A Framework for Systemic Sustainable Construction Industry Development (SSCID)

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Research Article

Keywords: Construction Industry, Sustainable Construction, System Thinking, Integration, BIM

Posted Date: December 29th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-131695/v1

Version of Record: A version of this preprint was published at Discover Sustainability on May 24th, 2021. See the published version at https://doi.org/10.1007/s43621-021-00033-y.

Abstract

The quest by most countries to achieve sustainable construction has met with several challenges as evidenced in low goal accomplishment. This is largely due to the fact that the issues have not been addressed within the context of the CI. Using the system thinking philosophy as applied to the construction industry, it should be possible to ensure sustainable development within the entire industry which should then spearhead sustainable construction as part of its sustainable development goals (SDGs). This paper proposes a framework by which a construction industry of a country could be developed sustainably and systemically. The methodology used involved an analytic study of relevant literature, reports and other documents on the implementation and challenges in sustainable development as applied to the construction industry. It identifies the major challenges and barriers militating against the CI development which must be addressed. It also posits that the goals of sustainable CI development should be linked to the SDGs. A framework is designed by which all the development of all the systems or organisations in the CI (all firms: construction, consulting, supplying, etc.) could be achieved taking cognisance of the identifiable components of CI development. This continuous process of ensuring sustainable development of the various organisations which shall be measured, monitored and managed (The 3Ms) will provide the needed environment for sustainable construction industry among other benefits. The framework is expected to operate on a construction industry information modelling (CIIM) principle and in an environment akin to the Building information modelling (BIM).

1.0 Introduction

The construction industry (CI) can be described as one that is very large, fragmented, and the least structured as compared with other industries. Its impact on the environment has been devastating, regarded as one that consumes a large percentage of the world's natural resources. The fear of the negative impact of led to the need for the consideration of sustainable construction which has been spearheaded by several authors (Kibert, 1994; Du Plessis et al., 2002; Du Plessis, 2007). Now the industry everywhere is focusing on the sustainable construction", reuse of buildings and constructions or their components", recycle of materials". As an economic investment, the relationship between sustainable construction and economic development is well posited (Myer, 2013; Olanrewaju & Abdul-Aziz, 2015).

A lot of progress has been made since its introduction, with the Rio Declaration (Agenda 21) (UNSD, 1992). The concept has since been transformed into seventeen measurable goals called the sustainable development goals (SDGs) (ICSU, ISSU, 2015). A significant fallout of this after 20 years, is that much has not been achieved (World Economic and Social Survey, 2013). The problem has largely been one of implementation and this is even more pronounced in developing countries. The challenges and barriers are numerous as they vary from country to country (Al-yami and Price, 2006; Saleh and Alalouch, 2015; Hasan and Zhan, 2016; Davies and Davies, 2017; Shan et al., 2017; Aghimien et al., 2018). This paper suspect that it has to do with the lack of appropriate structures and institutions to support its implementation. In the main the process has not been systemic. Literature is increasingly pointing to insufficient or confusing guidance, tools and indicators to measure, monitor and manage sustainable development appropriately. Concerns have been raised about the lack of appropriate tools to measure and monitor sustainability (Mccool and Stankey, 2004; Jaiyesimi, 2016). This lack of widely-acceptable method to determine the effectiveness or impact of sustainability is a major contributory factor limiting the achievement of its objectives.

Therefore, it is important to provide a framework for implementing a sustainable construction industry development systemically which could also assess the maturity levels of a country's sustainable construction industry development at any time. This is to address a major gap in this area of study. Through this framework, it is expected that countries would move from *concepts* to *practice* for sustainable construction industry. There is the need to *measure*, *monitor* and *manage* sustainability along its indicators and within the context of the triple-bottom line and the SDGs. Further, it is the position of this paper that for sustainable construction to be achieved everywhere, there is the need to align the SC goals to the SDGs to represent the main goals which a systemic CI development must achieve.

This study is powered by the system thinking philosophy. Draper (1993) has said that systems thinking is understood as the ability to see the world as a complex system where everything is connected to everything else. This paper posits that it is a deficiency in theory and practice and also counterproductive for different groups to pursue a common agenda, such as sustainability, in their separate and different self-contained environments. It is even worse when this is done without an attempt to link them in a bid to considering the whole picture.

The methodology used involved an analytic study of relevant literature, reports and other documents on the implementation and challenges in sustainable development as applied to the construction industry. Findings from these documents formed the basis of the synthesis which resulted in the development of the frameworks which seeks to theorise a model approach to achieving a systemic sustainable construction industry.

