An Innovative Methodology to Achieve Sustainability of Construction Projects in Australia – A Conceptual Study

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Abstract
The sustainability at construction can be defined as the effective project delivery without compromising the project cost, environmental and social impacts. However, sustainability at construction is often conceded due to several limitations in data collection, assessment and the project specific constrains. Eventually majority of the construction projects are directed towards achieving only one sustainability aspect in construction. Stakeholders in construction who are passionate about sustainability recognize the importance of maintaining a balance between the major sustainability aspects in construction. The current study has made an attempt to investigate and criticize the current tools and studies available to measure sustainability in construction. Based on the findings a new methodology is suggested to enable effective decision making which allows the integration of sustainability aspects in construction. The study is also a part of the initial research work on developing a sustainable toolkit to achieve effective decision making at construction.

Keywords
Sustainability, Construction, Cost, Environmental impacts, Optimisation

1. Introduction

Sustainability of a project is defined as the successful project completion with minimum environmental and social impacts (Ortiz, Castells et al. 2009). However, the major objective of a contractor is to successfully deliver the project with a maximum turnover. Besides the economic gains, due to the social obligations the contractor is compelled to minimize environmental and social impacts during the project delivery. The construction industry is found to be one of the major sectors that have high energy consumption and environmental emissions (Sandanayake, Zhang et al. 2016). Compared to other industries, construction industry is often subjected to more social scrutiny due to physical exposure to the public. Thus, contractors are frequently faced with the dilemma of having to compromise huge cost implications on trying to minimize these impacts. Moreover, the passionate contractors who are keen on maintaining a balance between the environmental and economic benefits find it extremely difficult to assess due to lack of decision making tools (Ding 2008).

At present there are several assessment tools that can measure sustainability aspects at the construction stage (Ding 2008). Majority of the tools are developed to assess one performance criteria which often results in time consuming assessment in comparing multiple criteria (Banani, Vahdati et al. 2016). For instance, the decision maker is compelled to use several assessment tools when comparing cost, environmental and social impacts from a construction project. In spite of the current assessment tools, stakeholders in the construction industry criticize the lack of a single tool that possess the potential of decision making at design stage to optimize the three major aspects (Sandanayake, Zhang et al. 2016). Moreover, integrating all the sustainability aspects to achieve decision making seems to a daunting task at present. Several emission studies in the construction stage of a building have stated the importance of detailed information of construction activities to conduct a comprehensive emission analysis at building construction (Yan, Shen et al. 2010, Sandanayake, Zhang et al. 2016). In some studies, difficulty to capture construction specific information and data are listed as one of the major issues of construction emission studies being neglected (Guggemos and Horvath 2005, Mao, Shen et al. 2013). Moreover the dynamic nature of construction, involvement of several stakeholders, transparency issues in data collection and communication barriers are some of the major complications that lead to data capture issues that complicates sustainability assessment of construction projects.

Sustainability assessment methods can be categorized into two types; assessment tools that measure sustainability aspects and guidelines or standards that provide a guideline to achieve a rating system (Ding 2008). In Australia, Green Star rating and ISCA ratings published by Green Building Council of Australia and Infrastructure Sustainability Council Australia (ISCA) provide valuable directions on how to achieve sustainability of a building or infrastructure project (Lees 2013, GBCA 2015). However there is no information provided on how to achieve those sustainable points. Especially in the case of construction stage of a project, where a number of constraints are affecting the sustainable delivery of a project seems to be a distinct achievement.

Therefore, the present study suggests an innovative methodology to capture, assess and optimize the sustainability aspects at the construction stage of a project. The methodology is the initial step towards developing a sustainable toolkit which will enable the decision making of designers and contractors in the construction industry.

2. Towards an innovative methodology to measure sustainability

The methodology suggested to achieve the sustainability during construction stage of a project involves three major steps. It was observed that Assessment of environmental and social impacts at construction requires considerable amount of data. However, with strict budgets and timelines, contractors are unable allocate additional resources to collect required data for sustainable assessment. Several other data capture issues, transparency issues and communications issues also occur due to the dynamic nature of the construction. Thus, the first step is to effectively capture the required data for the sustainable assessment. This is accomplished by developing a data capturing paltform that integrates the Building Information Model (BIM) and Infrastruture Information Model (IIM) to obtain the required infromation.

