of consumption and increase of population in the near future, as shown in Figure 13.

The continued use of old-fashioned designs and inefficient facilities are major problems challenging the industry. New building facilities are meant to be ‘Zero Carbon’ according to new standards and regulations targeted to this sector. However, existing facilities still need to be refurbished and modified to adapt to new standards of energy consumption as well. Eco-friendly buildings designed and developed with an efficient approach are catching the preference of an increasing number of people who are looking for affordable, reliable buildings which cover essential needs.

![World energy-related carbon dioxide emissions by fuel type, 1990–2040](source: U.S. Energy Information Administration, 2013)

### 4.4.4 Materials

In the UK, CI is the largest consumer of materials for construction according to the study carried out by the HM Government (2008) and his plan to diminish the existing problem related to the environment described in Table 5, with around 400 million tonnes of materials used every year, is an clear indicator of the deterioration of the environment as a consequence of such consumption figures.
### Table 5: Joint Government/Industry Strategy for the Construction Situation (HM Government, 2008)

<table>
<thead>
<tr>
<th>Chapter Headings</th>
<th>Overarching Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procurement</strong></td>
<td>To achieve improved whole life value through the promotion of best practice construction procurement and supply side integration, by encouraging the adoption of the Construction Commitments in both the public and private sectors and throughout the supply chain.</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>The overall objective of good design is to ensure that buildings, infrastructure, public spaces and places are buildable, fit for purpose, resource efficient, sustainable, resilient, adaptable and attractive. Good design is synonymous with sustainable construction. Our aim is to achieve greater use of design quality assessment tools relevant to buildings, infrastructure, public spaces and places.</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td>To enhance the industry’s capacity to innovate and increase the sustainability of both the construction process and its resultant assets.</td>
</tr>
<tr>
<td><strong>People</strong></td>
<td>An increase in organisations committing to a planned approach to training (e.g. Skills Pledges, training plans; Investors in People or other business support tools; Continuous Professional Development (CPD); life long learning). Reduce the incidence rate of fatal and major injury accidents by 10% year on year from 2000 levels.</td>
</tr>
<tr>
<td><strong>Better Regulation</strong></td>
<td>A 25% reduction in the administrative burdens affecting the private and third sectors, a 30% reduction in those affecting the public sector by 2010.</td>
</tr>
<tr>
<td><strong>Climate Change Mitigation</strong></td>
<td>Reducing total UK carbon dioxide (CO2) emissions by at least 60% on 1990 levels by 2050 and by at least 26% by 2020. Within this, Government has already set out its policy that new homes will be zero carbon from 2016, and an ambition that new schools, public sector non-domestic buildings and other non-domestic buildings will be zero carbon from 2016, 2018 and 2019 respectively.</td>
</tr>
<tr>
<td><strong>Climate Change Adaptation</strong></td>
<td>To develop a robust approach to adaptation to climate change, shared across Government.</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>To assist with the Future Water vision to reduce per capita consumption of water in the home through cost effective measures, to an average of 130 litres per person per day by 2030, or possibly even 120 litres per person per day depending on new technological developments and innovation.</td>
</tr>
<tr>
<td><strong>Biodiversity</strong></td>
<td>That the conservation and enhancement of biodiversity within and around construction sites is considered throughout all stages of a development.</td>
</tr>
<tr>
<td><strong>Waste</strong></td>
<td>By 2012, a 50% reduction of construction, demolition and excavation waste to landfill compared to 2008.</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td>That the materials used in construction have the least environmental and social impact as is feasible both socially and economically.</td>
</tr>
</tbody>
</table>
Not only does the depletion of resources negatively impact on the environment, but also the extraction and manufacturing of those resources implies the use of energy and other resources, as well as facilities that eventually will be transported and used in the final project, as shown is Figure 14 and Table 6.