2.0 Sustainable Construction Industry: Issues And Challenges

The significance of the study lies in the fact that there are clear challenges and barriers limiting the extent to which the objectives of sustainable development is being achieved within the construction industry. To approach sustainable development anywhere, a systemic approach is required. This means that the various problems, challenges and barriers need to be identified in a process of continued assessment and updating in order to ensure that a systemic view of the problem side is always held as part of the process. The barriers to sustainable construction are numerous, notable ones include: *higher investment to cost, lack of incentives, lack of public awareness, lack of demand, lack of government support, lack of database, lack of knowledge, lack of training, lack of motivation* (Davies & Davies, 2017; Hassan & Zhang, 2016). This study identifies the areas that could be

of focus in sustainable construction as: Procurement, Green Construction, Materials, Project Management, Supply Chain, Sustainable Building, Developing Countries. Each of these areas have their challenges and barriers to overcome in order to achieve sustainability. Together, they represent the challenges of sustainable construction. It is also observable that there are similarities about some of these challenges across the various areas. The commonest ones include issues about *cost, time*, *awareness, knowledge*, *communication*. This commonality indicates that the concept of sustainability if it will work, will require that a systemic approach is undertaken. Consequently, sustainable construction needs to have the "means" aspect items, the "ends" aspect items, and the barriers to overcome as standing in-between. Table 1 is an illustration of the various challenges being faced by the construction industry.

2.1 The Problems Militating against CI Development

In addition, evidence shows that the construction industry is plagued with several problems confronting its development agenda (World Bank, 1994; Nhabinde et al., 2012; FMI, 2015). Relevant ones include those relating to product development processes (e.g., client dissatisfaction), stakeholders (e.g., industry dissatisfaction) (World Bank, 2011; FMI, 2015; ICM, 2016) and the contracting processes (e.g., supply chain problems) (Latham, 1994; Egan, 1998; Baiden and Price, 2010; Wells, 2014). Most efforts directed at developing the industry have had the weakness of conceptualising it as an island and not as part of a broader global system. This situation underscores a fundamental problem to overcome in order to meet the expectations of sustainable construction and, hence, its development. Other key issues that affect the uniform and systemic management of the industry include: *the problems of fragmentation, complexity, culture and informality.* The extent to which these are relevant are discussed below.

2.2.1 The Issue of Fragmentations in the CI

Fragmentations in the industry tends to affect the quest for uniform and systematic organisation of the activities of the industry. Fragmentation has to do with "breaking of" into smaller parts, as against staying "whole" for holistic consideration. This is the natural state of the industry. To approach the industry's development holistically and for sustainability, thus, one of the first things to work around or overcome as a barrier is the issue of fragmentation.

The issue of fragmentation is seen both at the industry and project levels; and could also be considered at the spatial and functional perspectives (Curzon, 2001; Ruane and Görg, 2001; Defever, 2006). The industry level fragmentation; also referred to as "external fragmentation", results from the disintegration of expertise, situated knowledge, and specialists' inability to work together efficiently (Demaid & Quintas, 2006; Murdoch & Hughes, 2008). Examples include the lack of coordination that usually exist in the interest groups in the industry: local government, Land Commission, Town and Country Planning, Professionals and Contractors. This, impacts negatively on the industry's performance and GDP. The project level fragmentation is identified in the spatial and functional levels. The spatial level is seen the dispersion of clients, project team, and on the project by location, and the weather and exacerbated by the uniqueness of each project (Hartmann & Caerteling, 2005; Langford & Male, 2001). In pursuing a system is approach to CI development, this is a barrier that needs to be crossed. The functional perspective of fragmentation at the project level in the CI are attributable to the separation of design and construction process, lack of coordination, collaboration, integration and communication between and among various functional disciplines or professions on the project (Xue et al., 2005). This is also influenced by the diverse interest of multiple stakeholders in a project. In effect, the entire project implementation process (strategic definition, preparation of brief, concept of design, developed design, technical design, construction, handover and use) is affected by this challenge.

2.2.2 Complexity and Interconnectivity within the Industry

Other issues that need to be considered when pursuing a system approach to sustainable construction are the complex nature of the industry as well as its interconnectivity. Due to the many different stakeholders (with different characteristics and interest), organisations involved, and the product development processes, construction activities are very complex, by definition. In addition, the concept of sustainability itself is a complex subject (Du Plessis, 2007). Thus, fusing sustainability within the construction setting does not make it any simpler. Schalcher (2015) posited that two things describe complexity: the *system* and the *process*. Beyond the complexity of the industry, the process of project implementation is not of a simple, straightforward or repetitive nature that has characterised factory production. Every project is unique in several respect: design, project team, geographical locations, site condition etc. In the same way the process varies.

