

CONCEPTUAL TRANSFORMATION PROCESS MODEL FOR SUSTAINABILITY IN THE INFRASTRUCTURE SECTOR

RASHEED BABATUNDE ISA¹; FIDELIS EMUZE² AND DILLIP KUMAR DAS³

¹Doctoral student, Unit for Lean Construction and Sustainability, Central University of Technology, Free State, 20 President Brand Street, Bloemfontein, 9300, South Africa, Tel: (027) 781183338 Corr. E-mail: risa@cut.ac.za

²Associate Professor, Department of Built Environment, Central University of Technology, Free State Private Bag X20539, Bloemfontein, 9300, South Africa Tel: (051) 507 3089 Fax: (051) 507 3254 E-mail: femuze@cut.ac.za

³Senior Lecturer, Department of Civil Engineering, Faculty of Engineering and Information Technology, Central University of Technology, Free State, Bloemfontein, South Africa, Email: ddas@cut.ac.za

Business as usual (BAU) model of infrastructure delivery is contrary to the needs of sustainability in the built environment. This gap necessitates a South African study that is focus on sustainability in the infrastructure sector. A review of the management corpus led to the discovery and review of transformation process model, which was thereafter infused with core principles of lean and sustainability. The purpose of this paper is to present the preliminary findings of a case study used to assess the robustness of the conceptual model. Through the analysis and synthesis of collected data, it was discovered that a transformation model could serve as a purposive vehicle for embedding sustainability in the delivery of infrastructure projects in South Africa. The study also noted the need for further research that will serve confirmatory purposes for the proposed model.

Keywords: Infrastructure, Lean, Transformation Model, Sustainability, South Africa

1.0 INTRODUCTION

Construction industry in several developing countries has undergone transformation in a bid to cope with their national economic goals to align production (and consumption) practices with the growing global sustainability trends (Mousa, 2015). However, the approach adopted in meeting the current needs for infrastructure does not always conform to sustainability requirements. Business as usual (BAU) model of construction practice and infrastructure delivery is contrary to the needs of sustainability in the built environment. Infrastructure projects delivery can no longer be viewed in isolation, as it affects all sectors of the economy and accounts for about 50% of energy use. Construction activities have a major impact on physical development, government policies, community activities and welfare programme. In the United States of America (USA), buildings alone account for 40% of municipal solid waste, 30% of raw material use, 12% of portable water use, 49% of all energy produced, 77% of electricity produced, and 46.9% of carbon dioxide (CO₂) emission (Floyd and Bilka, 2012). These

do not only deplete the earthly physical resources, the transformation from mining raw material into the finished enclosure also requires huge amounts of embodied energy, with a potential contribution to the current planetary adjustment (Novak, 2012).

Sustainability is a growing economic development model based on the knowledge that aims to address the interdependence of economic growth and natural ecosystems and the adverse impact economic activities can have on the environment (Bangdome-Dery and Kootin-Sanwu, 2013). The available models for sustainable construction have not been able to move the development of construction industry policies to establish recognized practices of sustainable construction (SC) in South Africa. It has also been argue that less effort has been geared towards the adoption of modern framework that can enhance knowledge and understanding of the issues that could foster SC in a developing country (Mensah *et al.*, 2015).

Infrastructure development globally has served as measure for societal growth, however, is a major contributor to the proliferation of greenhouse gases (GHG), waste generation as well as the depletion of the inert resources (Forbes and Ahmed, 2011; Banawia and Bileca, 2014). The limited nature of non-renewable natural resources exposes the symptoms in the ecosystem of the unsustainable manner in which these resources are depleted. Therefore, the construction industry is anxious for the introduction of proactive measures that can spur the desired innovation in technology and resource management that will minimise the environmental burdens caused by infrastructure development and related activities (Crowford-Brown, 2012). That is, SC that will meet sustainable built environment in terms of socio-economic and environment dimensions can only be achieved through effective and efficient deployment of both material and techniques.

