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MODELLING SUSTAINABILITY TRANSITION IN THE KENYAN CONSTRUCTION INDUSTRY

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DECLARATIONS

DECLARATION BY THE CANDIDATE

I hereby declare that this thesis is my original work and has not been presented for a degree in any other learning institution.

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This thesis is dedicated to:

All built environment stakeholders who have in one way or the other (policy, practice, education, and/or, research) contributed towards efforts to ensure the construction industry pulls it weight to ensure sustenance of human life on earth both now and in future across the world,

Aluta Continua

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My late grandfather *Mwalimu* Kamau Wangi, may your soul continue resting in peace.

ABSTRACT

Ensuring human life sustenance, now and in future, is at the core of the sustainability agenda globally. Current sustainability concerns relate to uncontrolled population growth, pollution, natural resources depletion, widening wealth-gap, industrialization impacts, and, consumerism. World over, the rapid growth of the construction industry is part and parcel of these concerns owing to its known negative sustainability impacts. This is in addition to lagging behind in transitioning towards sustainability compared to other sectors and the Kenyan construction industry is not an exemption. It is against this background that this study investigated the lagging transition to sustainability, sustainable construction transition (SCT), in the Kenyan construction industry. It specifically sought to: assess SCT performance; assess prevalent SCT strategies including ranking of their implementation considerations; assess priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings of the SCT regime (policy and legislative); and, develop a model for enhanced industry SCT performance. Overall, the study based on socio-technical systems (STS) theory hypothesized, in the alternative, that SCT strategies including their implementation/context appropriateness considerations are significantly related with industry SCT performance. A mixed-methods approach, backed by pragmatism research philosophy, was adopted. Additionally, the study followed a descriptive and cross-sectional research design. For quantitative data, the study employed structured questionnaires targeting key design phase stakeholders (sample size=312 respondents). For an enhanced exploration of study variables, key informants (sample size=nine key informants) were targeted through interviews. Valid responses were 197 and four respectively.

The findings from the 197 valid responses quantitatively analysed indicated that SCT performance in the Kenyan construction industry was sub-optimal (M=2.8429). Notably, its ranking along the three facets of sustainability, in order of decreasing performance was: social (M=2.8542); economic (M=2.7986); and, environmental (M=2.6389). Further, the following five SCT strategies were identified to be prevalent: property value enhancement; enhancing functionality; development cost efficiency; energy conservation; and, operational cost rationalization (M>3). However, the overall adoption of SCT strategies was below average (M=2.9172). Additionally, SCT strategies implementation/context-appropriateness considerations were ranked in decreasing consideration order as: change readiness; socio-spatial sensitivity; multi-level governance; resilience; leveraging micro and small medium enterprises (MSMEs); and, leveraging internet of things (IoT)-driven big data and building information modelling (BIM) (M=2.8065, 2.7948, 2.7855, 2.6620, 2.5911, and, 2.3932 respectively). Overall, their consideration was below average (M<3). The SCT regime (policy and legislative), through 35 documents content analysis, was found to prioritize environmental aspects (31/35 documents) and strategic and tactical implementation with less focus on the socio-economic aspects (social=12/35, and, economic=6/35 documents) and operational implementation. It was driven by: codes, guidelines, and, plans; constitution and legislation – both groups 11/35 documents each; and, regulations (13/35 documents). They however lacked a centralized database and mainly focussed on regulation and control when compared to other operational mechanisms such as education and information. It also primarily targeted developers/owners/occupiers and government (>18/35 documents each) with lesser focus on other industry stakeholder groups (<18/35 documents each). The model developed identified SCT strategies and their implementation considerations of change readiness and leveraging MSMEs to be significant predictors of SCT performance (model predictive power=49.4%; predictive accuracy=62.3%; and, mean absolute percentage error (MAPE)=13.6%). The main conclusion reached is that enhanced joint optimization of SCT strategies including their implementation considerations of change readiness and leveraging MSMEs would result in enhanced industry SCT performance.

This study contributes to existing research and knowledge on SCT along the following fronts: development of pioneer SCT model for Kenya – addresses the sustainability challenges faced by the construction industry and the weaknesses of existing sustainable construction frameworks; extension of STS theory application to SCT; pioneer empirical investigation of the Kenyan SCT regime (policy and legislative); and, development of original scales for measurement of SCT performance, strategies, and, their implementation considerations. The findings, for enhanced industry SCT performance moving forward, highlighted the need for: implementation of SCT efforts after satisfactory stakeholders SCT strategies literacy, SCT readiness, and, onboarding of MSMEs; and, SCT policy and legislative regime's enhanced – focus on socio-economic aspects of SCT and operational level of implementation, centralized instruments database and leveraging them to back more than regulation and control, targeting of all major industry stakeholder groups, and, SCT strategies literacy, change readiness, and, onboarding of MSMEs backing. Additionally, future SCT studies can: use structural equation modelling (SEM); explore more SCT predictors; and, replicate this study in other nations.

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ABBREVIATIONS AND ACRONYMS

AAK	Architectural Association of Kenya
ACMK	Association of Construction Managers of Kenya
AECO	Architecture, Engineering, Construction, and, Operations (Industry)
AVE	Average Variance Extracted
BII	Biodiversity Intactness Index (Functional Diversity Measure)
BIM	Building Information Modelling
BORAQS	Board of Registration of Architects and Quality Surveyors (Kenya)
BU	Bottom-Up
CABE	Commission for Architecture and the Built Environment (England) – Former
CAD	Computer Aided Design
CBK	Central Bank of Kenya
CO_2	Carbon Dioxide
CR	Composite Reliability
CSR	Corporate Social Responsibility
E/MSY	Extinctions Per Million Species-Years (Genetic Diversity Measure)
EA	East Africa
EBK	Engineers Board of Kenya
EDGE	Excellence in Design for Greater Efficiencies (Green Building Rating Tool and Standard)
EIA	Environmental Impact Assessment
ERC	Energy Regulatory Commission (Kenya)
EU	European Union
GBIG	Green Building Information Gateway
GDP	Gross Domestic Product
GESIP	Green Economy Strategy and Implementation Plan (Kenya)
GHG	Greenhouse Gas
GoK	Government of Kenya
GSO	Global Sustainability Organization
HSE	Health and Safety Executive
HTMT	Heterotrait-Monotrait (Ratio)
IBM AMOS	International Business Machines Corporation Analysis of Moment Structures (Software for SEM)

IBM SPSS	International Business Machines Corporation Statistical Package for Social Sciences
IDAK	Interior Design Association of Kenya
IEEE	The Institute of Electrical and Electronics Engineers
IEK	Institution of Engineers of Kenya
IFC	International Finance Corporation
IoT	Internet of Things
IPD	Integrated Project Delivery
IQSK	Institute of Quantity Surveyors of Kenya
KGBS	Kenya Green Building Society
KPDA	Kenya Property Developers Association
KPIs	Key Performance Indicators
kWh	Kilowatt Hours
LAPSSET	Lamu Port-South Sudan-Ethiopia Transport
LEED	Leadership in Energy and Environmental Design
MAPE	Mean Absolute Percentage Error
MLG	Multi-Level Governance (Theory)
MSMEs	Micro, Small, and, Medium Enterprises
MTIHUD	Ministry of Transport, Infrastructure, Public Works, Housing, and, Urban Development (Kenya)
N	Nitrogen Flows
NACOSTI	National Commission for Science, Technology, and Innovation (Kenya)
NCA	National Construction Authority (Kenya)
NCCAP	National Climate Change Action Plan (Kenya)
NEMA	National Environment Management Authority (Kenya)
NGOs	Non-Governmental Organizations
OECD	Organization for Economic Co-operation and Development
P	Phosphorous Flows
PIT	Place Identity Theory
Q-Q	Quantile-Quantile (Plot)
RECMQS	Department of Real Estate, Construction Management, and Quantity Surveying (University of Nairobi, Kenya)
SA	South Africa

SBSs	Sick Building Syndrome Symptoms
SC	Sustainable Construction
SCT	Sustainable Construction Transition
SD	Sustainable Development
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEM	Structural Equation Modelling
SIs	Sustainability Indicators
SMEs	Small and Medium Enterprises
SOA	Sphere of Authority
SSD	Strong Sustainable Development
ST	Sustainability Transition
STS	Socio-Technical Systems (Theory)
TD	Top-Down
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UoN	University of Nairobi
USA	United States of America
WBDG	Whole Building Design Guide
WCED	World Commission on Environment and Development
WGBC	World Green Building Council
WSD	Weak Sustainable Development

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

This chapter sought to provide a general introduction, including establishing the need, of the study. Its output was to provide the specifics of the research problem explored, what the study sought to do, including, the associated fundamental basis of the study. This was ultimately aimed at providing a reference point against which the study outcomes were to be assessed. The chapter is structured in 13 main sections and as follows: background of the study – for the general study problem context; problem statement – the construction industry problem explored including associated knowledge gaps; research objectives – study aims; research questions – questions to be answered regarding the study aims; research hypotheses – possible answer to the main research question; justification of the study – value to the research community; significance of the study – potential value to research, policy, and, practice; scope of the study – theoretical, methodological, and, geographical study confines; assumptions of the study – postulations held true for the study though not empirically confirmed; study limitations – study constraints; study delimitations and exclusions – what the study did not set-out to do; definition of key terms – for a common understanding of key terms; and, organization of the thesis. These are discussed in detail in the next sections.

1.2 Background of the Study

1.2.1 Sustainability and Sustainable Development (SD)

Existence of human beings, both now and in future, is at the heart and soul of the sustainability agenda globally (Huge *et al.*, 2012; Carboni *et al.*, 2018). Sustainability in its broadest view can be defined as a state that allows continued existence of human life. To achieve this state, the following are required on an intra- and extra-generational basis: equity; meeting societal needs in an acceptable manner; balance between these needs and the earth's carrying capacity; and, prosperity. Sustainable development (SD) emerges as continuous dynamic process of ensuring human life sustenance (meeting the requirements to achieve a state of sustainability) (Du Plessis, 2002). This is in harmony with earlier explanation of SD by World Commission on Environment and Development (WCED) (1987): *"... process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future* *potential to meet human needs and aspirations"* p.57. Consequently, SD should not be seen as human development that can be sustained but rather as development that is needed to ensure sustainability (Du Plessis, ibid). This line of thought presents a departure from the conceptualization of sustainability and SD as synonymous and thus interchangeable, as postulated by Murray and Cotgrave (2007), Huge *et al.* (2011), and, Holland (2017), to being two different concepts. As such, sustainability emerges to be the goal and SD the means of achieving that goal.

The focus of sustainability and SD has changed with the evolution of civilizations. Sustainability concerns can be traced back to the Agrarian Age (before mid-18th Century) (Xiaoying, 2013). This age was characterized by heavy reliance on natural resources and basic tools (Lu, 2015). During this age, human activities, such as logging, mining, and, farming, were associated with the negative sustainability impacts such as loss of soil fertility and deforestation which led to early concerns on human life sustenance (Van Zon, 2002). Next came the Industrial Age (mid-18th – early 20th Century) characterized by development of natural resources, such as metals and fossil fuels, and introduction of mechanization (Lu, 2015). In this age, the impact of population growth on resources consumption, unlimited extraction of fossil fuels, and, forests exploitation were some of the main areas of concern (Du Pisani, 2006; Van Zon, 2002). Lastly, Networked Knowledge Age (from the late 20th Century onwards) has been largely characterized by knowledge, information technology, and, globalization (Lu, 2015). The focus has been on uncontrolled population growth, pollution, depletion of natural resources, widening wealth-gap, industrialization impacts, and, consumerism (Von Wright, 1997; Du Pisani, 2006). The technological aspect has informed the shift from a largely qualitative to quantitative means of ensuring sustainability consciousness generally. This is evident in smart wearables, appliances, building management systems, and, cities all over the world (Allen and Macomber, 2020).

1.2.2 Sustainability in the Construction Industry

Constructions industries worldwide are part and parcel of current sustainability concerns owing to their known negative sustainability impacts (economic, environmental, and, social) (Dania, 2016:1). Economically, sustainable construction (SC) is aimed at enhanced profitability through efficiency in resource usage (Woodall *et al.*, 2004). Resource usage inefficiency in the industry has been observed in relation to large share of: greenhouse gas emissions related to energy use; global energy use; waste generation; and, natural resources usage including undesirable resources fluctuation in the construction phase (United Nations Environment Programme (UNEP), 2021; Lamka *et al.*, 2018). Benefits of ensuring economic sustainability include acceptable costs throughout the various construction project phases (Kats, 2003:85). Additionally, an entity that is economically sustainable is more likely to practice environmental sustainability due to implied resources efficiency (Du Plessis, 2002:16-17). Environmentally, *"… the construction sector is also responsible for more than a third of global material resource consumption, including 12% of all fresh-water use …"* (UNEP, 2011:20). Additionally, *"… the built environment accounts for a large share of energy (estimated to be about 40% of global energy use) …"* (UNEP, 2021). Environmental sustainability concerns when considered and appropriately implemented, will lead to enhanced environmental quality and acceptable use of energy and natural resources (Kats, 2003:85). Some examples of these benefits, in reference to the construction industry, are: efficient energy use over the lifetime of a constructed facility; responsible sourcing of construction materials; and, minimization, including improved re-use, of construction waste.

Construction projects also often fail to meet social expectations as a result of adopted sustainability approaches prevailing over local conditions. The social dimension focuses on issues: legal land acquisition; local culture sensitivity; water and energy efficiency; safety of built facilities; thermal comfort; extent of local communities' engagement in construction; extent of use of locally available materials; locally understood construction methods; and, use of sustainable and affordable local construction materials (Pocock *et al.*, 2016). Disregard of these aspects in the construction industry is evidenced by unethical practices, such as: corruption and gender discrimination; low compliance with pre-set health and safety regulations; and, unjust labour practices (Du Plessis, 2002:15-16). Benefits of observing social sustainability include: improved wellbeing of involved stakeholders; and, an overall reduction in terms of turnover of employees and employee work absenteeism (Kats, 2003:67). Examples of such benefits, with specific reference to the construction industry, are: improved wellbeing to users of constructed facilities; and, reduction of liabilities to contractors relating to workplace related accidents and illnesses.

1.2.3 Sustainability Transition in the Construction Industry

"… the building and construction sector is one of the most important areas of intervention and provides opportunities to limit environmental impact as well as contribute to the achievement

of SD goals" (UNEP, 2021). The sector has been noted to be central to the economic development of nations through: provision of physical infrastructure to support human activities; its contribution of 5-10% and 5-15% of total employment; and, gross domestic product (GDP) respectively at national level worldwide. Additionally, the sector provides the physical context of human social interactions. The impact of the built environment on the human health and environment has also long been established including its negative environmental impacts in relation to: energy consumption; emissions; resulting waste; and, use of natural resources. Consequently, the industry has been under increasing focus by both governments and public to address these social and environmental challenges. However, efforts to address these issues in the industry have been hampered by limited stakeholder's coordination in the lifecycle of constructed facilities. As such, creation of stakeholders oriented conducive conditions and use of incentives have been put forward as central to uptake of sustainable building practices (UNEP, ibid). The foregoing discussion highlights: sustainability as a contemporary issue in the built environment; and, that there is need for a conducive industry environment for success in uptake of SC practices (process and product oriented).

Radical transformation in the design, construction, operation, and, decommissioning of built facilities is needed if the identified socio-environmental concerns are to be significantly addressed (Green Africa Foundation, 2018:7). It is from the realization inherent in the above context that the need for construction industry to shift from its conventional mode of operation (production and consumption) to a comparatively sustainable alternative emanates (Du Plessis, 2002:8-9; Ofori, 2007:5). This shift has been identified to be both radical and socio-technical in nature, and is commonly referred to as sustainability transition (ST)/sustainability transformation in academia (Elzen *et al.*, 2004; Grin *et al.*, 2010; Blythe *et al.*, 2018). This involves adoption of SC practices throughout the lifecycle of constructed facilities or part thereof. SC is the wholesome process whose goal is to revitalize and ensure balance at the interface between natural and built environments and while at it enhancing of quality of life, by upholding dignity and economic equity, of the human populace individually and collectively (Du Plessis, 2002:8-9). It has also been observed that the construction industry is lagging in transitioning towards sustainability (Glass, 2012; Aghimien *et al.*, 2018:2385; Willar *et al.*, 2021:110). It then emerges that for sustainability, construction industries should be steered towards a long-term radical shift from the current conventional and largely unsustainable practices (processes and products oriented) towards comparatively sustainable alternatives.

1.2.4 Sustainable Construction (SC) and Green Building

Whereas SC and green building have more often than not been used interchangeably, they emerge as two different concepts. As highlighted in Section 1.2.3, SC aims at realization of balance between natural and built environments and while at it, for the populace, ensuring: improved quality of life; and, economic equity. On the other hand, a green building is *"... a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment"* (World Green Building Council (WGBC) (2021). Green buildings focus on reducing environmental impacts of the built environment while SC in addition to the environmental concerns, also covers associated economic and social ramifications (Alwan and Saleh, 2020). Consequently: green buildings are a subset of SC; a sustainable building is green; and, a green building is not necessarily sustainable. Lastly, Al Alwan and Saleh (ibid) postulate that green building ensures environmental sensitivity through design while SC focuses on environmental and socio-economic sensitivity from a full lifecycle approach. As such: green building approaches primarily aim at achieving environmental sustainability; and, SC approaches primarily target joint economic, environmental, and, social sustainability.

UNEP (2014), highlighted the potential long-term benefits of Kenya transitioning to a green economy. These benefits were identified as: economic growth; cleaner environment; and, high productivity with economy-wide significant gains realized within a period of 7-10 years. Green Africa Foundation (2018:14-21) further outlined four main justifications of SC in Kenya to include: helping meet related international obligations such as on sustainable development goals (SDGs); driving national development agenda on fronts such as increasing resilience of built environment against climate change and its impacts, reduced lifecycle investment in built infrastructure, and, creation of more decent employment opportunities; contributing to Big Four Development Agenda for example, on the affordable housing front, green building approaches would ensure value for money through ethical sourcing of construction inputs; and lastly, it would enhance compliance with statutory legal instruments in relation to aspects of SC. This is on fronts such as: compliance with Article 42 of the 2010 Kenyan constitution on the right to clean and healthy environment to all Kenyans; and, the target of Kenya Building Research Centre's Strategic Plan 2017/2018 – 2021/2022 to mainstream green building approaches in Kenya. Consequently, for the Kenyan construction industry: green and/or SC approaches will confer significant sustainability benefits; and, these benefits include productivity driven economic growth, environmental protection and conservation, contribution to sustainability related obligations and agendas (national and international), and, enhanced compliance with SC policy regime.

1.2.5 Sustainable Construction Transition (SCT)

Negative sustainability impacts of the construction industry have been characterized as worse in developing nations, such as Kenya, compared to developed nations. These developing nations have also been identified to have comparatively less resources to deal with the sustainability challenges. On a positive note, underdevelopment in these nations offers room for a better and sustainable future compared to their developed counterparts. The urgency of ensuring SC in these developing nations has two main drivers: active ongoing construction activity implying continued unsustainability in case of inaction (failure to transition towards SC); and, increased demand on already limited resources. It should be noted that the socio-economic sustainability dimensions have received more attention in practice compared to the biophysical dimension which has been largely left at research and scholarly level (Du Plessis, 2002:21). Joseph (2019:83) observed different findings where ranking of the key SC considerations in the Kenyan construction industry ranked as social, environmental, and economic in order of decreasing importance. It is clear in both that environmental aspect of SC is not a major practice concern in developing nations comparatively which Du Plessis (ibid:21) associates with pressing socio-economic challenges.

The Kenyan government SC plan for the period 2016-2030 was identified as follows: greening 75% of new and renovated private and public buildings; increased stakeholders oriented green training programmes; and, increased number of adopted green building standards. This is aimed at delivering a built environment that is comparatively greener, efficient, and, with rationalized water and energy use. This is all ultimately aimed at ensuring sustainability in the design, construction, and, operation of constructed facilities. The key stakeholders in this plan were identified as: National Construction Authority (NCA); universities; county governments; private actors; Architectural Association of Kenya (AAK); Institution of Engineers of Kenya (IEK); and, Ministry of Transport, Infrastructure, Public Works, Housing and Urban Development (MTIHUD) under the leadership of Ministry of Lands and Physical Planning. This 15-year plan was estimated to cost 5 billion Kenyan shillings – (1 USD=Ksh. 138.45 as of May 2023) (Ministry of Environment and Natural Resources, 2016a:38). Similar efforts at the national level are evident in the Kenya Building Research Centre's Strategic Plan 2017/2018 – 2021/2022. This plan, with specific reference to SC, aimed to: mainstream green building; research on SC materials; and, developing supporting policy, guidelines, and, regulations for the Kenyan construction industry (Green Africa Foundation, 2018:21). This points to intentional efforts by the government to promote green building and SC in Kenya. However, there is limited empirical research on extent and the dynamics of implementation.

Contexts should inform sustainability strategies. Notably, most SC practices adopted by the developed nations are extended to their developing counterparts without due consideration of developing nations contexts. There are studies on SC in developing nations, and specifically Africa, although not as advanced and rich (in terms of scope, depth, and, content) as in their developed counterparts. As such, it becomes necessary to advance scholarly works in this direction for scalability of SC approaches for appropriateness to the developing world. Additionally, it cannot be assumed that one generic approach is best suited for all African countries due to their known diversity. On the other hand, these studies with specific reference to developing world, help identify key sustainability aspects in specific contexts. It has also been observed, given the case of Nigeria and Malaysia with low and Kenya with average SC awareness levels, that developing nations are most likely at different sustainability uptake levels (Dania, 2016:2-3, 57-60; Joseph, 2019:103). Other related aspects that come into play in this developed-developing nations duality include: availability of SC strategy leveraging platforms such as supportive institutional governance and robust technical capabilities; national priorities; and, building stock category (new or existing) (Dania, ibid:4-5,59). In view of the foregoing, for successful SCT the following are key: SCT strategies; and, their context appropriateness (social-spatial sensitivity; and, existence of supportive SCT strategy(ies) leveraging platforms).

The foregoing discussion raises two key questions which were explored in this study: how can ST in the construction industry, SCT, be achieved; and, how can context appropriateness be engrained in the adopted SCT strategies for enhanced industry SCT performance? For the former, there exist many technical strategies in line with SCT objectives though not in a single framework (such as in Akadiri *et al.*, 2012; Cairns, 2003; Cruz *et al.*, 2019). On the other hand, engraining context-appropriateness in the strategies is a grey area. The main theory identified to explain SCT phenomena in relation to SCT strategies and context appropriateness was socio-technical systems (STS) theory. This was to the effect that optimal and enhanced SCT performance is pegged on the joint optimization of technical strategies and context-appropriateness considerations (Kemp and Lente, 2011; Walker *et al.*, 2008:480). The supportive theories identified to explain context appropriateness were: theory of planned behaviour (TPB) – on SCT change readiness direct relationship with SCT intention (Ajzen and Fishbein, 1980; Bouckenooghe, 2010); place identity theory (PIT) – on SCT strategies socio-spatial sensitivity direct relationship with SCT behaviour (Proshansky *et al.*, 1983; Uzzel *et al.*, 2002); resilience theory – on resilience direct relationship with SCT (Antonovsky, 1979; Van Breda, 2018; Marchese *et al.*, 2018); and, multi-level governance (MLG) theory – on MLG (coordinated choice and/or necessity driven power dispersion from central national governments) significance in SCT (Marks, 1993; Cairney, 2019; Westman *et al.*, 2019).

1.3 Problem Statement

Over 30 years since WCED (1987) and despite the extensive scholarship in the field of sustainability science, ST is yet to be achieved (Dania 2016:59; Ives *et al.*, 2019). Approximately 25 years later since the onset of the sustainable construction transition (SCT) agenda (Shen *et al.*, 2006:20), which is the least time a socio-technical transition, such as SCT, can take as identified in this study, the construction industries globally are yet to fully transition to SC approaches (Glass, 2012; Aghimien *et al.*, 2018:2385; Willar *et al.*, 2021:110) and the Kenyan construction industry is not excluded. This is despite the industry being largely composed of small and medium enterprises (SMEs) given their well-known capabilities to adapt to change, as is the case for ST, compared to large enterprises (Condon, 2004; Wedawatta *et al.*, 2010:364; Ali, 2021). This implies that the actual global sustainability performance of the construction industry is not up to the expected levels. This highlights the overall research problem that this study sought to contribute solutions to, that is: the lagging transition into sustainability by the Kenyan construction industry. With sustainability being a holistic concept, the unsustainability of Kenyan construction industry takes a three-pronged approach: economically; environmentally; and, socially as explained below:

1.3.1 Economically – Inefficient Use of Resources

Kenyan building stock was estimated to be 37 million m^2 in 2018 (with residential spaces taking 81% of this stock) and was projected to reach 47 million m^2 in 2025 (Navigant, 2018; International Finance Corporation (IFC), 2017). In addition is the over 2 million housing units' deficit, as of 2017, and with majority of 61% urban dwellers living in informal settlements and the two are further complicated by an annual urbanization rate of 4.4% translating to an addition of 500,000 residents (World Bank Group, 2017:26). This highlights the substantial underdevelopment gap which the Kenyan construction industry will continue to seek to fill into the foreseeable future. Consequently, if the construction industry fails to shift from conventional to sustainable methods of production and consumption, there is the potential of continued negative economic, environmental, and, social impacts. With specific reference to the economic pillar of SC, if SC is not sufficiently adopted the industry risks not realizing the gains, in terms of profitability, associated with efficiency in resources usage. According to Woodall *et al.* (2004), the economic pillar of SC is aimed at *"... increasing profitability by making more efficient use of resources, including labour, materials, water and energy"*. Profitability in turn has been identified to be heavily dependent on the efficiency in usage of input resources – labour, materials, finance, plant, time, and, space (Lamka *et al.*, 2018:283).

Inefficient resources utilization has been observed in the Kenyan construction industry on fronts such as unacceptable resources levels fluctuations. This has been attributed to poor project scheduling and planning including lack of associated resource levelling tools. The resulting resources inefficiency has been observed to negatively affect project performance resulting in substantial time and cost overruns (Lamka *et al.*, 2018:283-284). On energy efficiency, buildings in East Africa (EA) consume up to 56% of the total electricity generated. This has been attributed to: artificial means of ensuring indoor comfort; energy intensive building materials production techniques; inconsiderate building users' behaviour; poor understanding of passive building principles; and, poor understanding of indoor thermal comfort. The process of generating the energy required by buildings has been identified to lead to greenhouse gas (GHG) emissions. It should also be noted that it has been postulated that appropriate design and interventions can deliver a 20% - 50% savings in energy consumption by buildings in EA. Consequently, energy efficiency in buildings has the potential of: reduced GHG emissions; cost savings; and, alleviating constraints imposed by limited energy capacity in the region such as electric power rationing (UNEP, 2018:21). Additionally, the construction industry has a multiplier effect on the national economy owing to its well acknowledged backward and forward linkages with other industries (Lamka *et al.*, 2018:283).

1.3.2 Environmentally – Slow Uptake of Green Building Approaches Heavily Leaning Towards New Building Stock

Environmentally, whereas the target is greening 75% of all large existing and new buildings, in Kenya, between the years 2016-2030 (UNEP, 2014:2), this target is still yet to be substantially met. As of 2018, there were 23 green buildings amounting to 1,259,781 square metres cumulatively (Green Building Information Gateway (GBIG), 2021). This figure is however disputed by NCA (2020:23) who had reported a total of 32 green buildings both new and renovated in the country. With a building stock that was 37 million square metres (Navigant, 2018) then, this represents a 3.4% green building stock. As of 16th June 2021, there were 28 green buildings amounting to 1,319,390 square metres (GBIG, 2021) cumulatively. With a (projected) building stock of 41 million square metres (IFC, 2017), this represents a 3.2% green building stock. Additionally, on industry professionals SCT capacity building as identified by Ministry of Environment and Natural Resources (2016:5), see Section 1.2.5: 18 professionals – architects, engineers, and, quantity surveyors – were trained on IFC Excellence in Design for Greater Efficiencies (EDGE) and 17 in Green Star (South Africa (SA)) green building rating tools (NCA, 2020:25) as of 2018. This was against a total of 3,763 registered professionals in the said three categories (NCA, 2019:36). Given that a total of 35 key professionals have been trained on the two green building rating tools, this gives a 0.93% green building rating capacity building rate.

Given that *"The success of any construction project is a direct reflection of the skills of the labour force behind it"* (NCA, 2020:21), the slow uptake of SC in Kenya can be partly attributed to the minimal capacity building on green building rating tools. The dominant green building rating tools in Kenya are IFC EDGE, Leadership in Energy and Environmental Design (LEED) (United States of America (USA)) and Green Star (SA). It cannot be left unmentioned that two more tools have been developed locally: Green Mark (by team of experts and stakeholders hosted by Green Africa Foundation); and, Safari Green (by AAK, University of Nairobi (UoN), and, UN (United Nations)-Habitat). These two are however yet to be extensively applied locally (NCA, 2020:25). It should be noted that green buildings largely address the environmental pillar of SC. This dimension is aimed at *"… preventing harmful and potentially irreversible effects on the environment by careful use of natural resources, minimising waste, protecting and where possible enhancing the environment"* (Woodall *et al.*, 2004). Markelj *et al.* (2014) asserts that this pillar covers: pollution and waste; energy use;

water (mains, rainwater, and, grey) use; building materials sourcing and use; and, land use aspects such as outdoor micro-climate effects of a constructed facility.

1.3.3 Socially – Inefficiency in Meeting Moral and Legal Obligations to Industry Stakeholders

The social pillar of SC is aimed at ensuring the construction industry complies with its moral and legal obligations to its stakeholders, such as suppliers, employees, and, surrounding community, throughout the project lifecycle (Woodall *et al.*, 2004; Adetunji *et al.*, 2003). *"... the social sustainability outcomes are best achieved by taking into account the satisfactions of the stakeholders"*. Three main categories of industry stakeholders have been identified as: industry – design and construction professionals and their support; neighbourhood community – populace sharing built environment with a construction project; and, users – populace using built facilities. This necessitates identification of key construction industry stakeholders, their social needs, and, the extent to which they are met in construction (Almahmoud and Doloi, 2016:35,38). It has been noted that this pillar of SC is less developed comparatively (Njoroge, 2013:42).

In line with social sustainability indicators as recommended by Almahmoud (2014:82), the following are some of the studies highlighting the Kenyan situation: low skills and knowledge enhancement – NCA (2014:7) reported that only 25% of all construction workers were skilled; gender inequity – construction companies' ownership – men 71%, construction workers – 81% male (NCA, 2014:7,8); health and safety – 64 fatalities for every 10,000 construction workers, in Kenya, compared to 0.44 in United Kingdom (UK) (2014), 3.8 in China (2013) and 25.5 in South Africa (2013/2014) (Kemei *et al.*, 2015:6; UK Health and Safety Executive (HSE), 2014; China Statistical Yearbook, 2013; Smallwood *et al.*, 2013); and, health of building users – evidence of sick building syndrome symptoms (SBSs) was observed amongst office workers in Nairobi City County as follows – eczema (3%), eye irritation (21%), fatigue (31%), dust allergy (24%), sore throat (25%), and, headache (27%) (Marete and Waweru, 2016:2).

1.3.4 Research Problem Summary and Related Past Research Efforts

An ideal sustainable construction industry would: ensure profitability through resources use efficiency; rational natural resources exploitation preventing harmful and potentially irreversible effects; and, acceptably meet its moral and legal obligations to its stakeholders (Woodall *et al.*, 2004; Adetunji *et al.*, 2003). From the foregoing discussion, it is clear that the

Kenyan construction industry is not significantly sustainable. This is despite the various initiatives by the various stakeholders such as SC agenda in the various national government plans and private sector led green building certification standards as is the case for Green Star (SA). It is in this realization that lies the need to explore ways in which the industry can transition towards comparatively sustainable modes of consumption and production. Given the multi-actor, multi-disciplinary, other industries interlinkages nature of the Kenyan construction industry, and, multi-dimensionality of SC, industry level SC transition becomes important to ensure: realization of SC gains; and, curbing the negative sustainability impacts of current industry practices as previously discussed. It is worth noting that most of the information shaping the Kenyan SC/SCT agenda has its origins in other nations. Consequently, the national SC agenda in Kenya is still in its formative stages.

Limited literature on SC in the Kenyan construction industry has been observed. A study by Joseph (2019) focused on the role of SC literacy, uptake, and, assessment in SC compliance with specific reference to the interior design market segment of the industry. Njoroge (2013) focussed on effectiveness of the regulatory framework in promoting SC in the Kenyan construction industry. Other notable studies and resources include: NCA (2020) on number of green buildings, green building rating standards capacity building, and, green building rating standards/tools; UNEP (2018) on built environment energy efficiency in EA; NCA (2014) on industry statistics such as gender composition of construction workers and construction firm's ownership; GBIG (2021) on information regarding certified green buildings in Kenya; Kemei *et al.* (2015) on health and safety in the Kenyan construction industry; Marete and Waweru (2016) on SBS among office buildings occupants in Nairobi City County; Green Africa Foundation (2018) and Safari Green (as discussed in NCA (2020)) on green building rating tools developed with local stakeholders input; Kenya Building Research Centre's Strategic Plan 2017/2018 – 2021/2022 which includes national agenda to mainstream SC (Green Africa Foundation, 2018:21); and, Ministry of Environment and Natural Resources (2016a) on national SC plan for the period 2016-2030. Notably, only Joseph (2019) and Njoroge (2013) explicitly considered the three pillars of SC. Consequently, this study sought to add to this limited literature by filling the knowledge gaps identified in Section 1.3.5 below.

1.3.5 Knowledge Gaps Explored by The Study

The above highlighted past studies on SC in the Kenyan construction industry offer valuable input to guide SCT. However, several key gaps in knowledge required further empirical exploration in a bid to enhance industry SCT performance. One, appraising the construction industry SCT performance. The reviewed past studies largely focussed on SC compliance driving the need, in this study, to assess SC performance from a ST perspective. This assessment would provide an up-to-date status on the progress (or lack thereof) in relation to the construction industry transitioning from the current conventional and largely unsustainable construction (process and product) practices to comparatively sustainable alternatives. Two, identification of prevalent SCT strategies as well as ranking their implementation considerations. The past studies highlighted above did not extensively and explicitly identify prevalent SCT strategies nor did they rank key factors considered when effecting the SCT strategies from a transition perspective. This information is critical in informing translation of SCT from a state of nebulousness to an actionable concept. Three, analysis of the SCT policy and legislative regime in place currently. None of the reviewed previous studies had explored the Kenyan SCT policy framework. To ultimately develop a model to, partly, guide improved SCT policy, it was important to understand how the current SCT policy regime worked. Lastly, proposing a model for SCT to guide policy and practice. This, unlike reviewed past studies, was the ultimate goal of this study. The resultant model was intended to: relate SCT strategies and their implementation considerations with SCT performance; and, help identify strategies and their implementation considerations that are significantly associated with optimized and enhanced SCT performance.

The four theories (TPB, PIT, Resilience Theory, and, MLG Theory) identified to explain SCT implementation considerations have largely been employed in generic ST research. This study sought to extend their application to ST's in the construction industry – SCT. Additionally, STS Theory was used to link SCT strategies and their implementation considerations with SCT performance. Consequently, the above identified research gaps were primarily explored based on the five theories.

1.4 Research Objectives

The main research objective of this study was:
To examine the key factors in the lagging sustainable construction transition (SCT) in Kenya with a view of developing a model to enhance industry SCT performance.

The specific research objectives that the study pursued are:

i. To assess the extent of SCT performance in the Kenyan construction industry
ii. To identify prevalent SCT strategies including the ranking of their implementation considerations in the Kenyan construction industry
iii. To examine Kenyan SCT policy regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings
iv. To develop a model for enhanced industry SCT performance linking SCT strategies including their implementation considerations with SCT performance

1.5 Research Questions

The main research question that this study sought to answer was:
What are the key factors in the lagging sustainable construction transition (SCT) in Kenya and how can they be modelled for enhanced industry SCT performance?

The specific research questions that were to be answered by this study are:

i. What is the extent of SCT performance in the Kenyan construction industry?
ii. What are the prevalent SCT strategies including the ranking of their implementation considerations in the Kenyan construction industry?
iii. What is the nature of the Kenyan SCT policy regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings?
iv. How can influences of SCT strategies including their implementation considerations on SCT performance be modelled to enhance industry SCT performance?

1.6 Research Hypotheses

Based on variables derived from the adopted theories, see Section 1.3, this study hypothesized that: the relation between SCT strategies, including their implementation considerations/context appropriateness considerations (independent variables), with industry SCT performance (dependent variable) can be explained as follows:

SCT strategies including their implementation considerations (context appropriateness considerations) *are significantly related* with construction industry SCT performance – alternative hypothesis (H_A)

The alternative explanation of the relation between SCT strategies, including their implementation considerations/context appropriateness considerations (independent variables), with industry SCT performance (dependent variable) can be explained as follows:

SCT strategies including their implementation considerations (context appropriateness considerations) *are not significantly related* with construction industry SCT performance – null hypothesis (H_O)

For purpose of this study, SCT strategies were identified in line with the objectives of SCT as outlined in Section 1.3 as follows: economically – enhanced labour productivity; development cost efficiency; operational cost rationalization; rationalization of demolition and materials recovery cost; and, property value enhancement; environmentally – materials, water, energy, and, land conservation; and lastly, socially – ensuring human well-being; ensuring resilience of built facilities against disasters; and, ensuring functionality. Additionally, the implementation considerations/context appropriateness considerations of the identified SCT strategies were SCT: change readiness; spatial sensitivity; resilience; and, appropriate multi-level governance including leveraging micro, small, and, medium enterprises (MSMEs) and select information technologies of internet of things (IoT)-driven big data and building information modelling (BIM). Lastly, industry SCT performance was evaluated from the perspective of: demand and supply of SC compliant processes and products; extent to which SCT objectives, as identified in Section 1.3, were being met; extent to which there is positive change of perceptions by industry stakeholders on SC compliant processes and products; and, extent to which technology is leveraged to overcome limits to exploitation of natural resources.

1.7 Justification of the Study

The construction industry is yet to fully transition from conventional and unsustainable to sustainable modes of production and consumption (Glass, 2012; Aghimien *et al.*, 2018:2385; Willar *et al.*, 2021:110). While the construction industry has been identified as central to the SD agenda, and while past studies have explored numerous SC independent variables, scholarly work on SCT remains limited. This is in addition to the well documented need to ensure SCT approaches are in harmony with their application contexts. This highlights the overall research problem explored by this study. This study argues that the joint optimization of technical SCT strategies and the engraining of context appropriateness considerations is central to optimal and enhanced industry SCT performance (see Section 1.2.5). Enhanced understanding of SCT strategies including how to ensure they are context appropriate could help SCT/SC research community by providing knowledge on: specific SCT strategies; and, factors contributing to their context appropriateness.

Additionally, construction industry practitioners and SCT policy stakeholders may find ways to enhance their practices and policies (including implementation and drafting of new policies) for enhanced industry SCT performance. This study ultimately sought to close the knowledge gap on: how (technically) SCT can be achieved in the construction industry; and, how context appropriateness can be engrained in SCT strategies for optimized and enhanced industry SCT performance. The key contributions which were expected as the output of this study included: better understanding of SCT strategies, including their context appropriateness, and their role in optimized and enhanced industry SCT performance; a detailed examination of the Kenyan SCT policy system to identify its priorities, instruments, stakeholder orientation, and, (any) inherent shortcomings; and, pragmatic findings for construction industry practitioners and SCT policy stakeholders on how to improve SCT practice and policies for enhanced industry SCT performance.

1.8 Significance of the Study

The findings of this study may be of interest to academia (including scholars), policy makers, and, practitioners in the built environment with specific reference to developing countries. Bearing in mind the limited scholarly works on SCT in developing nations, with possibilities of extension even to developed nations, and for scholars and academia, this study is part of the pioneer empirical studies on SCT in the Kenyan construction industry. This is along the following dimensions: independent variables – SCT strategies and their key implementation considerations; and, dependent variable – industry SCT performance. This was intended to contribute to: empirical awareness of the industry status in line with the variables; and, stimulating, including anchoring, further related research to offer empirical input to interventions geared towards enhanced industry SCT performance. This study postulates that current SCT challenges are partly a result of lack of theoretical awareness of the strategies and their implementation considerations. This awareness is central to any effective industry SCT performance improvement efforts.

With such advancement on the scholarly front, the findings may also serve to inform policy makers on some of the key elements that should be incorporated in crafting and/or revising SCT policies. This is especially on the need to ensure their appropriateness and consequently their effectiveness. Specifically, the findings of this study have the potential to inform crafting, revision and/or enhancement of SCT related legislation, regulations, building code, and, national infrastructural development plans. Additionally, the findings also highlighted the specific roles of the various SCT related policy making stakeholders such as national government, county governments, and, parastatals such as NCA. This study postulates that current SCT challenges are partly as a result of lack of empirical awareness on: functioning of the Kenyan SCT policy regime including (any) inherent shortcomings. Such awareness is necessary for any industry SCT performance improvement efforts from the policy front.

Lastly, with appropriate and supporting SCT policy system, the findings of this study have the potential to inform construction industry practitioners on enhanced uptake of SCT in all the phases of construction projects. This is through: clarifying the aims of SC (objectives); highlighting the range of SCT strategies; outlining the range of specific methods backing the various strategies; and, the SCT legal requirements to be met by the various stakeholders. Additionally, the findings can be used to engrain context appropriateness in SCT strategies implementation. This is along the following fronts: change readiness; social-spatial sensitivity; resilience thinking; and, MLG. This is in addition to leveraging MSMEs and select technologies of IoT-driven big data and BIM in SCT. This study postulates that current SCT challenges are partly a result of lack of models on how SCT can be onboarded in practice. Such models, for example the one developed in this study, are necessary for research-backed practice and consequently enhanced industry SCT performance.

1.9 Scope of the Study

Theoretically, this study was primarily anchored on STS theory supported by TPB, PIT, resilience, and, MLG theories (see Sections 1.2.5, 1.3, and, 1.6). The independent variables were identified as SCT strategies and their key implementation considerations while the dependent variable was identified as the industry SCT performance. It was ultimately aimed at developing a SCT policy and practice guiding model for the Kenyan construction industry.

On the methodological front, based on the pragmatism philosophy adopted, the study adopted a mixed-methods approach. This approach was supported by archival, interviews, and, survey research strategies. Additionally, data was collected over a specific point in time from construction industry stakeholders. The unit of analysis and observation was identified as individual key construction industry design phase stakeholder: practitioners – architects, interior designers, construction project managers, mechanical engineers, electrical engineers, civil and structural engineers, and, quantity surveyors; key informants from governance institutions – NCA, National Environment Management Authority (NEMA); Kenya Green Building Society (KGBS); and, Kenya Property Developers Association (KPDA); and, key informants from professional associations – AAK, Interior Design Association of Kenya (IDAK), Association of Construction Managers of Kenya (ACMK), Institution of Engineers of Kenya (IEK), and, Institute of Quantity Surveyors of Kenya (IQSK).

Lastly, on the geographical dimension, this study was conducted in Nairobi City County and the findings were extended to study population within Kenya. This is based on the fact that it is the national capital with a significantly bigger economy compared to other 46 Kenyan Counties and hence expected to be the model County for the construction industry in Kenya. Additionally, key project stakeholders, as identified above, practicing in Nairobi City County also tend to practice in the other counties.

1.10 Assumptions of the Study

The study was premised on the assumption that SCT performance of the Kenyan construction industry was sub-optimal. Further, that every key stakeholder in the Kenyan construction industry, as identified in this study, had at the very least a basic understanding of sustainability in relation to the built environment. Also, that most measurable aspects of SCT strategies and their key implementation considerations are held strongly enough by key construction industry stakeholders to an extent of influencing industry SCT performance. Additionally, that the construction industry in Nairobi City County is a true representation of the construction industry in the other 46 Kenyan counties. Lastly, that every key stakeholder in the Kenyan construction industry, as identified in this study, reasonably understood the industry operations including the associated SC concerns.

1.11 Study Limitations

There were limited previous studies on SCT in the construction industry fully embracing the three pillars/facets/dimensions of sustainability (economic, environmental, and, social) both locally and elsewhere. Additionally, the study was financially limited to the extent the researcher could independently fund. Further, physical data collection was limited due to the global COVID-19 pandemic that was ongoing for the better part of the duration of this study necessitating part online administration of questionnaires to the respondents. Also, the findings accuracy, pegged on quality of responses given by the key design phase stakeholders (for the data sourced using questionnaires) and key informants (for data sourced using interviews), could have been limited by intentional failure to disclose information that could have exposed professional shortcoming(s) of some of the respondents.

1.12 Study Delimitations and Exclusions

The study only covered SCT strategies and their key implementation considerations as independent variables with industry SCT performance as the dependent variable (as identified in Section 1.6). It further only focused on select information technologies in relation to SCT as follows: IoT; big data; and, BIM. Lastly, due to the potential large number of participants to this study, including financial constraints, the study population excluded: neighbourhood community – populace sharing built environment with a construction project; construction phase stakeholders such as contractors and suppliers; operation phase stakeholders such as facility managers and users; decommissioning phase stakeholders such as demolition specialists; and, other SCT related governance institutions such as Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) Corridor Development Authority.

1.13 Definition of Key Terms

Sustainable construction (SC) – Wholesome process whose goal is to revitalize and ensure balance at the interface between natural and built environments and while at it enhancing of quality of life, by upholding dignity and economic equity, of the human populace individually and collectively (Du Plessis, 2002:8-9).

Sustainable construction transition (SCT) – Radical socio-technical long-term shift from unsustainable to sustainable construction practices, environmentally and socio-economically, with corresponding change in stakeholders view of associated products, services, and, system aptness and leveraging on technology to overcome limits to exploitation of natural resources (Adapted from Markard *et al.*, 2012; Kemp and Lente, 2011:71).

SCT strategies – Co-ordinated and continuously improving action plan integrating sustainable construction objectives across temporal scales through mutually supportive approaches and based on needs, priorities, and, resources of given nation in context (Adapted from OECD, 2001a:25).

SCT change readiness – Measure of how willing/committed and prepared, including capacity build-up, the construction industry is towards sustainable construction change (Adapted from Holt and Vardaman, 2013).

SCT spatial sensitivity – Measure of appropriateness of sustainable construction transition strategies to specific locale combinations of economic, environment, social-cultural, and, community aspects (Adapted from Marsden, 2012:214; Horlings, 2016:32).

SCT resilience – The capacity of construction industry system to maintain its core functionality, with integrity in context of sustainability transition, including associated anatomy, identity, and, feedbacks (Adapted from Zolli and Healy, 2012:7; Walker *et al.*, 2004; Walker *et al.*, 2006).

SCT multi-level governance (MLG) – Coordinated choice and/or necessity driven system rules and mechanisms, through exercise of authority, dispersion from central national governments set up to facilitate sustainable construction transition in a given social set-up (Adapted from Cairney, 2019; Rosanau, 2000:225).

Micro, small, and, medium enterprises (MSMEs) – Category of enterprises having: annual turnover of up to Ksh. 100,000,000 (1 USD=Ksh. 138.45 as of May 2023); up to 250 employees; and, assets and financial investment value ranging from less than Ksh.5,000,000 to a ceiling as may be determined by Cabinet Secretary in charge of ministry dealing with MSMEs (*Micro and Small Enterprises Act 2012*).

Internet of Things (IoT) – Web of entities (people, devices, and, systems) exchanging information and interacting with the physical world through sensing, information processing, and, actuating (Electrical and Electronics Engineers (IEEE), 2020:20).

Big data – Data characterized by: large volumes beyond the capacity of existing data ecosystem; wide variety in terms of types and source; increased speed of data creation, processing, and, analysis – velocity; and, varying degrees of reliability and credibility (uncertainty) – veracity (Miele and Shockley, 2013:2-4).

Building information modelling (BIM) – Form of building data management where data is entered, visually and/or numerically, in a program to create a 3D model from which 2D views or even numerical data sets can be obtained and alterations in 2D view automatically update in the model (Martin, 2017:2).

1.14 Organization of the Thesis

The thesis is organized in six chapters.

Chapter one introduced the SCT problem in the Kenyan construction industry, anchor theories, the research objectives, study questions, hypotheses, justification, and, significance of the study including the associated assumptions, limitations, delimitations, and, definitions of key terms – research problem, its context, and, proposed way-forward.

Chapter two took an in-depth look at past literature on SCT, SCT strategies, their key implementation considerations, theoretical underpinnings, and, proposed a conceptual framework as to how they are conceptually related.

Chapter three discussed the research methodology for the study. In particular it presented: research philosophy; research reasoning and data required; research design approach; research population; sampling units and sampling frame; sampling and data collection approaches; data analysis and presentation approaches including planned validity and reliability tests; and, incorporated research ethics considerations – adopted research methodology.

Chapter four undertook an in-depth analysis of the SCT regime (policy and legislative) in the Kenyan construction industry. This covered its priorities, instruments, stakeholder orientations, and, (any) inherent shortcomings – objective three.

Chapter five covered the descriptive, validity, reliability, and, inferential statistical analysis of field study data. This was aimed at: understanding the demography of respondents; assessing industry SCT performance levels; assessing SCT strategies and their implementation considerations in Kenya; developing a model for enhanced industry SCT performance; and, testing the hypotheses – objectives one, two, and, four.

Chapter six covered the summary of findings from field study data and desk study analysis. This covered: outcomes of the research work within the context of the pre-set research objectives and hypotheses; study conclusion; achievements and contributions to knowledge; resulting practical implications and recommendations; future research directions identified; and, a reflection on the study.

The last section of this study is made of list of references for works cited in the study and appendices which include: fieldwork approvals; questionnaire; and, interview schedule – references and appendices.

CHAPTER 2

SUSTAINABLE CONSTRUCTION TRANSITION, STRATEGIES, AND, THEIR IMPLEMENTATION

2.1 Introduction

This chapter reviewed and analysed past literature in relation to the study variables to frame the study. It was ultimately aimed at developing a conceptual framework specifically highlighting the conceptual relationship between industry SCT performance, SCT strategies, and, their key implementation considerations. Specifically, this chapter: reviewed past literature on the concepts of SCT, SCT strategies, and, SCT strategy implementation considerations; and, offered the theoretical underpinnings for the study. This included an introduction that reviewed the concepts of sustainability, SD, STs, and, their convergence in SCT. The conceptual framework output was intended to be the basis of appraising key construction industry practitioners and select key informants on industry SCT performance and the contribution of SCT strategies and their implementation considerations. The chapter is structured in 6 main sections as follows: SCT and its context; SCT strategies; SCT strategies implementation/context appropriateness considerations; role of MSMEs and select information technologies (big data, IoT, and, BIM) in SCT; theoretical underpinnings; and lastly, conceptual framework. These are discussed in detail in the next sections:

2.2 Sustainable Construction Transition (SCT) and its Context

2.2.1 Sustainability Overview

Sustainability, in a broad sense, has emerged as an approach to ensure long-term sustenance of human life in context of universal mega-challenges such as changing climates, populations, technology, and, resources (Carboni *et al.*, 2018; Ives *et al.*, 2019). Murray and Cotgrave (2007) and Holland (2017) postulate that the terms sustainability and sustainable development (SD) can be used interchangeably. On the other hand, Du Plessis (2002), postulates they are two different concepts which is the viewpoint adopted by this study (see Section 1.2.1). Sustainability, as a concept, has been postulated as being complex and with multiplicity of values – meanings and appeals (Solow, 1991; Faber *et al.*, 2005; Medovoi, 2007). Brundtland Commission took an equity (a generational) perspective and described SD as development that ensures equity within the present generation populace while at the same time ensuring it is not at the expense of future generations populace (Brundtland, 1987). Solow (1991) in an economic perspective argued that goods and services can be substituted for each other and thus the general obligation of the present generation is to ensure future generations have the capacity for well-being as opposed to trying to necessarily maintain the status quo.

The 21st Century has been faced by some unique challenges. It is evident that the global population has been continuously increasing in size, with an increasing proportion of old people and has over time increasingly tended towards urbanization. This increase in population has in turn led to increased demand on already limited natural resources owing to largely unchecked consumption over time tipping the man-environment balance detrimentally. The climate has also changed due to a combination of increased demand for more natural resources, consumption of fossil fuels, and, pollution (air, land, and, water) amongst other factors (Allen & Macomber, 2020; Samways, 2022:35-36). It has also been noted that governments (national/federal and county/local) have been heavily burdened by these changes. It is in this realization that the role of private sector in complimenting public sector efforts is highlighted (Fukuyama, 2016; Allen & Macomber, 2020). It is also worth noting that scope definition of health has changed from just absence of disease to overall physical, mental, and, social wellness. Consequently, the built facilities (social, business, education, religious, and, recreational) are increasingly required to support overall wellness of their users (Allen & Macomber, 2020).

There has also been a change in the way people work. Now more than ever, there is a substantial global workforce of freelance, temporal, working from home or flexible time nature. In ensuring their overall wellbeing, this has called for user experience centred design of workplaces for optimum productivity. It is also undeniable that technological changes have heavily influenced most aspects of life. This has allowed for a shift from a largely qualitative to a largely quantitative means of ensuring sustainability consciousness of almost all human endeavours. This is evident in smart wearables, appliances, building management systems, and, cities over the world. Lastly for business enterprises, change in values has also been observed. The market focus/demand has shifted from just economic welfare (stakeholder primacy) to include positive environmental and social contributions (Allen and Macomber, 2020). All these major changes if not addressed threaten not only our sustenance but also that of future generations. As such they frame the sustainability focus of 21st Century moving forward and should be at the centre of all major decisions made. At the core of these changes are traditional approaches that did not have much potential specifically in the long-run hence the need for a shift.

These changes specifically in developing countries, such as Kenya, have been attributed to some of the pressing needs currently. These include but are not limited to increased population density, housing deficit, growth of informal settlements, inability of governments (national and local) to deliver on basic services such as accessible and affordable education and healthcare, unbridled urbanization, and, increased difficulty to meet basic needs, such as food, by the general populace (Du Pisani, 2006:91). This in addition to the direct adverse negative impact of some of the changes. For example, rise in ocean levels will lead to displacement of people living in low lying coastal areas, air pollution will cause acidic rain and its effects, general pollution (land, air, and, water) will lead to illnesses such as respiratory diseases, and, increased heavy precipitation instances will lead to displacement and in some cases death of people. All these impacts are a serious threat to human life and require immediate action(s) of both short-term and long-term nature (Tvaronavičienė, 2021:2-5).