*Figure 14: Life cycle of a construction project (Source: Construction Products Association, 2012)*
Figure 15 expands on the Building Life Cycle recycling process, in in every stage of the build process, emphasising disassembly as a critical process that becomes a cycle, feeding previous steps such as ‘Processing of Materials’, ‘Manufacture into Components’, ‘Assemble into Buildings’ and ‘Building Use’. The main purpose of this approach is to reduce considerably the use of raw materials, avoiding the environmental impact associated with their extraction. As a result, the amount of waste generated by this activity decreases significantly. Combining disassembly with

<table>
<thead>
<tr>
<th></th>
<th>Extracting virgin resources</th>
<th>Manufacturing</th>
<th>Packaging</th>
<th>Transport</th>
<th>Waste Impacts</th>
<th>Site Impacts</th>
<th>Maintenance and Refurbishment</th>
<th>Demolition and disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>For materials such as aggregates, raw materials extraction will be one of the principal impacts, but for more highly processed materials the production impacts are likely to dominate</td>
<td>The impact of manufacturing can be the major environmental impact especially if large amounts of energy are required as in the production of metals or cement.</td>
<td>The impact of packaging is usually small though too little packaging can increase product wastage. The disposal of packaging is often a big part of its impact.</td>
<td>Transport impacts are generally small in comparison to other life cycle impacts. Even when construction products are moved globally they are normally shipped which has a low environmental impact in comparison to road transport. The exception is for products such as aggregates and timber, which have relatively low manufacturing impacts and therefore higher relative impacts from transport, though they are still small.</td>
<td>Waste can be generated at several different stages of the life cycle - during the manufacturing process, on construction sites and during maintenance, replacement and demolition. DEFRA estimates the construction industry is responsible for over 40 million tonnes of waste generated each year although the majority of this is reused, recycled or recovered.</td>
<td>Studies revealed that 10-15% of materials sent to a building site end up as waste – the impacts of producing these materials, that are then wasted, is a considerable impact associated with the construction site.</td>
<td>These activities are estimated to be 45% of contractor output so a significant proportion of extraction and manufacturing impacts are likely to occur for materials used during maintenance and refurbishment projects.</td>
<td>Some products are unable to be reused or recycled and therefore end up as waste in landfill. Emphasis is now beginning to turn to consider end of life issues at the very start of the manufacture of a product so that it can be deconstructed and reused or recycled easily at end of life.</td>
</tr>
</tbody>
</table>
the other processes in the regular flow of built environment, the material life cycle is extended exponentially and therefore the general resource consumption reduces.

![Diagram of building life cycle and waste production](image)

*Figure 15: Elements of building life cycle and waste production (Source: Crowther, 2005)*

An alternative scheme for mitigating and minimising the current problem is the use of substitute recycled materials, reducing considerably the impact of traditional methods of construction. The design of new materials based on disposal and waste from demolition, for instance, is another interesting challenge currently carried out by some companies. The identification of LCA for those materials and facilities is the key to a dramatic decrease of the environmental impact.
4.4.5 Waste

The generation of waste by the construction and demolition sector has positioned both industries as the largest generators of waste in the UK, accounting for 120 million tonnes every year. The efficiency of materials is a limitation on current methods of construction, and therefore the waste is generated in different phases of the life cycle, as shown in Figure 16.

![Figure 16: Phases of waste generated in life cycle assessment (Source: Construction Products Association, 2012)](image)

LCA studies are important in quantifying overall impact; they consider various factors such as extraction, manufacturing, transport, installation, maintenance and disposal (see also Table 6). More sophisticated studies can reveal more details of the impact, particularly on those materials or products that cannot be reused. To manage and avoid excessive waste disposal, companies are regulated to follow a specific hierarchy to control waste: see Figure 17.
4.4.6 Water

The wide consumption of water resources for construction purposes varies depending on the phase, from the extraction of virgin materials to end-users. The current patterns of water consumption are alarming since it is believed that every person consumes around 150 litres of fresh water every day and it is predicted that this figure will rise in the near future due to increasing numbers of periods of drought and sudden rain, inducing the collapse the drainage systems of towns in England.

The preservation of water becomes potentially one of the most critical aspects of global warming. The shortage of land and landscapes has a significant impact not only for the draining systems equilibrium, but also for the biodiversity of species, which is particularly threatened in big cities. Also 5% of the UK’s total GHG emissions are due to hot water used at homes. Water is essential to the life of human beings and all kinds of species, and to make it drinkable and available to the community on a regular, uninterrupted basis demands the use of energy and specialised treatment facilities. New equipment, devices and creative designs of buildings capable of managing water resources properly are the current challenge for designers and architects. The purpose is to reduce the usage of water by a third over fifteen years, and this should generate a positive impact on the environment and also on the economy.
5. INTEGRATION OF VALUE MANAGEMENT AND SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY

The increase in awareness of Sustainability in the construction industry has intensified the search for methods which enables the incorporation of sustainability into the existing construction working environment. As one of the universally accepted method for value optimisation, value management study has shown great potentials of being the tool to enhance the integration of sustainability into the project plans, designs and decisions to achieve maximum sustainable value for the project objective in the most effectively and efficiently way. The process of integrating these two concept, VM and sustainability is not new as most value expert have proposed the idea and publications presented at the international conferences of the Institute of Value management (IVM) address this topic. The environmental, social and economic problems can be addressed by a sustainable value management agenda or model therefore ensuring value for the project stakeholders. Integrating sustainability during VM study will most likely generate economic and social advantages whilst minimising the environmental damages by employing suitable and environmentally friendly approach.