One of the underlying factors of this phenomenon is the fact that the construction industry operates on connectivity of a large number of different stakeholders and organisations and this makes it a difficult system to manage. This also makes it one of the most linked industries. In relation to construction projects, Geraldi (2008) stated that "the interconnectivity and interdependency between multiple sub-systems – organisational, technical, or social – together with their positioning as part of an uncertain and dynamic socio-cultural-political environments pose considerable difficulties in understanding and predicting the overall behaviour of construction project organization".

Because the industry is defined by projects and comprises of same it should be expected that sustainable development of the CI must, of necessity, encompass the influence of more project factors than have hitherto been considered. There is, thus, the need to "think industrial, act project" for a complete and sustainable solution to the development question. For example, the following are worthy of inquiry:

- The complexity of modern clients;
- The nature of the relationships between and among projects in a region or a country;

- How the various firms and projects and stakeholders in the industry of a country interconnect and impact on one another.

2.2.3 The Impact of Culture and Informalities on the CI

Handy (1993) has posited that for an organisation, culture evolves over time. Once established, it defines the behaviour of the organisation and influences not only the thought processes of the organisation, but also the attitude to work. Culture, thus, could work against best practices and the sustainable development concepts. In this regard, McSween (2003) defined culture as missions interacting with work processes and corporate values to create behaviour. Culture influences communication, management style, health and safety and the general work behaviours (Misnan and Mohammed, 2007; Varner and Beamer, 2005). If the industry is to be developed, one of the main objectives is to ensure work ethics, improved productivity and ensure industrial sustainability, then the impact of culture that has evolved over time need to be looked at and where necessary affected. Kirvrak et al. (2008) outline six cultural success factors of projects: *cultural awareness, experience in international projects, Benchmarking and learning, project location, company strategy* and *effective management system;* and eight major effects of cultural differences: *human resource management, knowledge management, communication management, safety management, time management, Negotiation management, risk management, quality management* and *IT management*.

Failure to investigate and efficiently manage these and other factors could be an impediment to the performance of the CI and its development (Latham, 1994 and Egan, 1998). This is because the behaviour of the CI of any country at a point in time is also defined by the interaction of various cultures prevailing.

Another issue to consider has to do with the extent of informality in the industry. “Informality,” is about the informal, casual or unofficial activities that occur in business firms, industries, societies and the economy as a whole (Gajendran et al., 2011). Wells (2007), quoting from the CIB task group 29 (later changed to works commission, 107), describes the informal sector of the CI as: “unregulated and unprotected individuals and enterprises engaged in economic activities in construction, including the supply of labour and the production of building materials and components for both the formal construction sector and directly in response to clients’ needs”. Informality in project execution, for example, has been known to impact on communication (Gorse and Emmitt, 2007). Lingard and Rowlinson (2005) also worked on the effect of informality on safety practices on site. Studies on informality are grey areas in CI research. A major concern about informality in the CI has to do with the methodology to use in its inquiry (Rooke and Kagliogu, 2007; Dainty, 2008; Rooke et al., 2009). In addressing the issues of informality, the paper is highlighting the extent of work to be done to “formalise” issues in order to support the systemic sustainable construction industry agenda. This is because organised data is an important component of a construction industry system.

Table 1 is a summary of the major challenges militating the construction industry as obtained from the foregoing.

Table 1
Challenges and Barriers to Sustainable Development

S/N	Areas of Sustainable Construction Challenges							
	Supply Chain	Procurement	Green Construction	Project Management	Sustainable Building	Diffusion	Developing Countries	Materials
1	Cost	Cost	Cost	Planning related	Cost	Financial	Rapid rate of urbanisation	Availability
2	Time	Time	Time	Client related	Information	Governmental	Deep poverty	Reuse
3	Awareness	Awareness	Awareness	Project related	Design process	Technical	Social inequality	Recycle
4	Training	Training	Knowledge	Project Team related	Construction process	Cultural Market	Low skill levels	Reduce
5	Technology	Technology	Technology	Materials and Equipment	Materials		Institutional incapacity	
6	Poor Organisation Structure	Motivation	Risk	Labour related	Technology		Weak governance	
7	Regulation	Resistant to change	Communication	External works related	Culture		Uncertain economic level	
8	Poor Supplier Commitment	Pressure on staff to deliver job	Culture	Informality			Uncertain environmental condition	
9	Competition	Company inertia		Culture			Informality	
10	Uncertainties	Communication					Culture	
11	Integration	Coordination						

3.0 Sustainable Construction And The Conflict Between The Triple Bottom Line

The Earth's capacity to regenerate itself is affected directly by society, the environment and the economy (also referred to as people, planet and profit) (CEM, 2008). This is referred to as the *triple bottom line*. As the Brundtland report suggests, only when we balance the requirements of all three complementary forces will we be truly sustainable. Sustainable construction demands that the triple bottom line of sustainability (i.e., the Environmental, Economic and Social "pillars") should be given equal attention. Further to this, the "Russian Doll and Five Capital Model" shows that economic activity is centrally placed and is constrained by social issues, which in turn are constrained by environmental factors (CEM, 2008). From these three the entire SDGs were born. The ultimate constraint, however, is the Earth's ecosystem which must always be given the needed attention. This is the central goal of sustainability. This has a direct impact on construction which stands as a major consumer of natural resources. The extent of consumption of construction activity on natural resources makes it an important ally in the quest for sustainable development.