Lean techniques (tools and practices) have primarily targeted reducing wastes in production process. The tools and practices have been developed either consciously or otherwise over time and are aimed at engendering continuous improvement in the production process and provision of enhanced value for stakeholders (Koskela, 1992), all of which resonate with the sustainable development goals. Therefore, most developed economy have advocates for a new paradigm of lean sustainable construction (LSC) that will engendered sustainable built environment through industry efficient and effective deployment of limited resources. Therefore, public infrastructures that will exhibit lean-sustainable values such as; conserve material consumption, protect natural environment, eliminate pollution and toxic materials and create a balanced socio-economic environment, will be required for an overall sustainable development (Kilbert, 2008; Corfe, 2013). However, despite the benefits of lean sustainable practices, the evolution of the right framework that can draw these values among stakeholders in construction organization have been a challenge. This gap necessitates a South African study that is focus on sustainability framework that could enhance balanced ecosphere and industry continuous improvement. In filling this gap, the next section of the paper presents the methodological choice, followed by a succinct account of the models used for sustainability studies. Thereafter, the paper presents the proposed model and concludes with preliminary findings to assess the robustness of the conceptual model.

2.0 RESEARCH METHODOLOGY

The purpose of this paper is to present the preliminary findings of a case study used to assess the robustness of a conceptual model compiled to promote LSC in the South Africa infrastructure sector. Within the construction context, a sound model serves as a template for improved infrastructure and it is vital to the success of sustainability goals.

To meet this target, the methodological choice was based on a qualitative research approach. The study relies on interpretative theoretical framework that is grounded in obtrusive measures and perspectives of industry experts (Creswell, 2013). Firstly, a comprehensive review of the management corpus in the fields of sustainability and organizational learning approaches were carried out to elicit an inform decision on a suitable model to meet the industry demands. This was followed by semi-structured interview of the industry experts in a selected case study to gain expert opinion on the modified model. Modification in this case means the infusion of core principles of lean and sustainability through the projects life cycle. Purposeful sampling in which the participants are selected according to a defining characteristic that makes them experts was utilized in the study (Nieuwenhuis, 2007; Leady and Ormrod, 2010). In particular, seven interviewees which include two each of project managers and consultants (of at least twelve years of industry experience), an academia, and two officials of government agency forms the panel of experts. The proposed model and its propositions guiding the logical linking of multiple sequential areas of inquiry was introduced and explained to the participants before the commencement of the interviews. This allows the interviewees to have a full grasp of the expected working of the transformation processes model.

3.0 THE REVIEW OF SUSTAINABILITY MANAGEMENT CORPUS

The perceptions gathered above testify to the variety of reasons for inquiring into the present models for construction industry. The previous work on the concept recognizes that the scope for possible futures is broader than BAU, which invites reconsideration of the current sustainability model and is a potential springboard for action. Multiple sustainability models are drawn upon to arrive at the proposed model for future South African sustainable infrastructure development. Some of the frameworks developed over time for achieving sustainability necessary for the industry's advancement, especially as relates to developing economy are presented.

3.1 Backcasting Model of Sustainable Development

The time lags between causes and symptoms of upstream and downstream activities explained the delay mechanism and complexity of the ecosphere. This characteristics running into decades, increases the complication for sound analysis and judgement of the ecosphere. Sometimes, this state reduces the concept to a matter of trade-offs in triple bottom line (TBL) of economy, environment and society. Dealing with this complexity in a comprehensive and systematic way requires an in-depth thinking into cause-effect chains of upstream activities by applying 'Backcasting' in the planning process (Holmberg and Robèrt, 2000; Cuginotti, Miller and Pluijm, 2008). Backcasting comprises of four basic steps, which are; awareness, baseline analysis of what the condition are, compelling vision of where to go, and series of action to get there. Cuginotti, Miller and Pluijm (2008) state that backcasting is particularly useful where there is a need for major change and a complex context, where dominant trends are part of the identified problem, when the problem to a great extent is a matter of externalities, and where the scope is wide enough and the time horizon long enough to leave considerable room for a deliberate choice that make sustainability a suitable context for backcasting. For holistic advancement in the industry to take place, industry management must be able to look ahead and set an achievable goal guided by the entities compelling vision. In doing this, a probable futuristic position can be envisioned and the means of attaining such milestone dynamically fashioned overtime. These make

sustainability a suitable context for backcasting adoption as has been widely used, particularly in Asia and the Netherlands.