5.1 Applying Sustainability into VM Process

“Sustainability issues should not be addressed as separate or individual issues, but should be considered at the pre-workshop phase as inputs and at the workshop phase as the processes which is the sustainable development in order to deliver the desired outcome which is sustainability” (Robert, 2000). Sustainability issues should be considered at the information, creativity and evaluation phases of the generic VM
process with uncertain outcomes at the technical level. Figure 18 presents the consideration of sustainability issues in the three generic VM phases

*Figure 18: The three effects of integrating sustainability into VM (Source: Abidin and Pasquire, 2007)*

The input of sustainability: Abidin and Pasquire (2007) explained that at the pre-workshop stage, the need of clients are defined and the information required for the workshop are gathered. They also stated that the importance of sustainability issues to the project should be made explicit to attract clients’ interest and stimulate demand for it (Abidin and Pasquire, 2007). They highlighted that the commitment to sustainability at this stage of VM practices is vital to secure the inclusion of these issues throughout the VM activities, and presented the activities involved in raising awareness on sustainability at this early stage of VM. This is presented in Figure 19.
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Figure 19: Improving awareness on sustainability at pre-workshop phase (Source: Abidin and Pasquire 2007)

Processing sustainability: The application of the pre-workshop agenda to produce the best solution or action plan for the client’s objectives is carried out at the workshop phase (Abidin and Pasquire, 2007). The degree to which the sustainability is considered in a project is influenced by the client and must be identified during the pre-workshop phase and clearly made aware to all value participants at the earliest stage of the VM workshop. During the creative phase ideas are generated and evaluated with the established project features and objectives. The most suitable idea is further developed and presented to the client representatives for approval with important features such as economic returns, social interest, environmental impacts and estimated construction cost and time clearly stated. Figure 20 illustrates the sustainability targets delivered through VM workshop activity with the inclusion of the pre-workshop and post-workshop effort.
Figure 20: Tasks relating to sustainability consideration in VM (Source: Abidin and Pasquire 2007)

The output of Sustainability: Post-workshop is where the proposal is implemented. The action plan generated during the workshop phase can be accepted, partially accepted or reject by the client. On approval of the proposal an action plan and post-workshop strategy is formulated. Figure 18 illustrates that integrating sustainability into VM process indicates an enhanced output of tangible value (profit, life cost, lesser time and quality enhancement) and intangible value (responsibility, pride and image).

5.2 Constraints of Integrating Sustainability and VM

Value experts have identified the following practical constraints which impedes the incorporation of sustainability into Value management process.

Lack of commitment from the clients: negative perception and lack of interest from the client due to perceived increase in project budget is a major barrier to the integration of sustainable targets into VM. This is as result of the client’s misconception of VM
as a cost reduction technique and the integration of sustainability as an additional cost, therefore opposing the VM principles.

*Lack of understanding of both concepts by the VM professionals:* Value managers should be experienced and well equipped with information about the ideologies and application of sustainability in construction in order to appropriately organise and manage the process and Value team for the successful incorporation of the two concepts.

*Lack of time:* According to Al-Saleh and Taleb (2010), incorporating sustainability into VM increases the overall VM process time because the aspects of sustainability are too vast and may need several VM workshops to be completed. Also the value experts need time in the pre-workshop phase of VM to persuade a non-committed client and stakeholders to consider Sustainability in the VM study because of its benefits to the project.

*Increase in cost:* The client’s approach towards integration of sustainability into VM process has been as a result of the misconception that sustainable practices increases project budget and construction projects are often characterised by budget overrun. On the Value experts have proven that sustainability generates reduced project overall life cycle cost because the sustainable value management study will help identify the most appropriate method and material to be used in the construction. According to Norton and McElligott (1995) “VM process can cut the total cost of a project by 10%, whilst only costing 1% of the total project cost to carry out, therefore, generating a savings ratio of 10:1”.