In light of all these negative impacts, ensuring and maintaining capital (manufactured, human, social, knowledge/intellectual, and, natural) stocks, in the right mixes, would guarantee sustenance of human life now (in context of economic, environmental, and, social shocks) and ultimately in future. Manufactured capital stocks include industrial and financial systems such as built facilities (product, transport, and, business) and stock exchange. Elements of human capital relate to matters literacy (mastery of knowledge and skills), physical well-being, and, populace. Social capital stocks relate to institutional, organizational, and, interactional dispositions. Intellectual capital components include but are not limited to: skills mastery; technical know-hows; and, scientific realizations. Lastly, natural capital relates to natural resources stocks. This conceptualization is based on the realization that for human life sustenance, welfare must be ensured, seen through economic, environmental, and social shocks (resilience) in the short-term and in the long-run. This view centralizes human well-being as the ultimate state in the long-term and sustainability in the short-term as being ensured through resilience to economic, environmental, and, social shocks (Laurent, 2018).

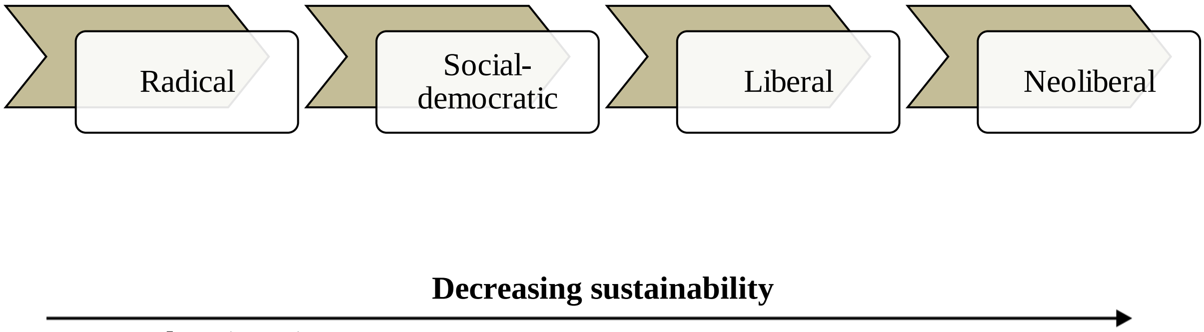
2.2.2 Sustainability Conceptualization

As postulated by Huge *et al.* (2012), the economic, environmental, and, social crises, also referred to as global mega-challenges by Carboni *et al.* (2018), occasioned by human activities are a reality and clear to all but the interpretation of the concept that addresses them, sustainable development (SD), is contested. Huge *et al.* (2012) continues that many interpretations exist reflecting particular world views. These different interpretations as shared by particular groups of people give rise to conceptual generalizations also known as discourses or debates. Whereas on one hand it has been argued that the various interpretations lead to constructive nebulousness (Robinson, 2004; Teal, 2010), on the other, it has been postulated that it gives room for terminological misapplication (Bosshard, 2000) and/or inadvertent simplification (Teal, 2010). According to Huge *et al.* (2012), the determination as to how sustainable an endeavour is, is highly dependent on the interpretation of sustainability adopted. This is owing to the existence of different viewpoints with some being more dominant than others. It is in this realization that lies the inherent need to review the various existing debates on interpretation of sustainability and SD. This is ultimately aimed at clarifying the implications of the various interpretations and identification of the specific interpretation adopted by this study.

The interpretation of SD can be approached from two main viewpoints: extent of capital forms substitutability; and, man – earth dominance. Primarily dependent on the degree of substitution of forms of capital, Davidson (2011) discussed four perspectives in order of decreasing sustainability as: radical; social-democratic; liberal; and, neoliberal. McManus (1996) postulates that radical interpretation advocates for greater extent conservation of vital natural stock as key to human life sustenance. Additionally, a social-democratic interpretation adopts a similar perspective but not as strict on key natural resources preservation. These two orientations take a largely non-substitution viewpoint of key natural capital. On the flip side, there lies the liberal and neoliberal interpretations. The neoliberal approach postulates that to a large extent human and intellectual (mainly technological) capital forms will overcome challenges imposed by limits to exploitation of natural resources. The liberal approach is of the position that critical capital forms are substitutable but to a lesser extent compared to the neoliberal way of thinking. These two approaches take a largely pro-substitution viewpoint of key capital forms.

These SD interpretation perspectives, are illustrated as a continuum from one extreme to the other in Figure 2.1 below:

Figure 2.1: Sustainability Interpretations Based on Capital Forms Substitutability Viewpoint

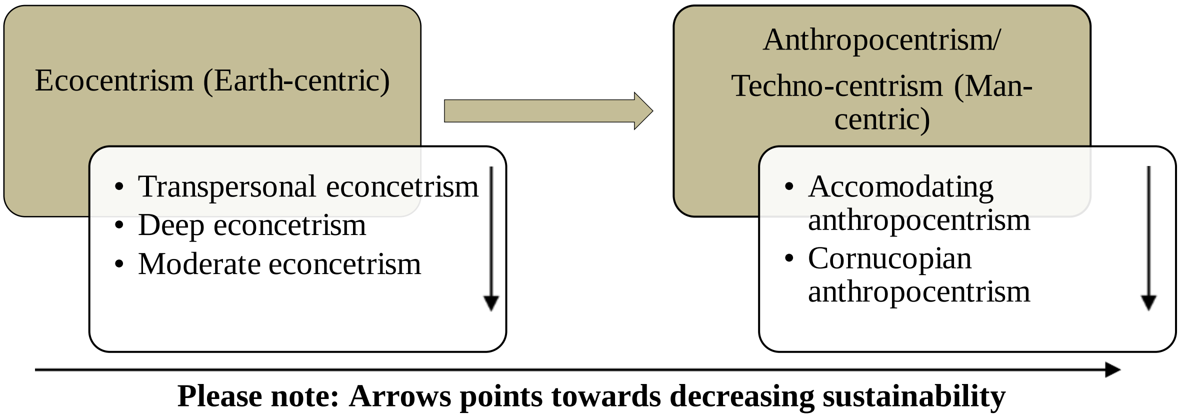


Source: Author (2023)

From a man-earth dominance perspective, the two opposing sides, in order of decreasing sustainability, are: ecocentrism; and, anthropocentrism or techno-centrism (Wilkinson, 2016). Anthropocentrism/techno-centrism is of the position that human beings are the most consequential species and dominate the rest of nature (Washington, 2015). On one end, of comparatively high sustainability, this position is accommodating environmentalism. It takes a resources conservation view, based on a belief system of faith in science and technology and calls for controlled growth. On the other end it has the cornucopian environmentalism. This position takes a resources exploitation view, based on a belief system of rational resource use and calls for maximized growth. Ecocentrism advocates are of the view that all living organisms and their natural environments are significant irrespective of their perceived value to human beings. In this viewpoint there are 3 sub-viewpoints (in order of decreasing sustainability): transpersonal; deep; and, moderate ecology. Transpersonal ecology is based on religious beliefs, does not believe in science and technology and views growth as not sustainable. Deep ecology is a rational version of transpersonal ecology based on ethics and value. Lastly, moderate ecology is a rational position based on value of ecosystems, conscious of earths carrying capacity and is also of the position that growth/development is not sustainable (Wilkinson, 2016).

These interpretation perspectives are as illustrated in Figure 2.2 below:

Figure 2.2: Sustainability Interpretations Based on Man-Earth Dominance Viewpoint



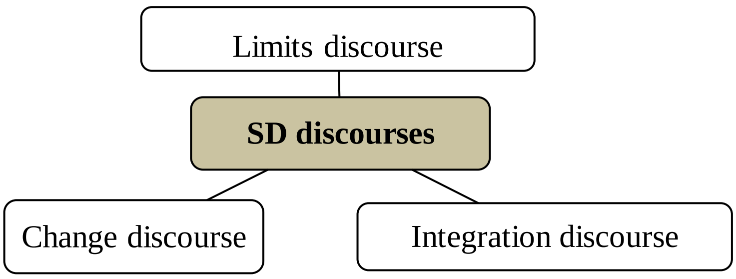
Source: Author (2023)

From the above, it is clear that different interpretations exist as to what is sustainability, and consequently SD, including the continuum of SD from high/strong (strong sustainable development – SSD) to low/weak (weak sustainable development – WSD). As such, it becomes important to clearly highlight the interpretational approach adopted for any study.

2.2.3 Sustainable Development (SD) Discourses

Discourses can also be referred to as conceptualizations, debates or typologies. This study adopts three main discourses as advanced by Huge *et al.* (2012): limits; integration; and, change. This is based on the fact that the said proposition advances earlier SD sub-discourses into three main discourses thus drawing from the individual expertise and at the same time minimising weakness that went into shaping the various sub-discourses. This was ultimately aimed at understanding the thematic areas of SD discourses which would then inform the option adopted for this study and the reasons thereof. These three perspectives are discussed, and illustrated in Figure 2.3, below:

Figure 2.3: SD Discourses



Source: Author (2023)

2.2.3.1 Limits discourse

The limits perspective is about relationship between man and nature within the context of limitations (Huge *et al.*, 2012). It is based on the premise that earth's carrying capacity is limited and hence the implied need to ensure anthropogenic development does not exceed the planetary limits (Meadows *et al.*, 1972; Huge *et al.*, 2012). Specifically, this discourse emphasizes that part of the earth's natural stock cannot be substituted and as such should be conserved (Neumayer, 2003). Based on the extent of capital form substitutability, this perspective tends towards a radical approach: greater extent conservation of vital natural stock as key to human life sustenance. From a man-earth dominance viewpoint, as advanced by Huge *et al.* (2012), it assumes an earth-centric approach – ecocentrism. As discussed in Section 2.2.2 above, ecocentrism on one extreme is based on religious beliefs and on the other extreme based on value of ecosystems, considerate of earths carrying capacity and is also of the position that growth/development is not sustainable. SD is thus seen as development within the planetary spatial carrying capacity. As such human activities are limited to the extent of substitutable planetary critical natural capital.

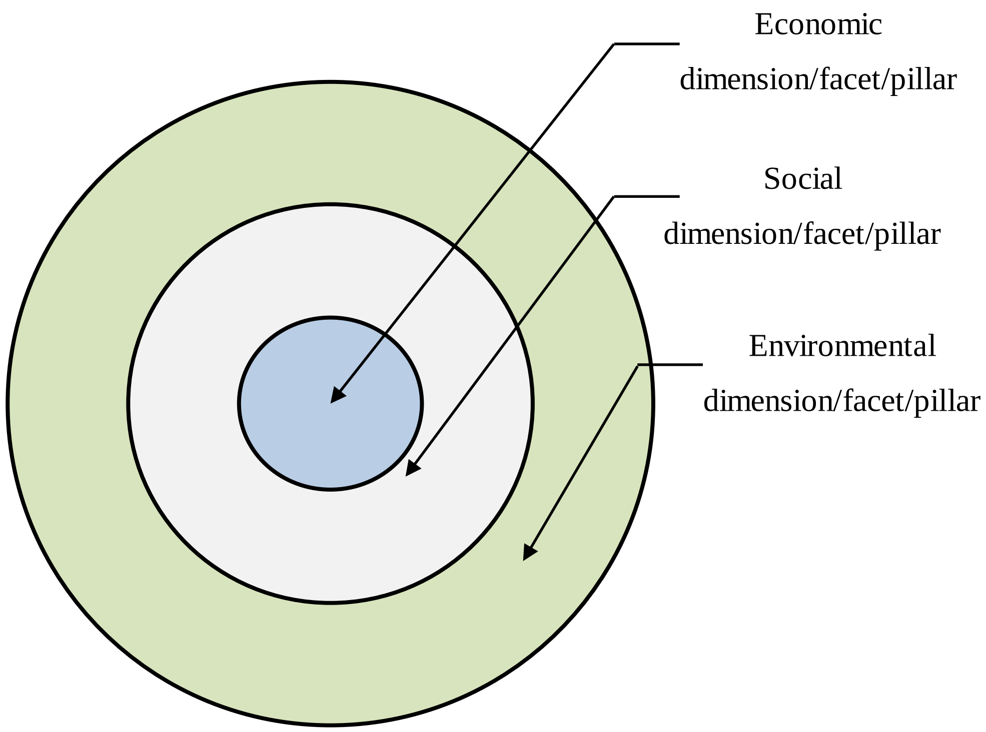
2.2.3.2 Change discourse

This perspective is based on the premise that SD is a change process as opposed to a fixed state (Huge *et al.*, 2012). It is about a shift from unsustainable modes of production and consumption towards more sustainable comparatives informed by the need to check irreversible depletion of planetary natural stock (Hardi, 2007). Based on the capital form substitutability approach, this perspective tends towards radical and social-democratic approaches: emphasizing on stopping and/or reducing irreversible depletion of critical natural stocks. From a man-earth dominance viewpoint, and similar to the limit's perspective, it assumes an earth-centric approach – ecocentrism ranging from transpersonal to moderate ecocentrism as discussed in Section 2.2.2 above. As such, SD emerges as a process focused on changing the course of human activities towards comparatively sustainable alternatives: sustainability transition (ST). Consequently, human activities are limited to the extent to which they begin to threaten depletion of critical natural resources. Additionally, as postulated by Rotmans and Van Asselt (2011), this discourse emphasizes on the role of networking and governance in realization of the desired change.

2.2.3.3 Integration discourse

This discourse is of the view that economic, environmental, and, social aspects are overarching in SD. This is as postulated by Joseph (2019:22) and Cotgrave and Riley (2013:4) as cited in Dania (2016:18) and as illustrated in Figure 2.4 below. This integration should be: of economic, environmental, and, social aspects; across temporal and spatial scales; across disciplines; and, across sectors (Robinson, 2004:378). This perspective is not explicit in regards to capital form substitutability approach. From a man-earth dominance viewpoint it tends to assume an earth-centric approach, as discussed in Section 2.2.2 above, in the sense that environmental dimension houses the social dimension which in turn houses the economic dimension (Esezobor, 2016:28; Joseph, 2019:22). As such, SD emerges as a process integrating economic, environmental, and, social aspects of development geared towards continued human life sustenance. Consequently, human activities are limited to the extent to which development is cognisant of economic, environmental, and, social facets of development. In a nutshell, this is a reform-oriented non-adversarial approach accommodating different interests (Hajer and Fischer, 1999). This has been postulated to accommodate different interpretations while at the same time proposing custom-made sustainability solutions to specific scenarios (Van Zeijl-Rozema *et al.*, 2008).

Figure 2.4: Integration Discourse of SD



Source: Author (2023)

2.2.3.4 Adopted SD perspective

This study adopted a SD perspective that fuses the three main discourses, limit's, change, and integration. Specifically, this study assumes the position that human activities are limited: to the extent of substitutable planetary critical natural capital (Section 2.2.3.1); to which they begin to threaten depletion of critical natural resources (Section 2.2.3.2); and, to the extent to which development is cognisant of economic, environmental, and, social facets of development (Section 2.2.3.3). Consequently, due to their inherent sustainability conceptualizations (discussed in detail in Sections 2.2.3.1 – 2.2.3.3), this study adopted a position that fuses both: capital form substitutability; and, man-earth dominance interpretation viewpoints. This was meant to take advantage of their rich diversity while at the same time minimizing any inadequacy that may arise in any conceptualization of SD that is not cognizant of either of them. This study specifically adopted a largely neoliberal – cornucopian anthropocentrism conceptualization of SD. The position is informed by Tulloch and Neilson (2014:35) discussion that understanding of economy-ecology relationship has changed over time. This is from capitalistic growth as detrimental to natural environment, and consequently human sustenance, to being viewed equivalently with ecological sustainability being driven by markets and capitalism aspects of the economy dimension. This specifically informs the neoliberal position assumed. On cornucopian anthropocentrism, this is informed by Solow (1991) seminal lecture relating to what we owe the next generation. Solow (ibid) postulated that for sustenance of human life both now and in future, the focus should be towards ensuring general well-being of human life as opposed to just leaving the natural stock unaltered. As such, this philosophy is embodied in cornucopian anthropocentrism: rational use and exploitation of resources for maximized growth.

2.2.4 Sustainability Transitions (ST)

Developing nations, as is the case for Kenya, experience sustainability issues in form of negative environmental and social impacts as a result of adopted economic growth approaches. This complicates the trade-off between economic growth consideration and conservation of planetary natural stock (Aerni, 2015). Kapsalis *et al.* (2019) postulates that this is because the measures adopted to ensure economic growth are not substantially linked with measures necessary for SD. Additionally, this highlights the need to deal with economic growth approaches to ensure that they are sustainability conscious in a bid to counter the resultant environmental and social consequences. Failure to address these issues has the potential of slowing down economic growth. As such for growth to be sustainable, the adopted approaches to achieve it must incorporate SD principles and practices. For sustainability transitions, and as advanced by Loorbach *et al.* (2017), change is from one state of dynamic equilibrium experiencing sustainability challenges to comparatively sustainable alternatives. A good example of such a change being the energy transition marking a change from heavy reliance on fossil fuels to renewable energy alternatives owing to the known negative sustainability implications of the former.

In dealing with major challenges facing the world today, as outlined in Section 2.2.1, inherently lies the need to adapt for sustenance of human life as we know it. Du Plessis (2002) postulates that SD is primarily focused on ensuring intra- and extra-generational human life sustenance (see Section 1.2). It has however been established that incremental changes are not sufficient to address these challenges and radical change is required instead. These radical socio-technical shifts have been termed as sustainability transition/sustainability transformation (Elzen *et al.*, 2004; Grin *et al.*, 2010; Blythe *et al.*, 2018). Such transitions are aimed at changing entrenched patterns of consumption and production in society's ways of doing things (Geels, 2004; Markard *et al.*, 2012; Kohler *et al.*, 2019) including associated assumptions, rules, and, practices (Rotmans *et al.*, 2001). Kemp and Lente (2011) postulate that in addition to facilitating change in established socio-technical systems, these transitions involve a change in how goods, services, and, systems are perceived. These transitions are heavily biased towards public good as opposed to individual gains (Geels, 2011; Kohler *et al.*, 2019). Regarding the process, these transitions involve many elements, such as infrastructure and supply chains with complex interactions on matters such as economics and power (Unruh, 2000; Geels, 2011; Kohler *et al.*, 2019).

It has also been advanced that these transition processes take a long time to execute ranging from, one generation – 25 years (Rotmans *et al.*, 2001), up to 50 years (Markard *et al.*, 2012) or even decades as discussed in Kohler *et al.* (2019). They can however be accelerated by unexpected occurrences (Rotmans *et al.*, 2001). Their implementation requires the input of the stakeholders at individual, corporate, and, institutional levels drawn from learning/research institutions, civil society, political structure, sectors, and, households (Markard *et al.*, 2012; Kohler *et al.*, 2019). Being socio-technical in nature, it has been acknowledged that there is no one pathway to ensure implementation of these transitions and their consequent success

(Badham *et al.*, 2000). Kohler *et al.* (2019) postulates there are numerous promising ST pathways in different domains and at the moment it is hard to tell which one will prevail. Additionally, sustainability has been challenged on need and speed of change. This is owing to the various vested economic interests by the various stakeholders challenged by sustainability initiatives. The nature of sustainability transitions as above discussed is summarized in Table 2.1 below:

Table 2.1: Nature of Sustainability Transitions (STs)

Key Component	Brief Explanation	Source
1. Need for change	Ensuring current and future sustenance of quality human life through comparatively sustainable production and consumption modalities	Du Plessis (2002)
2. Change context	Purposive radical social-technical change in context of deeply entrenched patterns of consumption and production	Kohler *et al.* (2019)
3. Change focus	Changing societal modes of production and consumption (socio-technical systems and perceptions of goods, services, and, systems) towards comparatively sustainable alternatives	Geels (2004), Markard *et al.* (2012), and, Lente (2011)
4. Stakeholders' composition	Learning/research institutions, civil society, political structure, sector, and, households at individual, corporate, and, institutional levels	Markard *et al.* (2012), and, Kohler *et al.* (2019)
5. Nature of process	Multi-dimensional: ST involves many elements under considerations such as supply chain and infrastructure with complex interactions	Unruh (2000), Geels (2011), and, Kohler *et al.* (2019)

Key Component	Brief Explanation	Source
6. Speed of change	Radical as opposed to incremental change in addressing sustainability challenges	Elzen *et al.* (2004), Grin *et al.* (2010), and, Blythe *et al.* (2018)
7. Beneficiary orientation	Largely oriented towards public/collective/common good as opposed to individual gains	Geels (2011), and, Kohler *et al.* (2019)
8. Value contestation	Sustainability initiatives are highly contested since they challenge existing economic positioning of the various stakeholders	Kohler *et al.* (2019)
9. Implementation approach	Equifinality: There are multiple pathways to achieve sustainability transitions	Badham *et al.* (2000)
10. Implementation timeline	Long-term: Anywhere between 25yrs to decades	Rotmans *et al.* (2001), Markard *et al.* (2012), and, Kohler *et al.* (2019)

Source: Author (2023)

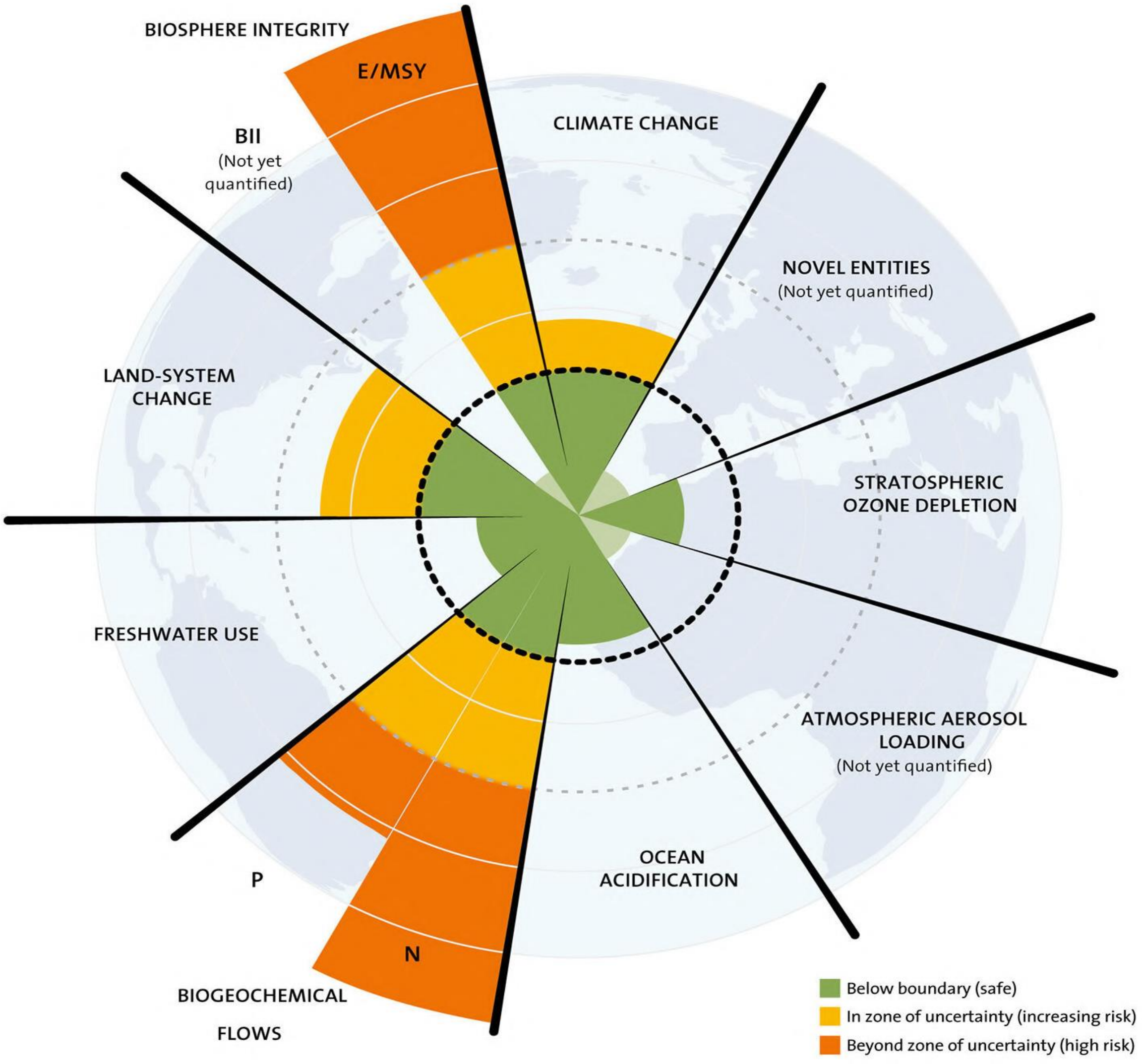
2.2.5 Sustainable Construction Transition (SCT) and Associated Market Operations

2.2.5.1 Sustainable construction transition (SCT)

The built environment is a complex system that supports societal needs such as housing and recreation, has a significantly long lifespan, and, involves many stakeholders. Additionally, the interaction of the built environment system with the ecological system has resulted in the well documented negative impacts on the latter (see Sections 1.2.2 and 1.3.2). Specifically, these negative impacts have been observed to be comparatively less noticeable and documented at constructed facility scale compared to the same but at planetary scale over time (Vanegas and Pearce, 2000:406-407). This has led to increased focus on the contribution of the built environment by the various stakeholders. Owing to its known direct and indirect contribution to this problem, the construction industry has seen increasing restrictions aimed at minimizing negative ecological impacts. These have assumed different forms which include regulations, laws, standards, and, pressure from other stakeholders such as civil society. However, it has been observed that some industry players, such as design and construction entities, see compliance with these restrictions as a challenge to be overcome as opposed to a means of reaping SC benefits for them and others (Kinlaw, 1992 as cited in Vanegas and Pearce, 2000:407). Drivers for SCT have been identified to include: negative ecological impacts; resources degradation and depletion; and, impacts on human health. It is however worth noting that SCT embeds the traditional project priorities of time, cost, quality, and, minimizing negative impacts in the context of sustainability (Vanegas and Pearce, 2000:407-408).

Steffen *et al.* (2015:736) as cited in Kedir *et al.* (2020:12) identified planetary boundaries of nine biophysical environment components under which human life should be sustainable. These biophysical environment components have been identified as: novel entities; ozone depletion; climate change; atmospheric aerosol loading; ocean acidification; biochemical flows (nitrogen and phosphorous); freshwater use; land-system change; and, biosphere integrity (genetic and functional). Four of these have been identified as above the safety boundary: climate change; biochemical flows; land-system change; and, genetic biosphere integrity as summarized in Figure 2.5 next page. It is also worth noting that Jaramillo and Destouni (2015) had partly disputed the findings of Steffen *et al.* (2015:736) to the effect that recent research indicate that global freshwater use was also beyond the planetary boundary. In response, Gerten *et al.* (2015:1217) highlighted that local tolerance levels were already exceeded but below the planetary boundary. According to Renz *et al.* (2016) as cited by Kedir *et al.* (2020:12), the construction industry has impacts, direct and indirect, on the nine biophysical environment components through the construction and operation of built facilities. As such, it is necessary for the industry to shift from conventional practices if we are to stay within planetary limits and ensure continued human life sustainability. This is even more so in the developing nations, such as Kenya, with huge development gap (see Section 1.3.1) which guarantees continued and active development of the built environment.

Figure 2.5: Biophysical Planetary Boundaries Status



Key: P = Phosphorous Flows, N = Nitrogen Flows, BII = Biodiversity Intactness Index (Functional Diversity Measure), and, E/MSY = Extinctions Per Million Species-Years (Genetic Diversity Measure)

Source: Steffen *et al.* (2015)

The construction industry affects the economic, environmental, and, social aspects of human life. In addition to impacts highlighted in Sections 1.2.2 and 1.3, the construction industry, globally, accounts for six percent of the global GDP and employs 100 million people. It also provides built facilities to support the various human needs, such accommodation, transport and recreation, and it is the single largest consumer of natural resources and raw materials. It has also been established that the built environment is responsible for 25-40% of carbon dioxide (CO_2) emissions and 30% of greenhouse gas emissions. With the huge underdevelopment occasioned by increasing population and urbanization, specifically in developing nations such as Kenya, more built facilities are needed to support human needs (Renz *et al.*, 2016:9; Global Construction Perspectives and Oxford Economics, 2013; UNEP, 2007 as cited in Renz *et al.*, 2016:9). In light of this great impact on human life, it is argued that any small improvement in the industry would have great positive effects on the society. As such, it is important the construction industry embraces to the SCT agenda in light of the inherent opportunities of a shift in practice and the well-known negative impacts of current conventional and unsustainable practices (Renz *et al.*, 2016:12,16).

Sustainable construction (SC) is the wholesome process whose goal is to revitalize and ensure balance at the interface between natural and built environments and while at it enhance of quality of life, by upholding dignity and economic equity, of the human populace individually and collectively (Du Plessis, 2002:8-9). Along the same line of thought, sustainability transitions (STs) have emerged as *"… long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption"* (Markard *et al.*, 2012:956). In addition to ST being on change of a system, such as construction and management of constructed facilities, it also includes a change in the way system actors reckon products, services, and, system aptness (Kemp and Lente, 2011:71). The synthesis of the above discussion, including the discussion in Sections 2.2.1-2.2.4, leads to the following definition of SCT by this study:

Sustainable construction transition (SCT) – Radical socio-technical long-term shift from unsustainable to sustainable construction practices, environmentally and socio-economically, with corresponding change in stakeholders view of associated products, services, and, system aptness and leveraging on technology to overcome limits to exploitation of natural resources.

2.2.5.2 SCT demand and supply components

The demand for sustainable and green property can be understood through two main theories: TPB; and, social cognitive theory (Onuaha *et al.*, 2017:22-24). Based on the planned behavior theory, intention is key to behavior and is driven by favorable: attitude towards behavior; perceived social pressure; and, perceived ease of behaving in a certain way and is based on past experiences and expected barriers (Ajzen, 1991:182, 188-189). On the other hand, the social cognitive theory postulate that forethought follows intention which eventually turns to action/behavior through motivation and expected beneficial implications (Diyana and Abidin, 2013:915). Consequently, Onuaha *et al.* (ibid) identified factors that stimulate the demand of sustainable property/components/materials as: personal and selfless; social responsibility; economic; and, financial motivations. Personal and selfless motivations relate to realization of the need for individual action in mitigating impacts of unsustainable processes and products and gaining reward(s) (internal and/or external). An example would include buying an energy efficient building to avoid high operational costs related to energy used. Social responsibility motivations relate to ensuring congruence with personal and/or corporate sustainability persuasions and communicating the same voluntarily, out of social pressures and/or as is required by employers/employing organizations. Lastly, economic and financial motivations relate to economic and financial benefits. These include: better return rates; reduced facilities operation costs; optimized economic lifecycle performance of facilities; obtaining grants and subsidies; enhanced user productivity and satisfaction; higher rents and/or resale value; quick market absorption; enhanced occupancy; and, enhanced residual value.

On the flipside, the supply for/decision to invest in sustainable and green property can be understood through social cognitive theory (Onuaha *et al.*, 2016:499). According to this theory, forethought follows intention which eventually turns to action/behavior through motivation and expected beneficial implications (Diyana and Abidin, 2013:915). Developers/investors are more likely to invest in sustainable products and processes if they deliver better returns (cost recovery and profits). Additionally, sustainability project financing incentives, such as through reduced interest rates, and positive price signals from existing SC investments would also entice investors/developers. On the marketing strategies front, a developer/investor is inclined to invest in SC: to meet growing demand including affordability for improved public image and consequently competitiveness and occupying niche opportunities offered by SC. Lifecycle cost savings also promote investment in SC products and processes. While investment decision in built environment is largely pegged on reasonable initial cost, SC offers benefits during the operational phase to both developers and users/occupants. Attractive tax incentives also have the potential of stimulating supply of SC compliant facilities. The incentives can target: stamp duty; credit property tax; capital gains tax; tax abatement; waivers; rebates and grants; and, loans taxes. Lastly, other key drivers of SC supply have been identified as: availability of SC skills for the various project phases; supporting government policies (mandatory and/or voluntary); SC certifications, awards, and, recognition; and, ethical motivations – avoiding non-compliance, environmental consciousness, and, social responsibility (Onuaha *et al.*, 2016:500-502; Diyana and Abidin, 2013:916-917).

Table 2.2 below summarizes the foregoing discussion:

Table 2.2: SCT Demand and Supply Drivers

Market Operation Component	Driver	Source
A. Demand	i. Personal and selfless motivations	Onuaha *et al.* (2017:23-24)
	ii. Social responsibility motivations	
	iii. Economic and financial motivations	
B. Supply	i. Better returns (cost recovery and profits)	Diyana and Abidin (2013:916-917), and, Onuaha *et al.* (2016:500-502)
	ii. Project financing incentives	
	iii. Market strategy motivations – operational advantage and marketing niche	
	iv. Lifecycle cost savings	
	v. Attractive tax incentives	
	vi. Availability of SC skills for the various project phases	
	vii. Supporting government policies (mandatory and/or voluntary)	
	viii. SC certifications, awards, and, recognition	
	ix. Ethical motivations – avoiding non-compliance, environmental consciousness, and, social responsibility	

Source: Author (2023)

2.3 SCT Strategies

2.3.1 Overview

A SD strategy is defined as: *"A co-ordinated set of participatory and continuously improving processes of analysis, debate, capacity-strengthening, planning and investment, which seeks to integrate the short and long term economic, social and environmental objectives of society – through mutually supportive approaches wherever possible – and manages trade-offs where this is not possible"* (OECD, 2001a:25). A standardised approach is however discouraged in favour of custom alternatives based on needs, priorities, and, resources of given nation in context (OECD, ibid:25). From the above definition, the components of a SD strategy can be identified as: societal socio-economic and environmental objectives; temporal dynamic integration of the objectives; and, approaches to be used to achieve the objectives. This study approaches SCT from the industry scale owing to the limited empirical SC studies on this when compared to project and city scales as highlighted in Cruz *et al.* (2019). It is also worth noting that SC efforts in the past have largely tended towards environmental sustainability (Cruz *et al.*, 2019). Vanegas and Pearce (2000:406, 408) postulates that for a successful SCT, the need for change should be convincing and a supporting strategy should be in place. Specifically, lifecycle SC considerations are required both in actual construction project delivery and associated supply chain. However, the challenge remains as to how this can be executed and from which point.

2.3.2 SCT Strategies (Including Supporting Multi-Level Approaches)

Based on the three pillars of sustainability (economic, environmental, and, social), SCT consequently has three objectives as identified in Section 1.3.

Economically, *"… increasing profitability by making more efficient use of resources, including labour, materials, water and energy"* (Woodall *et al.*, 2004). Other additional resources in construction have been identified as: plant; finance; and, time (Lamka *et al.*, 2018:283); and, land by Akadiri *et al.* (2012:132).

Environmentally, *"… preventing harmful and potentially irreversible effects on the environment by careful use of natural resources, minimising waste, protecting and where possible enhancing the environment"* (Woodall *et al.*, 2004).

Socially, ensuring the construction industry complies with its moral and legal obligations to its stakeholders throughout the project lifecycle such as suppliers, employees, and, surrounding community (Adetunji *et al.*, 2003; Woodall *et al.*, 2004).

While the above objectives holistically capture the scope of SCT, they are not explicit on how to achieve SCT (Cruz *et al.*, 2019). To facilitate realization of these SCT objectives, there are a number of strategies and associated support methods/practices that are available for use by the various industry stakeholders. They are discussed in detail below:

On the economic pillar of SCT and consequently based on SC objective one: enhanced profitability through increased efficiency in resources (labour, plant, finance, materials, and, technology) usage, there are five main SCT strategies. These are: enhanced labour productivity – has been identified as key indicator of efficiency in labour-intensive industries such as construction. Some of the specific methods/practices adopted for this strategy include resource levelling (Kuruga, 2017: xii); development cost efficiency – this strategy is to the effect that there should be deliberate effort to avoid unnecessary expenditures. This can be achieved through: optimal use of locally sourced materials; cost saving building technologies; components standardization; use of recycled and/or reclaimed building materials; and, design modularization; operational cost rationalization – to complement development cost efficiency, the costs in use should be rationalized from the project onset. This can be achieved through the following specific methods/practices – full lifecycle considerations during design and construction phases; rationalization of demolition and materials recovery cost despite the fact the constructed facility may involve change in ownership later. This can be achieved through enhancing: adaptive re-use of constructed facilities; ease of re-using building materials and/or components; and, demolition ease (Akadiri *et al.*, 2012:139-143) and lastly, and in a nutshell, labour, plant, finance, materials, and, technology efficiency is key for profitability in the construction industry (Lamka *et al.*, 2018:283).

In addition to the above, Markelj *et al.* (2014:8780) adds another SCT strategy for objective one: property value enhancement. This strategy is identified to be implemented through: having the constructed facility meet target market value expectations and sustain it over time; artistic outlook that enhances value; spatial planning of the constructed facility/facilities that enhance its/their value; and lastly, a constructed facility should be situated proximal to requisite support infrastructure such as ensuring residential building is proximal to health facility(ies).

Secondly, on the environmental pillar of SCT and consequently based on SC objective two: preventing damage and potential irreversible impacts on the natural environment, there are four main SCT strategies. These are: materials conservation – consideration of the impacts of building materials use on the environment through usage rationalization. Specifically, this can be realized through: deliberate design to minimize waste and pollution; specification of durable, natural, and, locally available building materials; and, specification of non-toxic/comparatively less toxic building materials; water conservation – water is used throughout the entire lifecycle of constructed facilities. As such, water efficiency can contribute to averting potential significant depletion of water resources. This can be through: enhanced use of rainwater; use of appropriate systems such as using low water pressure for reduced flow; design of low water demand landscapes; water efficient plumbing fixtures and/or systems; and, recycling grey water; energy conservation – with constructed facilities being associated with a substantial energy use over their lifecycle there is need for rationalized use of energy, reduction in fossil fuel usage and increased renewable energy use. This is possible through: use of building materials with low embodied energy; passive energy design; low energy intensive construction methods, transportation, and, technologies; and, insulation of building envelope; and lastly, land conservation – this strategy is aimed at rationalized use of land in developing the built environment in terms of controlled expansion of occupied land areas and the associated process and product impacts (Akadiri *et al.*, 2012:132-139).

Lastly, on the social pillar of SCT and consequently based on SC objective three: ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle, there are two main SCT strategies. Akadiri *et al.* (2012:143-146) recommends: protecting human health and comfort through ensuring thermal and acoustic comfort, maximizing use of daylight and natural ventilation, fitness for function, and, psychological comfort through appropriate aesthetics; and, ensuring resilience of built facilities against disasters through ensuring appropriate fire protection, resistance to natural disasters such as floods and earthquakes, and, crime prevention through design. Markelj *et al.* (2014:8780) suggests three SCT strategies as follows: ensuring wellbeing through thermal, visual, and acoustic comfort, appropriate ventilation, maximized user control of the indoor environment including safety and security of the users; ensuring functionality by ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently; and lastly, ensuring technical soundness by observing appropriate noise protection, resistance to earthquakes, and, fire protection.

In addition to the SCT objectives, strategies, and, methods discussed above, Cruz *et al.* (2019) advocates for differentiation of the methods to three key levels. These have been identified as: strategic level – long-term implementation and at industry scale incorporating all stakeholders; tactical level – medium-term implementation and at firm-level; and, lastly operational-level – short term implementation and at construction project-level. The SCT strategy methods highlighted in the preceding paragraph are largely at the operation level. Additional examples by Cruz *et al.* (2019) include: economically – implementing industrial standards and enhanced use of e-procurement; environmentally – enhanced full lifecycle environmental management of construction process; and, socially – improved safe working conditions for construction workers and enforcement of gender equity. At the tactical level, and economically, SCT strategy supporting methods include: value chain integration; human resources qualifications enhancement; effecting long-term profitability strategies such as diversification; effecting cost reductions; and, collaborations such as through partnerships. Environmentally: incorporation of environmental considerations in company strategies; developing indicators of firm's environmental impacts; and, development of management guides to improved environmental performance. Lastly, for the social dimension of SC at this level: developing an active corporate social responsibility (CSR) plan; facilitating staff knowledge upgrade; and, development of corporate strategy on achieving the SCT social objective as earlier discussed (Cruz *et al.*, 2019).

At the strategic level, SCT economic objective strategy support methods have been identified as: development of infrastructure plans for developing nations; development of urban rehabilitation plan in developed nations; internationalization of knowledge transfer to developing nations; enhancing sector competitiveness; promoting innovation; enhancement of financing mechanisms; and, enhanced role of tradable assets such as know-how. The SCT environmental objective strategy support methods have been identified to be: identification and exploration of intersectoral synergies, including a global strategy, on reducing the environmental impacts of the industry. Lastly, SCT social objective strategy support methods include development of sectoral social agenda and the associated political and managerial support. Additionally, for ease of monitoring the effectiveness of the methods, irrespective of the level – strategic, tactical, or, operational – there is need for key performance indicators

(KPIs). The set of indicators should be influenced by firm context and business portfolio contexts (Cruz *et al.*, 2019). Markelj *et al.* (2014) also highlights the role of local context in weighting the indicators to ensure the importance attached to each indicator in a given setting is understood. Examples of SCT strategy supporting methods KPIs to include: economically – labour cost in Euros and proportion of e-procurement deals in percentages; environmentally – energy consumption in Kilowatt Hours (kWh) and risk management qualitatively; and lasty, socially – work environment complaints in numbers and staff education cost in Euros (Cruz *et al.*, 2019). SCT strategies based on the promotion approach adopted, can be group into two categories: top-down; and, bottom-up (Esezobor, 2016:49-50). These categories are discussed in greater depth in Sections 2.3.3-2.3.5 below:

2.3.3 Top-down (TD) SCT Strategies Promotion Approach

Jensen (2007:853) postulates that top-down approaches are based on the general premise, at society level, the way present generations meet their needs should not jeopardize the ability of future generations to meet their own needs. These approaches are largely formulated and driven by SC experts and leaders and this has been the traditional approach. Some of the specific processes and requirements arising from top-down strategies identified include: SC policies; regulations; indexes; and, international agendas such as Agenda 21 for SC (Esezobor, 2016:49). In this approach experts and leaders choose the sustainability indicators (SIs) they consider appropriate for implementation (Fraser *et al.*, 2006:114). Cairns (2003:45-46) postulates that top-down sustainability strategies are necessary at the global scale. Their acceptance in smaller geographical scales is highly influenced by local context. The barriers to the effective development of these strategies include: complexity in developing solutions to sustainability goals of large temporal and spatial scales; integration of the said scales, ensuring harmony with bottom-up approaches and effective *"continuous feedback loops"* p.46; ensuring specifics do not distract the achievement of the wholistic scope of the strategy; complexity in identifying changes that necessitate corrective action; ethically dealing with uncooperative nations; sustaining availability of financial resources to run global sustainability organization (GSO); complexity in deciding when to pause and review effected approaches; and, ensuring democracy in GSO while still transitioning towards sustainability in a timely manner.

2.3.4 Bottom-up (BU) SCT Strategies Promotion Approach

Bottom-up approaches are based on the general premise of sustaining a system over time (Jensen, 2007:853). These approaches are largely formulated and driven by stakeholders' collaboration (Esezobor, 2016:49). Dania (2016:46-51) identified SC stakeholders to include: developers; construction firms; government (national and local); clients; owners; end-users; consultants/designers; suppliers/manufacturers; academia; and, advocacy groups as WGBC. The role of collaboration is highlighted by the realization that sustainability is best approached from a supply chain perspective as opposed to a firm level perspective (Pero, 2017:5). *"A participatory approach and interaction between stakeholders in the community is needed to successfully manage sustainable development. No individual or organization alone can achieve sustainable development. Rather, all stakeholders need to coordinate their efforts and link their activities, as well as combine, leverage, and share resources through collaborative arrangements"* **(**Leeb, 2014:21). According to Seuring and Gold (2013), as cited in Niesten *et al.* (2016), firms pursue ST through collaboration with: other firms; government agencies; NGOs; consumers; and/or, institutions of higher learning. According to Niesten *et al.* (2016), *"collaboration enhances sustainable benefits by creating legitimacy of sustainable technologies, reducing waste and improving environmental and social performance of firms"*.

Bottom-up sustainability strategies alternatives are equally important in dealing with specific issues and contexts. The rate of development of these bottom-up sustainability strategies has been observed to significantly differ across nations. It is however emphasized that both categories of sustainability strategies should be integrated for effectiveness of any of them. The barriers to the effective development of these BU strategies include: lack of will to do more than the minimum required by law; education opportunities, per capita wealth, and, age distribution disparities; conflicts of ethnic and religious nature; compassion levels for human populace in different spatial and temporal scales; language barrier; maintaining balance between collective good and individual gains; populace biophilia levels; and, levels of populace resource allocation fairness and equity. Additionally, sustainability goals are easy to state but it is not clear how that will be achieved across various ecozones given that regions tend to have different priority issues. Equally complicated is the way in which the various ecozones interact and how their respective populace can be persuaded to implement a global sustainability strategy (Cairns, 2003:45-46).

The foregoing discussion on SCT strategies is summarized in Table 2.3 below:

Table 2.3: SCT Strategies and Support Methods/Approaches

<table>
<tr><th colspan="3">SCT Strategies (Top-down and/or Bottom-up)</th></tr>
<tr><th>Economic Objective Strategies

Aimed at profitability through resources efficiency (Woodall et al., 2004)</th><th>Environmental Objective Strategies

Aimed at environmental protection (Woodall et al., 2004)</th><th>Social Objective Strategies

Aimed at moral and legal obligations compliance (Adetunji et al., 2003; Woodall et al., 2004)</th></tr>
<tr><td>i. Enhanced labour productivity
ii. Development cost efficiency
iii. Operation cost rationalization
iv. Rationalization of demolition and materials recovery cost
v. Property value enhancement

Source: Akadiri et al. (2012:139-143) and Markelj et al. (2014:8780)</td><td>i. Materials conservation
ii. Water conservation
iii. Energy conservation
iv. Land conservation

Source: Akadiri et al. (2012:132-139)</td><td>i. Ensuring well-being – protecting human health and comfort
ii. Ensuring resilience of built facilities against disasters such as earthquakes
iii. Ensuring functionality such as by ensuring ease of maintenance

Source: Akadiri et al. (2012:143-146) and Markelj et al. (2014:8780)</td></tr>
<tr><th colspan="3">Support (Implementation) Methods/Approaches Differentiation (Cruz et al., 2019)</th></tr>
<tr><th>Operation Level Methods

Short-term and at project level</th><th>Tactical Level Methods

Medium-term and at firm level</th><th>Strategic Level Methods

Long-term and at industry level</th></tr>
<tr><td>Some examples:
i. Optimal use of locally sourced materials – Economic
ii. Passive energy design – Environmental
iii. Improved safe working conditions for construction workers – Social

Source: Akadiri et al. (2012:139-143) and Cruz et al. (2019)</td><td>Some examples:
i. Value chain integration – Economic
ii. Developing indicators of firm’s environmental impacts – Environmental
iii. Developing an active CSR plan – Social

Source: Cruz et al. (2019)</td><td>Some examples:
i. Promoting innovation – Economic
ii. Identification and exploration of supportive intersectoral synergies – Environmental
iii. Development of sectoral social agenda – Social

Source: Cruz et al. (2019)</td></tr>
</table>

Source: Author (2023)

2.3.5 SCT Strategies Promotion Approach Considerations

Cairns (2003:49-50) recommends starting with both top-down and bottom-up sustainability strategies with no intermediary approaches. This is specifically so when the number of required trained personnel and information base is low. However, as they expand, more intermediary levels can be introduced progressively. Jensen (2007:853) argues that where there is conflict between the two approaches, ethically, the top-down alternative has the upper hand. With specific reference to construction organizations, Ikediashi *et al.* (2012:169) advocates for a top-down approach. In this case, SC practices are driven by management, at the strategic level, and that other staff, at the operation level, just align with the strategic direction adopted. Some of the reasons identified by Tunji-Olayeni *et al.* (2018:2-3) hindering development and implementation of SC strategies in construction firms include: low awareness levels – one can only develop and implement what they understand; perceived high cost of undertaking SC; poor support by the government; low SC demand by developers; poor SC expertise; unavailability of required building materials and assessment tools; lack of SC demonstration projects; and, cultural change resistance.

2.4 SCT Strategies Implementation/Context Appropriateness Considerations

2.4.1 Overview

Vanegas and Pearce (2000:406) in advocating for the importance of a convincing need to change in SCT highlighted the context of change theory in SCT. According to Dannemiller and Jacobs (1992), change is more likely to be successful when stakeholders change readiness is greater than the associated resistance. Limited coverage of ST from change perspective has been observed in SC literature. Specifically, no known study has focused on ST in the Kenyan construction industry from the said perspective. Few such studies have been found such as: Esezobor (2016:3) on the Nigerian construction industry proposing a multi-level approach to ST; and, Gomez and Yung (2019:55) on the Malaysian housing industry on readiness to develop green residential buildings. With the construction industry having been observed to lag in shifting towards sustainable modes of operation (Glass, 2012; Aghimien *et al.*, 2018:2385; Willar *et al.*, 2021:110), it becomes important to interrogate its preparedness to implement the shift from conventional to SC practices. This is explored in detail in Section 2.4.2 from the lens of theory of planned behaviour (TPB).

Spatially, it has been argued that while there is plenty ST research in developing nations, it cannot be assumed that local contexts in individual countries are insignificant (Dania, 2016: 57-60). Additionally, it has been argued that due to the spatial differentiation of scale and nature of sustainability challenges, there is need for place-based interventions. To this regard, it is recommended that ST approaches should *"Identify, evaluate, and address local societal needs"* (OECD, 2020). Levin-Keitel *et al.* (2018:8) postulates that physical and/or social spatial elements influence sustainability transitions which in turn transform the spatial components. Interestingly, the interface between space and STs has not been fully explored. This interface as defined by Coenen *et al.* (2012) refers to ST aspects of location, configurations and dynamism of the actors' networks. Levin-Keitel *et al.* (2018:1) further adds to the list: development variability; implementation scales; and, local embeddedness. This is specifically on the clarity on conceptualization of space adopted in the various studies and how spatial considerations are engrained in the transition process. As such, knowledge from spatial sciences would consequently lead to a better understanding of ST, including in the construction industry, and how best to embed it in different spatial contexts (Levin-Keitel *et al.*, 2018:11). This is explored in detail in Section 2.4.3 from the lens of place identity theory (PIT).

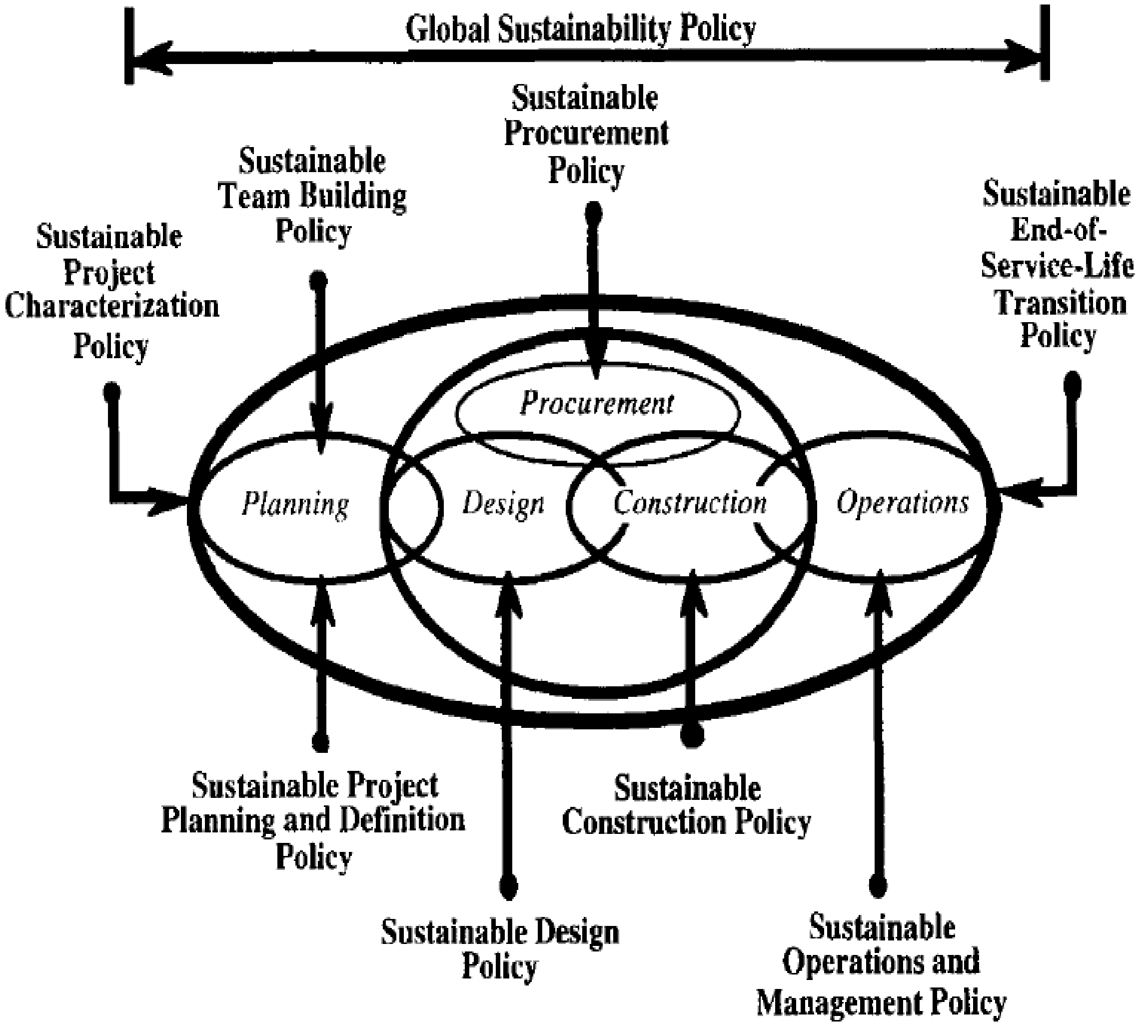
Change is required across spatial-temporal scales and levels of organizations to address the various global challenges (Anderies *et al.*, 2013). It is in this realization that they advocate for the value in merging theories of resilience, robustness, and, sustainability to capitalize on their individual capacity in addressing specific global challenges, at different scales and levels in a given context. In this same line of thought, Redman (2014) highlighted the need for researchers to explore the potential of linkages between resilience and sustainability sciences in a bid to *"... advance understanding of how best to accomplish maximum good for the society and the environment ..."*. This was with specific reference to three key aspects: boosting understanding of the transition system dynamics; informing shift from theory to practice; and, enhancing requisite inclusivity (for involved perspectives and populace). Both theories, sustainability and resilience, are complex and concern themselves with systemic issues cautioning against their oversimplification. Additionally, major themes of the two theories are centred around three conceptualizations: resilience as a component of sustainability; sustainability as part of resilience; and, both as different concepts (Marchese *et al.*, 2018). This study adopted the viewpoint that resilience is a component of sustainability and as such will facilitate enhanced

ST implementation in the construction industry. This is explored in detail in Section 2.4.4 from the lens of resilience theory.