The next two steps are to conduct assessment and optimization to obtain the most feasible sustainable outcome that can be implemented by the construction contractor at the site. Figure 1 highlights the process suggested by the research team for obtaining sustainable optimized targets for various construction projects.

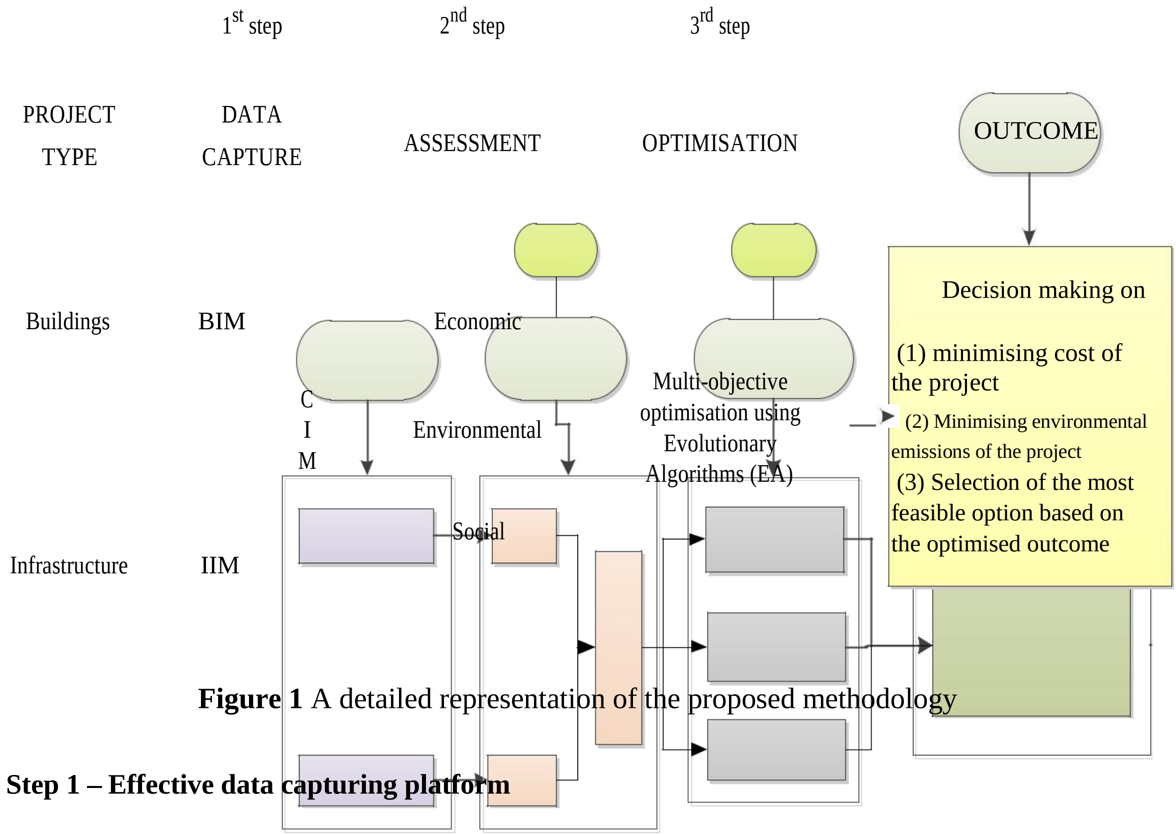

Figure 1 A detailed representation of the proposed methodology

2.1 Step 1 – Effective data capturing platform

At present all the construction projects including building and infrastructure projects are progressing towards a digitized platform in information management (Cheng, Lu et al. 2016). These models are called either Building Information Model (BIM) or Infrastructure Information Model (IIM) and are able to track the live progress of the construction project with accurate cost estimations (Hardin and McCool 2015). However the current BIM or IIM models are not capable of providing detailed information required for the sustainability assessment in construction projects. Thus an innovative information management platform is suggested to manage the information at design and execution stages of construction to perform a comprehensive sustainability assessment.