*Lack of framework:* the absence of a universally accepted model for integrating Sustainability and VM is a barrier to this approach.
6. MODELS

6.1 Existing Structural Model for VM and Sustainability Integration

Figure 21 shows the existing structural model for the integration of sustainability into VM. This process is carried out in three main phases:

1. Pre-Workshop
2. Workshop
3. Post-Workshop

6.1.1 Pre-Workshop Phase

The pre-workshop phase is the point in the sustainable VM study where the client identifies the project value drivers in conjunction with the sustainable target of the project. The stakeholders, value managers and value practitioners will then discuss and decide which of the value drivers and sustainability targets are beneficial and feasible for the project. The desirable value drivers and sustainable target information are then used to develop a structured project agenda to be considered for sustainable purposes at the following workshop phase. The commitment of sustainability in the project is well defined and every value management team member should be informed and work towards the achievement of a successful project.

6.1.2 Workshop Phase

After the pre-workshop phase has been carried out, an agenda for the workshop stage should be produced. The workshop phase is where the stakeholders make decisions that strive to accomplish the value drivers and sustainability targets set in the pre-workshop phase. The workshop phase is structured around a job plan which involves six activities. The first activity is to provide a detailed understanding of the necessary
information of the project to the team members. The function analysis is the next activity where the team members brainstorm to determine the function the project should deliver at its completion. The brainstorming is carried out bearing in mind the sustainability target in order to generate options for the creativity stage. The creativity stage is where ideas are developed by team members to tackle the stakeholder’s objectives. The ideas generated are evaluated based on their feasibility to solve the set function objectives. Some evaluation techniques include SWOT analysis and decision matrix.

The selected idea then proceeds for further development and the final workshop report is generated and presented to the value manager to be discussed with the stakeholders to ensure that all the objectives have been considered, and for acceptance and approval of an action plan for implementation. In the case where the proposal is partially accepted, the value team members have to review the proposal. In the event of complete proposal rejection by the client, the VM workshop has to be carried out again.

6.1.3 Post-workshop phase

This is where the action plan made in the workshop phase is implemented and any post-workshop meetings are held to resolve any disputes
6.1.4 Shortcomings of the existing model

The shortcomings of the existing structural model for integrating sustainability into VM are discussed in this section.

1. The model does not clarify where the sustainable targets are identified but goes on to relate it with the value drivers.

2. The acceptance, partial acceptance and rejection of the proposal should be carried out at the end of the workshop stage.

3. There is no linkage from a revised proposal at the post-workshop phase.

4. The existing model has been drawn using a flow chart rather than Data Flow Diagram (DFD) and does not indicate the flow of data from any external input internal database.

5. The layout of the existing model is complex and not easy to understand due to too much information on the diagram. It should be separated into levels for simplicity.
Figure 21: Existing structural model for integrating sustainability into VM (Zainul-Abidin and Pasquire, 2005)
6.2 Improved Proposed Model for Integration of Sustainability into VM

The proposed model, Figure 22, is a simplified diagram of the existing structural model for integrating sustainability into VM proposed by Zainul-Abidin and Pasquire (2005). The recommended diagram is drawn using Microsoft Visio which considers three different phases (pre-workshop, workshop and post-workshop) drawn at two levels of DFD. The model consists of a main database used for storage of all VM information and a secondary workshop database to store information carried out throughout the workshop phase which is later transferred to the main database. A decision making process is carried out after the workshop phase by the client, Value Manager, and VM expert. The client can accept, partially accept and decline the proposal from the workshop phase.

The dataflow for DFD (level 0) diagram, Figure 22, starts from the pre-workshop phase, where the project features, client objectives and sustainability target are identified. The project information and workshop agenda are stored in the main database and established within the Value team members at the workshop information phase. On completion of the workshop activities, the most suitable idea to meet client’s objectives is to develop and present to the client for approval, which is then saved to the workshop database. The approved idea is implemented at the post-workshop phase and post workshop meetings are arranged for resolution of any dispute or any changes in the workshop action plan. A final VM process report is document for use in the future.
Figure 22: Proposed Level 0 DFD for Integration of VM into sustainability model
6.2.1 Pre-Workshop Phase DFD (Level 1)

The pre-work phase DFD level 1 consists of the following activities: selection of value team members, information gathering based on client objectives and sustainable aspects, analysis of the information gathered and developing an agenda for the workshop phase as illustrated in Figure 23. It is important to get a good size and mix of skill for the value team and to clearly inform all team members of their roles and commitments. A huge Value team will constitute problems such as long period of decision making process and inadequate skills to achieve client’s goals. Information gathering can be carried out using the following techniques: interviews, surveys and questionnaires.