The triggers for organizational change can be categorized on one hand as either internal or external and on the other hand, proactive or reactive. Internal proactive change is driven by values, missions, and/or, perceptions while internal reactive change is triggered by functional requirements and/or need for physical integrity. Additionally, external proactive change is propelled by market, benchmarks, and/or, competition while the reactive alternative is driven by standards, codes, and/or, regulations. Organization change can be driven by a single category of these change triggers or any combination thereof. Internal and external proactive change drivers are identified as the most likely SCT governance approaches given that SCT is not mandatory nor purely externally imposed (Vanegas and Pearce, 2000:409-410). From the perspective of SCT as change for sustainability in the construction industry, Vanegas and Pearce (2000:410) advocates for a proactive 4-step approach: having a global/overall SCT policy; developing strategic objectives that comprehensively cover the policy; setting-up indicators to monitor and control progress towards the objectives; and lastly, detailed action plan for each indicator. In relation to Agenda 21, on impacts of human activities on the environment, UN (1992:3) highlighted: the primary role in implementation by governments; and, with active participation and support of other social entities such as NGOs. Most governments are cognisant of the great potential by other social entities such as NGOs and businesses in complimenting their efforts towards sustainability (Leeb, 2014:21). This governance aspect is explored in detail in Section 2.4.5 from the lens of multi-level governance (MLG) theory.

On project or practice level adoption of SC, it is recommended that the global/general SCT policy should be based on construction project lifecycle. As such, the overall SCT policy should be broken into: planning stage – team building and project planning policies; design stage – design policy; construction stage – SC policy; operations stage – operations and management policy; and, for procurement in all the stages – SC procurement policy. However, even before the planning stage commences, the project SCT context (industry segment and project type) should be clearly detailed for appropriateness – SC project characterization. Additionally, at the end of the entire project lifecycle, SC considerations are necessary on re-use, adaptation, and/or, recycling of facility and/or components thereof – sustainable end-of-service life. This is the framework within which SCT objectives, indicators, and, detailed action plans (as identified in Section 2.3.2) should be based on (Vanegas and Pearce, 2000:410). This breakdown is illustrated in Figure 2.6 below:

Figure 2.6: SCT Policy Implementation at Project/Practice Level



Source: Vanegas and Pearce (2000:411)

Lastly, in addition to the discussion above, as briefly highlighted in Sections 1.2 and 1.3:

i. The construction industry globally is largely composed of SMEs, and the Kenyan construction industry is not any different, and despite their well-known capability to adapt to change, when compared to larger firms, the industry is still lagging behind in effecting SCT; and,

ii. Being in the Networked Knowledge Age (from the late 20th Century onwards), technology has facilitated a shift towards quantitative approach to sustainability. This has been evidenced by the rise in smart wearables, appliances, building management systems, and, cities globally.

In line with the above, this study explored the role of: SMEs; and, select information technologies (big data, IoT, and, BIM) in SCT in details in Section 2.5 (2.5.1-2.5.3).

2.4.2 SCT Change Readiness

2.4.2.1 Change readiness and SCT

Organizational change can be traced back to Lewin's (three-stage model) of change of 1947. The first stage, unfreezing, involve individuals and organizations preparing for change. The second stage, moving, involve effecting the intended change and the last stage, freezing, is when change becomes an integral part of the organization in context (Burris, 2008). Consequently, and as postulated by Holt and Vardaman (2013), the origin of change readiness concept can also be traced to the same model and specifically the unfreezing stage in change process. Holt and Vardaman (ibid) postulate that change readiness is a measure of how willing/committed and prepared, capacity, a social set-up is towards planned or unplanned change. Stakeholders attitude towards change has been identified as key to a successful change process hence the need to focus on change readiness as a positive attitude to change (Rafferty *et al.*, 2013). Weiner *et al.* (2008) had observed that less scholarly attention had been given to change readiness at organizational level when compared to the individual level. Later on, in a multilevel review of change readiness study, Rafferty *et al.* (2013) identified two major limitations with literature on change readiness: limited scholarly work on affective/emotional element of change attitude; and, multilevel perspective had not been explored. This study attempted to partly fill this gap but in relation to SCT.

For STs, change is required at multiple levels – individual, group, and, organization and in numerous aspects in those levels (Weiner, 2009; Rafferty *et al.*, 2013) and more importantly it is required in a second order/fundamental typology (Porras and Robertson, 1992; Elzen *et al.*, 2004; Grin *et al.*, 2010; Blythe *et al.*, 2018). It has been argued that change makes those involved in it uncomfortable by the fact that it involves a shift from a state they are used to or even comfortable with to a new one and thus inherent in change of doing things (Lorenzoni *et al.*, 2007). Additionally, 7 in every 10 major change attempts fail (Kotter 1995; Beer and Nohria, 2000). Appelbaum *et al.* (2012:765), puts it at approximately 3 to 8 out of 10 while

Dinwoodie *et al.* (2015) puts this proportion at 5 to 7 out 10. Nikolaou *et al.* (2007) also notes that 7 out 10 successful changes failed to meet expected results. Kotter (1995) further postulates that failure to adequately prepare for change accounts for half of these major change attempts. Gerwing (2016) had highlighted that in the 20 - year period highlighted above, the rate of change failure, in an organizational context, had remained high. The above highlighted statistics highlight the inherent need for a strategic approach to major changes for improved success including meeting the desired end results in a given context and SCT is not exempted.

2.4.2.2 Multilevel change readiness

There are three main change readiness levels of analysis, that is: individual level; group/unit/department level; and, organizational level (Weiner, 2009; Rafferty *et al.*, 2013). In a nutshell, at individual level, two change readiness key drivers were identified. One was belief on need for change, requisite capacity to implement required change, and, expected benefits to one's job/role (cognitive component). The second one was positive emotional response, current and/or future, on the change in context (affective component). On the other hand, organizational/collective change readiness is driven by the same factors but at organizational/collective level (Rafferty *et al.*, ibid:116). It is additionally acknowledged that the processes that drive change readiness differ at the previously identified 3 levels of analysis. Consequently, the predecessors and impacts of change readiness are postulated to differ accordingly (Rafferty *et al.*, ibid:112). That notwithstanding, collective change readiness can be achieved through approaches such as: socialization in organizations (Van Maanen and Schein, 1979); the fact that organizations tend to select and keep employees that based on their fit to the organization and over time results in employees with similar as opposed to divergent viewpoints (Schneider, 1987:442, 444-445; Schneider *et al.*,1995:749,763); and, supportive organization culture, identity, and, leadership (Rafferty *et al.*, ibid:120).

Rafferty *et al.* (2013), in a review of past literature, grouped the predecessors of change readiness (cognitive and affective) in organizations as: external pressures; internal context enablers; personal characteristics (at individual level); and, group characteristics (at group level). The identified external sources of pressure were: industry changes; technological changes; government regulation changes; and, professional group membership. The predecessors associated with internal context were identified to be: change process involvement; effective change communication; supportive transformational leadership;

positive change history perceptions; previous exposure to change; organizational support perceptions; values compatibility between change leaders and recipients; and, employee's positive perceptions of organizational values. Thirdly, elements of individual characteristics, the constitutive elements, were listed as: positive self-concept such as the direct relationship between internal locus of control and getting along with change; and, risk tolerance such as the inverse relationship between risk aversion and coping with change (Judge *et al.*, 1999:115). Lastly, group characteristics that drive change readiness were identified to be: effective communication of change vision and implementation plan; developing change execution capability(ies); change leader(s) emotional aperture; positive change process perceptions; group participation; supportive group psychological safety (in terms of trust and respect); positive change climate; and, personal attributes positive affectivity levels in group(s).

The above discussed antecedents predicting change readiness have been further categorized into three main levels of analysis, as previously identified: individual; work group; and, organizational. The individual level of antecedents were identified to be: supportive change management processes; effective change communication; stakeholder participation; appropriate transformational leadership; and, positive personal attributes such as risk tolerance and positive self-concept. It has however been noted that with a bigger scale change, the change subjects are more likely to register less belief in the change, with an overall reduced positive change influence, and consequently lower overall change readiness evaluation judgement. At the work group level of analysis, change readiness antecedents were identified to include: well-articulated group level vision; leadership with emotional aperture; supportive group change climate; psychological safety (in terms of trust and respect); and, supportive homogenous project team emotive reactions to change. Lastly, at the organization level, these predecessors of change have been identified to be: positive top management attitude towards change; organization cultures particularized by support to development and adaptability; and, supportive organizational procedures and policies for handling emotional responses to change (Rafferty *et al.*, 2013:125-126).

According to Kapsalis and Kapsalis (2020), the ability of social set-ups, organizations or communities, to change is key to success of transitions irrespective of change process adopted. The desire to change, from a local community perspective and in relation to SD, is in turn brought about by: dissatisfaction with current situation; convincing vision; and, a practicality of the change at the preliminary stage (Beckhard and Harris, 1977). The key barriers to effective change, on the other hand, as identified by Oreg (2006) are: tendency towards routine; emotional response to change; rigidity in cognition; and, focus on the short-term/short-term planning. Change process should only be pursued when change readiness in a given context is greater than the associated resistance (Beckhard and Harris, ibid; Dannemiller and Jacobs, 1992:483). This is summed-up in the change formula outlined below as postulated by Dannemiller and Jacobs (ibid):

$$C = D * V * F > R$$

<u>Where:</u>

C = Change

D = Desire for change

V = Convincing vision

F = Practicality of first steps to a different future

R = Resistance to change

Dannemiller and Jacobs (1992:483) further postulated that, a critical mass of the organization, in a given context, would require the product of D, V, and, F to be greater than R for organization-wide C to occur. Since change leaders and subjects in organizations are individuals, it can then be said that the above highlighted predecessors of change are at individual level of analysis. Consequently, and in relation to SCT, this study suggests additional indicators of individual level of analysis change readiness to be: desire for change; convincing vision; and, practical first steps towards improved sustainability should be greater that than the change resistance. Čudanov *et al.* (2019:109) empirical investigation on the effectiveness of the change formula above indicated that it explained 30% of change variance. Consequently, this study sought to incorporate additional antecedents of change readiness from best practice to comprehensively assess Kenyan construction industry change readiness from a multilevel perspective. Given the industry in context, this study adopted the following three levels of analysis: individual – individual construction project team members and other individual stakeholders; workgroup – construction project teams (including other related stakeholder teams); and, organizational – firms from which the construction project team members are drawn (including SCT related governance institutions).

2.4.2.3 SCT from a change process perspective

For a long time, the Lewins' three-stage theory of 1947, as discussed in Section 2.4.2.1 above, held hegemony on change management (Todnem By, 2005) forming basis for newer approaches (Teczke *et al.*, 2017). Later on, an eight-step model for change was developed. It emphasizes the need to establish a sense of urgency for change, inspiring the need to shift from the current state of affairs, in a given context. This would then be followed by set-up of a steering coalition of key stakeholders whose support is necessary to effect desired change. Then it would be necessary to set the vision on desired state of affairs and the associated implementation strategy. The crafted vision would then have to be communicated to all involved with an aim of convincing them on the need and approach to change. At this point it becomes necessary to empower all involved for broad-based action by ensuring the associated organization structures and processes, including proactively handling barriers and enabling constructive feedback, to align with the pre-set vision. At this stage, the overall long-term goal, as embodied in the vision, is broken-down into short-term targets for practicality and encouraging continued action by realization of early wins. It is then opportune to consolidate gains including learning and improving from individual early experiences to facilitate more change. Lastly, once change is achieved, there is need to entrench it in the culture by incorporating the change in all aspects of a given social set-up (Kotter, 1995).

With ST being a long-term change process, as postulated by Markard *et al.* (2012) and Kohler *et al.* (2019), there is general consensus that it can be broken down into several phases. Newman (2007) divides the sustainability change management process into: awakening; pioneering; and, transformation phases with unique transition phases in between. The awakening phase involves realization of the centrality of sustainability issues to the organization in context. It is in this particular phase that change management is considered and consequently a role emerges out of it such as in form of creation of a sustainability officer role. The pioneering phase is described as one where the organization in context intentionally and collectively works towards attainment of the change towards addressing the sustainability issues identified in the awakening phase. Lastly, the transformation phase is characterized by new process and structure approaches informed by sustainability principles. Additionally, these changes at this phase are integrated into the basic functioning and targeted outcomes of the organization in context. The transition phases in between are characterized by change in focus from individual and/or trial mode to institutional-wide focus.

Rotmans *et al.* (2001) postulate that with ST being multi-dimensional and dynamic in nature, the consequent implication is that for a transition to happen, development must occur in several domains taking a systems perspective. Four distinct conceptual phases of ST were identified: pre-development; take-off; acceleration; and, stabilization. The first stage, pre-development, is identified as a dynamic state where the prevailing state does not significantly change. It is later on in the take-off stage that marks the beginning of change occasioned by a significant change in the existing system. This leads to the acceleration stage characterized by drastic change in the system due to changes in economic, environmental, and, social dimensions. It is in this phase that acquisition and embedding of appropriate knowledge and skills occurs. Lastly, all this culminates in the stabilization phase. It is in this phase that the change process slows down and a new dynamic state is established. They however emphasize that significant change does not necessarily occur in all domains at the same time during ST. Additionally, all transitions have periods of fast and slow execution resulting in relativity of speed and acceleration and the shift from one phase to the other is not linear.

This study adopted a fusion of the two perspectives to gain from the individual expertise that went into developing them. Firstly, the study specifically adopts the four phases advanced by Rotmans *et al.* (2001). This is on the basis that it recognizes the state before action, pre-development, unlike the three phases suggested by Newman (2007). Secondly, the postulation by Newman (ibid) on the transition between phases is adopted for providing clarity on required action. Lastly, this study also adopted the systems perspective advanced by Rotmans *et al.* (2001). It acknowledges the complexities involving transitions in systems as is the case for ST and consequently SCT (see Sections 2.2.4 and 2.2.5).

2.4.2.4 Discussion – Contextualizing the Literature

The literature reviewed in Sections 2.4.2.1-2.4.2.3, and as partly introduced in Section 2.4.1, provides insights on the role of change readiness in the change processes such as SCT. Specifically, that change readiness is key for success of change initiatives such as SCT. That notwithstanding, there were several observed limitations in the literature reviewed. Firstly, it was largely on general change management and thus not specific to the construction industry context. While this has the potential to limit its applicability, based on theory of planned behaviour, the direct relationship between change readiness and sustainability behaviour was affirmed (see Section 1.2.5). Additionally, the three levels of change – individual, group, and, organizational – were not entirely specific to the construction industry. Consequently, in the measurement of the variable, the levels were revised to: individual industry stakeholder; construction project team; and, industry organizations. More importantly, there was limited coverage of change readiness from ST viewpoint. While this was partly handled through the incorporation of literature on ST context, this study sought to further fill this gap by the outcome of field study data analysis on: SCT change readiness in Kenya; and, its relationship with industry SCT performance. From the foregoing discussion, the multilevel indicators of SCT change readiness are summed up in Table 2.4 below:

Table 2.4: Multilevel SCT Change Readiness Indicators

A. Individual Level SCT Readiness	
Summary Evaluation	
i. *Cognitive objective* – individual belief that: there is need for SCT; they have requisite capacity to implement SCT; and; SCT will have positive outcome on one's role/job	Rafferty *et al.* (2013:116)
ii. *Affective objective* – SCT will elicit, current and/or future, positive affective emotional response at the individual level	
Specific Indicators	**Sources**
i. SCT supportive management processes such as organization socialization and recruitment	Van Maanen and Schein (1979), Schneider (1987:442, 444-445), Dannemiller and Jacobs (1992:483), Schneider *et al.* (1995:749,763), and, Rafferty *et al.* (2013: 121-123,125)
ii. Effective sustainable construction change communication	
iii. Active stakeholder(s) participation on SCT	
iv. Appropriate SCT supportive leadership influence	
v. Stakeholders have positive personal attributes such as risk tolerance and positive self-concept	
vi. SCT drive *(in terms of: desire for change; convincing vision; and, practical first steps towards improved sustainability)* outweigh inherent change resistance	

B. Project Team Level SCT Readiness	
Summary Evaluation	
i. *Cognitive objective* – project team belief that: there is need for SCT; they have requisite capacity to implement SCT; and; SCT will have positive outcome for the project team	Rafferty *et al.* (2013:116)
ii. *Affective objective* – SCT will elicit, current and/or future, positive affective emotional response at the project team level	
Specific Indicators	**Sources**
i. Well-articulated project team level SCT vision	Rafferty *et al.* (2013:123-124, 125)
ii. SCT leadership with emotional aperture	
iii. Supportive project team change climate *(quality of interactions and tone)*	
iv. Psychological safety *(in terms of trust and respect)*	
v. Supportive homogenous project team emotive reactions to SCT	
C. Organizational Level SCT Readiness	
Summary Evaluation	
i. *Cognitive objective* – organization belief that: there is need for SCT; having requisite capacity to implement SCT; and; SCT will have positive outcome for the organization	Rafferty *et al.* (2013:116)
ii. *Affective objective* – SCT will elicit, current and/or future, positive affective emotional response at the organizational level	
Specific Indicators	**Sources**
i. Positive top management attitude towards SCT	Rafferty *et al.* (2013:124-125)
ii. Organization culture characterized by support to development and adaptability	
iii. Supportive organizational procedures and policies for handling emotional responses to change	

Source: Author (2023)

2.4.3 SCT Socio-Spatiality

2.4.3.1 An Overview

Place, as a concept, emerges to be locale specific combination of economic, environment, social-cultural, and, community aspects as opposed to just map/coordinates defined space and has its roots in planning and geography (Marsden, 2012:214; Horlings, 2016:32). It should be noted that: generic globalization processes have impacts, such as depletion of resources, that are spatially differentiated (Escobar, 2008); and, the social actors, such as built environment stakeholders, are part and parcel of it as the driving forces and/or as subjects. Consequently, globalization has been characterized by enhanced density and speed of the people – locale interconnections (Tsing, 2000:331). According to Ghavampour and Vale (2019:198, 199-200), the physical set-up is inextricable from its context, economic, environment, social-cultural, and, community, and hence emphasizes on the importance of both aspects in place-making (lifecycle approach to transformation of public spaces to enhance people – locale interconnections). It has also been established that the growing body of studies on STs has also not sufficiently addressed the role of place-making in sustainability (Marsden, ibid:214).

More importantly, limited coverage of spatial dimension in ST studies have been observed on the following fronts: locale aspect(s) of transitions; involved social-spatial relations; and, social-spatial relations dynamics. This has been suggested to consequently impede the development of a coherent ST theory due to limited variety of specific ST analysis (Coenen *et al.*, 2012:968-969; Hansen and Coenen, 2014:93). It is against this background that this study sought to explore how SCT, ST in the built environment, strategies can be implemented in a socio-spatially sensitive manner for enhanced effectiveness. In addition to enriching ST and SCT theories, it has been argued that for success, SD approaches have to be considerate of specific people – locale relationships (Marsden, 2012:215). Such a consideration is seen in Markelj *et al.* (2014:8790) recommendation that indicators in sustainability assessment frameworks should be weighted by local experts to incorporate the importance attached to each indicator as defined by locale uniqueness. In the same line of thought, Ghavampour and Vale (ibid:199) also criticized the appropriateness of global solutions to local issues including the extent of local community buy-in if any.

2.4.3.2 Phenomenology of Place

Little scholarly attention has been observed as to the in-depth specificities of where and how transitions occur (Hansen and Coenen, 2014:93), resulting in a scholarly area referred to as *"geography of transitions"* (Coenen *et al.*, 2012:968; Markard *et al.*, 2012:963; Levin-Keitel *et al.*, 2018). Several terms used in relation to space include: place; area; and, landscape. This has consequently been argued to lead to a contested interpretation of space. Regarding the locales of STs, three spatial scales have been identified as: local; regional; and, national (Levin-Keitel *et al.*, ibid). According to Hansen and Coenen (ibid), the necessary networks of varied actors are easily established at the local and regional spatial scales. As to the contested interpretation of space, three conceptualizations have been advanced: container; social-spatial; and, relational (a mix of container and social-spatial) (Levin-Keitel *et al.*, ibid).

The container interpretation relies heavily on the physical territory view of space that can be defined geometrically using coordinates. This interpretation is of the position that space and place are synonymous. This perspective has been criticized for: viewing space from a largely external viewpoint; and, not being considerate of the role of economic, social, and, physical networks in space creation. The social-spatial interpretation, fully considerate of the social context, is based on the premise that space is a social set-up with emphasis on social relations and the associated political and spatial governance aspects. This perspective has also been criticized for: viewing space in from a largely internal viewpoint; and, overemphasizing the social component of spatiality and consequently disconnected from the physical spatial aspects. Lastly, the relational interpretation, which provides a better differentiated spatial-scales perspective and with functional emphasis, is based on the fact that space is a *"… a (material) result of perceived facts and interpretations"* – socio-physical. This perspective does not lean towards external and internal space viewpoints but instead analyses their interaction (Levin-Keitel *et al.*, ibid). Unlike the earlier conceptualizations, the relational interpretation provides a middle ground fully conscious of both extremes and is the one primarily adopted by this study.

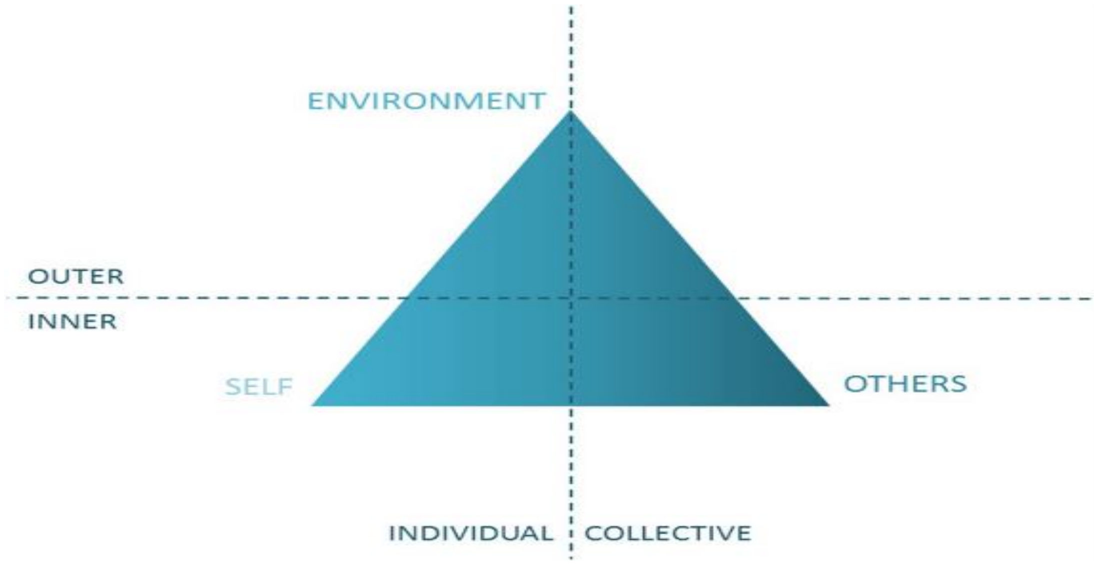
Further to the above conceptualizations, and based on their links with ST approaches as drawn for ST research, three distinct conceptualizations of space in transitions research emerge. In one of the perspectives, space emerges as a bridging concept. Here space, drawing from the relational space conceptualization, emerges as an umbrella concept: incorporating various perspectives to ST (trans – and interdisciplinary); and, elements of space/place to provide a better understanding of spatial elements of transitions. Secondly, space emerges as a normative concept. This transition-based conceptualization of space is a concept that: is space-pragmatic; attempts to offer spatially appropriate ST solutions; and, provides means (visions and guidelines) of sustainably integrating different sectoral ST perspectives. This conceptualization is linked to, among other disciplines, the built environment disciplines, such as architecture (Levin-Keitel *et al.*, 2018). Lastly, spaces can also be viewed as an approach to action. This ST based conceptualization of space cover: design of spaces and places for sustainability (including associated socio-economic and social cultural aspects of places); space as key to stakeholder collaboration and integration of disciplines and perspectives; and, basis of analysing institutional thickness, contexts, and, multi-scalar relations (Levin-Keitel *et al.*, ibid). Based on the foregoing discussions, the three ST based conceptualizations of space offer insights on the interface of space and STs such as SCT.

Place emerges as dynamic and dependent on expressions of the complex relationships between ecological, economic, and, community aspects of a given locale (Marsden, 2012:214). Rainnie *et al.* (2019:39-40) identified a list of key features that can be used to identify place/spatial sensitivity in transition programs as emphasis on: place – multi-scalar focus integrating multiple perspectives; local governance; assistance to affected persons; engaging local institutions; local value creation; flexible and accountable goal setting; and, consciousness of the emotional aspect of change. Grenni *et al.* (2019:412) takes a sense view of place where place is defined as a collection of meanings (sense of place) and values – importance attached to features of a place (place values). The meanings and values are referred to as the inner dimension of sustainability. According to Davenport and Anderson (2005), this is owing to the fact that they refer to the emblematic and emotional facets of place usually overshadowed by substantial material changes which according to Grenni *et al.* (ibid:418) include institutional change and behaviour. Grenni *et al.* (ibid:418) further opines that place values drives sense of place which in turn propels ST.

Horlings (2015:34) and Grenni *et al.* (2019:417) further postulate that meanings and values are key determinants of people's readiness to change and thus central to place-based sustainability transitions. Grenni *et al.* (ibid:413) postulates that for such transformation, multi-scalar geographical and policy change is required as pathways to fundamentally different futures.

This study adopts, from a relational processes point of view, an approach that has been advanced in conceptualizing place by Grenni *et al.* (ibid:417). This analytical framework builds-up on the four-quadrant – inner-individual, outer-individual, inner-collective, and, outer collective – integral model of conceptualizing change experiences by Wilber (2005). It also includes aspects of the Gustafson's three-dimensioned model on sense of place – dynamic interplay between aspects of self, others, and, the environment – Gustafson (2001). The resulting framework is arrived at by placing the triangle of the three-pronged model by Gustafson (2001) at the centre of the four-quadrants model by Wilber (2005) as illustrated in Figure 2.7 below.

Figure 2.7: Place Analytical Framework



Source: Grenni *et al.* (2019:417)

In the framework above, the three-pronged approach by Gustafson (2001) identifies aspects of sense of place and place values, that is – self, self-others, others, others-environment, environment, environment-self, and, self-others-environment place meanings. On the other hand, Wilber (2005) model identifies four fundamental aspects affected by change. Consequently, the resulting framework (see Figure 2.7) conceptualizes sense of place and place values as drivers to place-conscious transitions (Grenni *et al.*, 2019:417).

2.4.3.3 Place values and sense of place in the built environment

Carmona (2019:3) defines place value as the mix of values realized as a result of the molding process of places. CABE (2006) identified six types of value in the built environment: exchange value – concerns tradeable elements of the built environment; use value – about utility related to activities supported by facilities; image value – the extent to which built facilities can be identified and/or understood as good or bad; social value – measure of how supportive (or not) built facilities are to social interactions; environmental value – how natural capital stock considerate constructed facilities are; and, lastly cultural value – related to cultural significance of built environment in context. Carmona (2019) further categorized values of place, with specific reference to the built environment, into four: health; society; economy; and, environment. The health value category was based on the premise that the design of built facilities has the potential to avail a wide array of health benefits. The categories of the health benefits were identified as enhanced: quality of life; daily comfort; fitness; mental health; and, physical health.

Secondly, in relation to societal value, the study established that design of facilities in the built environment can help achieve social benefits such as: reduced accidents; reduced crime rates; improved inclusivity for disadvantaged groups; reduced social stratification; improved civic identity; and, better social environment for all. Thirdly, the way places are moulded can help deliver economic benefits such as: reduced cost of living and public expenditure; improved uptake of constructed facilities; and, reduced depreciation and improved feasibility of developments. Lastly, some of the environmental benefits that can be realized through place-making include, but are not limited to reduced: energy consumption and greenhouse gas emissions; thermal stress; wastes; pollution; and, adaptability to re-use over time (Carmona, ibid:12-13,20,32). The foregoing discussion puts forward a compelling case for place value-based approach in developing the built environment. These benefits are largely pro-sustainable clearly highlighting the potential role of place-consciousness as a driver of enhanced SCT uptake.

On the other hand, sense of place is defined as the, personal, general feeling about a place – interpretative and affective relationship between a given populace and a given locale. This feeling has been identified as key in environmental quality consciousness. In a review of seminal works on sense of place, three key aspects as to how people perceive places were identified as: physical features; activities; and, meanings (Najafi and Shariff, 2011:1054,1056,1059). According to Steele (1981), key aspects on physical features of a locale include sensory perceptions such as: sight – visual variety, ornaments, texture, scale, distance, and, size; aspects of sound; smell peculiarities; and, elements of touch such as extent of thermal comfort and relating to textures. The second key aspect was identified as the perceptions as to the activities supported by the locale in context. This include, but is not limited to, variety (including significance) of activities supported by the locale including the associated emotional qualities (Najafi and Shariff, ibid:1055, 1059). The third and last aspect was identified as meanings associated with the locale in context. Meaning(s) attached to a locale has been identified to be influenced by populace related factors such as: gender; age; beliefs; culture; familiarity; experiences; motivations; backgrounds; personality; and, attitudes (Najafi and Shariff, ibid: 1059). Seven aggregate states in relation to sense of place are: no sense of place; familiar; belonging; attached; identifying with locale goals; involved; and, willingness to sacrifice attribute and values for a locale in order of increasing sense of place (Shamai, 1991).

2.4.3.4 Discussion – Contextualizing the Literature

The literature reviewed in Sections 2.4.3.1-2.4.3.3, and as partly introduced in Section 2.4.1, highlights the centrality of socio-spatial sensitivity in appropriateness of SCT approaches. This was on the emphasis on both spatial and social contexts considerations for success of SD approaches such as SCT. This relationship was also affirmed by place identity theory (see Section 1.2.5). There were also several observed limitations in the literature reviewed. Firstly, was insufficient focus on the role of place-making in sustainability in ST studies (Marsden, 2013). This was dealt with by incorporation of placemaking (transformation of public spaces to enhance people – locale interconnections) in the indicators of socio-spatial sensitivity in SCT – see indicator (iii) in Table 2.5 below. Additionally, indicators of socio-spatial sensitivity in STs as identified by Rainnie *et al.* (2019) were generic, while those identified by Carmona (2019) and Najafi and Shariff (2011) were construction industry specific. The former were adapted for construction industry specificity for appropriateness as indicators of SCT socio-spatial sensitivity. More importantly, there was limited coverage of spatial dimension in ST studies. While this was partly handled through incorporation of socio-spatial sensitivity as an independent variable to the dependent variable of SCT performance, this study sought to further fill this gap by the outcome of field study data analysis on: SCT socio-spatial sensitivity in Kenya; and, its relationship with industry SCT performance. From the foregoing discussion, the indicators of social-spatial sensitivity in effecting SCT strategies are summed up in Table 2.5 below:

Table 2.5: SCT Socio-Spatial Sensitivity Indicators

Indicator	Source
i. Adaptation of generic SC approaches and tools for local appropriateness	Markelj *et al.* (2014:8790), Levin-Keitel *et al.* (2018), and, Ghavampour and Vale (2019:199)
ii. Multi-scalar spatial differentiation (local, regional, and, national) and integration of SC approaches	Levin-Keitel *et al.* (2018), and, Rainnie *et al.* (2019:39)
iii. Design of spaces and places for sustainability *(resource efficiency, natural resources conservation, and, moral and legal obligations compliance)*	Levin-Keitel *et al.* (2018)
iv. Incorporation of local/decentralized decision making in promotion and execution of SC approaches	Rainnie *et al.* (2019:35,39)
v. Intentional effort to assist populace negatively affected by transitioning towards SC and impacts of unsustainable construction practices	
vi. Engagement of local institutions such as learning institutions, professional associations and trade associations on SC approaches	
vii. Creation of SC value *(health, societal, economic, and, environmental)*, locally, in development of the built environment	Rainnie *et al.* (2019:35,39), CABE (2006), and, Carmona (2019:12-13,20,32)
viii. Flexible and accountable SCT goal setting in context of multi-scalar change of priorities over the long term	Rainnie *et al.* (2019:35,40)
ix. Consideration of sustainable change perceptions by the general public as to the desirability of the impacts related to the physical environment, supported activities, and, associated meanings	Rainnie *et al.* (2019:36,40), Najafi and Shariff (2011:1054,1056,1059), Steele (1981), and, Shamai (1991)

Source: Author (2023)

2.4.4 SCT Resilience

2.4.4.1 Resilience and SD

Some studies in the past, such as Anderies *et al.* (2013), Redman (2014), and, Marchese *et al.* (2018), have highlighted the value add in linking resilience theory to the sustainability science (see Section 2.4.1). Anderies *et al.* (ibid) advocated for merging of theories on robustness, sustainability, and, resilience in a bid to harness their individual potential in addressing particular global challenges, such as unsustainable construction practices, in different contexts collectively. Additionally, for better understanding as to the effect of individual sustainability actions at the system level, there is need for a framework that relates sustainability, various capital stocks, and, decision making, on one hand, and tools for analysing system non-linear feedback loops in the context of uncertainty on the other. According to Redman (2014), while it is important for researchers to explore the synergy between sustainability science and resilience theory, it is equally important to further pursue their distinctiveness. This study leans towards exploring their synergy: specifically, the means of integrating resilience in SCT strategies implementation for their enhanced effectiveness. Amongst the three main themes on the relation between resilience and sustainability, as postulated by Marchese *et al.* (2018), the above adopted position is in line with resilience as a component of sustainability conceptualization. On this front, the synergy has been postulated to have the potential to help inform: improved understanding of the transition system dynamics; shift from theory to practice; and, requisite inclusivity (for involved perspectives and populace) (Redman, ibid).

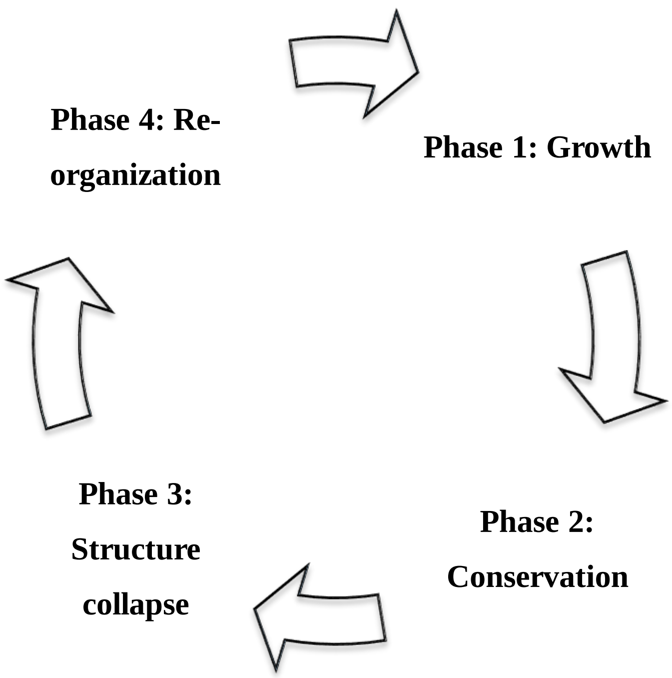
Both theories represent complex and key issues which are systemic in nature and efforts to explore their synergies should be careful not to oversimplify their similarities and/or differences. Additionally, application of both concepts should be in relation to specific contexts as opposed to between the two as just general concepts. Both concepts are in a way similar: they both take systems view; refer to state or feature(s) of a system in a given context; adopt common research methodologies such as life cycle analysis; and, are part of key global frameworks and agendas. However, the two concepts also exhibit certain differences: on spatial-temporal scales, sustainability focuses on larger and longer scales compared to resilience; in a community context, sustainability is largely inclined towards established ways of doing things while resilience focuses on adapting to new ways; on emphasis, sustainability focuses on system outcomes while on the other hand resilience focuses on system processes and features; and, lastly sustainability seems to have a largely institutional goal implementation approach while resilience is concerned with disturbance response (including preparedness) (Marchese *et al.*, 2018).

2.4.4.2 Resilience concept

According to Nuchter *et al.* (2021:1,11), and just like sustainability and SD (see Section 2.2), resilience suffers from multiple definitions which in turn leads to conceptual ambiguity. Resilience has been defined as the capacity, of a system, organization or individual, to maintain its core functionality, with integrity in context of change (Zolli and Healy, 2012:7), including associated anatomy, identity, and, feedbacks (Walker *et al.*, 2004; Walker *et al.*, 2006). According to Walker *et al.* (2004), the system is able to retain its functionality by: absorbing the arising disturbance; and, also through internal re-organization. It thus follows that, the greater the resilience of a socio-ecological system the greater its capacity to withhold disturbance. It is worth noting that socio-ecological systems have thresholds which when exceeded, the functionality and structure of such a system change resulting in a regime change which may be permanent, effectively permanent – that is, cannot be reversed in a period of time beneficial to the society, or, reversible. In a given regime that is without a regime shift, the system can assume different states. The desirability of a given system regime, such as sustainability in the construction industry, can be expressed economically, ecologically, or, socially. Additionally, any given regime can be preferred by certain quarters in a given social set-up and not others. Lastly regimes, whether desirable or not, can be resilient or otherwise (Walker *et al.*, 2006).

Walker *et al.* (2004) identified four key aspects of resilience as: latitude; resistance; precariousness; and, panarchy. Latitude refers to the maximum change a system/sub-system can hold without a permanent regime shift. The resistance aspect is the measure of how easy it is to effect a change in a socio-ecological system/sub-system. Precariousness is a measure of how close a system/sub-system state is to a threshold (as discussed in the previous paragraph). Lastly, panarchy refers to the systems state effect, in terms of latitude, resistance, and, precariousness, of other scales/subsystems, above and below scale of interest, in a given context. According to Walker *et al.* (2006), the dynamics of a system within and across scales can be explained in terms of adaptive cycle and panarchy (as above explained) respectively. The adaptive cycle has four phases, as illustrated in Figure 2.8 below: part one (fore loop) – growth and conservation phases; and, part two (back loop) – release of bound-up resources and reorganization phases. The typical flow in one cycle is characterized as follows: growth phase – with readily available resources, system structure build-up, and, high resilience; conservation phase – as structure grows, more resources are required resulting in reduced growth with increased vulnerability to disturbances; structure phase – disturbances lead to collapse of developed system structures and is characterized by release of accumulated resources; and lastly, reorganization of the structure occurs which consequently leads to a new cycle – re-organization phase.

Figure 2.8: Typical System Adaptive Cycle



Source: Author (2023)

Walker *et al.* (2006) further opined that three features of systems, such as socio-ecological systems, contribute to the dynamics of the system: resilience (discussed at length above); adaptability; and, transformability. In relation to resilience, as highlighted by Walker *et al.* (2004), systems have thresholds which are limits as to the extent of disturbance a system can absorb without a total shift in regime. It is also worth noting that different states exist within a given regime, that is, within regime thresholds. Additionally, system level dynamics are also influenced by dynamics of involved scales/subsystems. Adaptability, according to Walker *et al.* (ibid), has been defined as the capacity of the involved network of actors, to influence system resilience intentionally or otherwise. It then follows that, the capacity and will (intent) of the network of actors is a key determinant in ensuring a desirable regime or on the flip side avoiding an undesirable one (Walker *et al.*, 2004; 2006). Lastly, Walker *et al.* (2004) defines transformability, as the capacity to engineer a totally new system when the existing one is undesirable economically, ecologically, and/or, socially. Walker *et al.* (2006) however notes that the trajectories and processes that drive transformations are not fully understood. Additionally, the determinants of transformability, such as in SCT, have been identified as: incentives (to change or not) such as subsidies; system cross-scale awareness and responsiveness; experimentation willingness; capital reserves (human, natural, and, built); and, governance.

Regarding the dynamics a system within a scale, from an analysis of 15 case studies, it has been propositioned that: during release and renewal periods of the adaptive cycle, multiple re-organization pathways are possible; consequently, involved managers should consider multiple approaches; and, exceptions to the four phases in the adaptive cycle are possible due to lack of critical capital forms and large external disturbances. As to the dynamics of a system across scales: repetition of adaptive cycles in a given scale is driven by influences of upper scales; and, change in the adaptive cycle at a given scale can be influenced by synchronized lower scales. On resilience: critical changes in a system are determined by a small set of variables (usually three to five); ecological resilience is controlled by slow changing variables; social resilience is controlled by slow or fast changing variables; both the social and ecological domains of a system can be covered in a common framework; system performance is related to the number of functionally different groups in the said system; and, disturbance response diversity influences resilience. Regarding adaptability: it is primarily determined by governance and institutions system and amounts (absolute and relative) of all capital forms; and, can be enhanced through learning and *"... partially overlapping mental models of system structure and function"* (Walker *et al.*, 2006).

It should however be noted that: enhanced adaptability has the potential of unintentionally leading to loss of resilience; and, at the various domains and scales, systems have multiple thresholds interacting with each other leading to multiple possible alternate regimes but with just a few of them being feasible. Lastly, regarding transformation: is primarily determined by governance, capital reserves, experimentation, awareness and incentives; and, involves change of system state dimension and panarchy scales (Walker *et al.*, ibid).

2.4.4.3 Resilience-driven-SCT

The Kenyan construction industry can be said to be in an undesirable SC regime (see Section 1.3) hence the need to shift to a comparatively sustainable SC regime, SCT. Consequently, there is the implied need to weaken the resilience of the current undesirable SC regime or from a different perspective enhance the resilience of the desired SC regime. The emphasis in this study is on the latter, enhancing the resilience of the desired SC regime, which can be argued to also ensure the former. However, operationalizing resilience in a manner that sufficiently covers the depth developed over time in resilience science is not easy. This has been attributed to the fact that is difficult to measure resilience – as a property of complex systems it is revealed in context of uncertainty. It is against this background that a system resilience diagnostic framework has been developed. Part one of it focuses on five system resilience issues (systems lens) as follows: horizontal axis/exposure dimension – critical resource stress, societal stress, and, acute event stress; and, vertical axis/system structure impact on response dimension – interdependency; and, learning, foresight, and, self-organization capacity. Part two on the other hand focuses on resilience elements in three levels (resilience lens) as follows: structural resilience – on structural components of resilience; integrative resilience – on system interaction with its environment; and, transformative resilience – on enhanced transformability (Albani and Kupers, 2014:38-42).

With this study focussing on resilience as part of sustainability, the resilience lens was adopted as the basis of identifying indicators of resilience-driven-SCT. It is worth noting that an increase in resilience of a system leads to improved sustainability but the converse is not necessarily true (Marchese *et al.*, 2018). Structural resilience is on need for: redundancy – spare/reserve resources; modularity – integrated independent parts to contain shocks impact (form of decentralization); and, diversity – response and functional (Bresch *et al.*, 2014:52-56). From a SCT perspective: resources required are both human and non-human; modularity can be engrained through SC supply chain decentralization; and, diversity would be of SC products and process (see Sections 1.3, 2.3.4, and, 1.2.3 respectively). Additionally, integrative resilience lenses focus on: multi-scale interactions awareness; critical thresholds monitoring for appropriate control; and, social capital build-up and leveraging. (Bresch *et al.*, 2014:56-60). On SCT, they relate to: strategic, tactical, and, operational scales relationship awareness; SC indicators monitoring for timely and appropriate planning and action; and, stakeholders networking for bottom-up SCT respectively (see Sections 2.3.2 and 2.3.4). Lastly, transformative resilience lenses are on need for: distributed governance; foresight capacity; and, innovation and experimentation (Bresch *et al.*, 2014:60-64). In relation to SCT, they would involve: decentralized SCT decision-making; stakeholders' ability to proactively adapt or reduce vulnerabilities associated with possible futures SCT scenarios; and, creation of new options and ideas.

2.4.4.4 Discussion – Contextualizing the Literature

The literature reviewed in Sections 2.4.4.1-2.4.4.3, and as partly introduced in Section 2.4.1, highlights the interface of resilience and sustainability. This was with the specific emphasis on resilience as a component of sustainability and as such will facilitate enhanced ST implementation in the construction industry. This relationship was also affirmed by resilience theory (see Section 1.2.5). That notwithstanding, there were several observed shortcomings in the literature reviewed. Firstly, resilience has been identified as a complex variable to operationalize (Albani and Kupers, 2014). This was countered by the adoption of measures/elements of resilience as already developed in a framework by Bresch *et al.* (2014). Additionally, the indicators of resilience as derived from Bresch *et al.* (2014) were generic, not construction industry specific. They were thus adapted for construction industry specificity for appropriateness as indicators of SCT socio-spatial sensitivity in this study. Further, there were two aspects of resilience for SCT: weakening the resilience of undesirable SCT regime; and, strengthening the resilience of desirable SCT regime. This study focussed on the later as informed by the desired state inherent in the research problem (enhanced SCT performance) and with the understanding that it would also lead to the former. More importantly, there no was empirical evidence, in the reviewed literature, on the impact of resilience on sustainability or SCT performance. This study sought to fill this gap by the outcome of field study data analysis on: SCT resilience in Kenya; and, its relationship with industry SCT performance. Based on the foregoing discussion, the indicators of resilience-driven-SCT implementation are summed up in Table 2.6 below:

Table 2.6: Resilience Driven SCT Implementation Indicators

Indicator	Source
i. Spare/reserve resources (human and non-human) for sustainable construction change	Bresch *et al.* (2014:52-56)
ii. Sustainable construction supply chain decentralization	Bresch *et al.* (2014:52-56)

Indicator	Source
iii. Sustainable construction processes and products diversity	Bresch *et al.* (2014:52-56)
iv. Sustainable construction scales (industry long-term, organizational medium-term, and, project-level short-term) relationship awareness	Bresch *et al.* (2014:56-60)
v. Sustainable construction indicators monitoring for timely and appropriate planning and action	Bresch *et al.* (2014:56-60)
vi. Stakeholders networking for bottom-up SCT	Bresch *et al.* (2014:56-60)
vii. Decentralized SCT decision-making	Bresch *et al.* (2014:60-64)
viii. Stakeholders' ability to proactively adapt or reduce vulnerabilities associated with possible futures SCT scenarios	Bresch *et al.* (2014:60-64)
ix. Creation of new SC options and ideas through innovation and experimentation	Bresch *et al.* (2014:60-64)

Source: Author (2023)

2.4.5 SCT Governance

2.4.5.1 Overview

According to Rosenau (2000:225), governance is a system rules and mechanisms, through exercise of authority, set up to ensure preservation of systems including attainment of desired goals, such as SC in this study, in a given social set-up. The governance approaches can be formal and/or informal with distinct spheres of influence, that is, specific spheres of authority (SOAs) which define their capacity to stimulate required compliance. Consequently, compliance is a key indicator to the existence of SOA(s). Additionally, understanding the role of various SOAs in governance is pegged more on the degree of compliance they achieve as opposed to their respective legal prerogatives. Compliance is central to leadership and politics and is increasingly difficult to achieve with increased societal and global complexity. In addition to formal persuasions, as inherent in formal approaches, compliance is largely driven by amongst other factors: norms; habits; informal persuasions; and, shared perspectives. With increased system complexities, rule systems can be found outside government structures in:

NGOs; companies; professional associations; trade associations; and, advocacy associations amongst other social entities. It consequently emerges that there are two main governance approaches: government-led; and, others led by other social entities with their respective SOAs (Rosenau, ibid:225, 227-228). This highlights the implied potential downfall of solely focusing on government driven compliance. To avoid such an eventuality, this study focussed on both and with specific focus on SCT implementation.

Governance indicates *"... the totality of 'mechanism' and 'instruments' available for influencing social change in preordained directions"* (Lafferty, 2004:5). The policy instruments are categorized as: command-and-control; economic; liability/damage compensation; education and information; voluntary approaches; and, management and planning. The command-and-control instruments were identified to be: permits/licenses; emissions, quality, process, and, product standards; and, bans/prohibitions. The economic category of instruments include: performance bonds; non-compliance penalties; taxes; subsidies; tradeable quotas, and, emissions permits; resource pricing; and, deposit return schemes. Liability/damage compensation instruments include: mandated pollution insurance; extended producer responsibility; clear liability rules; and, compensation funds. The education and information category of instruments covers: awareness drives; information dissemination; eco-labelling; and, publicising non-compliance penalties. For the voluntary instruments, they include: negotiated agreements; voluntary programmes; and, unilateral commitments/contracts. Lastly, management and planning instruments include: land-use planning; development zoning; and, environmental management systems. The choice of policy instruments combinations should consider: economic impacts; political acceptability; compliance with applicable international agreements and/or rules; effectiveness; minimal cost to society; operation simplicity; minimal transaction cost; integration with other policies; maximizing flexibility in compliance; support for continuous compliance and innovation incentive; minimal negative impacts; and, support for international competitiveness (Lafferty, ibid:6; OECD, 2001b:132, 135-136).

The foregoing discussion on governance policy instruments and their implementation considerations was largely on environmental protection. This study postulates that the same, with some modifications as may be necessary in a given context, can be extended to the social and economic facets of sustainability and further into SCT.

2.4.5.2 Governance – concept and configurations

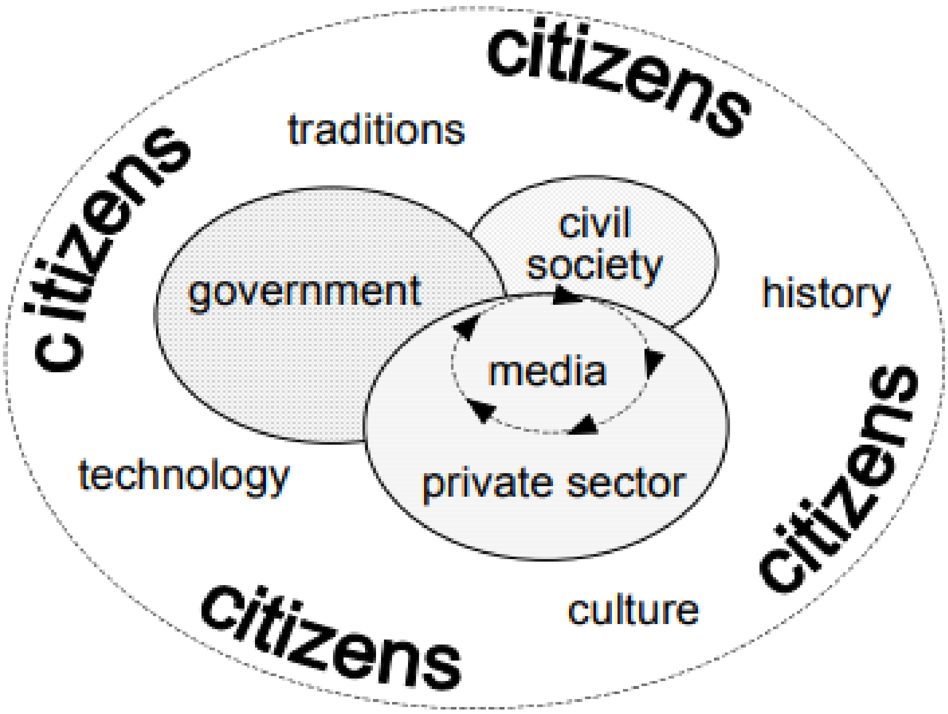
The word governance can be traced as far back as ancient Greece. The earlier interpretations for governance referred to administration exercised by state(s) over societies. States were identified as key to dealing with societal challenges and complexities. This approach has however attracted criticism owing to association with vices such as: corruption; inefficiency; abuse of power; and, failure of states. This has led to rethinking of the concept of governance which is currently seen to be bi-pronged: exercise of power and authority by state and the public sector – a top-down approach; and, a managerial approach focused on improving efficiency and organization in administration. This current conceptualization links policy and its management. This shift in conceptualizing governance has been informed by impacts of factors such as: globalization; global challenges such as economic crises; increased competition; and, erosion of state power. In its broadest sense, governance, refers to ways of enhancing multi-level societal coordination through dialogue and partnerships (Vymětal, 2007:5-7). Asaduzzaman and Virtanen (2016:5) pointed out that governance emerges as dynamic and in its core consists of decentralization, populace-orientation, and, enhanced stakeholder participation through networking.

Fukuyama (2016:6.2) outlined three main interpretations of governance: global/international governance; good governance; and, governance without government. Global/international governance refers to exercise of power and authority, for the general welfare of society, by non-state actors through cooperation at international scale. An example such non-state actors include: the EU; and, UN. Secondly, good governance refers state policy implementation by governments aimed at provision of basic public services and goods (public administration). Lastly, governance without government covers exercise of power and authority, for the general welfare of society, by non-state actors through cooperation at domestic scale. The network of actors here includes NGOs, non-market and other non-state entities. An example would be a private firm providing public-like goods as part of its corporate responsibility program. The shift of governance from primarily state actors towards non-governmental actors has been observed over time. This has been attributed to: increased complexity of modern society beyond the expertise and capacity of governments; distrust of hierarchical command and control by state actors; and, inefficiency in governments (Fukuyama, ibid:6.2-6.12).

Graham *et al.* (2003:2-3) identified components of governance to include: structures; processes; and, traditions related to power, decision making, relationships, and, accountability.

Graham *et al.* (ibid:3-5), in a bid to simplify understanding of governance, at a national scale, further identified four key societal sectors (situated amongst citizenry), which are interactive: government; private sector; civil society; and, media as illustrated in Figure 2.9 below. Their respective influence powers, and consequently illustrative sizes, vary across nations amongst other contextual influences. This is in line with postulation by Asaduzzaman and Virtanen (2016:2) that context, geographic and otherwise, is key in theorizing governance and has not always received the attention it deserves. Additionally, Graham *et al.* (2003:4), further emphasized the central role of media in any governance discussion owing to its role in: relaying information amongst sectors; the consequent opinion shaping; and, the potential to promote accountability. It is however worthwhile noting that, governance is applicable to multiple collective action configurations. Consequently five scales of governance were identified: global – beyond the influence of individual states; national – at state level such as national, county, urban, and, rural; organizational level; community level (Graham *et al.*, ibid:5-6; Asaduzzaman and Virtanen, ibid:5); and, service providers level (Asaduzzaman and Virtanen, ibid:5). It is worth noting that this study focused on how governance can enhance the effectiveness of SCT strategies upon implementation at construction industry level.

Figure 2.9: Key Sectors in Governance (At National/State Scale)



NB: The text boxes for various sectors above are not reflective of their respective SOAs.