Yet, there is an inextricable link and competing interest among the triple bottom line. As an illustration, it is significant to know that each of the three pillars of sustainability has a different objective to pursue and they sometimes contend with one another. For example, the dichotomy is clear between the quest for economic growth (brown) and that of environmental protection (green) pillars or dimensions of sustainability (McGranahan and Satterthwaite, 2000). The former aims at consumption while the latter focuses on protection. The factors that promote the accomplishment of the former appear to increase those factors that work against the latter. However, for purposes of sustainability the concept of "green economy" must be invoked; where a green economy is defined as: "an economy in which economic growth and environmental responsibility to work together in a mutually reinforcing fashion while supporting progress on social development" (ICC, 2012).

The views of Mcgranahan and Satterthwaite (2000) as expanded to include the expected green social/economic aspect is depicted in Table 2. Bringing the social dimension will certainly increase the complexity of the problem by trading between the comfort and survival of people and society today under green economic and environmental conditions as against what will really be needed to satisfy their unquenchable appetite to consume.

Table 2 The competing objectives among the Economic and Environmental Pillars of Sustainability

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Focus	Economic (Brown)	*Social/economic (green)*	Environmental (Green)
Key concern	Human well-being	*Business and society's well-being*	Eco-systemic well-being
Timeframe	Immediate	*Transitory*	Delayed
Scale	Local	*Think global, act local*	Think global, act local
Concerned about	Low-income groups	*All-income groups*	Future generations
View of nature	Manipulate and use	*Generate, recycle and re-use.*	Protect and work with
Environmental services	Provide more	*Optimise*	Use less
(Source: McGranahan and Satterthwaite, 2000, *expanded*).			

4.0 Towards A Systemic Sustainable Construction Industry

The foregoing shows that in pursuing sustainable construction over the years, it is the case that all the critical questions have not been given the needed consideration. The missing link is that the thoughts of sustainable construction has not been systemic. Further, it can also be concluded that SC has been considered as an end in itself without seeing it as only a subset of the broader set called sustainable construction industry (SCI). It is not possible, the paper contends, to achieve sustainability on a sub-system without considering the supersystem of which it forms part. Thus, among the several strategies proposed to achieving sustainable construction (Hill et al., 1994; Du Plessis, 2007; HM Government, 2008; Al-Yami and Price, 2006; Moore et al., 2017), a general limitation lies in the fact that they do not particularly focus on the entire construction industry system sustainability.

This paper provides a paradigm shift in the quest towards sustainable construction in two ways:

1. Emphasising on *construction industry* development and not merely "construction";
2. Using System Thinking.

In the light of this, the main questions posed in this paper are:

Q1: Can sustainable development be achieved anywhere without sustainable construction?

Q2: Can sustainable construction be achieved anywhere outside of a sustainable construction industry?

Q3: Can a construction industry be developed anywhere without alignment with and accomplishment of the SDGs?

Q4: Can a construction industry system anywhere be developed sustainably without system thinking?

Q5: How can the many barriers to sustainable construction industry development be crossed?

Addressing these questions is very important to understanding and appreciating the sustainable construction problem. The objectives of the paper are guided by these questions. The following epistemological considerations are proposed to address these deficiencies.

4.1 Align the Goals of CI activities with the SDGs

Even though goals 9 and 11 specifically and directly relate to construction activities, a critical study of the other SDCs shows that all of them have everything to do with construction and, in fact, need to depend on it for its accomplishments in varying degrees. Table 3 shows the author's assessment of the extent to which each of the SDGs depends on construction or a constructed facility for its accomplishment. Thus, the first consideration is that every step towards sustainability in the construction industry should have a goal in the SDGs to accomplish. In the table, the linkages of the SDGs on construction have been established at varying levels of dependency, from the level of a basic requirement, through a needed, a necessary and an indispensable requirement.