![Figure 23: DFD Level 1 – Pre-Workshop Phase](image)
6.2.2 Workshop Phase DFD (Level 1)

The workshop phase consists of six activities job plan to be systematically applied to generate an approved idea. After the evaluation phase, a decision is made to proceed with the selected idea or go back to the creative phase to generate more suitable ideas. When an ideal is approved at the decision stage it is further developed for presentation to the client for approval.

Figure 24: DFD Level 1 – Workshop Phase
6.2.3  Post-Workshop Phase DFD (Level 1)

This is the phase used to implement the action plan set up at the workshop phase. Post workshop meetings are arranged to resolve any disputes or change in scope and also to review how well the client’s objectives and sustainable issues were addressed. A the final documentation report is produced highlighting project costs, the problems encountered during the process and the advantages of applying VM into Sustainability in terms of environmental, social and economic benefits.

\[\text{Figure 25: DFD Level 1 – Post-Workshop Phase}\]
7. TOWARDS BETTER SUSTAINABLE CONSTRUCTION INDUSTRY

7.1 Recommendations

Both topics, sustainability and VM, are specialised areas of knowledge. The industry is currently being forced to combine sustainability into VM and vice versa, and almost every single project is now being carried on this basis. Although the topic is relatively new, the existing literature is subject to improvements proposed by the researchers of the current dissertation, arising from the following recommendations that include:

1. Despite the fact that the economic factor rules the hierarchy of priorities in the majority of projects, the emphasis on environmental issues is not an optional choice; a series of compulsory regulations have been implemented by government organisations to mitigate the impacts on the environment. For that reason it is important to prioritise the ‘green’ approach in the workshop phase.

2. The stakeholder’s role in enhancing VM and sustainability influences the importance given to one of the two issues; mainly the clients are looking for value added in terms of economic benefits, overlooking the sustainable part. The recommendation is to clearly define and state the client’s requirements, boundaries and scope, then make suggestions though the multi-disciplinary team of people in order to come up with the best alternative for the client. To achieve this, it is suggested that this approach should be carried out at the pre-workshop stages.
3. The importance of generating multiple alternatives throughout the workshops with clients is essential, to compare what is the most suitable option in terms of social, economic and environmental benefits.

4. The early meetings between the members of the VM team and stakeholders play a key role in introducing the sustainable approach into the project. The recommendation is to try to persuade the stakeholder to become involved in sustainable approaches.

7.2 Conclusions

The integration of VM and sustainability approaches to deliver a value-based outcome is benefitting clients, stakeholders, communities, the environment and the economy, providing enormous advances in the CI and at the same time promoting the research and development of new technologies to reduce the clear negative impact generated to the environment by the CI.

In some countries compulsory policies and regulations are intended to accomplish specific goals and objectives to reduce the impact generated on the environment, limiting traditional practices to be used and boosting creativity, innovation and increasing knowledge within the sector.

The introduction of sustainability into VM has changed over the past few decades. From the time that traditional VM was a process alone, the inclusion of sustainability has converted it into a sophisticated process where a specialised group of people from different disciplines work together. Staff, together with project sponsors, clients and stakeholders develops the best alternative to fulfil three basic demands in a project – environmental, social and economic – with a value added approach, within time and budget.
The decision making process once the alternative is on the table minimises the risks of failures. Since the planning phase demands a long period of time, it is essential this analysis is carried out in early stages of the project to avoid any delays or last minute changes in the original plans.

The application of sustainability into VM has brought a number of benefits, particularly to the environment. However, the awareness of sustainability issues is still being overlooked when it comes to economic priorities in certain projects. The effectiveness of the application of sustainability into VM depends on persuading staff, team members and clients to make the changes possible and feasible.

Although the models are meant to cover a whole range of projects, they can potentially not work in certain scenarios, simply because every project has its own outcome and purpose for clients and stakeholders. However, the models previously mentioned are a significant contribution and could be used as a guidance.
REFERENCES


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REFERENCES


REFERENCES