Source: Graham *et al.* (2003:3)

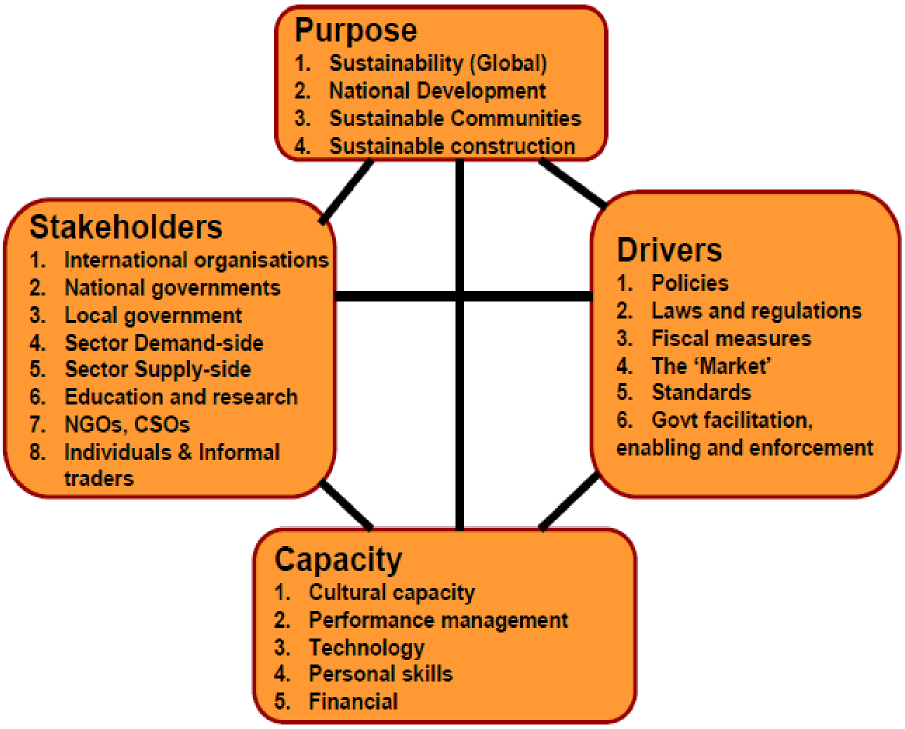
Rese *et al.* (2015:42) highlighted the norm of governance having an accompanying adjective such as in: corporate governance; policy governance; and, by extension and as is the case for this study, (SC) transition governance. This can be attributed to flexibility of the concept whose construct is dependent on the context and has many aspects as characterized by Vymětal (2007:7). This further contributes to the nebulousness associated with the term/concept. Governance is also concerned with the part of business that manage conflicts that arise out of: differing owner and administrators' interest; increasingly complex relationships; and, interests of all stakeholders. Additionally, governance has been traditionally approached from three main perspectives based on: agency theory; transaction costs theory; and, public governance. The agency theory-based perspective, rationalist perspective, is aimed at containing agents/administrators from acting at the expense of the owners. The governance mechanisms are based on: monitoring and control; contracts; and, limiting mechanisms. The transaction costs theory-based perspective, institutional perspective, is inclined towards efficient and economic management of transactions costs. The associated governance mechanisms have been identified to include: market; hierarchy; and, hybrid operations. Lastly, public governance-based perspective, governmentality perspective, is of the position that state manages interactions amongst organizations for collective public good. The associated governance mechanisms have been identified to include control mechanisms to prevent public officers from acting in their own interest and/or against public good (Rese *et al.*, ibid:43).

2.4.5.3 SCT Governance

Gilham (2010:230) developed a framework for SD governance in the built environment made up of four key components: purpose; drivers; stakeholders; and, capacity. The purpose component covered the objectives of SD governance framework which include attaining: sustainability through SD; sustainable communities; SC; and, national development. The drivers component covered the enablers for required sustainability change. These enablers were identified to include: policies (government and corporate); national laws and regulations; fiscal measures – tax and grants related; demand; codes, standards, and, (accreditation and certification) schemes; and, government facilitation, enabling, and, enforcement. The key stakeholders in achieving SD were identified to be: international organizations such as UN and international professional associations; national governments; local governments such as county governments as is the case for Kenya; industry demand-side actors such as developers and users; industry supply-side actors such as suppliers and contractors; research and education stakeholders; NGOs and civil society organizations; and, informal traders and individual stakeholders (Gilham, ibid: 106,117, 120-121, 131, 143-144, 122, 128-130, 229-230).

Lastly, the capacity component covered the abilities to achieve the sustainability purposes. Capacity elements were identified to include: financial capacity; leaders skills for good governance – leadership, direction, communication, and, controlling; technological capacity in terms of equipment, software, and, know how; performance management capacity in policy and strategy, mechanisms for good governance, regulation and legislation, financial mechanisms, and, education; and, cultural capacity in personal code(s) of conduct supporting personal responsibility, society open to change and at the same time supportive of innovation and creativity, and, shared ethical system at community level supportive of sustainability (Gilham, ibid:145, 149, 229-230). The foregoing discussion on the SD governance framework is summarized in Figure 2.10 below:

Figure 2.10: Built Environment SD Governance Framework



Source: Gilham (2010:230)

2.4.5.4 Discussion – Contextualizing the Literature

The literature reviewed in Sections 2.4.5.1-2.4.5.3, and as partly introduced in Section 2.4.1, highlights the interface of governance and sustainability. This was with the specific emphasis on the centrality of multi-level governance in realizing action in multi-actor, multi-sector, and, polycentric contexts, as is the case for SCT. This relationship was also affirmed by MLG theory (see Section 1.2.5). That notwithstanding, there were several observed shortcomings in the literature reviewed. Firstly, much of the literature was on general governance. This was in the context of observed limited empirical studies on SCT governance. This was countered by complementing it with Gilham (2010), a doctoral study, on SD governance in the built environment. Additionally, while the framework by Gilham (2010) is an impressive attempt to cover aspects/indicators of SD governance in the construction industry, it was observed to: not incorporate media as key SCT governance stakeholder as identified in Graham *et al.* (2003:4); and; be applicable up to a global scale. This necessitated: incorporating of media a key source of SCT governance SOA – see indicator (vi) in Table 2.7 below; and, omission of its indicators above the national scale which was the spatial scope in this study. Unlike Gilham (2010) which focussed on elements of SD governance, with Rosenau (2000) emphasizing on compliance as a key indicator of governance, all the indicators of SCT governance in this study were approached from the perspective of eliciting SCT compliance. More importantly, there was limited empirical evidence, in the reviewed literature, on the impact of MLG on sustainability or SCT performance. This study sought to fill this gap by the outcome of field study data analysis on: SCT MLG in Kenya; and, its relationship with industry SCT performance. From the foregoing discussion, the indicators of supportive multi-level governance in effecting SCT strategies are summed up in Table 2.7 below:

Table 2.7: Indicators of Supportive Multi-Level Governance in SCT Strategies Implementation

Indicator	Source
i. Decentralized SC steering, from primarily state actors towards non-governmental actors, that is populace-orientated and with enhanced stakeholder participation	Asaduzzaman and Virtanen (2016:5), and, Fukuyama (2016:6.2-6.12)
ii. National government driven SC uptake/compliance	Rosenau (2000:224-225), Graham *et al.* (2003:3-5), and, Gilham (2010:106,117,120-121,131,143-144,122,128-130,229-230)
iii. County governments driven SC uptake/compliance	

Indicator	Source
iv. Private sector actors, *such as: independent consultants, consultancy firms, construction firms, and, suppliers*, driven SC uptake/compliance	
v. Civil society actors, *such as: NGOs; professional associations; trade associations; and, advocacy associations for example KGBS*, driven SC uptake/compliance	
vi. Media driven SC uptake/compliance including: relaying SCT information; supportive SCT opinion shaping; and/or, encouraging SCT related accountability	Graham *et al.* (2003:3-5)
vii. Clarity and awareness of SCT objectives/purpose – *resource efficiency, natural resources conservation, and, moral and legal obligations compliance*	Gilham (2010:106,117,120-121, 229-230)
viii. SCT enabling context – *policies (government and corporate); laws and regulations; fiscal measures – tax and grants related; demand; codes, standards, and, (accreditation and certification) schemes; and, government facilitation, enabling and enforcement*	Gilham (2010:131,143-144, 229-230)
ix. Industry stakeholders' capacity, *financial, technological, personal skills, supportive culture, and, performance management,* to achieve SCT objectives (*resource efficiency, natural resources conservation, and, moral and legal obligations compliance)*	Gilham (2010:145,149,229-230)

Source: Author (2023)

2.5 Role of SMEs and Select Information Technologies in SCT

2.5.1 Small and Medium Sized Enterprises (SMEs) and SCT

Most SMEs owners and employees are more inclined to protect the local environments. This has been attributed to: their investment decisions are local; and, they are largely based in the said local environments. SMEs have significant (actual and potential) SD contribution to nations (developing and developed) such as: economically – locals' involvement in economic development leading to economic empowerment; environmentally – financial support to environmental conservation efforts; and, socially – employment creation just to mention but a few contributions (Medina-Muñoz and Medina-Muñoz, 2000:114,122; Mabasa *et al.*, 2023:11). For their enhanced SD contribution, the following was suggested: exploration of means by which competitive advantage to SMEs over large corporations can be conferred as a result of SD behaviour; and, SMEs should also independently continue with their specific SD contributions to achieve competitive advantage through differentiation (Medina-Muñoz and Medina-Muñoz, 2000:123). It is however worth noting that there is empirical evidence on the disconnect between SME owners and managers with the environmental agenda (Revell and Rutherfoord, 2003:26-27). Revell and Rutherfoord (ibid:33), highlighted the importance of actively engaging SMEs on the sustainability agenda for associated policy system to succeed. It was suggested that such engagement should include: consultative policy construction process; strengthening intermediary networks (can include trade associations, consultancy firms, and, employee organizations) for consultative implementation; and, robust legislative system in addition to voluntary agreements and supply chain pressures.

At the core of SMEs lie certain key focus areas which have been identified as: profitability; competitiveness; customer satisfaction; marketing of the goods and/or services; and, legal compliance. This category of enterprises has proved to be able to innovatively respond to rapid change due to: their smaller size compared to large enterprises; and, flexibility of their workforce. On the other hand, they also experience a unique disadvantage of lack of information regarding market changes making them unable to capitalize on change associated with sustainability. Consequently, as some SMEs emerge as sustainable practice market leaders, others see the change towards sustainability as a burden and lack the requisite mindset to see the opportunities afforded by these changes in the business environment. Regarding active engagement of SMEs on the sustainability agenda, inefficiency, in ensuring long-term behaviour change, of conventional engagement approaches such as seminars, internet, and, newsletters was observed. Instead, alternative approaches recommended include: on-site visits; face-to-face engagements; networking; guidance helplines; and, value-based relationships. Additionally, there is need to: counter barriers to sustainability change; and, convince SMEs on the value/benefits of sustainability such as enhanced services and/or goods demand and incentives (Condon, 2004:66,58). The foregoing discussion highlights the deliberate action required to facilitate ST, and by extension SCT, through SMEs.

In the Kenyan context, this study adopted the use of micro, small, and, medium enterprises (MSMEs) as opposed to SMEs in line with *Micro and Small Enterprises Act 2012*. As highlighted in Central Bank of Kenya (CBK) (2021:7), this category of enterprises is statutorily defined as having: annual turnover of up to Ksh. 100,000,000 (1 USD=Ksh. 138.45 as of May 2023); up to 250 employees; and, assets and financial investment value ranging from less than Ksh.5,000,000 to a ceiling as may be determined by Cabinet Secretary in charge of ministry dealing with MSMEs.

The literature reviewed above, and as partly introduced in Section 2.4.1, highlights the interface of MSMES and SCT. This was with the specific emphasis on the centrality of leveraging MSME for enhanced SCT performance given their industry hegemony (Wedawatta *et al.*, 2010:364; Ali, 2021). This line of thought was affirmed by MLG theory (see Section 1.2.5) where private sector actors were identified as a key source of SCT SOA (see Table 2.7). That notwithstanding, there were several observed shortcomings in the literature reviewed. Firstly, the literature reviewed focused on SMEs and not the comparatively bigger scope of MSMEs. Given that the applicable law, *Micro and Small Enterprises Act 2012*, in the geographical context of the study, Kenya, the study extended the scope of study to MSMEs. Additionally, with SCT yet to receive significant uptake in Kenya (see Section 1.3), it is debatable as to whether the conventional approaches of engaging MSMEs on SCT have received significant adoption. In light of this peculiarity, this study sought to assess the engagement of MSMEs based on both the conventional and alternative approaches as recommended by Condon (2004:66). More importantly, there was limited empirical studies, in the reviewed literature, on the leveraging, including impact of, MSMEs for sustainability and SCT globally and in Kenya. This study sought to fill this gap by: incorporation of MSMEs leveraging as an independent variable to the dependent variable of SCT performance; and, the outcome of field study data analysis on MSMEs leveraging in SCT in Kenya, and, its relationship with industry SCT performance. From the foregoing discussion, Table 2.8 below sums up the indicators of active MSMEs engagement in SCT strategies implementation:

Table 2.8: Indicators of Active MSMEs Engagement in SCT Strategies Implementation

Indicator	Source
i. SCT policy development and implementation in consultation with MSMEs *such as through trade and professional associations*	Revell and Rutherfoord (2003:33)
ii. Voluntary SC adoption by MSMEs	
iii. MSMEs SC adoption attributed to supply chain pressures	
iv. Robust legislative system in support of SC adoption by industry MSMEs	
v. Availability of SCT related market changes information to MSMEs	Condon (2004:66)
vi. Engaging MSMEs on SCT through: on-site visits; face-to-face engagements; networking; guidance helplines; and, value-based relationships *in addition to conventional approaches such as: seminars; internet; and, newsletters*	
vii. Intentional efforts to counter barriers to SC adoption by MSMEs *such as lack of market information*	
viii. MSMEs convinced on SC value/benefits	

Source: Author (2023)

2.5.2 Big Data and Internet of Things (IoT) Role in SCT

In this Networked Knowledge Age (Lu, 2015:150), or data revolution as postulated by Etzion and Aragon-Correa (2016:148), there is a shift towards quantitative approach to sustainability. This study argues that SCT is not exempted. This age has seen a rise in smart wearables, appliances, building management systems, and, cities globally. One of the supporting technologies has been identified as big data (Allen and Macomber, 2020:34-35). The difference between big data and regular data can be summed up in four key features, that is: large volumes beyond the capacity of existing data ecosystem; wide variety in terms of types and source;

increased speed of data creation, processing, and, analysis – velocity; and, varying degrees of reliability and credibility (uncertainty) – veracity (Miele and Shockley, 2013:2-4). Miele and Shockley (ibid:5) further postulated that business competitive advantage can be achieved using big data in the modern largely digitized marketplace. Value is derived from big data in the following order: deriving knowledge – big data is converted to information and consequently to knowledge; and, decision making – knowledge generated informs decisions taken and consequently the actions taken (Abbasi *et al.*, 2016:3-4).

Big data has been identified to: facilitate understanding unachievable with ordinary data; and, addresses limitations of traditional sampling approaches through aspects such as improved heterogeneity and automated data collection. This study primarily focused on the former, specifically on the various opportunities afforded by big data for enhanced SCT strategies implementation. Consequently, big data can confer a list of SCT related operational and strategic benefits to both state and non-state entities, among them: at the very least, much of the benefits associated with big data such as enhanced efficiency confer sustainability benefits as well; real-time big data can facilitate improved functional areas coordination for enhanced performance; non-business entities can be able to better monitor environmental changes for timely action; associated real time applications can help better align resource usage with resources, markets, and, behaviour which can in turn lead to reduced wastage and objective estimation of demand; enabling mass customization of goods and services towards sustainability including enhancing credibility of SD products by tracking supply chain; and, consultancies and government agencies creating service offerings to the market and/or citizenry based on sustainability associated data analytics (Etzion and Aragon-Correa, 2016:148-149).

Other benefits include: driving behaviour change towards sustainability through big data nudges such as through applications where users can compare energy uses in a bid to stimulate behaviour towards energy efficiency; supporting collaborative consumption through activities such as tech-based services for example Uber and Airbnb. They enhance efficiency such as in terms of reduced individually owned cars and thus pollution and economic utilization of idle housing facilities respectively; and lastly, through better understanding of market demand and supply forces, as afforded by big data, profitable renewable energy businesses are created. An example of such opportunities would include demand and supply coordinated user-to-grid solar and/or wind energy transmission. Other impacts at organizational level could include: current sustainability roles becoming redundant; need to enhance current sustainability roles on research capabilities such as data analysis and visualization; availability of better tools, on incorporating sustainability in organizations, for managers; due to supply chain considerations, the need for firms and departments to share information; increased data-driven sustainability reporting; increased availability of firm-level sustainability information; and, lastly the potential of focus shifting towards measurable sustainability aspects as opposed to a holistic approach (Etzion and Aragon-Correa, ibid:149-150, 152-153).

The other technology in relation to big data that has great SCT potential is IoT. The Institute of Electrical and Electronics Engineers (IEEE) (2020:20) defines IoT as a web of entities (people, devices, and, systems) exchanging information and interacting with the physical world through sensing, information processing, and, actuating. According to Salam (2020:4,10-11), IoT for Sustainability involves leveraging IoT in the quest for sustainability – acceptably harmonizing societal needs with environmental protection and at the same ensuring economic equity. Consequently, IoT for sustainability has five key elements: sustainability things/devices – with physical or virtual connection to IoT system; sensors/actuators for specific sustainability indicators; networked and communicating things/devices and sensors/actuators; IoT system – network of things, sensors/actuators, and, communication elements to achieve a specific sustainability objective; and, holistic IoT paradigm – network of IoT systems in a given context aimed at achieving specific sustainability objectives. Based on these elements, IoT systems functions have been identified as: sensing; data collection; networking; data storage; data processing; and, decision making based on information from data processing (Salam, ibid:11-13). The relationship between big data and IoT can be summed up as: IoT generated data stacks are stored in the cloud; the generated data stacks from various IoTs make up big data; and; use of analytic tools such as Splunk and Spark to analyze big data (from training data, to analytic tools, through queries, and, finally reports) (Yadav *et al.*, 2020:518).

The literature reviewed above, and as partly introduced in Section 2.4.1, highlights the interface of IoT-driven big data and SCT. This was with the specific emphasis on the centrality of leveraging technology, and specifically IoT-driven big data in this case, for enhanced SCT performance. This was in the context of rise in smart wearables, appliances, building management systems, and, cities globally (Allen and Macomber, 2020). This study sought to explore the potential of leveraging IoT-driven big data to drive enhanced SCT performance.

That notwithstanding, there were several observed shortcomings in the literature reviewed. Firstly, much of the IoT for sustainability literature reviewed was generic. This necessitated the adaption of resulting indicators for the construction industry context for appropriateness as measures of leveraging IoT-driven big data for SCT. Also, some of the applications highlighted can be argued to be minimal or non-existent for the Kenyan construction industry such as SD products supply chain tracking. This was in the context of sub-optimal SCT (see Section 1.3) and minimal uptake of digital technologies in the Kenyan construction industry. As such, for context appropriateness, such potential indicators were not included in the list of indicators adopted for this study. More importantly, there were limited empirical studies, in the reviewed literature, on leveraging IoT-driven big data for sustainability. This study sought to fill this gap by: incorporation of IoT-driven big data leveraging as an independent variable to the dependent variable of SCT performance; and, the outcome of field study data analysis on IoT-driven big data leveraging in SCT in Kenya, and, its relationship with industry SCT performance. From the foregoing discussion, Table 2.9 below sums up the main indicators of leveraging IoT-driven-big data in SCT strategies implementation:

Table 2.9: Indicators of Leveraging IoT-Driven-Big Data in SCT Strategies Implementation

Indicator	**Source**
i. Increased use of smart wearables, appliances, and, building management systems	Allen and Macomber (2020:34-35)
ii. Use of real time applications in aligning resources usage with resources, markets, and, behaviour	Etzion and Aragon-Correa (2016:149)
iii. Big data driven prods towards SC behaviour *such as applications where consumers can compare energy uses in a bid to stimulate behaviour towards energy efficiency*	Etzion and Aragon-Correa (2016:150)
iv. Big data driven collaborative consumption/use of constructed facilities *such as use of Airbnb platform for collaborative use of residences*	Etzion and Aragon-Correa (2016:150)

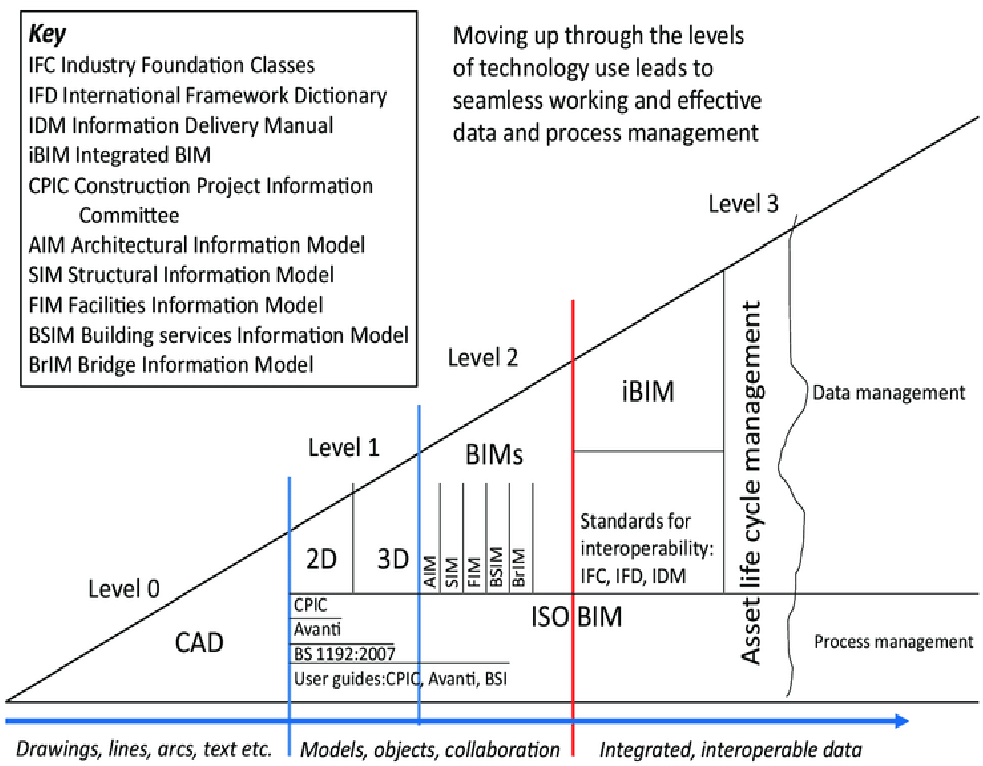
Source: Author (2023)

2.5.3 Building Information Modelling (BIM) and SCT

Martin (2017:2) defined BIM as a form of data management where data is entered, visually and/or numerically, in a program to create a 3D model from which 2D views or even numerical data sets can be obtained and alterations in 2D view automatically update in the model. BIM involves collaboration where the various project stakeholders, over the various phases in the project lifecycle, are able to create, modify, and/or, extract information from the project model based on their respective project roles. Consequently, in addition to being a representation of a constructed facility (in terms of physical and functional features), a building information model, also referred to as model, is a shared knowledge hub about the facility in context, and forms the basis of objective lifecycle decision making (WBDG, 2021). BIM softwares and associated tools have been identified to contribute to enhanced: collaboration (inter-organizational and inter-disciplinary); and, project lifecycle productivity and quality. This is by supporting: parameter-based facility modelling; spatial visualization; building behaviour modelling; comparatively efficient project management; collaboration; and, a lifecycle approach (Miettinen and Paavola, 2014:84,86-87).

There are two main frameworks for understanding BIM development and implementation: normative; and, activity-theoretical evolutionary. The normative framework is primarily based on use of national guidelines and successful implementation cases. Theoretical frameworks and maturity models additionally foster enhanced BIM implementation. The activity-theoretical evolutionary framework, on the other hand, is primarily based on process characterized by: open-ended technological and social development; simultaneous solutions integration and differentiation; and, learning, experimentation, and, invention of new uses (Miettinen and Paavola, ibid:85,87-90). According to the ubiquitous Bew and Richards (2008) BIM maturity model, including the summary by Dakhil *et al.* (2015:236-237), there exist four distinct stages in BIM adoption process: level zero – this stage is characterized by adoption of uncoordinated computer aided design (CAD) that is paper based; level one – managed CAD in 2D or 3D involving file based collaboration; level two – multi-disciplinary, but non-integrated, file-based 3D file based collaboration, and, library management; and, lastly level three – multi-disciplinary 3D models integration using networking technologies. The Bew-Richards BIM Maturity Levels Model is illustrated in Figure 2.11 below:

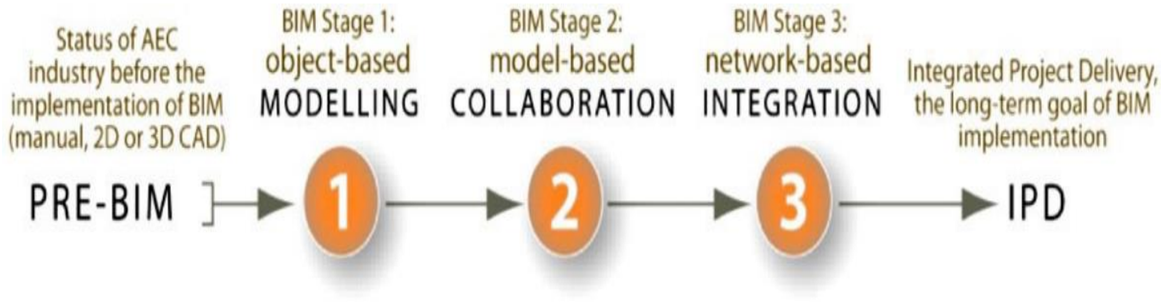
Figure 2.11: Bew-Richards BIM Maturity Levels Model



Source: Bew and Richards (2008)

Another three-stage BIM maturity model, exists as postulated by Succar (2009:361-363): pre-BIM; BIM stage one; BIM stage two; BIM stage three; and, integrated project delivery (IPD). Pre-BIM stage covers status of Architecture, Engineering, Construction, and, Operations (AECO) industry before BIM – dependence on 2D information to describe a 3D object. Phase one (object-based modelling) involves generation of single discipline 3D models using BIM softwares and related tools such as Revit® and ArchiCAD®. In this level there is no substantial model-based inter-disciplinary collaboration. Phase two (model-based collaboration) is characterized by active inter-disciplinary model-based collaboration. The model/part model interchanges are usually through: proprietary formats such as .RVT file format – between Revit® Structure and Revit® Architecture; and, non-proprietary formats such as IFC file format – between Tekla® and ArchiCAD®. Phase three (network-based integration) involve lifecycle inter-disciplinary integrated multi-model collaboration. The integration is supported by: model server technologies; databases; and/or, web-hosted softwares. Lastly, IPD (long-term BIM implementation) – amalgamation of domain technological, process, and, policies aspects (Succar, ibid:364-365). The above discussed BIM maturity levels, as postulated by Succar (ibid), are illustrated in Figure 2.12 below:

Figure 2.12: BIM Maturity Levels



Source: Succar (2009:363)

The evolution of BIM, with increasing complexity from 3D to 8D, provides more opportunity to increasingly incorporate SCT practices from design, through construction, to life-cycle management, and, ultimately decommissioning. Additionally, BIM has been postulated to have the potential to contribute to the three long-established key facets/pillars of sustainability: environmentally – BIM information can be used to make environmental conscious decisions over the lifecycle of constructed facilities; economically – can contribute to overall economic viability of a constructed facility through aspects such as efficient logistics, enhanced productivity, and, waste reduction; and, socially – has the potential to enhance overall well-being of constructed facilities users and the general society through support of aspects such as enhanced: indoor air quality, appropriate waste management; and, stakeholders engagement (Reizgevičius *et al.*, 2018:3). Martin (2017:3) highlighted the importance of designers onboarding sustainability considerations early in design process and validating them using BIM, through modelling, for better BIM-led sustainable constructed facilities. This is owing to the great influence of this project phase on the subsequent phases, that is: construction documentation; construction; operation; and, decommissioning. Roslan *et al.* (2019:153-154) highlighted that in this Networked Knowledge Age, construction industries need to readjust their business models and work processes if they are to continue offering value to the market. BIM was put forward as a good starting point.

The literature reviewed above, and as partly introduced in Section 2.4.1, highlights the interface of BIM and SCT. This was with the specific emphasis on the centrality of leveraging technology, and specifically BIM in this case, for enhanced SCT performance. This was also in the context of rise in smart wearables, appliances, building management systems, and, cities globally (Allen and Macomber, 2020). This study sought to explore the potential of leveraging

BIM to drive enhanced SCT performance. That notwithstanding, there were several observed shortcomings in the literature reviewed. Firstly, the literature highlights the need to coordinated construction project lifecycle decision making and action in leveraging BIM for SCT. Though cognisant of the disjoint between design and construction phases and stakeholders, including in the Kenyan construction industry, the indicators were identified from a lifecycle perspective being the ideal desired state. Additionally, the Kenyan construction industry context is characterized by sub-optimal SCT (see Section 1.3) and arguably minimal uptake of digital technologies. As such, as opposed to having IoT-driven big data (see Section 2.5.2) and BIM as two distinct independent variables, this study combined them into one – leveraging the technologies of IoT-driven big data and BIM for enhanced SCT. More importantly, there were limited empirical studies, in the reviewed literature, on leveraging BIM for sustainability holistically. This study sought to fill this gap by: incorporation of BIM leveraging as an independent variable to the dependent variable of SCT performance; and, the outcome of field study data analysis on BIM leveraging in SCT in Kenya, and, its relationship with industry SCT performance. From the foregoing discussion, Table 2.10 below sums up the main indicators of leveraging BIM in SCT strategies implementation:

Table 2.10: Indicators of Leveraging BIM in SCT Strategies Implementation

Indicator	Source
i. BIM driven environmental conscious decision making over the lifecycle of constructed facilities	Reizgevičius *et al.* (2018:3)
ii. BIM driven enhanced overall economic viability of constructed facilities *through aspects such as efficient logistics, enhanced productivity, and, waste reduction*	Reizgevičius *et al.* (2018:3), and, Roslan *et al.* (2019:153-154)
iii. BIM driven enhanced overall well-being of constructed facilities users and the general society *through support of aspects such as enhanced indoor air quality, appropriate waste management, and, stakeholders' engagement*	Reizgevičius *et al.* (2018:3)
iv. Onboarding sustainability considerations early in design process and validating them using BIM, through facilities parametric modelling	Martin (2017:3)

Source: Author (2023)

2.6 Theoretical Underpinnings – Nexus of SCT Performance, SCT Strategies, and, SCT Strategies Implementation Considerations

2.6.1 Overview

Social theories are a system of networked ideas offering explanation as to how a phenomenon of the social world works including the logic behind it. *"Evidence from studies may support, extend, reject, or modify a theory"* p.60. Empirical evidence is used to evaluate theory(ies) as opposed to defending it (them). A good theory is characterized by minimal complexity – few components/elements. Consequently, the rule of thumb is that if there are two convincing theories for a given phenomenon, if one has to choose one, the simpler one should be adopted to underpin the study in context. For strong research, theory(ies) employed should be clear, complete, and, well formulated. The four key components of social theories are: assumptions – empirically untested statements on beliefs necessary for development of a theoretical foundation; concepts – ideas expressed in form of words or symbols; relationships – specified relationships between the theoretical concepts; and, unit of analysis – concepts definitions alignment with adopted unit of analysis. Other key theory aspects are: theorizing direction – deductive starting from concepts and theoretical relationships towards empirical evidence and inductive starting towards a theory from empirical evidence; analysis level – micro-, meso-, and macro-level theories; theoretical focus – substantive and/or formal theories; explanation form – interpretive, causal, or, structural; and, theory range – theoretical framework, empirical generalizations, and, middle-range theories (Neuman, 2014:57-58,60-85).

The phenomenon of SCT is complex, involving many variables, and consequently not well understood. This points towards the need to employ multiple theories since one theory may not sufficiently explain the relationship between all the possible independent variables and SCT. Consequently, there are many theories that can be used to explain how people transition towards pro-sustainability behaviour including the logic behind it. Such theories can thus offer explanation as to how SCT strategies may be implemented for effectiveness in various contexts. However, with SCT being a fairly new research subject, there is barely any substantive theory on the subject. As such, this study employed several formal theories to explore SCT phenomenon with specific reference to the Kenyan construction industry. Neuman (ibid) defines formal theory as *"a type of theory that is general and applies across many specific topic areas"* p.72. The specific formal theories employed to underpin this study, as introduced in Section 1.2.5 are: TPB; PIT; resilience theory; MLG theory; and, STS theory.

They are discussed below in detail and with the concepts and assumptions that anchored this study. The review of these theories ultimately culminated in a theoretical framework summarizing the concepts and assumptions providing the theoretical foundation for this study.

2.6.2 Theory of Planned Behaviour (TPB)

TPB has its roots in the theory of reasoned action (TRA) which is of the general proposition that behaviour intention is driven by: favourable attitude; and, supportive social pressure. TRA main assumption is that the involved social entities have full voluntary control of behaviour. TPB later emerged to also include situations where social entities have limited voluntary control of behaviour (Ajzen, 2012:445). Consequently, one of the main theories on the relationship between attitude and behaviour is TPB (Ajzen and Fishbein, 1980). Ajzen (2001) defines attitude to be psychological object evaluation summary expressed in dimensions such as *"... good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable"* p.28. Behaviour on the other hand is defined as living organisms' physical phenomena (external changes or activities) functionally mediated by other current external phenomena (belonging to the organism or physically independent) (Uher, 2016). Change readiness has been identified as a well-studied change attitude (Bouckenooghe, 2010:502), and is extended to SCT in this study. Holt and Vardaman (2013) define change readiness as a measure of willingness/commitment and preparedness, capacity, of a social set-up towards change (planned or unplanned).

TPB is to the effect that, human behaviour is influenced by a combination of: behavioural beliefs – on the perceptions on the extent of outcomes desirability for given behaviour; normative beliefs – on social pressure perceptions towards given behaviour; and, control beliefs – on perceptions on the extent of behavioural control. Positive behavioural, normative and control beliefs lead to development of intention to perform a given behaviour. Additionally, with a reasonable degree of actual control over behaviour, the social entities in context are largely inclined to execute the behavioural intentions when an opportunity arises. It also argues that the currently available beliefs informing intention and consequently behaviour can change over time resulting in discrepancy between intentions and actions. Other assumptions of TPB have been identified to be: strong relationship between intention and behaviour (not causal); moderating effect of degree of control over behaviour; change in intentions will result in behaviour change; beliefs may be premised on incorrect, incomplete, irrational, or, biased information and may fail to reflect reality; routine behaviours involve relatively low cognitive effort compared to novel ones; and, intentions drive both routine and novel behaviour (Ajzen, 2012:448-452). From the foregoing discussion, this study postulates that SCT change readiness has a direct relationship with SCT behaviour intention.

Two TPB criticisms, as identified in Sniehotta *et al.* (2014:2-4), are discussed hereunder in context of this study. TPB has been identified to not sufficiently explain behaviour change. However, with SCT being a nascent area of study, and in the absence of established frameworks explaining it, this study sought to partly explore the proportion of SCT, if any, that can be explained by change readiness (as informed by TPB – see above). It has also been argued to not help in development of behavioural change interventions by practitioners. In the emerging SCT study area, this study argues that its utility is yet to be drawn. As such, this study sought to explore the potential of change readiness in facilitating SCT amongst industry practitioners. Based on the foregoing discussion, this study found TPB to be an appropriate theory to anchor SCT change readiness as a predictor of SCT performance.

2.6.3 Place Identity Theory (PIT)

Place-identity is a sub-structure of self-identity which is in turn is sub-structure of self-conceptualization/sense of self from self-theories. Self-theories are of the general proposition that self-conceptualization/sense of self is defined by cognition of one's distinctiveness and relationship with others. However, for self-identity, one's relationship with physical settings in which they operate becomes an additional constitutive element (Proshansky *et al.*, 1983). Place-identity is *"those dimensions of self that define the individual's personal identity in relation to the physical environment by means of a complex pattern of conscious and unconscious ideas, feelings, values, goals, preferences, skills, and behavioural tendencies relevant to a specific environment"* (Proshansky, 1978:155). This study lays specific emphasis on the mediating change function of place-identity. It is to the effect that discrepancies between one's place-identity and features of immediate physical environment give rise to cognitions aimed at eliminating or reducing the discrepancies. This may specifically involve: changing physical settings – can be based on one's cognitions (how to and what to do) or by depending on others; changing one's behaviour; and/or, changing the behaviour of others – those with power or authority are more inclined towards influencing others than those without (Proshansky *et al.*, 1983).

The place-identity properties have been identified as: dynamic and endless mix of past, present, and, anticipated physical settings cognitions; memory stored cognitions are highly stylized and selective; cognitions components are clustered and related within and across clusters for given physical settings and are also related to those of other settings; remote awareness of relevant cognitive structures; cognitive clusters also incorporate regulations, norms, rules, and, behaviours associated with given settings; demographic and sociocultural features of an individual are key components of their place-identity; territoriality, personal space, crowding, and, privacy values and norms for a given society are central to place-identity; early place-identity patterns are enduring in nature; even enduring patterns change to some extent in the long-run; place-identity may radically change (in the short or long terms) due to unexpected changes such as related to technology, ecology, demography, and, territorial intrusion (Proshansky *et al.,* ibid). A comparatively greater place-identity has been associated with a greater inclination towards sustainable behaviour. That notwithstanding, ST pathways choice is highly dependent on socio-spatial distinctiveness of a given context (Uzzel *et al.*, 2002:28). From the foregoing discussion, this study postulates that there is a direct relationship between SCT strategies socio-spatial sensitivity (as an indicator of place-identity and social-spatial distinctiveness recognition) and SCT behaviour.

The discussion below highlights PIT criticisms in context of this study. PIT does not avail much place-identity process and structure details (Twigger-Ross *et al.*, 2003:215). This was countered by adopting the function of place-identity relevant to SCT and as identified in Proshansky *et al.* (1983), change mediation – as discussed above, and consequently identification of SCT socio-spatial indicators based on the said function (see Section 2.4.3). Additionally, PIT has also been argued to lay specific emphasis on individualistic place identity (Dixon and Durrheim, 2000:29). This limited approach to place identity was countered by ensuring that indicators of socio-spatial sensitivity also considered group level indicators (see Table 2.5). Based on the foregoing discussion, this study found PIT to be an appropriate theory to anchor SCT socio-spatial sensitivity as a predictor of SCT performance.

2.6.4 Resilience Theory

Resilience theory has its origin in adversity studies and specifically the negative impact of adverse experiences on people (Van Breda, 2018). In this sense, the focus was primarily on well-being breakdown – *'pathogenic'* (Antonovsky, 1979). Earlier empirical studies, such as

Werner & Smith (1982), revealed that vulnerabilities, such as inadequate neonatal care, resulted in negative outcomes later such as mental health related outcomes. Here resilience was viewed as an outcome – positive outcome in the context of adversity (being resilient). Later it was observed that this relationship between vulnerabilities and outcomes was not universal. This ultimately led to the realization that there are mediating influences on the said relationship (such as in Kobasa (1979)). This led to a process view of resilience – reliance on mediating influences for positive outcome in the context of adversity – *'salutogenic'* (Antonovsky, ibid; Van Breda, ibid). This view is preferred for giving explanations for outcomes beyond just describing the outcome (Van Breda, ibid). As recommended by Ungar (2004) and Van Breda (ibid), and as adopted in this study, the term resilience is used for process definition and resilient for outcome definition. The above thinking is reflected in the definition of resilience by Van Breda (ibid) as: *"The multilevel processes that systems engage in to obtain better-than-expected outcomes in the face or wake of adversity"*.

While individual resilience/mediating processes are prominent, and criticized for this, contemporary resilience theory has increasingly tended towards system approach including social justice and power issues. Such individual mediating constructs identified from past studies include: hardiness; sense of coherence; self-efficacy; and, grit (Van Breda, ibid). It has been argued that: enhanced resilience leads to enhanced sustainability; and, system vulnerabilities undermining sustainability are best explored through resilience theory (Marchese *et al.*, 2018). The underlying assumptions are that resilience: suffers from power differentials influences; is affected by environmental resources availability; is function of macro-, mezzo-, exo- and micro-factors; is affected by religious affiliation, economic status, sexual orientation, age, gender, race, ethnicity, and, abilities (mental and physical); can be improved through social relationships networks; is both spiritual and biopsychosocial; involves dynamic man-environment transactional exchanges; may be interactive – having effect in combination with risk factors; may be at different levels on a continuum (opposite to risk); requires competence in operationalization; is associated with stress and coping capacity of a given populace; involves goodness of fit adaptation process; and, occurs across life course with different social units experiencing different paths of development (Greene, 2002). From the foregoing discussion, this study postulates that there is a direct relationship between resilience thinking (mediating influences) in the implementation of SCT strategies (adversity counter approaches) and SCT (outcome).

The discussion below highlights the two main resilience theory criticisms, as identified in Olsson *et al*. (2014), in context of this study. Resilience theory has been postulated as devoid of analytical power to study of transformations, such as SCT in this study. This study supports the postulation by Olsson *et al*. (ibid) that this position is as a result of theoretical misconception given that adaptability, fitting in a given regime, and transformation, geared towards regime changes, are different concepts within resilience. However, from a transformative resilience viewpoint, and foresight capacity specifically (see Section 2.4.4.3), given that foresight can inform anticipatory adaptation measures, the two are not necessarily mutually exclusive in transformations such as SCT. Lastly, neglect of power dynamics in resilience studies is the other major criticism. This was partly dealt with in this study by the acknowledgement of the assumption that resilience suffers from power differentials influences (see above). As recommended by Olsson *et al*. (ibid), the political context of resilience is partly addressed in indicator (vii) on role of decentralized SCT decision-making in SCT resilience (see Section 2.4.4.3 including Table 2.6). Based on the foregoing discussion, this study found resilience theory to be appropriate in anchoring SCT resilience as a predictor of SCT performance.

2.6.5 Multi-level Governance (MLG) Theory

The origin of MLG can be traced to seminal Marks (1993) where it was proposed for understanding European Union (EU) development and functioning. Schmitter (2004) defines MLG to be *"… an arrangement for making binding decisions that engages a multiplicity of politically independent but otherwise interdependent actors – private and public – at different levels of territorial aggregation in more-or-less continuous negotiation/deliberation/implementation, and that does not assign exclusive policy competence or assert a stable hierarchy of political authority to any of these levels"* p.49. MLG describes a multi-level (territorial/general purpose or functional/task-specific) phenomena at three analytical levels – policy-making, political mobilization, and, polity restructuring (Marks *et al.*, 1996; Hooghe and Marks, 2003:236). Consequently, MLG theory is a policy-making, political mobilization, and, polity restructuring theory. Additionally, such theorization can be on the three analytical levels simultaneously or alternatively (Piattoni, 2009:12). According to Cairney (2019), MLG describes changing relationships, tending towards power dispersion from central national governments, driven by choice and/or necessity. There are two types of MLG: Type I – characterized by general purpose jurisdictions, at limited number of levels, where membership boundaries are non-intersecting and are both systemwide and durable; and, Type II, embedded in Type I – characterized by task-specific jurisdictions, with many levels, where membership boundaries are intersecting and are flexible in design (Hooghe and Marks, ibid:236-239).

The benefit of MLG is inherent in its scale flexibility but has an attendant transaction cost associated with coordination of multiple jurisdictions to avoid socially irrational outcomes. These costs can be lowered through: reduced number of autonomous actors – inherent in Type I governance; and, limited actors interaction – inherent in Type II governance (Hooghe and Marks, ibid:239-240). Westman *et al.* (2019) postulate that MLG theory is key in explaining realization of action in multi-actor, multi-sector, and, polycentric contexts such as climate change. As steering mechanisms involving coordination of separated governance spheres in public interest issues, MLG ideas – such as partnerships and transitional networks proliferation – have been found to have positive and significant impact on climate change promotion and practice. This study thus postulates that MLG (coordinated choice and/or necessity driven power dispersion from central national governments) is significantly related to successful SCT strategies implementation (given that sustainability and construction industry are multi-actor, multi-sector, and, polycentric in nature). The underlying theoretical assumptions are: levels are legitimate; actors at a given level have agency and shared understanding of collective good within that level; and, in a given level, actors acknowledge each other as legitimate (Rennstich, 2017).

Five MLG theory criticisms, as identified in Stubbs (2005:66-67,69-73) and Saito-Jensen (2015:5), are discussed hereunder in context of this study. First is the observed tendency to evaluate MLG before fully understanding its dynamics (Stubbs, ibid). In addition to a sound theoretical basis (as discussed above), key constituents of SCT MLG were identified from the literature reviewed (see Section 2.4.5) before seeking to investigate how it is working in Kenya. Additionally, theoretical modelling has been identified to oversimplify governance (Stubbs, ibid). To address this limitation, identification of SCT MLG indicators was based on an existing SD governance framework by Gilham (2010) and enriching it in light of reviewed literature (see Section 2.4.5.4). Further, power dynamics have been downplayed in MLG (Stubbs, ibid). In this study, power and its stratification in SCT was investigated through SOAs of the involved stakeholders. Also, realist modernism not influenced by cultural turn has been observed to dominate MLG literature (Stubbs, ibid). The literature reviewed, and specifically Section 2.4.5.1, acknowledges that compliance in relation to governance is also influenced by the cultural aspects of norms, habits, informal persuasions, and, shared perspectives. Lastly, limited MLG empirical studies outside the comparatively regulated contexts such as EU has been observed (Saito-Jensen, ibid). This study sought to address this gap through empirically investigation of MLG in context of SCT in Kenya. Based on the foregoing discussion, this study found MLG theory to be appropriate in anchoring SCT MLG as a predictor of SCT performance.

2.6.6 Theoretical Framework Summary

Theoretical framework/system/paradigm is a general system: with several theories (formal and/or substantive); and, providing theoretical concepts and assumptions (According to Neuman, 2014:85). For this study, the same has been discussed at length above. Based on Sections 2.6.2-2.6.5 above, this study was anchored on: TPB; PIT; resilience theory; and, MLG theory. The inherent variables and their relationships are: SCT change readiness direct relationship with SCT intention and consequently behaviour; SCT strategies socio-spatial sensitivity direct relationship with SCT behaviour; resilience thinking direct relationship with SCT performance; and, MLG (coordinated choice and/or necessity driven power dispersion from central national governments) is significantly related to SCT, respectively. The assumptions underlying each theory and logic behind identification of the said variables was discussed at length in Sections 2.6.2-2.6.5. In a nutshell the foregoing discussion is to the effect that: context appropriateness can be engrained in technical SCT strategies implementation through enhanced change readiness, socio-spatial sensitivity, resilience thinking, and, MLG for enhanced SCT performance. The consequent hypothesis (alternative), see Section 1.6, for the study was identified to be: SCT strategies including their key implementation considerations (context appropriateness considerations) are significantly related with construction industry SCT performance.

From the foregoing, it is clear that SCT phenomena can be explained from the points of view of: technical SCT strategies; and, their context appropriateness/context appropriateness considerations (in terms change readiness, socio-spatial sensitivity, resilience thinking, and, MLG). ST/sustainability transformation, generically, has been identified to be both radical and socio-technical in nature (Elzen *et al.*, 2004; Grin *et al.*, 2010; Blythe *et al.*, 2018). According to Kemp and Lente (2011), ST facilitate change in entrenched socio-technical systems towards comparatively sustainable modes of production and consumption. This consequently points towards SCT phenomena, as construction industry specific ST, assuming the same properties. This ultimately implies that SCT phenomena, and as held in this study, is primarily anchored in socio-technical systems (STS) theory. Walker *et al.* (2008:480) identified principles which are the basis of STS theory to be: system performance is hinged on interactions (linear and non-linear) of social and technical components of the system in context; and, need for joint optimization of the two components for enhanced systems performance. Optimization of any one component, sub-optimization, has a tendency to increase non-linear and unpredictable relationships and also relationships injurious to systems performance. Consequently, for optimal and enhanced SCT performance, this study emphasizes on the joint optimization of technical strategies and context-appropriateness considerations (largely social in nature).

2.7 Conceptual Framework – From Literature and Theoretical Underpinnings

The sustainability priorities of the Networked Knowledge Age (from the late 20th Century onwards) have been identified as uncontrolled: population growth; pollution; depletion of natural resources; widening wealth-gap; industrialization impacts; and, consumerism. The construction industry globally is not excluded and shares in these sustainability challenges. This is more apparent when other key features of the industry such as long lifetime of construction activities, linkages with other industries, and, significant consumption of global natural resources are put in perspective. From the literature review conducted, it emerges that the construction industry globally is yet to fully shift to sustainable construction practices and lags behind other industries. This implies the current hegemony of conventional unsustainable construction practices over their comparatively sustainable alternatives. Within the well documented negative sustainability impacts of the construction industry, economically, environmentally, and, socially, lies the implied need to shift towards comparatively sustainable construction practices – SCT. This is meant to ensure the industry: curbs the current unsustainable construction practices and consequently their associated negative impacts; reaps the benefits of sustainability such as rationalized lifecycle costs of constructed facilities; and, most importantly, contributes to the quest for human life sustenance on earth across spatial and temporal scales. It is in this realization that deliberate effort is required to ensure the shift towards comparative sustainable construction practices (consumption and production), that is, SCT – see Sections 1.2 and 1.3.

This study identified SCT strategies as one of the key elements for the deliberate effort towards SCT. Specifically, strategies to effect SCT are to be based on the objectives of the three pillars of sustainability: economic; environmental; and, social. These project lifecycle objectives were identified as: increased profitability through efficient use of resources; preventing harmful and potentially irreversible effects on the environment; and, compliance with moral and legal obligations to its stakeholders respectively. Consequently, economic SCT strategies were identified as: enhanced labour productivity; development cost efficiency; operational cost rationalization; rationalization of demolition and materials recovery cost; and, property value enhancement. The environmental SCT strategies were identified as materials, water, energy, and, land conservation. Lastly, social SCT strategies were identified to be: ensuring human well-being; ensuring resilience of built facilities against disasters such as earthquakes; and, ensuring functionality such as through enhanced ease of maintenance. Additionally, specific methods that support the implementation of these strategies were identified (see Section 2.3.2). It is recommended that these strategy supporting methods are implemented in a multi-level approach: strategic – long term and at industry level; tactical – medium term and at firm level; and, operational – short term and construction project level. Additionally, SCT strategies can be: experts and leaders driven – top-down down; stakeholder collaboration driven – bottom-up; and/or, a combination of both – see Sections 2.2 and 2.3.

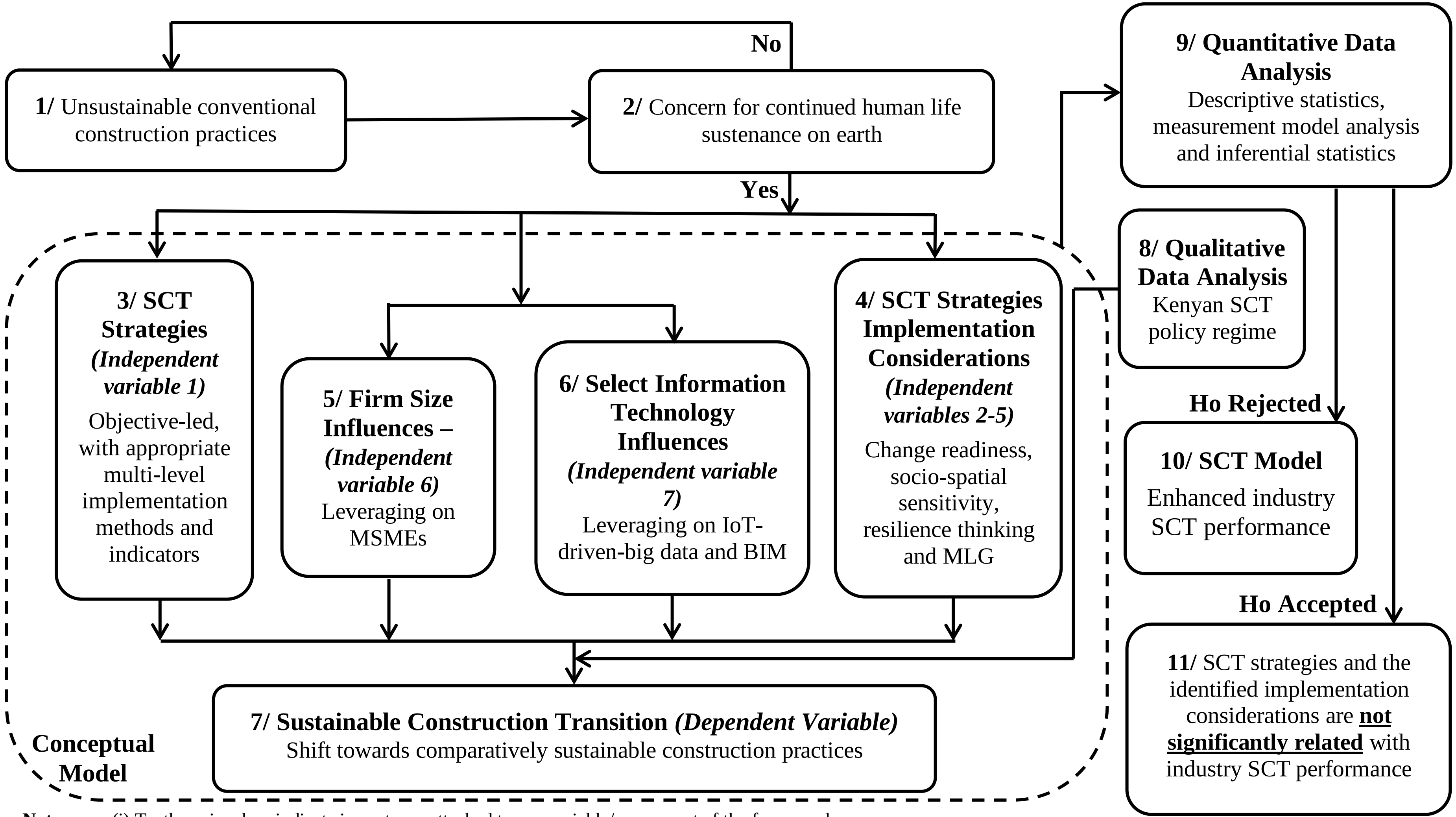
In addition to the SCT strategies, their implementation (context appropriateness) considerations were identified. One was that for successful SCT strategy implementation, it is necessary to ensure that the stakeholders are ready for the SCT change – SCT change readiness. This was identified to be at three levels: individual – some of driving factors include appropriate change communication and stakeholder participation; project team – some of driving factors include appropriate project team level vision and change climate; and, organization – some of driving factors include supportive management and culture. Secondly, it was found that socio-spatial sensitivity is also necessary if SCT strategies are to be effective on socio-spatially specific sustainability challenges. It emerged that this can be attained through: adaptation of generic SC approaches for local appropriateness; spatial multi-scalar differentiation and integration of the strategies; designing spaces and places for sustainability; incorporation of local/decentralized decision making; assisting populace negatively affected by SCT and impacts of unsustainable construction practices; engagement of local institutions; creation of SC value locally; flexible and accountable SCT goal setting; and, consideration of the emotional aspects of SCT change in terms of the populace perceptions as to its desirability – see Sections 2.4.1-2.4.3.