3.2 Relational Model of Sustainable Development

The relational sustainable development model is based on balancing of upstream activities (demand based) and the environmental limits of the eco-system for which human species depend for its survival. This delicate relationship between the natural and social system is determined by a number of intrinsic factors (Du Plessis, 2007). The first is 'needs' that have to be met by the society, which is usually dependent on the quality of life available within the immediate domain. This is followed by the preferred mode of technological, political, and economic considerations that guides the upstream activities of the mainstream society. These two factors are significantly linked to the inherent value system of the society. The manner in which constituents of a given society relates with one another vis-à-vis the biophysical environment has a strong correlation with the prevailing value system in the society. The carrying capacity of the environment and the non-renewable nature of the biosphere, in turn, limit the choices available to the society (Figure 1).

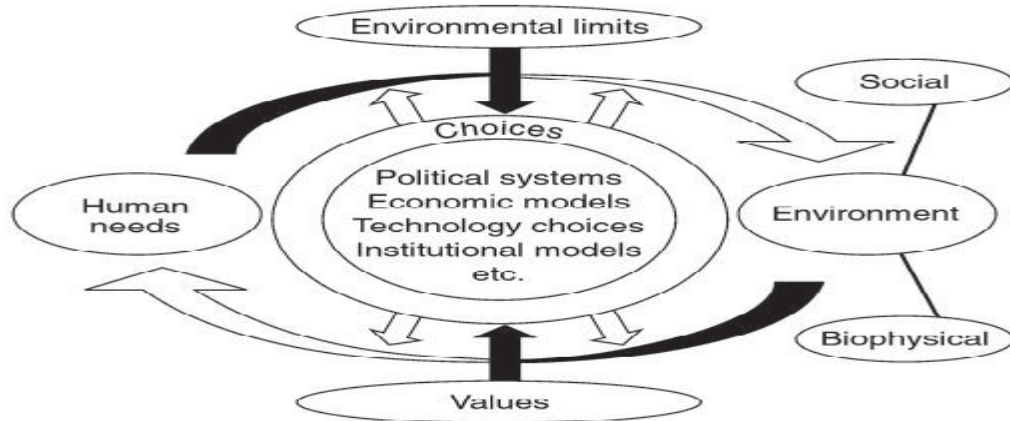


Figure 1: A relational model of sustainable development (Source: Du Plessis, 2007)

3.3 CIMO Model

CIMO model is a systems approach with a focus on the context-intervention-mechanism-outcome (CIMO) logic (Denyer and Tranfield, 2009). CIMO model is built around sustainable management (SM) in order to adopt a holistic perspective to sustainability. CIMO model consists of four basic components of SM:

- Context - institutional/social/natural setting;
- Intervention – behavioural/managerial/technical/structural;
- Mechanism - process improvement/innovation (5W + 1H), and
- Outcomes - social/environmental/economical.

The robustness of CIMO model was established in the work of Esquer-Peralta *et al.* (2008), using 24 experts in the field of sustainability for the purpose of discovering concepts with respect to SM. The model was found desirable for any innovative organization to prosper.

3.4 Transformation Process Model

The transformation process model (TPM) is an organization-wide SM initiative for stakeholders' interactions between social and natural systems, as a response to the competitive landscape in the new global economy (Madu and Kuei, 2012). Sustainability strategies and capabilities are increasingly important and complex for innovative enterprises in competitive environments around the world. For an organization to simultaneously achieve excellence in sustainable development dimensions of economic, environmental, and social performance respectively, it must undergo a transformation process. Such a process would engender a change from the BAU approach to SM. The TPM (Figure 2) is a theoretical framework for sustainability leaders and their value chain partners.