The data capturing platform; Construction Information Management (CIM) system is designed to effectively capture information required for the sustainability assessment at building construction. It provides an innovative solution for acquiring information both at design stage and construction stage to conduct sustainability assessment at the construction stage. Data libraries, templates and databases developed in CIM platform with end-to-end encryption will reduce the data transparency and privacy issues in data inputs. Integration of the CIM platform with the ongoing BIM or IIM models will significantly improve the issues like time management, co-ordination and integration issues. Figure 2 illustrates the information flow through CIM platform to capture necessary data required for sustainability assessment. The CIM platform designed can address four major issues in data capture.

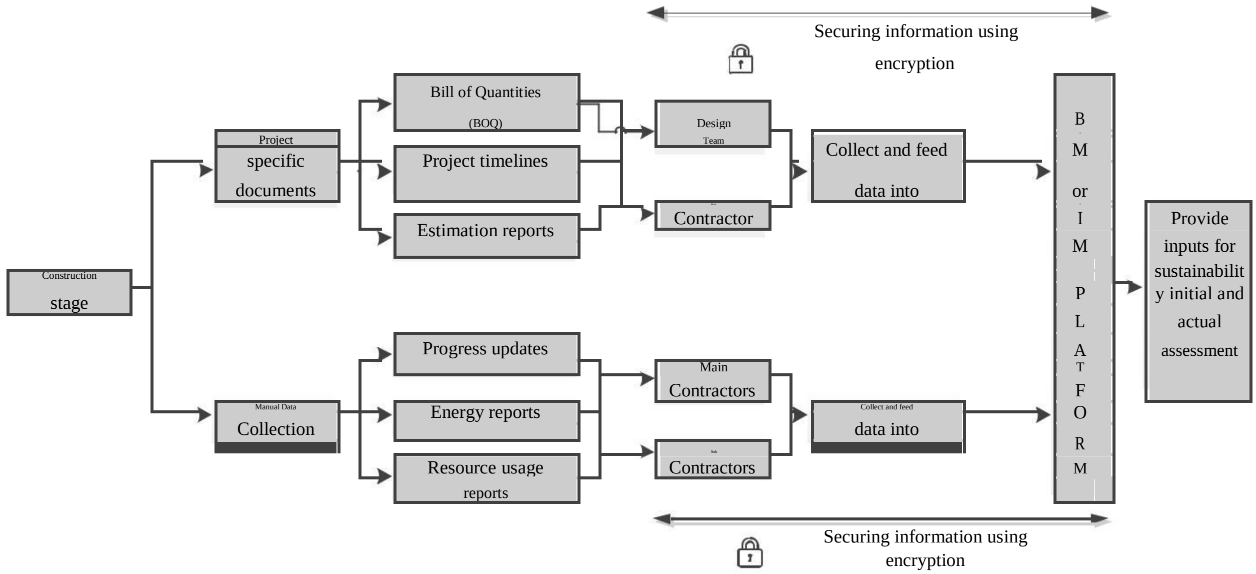

Figure 2 Data Capturing Platform using CIM

2.2 Step 2 – A comprehensive assessment criteria

The assessment criterion is mainly focused on estimating the three major aspects of sustainability at the construction stage and the important aspects to be considered in conducting the assessment.

- Environmental impact assessment methodology and aspects

Environmental impact assessment is expected to capture the major aspects of construction that contribute to environmental impacts. The major sources of environmental emissions at the construction stage are due to embodied emissions from construction materials, emissions due to equipment usage and transportation and emissions due to electricity consumption (Yan, Shen et al. 2010). These emissions are divided into direct and indirect emissions based on the emission type (Sandanayake, Zhang et al. 2016). The emissions are then categorised into several impacts

Figure 3 summarises the assessment process to estimate emissions that contribute to air quality. Apart from air quality damage the following environmental impacts will be considered in the assessment.

Energy consumption – This impact category aims to energy consumed during equipment usage, electricity consumption and materials usage. Any actions taken to optimise energy consumption can be merited using the evaluation scheme suggested in the assessment.

Land usage and ecology – Land usage measure the percentage of green lands used during the construction and the amount of damages to the eco system in terms cutting down trees. The category will also reward any replantation adopted during the process and any measures undertaken to reduce hazardous materials into land and environment.