Thirdly, resilience was also been identified as a key consideration in the implementation of SCT strategies. This study argues that enhanced resilience has the potential to boost SCT hence an important consideration in SCT strategies implementation. This is along the fronts of assessing: availability of spare/reserve resources (human and non-human) for SC; SC supply chain decentralization; SC processes and products diversity; SCT scales (industry long-term, organizational medium-term, and, project-level short-term) relationship awareness; SC indicators monitoring for timely and appropriate planning and action; stakeholders networking for bottom-up SCT; decentralized SCT decision-making; stakeholders' ability to proactively adapt or reduce vulnerabilities associated with possible futures SCT scenarios; and, creation of new SC options and ideas through innovation and experimentation. The fourth SCT strategy implementation consideration was identified as appropriate multi-level governance. This was based on the identified centrality of MLG in realization of action in multi-actor, multi-sector, and, polycentric contexts such as SCT. Indicators of supportive governance were identified to be: decentralized SC steering; government (national and counties) driven SC uptake/compliance; private sector actors, such as independent consultants, driven SC uptake/compliance; civil society actors, such as NGOs, driven SC uptake/compliance; media driven SC uptake/compliance; clarity and awareness of SCT objectives; SCT enabling context; and, stakeholders' capacity to achieve SCT objectives – see Sections 2.4.1, 2.4.4-2.4.5.

With the construction industry globally being MSMEs driven, MSMEs can be leveraged to enhance implementation of SCT strategies. This is in addition to their well-known ability to quickly respond to change compared to large enterprises. Their active engagement in the SCT agenda was identified to be a factor of: active participation in SCT policy development and implementation; voluntary SC adoption; supply chain pressure driven SC adoption; SC supportive legislative system; availability of SCT related market changes information; engaging them through – on-site visits, face-to-face engagements, networking, guidance helplines, and, value-based relationships in addition to conventional approaches such as seminars, internet, and, newsletters; countering barriers to SCT adoption; and, convincing them on SC value/benefits. With the Networked Knowledge Age being characterized by information technology, sustainability and SCT are not left behind. This study identified IoT-driven-big data to have the potential to enhance SCT strategies implementation. It can be leveraged as follows: using smart wearables, appliances, and, building management systems; using of real time applications in aligning resources usage with resources, markets, and, behaviour; supporting tech-based prods towards SC behaviour; and, supporting tech-based collaborative consumption/use of constructed facilities – see Sections 2.4.1, 2.5.1-2.5.2.

BIM has also been identified to have potential to enhance SCT strategies implementation. It can be leveraged by using it to facilitate: environmental conscious decision making over the lifecycle of constructed facilities; overall economic viability of constructed facilities; overall well-being of constructed facilities users and the general society; and, onboarding and validating sustainability considerations during design – see Sections 2.4.1 and 2.5.3. The above discussion, including the theoretical underpinnings, leads to the conceptual framework adopted for this study as illustrated in Figure 2.13 next page.

Figure 2.13: Conceptual Framework



Notes: (i) Textbox size does indicate importance attached to any variable/component of the framework
(ii) SCT strategies can be implemented directly but the identified considerations and influences can enhance implementation ease

Source: Author (2023)

2.8 Chapter Summary

This chapter focused on: review of past literature on SCT, SCT strategies, and, their implementation considerations – part of research objectives one and two; and, discussing the theoretical underpinnings for the study. In order to establish context, this chapter also looked into the concepts of sustainability, SD, sustainability transitions, and, their convergence in SCT. Additionally, the chapter also set-out to develop a conceptual model relating SCT, SCT strategies, and, their implementation considerations. SCT strategies were identified, and in line with the objectives of, the three pillars of sustainability: economic – such as resource efficiency; environmental – such as energy conservation; and, social – such as enhancing wellbeing. Additionally, specific methods that support the attainment of the SCT strategies were identified including their three implementation levels – strategic, tactical, and, operation. Additionally, it emerged that SCT change readiness, spatial sensitivity, resilience thinking, and, appropriate multi-level governance are central to enhanced implementation of SCT strategies. Lastly, leveraging on MSMEs, given their industry dominance and known ability to respond to change, and, leveraging IoT-driven-big data and BIM were found as additional factors that could ease implementation of SCT strategies. The resulting conceptual model identified industry SCT performance as the dependent variable and change readiness, spatial sensitivity, resilience, appropriate multi-level governance, and, leveraging MSMEs and select information technologies influences of IoT-driven-big data and BIM as the independent variables. The next chapter, Chapter three, discussed the research methodology adopted exploring research questions one to four.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the general research approach adopted to explore the research problem: lagging of the Kenyan construction industry in transitioning to SC, that is, SCT. This was meant to ensure that the study employed sound scientific research methodology. This was specifically on the approach adopted to: answer the pre-identified research questions (see Section 1.5); and, test the pre-set research hypotheses (see Section 1.6) – to test the nature of relationships between independent and dependent variables (as identified in Chapter two). It was ultimately aimed at identification of specific procedures adopted and the underlying reasons and logic including the associated methods/tools. It is specifically structured in nine main sections on adopted: research philosophy; research reasoning and data; research design and strategies; target population, sampling units, and, sampling frame; sampling approach; data sources, collection methods, research instruments, and, research tools; approaches adopted to ensure research instruments reliability and validity; data analysis (descriptive statistics, validity, reliability, and, inferential statistics analysis) and presentation approaches; and lastly, ethical considerations. They are discussed in detail in the next sections.

3.2 Research Philosophy

Research philosophy is a *"… system of the researcher's thought, following which new, reliable knowledge about the research object is obtained"* (Žukauska *et al.*, 2018:121). Žukauska *et al.* (ibid:121) highlight the role of research philosophy as being *"… the basis of the research, which involves the choice of research strategy, formulation of the problem, data collection, processing, and analysis"*. Khatri (2020:1435) refers to the philosophical basis of research work as research paradigm. Easterby-Smith *et al.* (2008) as cited in Žukauska *et al.* (2018:121,124) identify the components of research paradigm to be: ontology – nature of reality; epistemology – ascertaining existence of assumed reality (also see Sutrisna, 2009; Saunders *et al.*, 2009:110, 112); and, methodology – techniques used by a researcher in exploring reality. Saunders *et al.* (ibid:119) adds axiology, the researcher's perspective on the role of values in research conduct, to this list. Table 3.1 next page summarizes the four main research paradigms: positivism; realism; interpretivism; and, pragmatism – as identified by Saunders *et al.* (2009).

Table 3.1: Research Paradigms

	Positivism	**Realism**	**Interpretivism**	**Pragmatism**
Ontology – *nature of reality*	Reality is objective, external, and, independent of social actors	Reality is objective, independent of human mind *(realist)*, but is interpreted through social conditioning *(critical realist)*	Reality is socially constructed, subjective, may change, and, multiple	Reality is external, and, multiple. View chosen to best enable answering of research question(s)
Epistemology – *make up of acceptable knowledge*	Credible data can only be provided by observable phenomena	Observable phenomena provide credible data and facts *(realism).* Alternatively, phenomena create sensations which are open to misinterpretation *(critical realism)*	Subjective meanings and social phenomena	Either/both observable phenomena and subjective meanings can provide acceptable knowledge depending on research question(s)
Axiology – *role of values*	Research is undertaken in a value-free way; the researcher is independent of the data; and, maintains an objective stance	Research is value laden; researcher is biased by world views, cultural experiences, and, upbringing; and, these will impact the research	Research is value bound; the researcher is part of what is being researched; cannot be separated; and, so will be subjective	Findings interpretation factors in values and researcher may adopt both subjective and objective viewpoints
Techniques – *typically employed in data collection*	Highly structured, large samples, measurement/ quantitative, but can use qualitative	Method chosen should fit the subject matter/quantitative or qualitative	Small samples, in-depth investigations, and, qualitative	Mixed or multiple method designs/ quantitative and qualitative

Source: Adapted from Saunders *et al.* (2009:119)

While several research paradigms are possible, and to avoid delimitations imposed by extreme paradigms, an intermediary paradigm allows reconciliation of problem, philosophy, and, methodology by the researcher (Žukauska *et al.*, 2018:121). In line with this postulation, and from the foregoing discussion, this study adopted pragmatism research paradigm. This was largely premised on the need to allow the research questions dictate the applicable ontology, epistemology, axiology, and, methodology as opposed to fitting the study into a predetermined research paradigm. A similar paradigm was adopted in the doctoral study Chang (2016:90) on a transition approach to sustainability in the Chinese construction industry. As such, the specifics of the research paradigm adopted, pragmatism, are as summed up below.

The research questions in context are: what is the extent of SCT performance in the Kenyan construction industry; what are the prevalent SCT strategies including the ranking of their implementation considerations in the Kenyan construction industry; what is the nature of the Kenyan SCT policy regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings; and, how can influences of SCT strategies including their implementation considerations on SCT performance be modelled to enhance SCT performance? Ontologically, the status of Kenyan construction industry in relation to the conceptual model is an objective reality, and, it is expressed by key industry stakeholders subjectively. Additionally, status of the Kenyan SCT policy regime is independent of human mind but is interpreted through social constructions. Epistemologically, and based on the ontological stances adopted, both field observations (by providing credible data and facts) and subjective means will provide acceptable knowledge to answer the research questions. On the axiological front, the research is value bound. Specifically, the research topic is of significance to society (see Section 1.8) and the recommended best practice in ethical conduct of research was adopted (see Section 3.10). Lastly and consequently, methodologically, the study adopted a mixed-methods approach to research design. As such the study had quantitative and qualitative components as discussed in detail in Section 3.3.

3.3 Research Reasoning and Data

Research reasoning is defined as the *"logic of the research, the role of existing body of knowledge gathered in the literature study, the way researchers utilize the data collection and subsequent data analysis"* (Sutrisna, 2009). There are two main types of research reasoning: deductive; and, inductive. In deductive reasoning, literature review is undertaken, it informs identification of research problem and consequently the research questions and hypotheses.

Research questions are answered and hypotheses tested through analysis of collected data. The other type of reasoning is identified as inductive reasoning. This approach is comparatively less structured, there are no presuppositions and is aimed at gaining deep understanding about a phenomenon (Sutrisna, ibid). This study adopted a combination of both types: deductive reasoning to frame the entire study; deductive for research questions one, two, and, four; and, inductive reasoning for research question three. It should be noted that the study largely adopted deductive reasoning approach. Regarding research data, Sutrisna (ibid) postulates that where a quantitative and qualitative research approaches are adopted (as is established from the research paradigm adopted – see Section 3.2 above), it then follows that the data collected was a combination of quantitative and qualitative data.

3.4 Research Design Overview and Research Strategies

Research design refers to the procedure adopted, by a researcher, in answering research question(s) in a manner that is valid, objective, accurate, and, economic. Additionally, it is important to give reasons and logic/rationale and defend/justify the various steps in the adopted procedure with support from reviewed literature. It identifies: study design approach; study population; means of identifying the population; sample selection; sample selection approach(es); consent seeking from sampling units; data collection approach; and, how ethical considerations will be addressed (Kumar, 2011). This section, Section 3.4, specifically looked at the research design approach and the next sections all other aspects of research design as adopted in this study including outlining the associated rationale and justification. This study had a cross-sectional design as it sought to establish the status of SCT performance in the Kenyan construction industry and the contribution of the identified SCT strategies and their implementation considerations at one moment in time. Additionally, the general nature of this study was descriptive. As explained by Kothari (2004:2,3), descriptive research aims at explaining the past and/or current status of a phenomena where the researcher has no control over the variables involved. The researcher *"... can only report what has happened or what is happening"*. This study sought to establish some past and present aspects of the independent and dependent variables with the aim of informing future policies and practice towards improved SCT in the Kenyan construction industry. Consequently, the approach adopted by this study is descriptive cross-sectional research design.

A number of research strategies are available for executing the various research designs. One of them is experimentation – manipulation of independent variable(s) through interventions to test effect, if any, on the dependent variable in controlled conditions. This strategy is typically used in explanatory and exploratory research. Surveys are another strategy for collecting quantitative data and/or data on reasons behind phenomena. They typically use questionnaires, structured observations, and, structured interviews and are used in descriptive and exploratory research. The other option is case studies which involve investigation of phenomena in their real-life contexts. They employ use of observation, interviews, questionnaires, and, documents analysis and are typically used in exploratory and explanatory research. Action research is another alternative which is iterative and purpose-based and typically involves stakeholders and has implications beyond current research. It is largely premised on the combination of data collection and change facilitation. Grounded theory on the other hand involves theory building using deductive and inductive reasoning. This is usually through the process of testing propositions based on collected data (Saunders *et al.*, 2009:141-150).

Another option is ethnography where a phenomenon is investigated in its natural context in which the researcher must immerse themselves in. It is typically adopted where understanding and interpretation of phenomena is from the perspective of the involved subjects. Lastly, archival research can be employed through use of existing documentation, of reality being investigated as opposed to research documentation, as the primary data source. It is typically used in descriptive, exploratory, and, explanatory research (Saunders *et al.*, ibid:141-150). The adopted descriptive cross-sectional design, research questions, and, the foregoing discussion was the basis of selecting the research strategies employed as highlighted next. For research questions one, two, and, four, surveys: to obtain information on industry SCT performance, the contribution of the various SCT strategies (including their implementation considerations and their rankings) through structured questionnaires; and, semi-structured interviews to get in-depth information regarding the study variables from key informants – practice data component of the study. Lastly, for research question three, archival research and specifically analysis of SCT related policy and legislative documentation to identify priorities, instruments, stakeholder orientation, and, (any) inherent shortcomings – policy data component of the study.

3.5 Target Population, Its Components, and, Their Sources

According to Kumar (2011), the target population of a study, also referred to as the universe (see Kothari, 2004:153; King'oriah, 2004:22), refers to the group of people from whom information necessary to answer the pre-set research questions is acquired. King'oriah (2004:22-23) defines a population as: *"… large group of people, animals or objects; each with* *individual characteristics, out of which a statistician wishes to make specific inferences after exhaustive quantification and analysis of such individual characteristics"*. This study had its research questions centred around the perspectives of key construction project stakeholders. Specifically, the target population of the study was identified as practitioners and SCT related key informants in the Kenyan construction industry. The number of these stakeholders could be determined, such as from the various professional associations and employment records. This population thus emerged to be what Kothari (2004) refers to as a finite population. The construction industry main business revolves around delivery of construction projects which can be architectural, interior design, and/or, infrastructural, such as dams, roads, rails, and, airports. These projects can be split into four main phases: design; construction; operation and maintenance; and, decommissioning. According to Kothari (2004:153), sampling units are the basic units, of a target population, from which characteristics at the centre of a given research are observed/obtained.

Based on the typical construction project phases and related SCT governance system, the study population was identified as follows: key design phase stakeholders (practitioners and governance institutions stakeholders) in the Kenyan construction industry. The specific population components/sampling units, for the questionnaires (see Section 3.4), were further defined to include design stage practitioners: architects; interior designers; construction managers/project managers; mechanical engineers; electrical engineers; civil and structural engineers; and, quantity surveyors; and, for the semi-structured interviews (see Section 3.4), SCT related key informants drawn from governance institutions and administrators of industry professionals: NCA; NEMA; KGBS; AAK; KPDA; IDAK; IQSK; ACMK; and, IEK. This specific definition of the study population and its components is due to the acknowledgement that these said stakeholders are central in the construction project lifecycle. It should be noted that construction, operation, and decommissioning phase stakeholders were excluded due to: study time limits; and, the understanding that design phase practitioners and governance institutions stakeholders have a lot of influence on the three excluded phases. As such, if the construction industry is to change from conventional and largely unsustainable practices to SC alternatives, the design phase stakeholders are the ones to drive the change. This is by virtue of having significant impact – in terms of building features and functioning, materials, finishes, construction methods, fittings, appliances, and, building systems specifications – on the lifecycle of constructed facilities.

Lastly, the list from which the study sample was drawn from, source list/sample list (see Kothari, 2004:56), was delimited to: the said stakeholders with locality of practice as Nairobi City County; Kenyan construction industry (interior design, architectural, and, infrastructural market segments); registered by relevant professional body; and/or, professionals in SCT related policy and/or practice enforcement/regulation capacities.

3.6 Sampling Approach

3.6.1 Overview

Sampling, in quantitative research, is the process where part of a larger group is identified for purposes of data collection and analysis where the resulting findings can be generalized for the entire population in context. In this case, focus is always on ensuring the part (sample) is not biased and is representative of the larger group (population). Additionally, in this type of research, a bigger sample is preferred on the premise that it incorporates diverse sampling units and as such tends towards being largely representative of the population. On the other hand, in qualitative research, sampling is used to gain in-depth knowledge about the study variables from individuals with the assumption that the individuals involved are typical to the group from which they are drawn and as such will provide understanding of their group. Here, sample selection is informed by numerous factors such as respondents' accessibility, researchers' perception on how knowledgeable the respondents are on the subject in context, and, extent of individual case similarity to the rest of the group. In qualitative research no emphasis is placed on sample size given the intention is to establish extent of diversity and not the magnitude. In such an approach, data is collected to a point where no new/significant information is being unearthed (Kumar, 2011).

In sampling, there are two main activities: sample size determination; and, identification of sampling units from the sampling frame (Saunders *et al.*, 2009:222). Israel (2012:2) identified four sample sizing approaches: census – for small populations, below 30 sampling units as identified in Saunders *et al.* (2009:218), the entire population should be sampled; replication – using a size that has been previously used in a similar study; published tables – using published sample sizing tables; and, formula approach – using sample sizing formulae. After sample size determination, there are two main techniques of selecting sampling units from sampling frame (sampling): probability sampling; and, non-probability sampling. In probability sampling the sampling units are randomly selected from the study population. The sampling techniques under this category are: random/simple random sampling – each sampling unit has an equal chance of being selected from sampling frame; systematic sampling – sampling units are selected at intervals from sampling frame from a random start point; stratified random sampling – sampling framing is divided in relevant and significant categories/strata from which sampling units are selected randomly or systematically; cluster sampling – sampling frame is divided in discrete groups/clusters from which sampling units are selected randomly or systematically; and, multi-stage/multi-stage cluster sampling – this is an advanced version of cluster sampling where the research is carried out in different stages and in each stage cluster sampling approach is adopted (Saunders *et al.*, ibid:213, 222-231).

On the other hand, in non-probability sampling the sampling units are not randomly selected from the study population. The sampling techniques under this category are: quota sampling – this is the non-probability version of stratified sampling with quota targets to ensure they are representative of the population; purposive/judgemental sampling – involves use of personal judgement to select sampling units which are best for given research context; snowball sampling – involves having the initially contacted sampling units help identify more sampling units; self-selection sampling – involves having each sampling unit, typically individuals, identify willingness to participate; and, convenience/haphazard sampling – involves selecting of sampling units that are easiest to obtain (Saunders *et al.*, ibid:213, 233-241). From the foregoing discussion there are numerous sampling approaches available hence the need to select the ones best suited for this study. The specific sampling approaches adopted for the quantitative and qualitative components of this study are discussed in Sections 3.6.2 and 3.6.3.

3.6.2 Adopted Quantitative Research Sampling Approach

This component of the study was primarily based on survey research strategy and specifically the use of structured questionnaires (see Section 3.4). On sample sizing, the study adopted the formula approach for sample size calculation/determination. This was informed by the need for objectivity in sample sizing. This involves: specifying data confidence levels; tolerable error margins; applicable population size; and, degree of variability in variables being measured in the population as recommended by Saunders *et al.* (2009:213, 218) and Israel (2012:1-2). The specific formula approach adopted was as postulated by Czaja and Blair (1996) as adopted in (the doctoral studies) Ankrah (2007:141-142) and Oyewobi (2014:112-113):

Step one: Sample size computation

$$ss = \frac{z^2 \times p\,(1-p)}{c^2} = \frac{1.96^2 \times 0.5\,(1-0.5)}{0.1^2} = 96.04$$

Where:

ss = Sample size

z = Standardized variable – The study assumed a 95% confidence level (0.05 significance level), as adopted in Ankrah (2007:141), resulting in z = 1.96

p = Probability of picking a choice (in decimal) – Taken as 0.5 as recommended by Czaja and Blair (1996)

c = Confidence interval (in decimal) – Taken as 0.1 as adopted in Ankrah (2007:141-142)

Step two: Correction for finite population

$$\text{Corrected ss} = \frac{ss}{1 + \frac{ss - 1}{\text{population size}}} = \frac{96.04}{1 + \frac{96.04 - 1}{3810}} = 93.70$$

Where:

ss = Sample size as computed in step 1 above = 96.04

Population size: As per Table 3.2 below = 3810 stakeholders

Table 3.2: Population Size

Sampling Units Category	Number	Source as of 7th May 2022
1. Architects	932	Board of Registration of Architects and Quality Surveyors (BORAQS) website – https://boraqs.or.ke/registered/architects
2. Interior designers	110	IDAK records (from secretary general)
3. Construction project managers	211	ACMK records (from assistant registrar)

Sampling Units Category	Number	Source as of 7th May 2022
4. Mechanical engineers	298	Engineers Board of Kenya (EBK) website: Consulting engineers – https://ebk.go.ke/consulting-engineers/?tk=1654080958 Professional engineers – https://ebk.go.ke/professional-engineers/?tk=1654081023
5. Electrical engineers	404	
6. Civil engineers	1266	
7. Quantity surveyors	589	BORAQS website – https://boraqs.or.ke/registered/qs
Population Size	**3810***	

* *The raw sampling units' numbers, per category, obtained from the indicated sources were further processed (to ensure alignment with the pre-set sampling frame as identified in Section 3.5) to arrive at the numbers indicated above.*

Source: Author (2023)

Step three: Correction for non-response

Several recommendations exist on correcting computed sample sizes for non-response. These include: 20-30% response rate for postal surveys in the construction industry (Akintoye, 2000:79); general 30% addition to computed sample size (Israel, 2012:5); 30% response rate for delivered and collected questionnaires; 50-70% response rate for telephone and structured interview administered questionnaires; 30% or less response rate for internet and intranet administered questionnaires (Saunders *et al.*, 2009:364). Given that the questionnaires in this study were administered over the internet and some delivered and collected, a 30% response rate was assumed based on the foregoing discussion. A similar response rate was as adopted by Oyewobi (2014:113) in a doctoral study on strategic management in construction. The corrected sample size computed in step two above, was further corrected for non-response as follows:

Corrected ss adjusted for non-response = Corrected ss (as computed in step two above) /response rate = 93.70/0.30 = 312 respondents

Lastly, the study further adopted stratified sampling technique to identify specific sampling units for the study from the sampling frame. This was informed by the fact that the population has several strata with different sizes hence the need to ascertain that the sizing ensures they are representative of their respective categories. Seven categories were identified as: architects; interior designers; construction managers/project managers; mechanical engineers; electrical engineers; civil and structural engineers; quantity surveyors (see Section 3.5). Tabulated below, in Table 3.3, is the breakdown of the sample size per category of respondents:

Table 3.3: Key Industry Stakeholders Sample Size

Sampling Units Category	**Number**
1. Architects	76
2. Interior designers	9
3. Construction managers/project managers	17
4. Mechanical engineers	25
5. Electrical engineers	33
6. Civil (and structural) engineers	104
7. Quantity surveyors	48
Sample Size Total	**312**

Source: Author (2023)

3.6.3 Adopted Qualitative Research Sampling Approach

This component of the study was based on: survey research strategy and specifically the use of semi-structured interviews to get the input of key informants regarding the study variables; and, archival research strategy and specifically analysis of SCT related policy and legislative documentation (see Section 3.4). Regarding data collection from key informants through structured interviews, there was no pre-set sample size. This was because in qualitative research no emphasis is placed on sample size (Kumar, 2011 – see Section 3.6.1). On the sampling unit's identification front, the study employed purposive sampling technique. The identified governance institutions and professional associations were contacted and identified their most appropriate key informant on the study subject. A similar approach was applied in Dania (2016:114). The key informants were purposefully drawn from identified SCT related governance institutions and administrators of industry professional associations. Specifically: NCA; NEMA; KGBS; AAK; KPDA; IDAK; IQSK; ACMK; and, IEK (see Section 3.5). Regarding the archival research strategy also adopted in this qualitative component, the sample was similarly not sized for the same reasons. On the sampling front, the study also adopted purposive sampling technique. Kenyan policy and legislative documentation with SCT/SC specific provisions was identified for analysis.

3.7 Data and Data Collection

3.7.1 Overview

This study obtained information to frame the study and answer the research questions by collecting data of both primary and secondary nature. This was as informed by the adopted research paradigm and consequently the supporting reasoning as discussed in Section 3.3. The primary data, first-hand information, sought by the study was obtained through: self-administered questionnaires – each sampling unit responding to same questions set in a pre-set order; and, semi-structured interviews – purposeful discussion based on list of questions and themes and can vary for the various interviews (see Saunders *et al.*, 2009:318,320,360,363). This was informed by the adopted research design and consequently the supporting research strategies of survey and interview – see Section 3.4. Both the questionnaires and interviews were designed in a manner that covered the various variables that were the subject of this study as identified in the conceptual framework – see Section 2.7. For secondary data, the study acquired information from: peer-reviewed journal articles; tertiary level textbooks; past research projects (dissertations and theses); government publications; conference proceedings; institutional publications; and, relevant websites. The choice of this approach was based on deductive reasoning employed to anchor the: the research problem; research questions; hypotheses; conceptual framework; research methodology; and, interpretation of resulting findings after data analysis – see Section 3.3. Additionally, secondary data supported research strategy of archival research employed for research question number 3 – see Section 3.4.

3.7.2 Preparation for Data Collection

3.7.2.1 Variables operationalization

The researcher started the preparation for data collection by developing questionnaires and interview schedules (see appendices five and seven). Both instruments were developed to assess: SCT performance of the Kenyan construction industry – dependent variable; status and contribution of identified SCT strategies to current SCT performance including their ranking – independent variable one; status and contribution of SCT strategies implementation considerations to SCT performance including their ranking – independent variables two to five; and, contribution of MSMEs and select information technologies of IoT-driven big data and BIM to SCT performance – independent variables six and seven. The definitions and summary of the variables, their indicators and measurement approaches are summarized in Table 3.4 on the next page.

After operationalizing the variables, the actual questionnaire and interview schedule were structured in ten parts. Part one was on SCT definition for common understanding of the term SCT by the respondents. Part two was on respondents' general information. The five questions in this part covered: professional category – for response rate computation; duration of practice – to assess familiarity with industry operations; industry market segment – to assess population representation in terms of industry market segmentation; project types – to assess whether they are mainly involved in new, refurbishment, and/or, redevelopment works; and, availability of a sustainability policy – to assess organizational/practice commitment to sustainability. Parts three to ten covered the eight study variables individually and in the following order: SCT performance (dependent variable); SCT strategies (independent variable one); SCT change readiness (independent variable two); SCT socio-spatial sensitivity (independent variable three); SCT resilience (independent variable four); SCT multi-level governance (independent variable five); leveraging MSMEs in SCT (independent variable six); and, leveraging IoT-driven big data and BIM in SCT (independent variable seven).

Table 3.4: Variables Operationalization

Variable	Definition/Explanation/Parameters	Indicators	Measurement Approaches
1. Industry SCT Performance *(dependent variable) – Section 3 of the questionnaire/interview schedule*	Enhanced industry transition towards sustainability in terms of: positive perception of SC compliant processes and products; leveraging technology to overcome limits to exploitation of natural resources; SC demand and supply; profitability due to efficiency in resource usage; water, land, energy, and, materials conservation; and, legal and moral obligations compliance (Author, 2023)	Stakeholders' perception of SC process and products; use of technology to overcome limits in exploitation of natural resources in construction; SC demand and supply performance; SC economic performance; SC environmental performance; and, SC social performance *(see Sections 2.2.5.1, 2.2.5.2 and 2.3.2*)	5-point Likert Scale, *1–very small, 2–small, 3–average, 4–large, and, 5–very large,* questions on the extent statements in support of enhanced industry SCT performance are true – *Questionnaire to stakeholders* Open ended question on industry SCT performance – *Key informants interview schedule*
2. SCT strategies *(independent variable 1) – Section 4 of the questionnaire/interview schedule*	Co-ordinated and continuously improving action plan integrating sustainable construction objectives across temporal scales through mutually supportive approaches and based on needs, priorities, and, resources of given nation in context (Adapted from OECD, 2001a:25)	Economic SCT strategies; environmental SCT strategies; and; social SCT strategies *(see Sections 2.3.2-2.3.5 – Includes supporting methods and levels of implementation*)	5-point Likert Scale, *1–very small, 2–small, 3–average, 4–large, and, 5–very large,* questions on extent of adoption in practice – *Questionnaire to stakeholders* Open ended question on SCT strategies employed – *Key informants interview schedule*

Variable	Definition/Explanation/Parameters	Indicators	Measurement Approaches
3. SCT strategies implementation considerations *(independent variables 2-5) – Sections 5-8 of the questionnaire/interview schedule*	SCT Change readiness: measure of – how willing/committed and prepared including capacity build-up, the construction industry is towards SCT change (Adapted from Holt and Vardaman, 2013) SCT spatial sensitivity: measure of appropriateness of SCT strategies to locale specific combination of economic, environment, social-cultural, and community aspects (Adapted from Marsden, 2012:214; Horlings, 2016:32) Resilience thinking in SCT: capacity of construction industry system to maintain its core functionality, with integrity, in context of sustainability transition (Adapted from Walker *et al.*, 2004; Walker *et al.*, 2006; Zolli and Healy, 2012:7) Appropriate SCT governance: coordinated choice and/or necessity driven system rules and mechanisms decentralization to facilitate sustainable construction transition in a given social set-up (Adapted from Rosanau, 2000:225; Cairney, 2019)	SCT change readiness – *see Table 2.4* SCT spatial sensitivity – *see Table 2.5* SCT Resilience thinking – *see Table 2.6* SCT governance – *see Table 2.7* *(see Sections 2.4.1-2.4.5*)	5-point Likert Scale, *1–very small, 2–small, 3–average, 4–large, and, 5–very large,* questions on extent to which the identified considerations have been leveraged for SCT – *Questionnaire to stakeholders* Open ended questions on evaluation of leveraging identified SCT implementation considerations – *Key informants interview schedule*

Variable	Definition/Explanation/Parameters	Indicators	Measurement Approaches
4. Contribution of MSMEs and select information technologies (IoT-driven-big data and BIM) to industry SCT performance *(independent variables 6-7) – Sections 9-10 of the questionnaire/interview schedule*	MSMEs role: extent to which MSMEs have been leveraged to drive the SCT agenda (Author, 2023) IoT-driven-big data role: extent to which IoT-driven-big data has been leveraged to drive the SCT agenda (Author, 2023) BIM role: extent to which BIM has been leveraged to drive the SCT agenda (Author, 2023)	Leveraging MSMEs for SCT – *see Table 2.8* Leveraging IoT-driven-big data for SCT – *see Table 2.9* Leveraging BIM for SCT – *see Table 2.10* *(see Sections 2.5.1-2.5.3*)	5-point Likert Scale, *1–very small, 2–small, 3–average, 4–large, and, 5–very large*, questions on extent to which the identified firm size and technological influences have been leveraged for SCT – *Questionnaire to stakeholders* Open ended questions on evaluation of leveraging identified SCT implementation influences – *Key informants interview schedule*

Source: Author (2023)

3.7.2.2 Research authorization and piloting

The second stage involved: obtaining introduction letter from the Department of Real Estate, Construction Management, and Quantity Surveying (RECMQS); and, research license from National Commission for Science, Technology, and, Innovation (NACOSTI). NACOSTI is required to approve all scientific research in Kenya – function six (NACOSTI, 2022). Thirdly, the researcher recruited research assistants and trained them to assist in questionnaire administration and conduct of interviews including the importance of the study and scheduled, using Microsoft Project 2019, the various data collection activities for tracking purposes. Specifically, the four research assistants recruited were trained for a period of five days which included mock research instruments administration exercise.

Lastly, the draft questionnaires and interview schedules were piloted. A pilot study is a *"small-scale study to test a questionnaire, interview checklist or observation schedule, to minimise the likelihood of respondents having problems in answering the questions and of data recording problems as well as to allow some assessment of the questions' validity and the reliability of the data that will be collected"* p.597 (Saunders *et al*., 2009). Such a simulation of survey instrument usage helps monitor: respondents ease to complete questionnaires; ease of instrument administration and scoring; and, instrument administration logistics. The outcome of the pilot study informs enhancement of the survey instrument and instrument administration logistics planning (Fink, 2003:108-112). Saunders *et al*. (ibid:394) emphasizes on the need to pilot research instruments before administration. This study adopted a pilot study sample size of 11 respondents which is above the minimum of ten as recommended by Fink (ibid:108). It was composed of: for questionnaires (see Section 3.6.2) – two architects, one interior designer, one construction manager/project manager, one mechanical engineer, one electrical engineer, two civil and structural engineers, and, one quantity surveyor; and, for interviews (see Section 3.6.3) – two SCT/SC related key informants (all drawn from the study sampling frame as defined in Section 3.5).

The reliability (internal consistency) analysis, using Cronbach's alpha (see Section 3.8.2), for the draft questionnaire responses yielded the following results: industry SCT performance (eight indicators) – *0.418 (below lower acceptance limit of 0.7)*; SCT strategies (12 indicators) – 0.888 (acceptable); SCT change-readiness (14 indicators) – 0.932 (acceptable); SCT socio-spatial sensitivity (9 indicators) – 0.762 (acceptable); SCT resilience (8 indicators) – *(negative) 0.479 (below lower acceptance limit of 0.7)*; SCT multi-level governance (9 indicators) – 0.830

(acceptable); MSMEs leveraging in SCT (9 indicators) – *0.649 (below lower acceptance limit of 0.7)*; and, leveraging IoT-driven big data and BIM in SCT (8 indicators) – 0.822 (acceptable). For the variables with reliability below the lower acceptance limit, the indicators were revised in the final questionnaire. For industry SCT performance, indicator six had negative correlation (-0.71) and indicator eight had very low correlation (0.194) with the construct total. They were revised, to align with reviewed literature. For SCT resilience, the construct was reconstructed, it had erroneously used the system components of resilience as opposed to resilience elements. Lastly, for MSMEs leveraging in SCT, indicator one if deleted, based on item-total statistics, resulted in the variable having a score of 0.722. The indicator was deleted and the construct scored 0.722. These revisions were informed by the recommendations by Tavakol & Dennick (2011:54). Additionally, the respondents recommended simplification in the wording of the questions for both instruments. It had also been observed that some respondents did not fully understand some questions making their administration take way longer than anticipated and with the potential to elicit unintended responses. Their wording was revised accordingly.

The pilot study data was discarded in light of the major revision in the SCT resilience variable and was not analysed further. The main field study was launched after revising the research instruments to the approval of the allocated supervisors.

3.7.3 Conduct of Data Collection

The field study entailed: structured questionnaires administration; and, semi-structured interviews (see Section 3.7.1). For the questionnaires, and to maximize response rate, the study employed a mix of: face-to-face administration; and, part online (through email) administration. This was informed by the need to: facilitate follow-up since the specific sampling units yet to respond were known; and, to ease administration to difficult to access respondents respectively (Saunders *et al*., 2009:398). Where the respondents were not easily accessible, *inter alia* due to the COVID-19 pandemic that was ongoing at the time, for face-to-face questionnaire administration, online administration was adopted. Face-to-face administration involved: pre-survey contacts with the respondents – informing them to expect a questionnaire (including introducing the study); delivery of the questionnaires; calling to collect filled questionnaires; collecting filled questionnaires; and, regular follow-up of sampling units yet to respond. On the other hand, online administration of the questionnaires involved: pre-survey contacts with potential respondents – informing them to expect a questionnaire (including introducing the study); sharing the hyperlink to the questionnaire; and, regular follow-up of sampling units yet to respond. This was as recommended by Saunders *et al*. (ibid: 397-398, 400). For the interviews, they involved: scheduling in advance; sending interview agenda; sending reminder and interview questions ten days before interview; asking for permission to record the interview; and, offering a copy of the questions (including the introduction letter) during the interview. This was as recommended in Leedy and Omrod (2015:287).

3.8 Tests of Soundness of Measurements

3.8.1 Validity and Reliability Overview – Quantitative

For measurements to be sound, they *"... must meet the tests of validity, reliability and practicality"* p.73. The most important of the three is the validity test that aims to measure the extent to which a research instrument measures what it intends to measure, also referred to as internal validity. This is ultimately aimed at ensuring that the differences established from data collected using the research instrument in context reflects actual differences in the research subjects (Kothari, 2004). There are three main categories of validity: face and content – former is based on establishing whether there is a logical link between research questions and objectives while the latter focuses on ensuring that all the issues in a given study are adequately addressed; concurrent and predictive validity – former is a measure of extent to which the assessment with the research instrument in context compares with another assessment concurrently while the latter is a measure of the extent a research instrument can predict an outcome; and, construct validity involves statistical measure of the extent as to which each study construct contributes to *"... total variance observed in a phenomenon"*. Simply and generally put, that is the contribution of each independent variable on the dependent variable (Kumar, 2011).

External validity on the other hand, outlines the population to which study findings are generalizable including: settings; and, variables – independent and dependent. Reliability of a research instrument refers to the extent it can produce consistent results (Kumar, 2011). Kothari (2004) postulates that key aspects of reliability are: stability – measure of the extent of producing consistent results for one respondent on numerous occasions; and, equivalence – measure of error in measurements due to change in researchers or samples of the study elements.

3.8.2 Adopted Validity and Reliability Approaches – Quantitative

On external validity, the findings of this study were set to be generalizable to: population of key stakeholders in the construction industry as identified in Section 3.5 above; in the Kenyan construction industry; SCT strategies and their key implementation considerations as the independent variables as identified in the study; and lastly, on industry SCT performance as the dependent variable. This study further sought to ensure internal validity as follows: face validity – linking research questions with pre-set research objectives; content validity – ensuring that each variable in the study is measured using various elements/indicators drawn from existing literature; on construct validity, as advanced by Fornell and Larcker (1981) and applied in Xu (2014): convergent validity – through statistical computation of composite reliability (CR), minimum factor loading, and, average variance extracted (AVE) and all were to be equal to or above acceptance levels of 0.7 (Xu, 2014), 0.3 (Hair *et al.*, 2010), and, 0.5 (Xu, 2014) respectively for convergent validity to be achieved; and, discriminant validity – through analysis of squares roots of AVE and correlation between variables where if the former is higher than the later, discriminant validity is said to have been achieved. For reliability, this study sought to ensure stability and equivalence, as recommended by Kothari (2004) through: ensuring standardized conditions (in terms of introductions and explanations given including time period) when collecting data; and, training research assistants to minimize differences during questionnaire and interview administration respectively. Additionally, reliability was assessed quantitatively using Cronbach's alpha as recommended by Hair *et al.* (2010).

3.8.3 Validity and Reliability Approaches – Qualitative

Kumar (2011) advocates for the need to ensure validity and reliability in qualitative research. According to Trochim and Donnelly (2007:149) as cited in Kumar (2011): the internal validity equivalent in qualitative research is credibility. It is a measure of the extent to which the respondents concur with the study findings. Additionally, the external validity equivalent in qualitative research is transferability. It refers to the extent of findings generalization and replicability in other contexts. Kumar (ibid) suggests that this can be achieved through a detailed explanation of the process adopted for replicability in other contexts. Lastly, the reliability equivalent in qualitative research is dependability. It relates to the extent to which the same findings can be obtained if the process is repeated. Similar to transferability, Kumar (ibid) suggests that this can be achieved through a detailed explanation of the process adopted for replicability in the same context(s). For this study, the researcher: presented the interview findings to willing respondents to ascertain concordance – for credibility; and, clearly explained the process adopted for possible future replicability (see Sections 3.2-3.8) – for transferability and dependability.

3.9 Data Analysis and Presentation

3.9.1 Units of Analysis and Observation

Unit of analysis is basically the unit subject to analysis in a given study and is determined by the data that goes into analysis (Mile, 2019:2-3; Trochim, 2021). In this study, the quantitative analysis was based on the individual responses of key construction industry stakeholders (see Section 3.5) drawn from the Kenyan construction industry. It then follows that the unit of analysis for this study was the individual key construction industry stakeholder (architect, interior designer, construction manager/project manager, civil and structural engineer, mechanical engineer, electrical engineer, and, quantity surveyor including: NCA; NEMA; KGBS; AAK; KPDA; IDAK; IQSK; ACMK; and, IEK SCT/SC related key informants). On the other hand, qualitative analysis was based on individual SCT policy themes. Consequently, these themes were the units of analysis for the qualitative part of this study. This study adopted the definition by Mile (2019:4-5) of unit of observation as the entity described by the data collected in a given research. The quantitative data collected in this study was meant to describe the individual key stakeholder, in the Kenyan construction industry, perceptions on the pre-identified study variables. On the other hand, the qualitative data of this study was meant to describe the Kenyan SCT policy and legislative system. As such for the qualitative part of this study, the Kenyan SCT policy and legislative regime was the unit of observation. Consequently, it emerges that for the quantitative part, unit of analysis and observation were one and the same but different for the qualitative part of the study.

3.9.2 Quantitative Data Analysis and Presentation

The study adopted a three-stage approach to data analysis: descriptive statistics – to classify, summarize, and, explain the collected data using frequencies (distribution), means (central tendency), and, standard deviation (dispersion) – see Kingoriah (2004:36) and Boone and Boone (2012); validity and reliability analysis – to test the validity and reliability of research instruments used (as explained in Section 3.8); and, inferential statistics – modelling relationship between study variables and testing the pre-set hypotheses (as discussed hereunder). This approach draws from two two-stage approaches: adopted by Joseph (2019:66) in a study on sustainability compliance in the Kenyan construction industry – descriptive and inferential statistics; and, Xu (2014:61) in a study on continued use of online games with a similar conceptual framework – validity and reliability analysis and hypotheses testing. The field data was primarily collected on a 5-point Likert scale where the responses to the various questions under a given variable were summed up to obtain a composite score. Consequently, the resulting data was Likert Scale data as opposed to Likert-type data. According to Clason and Dormody (1994:31) and Boone and Boone (2012): Likert Scale data is a generated through analysis of four or more questions whose responses are combined into a composite variable/score; and, Likert-type data, on the other hand, is a generated through analysis one or more questions with no attempt to combine their responses into a composite variable/score. However, for both, the response data is collected from questions with response alternatives such as strongly disagree (1), disagree (2), neutral (3), agree (4), and, strongly agree (5).

The study employed coefficient of correlation (r) to assess the strength and direction of relationship between each independent variable and the dependent variable. A similar approach was adopted in Kieti (2015:138). Lastly, based on the Likert Scale type of data as identified above, Boone and Boone (2012) recommend inferential statistics of Pearson's r, t-test, analysis of variance, and/or, regression. On this front, the study adopted the use of multiple linear regression to model the relationship between dependent and independent variables. This is based on the postulation by King'oriah (2004:364) that where a dependent variable is predicted using more than one independent variable linearly, the relationship can be explained using multiple linear regression. To test the significance, and test the hypotheses, of the regression model, the study adopted the use of the F-statistic test. King'oriah (ibid:381-386) postulates that analysis of variance, using F-statistic, is useful in explaining the joint and simultaneous impact of several independent variables on the dependent variable as was the case for this study. The resulting model had its validity assessed using a 25% holdback of the sample data. A similar sample splitting approach, based on review of past recommendations, was adopted in Ankrah (2007:147). The splitting was informed by the fact that due to limited time for the study, it was effectively impractical to collect additional data to validate the model. Snee (1977:420) postulated that in such a situation, splitting comes in handy. The collected sample data was split into: estimation data – for variables relationship modelling (75%); and, prediction data – to assess models' predictive accuracy (25%).

From the foregoing discussion, the study adopted a parametric approach to inferential statistics. This deliberate choice was informed by postulations by: Boone and Boone (ibid) that Likert Scale data is parametric; and, Carifio and Perla (2008:1150) that Likert scale data is to be taken at interval scale specifically when each variable had at least eight aggregated Likert items. The study adopted the use of IBM SPSS (Statistical Package for the Social Sciences) v23, IBM AMOS (Analysis of Moment Structures) v23, and, Microsoft Excel 2019 as the data analysis tools. The outcomes of data analysis were presented: in form of tables, charts, and graphs; and, with accompanying narration to explain them in context of the already reviewed literature.

3.9.3 Qualitative Data Analysis and Presentation

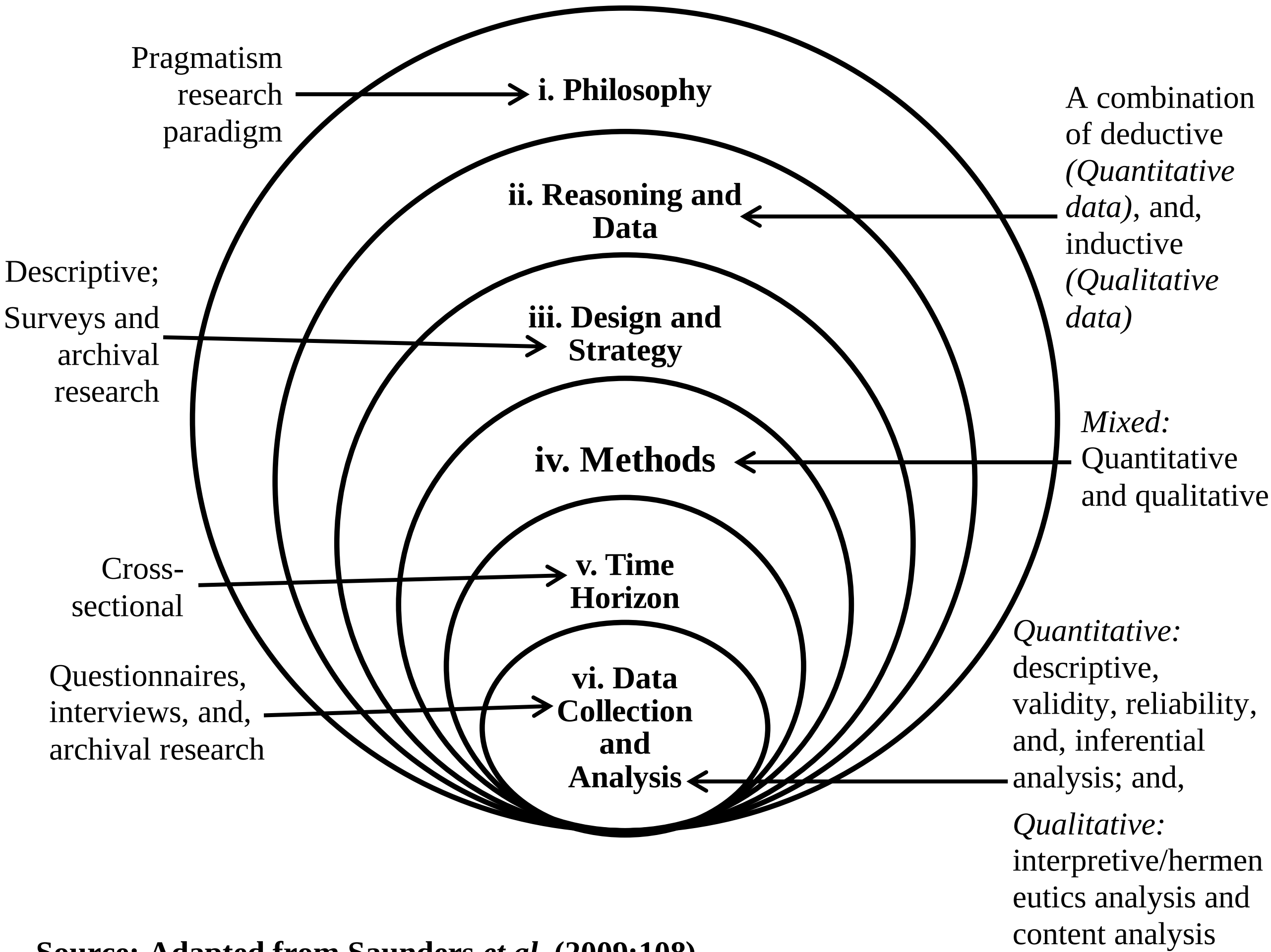
For the qualitative component of this study, this study took a three-step approach as recommended by Saunders *et al.* (2009:485,489,490): preparing data for analysis; selecting appropriate analysis approaches; and, analysis. In data preparation phase, this involved: transcribing audio recordings from interviews; and, downloading SCT related policy and legislative documents (for research question three) including selecting the ones appropriate for further analysis in Chapter four. Six analysis approaches, were put forward by Merriam (1998:156-161): ethnographic analysis – identification of culture and social regularities related categories; narrative analysis – context-driven interpretation of stories; phenomenological analysis – description of individuals lived/perceived experience; constant comparative analysis – concept development through simultaneous data coding and analysis; content analysis – categories development from coding of raw data capturing specific features of the content from documents; and, analytic induction – continuous revision of hypothesis to align with all phenomenon cases unearthed by the researcher. Additional options from Bernard (2000:437-469), as discussed in Kawulich (2004:97-98), include: interpretive/hermeneutics analysis – analysis of text to understand original meanings; narrative and performance analysis – unearthing similarities in stories; discourse analysis – context-specific language analysis; grounded theory – theory build-up through linkage of concepts from data; and, cross-cultural analysis – based on Papayiannis and Anastassiou-Hadjicharalambous (2011), human behaviour comparison across cultures.

From the foregoing discussion and for the interviews, the study adopted interpretive/hermeneutics analysis approach. This was informed by the need to develop in-depth understanding of the current state of the study variables in light of limited, and in some cases non-existent, empirical research on the same. Additionally, content analysis option was adopted for objective three to permit empirical analysis of the Kenyan SCT policy and legislative documentation to identify: priorities; supporting instruments; stakeholder orientations; and, (any) inherent shortcomings. Content analysis involves *"A detailed and* *systematic examination of the contents of a particular body of material (e.g., television shows, magazine advertisements, internet websites, works of art) for the purpose of identifying patterns, themes, or biases within that material"* (Leedy and Omrod, 2015:102). This approach, as postulated by Zhang and Wildemuth (2005:2-5), involved: data preparation – downloading documents, manual screening, and, selection (only those with SCT/SC specific provisions, given the research question in context) for further analysis; unit of analysis definition – the individual policy themes; categories development through data coding – while the categories were clear from the research question (priorities, supporting instruments, and, stakeholder orientations), no codes were pre-set and were to be developed during analysis (open coding); making conclusions – this involved making sense of the categories to identify inherent shortcomings in line with the best practice as identified in Chapter two; and, reporting the findings – this involved a summary of the findings in line with the research question.

Specifically, for data preparation, this study identified SCT related policy and legislation documentation from: a list in draft GreenMark standard for green buildings (Green Africa Foundation, 2018:16-21); MTIHUD website; NCA website; NEMA website; various Acts of Parliament; Constitution of Kenya 2010; County government websites; various regulations/subsidiary legislations; and, national plans, policies, and, codes. They were then downloaded, screened, and only those with specific SC/SCT provisions/content were selected for analysis. Based on the variety of sources, including considering an earlier list on the same in Green Africa Foundation (ibid:16-21), the resulting documents were considered representative of the Kenyan SCT policy and legislative regime and adequate to fully answer research question three. With the unit of analysis being the individual policy themes, codes were assigned to texts of any length representing a singular SC/SCT theme. Coding involved labelling text to facilitate analysis and was informed by content of the policy and legislation documentation. Additionally, the resulting information was further analysed to categorize the coding units into high order categories inherent in research question three: priorities, instruments, and, stakeholder orientation. The categories were also further analysed to reveal shortcomings, if any, in line with the best practice identified in Chapter two including the resulting conceptual framework. Lastly, data analysed qualitatively was presented in terms of textual narratives, tables, and, charts. A similar empirical analysis approach of policy was adopted in the doctoral study Chang (2016) in reviewing China's policies in facilitating transition to SC.

The adopted research methodology, as discussed in Sections 3.2-3.9, is summarized as illustrated in the research 'onion' in Figure 3.1 next page:

Figure 3.1: Research *'Onion'*



Source: Adapted from Saunders *et al.* (2009:108)

3.10 Ethical Considerations

Ethical considerations relate to right and wrong behaviour on research conduct, ensuring respondent's dignity, and, publication of resulting information (Fouka and Mantzorou, 2011). As highlighted in Section 3.2, the pragmatism research paradigm philosophy adopted for this study recognized that this study was ethics-bound. As such, the researcher sought to engrain ethical considerations, as deduced from Kumar (2011), on the following fronts: bias avoidance – through avoiding deliberate concealment of any part of resulting findings and distortion of the results; use of appropriate research methodology – backed with rationale and justification, to the best of researchers knowledge; ensuring factual and unbiased reporting of research findings; appropriate use of resulting information – avoiding use of data collected in a manner that in any way would result in harm to the respondents by highlighting the intended/potential use of the resulting information and having them decide whether they want to participate in the study; requesting for respondents informed consent to participate in the study; ensuring confidentiality – by ensuring that the specific respondents remain anonymous, the information they provide is not used for purposes other than the study, and, if information on their identity was obtained for purposes of follow-up research activities, the researcher ensured that no other persons had access to such information; avoiding sensitive information not required for purposes of this study such as respondents age, income, and, marital status; and, not providing incentives to respondents before data collection.