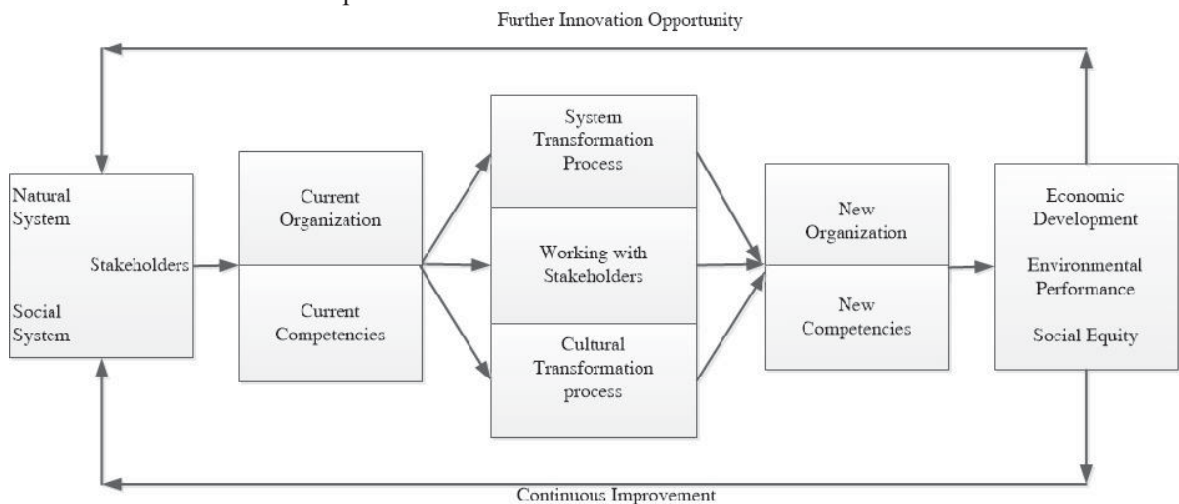


Figure 2: The transformation process model (Source: Madu and Kuei, 2012)

As illustrated in Figure 2, stakeholders interact with both natural and social systems. This interaction speaks to the all-inclusive nature of stakeholders' needs and requires a delicate balancing of sustainability requirements. For example, core competencies for sustainability need to be recognized and evaluated for interventions over time. The target here is to move the current situation into a more effective and efficient one. This transformation stage highlights the three main areas where the process of change will impact upon a system transformation process, working with stakeholders, and a cultural transformation process. These are the critical principles required to transform the current organization at a point of reflection to a competitive state. The community management involving leadership, employee fulfilment, conflict management, and cultural acceptance have economic, environmental, and social impacts (Epstein's, 2009). This implies that organizations must take into consideration these concerns throughout project whole life cycle and commit the necessary resources to ensure the attainment of sustainability. Once this transformation is achieved and a process for sustainability is mature, new competencies are attained leading to the birth of a new organization. However, the transformational process assumes a continuous cycle. The organization operates as an open system that evaluates the process maturity for sustainability at a point of reflection, receives feedback from its internal as well as external environments for further innovation and continuous improvement opportunities. This process involves evaluation of value creation relative to risks and costs.

For the purpose of this study, the approach to industry innovation and learning adopted for the delivery of sustainable public infrastructure is proposed to be situated in TPM. The choice of the TPM approach arises because TPM principles resonate with lean-sustainability philosophy and expectations. The TPM provides the rudiments for self-evaluation, cooperation, continuous improvement and opportunities for further innovation in all critical segments of transformation processes of system and culture, and working with stakeholders.

4.0 PROPOSED TRANSFORMATION MODEL FOR INFRASTRUCTURE DEVELOPMENT

This study is part of on-going doctoral research aiming to produce a mechanism for operationalising the integration of lean and sustainability in the South Africa infrastructure sector to engender sustainable development. Sustainability indicators have been widely reported (Shen *et al.*, 2007; Edum-Fotwe and Price, 2009; Emuze, 2015) to encompass the natural and socio-economic aspects of infrastructure development and its effect on various stakeholders in the industry. These cut across the project value chain in relation to processes, resources, leadership, people, financial, environmental and the entire ecosphere through project lifecycle (Bilec, *et al.*, 2010). Lean principles as a waste reduction tools, is an effective ways of enhancing the various spheres of KPIs for infrastructure development. It can then be infer that indicators for lean and sustainability (LSI) are those indices that can be seen as a standard of judgement by which lean and sustainable values can be measured. Value can be the template through which stakeholders navigate between natural and social systems to achieve a broader vision of sustainability. The challenges of global infrastructural issues can be untied, using value as an appropriate construct of change in the context of the construction process improvements (Du Plessis, 2007; Novak, 2012). It is on this premise that the TPM is infused with core principles of lean and sustainability using value as construct for industry transformation (Figure 3).