Table 3
Linkages between Construction and SDGs

1st Degree Linkage		**2nd Degree Linkage**		**3rd Degree Linkage:**		**4th Degree Linkage**	
Construction as a Basic Requirement	Infrastructure Required	**Construction as a Needed Requirement**	Infrastructure Required	**Construction as a Necessary Requirement**	Infrastructure Required	**Construction as an Indispensable Requirement**	Infrastructure Required
1. No Poverty (G1)	*Offices, factories for production, Banks and Financial Institutions, etc.*	1. Good Health and Well-being (G3)	*Health facilities, Hospitals, etc.*	1. Quality Education G4	*Classrooms, Staff Offices and Bungalows, etc.*	1. Industry, innovation and infrastructure (G9)	*Production Factories, Laboratories, Research Centres, Roads, Railways, Bridges, Housing, etc.*
2. Zero Hunger (G2)	*Offices, Production Factories, Agricultural facilities, etc.*	2. Decent work and economic growth G8	*Offices, Production Factories, etc.*	2. Clean water and sanitation (G6)	*Water Treatment Facilities, Offices, Waste Treatment Facilities, etc.*	2. Sustainable cities and communities (G11)	*Roads, Railways, Bridges, Housing, Banks, Shopping Centres, etc.*
3. Gender Equality (G5)	*Offices, Accommodation, etc.*	3. Life on land (G15)	*Accommodation, Housing, Roads, Bridges, Railways, Offices, Production Factories, etc.*	3. Affordable and clean energy (G7)	*Dams for Hydro-electricity, Factories for Solar Production, Offices for Energy Distribution, etc.*		
4. Responsible consumption and production (G12)	*Offices, Production Factories, etc.*	4. Climate Action (G13)	*Offices, Conferences, Scientific laboratories, etc.*	4. Peace, Justice and Strong institutions (G16)	*Courts, Parliament Houses, Police Stations, Military Barracks, Prisons Quarters, etc.*		
5. Life below water (G14)	*Offices, Tunnels, Facilities on Land and Undersea, etc.*			5. Reduced inequality within and among countries (G10)	*International Organisation offices, Offices and houses for diplomatic corps, International Courts, etc.*		
6. Partnership for goals (G17)	*Offices, Production Factories, etc.*						

4.2 Employ System Thinking

The CI is too fragmented, interconnected and complex to be developed sustainably without considering its systemic nature. The various parts of the CI system must be seen to depend on each other and support each other as a system and to move together. According to UNESCO (2017), it is not enough to depend on technology, politics and financial consideration when pursuing the goals of sustainable development. Thus, a methodology

that is holistic in nature, and the one that will support the building of a resilient system and adaptable structures to take care of complexity is rather recommended (OECD, 2017). The issues involved in achieving sustainability require a holistic consideration of all the items concerned. According to Ison (2010), for a system to exist, there should be an integration of the component parts into making it a whole and that this integration should result in a special relationship between the parts with essential emergent properties. Within the CI, systems are organisations and firms operating to define the CI work as a system of systems. These include: clients, contractors, consultants, suppliers, etc., and even projects as temporary organisations (Lundin and Söderholm, 1995). System thinking has been seen as an invaluable tool in addressing complex problems of sustainability. Cloud (2009) has said: “system dynamics and systems thinking can be taught without involving sustainability, but sustainability cannot be taught without involving systems thinking.” Systems can be defined as elements joined together by dynamics that produce an effect, create a whole or influence other elements of a system. For this reason, systems thinking is the main approach recommended for any studies on SC and SCI. The CI shall be considered as a system of systems with all organisations in the industry as the constituent systems.

4.3 Develop the Components of the CI

Construction industry development has always been considered as hinging on a deliberate process undertaken under a well-mange conditions (Task Group 29, 1998; CIB,1999; Ofori, 2012). The benefits of such a venture include increased value for money, competitiveness of construction enterprises and the optimisation of the role of stakeholders’ performance (Ofori, 2012). This brings to the fore the need to focus on the development of the components of the industry. Ofori (2015) identified the components of construction industry development as: *technology development, corporate development, institution building, material development, human resource development, documentation, procedures and practices*, and *operating environment.*

In a related discussion, the present state of the CI and the global trends that will impact on the industry was assessed by the World Economic Forum (WEF) and a conceptual industry-transformation framework was introduced listing a number of measures (WEF, 2016). The WEF (2016) grouped these measures into eight topical areas: (a) technology material and tools (b) processes and operations (c) strategy and business model innovation (d) people, organisation and culture (e) industry collaboration (f) joint industry marketing (g) regulation and policies and (h) public procurement. These were further classified into three categories as: (i) measures taken by private companies on their own; (ii) measures taken by companies in collaborations with their peers –or by the industry as a whole; and (iii) measures taken by the government, acting both as the regulator, and as a major project owner. According to the report, the future transformation of the CI would be shaped by (a) market and customer trends, (b) sustainability and resilient trends, (c) societal and workforce trends, and finally, (d) political and regulatory trends.