3.11 Chapter Summary

The study adopted pragmatism research paradigm with a supporting mixed methods approach. The study further adopted descriptive cross-sectional research design. The research strategies adopted were: surveys for research questions one, two, and, four; and, archival research to frame the study and respond to research question three. The target population was key stakeholders (design phase and governance institutions stakeholders) in the Kenyan construction industry. The sampling units were: architects; interior designers; construction managers/project managers; mechanical engineers; electrical engineers; civil and structural engineers; and, quantity surveyors (design stage practitioners); and, NCA; NEMA; KGBS; AAK; KPDA; IDAK; IQSK; ACMK; and/or, IEK SCT/SC related key informants. They were: drawn from Nairobi City County; for design phase practitioners they were professionally registered, and; for key informants, they were in SCT/SC related policy and/or practice capacities. For questionnaires, a formula approach to sample sizing was adopted and sampling through stratified sampling technique. For key informant interviews and content analysis, sampling was through purposive sampling technique. Appropriate measures to ensure validity and reliability for the resulting data were also put in place. Regarding quantitative data analysis, the study employed appropriate statistics (descriptive and inferential) including validity and reliability analysis computations. On the qualitative front, the study adopted interpretive/hermeneutics and content analysis approaches. The findings presentation approaches and rationale underlying the various sections of the methodology were also provided. Lastly, requisite ethical considerations were also identified for incorporation in the study. The next chapter, Chapter four, explored the SCT policy and legislative regime in Kenya.

CHAPTER FOUR

QUALITATIVE DATA ANALYSIS AND FINDINGS

4.1 Introduction

There exist a number Kenyan laws, regulations, policies, and, related publications which have provisions that support SCT. This chapter reviewed and analysed this Kenyan SCT policy and legislative regime in a bid to answer research question three: what is the nature of the Kenyan SCT policy regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings? The analysis first sought to explore the priorities, instruments, and, stakeholder orientation of the Kenyan SCT policy and legislation regime. It was also aimed at identifying areas of improvements to the policy and legislative regime to ensure its efficiency and effectiveness towards SCT. This was to be a point of reference for practitioners and policymakers in the Kenyan construction industry on the SCT policy and legislative front. This chapter was structured in three main sections. Section 4.2 covered SCT related themes identification and their coding in line with the categories in research question three – priorities, instruments, and, stakeholder orientation. Section 4.3 presented findings and detailed discussion on identified priorities, instruments, and, stakeholder orientation. Lastly, Section 4.4 highlighted the identified collective shortcomings in context of best practice. The findings of this chapter were the basis of the policy recommendations outlined in chapter six geared towards enhanced industry SCT performance.

4.2 Themes Identification and Coding

Thirty-five SCT policy and legislative documents were selected for further analysis from the data preparation stage. Some of the SCT related policy and legislative regime documents, as identified in Green Africa Foundation (2018:16-21) were excluded from this study. Their exclusion was based on: having been replaced by new versions (which have been included); not being explicit on the link between their provisions and SCT; and lastly, being draft guidelines, which have now been ratified in subsidiary legislation. After identification and screening, the selected SCT policy and legislative documentation was coded. This involved systematic analysis and comparison of the policy documentation text to identify inherent SC/SCT related themes. During this initial coding stage, the identified themes short descriptors or labels, also known as themes codes, were identified. Given that the categories were predetermined, as inherent in research question three, codes generation was informed by the categories. Based on the nature of the source documents, the study first identified that they were grouped into three main themes: subsidiary legislation/regulations; constitution and Acts of parliament; and, codes, guidelines, and, plans. As such, this became the first coding stream.

On further analysis, based on the description of the specific SC/SCT related provisions, it was observed that the identified policy and legislative documents could be further grouped as focused on: economic; environmental; and/or, social pillars of SC/SCT. This consequently became the second coding stream. Lastly, on further analysis, it also became apparent, based on specific content description, that the documents targeted different industry stakeholders. These were identified as: government (national and county); developers/occupiers/owners; professional consultants; contractors; and, suppliers/manufacturers/producers. As such, this became the third coding stream. In a nutshell, the codes were thematically identified as: group one – subsidiary legislation/regulations, constitution and Acts of parliament, and, codes, guidelines, and, plans; group two – economic, environmental, and social; and, group three – action by government (national and county), developers/occupiers/owners, professional consultants, contractors, and, suppliers/manufacturers/producers. From the foregoing discussion it is clear that the SCT policy and legislative regime: has attempted to cover the three facets of SCT (economic, environmental, and social); through the identified policy instruments, such as regulations, legislation, and, national agendas; and, which in turn have targeted different stakeholders in the Kenyan construction industry in their provisions.

Tables 4.1-4.3 next outline the specific SCT policy and legislative documentation analysed as differentiated into the three coding streams identified above. These are: coding stream one – subsidiary legislation/regulations, constitution and Acts of parliament, and, codes, guidelines, and, plans; coding stream two – economic, environmental, and/or, social pillars of SC/SCT; and, coding stream three – government (national and county), developers/occupiers/owners, professional consultants, contractors, and, suppliers/manufacturers/producers. Additionally, for each SCT policy or legislative document, a brief explanation of the identified main SCT related provision used to inform the coding decision for the second and third coding streams is also provided.

Table 4.1: Kenyan SCT Policy Regime – Regulations/Subsidiary Legislation

Instruments – Coding Stream 1: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
1. *The Environmental Management and Coordination (Conservation of biological diversity and resources, access to genetic resources and benefit sharing) Regulations 2006*	Prohibits all activities, such as construction, that have impact on any ecosystem. It also requires environmental impact assessment (EIA) for all activities, such as construction, that may lead to unsustainable use of natural resources	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets developers
2. *The Environmental Management and Coordination (Water quality) Regulations 2006*	Covers: prevention of water pollution/control of effluent discharge; acceptable domestic, industrial, irrigation, and, recreation water standards; and, protection of water sources	Water conservation (environmental)	Targets contractors, water suppliers, owners/operators of industrial facilities, irrigation schemes, and, water bodies used for recreation purposes

Instruments – Coding Stream 1: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
3. *The Environmental Management and Coordination (Waste management) Regulations 2006*	Guides the management of waste (solid, industrial, hazardous, pesticides and toxic substances, biomedical, and, radioactive), which are common/possible during the construction and operation phases of constructed facilities	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets developers/owners/occupiers and contractors
4. *The Environmental (Impact assessment and audit) (Amendment) Regulations 2009*	Outline the rules on EIA procedure (including environmental auditing and monitoring), which applies to construction projects, including registration of EIA experts	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets developers and EIA experts/professionals
5. *The Environmental Management and Coordination (Noise and excessive vibration pollution) (Control) Regulations 2009*	Regulations provide standards on maximum allowable noise and vibrations from a constructed facility, construction site, demolition site, mines, and, quarries (including associated licensing and exclusions)	Protecting human health and comfort (social)	Targets developers/owners/occupiers of constructed facilities, contractors and suppliers of building materials (raw or finished) sourced from mines and quarries

Instruments – Coding Stream 1: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
6. *The Environmental Management and Coordination (Wetlands, riverbanks, lake shores, and, sea shore management) Regulations 2009*	Requires EIA for endeavours, such as construction, with adverse effects on wetlands, riverbanks, and, shores	Land and water conservation (environmental)	Targets developers
7. *The Energy (Energy management) Regulations 2012*	On energy consumption management in industrial, commercial, and, institutional constructed facilities	Energy conservation (environmental) and operation cost rationalization (economic)	Targets developers/owners/occupiers of constructed facilities
8. *The Energy (Solar water heating) Regulations 2012*	Requires installation and use of solar water heating systems for all constructed facilities using above 100 litres of hot water daily	Energy conservation (environmental) and operation cost rationalization (economic)	Targets developers/owners/occupiers and design phase professionals

Instruments – Coding Stream 1: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
9. *The Environmental Management and Coordination (E-waste management) Draft Regulations 2013*	These draft regulations cover registration and responsibilities of e-waste producers and recyclers (including generators such as constructed facilities or sites). They additionally outline the responsibilities of collection centres and refurbishers/repairers including guidelines on control and handling	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets developers/owners/occupiers and contractors
10. *The Environmental Management and Coordination (Air Quality) Regulations 2014*	Provides guidelines on prevention, control, and, mitigation of air pollution from stationary sources such as paint manufacturing plants and mobile sources such as vehicles used in construction (including indoor air quality)	Environmental	Producers, contractors, and, developers/owners/occupiers of premises
11. *The Energy (Appliance's energy performance and labelling) Regulations 2016*	Standards on energy performance rating and labelling of appliances used during the construction and operation phases of constructed facilities such as lamps, refrigerators, motors, and, non-ducted air conditioners	Energy conservation (environmental) and operation cost rationalization (economic)	Targets suppliers/manufacturers/producers

Instruments – Coding Stream 1: Regulations/Subsidiary Legislation			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
12. *The Draft Environmental Management and Coordination (Toxic and hazardous industrial chemicals and materials management) Regulations 2019*	These regulations cover hazardous industrial chemicals and materials, such as asbestos in construction, management on: classification; registration; labelling; packaging; advertising; manufacturing, importing; exporting; distribution; storage; transportation; and, handling	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets contractors and suppliers
13. *The Draft Environmental Management and Coordination (Sand Harvesting Control and Management) Regulations 2022*	These draft regulations provide guidelines on sustainable sand harvesting and transport (including general management, approvals, and, licensing)	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Government (national and counties) and sand harvesters, suppliers and transporters

Source: Author (2023)

Table 4.2: Kenyan SCT Policy Regime – Constitution and Acts of Parliament

Instruments – Coding Stream 1: Constitution and Acts of Parliament			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
1. *The Employment Act 2007*	Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages; basic minimum conditions in employment; protection of children; and, employment disputes	Ensuring the construction industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (social)	Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors, and, suppliers
2. *The Occupational Safety and Health Act 2007*	Outlines the duties of facilities occupiers, self-employed persons, employees, designers, manufacturers, importers, and, suppliers in ensuring health, safety, and, welfare in the context of workplaces	Ensuring human well-being (social)	Targets contractors, consultants, developers/owners/occupiers, designers, manufacturers, importers, and, suppliers
3. *The Work Injury Benefits Act 2007*	Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases, disablement (temporary or permanent), and, death	Ensuring human well-being (social)	Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors, and, suppliers amongst other related employers

Instruments – Coding Stream 1: Constitution and Acts of Parliament			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
4. The Kenyan Constitution 2010	Article 10 (2) – Identifies SD as a national governance value and principle Article 42 – Identify the right to clean and healthy environment for everyone	Covers the three dimensions of sustainability (economic, environmental, and, social)	All – Targets governments (national and county), developers/owners/occupiers, professional consultants, contractors, and, suppliers/manufacturers/producers
5. *The National Construction Authority Act 2011*	NCA (a national organization) is empowered to conduct/commission research and advise the relevant cabinet secretary on any matter relating to the construction industry, not excluding SC	This covers all the three facets of SC (economic, environmental, and, social)	Targets national government
6. *The Public Health Act 2012*	Requires prevention and removal of nuisance in relation to, but not limited to: unsafe accumulation of materials; chimney discharging significant amounts of smoke; land in state that poses health risk; factory or business facilities unsafe emissions; and, effluents and buildings situated, erected, used,	Preventing damage and potential irreversible impacts on the natural environment (environmental) and ensuring human wellbeing (social)	Targets county governments and developers/owners/occupiers

Instruments – Coding Stream 1: Constitution and Acts of Parliament			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
	or, maintained in a manner that is injurious to human health		
7. *The Environmental Management and Coordination (Amendment) Act 2015*	Cabinet secretary in charge of environment is mandated to set the national environment protection direction; NEMA and County Environment Committees established to supervise and coordinate all matters environment nationally and in counties respectively; specifies the nature of construction projects and construction related endeavours for which EIA is mandatory; and, environmental offences (such as inspection, EIA, and, pollution related)	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets government (national and county), developers, contractors, producers, and, EIA experts/professionals
8. *The Climate Change Act 2016*	One of the aims of the Act is to mainstream climate change sensitivity, including SD, in the planning, execution, and, decision making of developments	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments

Instruments – Coding Stream 1: Constitution and Acts of Parliament			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
9. *The Water Act 2016*	On regulation, management, and, development of sewerage and water services and establishes National Water Harvesting and Storage Authority partly charged with developing and enforcing water harvesting policy	Water conservation (environmental)	Targets national and county governments
10. *The Energy Act 2019*	Cabinet secretary on energy to: promote the development and use of renewable energy such as biomass; and, energy efficiency and conservation nationally	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments
11. *The Physical and Land Use Planning Act 2019*	Sets out to, amongst other objectives, provide a multi-level (national, county, and, local) framework for sustainable land use, planning, and, management	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments

Source: Author (2023)

Table 4.3: Kenyan SCT Policy Regime – Codes, Guidelines, and, Plans

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
1. *Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*	Has provisions on: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	Preventing damage and potential irreversible impacts on the natural environment (environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (social)	Targets professional consultants, owners, developers and occupiers, contractors, suppliers, and, local governments
2. Ministry of Lands (2009)	Sessional Paper No. 3 of 2009 on National Land Policy – Sections 140 and 141 recommend: prohibition of untreated waste, a by-product of the operation phase of constructed facilities, into water bodies; promoting and mandating segregation and labelling of waste to ease its management; regulation of all quarrying and	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets developers/owners/occupiers, contractors, and, suppliers/manufacturers/producers

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
	excavation activities; promoting re-use of urban waste; developing guideline on dumpsites rehabilitation; mandating EIA and environmental audit for development activities likely to degrade the environment; environmental degradation monitoring; polluter pays principle enforcement; and, ensuring public participation in environmental management		
3. *The (Proposed) Planning and Building Regulations 2009*	Partly aims at promoting optimal resource usage and enhancing convenience, health, and, safety in relation to construction sites and constructed facilities. It provides guidelines on: accessibility of constructed facilities; energy efficiency and thermal comfort; water harvesting; conducive indoor air quality; prohibition of objectionable sewerage discharge; prohibition of dangerous demolition	Preventing damage and potential irreversible impacts on the natural environment (environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (social)	Targets government (national and county), professional consultants, building owners and occupiers, contractors, and, suppliers

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
	methods; control of dust and noise from excavation, erection, or, demolition work; appropriate disposal of waste materials; and, standards for various installations such as water closets amongst other provisions		
4. Energy Regulatory Commission (ERC) (2013)	ERC baselines and benchmarks and the designation of industrial, commercial, and, institutional energy users in Kenya – this study facilitated development of baselines and benchmarks for energy performance and designation of energy users (industrial, commercial, and, institutional). This was intended to raise awareness and facilitate decision making on energy conservation and efficiency in line with *The Energy (Energy management) Regulations 2012* (see Table 4.1)	Energy conservation (environmental)	Targets developers, owners, and, occupiers of constructed facilities

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
5. Ministry of Environment, Water and Natural Resources (2013)	National environmental policy – Section 5.6 requires the government to: conduct periodic EIA for all infrastructural projects; develop and implement an environmentally conscious infrastructure development strategy and action plan; and, conduct social impact assessment, public participation, EIA, and, strategic environmental assessment (SEA) in the approval and planning of infrastructural projects	Preventing damage and potential irreversible impacts on the natural environment (environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (social)	Targets national and county governments
6. NEMA (2014)	National solid waste management strategy – recognizes construction and demolition as one of the main sources of waste in Kenya. In a bid to ensure a healthy, safe, and, secure environment, this strategy seeks to achieve 80%, 50%, and, 30% waste recovery (in terms of compositing to energy and recycling) and the remaining 20%, 50%, and, 70% for sanitary	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
	landfilling by the years 2030, 2025, and, 2020 respectively		
7. Ministry of Environment and Natural Resources (2016a)	Green Economy Strategy and Implementation Plan 2016-2030 (GESIP) – requires promotion of sustainable built environment from design, through construction, to operation phases of constructed facilities. Some of the specific strategies include: increasing share of renewable energy in the energy mix; and, promoting sustainable design, construction, and, operation of constructed facilities	Covers the three facets/pillars of SC (economic, environmental, and, social)	Targets national and county governments
8. Ministry of Environment and Natural Resources (2016b)	Sessional Paper No.5 of 2016 on national climate change framework policy – Advocates for *"… integration of climate change risks and opportunities in the design, operation and management of infrastructure"* p. 11	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
9. Green Africa Foundation (2018)	Kenya Building Research Centre's strategic plan 2017/2018 – 2021/2022: has the following key result areas – developing policies, regulations, and, guidelines on green buildings; conducting research on and gazetting SC materials; and, oversee mainstreaming of green building principles in the construction industry	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national government
10. Ministry of Environment and Forestry (2018)	Kenya National Climate Change Action Plan (NCCAP) 2018-2022 – this plan recommends, but is not limited to: promotion of green buildings; sustainable privately owned land timber production; and, enhanced energy conservation and efficiency	Preventing damage and potential irreversible impacts on the natural environment (environmental)	Targets national and county governments

Instruments – Coding Stream 1: Codes, Guidelines, and, Plans			
Policy Document	**SCT Related Provision**	**SCT Priorities – Coding Stream 2**	**Stakeholder Target – Coding Stream 3**
11. *The (Draft) National Building Code 2022 – Scheduled to be in operation from 2023*	Aims at enhancing order, health, and, safety in and around construction works (including resulting constructed facilities) and provides: guidelines related to all construction project phases (including requirement for conformance to sustainable design strategies); materials and other components standards; and, disaster management standards amongst other provisions	Preventing damage and potential irreversible impacts on the natural environment (environmental) and ensuring the industry meets its moral and legal obligations to its stakeholders throughout the project lifecycle (social)	Targets county governments, professional consultants, building owners and occupiers, contractors, and, suppliers

Source: Author (2023)

For clarity of the obligations placed upon the various industry stakeholders, Tables 4.4-4.8 next page clearly identified the various policy and legislative documents (excluding drafts), their stakeholder orientation, including, the inherent obligations.

Table 4.4: SCT Policy Regime Stakeholder Orientation – National and County Governments

A. Role of National and County Governments	
Main SCT Policy Provision	**Source**
1. Enforcing provisions related to: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	*Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*
2. Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages; basic minimum conditions in employment; protection of children; and, employment disputes	*The Employment Act 2007*
3. Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases (scheduled and unscheduled), disablement (temporary or permanent), and, death	*The Work Injury Benefits Act 2007*
4. Promotion of SD as a national value and principle, and, ensuring and safeguarding the right to clean and healthy environment for everyone	The Kenyan Constitution 2010
5. Through NCA, conduct/commission research and advise the relevant cabinet secretary on any matter relating to the construction industry, not excluding SC/SCT	*The National Construction Authority Act 2011*

A. Role of National and County Governments	
Main SCT Policy Provision	**Source**
6. Requires prevention and removal of nuisance injurious to human health by local authorities	*The Public Health Act 2012*
7. Must: conduct periodic EIA for all infrastructural projects; develop and implement an environmentally conscious infrastructure development strategy and action plan; and, social impact assessment, public participation, EIA, and, SEA in the approval and planning of infrastructural projects (Section 5.6) – national environmental policy	Ministry of Environment, Water and Natural Resources (2013)
8. This strategy seeks to achieve 80%, 50%, and, 30% waste recovery (in terms of compositing to energy and recycling) and the remaining 20%, 50%, and, 70% for sanitary landfilling by the years 2030, 2025, and, 2020 respectively – national solid waste management strategy	NEMA (2014)
9. Cabinet secretary in charge of environment mandated to set the national environment protection direction, NEMA and County Environment Committees established to supervise and coordinate all matters environment nationally and in counties respectively	*The Environmental Management and Coordination (Amendment) Act 2015*
10. To mainstream climate change sensitivity, including SD, in the planning, execution, and, decision making of developments	*The Climate Change Act 2016*
11. Regulation, management, and, development of sewerage and water services and establishes National Water Harvesting and Storage Authority partly charged with developing and enforcing water harvesting policy	*The Water Act 2016*

A. Role of National and County Governments	
Main SCT Policy Provision	**Source**
12. Requires promotion of sustainable built environment from design, through construction, to, operation phases of constructed facilities. Some of the specific strategies include: increasing share of renewable energy; and, promoting sustainable design, construction, and, operation of constructed facilities – Green Economy Strategy and Implementation Plan (GESIP) 2016-2030	Ministry of Environment and Natural Resources (2016a)
13. Promoting *"… integration of climate change risks and opportunities in the design, operation and management of infrastructure"* p. 11 – Sessional Paper No.5 of 2016 on national climate change framework policy	Ministry of Environment and Natural Resources (2016b)
14. Promotion of green buildings, sustainable privately owned land timber production, and, enhanced energy conservation and efficiency – Kenya National Climate Change Action Plan (NCCAP) 2018-2022	Ministry of Environment and Forestry (2018)
15. Developing policies, regulations, and, guidelines on green buildings; conducting research on and gazetting SC materials; and, oversee mainstreaming of green building principles in the construction industry – Kenya Building Research Centre's strategic plan 2017/2018 – 2021/2022	Green Africa Foundation (2018)
16. Cabinet secretary on energy to: promote the development and use of renewable energy such as biomass; and, energy efficiency and conservation nationally	*The Energy Act 2019*
17. Development of the national physical and land use development plan which is the basis for national: environmental improvement, protection, and, conservation; and, optimal use of natural resources (including land). Additionally, cascading the same at the local level through county and local physical and land use development plans	*The Physical and Land Use Planning Act 2019*

Source: Author (2023)

Table 4.5: SCT Policy Regime Stakeholder Orientation – Developers, Occupiers, Owners, and, Operators of Built Facilities

B. Role of Developers, Occupiers, Owners, and, Operators of Built Facilities	
Main SCT Policy Provision	**Source**
1. Compliance with provisions on: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	*Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*
2. Prohibits all activities, such as construction, that have impact on any ecosystem. It also requires EIA for all activities, such as construction, that may lead to unsustainable use of natural resources	*The Environmental Management and Coordination (Conservation of biological diversity and resources, access to genetic resources and benefit sharing) Regulations 2006*
3. Guides the management of waste (solid, industrial, hazardous, pesticides and toxic substances, biomedical, and, radioactive), which are common/possible during the construction and operation phases of constructed facilities	*The Environmental Management and Coordination (Waste management) Regulations 2006*
4. Covers: prevention of water pollution/control of effluent discharge; acceptable domestic, industrial, irrigation, and, recreation water standards; and, protection of water sources	*The Environmental Management and Coordination (Water quality) Regulations 2006*

B. Role of Developers, Occupiers, Owners, and, Operators of Built Facilities	
Main SCT Policy Provision	**Source**
5. Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages; basic minimum conditions in employment; protection of children; and, employment disputes	*The Employment Act 2007*
6. Ensuring health, safety, and, welfare in workplaces, this includes constructed facilities	*The Occupational Safety and Health Act 2007*
7. Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases (scheduled and unscheduled), disablement (temporary or permanent), and, death	*The Work Injury Benefits Act 2007*
8. Compliance with requirement for EIA and environmental audit for development activities likely to degrade the environment; environmental degradation monitoring; polluter pays principle enforcement, and; ensuring public participation in environmental management – Sessional Paper No. 3 of 2009 on National Land Policy	Ministry of Lands (2009)
9. Outline the rules on EIA procedure (including environmental auditing and monitoring), which applies to construction projects, including registration of EIA experts	*The Environmental (Impact assessment and audit) (Amendment) Regulations 2009*
10. Regulations provide standards on maximum allowable noise and vibrations from a constructed facility, construction site, demolition site, mines, and, quarries (including associated licensing and exclusions)	*The Environmental Management and Coordination (Noise and excessive*

B. Role of Developers, Occupiers, Owners, and, Operators of Built Facilities	
Main SCT Policy Provision	**Source**
	vibration pollution) (Control) Regulations 2009
11. Requires EIA for endeavours, such as construction, with adverse effects on wetlands, river banks, and, shores	*The Environmental Management and Coordination (Wetlands, river banks, lake shores and sea shore management) Regulations 2009*
12. Promotion of SD as a national value and principle, and, ensuring and safeguarding the right to clean and healthy environment for everyone	The Kenyan Constitution 2010
13. Owner/developer of industrial, commercial, and, institutional facilities required to: develop energy management policy; cause energy audits every 3 years; develop energy investment plan; take energy conservation measures to achieve at least 50% of the set targets; and, develop energy management implementation plan	*The Energy (Energy management) Regulations 2012*
14. Installation and use of solar water heating systems for all constructed facilities using above 100 litres of hot water daily	*The Energy (Solar water heating) Regulations 2012*
15. Requires removal of nuisance injurious to human health by owners/occupiers of built facilities proximal to the nuisance	*The Public Health Act 2012*

B. Role of Developers, Occupiers, Owners, and, Operators of Built Facilities	
Main SCT Policy Provision	**Source**
16. This study facilitated development of baselines and benchmarks for energy performance and designation of energy users (industrial, commercial, and, institutional). This was intended to raise awareness and facilitate decision making on energy conservation and efficiency in line with *The Energy (Energy management) Regulations 2012* (see Table 4.1)	ERC (2013)
17. Occupiers and operators of built facilities operators to ensure compliance with indoor air quality standards	*The Environmental Management and Coordination (Air Quality) Regulations 2014*
18. Specifies the natures of construction projects and construction related endeavours for which EIA is mandatory; and, environmental offences (such as inspection, EIA, and, pollution related)	*The Environmental Management and Coordination (Amendment) Act 2015*

Source: Author (2023)

Table 4.6: SCT Policy Regime Stakeholder Orientation – Professional Consultants

C. Role of Professional Consultants	
SCT Policy Provision	**Source**
1. Compliance with provisions on: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	*Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*
2. Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages; basic minimum conditions in employment; protection of children; and, employment disputes	*The Employment Act 2007*
3. Ensuring health, safety, and, welfare in workplaces through designs, this includes construction sites and constructed facilities	*The Occupational Safety and Health Act 2007*
4. Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases (scheduled and unscheduled), disablement (temporary or permanent), and, death	*The Work Injury Benefits Act 2007*

C. Role of Professional Consultants	
SCT Policy Provision	**Source**
5. Outline the rules on EIA procedure (including environmental auditing and monitoring), which applies to construction projects, including registration of EIA experts	*The Environmental (Impact assessment and audit) (Amendment) Regulations 2009*
6. Promotion of SD as a national value and principle, and, ensuring and safeguarding the right to clean and healthy environment for everyone	The Kenyan constitution 2010
7. Design for installation and use of solar water heating systems for all constructed facilities using above 100 litres of hot water daily	*The Energy (Solar water heating) Regulations 2012*
8. Specifies consequences of environmental offences (such as obstructing inspection, falsifying EIA reports, and, pollution contrary to the provisions of the Act)	*The Environmental Management and Coordination (Amendment) Act 2015*

Source: Author (2023)

Table 4.7: SCT Policy Regime Stakeholder Orientation – Contractors

D. Role of Contractors	
Main SCT Policy Provision	**Source**
1. Compliance with provisions on: statutory requirements for development approvals; requiring buildings to be sited in a manner ensuring hygienic and sanitary conditions and avoiding nuisance to neighbouring owners and/or occupiers; safety and protection of persons affected by construction works; and, building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	*Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*
2. Guides the management of waste (solid, industrial, hazardous, pesticides and toxic substances, biomedical, and, radioactive), which are common/possible during the construction and operation phases of constructed facilities	*The Environmental Management and Coordination (Waste management) Regulations 2006*
3. Covers: prevention of water pollution/control of effluent discharge; acceptable domestic, industrial, irrigation, and, recreation water standards; and, protection of water sources	*The Environmental Management and Coordination (Water quality) Regulations 2006*
4. Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages, basic minimum conditions in employment; protection of children; and, employment disputes	*The Employment Act 2007*
5. Ensuring health, safety, and, welfare in workplaces, this includes construction sites	*The Occupational Safety and Health Act 2007*

D. Role of Contractors	
Main SCT Policy Provision	**Source**
6. Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases (scheduled and unscheduled), disablement (temporary or permanent), and, death	*The Work Injury Benefits Act 2007*
7. Ensuring compliance with the following provisions: prohibition untreated waste, a by-product of the operation phase of constructed facilities, into water bodies; promoting and mandating segregation and labelling of waste to ease its management; regulation of all quarrying and excavation activities; promoting re-use of urban waste (Sections 140 and 141) – Sessional Paper No. 3 of 2009 on national land policy	Ministry of Lands (2009)
8. Regulations provide standards on maximum allowable noise and vibrations from a constructed facility, construction site, demolition site, mines, and, quarries (including associated licensing and exclusions)	*The Environmental Management and Coordination (Noise and excessive vibration pollution) (Control) Regulations 2009*
9. Promotion of SD as a national value and principle, and, ensuring and safeguarding the right to clean and healthy environment for everyone	The Kenyan Constitution 2010
10. Compliance with guidelines on prevention, control, and, mitigation of air pollution from mobile sources such as vehicles used in construction	*The Environmental Management and Coordination (Air Quality) Regulations 2014*
11. Specifies consequences of environmental offences (such as obstructing inspection, falsifying EIA reports, and, pollution contrary to the provisions of the Act)	*The Environmental Management and Coordination (Amendment) Act 2015*

Source: Author (2023)

Table 4.8: SCT Policy Regime Stakeholder Orientation – Suppliers, Manufactures, and, Producers

E. Role of Suppliers, Manufacturers, and, Producers	
Main SCT Policy Provision	**Source**
1. Compliance with provisions on building materials requirements in relation to aspects such as structural soundness, fire safety, and, weatherproofing	*Building Code (Current) – The Local Government (Adoptive By-Laws) (Building) Order 1968; and, The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968*
2. Covers: prevention of water pollution/control of effluent discharge; acceptable domestic, industrial, irrigation, and, recreation water standards; and, protection of water sources	*The Environmental Management and Coordination (Water quality) Regulations 2006*
3. Prohibits: forced labour; discrimination in employment; and, sexual harassment. It also provides guidelines on: protection of wages, basic minimum conditions in employment; protection of children; and, employment disputes	*The Employment Act 2007*
4. Ensuring health, safety, and, welfare in workplaces through manufactured, imported and/or supplied items	*The Occupational Safety and Health Act 2007*
5. Provides guidelines on employees (including government employees) compensation, by their employers, due to occupational related diseases (scheduled and unscheduled), disablement (temporary or permanent), and, death	*The Work Injury Benefits Act 2007*
6. Sections 140 and 141 recommends: prohibition of untreated waste into water bodies; promoting and mandating segregation and labelling of waste to ease its management; regulation of all quarrying	Ministry of Lands (2009)

E. Role of Suppliers, Manufacturers, and, Producers	
Main SCT Policy Provision	**Source**
and excavation activities; promoting re-use of urban waste; developing guideline on dumpsites rehabilitation; mandating EIA and environmental audit for development activities likely to degrade the environment; environmental degradation monitoring; polluter pays principle enforcement; and, ensuring public participation in environmental management	
7. Regulations provide standards on maximum allowable noise and vibrations from a constructed facility, construction site, demolition site, mines, and, quarries (including associated licensing and exclusions)	*The Environmental Management and Coordination (Noise and excessive vibration pollution) (Control) Regulations 2009*
8. Promotion of SD as a national value and principle, and, ensuring and safeguarding the right to clean and healthy environment for everyone	The Kenyan Constitution 2010
9. Provides guidelines on prevention, control, and, mitigation of air pollution from stationary sources such as paint manufacturing plants	*The Environmental Management and Coordination (Air Quality) Regulations 2014*
10. Specifies consequences of environmental offences (such as obstructing inspection, falsifying EIA reports, and, pollution contrary to the provisions of the Act)	*The Environmental Management and Coordination (Amendment) Act 2015*
11. Standards on energy performance rating and labelling of appliances used during the construction and operation phases of constructed facilities such as lamps, refrigerators, motors, and, non-ducted air conditioners	*The Energy (Appliance's energy performance and labelling) Regulations 2016*

Source: Author (2023)

4.3 Priorities, Instruments, and, Stakeholder Orientation

This chapter partly sought to identify the priorities, instruments, and, stakeholder orientation of the Kenyan SCT policy and legislative regime.

Priorities were informed by the three integrated facets/pillars of SCT (see Section 2.3.2). Here the study sought to assess the extent to which the regime addressed the economic, environmental, and social pillars of SCT respectively. The findings in Section 4.2 indicate that the Kenyan policy and legislative regime largely focused on the environmental pillar of SCT (31/35 instruments) with lesser focus on the social (12/35 instruments) and economic pillars (6/35 instruments) – coding stream two. This means that the Kenyan policy and legislative regime was focused on environmental conservation, meeting moral and legal obligations, and, ensuring profitability through resource use efficiency (see Section 2.3.2), in decreasing order of priority. Similar hegemony of the environmental pillar was observed in the Chinese SCT policy regime (Chang, 2016:118-119). This direction, for Kenya, can be attributed to being motivated by political acceptability and compliance with applicable international agreements and/or rules, see Section 2.4.5.1, in context of continued dominance, comparatively, of pro-environmental agendas (global, regional, and, local) such as green economy transition in Kenya and SDGs internationally (see Section 1.2.4). Additionally, a keen look at the specific SCT provisions, see Tables 4.1-4.3, indicate that the priorities were primarily at strategic and tactical levels when compared with operational level of implementation. This highlights that the priorities were largely at long-term industry-level and medium-term firm-level implementation when compared with short-term project-level implementation (see Section 2.3.2). This can be attributed to the fact that the provisions were largely multisectoral and not construction industry specific unless where the instrument in context was solely for the construction industry.

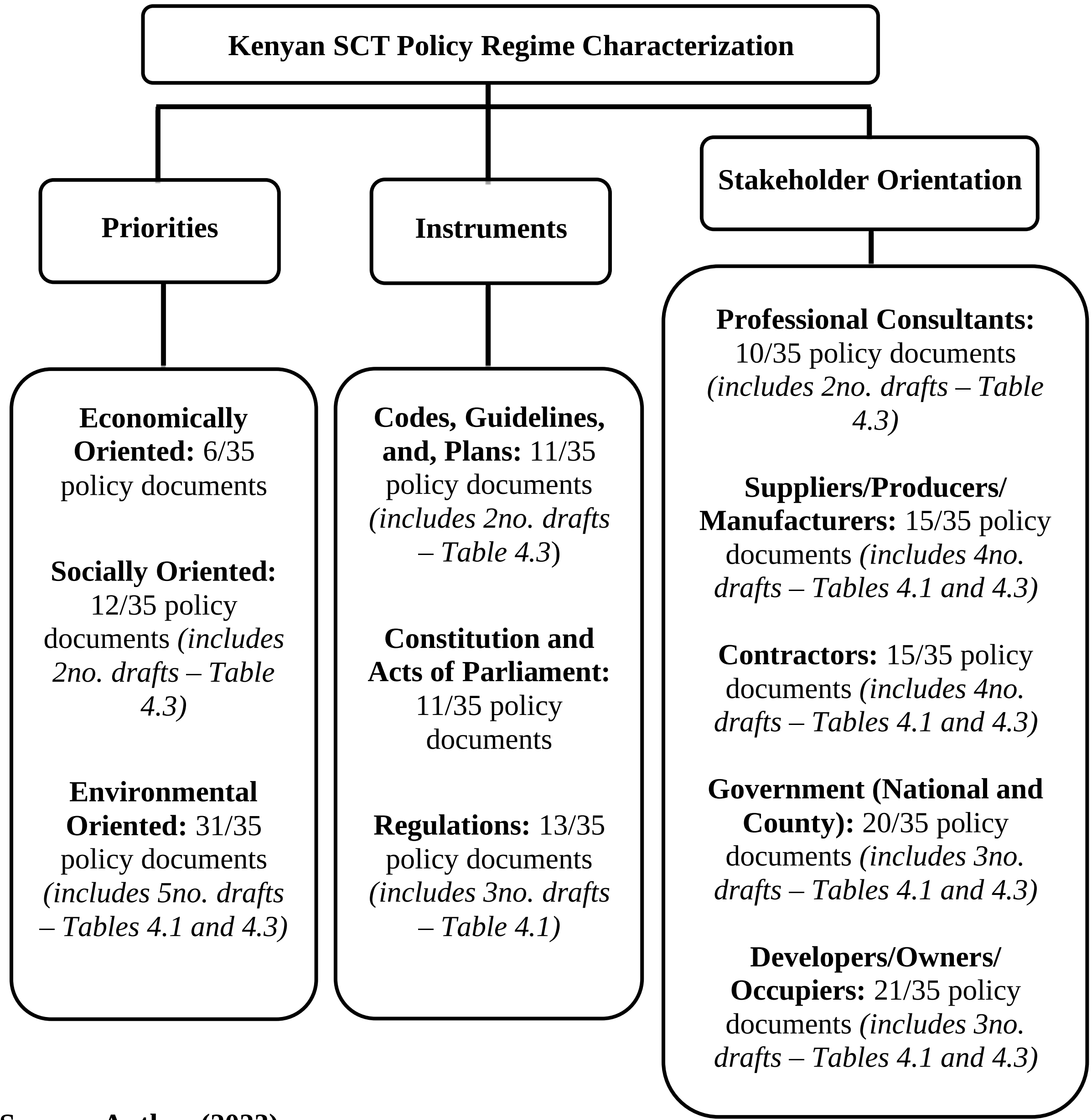
Secondly, policy instruments identification was informed by Chang (2016:104) differentiation of China's SC policy system instruments and the need to understand the Kenyan one. From coding stream one, the findings in Section 4.2 indicate that Kenyan policy system was driving the SCT agenda through: subsidiary legislation/regulations (13/35); constitution and Acts of parliament (11/35), and; codes, guidelines, and, plans (11/35). The development of Kenyan SCT policy and legislative, based on being a mix of regulations and policies, points towards a top-down approach to SCT (see Esezobor, 2016:49 – Section 2.3.3) that is, largely experts and leaders driven. This can be attributed to the fact they were largely intersectoral and not construction industry-specific, but had SCT/SCT related provisions. That notwithstanding, bottom-up, stakeholders' collaboration formulated and driven, strategies are equally important in dealing with specific issues and contexts (Cairns, 2003). This highlighted an existing gap for complementary Kenyan SCT strategies that are construction industry stakeholders' collaboration driven for industry specific approaches which could even be regionally differentiated (see Section 2.3.4). Based on their respective numbers, the three categories of instruments emerged to be employed approximately equally. This indicates a fairy well balanced use of policy and legislative instruments to drive the SCT agenda in Kenya. However, they were many and without a centralized database. However, most of the environmental ones were publicly available on the NEMA website. This brought to the fore the unavailability of industry level platform(s) collating SC related policy and legislative instruments in Kenya. This chapter however collated them and went ahead to outline inherent SCT specific obligations for the main stakeholder groups (see Tables 4.4-4.8).

Lastly, stakeholder orientation identification was informed by need to investigate the current targeting of the various industry stakeholders by the Kenyan SCT policy and legislative regime. The addressees of the various policy instruments and their respective obligations were identified. This category was informed by Chang (2016:108) identification of stakeholders and their obligations in the China's SC policy system and the need to understand the Kenyan one. It is clear from Section 4.2 that the regime was largely focused on the SCT role of developers/owners/occupiers and government (national and county), each addressed by >18 instruments, compared to the rest of the industry stakeholders, each addressed by <18 instruments – coding stream three. This means that the Kenyan SCT policy and legislative regime sought to elicit enhanced industry SCT performance largely through government and developers/owners/occupiers and with comparatively less targeting of contractors, suppliers/producers/manufacturers, and, professional consultants (in order of decreasing targeting). This can also be attributed to the fact that the regime was largely intersectoral and not construction industry-specific, but had SCT/SCT related provisions. Consequently, it did not fully embrace the key SCT supply chain roles for the construction industry. This makes a compelling case for complementary bottom-up SCT strategies as discussed in the preceding paragraph to address this gap. Interestingly the findings in Section 4.2 did not identify incorporation of media and civil society in SCT agenda even though they were identified to have a role in the SCT agenda (see Table 2.7). This points towards the failure to fully acknowledge the multi-actor, multi-sector, and, polycentric nature of SCT in the development of the Kenyan policy and legislative regime.

Overall, the foregoing discussion characterizes Kenyan SCT policy and legislative regime as: largely focused on environmental sustainability and at strategic and tactical implementation levels; driven through subsidiary legislation, constitution and Acts of parliament, and, codes, guidelines, and, plans; and, which mainly target developers/owners/occupiers and government (national and county).

The foregoing discussion is summarized in Figure 4.1 below:

Figure 4.1: Kenyan SCT Policy Regime – Priorities, Instruments, and, Stakeholder Orientation



Source: Author (2023)

4.4 Inherent Shortcomings

Research question three also partly sought to identify (any) shortcomings inherent in the priorities, instruments, and, stakeholder orientation of the Kenyan SCT policy and legislative regime – as discussed in Section 4.3. To facilitate this, the best practice in the three categories was referred to as identified from Chapter two including additional related studies.

On SCT priorities, Section 2.2.3.3 identified the environmental dimension as the bigger facet housing the society, hence the social dimension, which ultimately houses the economic dimension (Esezobor, 2016:28; Joseph, 2019:22). To this regard, the priorities of the Kenyan SCT policy and legislative regime largely reflect this ideal SCT facets nesting. That is: environmental conservation; meeting moral and legal obligations; and, ensuring profitability through resource use efficiency (in order of decreasing prioritization) – see Section 4.3. That notwithstanding, with each pillar/facet having a specific SCT objective (see Section 2.3.2), no pillar/facet would appear inferior to the other. On this front, the regime had largely focused on the environmental pillar/facet – preventing damage and potential irreversible impacts on the natural environment (environmental sustainability). Also inherent in the specific provisions of the various policy and legislative documents is the inclination towards the strategic and tactical levels of implementation with comparatively little focus on the operational level, that is, at the construction project-level and in the short-term (see Section 2.3.2). These two shortcomings have the potential to reduce the regimes' comprehensiveness in terms of sub-optimal: coverage of SCT objectives (economic, environmental, and, social); and, multi-level SCT implementation (long-term industry-level, medium-term firm level, and, short-term project-level). As such, SCT policy and legislative instruments and amendments to existing ones should cover enhanced: incorporation of economic and social SCT objectives – towards a holistic approach to SCT; and, short-term construction project-level of implementation – for comprehensive multi-level approach.

Regarding instruments, Chang (2016:104-105) identified the SC policy system in China as being operationalized using the following instruments: laws; regulations; and, instructions in terms of circulars, notices, plans, opinions, and, interim measures. The Kenyan counterpart has been identified to be driven through: subsidiary legislation/regulations; constitution and Acts of parliament; and, codes, guidelines, and, plans (see Section 4.3). Though generally in concordance with a developed nation such as China, the observed many instruments, and without a centralized database, have the potential to lead to sub-optimal and fragmented, SCT policy and legislative regime-led, practice, policy, and, research. A database with all SCT related policy and legislative documentation could inform comprehensive SCT practice, policy, and, research. The analysis in this chapter, specifically Tables 4.1-4.8 is a good starting point as it outlines the various documents, their specific SCT provisions, and, associated industry stakeholders' obligations. Additionally, the findings in SCT 4.3 highlighted that the instruments mix, regulations and policies, is associated with a top-down approach to SCT. In the inherent need to complement the SCT policies and legislative instruments with bottom-up SCT strategies (see Section 4.3), Chang (2016:106-118) highlighted other roles of SCT policy and legislative instruments in addition to regulation and control as is largely the case for Kenya. These include backing: economic incentives – subsidies, awards, and, financial innovations such as build-operate-transfer which would promote economic sustainability; and/or, other supporting activities – demonstration projects, publicity, standards and evaluation, and, technological innovations such as green construction technologies. They can also be in form of: liability/damage compensation instruments supporting mandated pollution insurance, extended producer responsibility, clear liability rules, and, compensation funds; education and information instruments on awareness drives, information dissemination, eco-labelling, and, publicising non-compliance penalties; and, voluntary instruments on negotiated agreements, voluntary programmes, and, unilateral commitments/contracts (OECD, 2001b:132,135-136; Lafferty, 2004:6) **–** see Section 2.4.5.1.

Lastly, on stakeholder orientation, the findings highlighted that Kenyan SCT policy and legislative regime had comparatively less targeting of: the design stage (professional consultants); construction stage (contractors); and, procurement support entities (suppliers, manufacturers, and, producers) – Section 4.3. This points towards the SCT policy and legislative regime sub-optimally targeting the three stakeholder groups (professional consultants, contractors, and, suppliers/manufacturers/producers) and hence not leveraging their unique roles in the SCT supply chain. This has the potential to minimize the effectiveness and efficiency of the SCT policy and legislative regime in eliciting enhanced industry SCT performance. Section 2.4.1 highlighted that SCT policy should ideally be differentiated according to the project lifecycle: SC project characterization; planning stage; design stage; operations stage; and, procurement in all the stages. Additionally, there is need to target civil society and media having been identified as key societal sectors in governance (Graham *et al.*, 2003:3-5). The role of NGOs and civil society organizations (CSOs) was identified as: driver for SCT change through a watchdog role; partnering with research institutions to craft and disseminate new practices and technologies locally; and, independent monitoring and evaluation of industry performance (Gilham, 2010:126, 140). Media was also identified to have the potential to support SCT in the following ways: relaying information amongst sectors; the consequent opinion shaping; and, promoting accountability (Graham *et al.*, 2003:4) – see Section 2.4.5.2. This has the potential to lead to lack of significant regime buy-in, including active participation, by the said stakeholder groups on recognition of being left-out. As such, future SCT policy and legislative instruments and amendments to existing ones should have enhanced targeting of: professional consultants; contractors; suppliers/manufacturers/producers; NGOs; CSOs; and, media.

While the current policies and legislative instruments in Kenya have provisions geared towards enhanced construction industry SCT performance, the SCT policy and legislative regime is not without areas of improvement. The above discussion highlights a good starting point towards an enhanced and effective SCT policy and legislative regime in Kenya.

4.5 Chapter Summary

This chapter sought to analyze the Kenyan SCT policy and legislative regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings. Identification of the inherent shortcomings was ultimately aimed at making appropriate recommendations for improved SCT policy and legislative regime as an avenue for enhanced and optimized industry SCT performance. The findings indicated that the regime: priorities – primarily focus on environmental sustainability targeting strategic and tactical implementation levels with minimal focus on SCT socio-economic objectives and operational level of implementation which reduces its comprehensiveness; instruments – driven by regulations, the constitution, and, Acts of Parliament, as well as codes, guidelines, and, plans, from multiple sources, primarily aimed at regulation and control and not the other policy instruments functions hence not delivering on their full potential; and, stakeholder orientation – primarily targeting developers/owners/occupiers and government with less focus on the other stakeholder groups and thus not leveraging their specific SCT supply chain roles. The resulting shortcomings were: priorities – need for improved focus on SCT's socio-economic objectives and operational level of implementation; instruments – need for a central database and leveraging them to support economic incentives, supporting activities, liability compensation, education and information, voluntary programs, and, management and planning; and, stakeholder orientation – improved targeting of contractors, suppliers/producers/manufacturers, professional consultants, NGOs, CSOs, and, media. Chapter five next covered quantitative data analysis of field data including the input of key informants.

CHAPTER FIVE

QUANTITATIVE DATA ANALYSIS AND FINDINGS

5.1 Introduction

This chapter reviewed, analysed, and, discussed field data in a bid to answer research questions: one – what is the extent of SCT performance in the Kenyan construction industry; two – what are the prevalent SCT strategies including the ranking of their implementation considerations in the Kenyan construction industry; and, four – how can influences of SCT strategies including their implementation considerations on SCT performance be modelled to enhance SCT performance? Additionally, it also set-out to test the alternative hypothesis that SCT strategies including their implementation considerations (context appropriateness considerations) are significantly related with construction industry SCT performance. It was structured in six main sections: Section 5.2 discussed the response rate of the study survey (using questionnaires targeting key industry stakeholders and interviews for the key informants); Section 5.3 covered respondents' demographics – on the nature of the study respondents; Section 5.4 on data screening – to check on completeness of data including assumptions underlying inferential statistical analysis and data splitting; Section 5.5 on validity and reliability analysis for the questionnaires administered; and, Sections 5.6 and 5.7 on statistical analysis (descriptive and inferential). The findings of this chapter were also to be the basis of the recommendations outlined in chapter six geared towards enhanced industry SCT performance.

5.2 Survey Response Rate

Based on the sample size computed in chapter three (see Sections 3.6.2 and 3.6.3), 312 questionnaires were administered (physically and online) to the key industry stakeholders and nine structured interview invites, for key informants, were sent-out. The questionnaires were administered between 15th November 2022 to 15th January 2023 while the interviews were conducted between 24th January to 15th February 2023. 199 questionnaires were filled and returned (physical and online submissions) and four structured interviews were successfully conducted. Out of the 199 returned questionnaires, two were excluded from further analysis on account of: one being incomplete; and, the other had a single reaction, on the lower extreme of the measurement scale, to all study variables. As such only 197 questionnaires were selected for the next phase of analysis. Consequently, the overall valid response rate was 63% for questionnaires and 44% for the interviews and the breakdown is outlined in Table 5.1 below:

Table 5.1: Survey Response Rate

Respondents Category	Sample Size	Actual Responses	Response Percentage
1. Architects	76	41*	54%
2. Interior designers	9	9	100%
3. Construction managers/project managers	17	17	100%
4. Mechanical engineers	25	15	60%
5. Electrical engineers	33	19	58%
6. Civil/structural engineers	104	55	53%
7. Quantity surveyors	48	41*	85%
Structured questionnaires summary	**312**	**197**	**63%**
8. Key informants	9	4	44%
Structured interviews summary	**9**	**4**	**44%**

** One respondent's response was excluded as explained above.*
Additionally, some respondents identified as belonging to more than one professional category. In response rate computation, such respondents were only counted in their core professional category (as established during questionnaire administration) to avoid double counting.
Source: Field Data (2023)

The study had estimated to require approximately 94 respondents (before adjustment for non-response) and the expected response rate to be 30% (see Section 3.6.2). It can thus be argued that 197 respondents and at 63% response rate was adequate for data analysis having surpassed the two pre-set limits. This also in context of: 30% response rate for delivered and collected questionnaires; 30% or less for internet and intranet administered questionnaires (Saunders *et al.*, 2009:364), as was the case for this study; and, 26% in Oyewobi (2014:113) which was considered acceptable in construction management. Additionally, the failure to achieve the ideal 100% response rate can be attributed, though not limited, to the following: the well documented low response to academic surveys in the construction industry (see Section 3.6.2); for respondents contacted via emails, it is possible that some of the emails were filtered as junk emails and never reached the potential respondents priority email inbox; a significant number of self-employed potential respondents without any known physical location for their business. This necessitated reaching-out out to them on online platforms such as LinkedIn though even then, the overall response rate was very low; and, it is also possible that some of the potential respondents failed to respond to the survey on account of SCT not being an appealing subject to them.

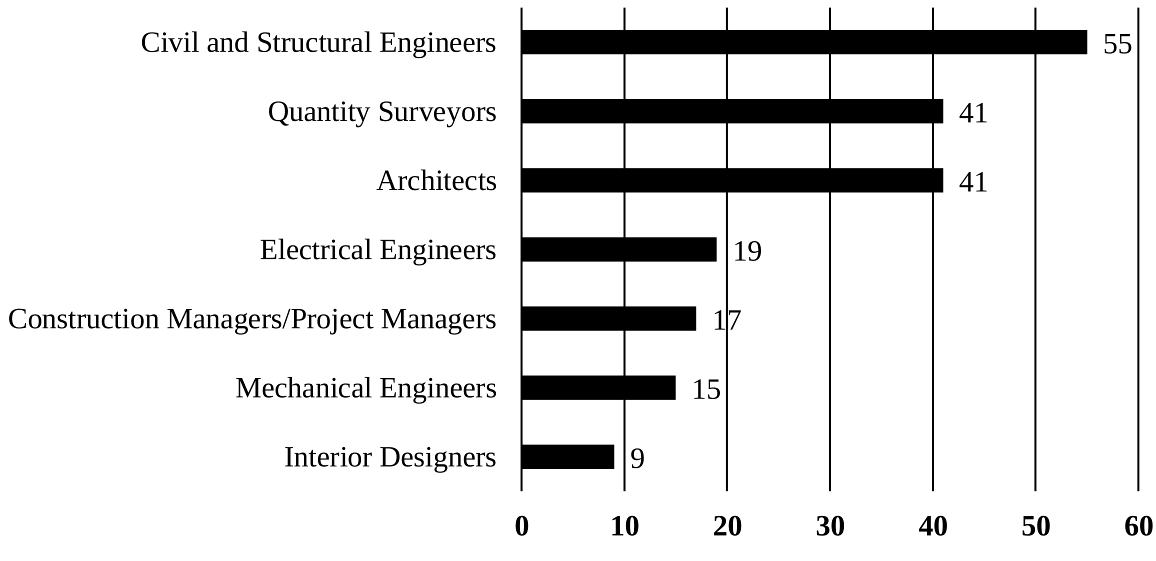
5.3 Respondents Demographics

The survey respondents' demographics were captured through questions one to five of the questionnaire. This was along the following fronts, respondents: professional category(ies); industry practice duration; practice industry market segment(s) – interior design, architectural, and/or, infrastructural; nature of typical construction projects – new, refurbishment/renovation, and/or, redevelopment; and, availability of a practice sustainability policy. The outcome of the analysis of this information is as presented in Sections 5.3.1-5.3.5 below:

5.3.1 Professional Category(ies)

Figure 5.1 below shows the professional categories profile of the study respondents. Out of the 197 respondents: 28% were civil and structural engineers; 21% quantity surveyors; 21% architects; 10% electrical engineers; 9% construction managers/project managers; 8% mechanical engineers; and, 5% interior designers. These findings indicate that indeed the study respondents were from all the sampling unit's categories identified in Section 3.5 (see Section 3.7.2.1). Consequently, all the sampling units participated in the study as anticipated. As such, the resulting data incorporates the perspectives of all key design phase practitioners (as identified in this study), drawn from the Kenyan construction industry.

Figure 5.1: Respondents Professional Categories Profile

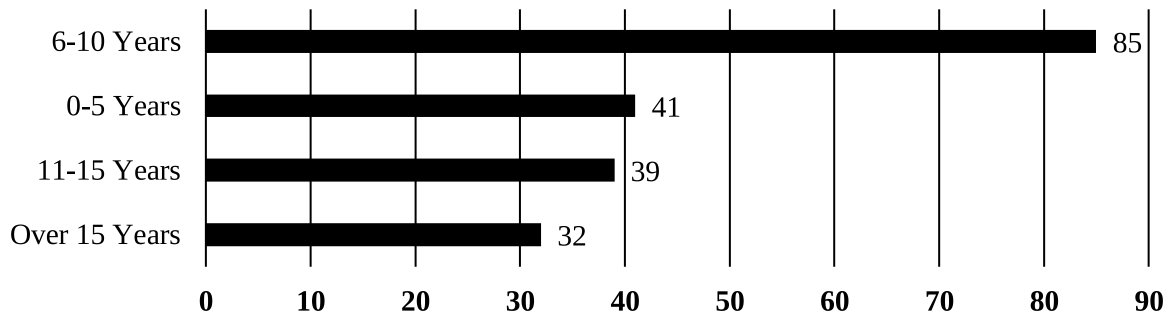


Source: Field Data (2023)

5.3.2 Industry Practice Duration

Figure 5.2 below shows the construction industry practice duration profile of the study respondents. Out of the 197 respondents: 43% had 6-10 years' experience; 21% had 0-5 years' experience; 20% had 11-15 years' experience; and, 16% had over 15 years' experience. In a nutshell 79% of the respondents had over five years' experience in the construction industry.