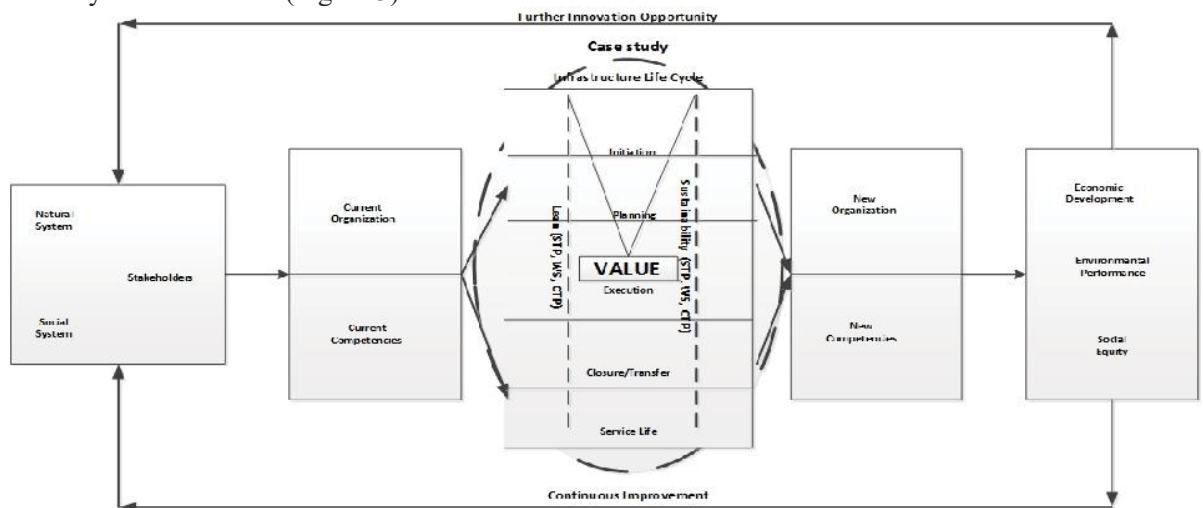


Figure 3: Transformation Model for Infrastructure Development (Adapted from: Madu and Kuei, 2012; Novak, 2012).

Establishing value as an appropriate construct for industry transformation in the context of the infrastructural development provides a focal point for the built environment sustainable development. The proposition is that there can be a synergistic link between

lean construction and sustainability expressed through the construct of value. Value creation through lean-sustainability paradigm in infrastructure life cycle could lead to new competences and new organizations for continuous improvement and further innovative opportunities. This is then presented for evaluation from expert opinion for preliminary findings.

5.0 INTERVIEW FINDINGS AND DISCUSSION

The transcribed interview data were analysed and inferences were drawn on the proposed transformation model. The outcomes of the semi-structured interviews are presented herewith.

Needs - the interviewees largely cohere in their agreement in recognising the need for a framework for transformative processes in the construction industry, especially in relation to sustainability targets. A framework that is holistic in its approach to transformative and collaborative actions towards meeting stakeholder's demands and future expectations of planetary order. The recent COP21 indicates that stakeholders crave for a framework that will guide the industry to attain the global goals of improved health and well-being, industry productivity, and attaining the target of reducing the global warming by 2°C and building related emissions by 80 gigatonnes by 2050 (Green Building Council South Africa (GBCSA), 2016). These can only be achieved by a holistic model that is all encompassing, well research, and adequate in creatively guiding / measuring of the interrelationship between natural and social sphere, in the construction context.