It is important to look at the industry-transformation framework in the light of the green economic framework and along its roadmap (ICC, 2012) completely. It is expected that this would profoundly change the industry as a system and lead it towards the path of sustainable growth. Given the construction industry’s societal, environmental and economic importance, it is expected that any improvements in performance will also have a strong and varying effect on all three domains. Therefore, it is the considered position of these authors to model a conceptual framework that will achieve the following purposes:

1. Indicate the delineating of all the key components of CI development
2. Th classification of the action points
3. The future Megatrends in the CI
4. The links with the triple-bottom line in sustainability
5. The expected benefits for the CI.

Table 4
bn The Conceptual Framework for SCID through the Components of CI (Ofori, 2012, 2015; WEF, 2016)

Components of CI development (Ofori, 2015)	Conceptual Industry Transformation framework (WEF, 2016)		The CI future Megatrends as Moderators	Focusing on Sustainability and the SDGs	Expected benefits of CI development (Ofori, 2012)
	Measures	**Classification of Action Groups**			
Technology development	Technology	Measures undertaken by private companies	• Market and customer trends • Sustainability and Resilient trends • Societal and Workforce trends • Political and Regulatory trends	• Society • Economy • Environment	Stakeholder and participant optimisation through technology
Corporate development	Strategy and business model innovation				Viability and competitiveness of domestic construction enterprises
Human resource development	People, organisation and culture				Stakeholder and participant optimisation of institutional enhancement through human resource development
Institution building	Public procurement	Measures undertaken by governments	• Market and customer trends • Sustainability and Resilient trends • Societal and Workforce trends • Political and Regulatory trends	• Society • Economy • Environment	Stakeholder and participant optimisation through institutional enhancement
	Regulation and policy				
Material development	Materials and tools	Measures undertaken by industry	• Market and customer trends • Sustainability and Resilient trends • Societal and Workforce trends • Political and Regulatory trends	• Society • Economy • Environment	Increased money for clients and industry
Documentation	Process and operations				Environmental responsibility of the delivery process
Procedures and practices					Stakeholder and participant optimisation through processes
Operating environment	Industry collaboration				
	Joint industry marketing				

Table 4 is conceptual framework that can aid the modelling of a SSCID anywhere.

In Table 4, the first three columns show how the components of CI development (Ofori, 2015) are aligned with the measures of the conceptual industry-transformation framework of the WEF (2016).

It is important to note the similarity and how the two sets of items reinforce each other. By this synthesis, it was possible to classify them into the three groups. In transforming the CI industry these are the key areas to look at and develop. They form the main framework by which CI development process should be structured and managed. Column four shows the four megatrends that will shape these developments which must be moderators of the process. CI system developers must closely monitor these trends and continuously manage the components appropriately. Column five is to bring to bear the aspect of sustainability and the SDGs. The areas in the CI that stands to benefit directly by the developments in these components are listed in column six. These had been initially outlined by Ofori (2012).

4.4 Engineer the CI as a System to Achieve Sustainability

The next step is to engineer the CI system to achieve sustainability. The development of the CI and its sustainability should always be a “deliberate” effort. There is the need, therefore, to “engineer” or “design” the CI as a system. To achieve this the “SIMILAR” approach outlined by Bahill and Gissing (1998) was adopted and adapted as the model. This is outlined as below:

i. **State the problem:** This entails identifying and understanding the need the system is intended to serve, i.e., to ensure a sustainable CI. In addition, it is also about establishing the need for change, discovering requirements and clearly defining CI system functions.

ii. **Investigate alternatives:** Once the need for change is established, it is expected that the approaches to bringing about the change are allowed to generate several alternatives. These should be investigated and evaluated based on performance, cost, risk and sustainability.

iii. **Model the system:** This involves designing, simulations, testing, verification and validating. The model is run to clarify requirements, reveals bottlenecks and fragmented activities, reduces cost and exposes duplication of efforts. This is basically done in an IT environment, e.g., Building Information Management (BIM).

iv. **Integrate:** At this stage the various components and sub-systems are actually re-engineered and aligned together so they work as a whole. This requires extensive communication and coordination.

v. **Launch the system:** Launching the system means running the system and producing outputs – making the system do what it was intended to do.

vi. **Assess performance.** Performance is assessed using evaluation criteria, technical performance measures and measures – measurement is the key. If you cannot measure it, you cannot control it. If you cannot control it, you cannot improve it.

vii. **Re-evaluation:** Re-evaluation should be a continual and iterative process to achieve optimisation.