Figure 5.2: Respondents Industry Practice Duration Profile



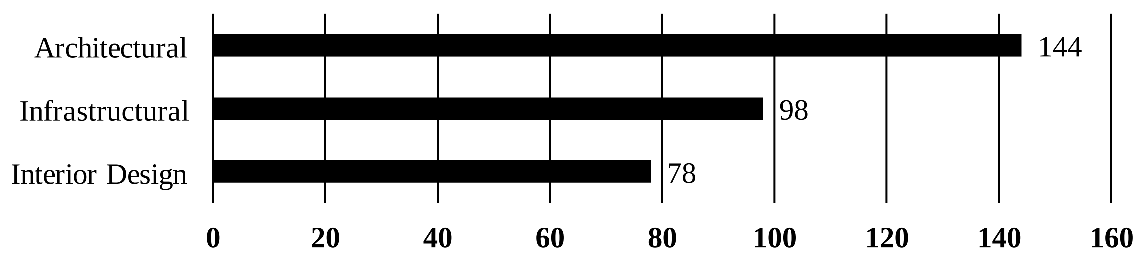
Source: Field Data (2023)

These findings indicate that the study respondents were reasonably familiar with the operation of the construction industry (see Section 3.7.2.1). Consequently, they were appropriate for the study which required them to evaluate the Kenyan construction industry in relation to the study variables.

5.3.3 Industry Market Segment(s)

Figure 5.3 below shows the construction industry market segments profile of the study respondents. Out of the 197 respondents: 73% practiced in the architectural market segment of the construction industry; 50%, infrastructural market segment; and, 40%, interior design market segment. It should be noted that most respondents practiced in more than one of the three construction industry market segments.

Figure 5.3: Respondents Practice Industry Market Segments Profile



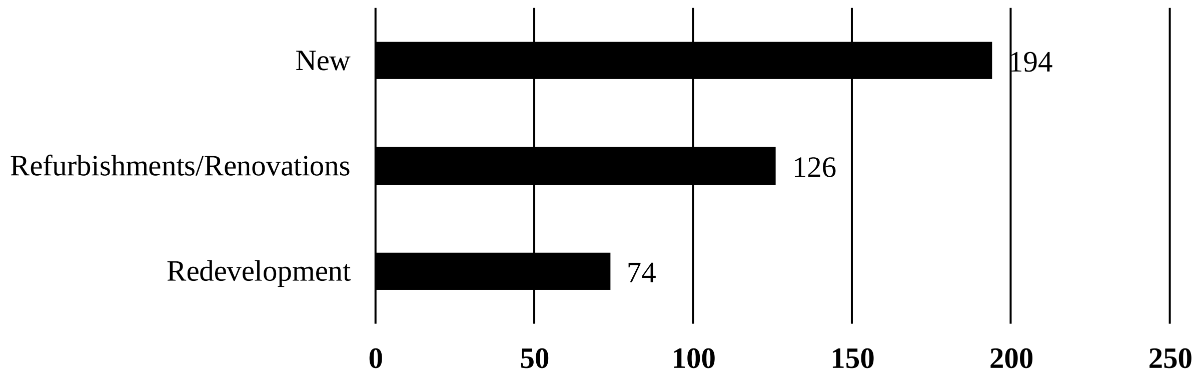
Source: Field Data (2023)

These findings indicate that the study population was representative of the construction industry in terms of the main industry market segments (see Section 3.7.2.1). Consequently, their views in the study responses were representative of the Kenyan construction industry market segmentation.

5.3.4 Nature of Construction Projects Handled

Figure 5.4 below shows the profile of the construction projects handled by study respondents. Out of the 197 respondents: 98% were handling new construction projects; 64% refurbishment/renovation construction projects; and, 38% redevelopment construction projects. It should be noted that most respondents handled more than one of the three categories of construction projects.

Figure 5.4: Respondents Typical Construction Projects Profile



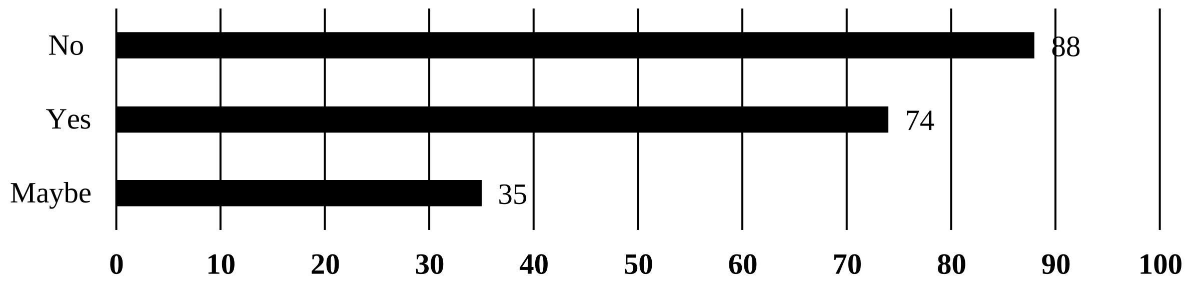
Source: Field Data (2023)

These findings indicate that the study population was representative of the construction industry in terms of the main categories of construction projects (see Section 3.7.2.1). Consequently, their views in the study responses were representative of the Kenyan construction industry projects categorization.

5.3.5 Availability of a Sustainability Policy

Figure 5.5 below shows the availability of a sustainability policy in the respondents' organizations/practices. Out of the 197 respondents: 45% reported not having sustainability policy in their organization/practice; 37% had it; and, 18% were not sure. A majority of the respondents either did not have the policy in their organization/practice or were unsure as to its existence.

Figure 5.5: Availability of Practice Sustainability Policy



Source: Field Data (2023)

These findings indicate that a majority of the respondents lack or were unsure of a formal organizational/practice commitment to sustainability in form of a policy (see Section 3.7.2.1). Consequently, this points towards low formal and voluntary commitment to sustainable construction in the Kenyan construction industry.

5.4 Variables Data Screening

This section sought to: highlight field data splitting approach; identify and manage outliers (if any); assess data normality; assess variables multicollinearity (if any); and, assess homoscedasticity before any further analysis. The resulting findings are covered in Sections 5.4.1-5.4.5 below:

5.4.1 Data Splitting

As recommended by Hair *et al.* (2010) and adopted in Ankrah (2007:147), this study sought to validate the resulting regression model. This was to be achieved through splitting of the field dataset into: analysed sample/model training set (75%); and, held-back sample/model testing set (25%) – see Section 3.9.2. The field dataset of 197 observations was split as summarized in Table 5.2 below:

Table 5.2: Data Splitting

Sample Split	Sample Size	Sample Proportion
Analysed sample/model training set	144	73%
Held-back sample/model testing set	53	27%
Total	**197**	**100%**

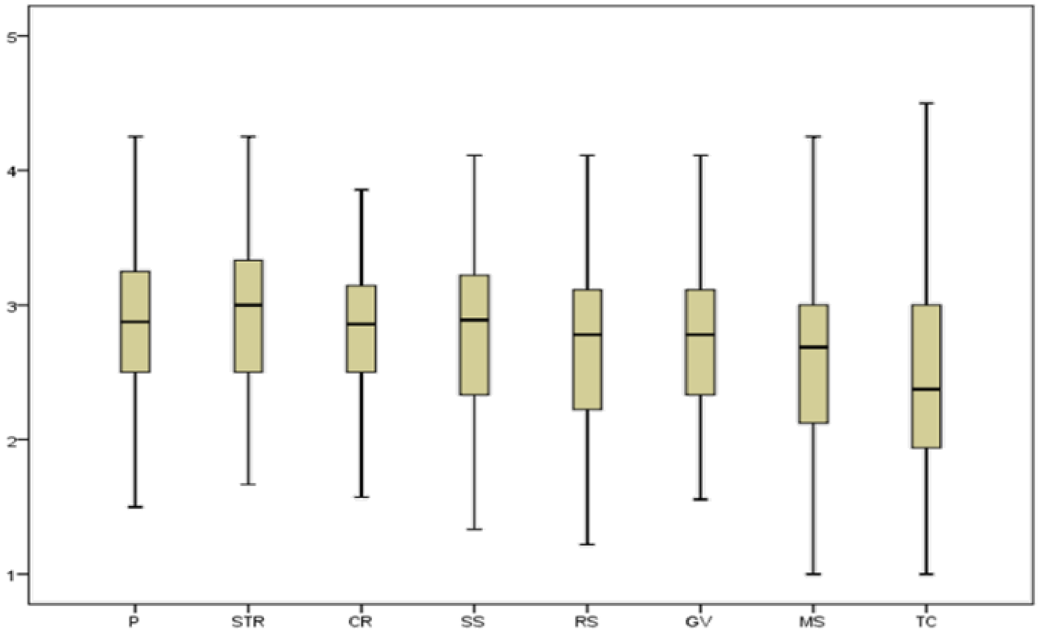
** IBM SPPS v23 sample splitting was based on approximate percentages. As such, a 75%:25% splitting input generated the 73%:27% output.*

Source: Field Data (2023)

5.4.2 Outliers

Outliers *"… lead to inflated error rates and substantial distortions of parameter and statistic estimates when using either parametric or nonparametric tests …"* p.1. This then necessitates their identification and handling (Osborne and Overbay, 2004). To detect outliers in the analysed sample dataset of 75%, boxplot of all the study variables was generated using IBM SPSS v23. See Figure 5.6 below for the resulting plot.

Figure 5.6: Variables Boxplot



<u>Key:</u> P – SCT performance, **STR** – SCT strategies, **CR** – SCT change readiness, **SS** – SCT socio-spatial sensitivity, RS – SCT resilience, **GV** – SCT governance, **MS** – Leveraging MSMEs for SCT, and, **TC** – Leveraging big data and BIM for SCT (the box plots are in this order from left to right)

Source: Field Data (2023)

It is evident from the boxplot that no cases/observations lie below or above the lower or upper limits, respectively, of any given variable. As such, no outliers were detected for the eight variables. The dataset was thus ready for the next analysis step.

5.4.3 Normality

Normality of data is one of the underlying assumptions for multivariate techniques such as multivariate regression analysis in this study. Specifically, normality is necessary for validity of F and *t* statistics (Hair *et al.*, 2010). Normality of the data per variable was assessed using a combination of quantile-quantile (Q-Q) plots and histograms (see the actual plots in appendices eight and nine). Both were generated using IBM SPSS v23. The resultant findings are summarized in Table 5.3 below.

Table 5.3: Histogram and Q-Q Plots Analysis

Variables (Variable Code)	Normality Tests Outcome (Q-Q and Histograms Plots)
SCT performance (P) SCT strategies (STR) SCT change readiness (CR) SCT socio-spatial sensitivity (SS) SCT resilience (RS) SCT governance (GV) Leveraging MSMEs for SCT (MS) Leveraging big data and BIM for SCT (TC)	Q-Q plots *(test 1)* observations: plotted points are largely linear; they are tightly grouped around the line; and, there are no points significantly deviating from the plotted line (outliers). Histogram plots *(test 2)* observations: approximately bell-shaped; histograms are largely symmetrical; majority of the points are within main distribution; and, no histogram appears too peaked. *Interpretation:* Based on the findings from Q-Q plots and histogram plots, the study data (for all the variables) was normally distributed.

Source: Field Data (2023)

5.4.4 Multicollinearity

Multicollinearity exists where independent variables have strong relationships amongst themselves. This makes it difficult to assess their individual contributions to the dependent variable (King'oriah, 2004). The relationships between independent variables were assessed to ensure that no pair of independent variables was strongly correlated as to cloud the assessment of their individual contributions to the dependent variable. This was done using IBM SPSS v23 using the measures of variance inflation factors (VIF) and condition indices. The resultant findings are summarized in Tables 5.4 and 5.5 respectively below.

Table 5.4: Multicollinearity Test 1 – Variance Inflation Factors (VIFs)

Variables (Variable Code)	Variance Inflation Factor (VIF)
SCT strategies (STR)	1.629

Variables (Variable Code)	Variance Inflation Factor (VIF)
SCT change readiness (CR)	2.357
SCT socio-spatial sensitivity (SS)	2.851
SCT resilience (RS)	2.192
SCT governance (GV)	2.343
Leveraging MSMEs for SCT (MS)	2.345
Leveraging big data and BIM for SCT (TC)	1.390

Source: Field Data (2023)

Table 5.5: Multicollinearity Test 2 – Condition Indices

Model	Dimension	Condition Index	Variance Proportions							
			(Constant)	STR	CR	SS	RS	GV	MS	TC
1	1	**1.000**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	**10.529**	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.85
	3	**13.706**	0.17	0.13	0.01	0.02	0.04	0.02	0.22	0.02
	4	**18.001**	0.31	0.12	0.04	0.04	0.20	0.18	0.07	0.00
	5	**19.098**	0.19	0.07	0.00	0.18	0.59	0.04	0.00	0.07
	6	**19.596**	0.00	0.08	0.05	0.17	0.11	0.16	0.58	0.00
	7	**23.426**	0.06	0.57	0.53	0.07	0.05	0.09	0.02	0.01
	8	**26.804**	0.27	0.00	0.37	0.51	0.01	0.50	0.10	0.04

Source: Field Data (2023)

Multicollinearity exists for VIF and condition index values above the thresholds of 5-10 and 10-30 respectively (Kim, 2019). The analysis results tabulated above indicated that all VIF scores are below the lower threshold of 5 and all condition indices below the upper threshold of 30. This clearly indicates that the independent variables were not strongly correlated and thus all proceeded for further analysis.

5.4.5 Homoscedasticity

Homoscedasticity of data is one of the underlying assumptions for multivariate techniques such as multivariate regression analysis in this study. It exists where dependent variable has equal variance levels across the range of predictor variable(s). Its absence, heteroscedasticity, affects standard errors making hypothesis tests too insensitive or stringent (Hair *et al.*, 2010). To assess homoscedasticity, scatterplots of standardized predicted values (ZPRED) on the x-axis and standardized residuals (ZPRESID) on the y-axis and a lowess (locally weighted scatterplot smoothing) curve fitted for each independent variable (see appendix ten). The observations from the plots were as follows: the residuals are randomly scattered around the lowess plot; there is no visible pattern or trend in the points; and, spread of residuals (ZPRESID) is constant across the range of predicted values (ZPRED). These observations are in line with the expected indicators of homoscedasticity. As such, the data complied with the assumption of homoscedasticity and was thus appropriate for multivariate techniques such as multivariate regression analysis in this study.

5.5 Validity and Reliability Analysis

Hair *et al.* (2010) recommends the assessment of degree of measurement errors, in a given measure, through the approaches of validity and reliability and in that order. To ensure the soundness of data collection instrument, questionnaire, and the resulting measurements, their validity and reliability were assessed in line with the (pre-set) measures in Section 3.8. The outcome of this analysis is as presented in Sections 5.5.1-5.5.2 below:

5.5.1 Validity Analysis

Convergent validity was assessed using the measures of composite reliability (CR), minimum factor loading, and, average variance extracted (AVE) computed using a combination of IBM AMOS v23 (for factor loading computations) and Microsoft Excel 2019 (for computing CR and AVE from factor loadings). The resultant findings, summarized in Table 5.6 below, were as follows: CR scores were above the acceptance level of 0.7; six out of eight minimum factor loadings (for P, CR, SS, RS, MS, and, TC) were above the acceptance level of 0.3; and, AVE for four out of eight variables (SS, RS, MS, and, TC) was approximately at or above the acceptance level of 0.5. According to the seminal Fornell and Larcker (1981:46) and Malhotra *et al.* (2017:808), on the basis of only CR, one may conclude that the convergent validity is sufficient even if AVE is less than 0.5. Malhotra *et al.* (ibid:808) attributes this to AVE being a comparatively conservative measure of convergent validity. On the basis of this postulation, given that variables P, STR, CR, and, GV had composite reliability scores above the 0.7 threshold, despite their respective AVE scores being marginally below the 0.5 threshold, this study concluded that convergent validity was adequate. As such, in a nutshell, the foregoing discussion clearly highlights that convergent validity for all the study variables was adequate.

This means that the set of indicators for any given variable in the study was measuring intended variable (See Hair *et al.*, 2010).

Table 5.6: Variables Validity (Convergent) Analysis

Variables (Variable Code)	Composite Reliability (CR)	Minimum Factor Loading	Average Variance Extracted (AVE)
SCT performance (P)	0.825	0.437	*0.382
SCT strategies (STR)	0.883	*0.168	*0.404
SCT change readiness (CR)	0.889	0.311	*0.373
SCT socio-spatial sensitivity (SS)	0.894	0.664	0.485
SCT resilience (RS)	0.879	0.499	0.450
SCT governance (GV)	0.813	*0.239	*0.369
Leveraging MSMEs for SCT (MS)	0.875	0.503	0.487
Leveraging big data and BIM for SCT (TC)	0.940	0.692	0.665

* Score below the recommended threshold.

Source: Field Data (2023)

Discriminant validity was assessed using: Fornell and Larcker (1981) criterion (see Section 3.8.2) – AVE square roots were computed using Microsoft Excel 2019 and correlation coefficients using IBM SPSS v23; and, Heterotrait-Monotrait (HTMT) ratios (as an additional measure as recommended by Henseler *et al.* (2015)) – also computed using a combination of IBM AMOS v23 (to compute correlation between indicators) and Microsoft Excel 2019 (to compute HTMT ratios). The resultant findings are summarized in Tables 5.7 and 5.8 respectively below. All the AVE square roots were greater than variable pair correlation coefficients, as recommended by Fornell and Larcker (ibid) as evidence of discriminant validity, save for: SCT socio-spatial sensitivity and change-readiness (SS-CR); SCT governance and socio-spatial sensitivity (GV-SS); and, leveraging MSMEs in SCT and SCT governance (MS-GV) – see Table 5.7. Their discriminant validity insufficiency was by small margins of 0.053, 0.076, and, 0.051 respectively. On the other hand, HTMT ratios were less than threshold of 0.85-0.90, as recommended in Henseler *et al.* (ibid:121), for all construct pair correlations – see Table 5.8. However, Fornell and Larcker (ibid) criterion has been identified to be: comparatively stringent measure of discriminant validity (Voorhees *et al.*, 2015:124; Wang and Netemeyer, 2002:222); and, unreliable in detecting lack of discriminant validity (Henseler *et al.*, ibid:115,120). In light of these criticisms to Fornell and Larcker (ibid) criterion and its conflicting results with the HTMT approach in this study, the HTMT approach findings were adopted as the main measure of discriminant validity in this study.

Table 5.7: Discriminant Validity Test 1 – Fornell and Larcker (1981) Approach

	P	STR	CR	SS	RS	GV	MS	TC
P	**0.618**							
STR	0.576	**0.636**						
CR	0.608	0.585	**0.611**					
SS	0.537	0.539	*0.664	**0.696**				
RS	0.521	0.426	0.588	0.625	**0.671**			
GV	0.383	0.381	0.515	*0.683	0.569	**0.607**		
MS	0.558	0.392	0.601	0.634	0.629	*0.658	**0.698**	
TC	0.268	0.266	0.374	0.326	0.478	0.423	0.402	**0.816**

* Correlation coefficient > AVE square root.

AVE square root values are in bold and the correlation coefficients are not.

Source: Field Data (2023)

Table 5.8: Discriminant Validity Test 2 – HTMT Ratios Approach

	P	STR	CR	SS	RS	GV	MS	TC
P								
STR	0.708							
CR	0.698	0.656						
SS	0.616	0.592	0.752					
RS	0.602	0.501	0.669	0.711				
GV	0.420	0.356	0.466	0.705	0.509			
MS	0.485	0.356	0.466	0.466	0.460	0.533		
TC	0.278	0.283	0.362	0.371	0.509	0.305	0.339	

Source: Field Data (2023)

As such, in a nutshell, Table 5.8 clearly highlights that discriminant validity for all the study variables was adequate. This means that each individual variable was sufficiently different from the others in the study (see Hair *et al.*, 2010).

5.5.2 Reliability Analysis

Reliability was assessed using the measure of Cronbach's alpha as recommended by Hair *et al.* (2010). It was computed using IBM SPSS v23. The resultant findings are summarized in Table 5.9 below:

Table 5.9: Variables Reliability Analysis

Variables (Variable Code)	Cronbach's Alpha (No. of Indicators)
SCT performance (P)	0.827 (8)
SCT strategies (STR)	0.881 (12)
SCT change readiness (CR)	0.888 (14)
SCT socio-spatial sensitivity (SS)	0.893 (9)
SCT resilience (RS)	0.874 (9)
SCT governance (GV)	0.843 (9)
Leveraging MSMEs for SCT (MS)	0.890 (8)
Leveraging big data and BIM for SCT (TC)	0.941 (8)

Source: Field Data (2023)

With the Cronbach's alpha for every construct being above the minimum 0.7 threshold, as recommended by George and Marley (2003:231) and Hair *et al.* (2010), it is evident that reliability was achieved. Specifically, all the study constructs had over 0.8 Cronbach's alpha score which George and Marley (ibid) consider good internal consistency reliability. This means that the degree of consistency between the indicators of each variable in this study was acceptable.

5.6 Descriptive Statistics Analysis

Next, the descriptive statistics of the eight composite study variables, namely: SCT performance; SCT strategies; SCT change readiness; SCT socio-spatial sensitivity; SCT resilience; SCT multi-level governance; leveraging MSMEs in SCT; and, leveraging big data and BIM in SCT, were assessed. Each variable was measured using at least eight indicators (see Section 3.9.2 for the rationale). The specific indicators were: generated from the conceptual framework adopted for the study (see Section 2.7); and, backed by adopted theoretical framework (see Section 2.6) and reviewed sustainable construction literature (see Sections 2.2-2.5). It should be noted that: each variable had its indicators measured on a 5-point Likert scale (1 – very small, 2 – small, 3 – average, 4 – large, and, 5 – very large); additionally, the descriptive statistics assessed, for any given variable, included – variable indicators, indicators and variable means (Ms), indicators and variable standard deviations (SDs), and, variable indicators ranking; and, the means were to be interpreted as follows: below average (very small 1.0000-1.9999 and small 2.0000-2.9999); average 3.0000-3.9999; and, above average (large 4.0000-4.9999 and very large 5.0000). The outcome of this analysis is discussed in detail in Sections 5.6.1-5.6.9 below.

5.6.1 Industry SCT Performance

This study sought to assess SCT performance in Kenya. This dependent variable, industry SCT performance (P), was measured using eight indicators (P1-P8) and Table 5.10 below summarizes the resulting descriptive statistics.

Table 5.10: Industry SCT Performance

Industry SCT Performance (P) Indicators	M	SD	Rank
P4 – There is demand for sustainability compliant processes and products	3.1528	0.92607	**1**
P2 – There is change in industry stakeholders' perceptions towards support of sustainability compliant products	2.9514	0.80497	**2**
P1 – There is change in industry stakeholders' perceptions towards support of sustainability compliant processes	2.9306	0.76325	**3**
P8 – There is compliance with moral and legal obligations to stakeholders, such as government and site employees	2.8542	1.00327	**4**
P6 – There is resources (labour, materials, finance, space, plant, and, time) use efficiency	2.7986	0.94299	**5**
P3 – There is use of technology to overcome limits to exploitation of natural resources employed in construction such as water, land, and, building materials	2.7222	0.86457	**6**

Industry SCT Performance (P) Indicators	M	SD	Rank
P5 – There is supply of sustainability compliant processes and products	2.6944	0.87927	**7**
P7 – There is water, land, energy, and, materials conservation	2.6389	0.88981	**8**
Overall Construct (N=144)	**2.8429**	**0.59642**	

Source: Field Data (2023)

Overall, the survey findings indicated a small/below average (M=2.8429) extent shift from the conventional and largely unsustainable to comparatively sustainable construction practices by the Kenyan construction industry. Consequently, SCT performance in Kenya can be said to be sub-optimal. This affirms the postulation that construction industries globally are yet to fully transition towards SC by Glass (2012), Aghimien *et al.* (2018:2385), and, Willar *et al.* (2021:110) was true for Kenya. The overall SD score of 0.59642 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. P4 had the highest mean score (M=3.1528) indicating that respondents perceived strongest shift towards SC, SCT, in terms of demand for sustainability compliant processes and products. This suggests that while the overall SCT performance was sub-optimal, there was growing demand for SC processes and products. In contrast, P7 had the lowest mean score (M=2.6389) indicating that the respondents perceived the least shift towards SC in terms of water, land, energy, and, materials conservation. This implies that water, land, energy, and, materials conservation was a major SCT sub-optimality front in Kenya. In a nutshell, the ranking of industry SCT performance in Kenya was P4, P2, P1, P8, P6, P3, P5, and, P7 in order of decreasing performance.

Interestingly, demand for SC compliant products and processes was observed to be much greater than supply (see P4 and P5). As argued by Onuaha *et al.* (2017:23-24), this comparatively high demand can be explained by increased personal and selfless, social responsibility, and, economic and financial motivations. On the other hand, as highlighted by Onuaha *et al.* (2016:500-502) and Diyana and Abidin (2013:916-917), the comparatively low supply can be explained by lack of: better returns; project financing incentives; market strategy motivations – operational advantage and marketing niche; lifecycle cost savings; attractive tax incentives; SC skills for the various project phases; supporting government policies; SC certifications, awards and recognition; and, ethical motivations. Additionally, the performance along the three facets of SC, in order of decreasing performance, ranked as social, economic, and, environmental (see P8, P6, and, P7). This finding is in line with the postulation by Du Plessis (2002:21) that socio-economic sustainability dimensions have received more attention in practice compared to the biophysical dimension which has been largely left at research and scholarly level. It is however in part contradiction with the finding in Joseph (2019:83) where ranking of the key SC considerations in the Kenyan construction industry ranked as social, environmental, and, economic in order of decreasing importance. This can be attributed to the small sample size of 46 respondents adopted in the said study which may have limited the generalizability of the findings. Lastly, the following were also observed: an almost average change in perceptions in support of SC products and processes (see P2 and P1); and, a comparatively lower use of technology to overcome limits to exploitation of natural resources employed in construction (see P3).

Additionally, key informants highlighted the following for the Kenyan construction industry: lack of an existing holistic SCT performance assessment frameworks/measures thus challenging to objectively report on SCT performance; the number of green rated buildings appeared to be an objective SCT performance assessment (related) yardstick; the publicly available data on number of green buildings was still suppressed due to the fact that developers had to give consent for publicization of such information; and, that overall, SCT was still nascent.

5.6.2 SCT Strategies

This study sought to assess SCT strategies employed in Kenya. This independent variable one, SCT strategies (STR), was measured using 12 indicators (STR1-STR12). Table 5.11 below summarizes the resulting descriptive statistics.

Table 5.11: SCT Strategies

SCT Strategies (STR) Indicators	M	SD	Rank
STR5 – Property value enhancement – Deliberate effort to enhance property value such as through artistic/architectural design	3.3333	0.97522	**1**

SCT Strategies (STR) Indicators	M	SD	Rank
STR12 – Enhancing functionality – Ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently	3.2778	0.96400	**2**
STR2 – Development cost efficiency	3.1042	0.94402	**3**
STR8 – Energy conservation – Aimed at rationalized use of energy	3.0486	0.90322	**4**
STR3 – Operational cost rationalization	3.0000	0.88500	**5**
STR10 – Enhancing human well-being – Protecting health and comfort	2.9722	0.97482	**6**
STR6 – Water conservation – Water use rationalization	2.9653	0.83132	**7**
STR9 – Materials conservation – Materials use rationalization	2.8958	0.80834	**8**
STR7 – Land conservation – Geared towards rationalized use of land	2.8333	0.93868	**9**
STR1 – Labour productivity enhancement	2.7986	0.81575	**10**
STR11 – Enhancing resilience against disasters such as fires, floods, earthquakes, and, crime prevention through design	2.7569	0.91794	**11**
STR4 – Demolition and materials recovery cost consideration	2.0208	0.78863	**12**
Overall Construct (N=144)	**2.9172**	**0.59028**	

Source: Field Data (2023)

Overall, the survey findings indicated a small/below average (M=2.9172) extent of employing the listed SCT strategies in the Kenyan construction industry. Consequently, this points towards minimal/sub-optimal adoption of the listed strategies to achieve SCT in the Kenyan construction industry. With the observed SCT sub-optimality in Kenya (Section 5.6.1), these findings are consistent with the postulation by: Vanegas and Pearce (2000:406, 408) on the primacy of convincing need for change and strategy for successful SCT; and, Cruz *et al.* (2019) that SCT objectives (environmental and socio-economic) are by themselves not explicit on how to achieve SCT – see Section 2.3.2. This highlights a good starting point towards SCT in Kenya by active adoption of the listed strategies. The overall SD score of 0.59028 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. STR5 had the highest mean score (M=3.3333) indicating that respondents perceived property value enhancement as the most commonly adopted SCT strategy. This suggests that irrespective of the well document benefits of SC, economic considerations are a primary factor in its adoption in Kenya. On the other hand, STR4 had the lowest mean score (M=2.0208) indicating that the respondents perceived demolition and materials recovery cost consideration to be the least considered SCT strategy in Kenya. This implies minimal, if any, SC consideration for the decommissioning/demolition phase of constructed facilities on Kenya. In summary, the ranking of SCT strategies in Kenya was STR5, STR12, STR2, STR8, STR3, STR10, STR6, STR9, STR7, STR1, STR11, and, STR4 in order of decreasing adoption.

The ranking of economic SCT strategies, in order of decreasing adoption was: property value enhancement; development cost efficiency; operational cost rationalization; labour productivity enhancement; and, demolition and materials recovery cost consideration (see STR5, STR2, STR3, STR1, and, STR4). The environmental SCT strategies in order of decreasing adoption were identified as: energy conservation; water conservation; materials conservation; and, land conservation (see STR8, STR6, STR9, and, STR7). Lastly, the social SCT strategies in order of decreasing adoption were identified as: enhancing functionality; enhancing human well-being; and, enhancing resilience against disasters such as fires, floods, earthquakes, and, crime prevention through design (see STR12, STR10, and, STR11). The prevalent SCT strategies (M=/>3) ranked in order of decreasing adoption were: property value enhancement; enhancing functionality; development cost efficiency; energy conservation; and, operational cost rationalization, that is, STR5, STR12, STR2, STR8, and, STR3. They can thus be said to be force behind the developing SCT. A closer look at them narrows down the motivations towards increased demand for sustainability compliant products and processes from increased personal and selfless, social responsibility, and, economic and financial motivations (see Section 5.6.1 as adopted from Onuaha *et al.*, 2017:23-24), to primarily economic and financial motivations.

An average of the respective indicator means highlighted that the ranking of the strategies per SCT objective, in order of decreasing adoption, was: social (M=3.0023); environmental (M=2.9358); and, economic (M=2.8514). This is in part contradiction with SCT performance (see Section 5.6.1) which, in order of decreasing performance, was social, economic, and, environmental. This highlights a mismatch between SCT strategies and performance pointing towards that the former cannot fully account for the latter on their own. This supports the theoretical stance, of STS theory (see Section 2.6.6), adopted that SCT performance is pegged on joint optimization of SCT strategies and their social implementation considerations. Additionally, key informants highlighted the specific methods supporting the SCT strategies in Kenya included: design (passive and active/mechanical) including the increased onboarding of BIM in SC endeavours by design phase practitioners; SC advocacy, certifications, and, capacity building such as done by KGBS; energy auditing as backed by *The Energy (Energy management) Regulations 2012 (KE)*; minimum (appliances) energy performance standards as backed by *The Energy (Appliance's energy performance and labelling) Regulations 2016 (KE);* and, increased inflow of SC compliant materials and methods/technologies such as 3D printing. However, even with this inflow, the requisite local technical capacity building had a long way to go.

5.6.3 SCT Change Readiness

This study sought to assess SCT change readiness in Kenya. This independent variable two, SCT change readiness (CR), was measured using 14 indicators (CR1-CR14). Table 5.12 below summarizes the resulting descriptive statistics.

Table 5.12: SCT Change Readiness

SCT Change Readiness (CR) Indicators	M	SD	Rank
CR12^{O} – Top management has positive attitude regarding change towards sustainable construction	3.2083	0.91510	**1**
CR7^{T} – Typically, there is well articulated project team level sustainable construction change vision	3.0972	0.70284	**2**
CR6^{I} – SCT drive (in terms of: desire for change; convincing vision; and, practical first steps) outweigh SCT resistance	3.0278	0.95306	**3**
CR13^{O} – Organizational culture is characterized by support to development and adaptability	2.9722	0.81887	**4**
CR9^{T} – There is supportive change climate	2.9722	0.90023	**5**
CR10^{T} – Project team members are able to articulate themselves on SCT without fear of negative consequences related to trust and respect accorded to them by other project team members	2.9375	0.98392	**6**
CR5^{I} – Stakeholders have positive personal attributes such as risk tolerance and positive self-concept	2.8889	0.87794	**7**

SCT Change Readiness (CR) Indicators	M	SD	Rank
CR8[T] – Project team leadership is conscious to collective emotional response towards sustainable construction change	2.7986	0.83272	**8**
CR3[I] – There is active stakeholders' participation on SCT	2.7222	0.90410	**9**
CR2[I] – There is effective sustainable construction change communication	2.6806	0.89014	**10**
CR11[T] – There are supportive emotional reactions to sustainable construction change	2.6597	0.93242	**11**
CR4[I] – There is SCT supportive leadership influence	2.6181	0.86902	**12**
CR14[O] – There are supportive organizational procedures and policies for handling emotional responses to SCT	2.4375	0.79964	**13**
CR1[I] – There are SCT supportive management processes such as organizational socialization and recruitment	2.2708	0.86274	**14**
Overall Construct (N=144)	**2.8065**	**0.56007**	

[O] Organizational level SCT change readiness indicator
[T] Project team level SCT change readiness indicator
[I] Individual stakeholder level SCT change readiness indicator
Source: Field Data (2023)

Overall, the survey findings indicated a small/below average (M=2.8065) extent of change readiness towards SCT in the Kenyan construction industry. This can be attributed to the big scale of change, as is the case of SCT, which Rafferty *et al*. (2013) associates with lower overall change readiness evaluation judgement. Consequently, this points towards SCT change readiness that is still in its initial/formative stages and which would need SCT scale of change to be divided into small chunks, such as per SCT objective, for enhanced change readiness. With the observed SCT sub-optimality in Kenya (Section 5.6.1), these findings are consistent with the postulations by Dannemiller and Jacobs (1992), Kotter (1995), and, Rafferty *et al.* (2013) on the direct relationship between change readiness and successful change (such as SCT in this context). This highlights the need to intentionally engage in change readiness building at the individual, project team, and, organizational levels for enhanced and ultimately optimal and enhanced SCT in Kenya. The overall SD score of 0.56007 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. CR12 had the highest mean score (M=3.2083) indicating that, at organizational level, top management had positive attitude regarding change towards SC. This suggests that the management of construction industry stakeholders' organizations were reasonably ready to actively engage in SCT.

On the other hand, CR1 had the lowest mean score (M=2.2708) indicating that the respondents perceived change readiness to be lowest on the availability of supportive management processes such as organizational socialization and recruitment front. This implies that little was being done with reference to individual industry stakeholders, such as in terms of socialization and recruitment, in Kenya, to ensure enhanced SCT. In summary, the ranking of industry SCT change readiness in Kenya was CR12, CR7, CR6, CR13, CR9, CR10, CR5, CR8, CR3, CR2, CR11, CR4, CR14, and, CR1 in order of decreasing readiness. An average of the respective indicator means highlight that the ranking of overall SCT change readiness at the three levels, in order of decreasing readiness, was: project team level (M=2.8930); organizational level (M=2.8727); and, individual level (M=2.7014). This highlights how SCT change-readiness building efforts should be prioritized, that is project team level, organizational level, and, individual stakeholder level in order of increasing priority.

At the organizational level, SCT change readiness was ranked as follows in order of decreasing readiness: top management has positive attitude regarding SCT; organizational culture is characterized by support to development and adaptability; and, there are supportive organizational procedures and policies for handling emotional responses to SCT (see CR12, CR13, and, CR14). At the construction project team level, SCT change readiness was ranked as follows in order of decreasing readiness: there is well articulated project team level SC change vision; there is supportive change climate; project team members are able to articulate themselves on SCT without fear of negative consequences related to trust and respect accorded to them by other project team members; project team leadership is conscious to collective emotional response towards SCT; and, there are supportive emotional reactions to SCT (see CR7, CR9, CR10, CR8, and, CR11). Lastly, at the individual stakeholder level, SCT change readiness was ranked as follows in order of decreasing readiness: SCT drive outweigh SCT resistance; stakeholders have positive personal attributes such as risk tolerance and positive self-concept; there is active stakeholders' participation on SCT; there is effective SC change communication; there is SCT supportive leadership influence; and, there are SCT supportive management processes such as organizational socialization and recruitment (see CR6, CR5, CR3, CR2, CR4, and, CR1).

Additionally, key informants highlighted that: at the individual stakeholder level, SCT drive tended towards increasing as inferred from the growing number of green rating tools trained professionals quarterly such as by KGBS; the SCT readiness of individual construction team stakeholders such as skilled and unskilled workers was still low; developers (individuals and organizations) main focus tended towards the economic bottom line with overall very low SCT readiness; at the organizational level, SCT readiness was largely good on paper but totally lacking in implementation; and, the need for enhanced SCT awareness to enhance SCT change readiness.

5.6.4 SCT Socio-Spatial Sensitivity

This study sought to assess SCT socio-spatial sensitivity in Kenya. This independent variable three, SCT socio-spatial sensitivity (SS), was measured using nine indicators (SS1-SS9). Table 5.13 below summarizes the resulting descriptive statistics.

Table 5.13: SCT Socio-Spatial Sensitivity

Industry SCT Socio-Spatial Sensitivity (SS) Indicators	M	SD	Rank
SS3 – There is design of spaces and places for sustainability	3.2292	0.97320	**1**
SS7 – There is creation of sustainable construction value *(health, societal, economic, and, environmental)* locally	3.2014	0.97220	**2**
SS6 – There is engagement of local institutions, such as learning institutions, professional associations, and, trade associations, on sustainable construction approaches	2.9861	0.98936	**3**
SS4 – There is incorporation of local decision making in promotion and execution of sustainable construction approaches	2.8403	0.89804	**4**
SS2 – There is geographical differentiation *(local, regional, and, national)* and integration of sustainable construction approaches	2.6528	0.83891	**5**
SS1 – There is adaptation of generic sustainable construction approaches and tools for local appropriateness	2.6319	0.82569	**6**
SS9 – There is consideration of sustainable change perceptions by the general public	2.6250	0.91510	**7**

Industry SCT Socio-Spatial Sensitivity (SS) Indicators	M	SD	Rank
SS5 – There is intentional effort to assist people negatively affected by: SCT; and, impacts of unsustainable construction practices such as victims of site accidents	2.5347	0.92300	**8**
SS8 – There is flexible and accountable SCT goal setting in relation to change of priorities over the long term	2.4514	0.84315	**9**
Overall Construct (N=144)	**2.7948**	**0.66878**	

Source: Field Data (2023)

Overall, the survey findings indicated a small/below average (M=2.7948) extent of SCT socio-spatial sensitivity in the Kenyan construction industry. Consequently, this indicates minimal/below average extent of social-spatial appropriateness in SCT approaches in Kenya. With the observed SCT sub-optimality in Kenya (Section 5.6.1), these findings are aligned with the postulation by Marsden (2012:215) on the centrality of specific people – locale relationships in SD approaches success. This highlights the need to ensure SCT approaches adopted are both socially and spatially appropriate for enhanced and ultimately optimal SCT in Kenya. The overall SD score of 0.66878 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. SS3 had the highest mean score (M=3.2292) indicating the highest level of SCT approaches socio-spatial appropriateness in design of spaces and places for sustainability in Kenya. Despite the observed SCT sub-optimality, low change readiness level and low socio-spatial appropriateness level of adopted SCT approaches, the findings above indicated uptake of SCT in design of places and spaces. On the other hand, SS8 had the lowest mean score (M=2.4514) indicating that the respondents perceived SCT social-spatial sensitivity to be lowest on flexible and accountable SCT goal setting in relation to change of priorities over the long-term front. This implies temporal insensitivity in terms of SCT goals setting and accountability in Kenya. In summary, the ranking of industry SCT approaches socio-spatial appropriateness in Kenya was SS3, SS7, SS6, SS4, SS2, SS1, SS9, SS5, and, SS8 in order of decreasing socio-spatial appropriateness.

From the findings above, it appears that the Kenyan construction industry was dealing with sustainability challenges (eliminating or reducing) primarily through changing physical settings. This was supported by the observed: availability of numerous green rating tools such as IFC EDGE, LEED, and, Green Star; training of design phase practitioners on the said tools (NCA, 2020:25); and, increase in number of green buildings (GBIG, 2021). They additionally indicate comparatively less focus on the additional approaches (in relation to place-based interventions) of: changing one's behaviour; and/or, changing the behaviour of others – those with power or authority are more inclined towards influencing others than those without, as highlighted by Proshansky *et al.* (1983). A good example of this in Kenya was the part attribution of high electricity consumption by buildings in EA to inconsiderate building users' behaviour (UNEP, 2018:21). Further, spatial and temporal differentiation/sensitivity in SCT approaches had also received comparatively less focus in Kenya (see SS2 and SS8). Spatially, SCT can be differentiated and integrated along local, regional, and, national scales as recommended by Levin-Keitel *et al*. (2018) for STs. On the temporal front, there was need for active consideration of changes in the socio-spatial peculiarities in which place-based interventions, such as SCT in this case, are executed to ensure their appropriateness as highlighted in Proshansky *et al.* (1983).

Additionally, key informants highlighted that: the environmental aspect of SCT generally required comparatively greater spatial localization; there were two locally developed green building rating tools – Green Mark and Safari Green; LEED and Green Star green building rating tools were localized for Kenyan adoption; IFC EDGE took into account climate data for different towns in Kenya, regulations, and, building code in developing baselines including regular updates; some of the ways in which social appropriateness was incorporated included: design – such as vernacular architecture, and, construction – local sourcing of materials and labour including training locals on how to use SC technologies; and, government bureaucracy was a major hinderance to adoption of new technologies and materials – it took at least 18 months to get requisite standardization approvals.

5.6.5 SCT Resilience

This study sought to assess SCT resilience in Kenya. This independent variable four, SCT resilience (RS), was measured using nine indicators (RS1-RS9). Table 5.14 below summarizes the resulting descriptive statistics.

Table 5.14: SCT Resilience

Industry SCT Resilience (RS) Indicators	M	SD	Rank
RS8 – Stakeholders' have the ability to proactively adapt or reduce vulnerabilities associated with possible future SCT scenarios	2.9792	1.04090	**1**
RS3 – There is variety of sustainable construction processes and products	2.8819	0.87303	**2**
RS9 – There is creation of new sustainable construction options and ideas through innovation and experimentation	2.8611	0.88981	**3**
RS6 – There is stakeholders networking for bottom-up SCT	2.7639	1.03766	**4**
RS4 – There is sustainable construction scales (industry long-term, organizational medium-term, and, project-level short-term) relationship awareness	2.6736	0.81789	**5**
RS5 – There is sustainable construction indicators monitoring for timely and appropriate planning and action	2.5903	0.89609	**6**
RS7 – There is decentralized SCT decision-making	2.4931	0.87703	**7**
RS2 – There is sustainable construction supply chain decentralization	2.4444	0.82596	**8**
RS1 – There are spare/reserve resources (human and non-human) for sustainable construction change	2.2708	0.96960	**9**
Overall Construct (N=144)	**2.6620**	**0.64707**	

Source: Field Data (2023)

Overall, the survey findings indicated a small (M=2.6620) extent of SCT resilience in the Kenyan construction industry. This points towards minimal (below average) capacity in terms of preparedness and response to industry disturbances associated with SCT in Kenya. With the observed SCT sub-optimality in Kenya (Section 5.6.1), these findings are in line with the postulation that enhanced resilience leads to enhanced sustainability (Marchese *et al.*, 2018). This highlights the need to ensure enhanced resilience of the desired SCT regime in Kenya. The overall SD score of 0.64707 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation score indicating that individual indicators were fairly consistent and close to the mean. RS8 had the highest mean score (M=2.9792) indicating the highest level of SCT resilience in stakeholders' ability to proactively adapt or reduce vulnerabilities associated with possible future SCT scenarios. This finding indicated an almost average capacity of industry stakeholders to ensure SCT proactively. On the other hand, RS1 had the lowest mean score (M=2.2708) indicating that the respondents perceived SCT resilience to be lowest on spare/reserve resources (human and non-human) for sustainable construction change front. This highlights the need to ensure there are resources (human and non-human) dedicated to realization of SCT in Kenya. In summary, the ranking of industry SCT resilience indicators in Kenya was RS8, RS3, RS9, RS6, RS4, RS5, RS7, RS2, and, RS1 in order of decreasing resilience.

The structural elements of the ways in which the Kenyan construction industry was engaging in for better-than-expected sustainability outcomes in the wake of lagging SCT, structural resilience, ranked as follows in order of decreasing onboarding: SC processes and products variety; SC supply chain decentralization; and, spare/reserve resources (human and non-human) for SC change (see RS3, RS2, and, RS1). Further, elements of industry interaction with its environment on SCT, integrative resilience, ranked as follows in order of decreasing onboarding: stakeholders networking for bottom-up SCT; SCT scales (industry long-term, organizational medium-term, and, project-level short-term) relationship awareness; and, SCT indicators monitoring for timely and appropriate planning and action (see RS6, RS4, and, RS5). Lastly, transformability elements, transformative resilience, ranked as follows in order of decreasing onboarding: stakeholders' ability to proactively adapt or reduce vulnerabilities associated with possible future SCT scenarios; creation of new SC options and ideas through innovation and experimentation; and, decentralized SCT decision-making/distributed governance (see RS8, RS9, and, RS7).

Overall, their ranking, in order of decreasing prominence, based on the average of mean scores for respective indicators was: transformative resilience (M=2.7778) – capacity to engineer a totally new SCT regime when the existing one is undesirable economically, ecologically, and/or, socially – in response or in anticipation (see Bresch *et al.*, 2014; Walker *et al.*, 2004); integrative resilience (M=2.6759) – understanding of mutual dependency between the construction industry, on SCT, and its environment including associated opportunities and risks (see Bresch *et al.*, 2014); and, structural resilience (M=2.5324) – internal capacity of the construction industry to resist disruptions associated with SCT (see Bresch *et al.*, 2014). This highlights how SCT resilience building efforts should be prioritized, that is transformative resilience, integrative resilience, and, structural resilience in order of increasing priority.

Additionally, key informants highlighted that: there was need to further enhance SCT resilience capacity of industry stakeholders though there was some progress; training, including in learning institutions, was one of the ways that their SCT resilience capacity could be enhanced; there was need to establish high level systems such as action plans and strategies to support SCT resilience; industry stakeholders needed to be proactive in building their SCT resilience capacity; and, for construction related manufacturing, there was need for enhanced monitoring of production-side sustainability considerations for timely and appropriate planning and action.

5.6.6 SCT Multi-Level Governance (MLG)

This study sought to assess SCT multi-level governance in Kenya. This independent variable 5, SCT multi-level governance (GV), was measured using nine indicators (GV1-GV9). Table 5.15 below summarizes the resulting descriptive statistics.

Table 5.15: SCT Multi-Level Governance

Industry SCT MLG (GV) Indicators	M	SD	Rank
GV4 – There is private sector actors, such as: independent consultants; consultancy firms; construction firms; and, suppliers, driven sustainable construction uptake/compliance	3.2847	0.82499	**1**
GV5 – There is civil society actors, such as: NGOs; professional associations; trade associations; and, advocacy associations for example Kenya Green Building Society (KGBS), driven sustainable construction uptake/compliance	3.2639	0.87695	**2**
GV1 – There is decentralized sustainable construction steering, from primarily state actors towards non-governmental actors	3.1389	0.76287	**3**
GV8 – There is a SCT enabling context – policies (government and corporate); laws and regulations; fiscal measures – tax and grants related; demand; codes, standards, and, [accreditation and certification] schemes; and, government facilitation, enabling, and, enforcement	2.6944	0.96279	**4**
GV2 – There is national government driven sustainable construction uptake/compliance	2.6458	0.82334	**5**

Industry SCT MLG (GV) Indicators	M	SD	Rank
GV7 – There is clarity and awareness of SCT objectives – resource efficiency, natural resources conservation, and, moral and legal obligations compliance	2.6319	0.91412	**6**
GV6 – There is media driven sustainable construction uptake/compliance including: relaying SCT information; supportive SCT opinion shaping; and/or, encouraging SCT related accountability	2.5972	1.09876	**7**
GV9 – Industry stakeholders' have the capacity to achieve SCT objectives (resource efficiency, natural resources conservation, and, moral and legal obligations compliance)	2.5833	0.91987	**8**
GV3 – There is county governments driven sustainable construction uptake/compliance	2.2292	0.80834	**9**
Overall Construct (N=144)	**2.7855**	**0.59476**	

Source: Field Data (2023)

Overall, the survey findings indicated a small (M=2.7855) extent of SCT supportive multi-level governance in the Kenyan construction industry. This points towards minimal (below average) extent of steering of the Kenyan construction industry towards SCT. With the observed SCT sub-optimality in Kenya (Section 5.6.1), these findings support the view by Westman *et al.* (2019) that MLG is key in explaining realization of action in multi-actor, multi-sector, and, polycentric contexts such as SCT. This emphasizes the need for enhanced coordinated choice and/or necessity driven power dispersion from central national governments for successful SCT strategies implementation. The overall SD score of 0.59476 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. GV4 had the highest mean score (M=3.2847) indicating the largest SCT sphere of influence to be private sector actors, such as: independent consultants; consultancy firms; construction firms; and, suppliers. This finding indicates the current hegemony of private sector actors in

SCT related approaches in Kenya. On the other hand, GV3 had the lowest mean score (M=2.2292) indicating that county governments had the smallest SCT sphere of influence in Kenya. This highlights the need to for active championing of SCT agenda by the government and more so at the county level. In summary, the ranking of industry SCT MLG indicators in Kenya was GV4, GV5, GV1, GV8, GV2, GV7, GV6, GV9, and, GV3 in order of decreasing SCT spheres of influence.

Notably, private and civil societies actors held hegemony over government (national and county) and media in SCT governance in Kenya (see GV4, GV5, and, GV1 versus GV2, GV6, and, GV3). Additionally, the national government was observed to stimulate comparatively higher SCT performance than county governments (see GV2 and GV3). This can be attributed to: county governments were relatively new entities in Kenya (established in 2010 – see The Kenyan Constitution 2010) and as such they were yet to fully get their footing in SCT; and, much, if not all, of the policy and legislative regime instruments with SCT provisions were at the national government level (see chapter four). It is also worthwhile to note that the capacity of industry stakeholders to achieve SCT objectives (resource efficiency, natural resources conservation, and, moral and legal obligations compliance), GV9, registered a relatively low score. This finding can be partly explained by the observations of NCA (2020) on: minimal capacity building on green building rating tools; and, the association of project success, and in this case SCT performance, with requisite skilled labour force – see Section 1.3. Lastly, enabling SCT context registered a below average score (see GV8). This finding can partly be explained by the observed sub-optimality of the SCT regime (policy and legislative) in Kenya – see chapter four.

Additionally, key informants highlighted that: there was no organized structure on SCT governance in Kenya; an organized SCT governance structure was being worked on by NEMA and NCA; there was need to centralize the many individual SCT governance efforts, at different levels, by the involved institutions; the current SCT governance regime largely targeted voluntary SC adoption; and, the SCT governance regime impact could be comparatively effective if government-led.

5.6.7 MSMEs Leveraging in SCT

This study sought to assess leveraging of MSMEs in SCT Kenya. This independent variable six, leveraging of MSMEs in SCT (MS), was measured using eight indicators (MS1-MS8). Table 5.16 below summarizes the resulting descriptive statistics.

Table 5.16: MSMEs Leveraging in SCT

MSMEs Leveraging (MS) Indicators	M	SD	Rank
MS7 – There are intentional efforts to counter barriers to sustainable construction adoption by MSMEs such as lack of market information	2.7153	0.98707	**1**
MS8 – MSMEs are convinced on sustainable construction value/benefits	2.6319	0.81718	**2**
MS3 – There is sustainable construction adoption by MSMEs attributed to supply chain pressures	2.6250	0.89188	**3**
MS2 – There is voluntary sustainable construction adoption by MSMEs	2.6250	0.80969	**4**
MS6 – MSMEs are engaged on SCT through: on-site visits; face-to-face engagements; networking; guidance helplines; and, value-based relationships in addition to conventional approaches such as – seminars, internet, and, newsletters	2.5694	1.03541	**5**
MS1 – SCT policy development and implementation is in consultation with MSMEs such as through trade and professional associations	2.5694	0.79906	**6**
MS4 – There is a robust legislative system in support of sustainable construction adoption by industry MSMEs	2.5278	1.01695	**7**
MS5 – There is availability of SCT related market changes information to MSMEs	2.4653	0.89999	**8**
Overall Construct (N=144)	**2.5911**	**0.68580**	

Source: Field Data (2023)

Overall, the survey findings indicated a small (M=2.5911) extent of MSMEs leveraging, in SCT, in Kenya. This points towards sub-optimal leveraging of MSMEs in SCT agenda in Kenya. In context of the observed industry SCT performance sub-optimality, see Section 5.6.1, this supports the call by Revell and Rutherfoord (2003:33) to actively engage SMEs on the sustainability agenda for its success. The overall SD score of 0.68580 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation score indicating that individual indicators were fairly consistent and close to the mean. MS7 had the highest mean score (M=2.7153) indicating the largest attempt to leverage MSMEs in SCT being on intentional efforts to counter barriers to sustainable construction adoption by MSMEs such as lack of market information. This finding, as one of the recommendations by Condon (2004), points towards some progress in enabling MSMEs to effect SCT. On the other hand, MS5 had the lowest mean score (M=2.4653) indicating minimal availability of SCT related market changes information to MSMEs. This highlights that unavailability of market information regarding SCT was a major impediment to leveraging of MSMEs in SCT in Kenya. In summary, indicators ranking for active leveraging of MSMEs, in SCT, in Kenya was MS7, MS8, MS3, MS2, MS6, MS1, MS4, and, MS5 in order of decreasing leveraging.