Requirements – for any model to be effective in meeting the construction industry need, it must be complete in revising the culture adopted by stakeholders in the fragmented industry. The interviewees emphasized that promoting sustainable construction in this culture would entail a significant collaborative effort on several fronts, namely: governmental, professional, academic, and the community. This should happen in the face of varying motives for industry collaboration. The model must also highlights the expected role of each stakeholder in a systematic manner to eliminate bureaucratic experience associated with a fragmented value chain. The interviewees affirmed that the model must have two distinguished characteristics: on one hand, the ability to address some fundamental sustainability barriers such as; culture - the flawed market practices, inadequate construction legislation, absence of the governmental role - lack of supervision and law enforcement, stakeholders demands, and knowledge gap. On the other hand, promote sustainability enablers such as; education, competitiveness, demands, leadership, and legislation for sustainable development.

Suitability - in meeting the aforementioned requirements, the interviewees affirm the robustness of the transformation process model to address the ills militating against uptakes of sustainability practices in the infrastructure sector. They point at its potential to engender the needed efficiency and effectiveness of the industry and seem feasible for industry transformation. As the model draws from popular sustainable development concepts of looking at the world in a futuristic manner - a going-concern by;

- determining the future target – sustainability development,
- evaluating the present position – resources and stakeholders, and
- Process of transforming the industry overtime – synchronising lean-sustainable principles with it inherent principles over the projects life cycle.

It is on these findings as demonstrated by the needs for framework, its requirements and industry suitability that a concluding thought is formed.

6.0 CONCLUSION

The purpose of this paper is to present the preliminary findings of a case study used to assess the robustness of proposed TPM for sustainable infrastructure in South Africa. TPM is an attempt to respond to stakeholders' needs for a framework that will guide the industry towards sustainability-conscious systems to attain the global goals as exemplified by the recent COP21 in France. Various models have been developed and adopted to promote sustainability concerns in the construction industry. Such models include backcasting model, relational model, and CIMO model. While all of these are of good essence in sustainability development, TPM gives room to evaluate the stakeholders' current competences in relation to social and natural interactions.

The model highlights core areas for industry transformation process; cultural, system and working with stakeholders that serves as a natural appeal for lean-sustainability principles. The core components of the transformation process model are: awareness - baseline analysis of interaction between natural, social and human resources; the compelling vision of future industry – sustainable infrastructure; and in between, is the series of actions to reach the vision – composed of internal and external enablers that focuses on three main areas where the process of change will impact upon; a system transformation process, working with stakeholders, and a cultural transformation process (Figure 3). Human agency is at the centre of transformation in this model making it a perspective to be considered. Through the analysis and synthesis of collected data, it was discovered that a transformation model could serve as a purposive vehicle for embedding sustainability in the delivery of public sector projects. The study also notes the need for further research that will develop the segments of the model to a more usable mechanism for the industry and also serve as confirmatory purposes for the proposed model.

References

- Banawia, A. and Bileca, M.M., A framework to improve construction processes: Integrating Lean, Green and Six Sigma. *International Journal of Construction Management*, 14(1), 45–55, 2014.
- Bangdome-Dery, A. and Kootin-Sanwu, V., Analysis of barriers (factors) affecting architects in the use of sustainable strategies in building design in Ghana. *Research Journal in Engineering and Applied Sciences (RJEAS)*, 2(6), 418-426, 2013.
- Bilec, M., Ries, R. *et al.*, Life-cycle assessment modelling of construction processes for buildings. *Journal of Infrastructure Systems*, 16(3), 199-205, 2010.
- Corfe, C., *Implementing Lean in construction: Lean and the sustainability agenda*. C726 © CIRIA Construction Industry Research & Information Association, Classic House, London, 2013. RP978. Available from www.ciria.org/service/lean [Retrieved on 23/09/2014].
- Crawford-Brown, D., Sustainable development. In: *Madu, C. N. and Kuei, C. (eds), Handbook of Sustainability Management*. Singapore, World Scientific Publishing Co, 2012.
- Creswell J.W., *Quantitative inquiry and research design: choosing among five approaches*. London, Sage, 2013.
- Cuginotti, A., Miller, K.M. and Pluijm, F.V., Design and Decision Making: Backcasting using principle to implement cradle-to-cradle. *Unpublished Thesis submitted for completion of Master of Strategic Leadership towards Sustainability, Blekinge Institute of Technology, Karlskrona, Sweden*, 2008.
- Denyer, D. and Tranfield, D., Producing a systematic review. In: *Buchanan, D. and Bryman, A. (Eds), the Sage Handbook of Organizational Research Methods*, 671-689, 2009.
- Du Plessis, C., A strategic framework for sustainable construction in developing countries. *Construction Management and Economics*, 1(25), 67–76, 2007.