Water consumption – The impact aims to measure the amount of portable water used during the construction stage of the project. This water usage will merit the recycle water used for fresh sewage processing.

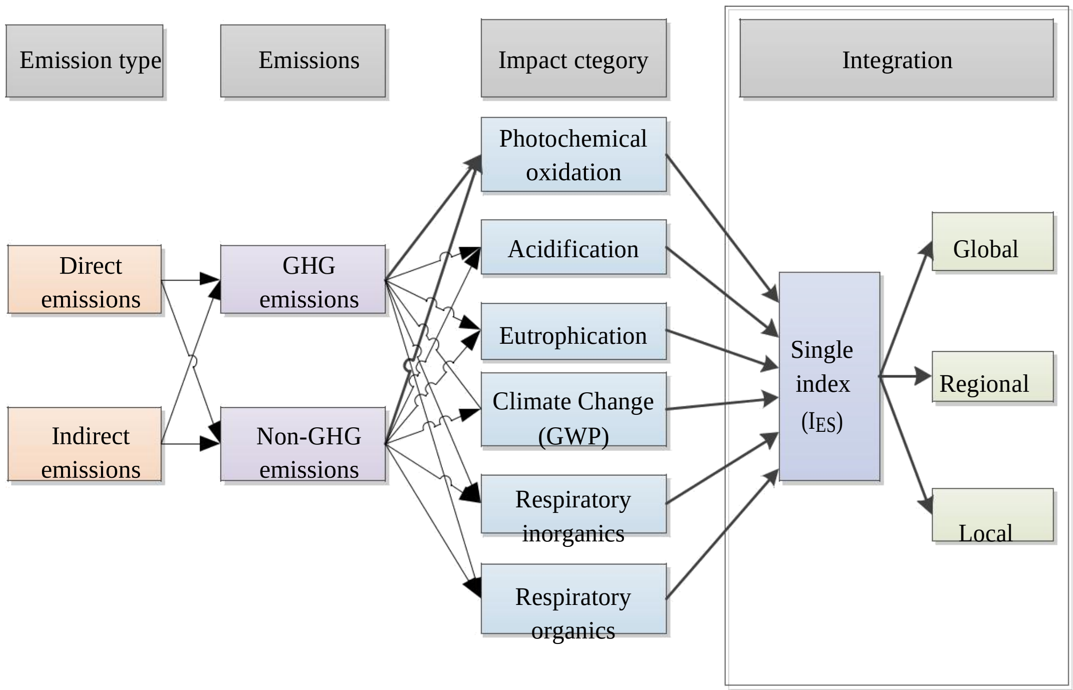

Figure 3 The suggested environmental impact assessment for air quality at the construction stage

These assessment criteria will cover the following aspects related to environmental impacts at the construction stage.

Energy and Carbon – The assessment will estimate the energy consumption and carbon emissions associated with each emission source at the construction stage of a project.

Land and water usage – The environmental assessment suggested in the study is will measure the land and water used for the construction. The land usage will incorporate the effects of using green lands, farm lands. Water usage aims to measure how effectively the project has managed the water consumption by minimising potable water usage.

Materials and waste – The aspect will measure the material usages, estimate wastages, calculate the amount of materials recycled or reused and the contribution towards the environmental impacts.

Discharges to air, land and water – Air, water and land pollutions and the corresponding impacts will be estimated in this aspect.

- Economic and social analysis

Economic analysis at the construction stage should focus on evaluating construction costs associated with major activities of construction.

2.3 Step 3- Detailed decision making process

The major objective of a sustainable contractor is to maximise the overall project while minimising environmental impacts. However achieving economic and environmental sustainability is often influenced by the project specific limitations such as resource availability, construction quality, duration and safety (Zhong, Ling et al. 2016). The multi-criteria approaches suggested in literature studies are highly subjective and unable to include analyze all the constraints effectively (Ding 2008). Therefore an optimization methodology using evolutionary algorithms is suggested to obtain the feasible sustainable solutions without compromising the project specific limitations.