5.0 Developing A Framework For Implementing Sscid

Once the CI system is engineered, it will be necessary to implement it. This requires a process that is both systemic and systematic for its efficiency and effectiveness. On the basis of the above foundations a framework for implementing SSCID is proposed. This framework will also provide a means of assessing its maturity level. The approach requires a critical identification of all the systems (organisations) that makes up the industry and then engineer all the systems into one system of systems which could take off, be directed and even halted by the “press of the right button” with the use of an integrated IT tool. A construction industry information modelling (CIIM) tool that operates in an environment akin to the Building Information Modelling (BIM) is envisaged. Indeed, the BIM environment could be adopted and adapted as the starting point for its implementation. The system being engineered should be capable of being supported by the BIM environment through the various levels where BIM becomes CIIM. This is because BIM, to all intents and purposes, has functions that promote integration and collaboration within project execution. Its potential of achieving same for the CI as a whole is clearly perceivable.

Table 5 considers a systemic, sustainable construction industry development implementation strategy. The process involves the design of a CI system of systems which ensures that all the systems: clients, consultants, contractors, and so on, as identifiable, are developed along the eight (8) components of CI development (Ofori, 2015) based on an organised national data bank. For each system or organisation, the focus is to ensure a component-by-component development along the Social (S), Economic (E) and Environmental (Ev.) dimensions. This measures the level of sustainable development of the organisation at any point in time.

Thus, the sustainable development of each of the different organisations in the industry, i.e., clients, contractors, consultants, etc., (considered as systems of a CI), is ensured through a deliberate effort in the components, i.e., Technology, Corporate, Human Resource, Materials development, etc., (as are applicable), taking into consideration the pillars of sustainability in each case. Along each row (horizontal), each of the systems or organisations in the CI is developed in a particular component as applicable, for example, a particular “Technology”. The cumulative effect measures the development of the component in the industry as a whole to a certain maturity level.

Similarly, the vertical results in the table measure the overall sustainable development of each system or organisation along all the components of CI development. This indicates the extent to which a system or organisation in the industry has developed along the components to a certain maturity level. These individual results are also important for the monitoring and management of the sub-systems or organisations in the industry.

The overall results of all these will show the maturity level of the particular country’s CI development as well as its sustainability.

6.0 Assessing The Maturity Level Of Scid

This section illustrates how the maturity levels of (1) the systems and (2) the components are assessed.

The assessment of systemic, sustainable development proposed by this research shall be accomplished by the hierarchical measurement using the indicators related to the social, economic and environmental dimensions of each system in the industry. These shall be represented in *percentages* as a comparison between industry standards and actual performance. Thus, below each pillar, the overall percentage value is recorded at the level of development in a particular component. These are then averaged to represent the maturity level of sustainable development of the system under that component.

The overall score is the average scores across the three pillars:

[E + S + Env]/3……..(1)

6.1 The Maturity Level of the development of a Systems

This figure is inserted as the maturity level of a component under a system.

For example, in the case of a client, the percentage score of the social, economic and the environmental pillars are assessed and scored and averaged under each of the components, i.e., Technology Development (TD) valued as “cl-TD”; under corporate development, valued as “cl-CD”, etc. This is repeated for all the organisations.

Substituting “cl-TD”, “cl-CD”, etc., for clients with K_1, K_2, …K_n and

Using the formula:

K = 1/3[S(social) + E(economics) + E(environment)] ≤ 100%, for each organisation under a component, and,

Sust.-K-Dev. = $K_1 + K_2 + K_3 + \ldots + K_n$

Thus, the maturity level of a system or organisation “K” in the industry at a point in time is represented by:

Sust.-K-Dev. = 1/100n [$K_1 + K_2 + K_3 + \ldots\ldots K_n$] ……(2)

Where all the scores are in percentages.

Thus,

Sust. -cl-D=[(cl-TD) +(cl-CD) +(cl-HR) +(cl-IB) +(cl-MD) +(cl-Dtn) +(cl-PP) +

(cl-OE)]/800 for the eight components.

and, Sust-cl-D ≤ 100, for client organisations in the industry.

This stands for *sustainable client organisation development.*

This is repeated for all the other organisations or systems within the industry.