- Du Plessis, C., *et al.*, Agenda 21 for Sustainable Construction in Developing Countries, CSIR Report BOU/E0204, CSIR, CIB & UNEP-IETC, Pretoria, 2002.
- Edum-Fotwe, F.T. and Price A.D.F., A social ontology for appraising sustainability of construction projects and developments. *International Journal of Project Management*, 27: 313–322, 2009.
- Emuze, F.A., Behaviourism versus leadership: A transformational need for sustainability in the built environment.” In: *Opoku A and Ahmed V (ed), Leadership and Sustainability in the Built Environment*, London, Taylor and Francis, 2015.
- Epstein, M.J., *Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts*. San Francisco, CA, Berrett-Koehler Publishers, 2009.
- Esquer-Peralta, J., Valazquez, L. and Munguia, N., Perceptions of core elements for sustainability management systems (SMS). *Management Decision*, 46 (7), 1027-1038, 2008.
- Floyd, A.C. and Bilka, A., *Green building: a professional’s guide to concepts, codes and innovation: Includes igCC provisions*. Hampshire, Cengage, 2012.
- Forbes L.H and Ahmed S.M., *Modern construction: lean project delivery and integrated practices*, Boca Raton, CRC Press, 2011.
- GBCSA, GBCSA commits to introduce net zero certification and six meaningful goals, at COP21. *Construction World*, 12-13, March, 2016.
- Holmberg, J. and Robèrt, K-H., Backcasting from non-overlapping sustainability principles– a framework for strategic planning. *International Journal of Sustainable Development and World Ecology*, 7(1), 291-308, 2000.
- Kibert, C.J., *Sustainable construction: green building design and delivery*. New Jersey, John Wiley & Sons, Inc., 2008.
- Koskela, L., *Application of New Production Philosophy to Construction*. CIFE Technical Report No. 72, 15-17. Stanford University, CA, 1992.
- Leedy, P.D. and Ormrod, J.E., *Practical research: planning and design*. (9th ed.), Upper Saddle River, NJ: Pearson, 2010.
- Madu, C.N. and Kuei, C., Introduction to Sustainable Management. In: *Madu, C.N. and Kuei, C. (eds), Handbook of Sustainability Management*. Singapore, World Scientific Publishing, 2012.
- Mensah, S., Ayarkwa, J. And Nani, G., Adapting to environmental sustainable construction in developing countries: a multi-theory conceptualization. In: *Smart and Sustainability Built Environment Proceedings (SASBE)*, Pretoria, South Africa, 196-205, 2015.
- Mousa, A., A Business approach for transformation to sustainable construction: An implementation on a developing country. Resources. *Conservation and Recycling*, 101, 9–19, 2015.
- Nieuwenhuis, J., Qualitative research designs and data gathering techniques. In: K Maree (ed), *First steps in research*, pp. 69-97, Pretoria, van Schaik, 2007.
- Novak, V.M., Value paradigm: revealing synergy between lean and sustainability. In: *Proceedings of the 20th Conference of the International Group for Lean Construction (IGLC)*, 18-20 July, San Diego, USA, 51-60, 2012.
- Sarkis, J., Zhu, Q., and Lai, K.H., An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics*, 130(1), 1-15, 2011.
- Shen, L., Hao, J.L., Tam, V.W. and Yao, H., A checklist for assessing sustainability performance of construction projects.” *Journal of Civil Engineering and Management*, 13(4), 273–281, 2007.
- Wong, P.S.P., Thomas Ng, S.T. and Shahidi, M., Towards understanding the contractor’s response to carbon reduction policies in the construction projects, *International Journal of Project Management*, 31, 1042 – 1056, 2013.