Evolutionary algorithms is a useful methodology in finding a feasible optimal set of solutions (Deb and Sundar 2006). The method is useful when multi-objective optimisation is required to achieve the most feasible output (Fonseca and Fleming 1995). The following example shown in Figure 4 highlights a Cost vs. Emissions curve for specific construction activity subjected to several site constraints such as transportation distance, availability of materials and resource usage optimisation. It is seen that options A and D are the optimal solutions if only emissions and cost are considered respectively. However it is evident that they are not the most sustainable solution considering both cost and emissions together. Evolutionary algorithm will help to identify this most sustainable solution (which lies in between A and D) for the given activity subjected to the mentioned constraints.

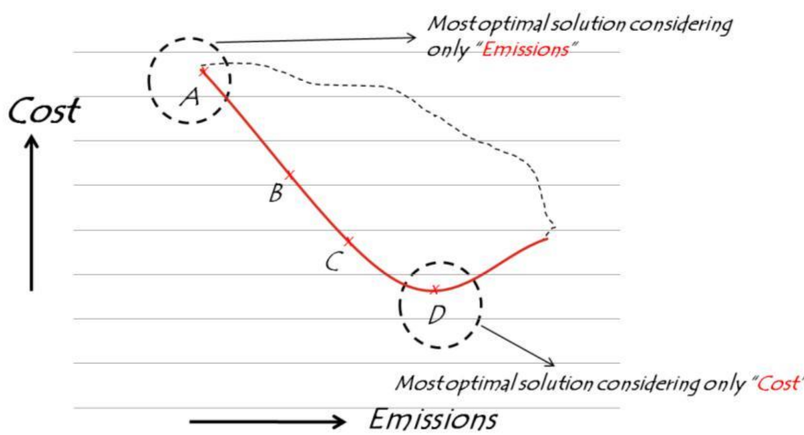

Figure 4 Cost vs Emissions curve drwan for a specifc activity

3. Concluding Remarks and recommendations

Sustainability in a project can often be defined as the achievement of project delivery with effective management of environmental and social impacts. This broad concept is the basis of sustainable development and judgment criteria in ensuring long-term economic, environmental and social well-being of the society. Applied to the construction industry, this can be achieved by efficient resource allocation, use of sustainable materials, minimizing energy consumption and minimizing construction waste in terms of reuse and recycling.

Construction industry is one of the largest sectors of resource consumption and contributors of environmental emissions. Besides, construction industry is often subjected to public criticism due to major social impacts that affect the general public. Amidst all these concerns, contractors are obliged to maintain a healthy turnover to achieve high economic goals of the organization. Thus, sustainable delivery of a construction project is a daunting task, with contractors facing with the dilemma of upholding a balance between economic, environmental and social impacts. Consequently, an integrated methodology or tool will no doubt contribute in achieving the sustainable standards in construction. On one hand it will provide a guideline for evaluating sustainable aspects in construction, whilst on the other it can act as a comparative tool to compare sustainable performance of several construction projects.

The paper investigated several studies and sustainable tools that are currently available to identify the drawbacks, limitations and complications in analyzing environmental, economic and social impacts at the construction stage. The review observed that these limitations associated with data capture, capabilities in assessment tools and decision making skills in the current assessment tools and methods restrict a comprehensive sustainable assessment at the construction stage. However, there is a contemporary requirement of a sophisticated tool that integrates all the sustainable aspects to assist decision making.

The paper suggested an innovative methodology that has the potential of addressing the three major limitations of sustainability assessment; data capture, comprehensive assessment and decision making. The BIM and CIM based platforms suggested in the methodology can accomplish the process of effective information management. The detailed assessment methodology proposed in the paper provides insights in evaluating cost, environmental and social aspects of construction projects. In-depth analyses at activity level will simplify the decision making in selecting optimum materials, equipment and transportation. Unlike other multi-criteria approaches, the optimization approach prior to decision making will provide more practically feasible solutions without compromising site based limitations.

The paper presents an initial study that suggests an integrated methodology for assessing sustainability aspects in the construction process. The research team is in the process of developing a similar automated toolkit that enables effective decision making prior to execution at the construction stage. Once developed, the tool will have the capacity to enhance the decision making at construction project level. Further studies are also encouraged on developing the tool into a complete process that can assist decision making at organization level.

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