Table 5
A Framework for Implementing Systemic Sustainable Construction Industry Development

Components of CI development	**Construction Industry Systems**																					**Results Showing sustainable development of a CI component**
	Clients (cl)			**Projects (pj)**			**Consultants (cns)**			**Contractors (cnt)**			**Subcontractors (sc)**			**Suppliers (sp)**			**Regulatory bodies(rb)**			
	S	**E**	**Ev.**	**S**	**E**	**Ev.**	**S**	**E**	**Ev.**	**S**	**E**	**Ev.**	**S**	**E**	**Ev.**	**S**	**E**	**Ev.**	**S**	**E**	**Ev.**	
Technology development **(TD)**	cl-TD			pj-TD			cns-TD3			cnt-TD			sc-TD			sp-TD			rb-TD			Sust.CI-TD
Corporate development **(CD)**	cl-CD			pj-CD			cns-CD			cnt-CD			sc-CD			sp-CD			rb-CD			Sust.CI-CD.
Human resource development **(HR)**	cl-HR			pj-HR			cns-HR			cnt-HR			sc-HR			sp-HR			rb-HR			Sust.CI-HR
Institution building **(IB)**	cl-IB			pj-IB			cns-IB			cnt-IB			sc-IB			sp-IB			rb-IB			Sust.CI-IB
Material development **(MD)**	cl-MD			pj-MD			cns-MD			cnt-MD			sc-MD			sp-MD			rb-MD			Sust.CI-MD
Documentation **(Dtn)**	cl-Dtn			pj-Dtn			cns-Dtn			cnt-Dtn			sc-Dtn			sp-Dtn			rb-Dtn			Sust.CI-Dtn.
Procedures and practices **(PP)**	cl-PP			pj-PP			cns-PP			cnt-PP			sc-PP			sp-PP			rb-PP			Sust.CI-PP
Operating environment **(OE)**	cl-OE			pj-OE			cns-OE			cnt-OE			sc-OE			sp-OE			rb-OE			Sust.CI-OE
Results showing Sustainable development of a CI organisation	**Sust.**-cl-**Dev.**			**Sust.**-pj-**Dev.**			**Sust..**-cns-**Dev.**			**Sust.**-cnt-**Dev.**			**Sust.**-sc-**Dev.**			**Sust.**-sp-**Dev.**			**Sust.**-rb-**Dev.**			Sust.CID

Taking the figures horizontally, each row represents the series of maturity levels of the respective components: *Technology, Corporate, Human, Institution Building, Material Development, Documentation, Procedure and Practices and Operating Environment.*

What it means is that the assessed score of each organisation of CI also represents the maturity level of the respective component under the relevant organisation as assessed with respect to its sensitivity to the three pillars of sustainability (economic, social and environmental dimensions) for each organisation.

6.2 The Maturity Level of a CI Component

Thus, the row addition of the scores across the various organisations gives the sustainable construction industry with regard to the industry wide maturity level of the relevant component.

Using 'P' to represent the development of a component within the industry,

Sust.-CI.Dev-P = $1/100n[P_1 + P_2 + P_3 + \ldots P_n]$ ……..(3)

where P_1, P_2, P_3, ….P_n represent the assessed development of the component P under each of the systems or organisations in the industry.

Therefore, for Technology Development (TD) for example,

Sust.-CI-TD = [(cl-TD) + (pj-TD) + (cns-TD) + (cnt-TD) + (sc-TD) + (sp-TD) +

(rb-TD)]/100

and SCI-TD $\leq$ 100

Therefore, the score of the industry standards shall always be controlled by the scores under the triple bottom line of sustainability.

The matrix is expected to provide the following results at any point in time:
1. The results of the state of development of each CI organisation in the light of each component of CI development. This shows the maturity level of the organisation under each component.

2. The overall result of the state of sustainable development of each CI organisation across the eight components of CI development (vertical aggregation).

3. The result of the state of development level of each component of CI development in each of the CI organisations.

4. The overall result of the state of development of a component of CI development across the various organisations of the CI at any point in time (horizontal aggregation).

5. There shall be only one result of the Sustainable Construction Industry Development which is obtainable by either horizontal or vertical aggregations of the totals. The summation of all the results.

7.0 Conclusion

The major contribution of this paper to the debate on the CI development agenda is the emphasis on ensuring sustainability using a systemic approach. In addition, this study propounds that sustainable construction industry development should be seen as part of the global agenda of a sustainable world as it began with the Agenda 21 and the SDGs. The CI as system of construction systems is also a part of a larger global system. Thus, sustainable construction should form part of the industry's agenda of sustainability. In particular, sustainable construction industry development should be seen as a continuous process of deliberately ensuring that a holistic approach is adopted to achieve the transformational goals of the industry taking into consideration the concept of sustainability. This means that researchers who are contributing to the debate must consider, alongside the approaches towards achieving the goals of sustainable construction, the impacts, attractions, disruptions and the distractions from other industries or systems. This is the ultimate goal of SCID.

Based on the foregoing, the paper posits that the issues involved in sustainable construction depict a complex problem, more than has hitherto been considered. Therefore, this must be pursued with a different way of thinking, a different world view and a different approach to solving the problems. Systems approaches to the problem is recommended for research and development in SC. The aim is to ensure a system change, a transformation in the construction industry (OECD, 2017).

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