Notably, robust legislative system in support of SC adoption by industry MSMEs (see MS4) had a relatively low score similar to the one for enabling SCT context in Section 5.6.6. As such, it can also be partly attributed to the observed sub-optimality of the SCT regime (policy and legislative) in Kenya – see chapter four. This view is additionally supported by the observation that SCT policy development and implementation in consultation with MSMEs also had a low rank score (see MS1). Additionally, the unique disadvantage of lack of information by MSMEs regarding market changes making them unable to capitalize on change associated with sustainability, as postulated by Condon (2004), was confirmed true even for the Kenyan construction industry (see MS5). Notably, the recommendations by Condon (2004) on active onboarding of MSMEs in SD had a comparatively better rank score. In order of decreasing adoption, they are: intentional efforts to counter barriers to SC adoption by MSMEs (MS7); convincing MSMEs on SC value/benefits (MS8); and, engaging them using the alternative approaches of on-site visits, face-to-face engagements, networking, guidance helplines, and, value-based relationships (MS6). Lastly, the findings also indicate that MSMEs were adopting SC mainly due to supply chain pressures as opposed to voluntarily (see MS3 and MS2).

Additionally, key informants highlighted that: with Kenya being a developing economy, most MSMEs primary focused on productivity as opposed to sustainability; incentives such as tax exemptions had the potential to realize enhanced onboarding of MSMEs in the SCT agenda; after a reasonable level of onboarding of MSMEs in the SCT agenda voluntarily, it could be made mandatory; MSMEs could also be encouraged by giving them platforms to showcase their SC efforts – an example of this is the Jenga Green library by KGBS (KGBS, 2022) where suppliers showcased the SC compliant building products they offer; and, an enabling environment by the government also had the potential to elicit enhanced onboarding of MSMEs in the SCT agenda.

5.6.8 IoT-Driven Big Data and BIM Leveraging in SCT

This study sought to assess leveraging of IoT-driven big data and BIM in SCT in Kenya. This independent variable seven, leveraging of IoT-driven big data and BIM in SCT (TC), was measured using eight indicators (TC1-TC8). Table 5.17 below summarizes the resulting descriptive statistics.

Table 5.17: IoT-Driven Big Data and BIM Leveraging in SCT

IoT-Driven Big Data and BIM Leveraging (MS) Indicators	M	SD	Rank
TC1 – There is increased use of smart wearables, appliances, and, building management systems	2.6528	1.03990	**1**
TC6 – There is BIM driven enhanced overall economic viability of constructed facilities through aspects such as efficient logistics, enhanced productivity, and, waste reduction	2.4653	0.86835	**2**
TC5 – There is BIM driven environmental conscious decision making over the lifecycle of constructed facilities	2.4375	0.90622	**3**
TC7 – There is BIM driven enhanced overall well-being of constructed facilities users and society through support of aspects such as enhanced indoor air quality, appropriate waste management, and, stakeholders' engagement	2.3819	0.94607	**4**
TC4 – There is big data driven collaborative consumption/use of constructed facilities such as use of Airbnb platform for collaborative use of residences	2.3472	0.95580	**5**
TC2 – There is use of real time applications in aligning resources usage with resources, markets, and, behaviour	2.3125	0.96417	**6**
TC8 – There is onboarding of sustainability considerations early in design process and validating them using BIM, through facilities parametric modelling	2.2986	0.90128	**7**

TC3 – There are big data driven prods towards sustainable construction behaviour such as applications where consumers can compare energy uses in a bid to stimulate behaviour towards energy efficiency	2.2500	1.01389	**8**
Overall Construct (N=144)	**2.3932**	**0.80018**	

Source: Field Data (2023)

Overall, the survey findings indicated a small (M=2.3932) extent IoT-driven big data and BIM leveraging in Kenya. This points towards sub-optimal leveraging of IoT-driven big data and BIM in the SCT agenda in Kenya. Given the observed sub-optimal SCT (see Section 5.6.1), it is evident that Kenyan construction industry was yet to enjoy big-data associated sustainability benefits as outlined in Etzion and Aragon-Correa (2016). The overall SD score of 0.80018 indicate variability in responses to the scale (set of variable indicators). However, this is a small deviation indicating that individual indicators were fairly consistent and close to the mean. TC1 had the highest mean score (M=2.6528) indicating increased use of smart wearables, appliances, and, building management systems. This finding, further indicates that the Kenyan construction industry is not left out in the increased uptake of smart wearables, appliances, building management systems, and, cities all over the world as postulated by Allen and Macomber (2020). On the other hand, TC3 had the lowest mean score (M=2.2500) indicating least progress on big data driven prods towards sustainable construction behaviour such as applications where consumers can compare energy uses in a bid to stimulate behaviour change towards energy efficiency. This highlights one of the areas that can be targeted in enhanced uptake of IoT-driven big-data for SCT. In summary, the ranking of leveraging IoT-driven big data and BIM in SCT indicators in Kenya was TC1, TC6, TC5, TC7, TC4, TC2, TC8, and, TC3 in order of decreasing leveraging.

In SCT, BIM uptake was observed to be comparatively better – average mean of 2.3958, when compared to IoT-driven big data uptake – average mean of 2.3906. Specifically, the adoption of BIM in SCT was observed as follows in order of decreasing adoption: BIM driven enhanced overall economic viability of constructed facilities through aspects such as efficient logistics, enhanced productivity, and, waste reduction (TC6); BIM driven environmental conscious decision making over the lifecycle of constructed facilities (TC5); BIM driven enhanced overall well-being of constructed facilities users and the general society through support of aspects such as enhanced indoor air quality, appropriate waste management, and, stakeholders' engagement (TC7); and, onboarding of sustainability considerations early in design process and validating them using BIM, through facilities parametric modelling (TC8). Interestingly, on IoT-driven big data in SCT, smart wearables, appliances, and, building management systems (TC1) had received enhanced uptake compared to, in order of decreasing adoption: big data driven collaborative consumption/use of constructed facilities (TC4); use of real time applications in aligning resources usage with resources, markets, and, behaviour (TC2); and, big data driven prods towards sustainable construction behaviour such as applications where consumers can compare energy uses in a bid to stimulate behaviour towards energy efficiency (TC3). It as such appears that the Kenyan construction industry was yet to substantially leverage IoT in its transition towards enhanced sustainability which Salam (2020) refers to as IoT for sustainability.

Additionally, key informants also highlighted that: BIM had received comparatively higher adoption in SCT compared to IoT-driven big data in Kenya; a regulatory framework had the potential to enhance uptake of BIM for SCT; IoT-driven big data for SCT is minimally employed in Kenya on the energy efficiency front and in niche industry market segments such as hospitality; major challenges to adoption of IoT-driven big data were high cost and local unavailability; IoT-driven big data may only receive significant uptake, in SCT, after BIM; and, there was need for enhanced awareness drives targeting industry stakeholders on how they can leverage BIM and IoT-driven big data for enhanced SCT.

5.6.9 SCT Strategies Implementation Considerations Ranking

Research question two, partly sought to rank SCT strategies implementation/context-appropriateness considerations in the Kenyan construction industry (see Section 1.5). This was specifically aimed at ranking independent variables two to seven on SCT: change readiness (CR); socio-spatial sensitivity (SS); resilience (RS); multi-level governance (GV); leveraging of MSMEs (MS); and, leveraging of IoT-driven big data and BIM (TC). They were individually discussed in detail in Sections 5.6.3-5.6.8. This ranking was informed by the main anchor theory, socio-technical systems (STS) theory, which postulate that optimal and enhanced SCT performance (dependent variable – see Section 5.6.1) is pegged on the joint optimization of technical strategies (SCT strategies – see Section 5.6.2) and context-appropriateness considerations (SCT strategies implementation considerations – see Sections 5.6.3-5.6.8). The outcome of this ranking is as summarized in Table 5.18 below:

Table 5.18: SCT Strategies Implementation Considerations Ranking

SCT Strategies Implementation/Context-Appropriateness Considerations (Code)	M	SD	Rank
Change readiness (CR)	2.8065	0.56007	**1**
Socio-spatial sensitivity (SS)	2.7948	0.66878	**2**
Appropriate multi-level governance (GV)	2.7855	0.59476	**3**
Resilience (RS)	2.6620	0.64707	**4**
Leveraging MSMEs (MS)	2.5911	0.68580	**5**
Leveraging IoT-driven big data and BIM (TC)	2.3932	0.80018	**6**

Source: Field Data (2023)

The findings indicated that the top three SCT strategies implementation/context-appropriateness considerations in Kenya were: change readiness; socio-spatial sensitivity; and, appropriate multi-level governance, in order of decreasing consideration – they are discussed in detail in Sections 5.6.3, 5.6.4, and, 5.6.6 respectively. This means that in the implementation of SCT in Kenya, the top three implementation considerations were: stakeholders' readiness for SCT; social and spatial appropriateness of SCT approaches; and, decentralized SCT steering. Additionally, the bottom three SCT strategies implementation/context-appropriateness considerations in Kenya were: resilience; leveraging MSMEs; and, leveraging IoT-driven big data and BIM, in order of decreasing consideration – they are discussed in detail in Sections 5.6.5, 5.6.7, and, 5.6.8 respectively. This means that in the implementation of SCT in Kenya, the bottom three implementation considerations were: capacity building to adapt and/or respond to SCT disturbances; actively onboarding MSMEs in SCT efforts; and, leveraging technology (IoT and BIM) in SCT efforts. It should be noted that the variable means ranged from 2.3932 to 2.8065 indicating a small/below average extent of consideration given that the variables were measured on a on a 5-point Likert scale (1 – very small, 2 – small, 3 – average, 4 – large, and, 5 – very large). This means that irrespective of the ranking, the consideration of change readiness, socio-spatial sensitivity, resilience, multi-level governance, leveraging of MSMEs, and, leveraging of IoT-driven big data and BIM was to a small extent/below average/sub-optimal.

In light of the observed industry SCT performance sub-optimality (Section 5.6.1) and sub-optimal adoption of SCT strategies in practice (Section 5.6.2), the overall sub-optimal leveraging of strategies implementation considerations (as highlighted above) support STS theory that technical strategies and their implementation considerations are jointly of direct relationship with industry SCT performance. Lastly, the standard deviations per variable ranged from 0.80018 to 0.56007 indicating variability in responses to the variable scales (set of variable indicators). However, this is a small deviation (<1) indicating that individual indicators for any given SCT implementation consideration (variable) were fairly consistent and close to the mean.

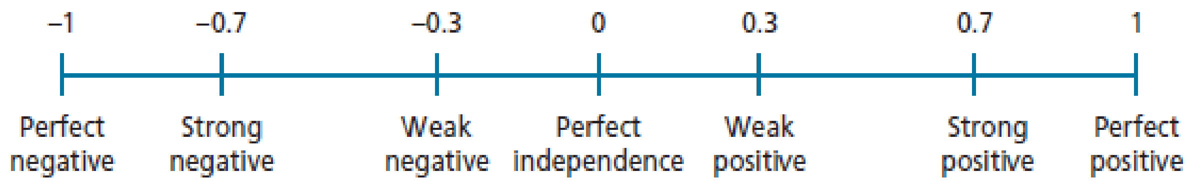
5.7 Inferential Statistics Analysis

Next, the inferential statistics were assessed. They sought to: assess relationship between study variables – correlation analysis; model relationship between the dependent and independent variables to identify significant predictors – regression analysis; validate the resulting model; and, test the pre-set hypothesis. This was aimed at deriving meaningful and reliable conclusions about the study population from the sample with specific reference to the research questions and hypothesis. This was ultimately meant to contribute to an enhanced understanding of SCT in Kenya. The outcome of this analysis is discussed in detail in Sections 5.7.1-5.7.3 below:

5.7.1 Correlation Analysis

Correlation analysis was conducted on study variables using IBM SPSS v23. This was aimed at assessing the strength and direction of relationships between the dependent variable (P) and independent variables (STR, CR, SS, RS, GV, MS, and, TC). This was ultimately aimed at: selecting independent variables significantly associated with SCT performance; and, dropping those not significantly associated with SCT performance. Only the former were to be included in the regression analysis to assess their SCT performance predictive power. A similar approach was adopted in Kieti (2015:138) in a doctoral study on urban housing affordability in Kenya. The interpretation of the resulting correlation coefficients was as per Figure 5.7 below:

Figure 5.7: Correlation Coefficients Interpretation Scale



Source: Saunders *et al.* (2009:459)

Table 5.19 below summarizes the resulting correlation coefficients (r) findings.

Table 5.19: Study Variables Correlation

	P	**STR**	**CR**	**SS**	**RS**	**GV**	**MS**	**TC**
P	1							
STR	**0.576****	1						
CR	**0.608****	0.585**	1					
SS	**0.537****	0.539**	0.664**	1				
RS	**0.521****	0.426**	0.588**	0.625**	1			
GV	**0.383****	0.381**	0.515**	0.683**	0.569**	1		
MS	**0.558****	0.392**	0.601**	0.634**	0.629**	0.658**	1	
TC	**0.268****	0.266**	0.374**	0.326**	0.478**	0.423**	0.402**	1

** Correlation is significant at the 0.01 level (2-tailed).

Source: Field Data (2023)

The survey findings indicate that SCT performance (P) was moderately correlated ($0.3<r<0.7$) with SCT change readiness (CR), SCT strategies (STR), leveraging MSMEs in SCT (MS), SCT socio-spatial sensitivity (SS), SCT resilience (RS), and, appropriate multi-level governance (GV). The correlation coefficients (r) were +0.608, +0.576, +0.558, +0.537, +0.521, and, +0.383 respectively in order of decreasing association strength. Additionally, the correlation coefficients were positive, as such, enhanced CR, STR, MS, SS, RS, and, GV would be associated with enhanced P. On the other hand, SCT performance (P) was weakly correlated ($0.0<r<0.3$) with leveraging IoT-driven big data and BIM in SCT (TC). The correlation coefficients (r) was +0.268 (which can achieve the threshold of 0.3 if rounded off to one decimal place). Even for this, the correlation was positive, as such, enhanced TC would be associated with enhanced P. Lastly, all the above discussed positive correlations between the dependent and independent variables were flagged as significant at the 0.01 level (2-tailed test) – $p<0.01$. This is a more stringent threshold than the typical 0.5 recommended by Saunders *et al.* (2009:459) and adopted in Kieti (2015:138) and in this study (see Section 3.6.2). Consequently, with the all the independent variables having been significantly correlated with the dependent variable, they all proceeded to regression analysis. Their overall ranking in terms of decreasing strength of positive association with SCT performance was: CR; STR; MS; SS; RS; GV; and, TC. Notably, no variable pair correlation coefficient (r) was above 0.8 which would confirm multicollinearity (Shrestha, 2020:41). This additionally confirms the finding on lack of multicollinearity as highlighted in Section 5.4.4.

5.7.2 Multiple Regression Analysis

Regression analysis in SPSS v23 was done in three stages as adopted in Kieti (2015): stage one – 'ENTER' regression method for all the seven independent variables; stage two – 'ENTER' regression method for only the significant predictors; and, stage three – 'STEPWISE' regression method of significant predictors only. Stage one was aimed at identification of key predictors, stage two at assessing whether elimination of (any) non-significant predictors improved model fit, and, stage three at ranking the significant predictors in order of their contribution to SCT performance. Lastly, this section concluded by validating the generated regression model (using the 75% model training dataset) by testing its predictive accuracy on the 25% model testing set held back. The resulting findings are discussed in detail in Sections 5.7.2.1-5.7.2.4 below.

5.7.2.1 Stage 1 regression – 'ENTER' method for all independent variables

Table 5.20 below summarizes the regression model for stage one.

Table 5.20: Model 1 Summary (With all Independent Variables)

Model Summary									
					Change Statistics				
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.716	0.512	0.487	0.42706	0.512	20.415	7	136	0.000
Predictors: (Constant), TC, STR, MS, CR, GV, RS, SS									

Source: Field Data (2023)

The findings above indicated that SCT strategies (STR), SCT change readiness (CR), STR socio-spatial sensitivity (SS), SCT resilience (RS), SCT MLG (GV), MSMEs leveraging in SCT (MS), and, IoT-driven big data and BIM leveraging in SCT (TC) account for approximately 51% (R^2=0.512) of the change in SCT performance. The adjusted R^2, which takes into consideration number of independent variables and study participants (see Kieti, 2015:148), moderates the power of the independent variables (STR, CR, SS, RS, GV, MS, and, TC) to predict SCT performance to approximately 49% (adjusted R^2=0.487). The standard error of estimate (SEE), measure of models' variance between actual and predicted SCT performance values (see Kieti, 2015:149), was 0.42706. This simply means that the average distance between observed SCT performance values is 0.42706 standard errors of estimates from the model regression line (see King'oriah, 2004:280-287). On the significance of the overall regression equation, F=20.415 is associated with a p(Sig. F Change)=0.000 which is less than the adopted alpha value of 0.05. This indicates that the model was acceptable as recommended by Saunders *et al.* (2009:450). The unstandardized B coefficients indicate the extent SCT performance (dependent variable) changes in relation to one unit change in any of the independent variables. As summarized in Table 5.21 below, one unit change in SCT strategies (STR), SCT change readiness (CR), STR socio-spatial sensitivity (SS), SCT resilience (RS), SCT multi-level governance (GV), MSMEs leveraging in SCT (MS), and, IoT-driven big data and BIM leveraging in SCT (TC) would result in +30.7%, +23.3%, +6.3%, +12.8%, -14.5%, +24.8%, and, -2.8% change in SCT performance respectively.

Table 5.21: Model 1 Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.604	0.220		2.742	0.007
	STR	**0.307**	**0.077**	**0.304**	**3.973**	**0.000**
	CR	**0.233**	**0.098**	**0.219**	**2.380**	**0.019**
	SS	0.063	0.090	0.071	0.699	0.486
	RS	0.128	0.082	0.139	1.571	0.118
	GV	- 0.145	0.092	- 0.145	- 1.577	0.117
	MS	**0.248**	**0.080**	**0.286**	**3.115**	**0.002**
	TC	- 0.028	0.053	- 0.038	- 0.536	0.593

a. Dependent Variable: P

* Significant predictors of SCT performance (P) and their statistics are in bold

Source: Field Data (2023)

Interestingly, GV and TC, were positively correlated with P (see Section 5.7.1) while regression coefficients indicate a negative relationship. IBM (2020) associates this with suppressor effects in regression. Falk and Miller (1992:75-76) explain that this is a clear indication that the original variable relationship has been suppressed. They further assert that this can be due to: original relationship being close to zero with signs difference being due to random variation around zero. In this case the signs in correlation coefficients should be adopted in interpretation; two or more variables being highly related and redundant. In this case switching signs is due to variables order in the equation. In this case, omission of a redundant variable should not result in reduction of R^2 but change of regression coefficient sign of another variable. As such one or more of the redundant variables should be eliminated; and, major predictor suppressing the effect of another predictor. In this case omission of major predictor would result in reduction of R^2. In this case the equation should retained as is and correct sign adopted in interpretation should be the one of regression coefficients.

In the case of this study, GV and TC had their correlation coefficients with P as 0.383 and 0.268 respectively. This can be interpreted as being close to zero generally and in context of the ranking of all independent variables in this study (see Section 5.7.1). Additionally, an attempt to discard them individually from the model resulted in R^2 of 50.3% and 51.1% respectively, a reduction in R^2 from 51.2%, and with no change of the regression coefficient sign in any other variable. Based on the foregoing recommendations by Falk and Miller (1992:75-76), the change of signs in these two variables can be reasonably attributed to original relationship (in correlation) being close to zero. Consequently, the negatives in regression coefficients are replaced with positives in the correlation coefficients. As such, results in Table 5.21 should be interpreted as follows – one unit change in SCT strategies (STR), SCT change readiness (CR), STR socio-spatial sensitivity (SS), SCT resilience (RS), SCT multi-level governance (GV), MSMEs leveraging in SCT (MS), and, IoT-driven big data and BIM leveraging in SCT (TC) would result in +30.7%, +23.3%, +6.3%, +12.8%, +14.5%, +24.8%, and, +2.8% change in SCT performance respectively. The resulting model is stated below:

Model one:

$$P = 0.604 + 0.307\,STR + 0.233\,CR + 0.063\,SS + 0.128\,RS + 0.145\,GV + 0.248\,MS + 0.028TC$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

CR = SCT change readiness

SS = SCT socio-spatial sensitivity

RS = SCT resilience

GV = SCT multi-level governance

MS = Leveraging MSMEs in SCT

TC = Leveraging IoT-driven big data and BIM in SCT

5.7.2.2 Stage 2 regression – 'ENTER' method for significant independent variables

Table 5.22 below summarizes the regression model for stage two.

Table 5.22: Model 2 Summary (With all Significant Independent Variables)

Model Summary									
					Change Statistics				
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**df1**	**df2**	**Sig. F Change**
2	0.703	0.494	0.483	0.42873	0.494	45.580	3	140	0.000
Predictors: (Constant), STR, MS, CR									

Source: Field Data (2023)

The predictive power of the model decreased to 49% (R^2=0.494) from the 51% (R^2=0.512) in the previous model (model one). The adjusted R^2, which takes into consideration number of independent variables and study participants, moderates the power of the significant independent variables to predict SCT performance to 48% (adjusted R^2=0.483) from 49% (adjusted R^2=0.487) in model one. The standard error of estimate (SEE), measure of models' variance between actual and predicted SCT performance values, increased marginally from 0.42706 in model one to 0.42873. On the significance of the overall regression equation, F value increased to 45.580 from 20.415 in the previous model (model one). It should however be noted that both are associated with a p(Sig. F Change)=0.000 which is less than the adopted alpha value of 0.05. This indicates that model two was also acceptable as recommended by Saunders *et al.* (2009:450). The unstandardized B coefficients indicate the extent SCT performance (dependent variable) changes in relation to one unit change in any of the independent variables. As summarized in Table 5.23 below, one unit change in SCT strategies (STR), SCT change readiness (CR), and, MSMEs leveraging in SCT (MS) would result in +32.0%, +27.0%, and, +24.5% change in SCT performance respectively. In the previous model, these variables accounted for +30.7%, +23.3%, and, +24.8% respectively.

Table 5.23: Model 2 Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	0.516	0.206		2.508	0.013
	STR	0.320	0.075	0.317	4.270	0.000
	CR	0.270	0.091	0.254	2.966	0.004
	MS	0.245	0.066	0.282	3.737	0.000

a. Dependent Variable: P

Source: Field Data (2023)

The results indicate that R^2, moderated R^2 and SEE have marginally reduced in model two (with significant predictors only), both models (one and two) are statistically significant in predicting SCT performance, and, the F (ratio of explained variance to unexplained variance – see King'oriah, 2004:238) statistic has significantly improved in model two. Model two is as such a comparatively better fit on the basis of: enhanced ratio of explained variance to unexplained variance, hence comparatively lower p-value suggesting a better fit for the data; and, enhanced effect size of the significant dependent variables (STR, CR, and, MS), which appear to have been suppressed by the non-significant variables in model one. Consequently, model two is the one that was adopted for this study and as stated below:

Model two:

$$P = 0.516 + 0.320\ STR + 0.270\ CR + 0.245\ MS$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

CR = SCT change readiness

MS = Leveraging MSMEs in SCT

5.7.2.3 Stage 3 regression – 'STEPWISE' method for significant independent variables

Table 5.24 and 5.25 below summarizes the output of stage three regression.

Table 5.24: Model 3 Summary

Model Summary				
Model	**R**	**R^2**	**Adjusted R^2**	**Std. Error of the Estimate**
3a	0.608[a]	0.370	0.366	0.47501
3b	0.666[b]	0.444	0.436	0.44801
3c	0.703[c]	0.494	0.483	0.42873
a. Predictors: (Constant), STR				
b. Predictors: (Constant), STR, CR				
c. Predictors: (Constant), STR, CR, MS				

Source: Field Data (2023)

Table 5.25: Model 3 Coefficients

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
3a	(Constant)	1.025	0.203		5.049	0.000
	CR	0.648	0.071	0.608	9.135	0.000
3b	(Constant)	0.624	0.213		2.932	0.004
	CR	0.440	0.082	0.413	5.328	0.000
	STR	0.338	0.078	0.334	4.316	0.000
3c	(Constant)	0.516	0.206		2.508	0.013
	CR	0.270	0.091	0.254	2.966	0.004
	STR	0.320	0.075	0.317	4.270	0.000
	MS	0.245	0.066	0.282	3.737	0.000
a. Dependent Variable: P						

Source: Field Data (2023)

Model 3a (as summarized below), according to Table 5.24, with SCT strategies (STR) as the only predictor of SCT performance accounts for 37% (R^2=0.370) change in SCT performance. The model has the adjusted R^2, moderating R^2 considering number of independent variables and study participants, of 0.366 (indicating a moderated 36.6% predictive power). The SEE for this model is 0.47501. Additionally, as outlined in Table 5.25, one unit change in SCT strategies (STR) would result in +64.8% change in SCT performance.

Model 3a:

$$P = 1.025 + 0.648\ STR$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

Model 3b (as summarized below), according to Table 5.24, has SCT strategies (STR) and SCT change readiness (CR) accounting for 44% (R^2=0.444) variance in SCT performance. This indicates that addition of CR has boosted the predictive power of the model by 7.4% (44.4%-37.0%). The model has an improved adjusted R^2, moderating R^2 considering number of independent variables and study participants, of 0.436 (indicating a moderated 44% predictive power). The SEE for this model has also improved (reduced comparatively) to 0.44801. Additionally, as outlined in Table 5.25, one unit change in SCT strategies (STR) and SCT change readiness (CR) would result in +44% and +33.8% change in SCT performance respectively.

Model 3b:

$$P = 0.624 + 0.440STR + 0.338\ CR$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

CR = SCT change readiness

Model 3c (as summarized below), according to Table 5.24, has SCT strategies (STR), SCT change readiness (CR), and, leveraging MSMEs in SCT (MS) accounting for 49% (R^2=0.494) variance in SCT performance. This indicates that addition of MS has further boosted the predictive power of the model by 5% (49.4%-44.4%). The model has a comparatively improved adjusted R^2, moderating R^2 considering number of independent variables and study participants, of 0.483 (indicating a moderated 48% predictive power). The SEE for this model has also further improved (reduced comparatively) to 0.42873. Additionally, as outlined in Table 5.25, one unit change in SCT strategies (STR), SCT change readiness (CR), and, leveraging MSMEs in SCT would result in +32%, +27%, and, +24.5% change in SCT performance respectively.

Model 3c/final model:

$$P = 0.516 + 0.320\ STR + 0.270\ CR + 0.245\ MS$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

CR = SCT change readiness

MS = Leveraging MSMEs in SCT

This is the final model that was adopted for predicting SCT performance in the Kenyan construction industry. Its ranking of significant predictors of SCT performance (P) were SCT strategies (STR), SCT change readiness (CR), and, leveraging of MSMEs in SCT (MS) in decreasing order of individual variable predictive power.

5.7.2.4 Final Regression Model Validation

The study sought to validate the final model to ensure it was: representative of the population as a whole (generalizability); and, appropriate in usage (transferability) as recommended by Hair *et al.* (2010). 53 questionnaires results were randomly selected using IBM SPSS v23 from the main dataset and held back for model validation (see Sections 3.9.2 and 5.4.1). Given that the model had a predictive power of 49.4% (R^2=0.494), it is clear that there were other factors not accounted for in this model and that explain the remaining 50.6% of SCT performance. This 50.6% could possibly be due to the (untested) impact of SCT policy and legislative regime on industry SCT performance. Consequently, the model developed cannot predict exact SCT performance. As such, pragmatically, if the models' predicted values were in the same direction as the actual values (below or above the mean), the model can be said to be valid. For ease of comparison, the standardized SCT performance values (predicted and actual) for held back sample were compared. Negative and positive standardized values would indicate below average and above average SCT performance respectively. They are easier to interpret than their non-standardized equivalents where one would have to look at the magnitude of each value against the 5-point Likert scale. A similar approach was adopted in Ankrah (2007:265-266) in a doctoral study on the impact of culture on construction project performance. As such the validation test involved comparing how accurate the model would be in predicting SCT performance values as below or above average. Table 5.26 below summarizes the outcome of this assessment.

Table 5.26: Testing Set (25%) Actual vs. Training Set (75%) Predicted Values

SCT Performance (Cases 1-27)			SCT Performance (Cases 28-53)		
Actual	**Predicted**	**Fit**	**Actual**	**Predicted**	**Fit**
-0.21456	-1.12596	✓	-2.22131	-0.64918	✓
1.34625	2.14139	✓	1.56922	1.64276	✓
-0.21456	0.39530	*x*	-0.43753	-0.48294	✓
-0.66050	0.74628	*x*	-0.66050	0.42032	*x*
-1.55239	-1.29916	✓	-0.88348	0.02247	*x*
-0.88348	-1.48531	✓	-0.43753	-0.06827	✓
0.45436	0.21065	✓	0.23139	0.99639	✓
1.56922	1.83437	✓	0.00841	0.23893	✓
0.00841	-1.89514	*x*	1.56922	0.23910	✓
0.00841	-0.23926	*x*	-0.66050	-0.02131	✓
2.23814	-0.77331	*x*	-0.88348	-0.64759	✓
0.00841	1.14245	✓	0.00841	-0.16059	*x*
0.67733	1.23293	✓	0.00841	0.05604	✓
0.90030	1.44287	✓	0.00841	-0.05655	*x*
-1.10645	-3.42469	✓	-0.21456	-0.89436	✓
-0.21456	-1.76740	✓	0.00841	0.31628	✓
-0.88348	0.30456	*x*	-0.88348	0.44217	*x*
-1.10645	-1.99733	✓	0.00841	0.15841	✓
1.56922	0.14854	✓	0.23139	-0.11364	*x*
-2.44428	0.00353	*x*	0.23139	0.19039	✓
-1.10645	0.33002	*x*	0.45436	0.84689	✓
-0.88348	-0.05664	✓	-0.88348	0.72787	*x*
-0.21456	0.17691	*x*	0.00841	0.06943	✓
2.23814	-0.31309	*x*	0.90030	-0.00272	*x*
0.67733	-0.79516	*x*	0.45436	-0.11355	*x*
1.34625	0.90891	✓	0.90030	0.88221	✓
0.00841	0.11480	✓			
Accurate predictions (No.) Total 1		**16/27**	**Accurate predictions (No.) Total 2**		**17/26**
Grand total: Accurate predictions (No.) – 33/53; and, prediction accuracy (%) – 62.3% (Approximately 62%)					

✓ – Accurate prediction (both actual and predicted jointly above or below average)

x – Inaccurate prediction (both actual and predicted not jointly above or below average)

Source: Field Data (2023)

Additionally, mean absolute percentage error (MAPE) statistic was also employed to assess the extent to which predicted values deviated from the actual values when using the model. MAPE is an average of absolute differences between actual and predicted values expressed as a percentage of actual value – it is a percentage measure of the models' estimation error (Kieti and Ogolla, 2021:40). Non-standardized actual (from model testing set) and predicted values (from model training set) of SCT performance were used to compute MAPE using Microsoft Excel 2019. A similar approach was adopted in Kieti and Ogolla (ibid) in a study on hedonic valuation of apartments in Kenya specifically in evaluating the model developed. Table 5.27 below summarizes the outcome of this assessment.

Table 5.27: MAPE Computations

SCT Performance (Cases 1-27)			SCT Performance (Cases 28-53)		
Actual (A)	**Predicted (P)**	**Absolute Error (A-P)/(A)**	**Actual (A)**	**Predicted (P)**	**Absolute Error (A-P)/(A)**
2.880	2.550	0.1146	2.880	2.990	0.5486
3.750	3.650	0.0267	4.250	2.820	0.1031
2.880	3.060	0.0625	3.380	2.660	0.0073
2.630	3.180	0.2091	3.750	3.240	0.1673
2.130	2.490	0.1690	3.000	2.970	0.1760
2.500	2.430	0.0280	1.750	2.710	0.0582
3.250	3.000	0.0769	3.880	3.480	0.0447
3.880	3.550	0.0851	2.750	2.770	0.0033
3.000	2.290	0.2367	2.630	3.070	0.2242
3.000	2.850	0.0500	2.500	2.940	0.1103
4.250	2.670	0.3718	2.750	2.910	0.0840
3.000	3.310	0.1033	3.130	3.270	0.0433
3.380	3.350	0.0089	3.000	3.010	0.0167
3.500	3.420	0.0229	3.880	3.010	0.0300
2.380	1.770	0.2563	2.630	2.920	0.0868
2.880	2.330	0.1910	2.500	2.710	0.0133
2.500	3.030	0.2120	3.000	2.870	0.2320
2.380	2.250	0.0546	3.000	2.950	0.0067
3.880	2.980	0.2320	3.000	2.910	0.0767
1.630	2.930	0.7975	2.880	2.630	0.0447
2.380	3.040	0.2773	3.000	3.040	0.0092
2.500	2.910	0.1640	2.500	3.080	0.2680
2.880	2.550	0.0382	3.000	2.980	0.0167
3.750	3.650	0.3365	3.130	2.890	0.1629

SCT Performance (Cases 1-27)			SCT Performance (Cases 28-53)		
Actual (A)	**Predicted (P)**	**Absolute Error (A-P)/(A)**	**Actual (A)**	**Predicted (P)**	**Absolute Error (A-P)/(A)**
2.880	3.060	0.2130	3.130	2.990	0.1108
2.630	3.180	0.1360	3.250	3.220	0.0771
2.130	2.490	0.0100	**Total 2**		**2.7219**
Total 1		**4.4838**	**Grand Total (Total 1+2)**		**7.2057**
MAPE = (7.2057/53) * 100 = 13.6%					
Interpretation: Model predictions are averagely 13.6% off from actual values					

Source: Field Data (2023)

The tabulated results (Table 5.26 and 5.27) indicate that the model, in addition to its 49.4% predictive power (R^2=0.494), its predictive accuracy for SCT performance was 62.3%, and, its predictions were averagely 13.6% off from the true values. In context of this predictive power, predictive accuracy, and, MAPE it is evident that industry SCT performance can be reliably predicted better with the model than without it. As such, it is evident that the model is valid and can be used for prediction of industry SCT performance on new data with a reasonable accuracy level.

5.7.3 Hypotheses Testing

The study sought to test the significance of the relationship between the study variables. Specifically, the null hypothesis (H_O) was SCT strategies including their implementation considerations (context appropriateness considerations) are not significantly related with construction industry SCT performance. On the other hand, the alternative hypothesis (H_A) was that SCT strategies including their implementation considerations (context appropriateness considerations) are significantly related with construction industry SCT performance. Based on the regression results for the final model (Section 5.7.2.4): SCT strategies (STR); and, their implementation/context appropriateness considerations of SCT change readiness (CR) and leveraging MSMEs in SCT (MS) are significantly related to SCT performance (P). However, the following SCT strategies implementation/context appropriateness considerations were not significantly related to SCT performance: SCT socio-spatial sensitivity (SS); SCT resilience (RS); SCT multi-level governance (GV); and, leveraging IoT-driven big data and BIM in SCT (TC) – see Section 5.7.2.1. While not all SCT strategies implementation considerations were significant predictors of SCT performance, it cannot be held that SCT strategies implementation considerations are not significantly related to SCT performance. As such, this study concluded that null hypothesis is rejected and the alternative hypothesis supported. A similar approach was adopted in Ankrah (2007:277) on the impact of culture on construction project performance. Specifically, it was observed that even though not all aspects of culture were significant predictors of construction project performance and that not all measures of construction project performance were associated with significant aspects of culture, evidence supported the hypothesis that culture had impact on construction projects performance. Despite the said factors not being significant predictors of SCT performance, they were positively correlated with SCT performance (see Section 5.7.1).

5.8 Chapter Summary

This chapter was aimed at answering research questions one, two, and, four (see Section 1.5). Research question one sought to assess the extent of SCT performance in Kenya. The findings indicated: sub-optimal performance; notable growth of SC processes and products demand; water, land, energy, and, materials conservation is a major SCT sub-optimality front; and, the ranking and discussion of the other performance indicators in between is provided in Section 5.6.1. Research question two partly sought to assess prevalent SCT strategies in Kenya. Their ranking in order of decreasing prevalence was: property value enhancement; enhancing functionality; development cost efficiency; energy conservation; and, operational cost rationalization. All the strategies (prevalent and otherwise) were also ranked and discussed in Sections 5.6.2. Research question two also partly sought to assess ranking of SCT strategies implementation/context-appropriateness considerations. Their ranking in order of decreasing consideration was: change readiness; socio-spatial sensitivity; multi-level governance; resilience; leveraging MSMEs; and, leveraging IoT-driven big data and BIM (see Section 5.6.9). They were also individually discussed at length in sections 5.6.3-5.6.9. Research question four sought to develop a model linking SCT strategies including their implementation considerations with SCT performance. SCT strategies and the implementation considerations of CR and MS were found to be significant predictors of SCT performance (R^2=49.4%). The model on validation had a 62.3% predictive accuracy and MAPE of 13.6%. These findings supported the alternative hypothesis that SCT strategies including their implementation considerations are significantly related with construction industry SCT performance. Chapter six next covered conclusion of the study, and, arising recommendations.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter offers a summary of the study outcomes in light of: research problem, questions, and, hypothesis (including scope) – see chapter one; theoretical and conceptual frameworks – see chapter two; adopted research methodology – see chapter three; qualitative data analysis – see chapter four; and, quantitative data analysis (including interview input from key informants) – see chapter five. It specifically presents the summary of findings, conclusions drawn, achievements and contributions to knowledge, findings implications, and, resulting recommendations. This was aimed at communicating the study outputs. It was structured into seven main sections: Section 6.2 presented an overview of the overall research problem, research questions, and, hypothesis; Section 6.3 covered summary of key findings for the research objectives and study hypotheses test results; Section 6.4 on conclusion of the study in line with the study findings; Section 6.5 on achievements and contributions to knowledge of the study; Section 6.6 on implications of the findings and arising recommendations; Section 6.7 on suggested directions for future research; and, Section 6.8 on critical reflection on the study. Unlike the other chapters which had their outputs feeding into subsequent chapter(s), this chapter is a collection of outputs from preceding chapters, their implications, and, recommendations.

6.2 Revisiting the Research Problem, Questions, and, Hypotheses

Construction industries have been observed to lag in transitioning towards sustainability and this thesis argued that the Kenyan construction industry is not excluded. As such, conventional and largely unsustainable products, processes, and, practices hold hegemony over sustainable construction (SC) alternatives. This evoked two key questions which this study sought to explore: how can sustainability transition (ST) in the construction industry, sustainable construction transition (SCT), be achieved; and, how can context appropriateness be engrained in the adopted SCT strategies for enhanced industry SCT performance? In the context of the well documented unsustainability of the Kenyan construction industry along the economic, environmental, and, social facets, this study sought to explore this lagging transition towards SC. This was specifically through research objectives on: extent of SCT performance; prevalent SCT strategies including the ranking of their implementation considerations; SCT policy and legislative regime in terms of its priorities, instruments, and, stakeholder orientation including (any) inherent shortcomings; and, how influences of SCT strategies including their implementation considerations on SCT performance can be modelled to enhance SCT performance. Additionally, the study hypothesized, in the alternative, that SCT strategies including their implementation considerations (context appropriateness considerations) are significantly related with construction industry SCT performance. The above highlighted was the context including what this study sought to investigate.

6.3 Key Findings Summary

Sections 6.3.1-6.3.6 below present the summary of findings for the research objectives and hypotheses test results.

6.3.1 Specific Objective 1: Extent of Industry SCT Performance

The field study results indicated that the Kenyan construction industry had not significantly transitioned from conventional and largely unsustainable products, processes, and, practices to sustainable construction alternatives. This sub-optimal/below average industry SCT performance was characterized by the following, in decreasing performance order: growing demand for sustainability compliant processes and products; change in industry stakeholders' perceptions towards support of sustainability compliant products; change in industry stakeholders' perceptions towards support of sustainability compliant processes; compliance with moral and legal obligations to stakeholders, such as government and site employees; construction resources (labour, materials, finance, space, plant, and, time) use efficiency; use of technology to overcome limits to exploitation of natural resources employed in construction (such as water, land, and, building materials); supply of sustainability compliant processes and products; and, environmental (water, land, energy, and, materials) conservation. Notably, the growing demand for sustainability compliant processes and products, comparatively, tended towards optimality (was average) while the rest of SCT performance indicators, as listed above, were below average (tending towards sub-optimality).

Other notable related findings were: demand for SC compliant products and processes was much greater than supply; SCT performance along the three facets of SC, in order of decreasing performance, ranked as social, economic, and, environmental; there was lack of an existing holistic SCT performance assessment frameworks/measures; the number of green rated buildings was identified as a possible objective SCT performance (related) assessment yardstick; publicly available data on number of green buildings was suppressed due to the fact that developers had to give consent for publicization of such information; and, overall, SCT was still nascent.

6.3.2 Specific Objective 2 (Part 1): Prevalent SCT Strategies

The field study results revealed the prevalent sustainable construction strategies in Kenya to be: property value enhancement – intentional efforts to enhance property value; enhancing functionality – ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently; development cost efficiency; energy conservation; and, operational cost rationalization. The results further highlighted an overall minimal/sub-optimal/below average adoption of sustainable construction strategies in Kenya. Specifically, the strategies (prevalent and otherwise) in order of decreasing adoption were: property value enhancement – deliberate effort to enhance property value such as through artistic/architectural design; enhancing functionality – ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently; development cost efficiency; energy conservation – aimed at rationalized use of energy; operational cost rationalization; enhancing human well-being – protecting health and comfort; water conservation – water use rationalization; materials conservation – materials use rationalization; land conservation – geared towards rationalized use of land; labour productivity enhancement; enhancing resilience against disasters such as fires, floods, earthquakes, and, crime prevention through design; and, demolition and materials recovery cost consideration.

In line with SCT objectives, these strategies in decreasing adoption order ranked as: social; environmental; and, economic. Additionally, the results highlighted the specific methods supporting the SCT strategies in Kenya to include: design (passive and active/mechanical) coupled with increased onboarding of BIM in sustainable construction endeavours by design phase practitioners; sustainable construction advocacy, certifications, and, capacity building such as done by KGBS; energy auditing in constructed facilities as backed by *The Energy (Energy management) Regulations 2012 (KE)*; minimum appliances energy performance standards as backed by *The Energy (Appliance's energy performance and labelling) Regulations 2016 (KE)*; and, increased inflow of SC compliant materials and methods/technologies such as 3D printing though the requisite local technical capacity building had a long way to go.

6.3.3 Specific Objective 2 (Part 2): SCT Strategies Implementation Considerations Ranking

The results identified implementation considerations for SCT strategies, in decreasing consideration order, in Kenya to be: stakeholders' readiness for SCT; social and spatial appropriateness of SCT approaches; supportive decentralized SCT steering; SCT resilience – capacity to adapt and/or respond to SCT associated disturbances; leveraging MSMEs in SCT; and, leveraging IoT-driven big data and BIM in SCT. Overall, the six implementation considerations for SCT strategies, irrespective of the above highlighted ranking, were adopted to a small extent (below average/sub-optimal). In light of the observed industry SCT performance sub-optimality and sub-optimal adoption of SCT strategies in practice, the overall sub-optimal leveraging of SCT strategies implementation considerations (as highlighted above) support STS theory that technical strategies and their implementation considerations have a joint and direct relationship with industry SCT performance. The study revealed additional key findings. First, SCT change readiness scales were ranked in decreasing readiness order as follows – construction project team level, organizational level, and, individual level. Second, the Kenyan construction industry was dealing with sustainability challenges primarily through changing physical settings with comparatively less focus on the additional approaches (in relation to place-based interventions) of changing one's behaviour, and/or, that of others.

Third, SCT resilience scales were ranked in decreasing resilience order as follows – capacity to engineer a totally new SCT regime when the existing one is undesirable in response or in anticipation (transformative resilience), understanding of mutual dependency between the construction industry, on SCT, and its environment including associated opportunities and risks (integrative resilience), and, internal capacity of the construction industry to resist disruptions associated with SCT (structural resilience). Fourth, private and civil societies actors held hegemony over government (national and county) and media in governance of SCT in Kenya. Fifth, MSMEs were adopting SC mainly due to supply chain pressures as opposed to voluntarily. Lastly, BIM experienced comparatively higher adoption in SCT compared to IoT-driven big data in Kenya.

6.3.4 Specific Objective 3: SCT Regime (Policy and Legislative) Priorities, Instruments, and, Stakeholder Orientation including (any) Inherent Shortcomings

The qualitative study results identified the priorities of the Kenyan SCT regime (policy and legislative) as primarily focused on environmental sustainability and strategic (industry-level and long-term) and tactical (organizational-level and medium-term) implementation levels. The associated shortcomings were minimal focus on: SCT socio-economic objectives; and, operational (construction project-level and short-term) level of implementation. These shortcomings indicate reduced comprehensiveness in covering the three integrated facets of SCT (economic, environmental, and, social) and associated implementation levels (strategic, tactical, and, operational). Regarding the instruments, the Kenyan SCT regime (policy and legislative) was observed to be operationalized through: regulations; the constitution, and Acts of Parliament; and, codes, guidelines, and, plans. These instruments were however: from multiple sources, and, primarily aimed at regulation and control. The associated shortcomings were: lack of a centralized instruments database; and, instruments having comparatively less backing for economic incentives, supporting activities such as demonstration projects, liability/damage compensation such as mandated pollution insurance, education and information such as eco-labelling, and, voluntary SC adoption. These shortcomings have the potential to lead to: sub-optimal and fragmented, SCT policy and legislative regime-led, practice, policy, and, research; and, limited role in facilitating SCT respectively.

Lastly, on stakeholder orientation, the Kenyan SCT regime (policy and legislative) was observed to primarily target developers/owners/occupiers and government (national and counties). The inherent shortcomings were: comparatively less targeting of design stage (professional consultants), construction stage (contractors), and, procurement support entities (suppliers, manufacturers, and, producers); and, no incorporation of media and civil society in SCT agenda. These shortcomings have the potential to: minimize the effectiveness and efficiency of the regime in eliciting enhanced industry SCT performance; and, lead to lack of significant regime buy-in, including active participation, by stakeholder groups who perceive themselves as being left-out.

6.3.5 Specific Objective 4: Develop SCT Model Linking SCT Performance, SCT Strategies, and, Their Implementation Considerations

Field study results indicated that SCT strategies, SCT change readiness, and, leveraging MSMEs in SCT were significant predictors of industry SCT performance. Specifically, the model developed (as restated below), has the three predictors jointly accounting for 49.4% variance in SCT performance. These findings also support the anchor theory, STS theory, that technical strategies (SCT strategies) and their implementation considerations (SCT change readiness and leveraging MSMEs in SCT – as identified above) have a joint and direct relationship with industry SCT performance. Considering the number of independent variables and study participants, the model's predictive power was moderated to 48.3% – adjusted R^2. Also, the average distance between observed SCT performance values was 0.42873 standard errors of estimates (SEE) from the model regression line. Additionally, one unit change in SCT strategies, SCT change readiness, and, leveraging MSMEs in SCT would result in +32%, +27%, and, +24.5% change in SCT performance respectively. Lastly, on validation, the developed model was found to have a predictive accuracy of 62.3% and MAPE of 13.6%. In context of its predictive power, predictive accuracy, and, MAPE, it is evident that SCT performance can be reliably predicted better with the model than without it. As such, it is evident that the model is valid and can be used for prediction of SCT performance on new data with a reasonable accuracy level.

SCT prediction model developed and validated:

$$P = 0.516 + 0.320\ STR + 0.270\ CR + 0.245\ MS$$

<u>Where:</u>

P = Industry SCT performance

STR = SCT strategies

CR = SCT change readiness

MS = Leveraging MSMEs in SCT

Additionally, the study suggested steps in operationalization of the model. First, the variables (including the constant) should be assigned weights (variable weights) and as outlined in the model: constant = 0.516; STR = 0.320; CR = 0.270; and, MS = 0.245. Second, the indicators for each variable should be measured on a scale of one to five, with the variable measurement/score being the average of the respective indicators scores. Third, weighted score per variable should be computed by multiplying variable score with respective variable weight. Fourth, individual weighted scores should be added to assess industry SCT performance. Lastly, since the measurements are on a scale of one to five and the model's predictive power is 49.4%, the SCT performance can be expressed as a percentage by dividing the performance value by five and multiplying the result by 49.4. Below is an example utilizing the data in Section 5.6:

Model:

P = 0.516 + 0.320 STR + 0.270 CR + 0.245 MS

Step one, assigning variable weights:

constant = 0.516, SCT strategies = 0.320, SCT change readiness = 0.270, and, leveraging MSMEs in SCT = 0.245

Step two, variable scores out of five:

STR = SCT strategies = 2.9172 (see Table 5.11)

CR = SCT change readiness = 2.8065 (see Table 5.12)

MS = Leveraging MSMEs in SCT = 2.5911 (see Table 5.16)

Step three, weighted scores computation:

STR = SCT strategies = 2.9172 * 0.320 = 0.9335

CR = SCT change readiness = 2.8065 * 0.270 = 0.7578

MS = Leveraging MSMEs in SCT = 2.5911 * 0.245 = 0.6348

Step four, industry SCT performance assessment:

P = 0.5160 + 0.9335 + 0.7578 + 0.6348 = 2.8421 (aligns with Table 5.10)

Step five, industry SCT performance assessment as a percentage:

P = (2.8421/5.0000) * 49.4 = ~ 28% (the Kenyan construction industry can be reported to be at 28% SCT performance based on the field data collected). The more the percentage tends towards the maximum of 49.4%, the better the SCT performance.

6.3.6 Hypotheses

The study results supported rejection of the null hypothesis that SCT strategies including their implementation considerations (context appropriateness considerations) are not significantly related with construction industry SCT performance. They thus supported the alternative hypothesis that SCT strategies including their implementation considerations (context appropriateness considerations) are significantly related with construction industry SCT performance. This was based on the following specific findings: SCT strategies; and, their implementation/context appropriateness considerations of SCT change readiness, and, leveraging MSMEs in SCT were found to be significant predictors of industry SCT performance. While not all implementation considerations of SCT strategies were significant predictors of SCT performance, some were. However, it should be noted that the SCT strategies implementation/context appropriateness considerations which were found to not be significant predictors of SCT performance were: SCT socio-spatial sensitivity; SCT resilience; SCT multi-level governance; and, leveraging IoT-driven big data and BIM in SCT. They were however positively correlated/associated with industry SCT performance and as such, their enhancement would be associated with enhanced industry SCT performance.

6.4 Conclusion

The literature reviewed including the results from empirical analysis of data (both quantitative and quantitative) led to the following conclusions by this study:

First, the Kenyan construction industry was not excluded from the lagging transition of the general global construction industry from conventional and largely unsustainable products, processes, and, practices to comparatively sustainable alternatives. This lag, for Kenya, was a factor of: sub-optimal adoption of sustainable construction strategies (fully encompassing the economic, environmental, and, social SCT objectives – including long-term industry-level, medium-term organizational-level, and, short-term construction project-level implementation); inadequate industry stakeholders' readiness towards sustainable construction (at individual stakeholder, project team, and, organizational scales); and, insufficient leveraging of industry MSMEs given their industry hegemony. It was additionally attributed to inadequacies in the SCT policy and legislative regime (as highlighted hereunder).

Second, current sustainable construction practices were primarily aimed at: property value enhancement – intentional efforts to enhance property value; enhancing functionality – ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently; development cost efficiency; energy conservation; and, operational cost rationalization. Their implementation was to a small extent considerate of the following factors: stakeholders' readiness for SCT; social and spatial appropriateness of SCT approaches; supportive decentralized SCT steering; SCT resilience – capacity to adapt and/or respond to SCT associated disturbances; leveraging MSMEs in SCT; and, leveraging IoT-driven big data and BIM in SCT (in decreasing consideration order). Overall, SCT in the Kenyan construction industry was identified to be in early development stage.

Third, the policy and legislative regime driving SCT in Kenya was: primary prioritizing environmental sustainability (water, energy, materials, and, land conservation) focussed on long-term industry-level and medium-term organizational-level implementation scales; driven by a mix of policies and legislative instruments mainly aimed at regulation and control; and, largely targeted developers/owners/occupiers and government (national and counties). Its apparent areas of improvement were: enhanced focus on social and economic sustainability and short-term construction project-level implementation scale; centralization of instruments including enhancing them to do more than regulation and control; and, improved targeting of professional consultants, contractors, suppliers, manufacturers, and, producers (including onboarding media and civil society in SCT programs).

Lastly, the key drivers for enhanced industry SCT performance in Kenya were: adoption of sustainable construction strategies (fully encompassing the economic, environmental, and, social SCT objectives – including long-term industry-level, medium-term organizational-level, and, short-term construction project-level implementation); building industry stakeholders' readiness towards sustainable construction (at individual stakeholder, project team, and, organization scales); and, active onboarding of MSMEs in SCT programs. Additionally, enhanced industry SCT performance would also be associated with improved: social and spatial appropriateness of SCT approaches; supportive decentralized SCT steering; SCT resilience – capacity to adapt and/or respond to SCT associated disturbances; and, leveraging IoT-driven big data and BIM in SCT.

6.5 Achievements and Contributions to Knowledge

The achievements and original contributions to knowledge of this study are discussed in detail in Sections 6.5.1-6.5.2 respectively hereunder:

6.5.1 Achievements

The study was able to realize a set of achievements. First, the four study objectives were fully realized and consequently, the inherent research questions, as pre-set in Section 1.5, were fully answered. Second, the hypothesized linear positive and significant relationship between SCT strategies, their implementation/context-appropriateness considerations, and, SCT performance tested, based on socio-technical systems (STS) theory, was confirmed. Third, given that determination as to how sustainable an endeavour is, is highly dependent on the interpretation of sustainability adopted, the contested interpretations of sustainable development (SD) and sustainability where some studies argued they were synonymous and others not were explored. Specifically: sustainability emerged as the goal and SD the means of achieving it; main SD conceptualizations and discourses were explored; and, the study specified the adopted interpretation. Lastly, were the original contributions to knowledge realized from the study. They included: development of a pioneer SCT model for Kenyan construction industry; extension of socio-technical systems (STS) theory application to SCT; pioneer empirical investigation of the Kenyan SCT regime (policy and legislative); development of original scales for measurement of industry SCT performance, strategies, and, select implementation considerations. These contributions are discussed in detail in Section 6.5.2 below.

6.5.2 Contributions to Knowledge

Below outlined were the resulting original contributions to knowledge:

First, development of pioneer SCT model for the Kenyan construction industry. Based on socio-technical systems (STS) theory, this study linked SCT strategies and their implementation/context-appropriateness considerations (of change readiness and leveraging MSMEs) with SCT performance into one model. Notably, the model was of reasonable predictive power (49.4%), predictive accuracy (62.3%), and, MAPE (13.6%). Additionally, the non-significant predictors (SCT socio-spatial sensitivity, resilience, multi-level governance, and, leveraging IoT-driven big data and BIM) were positively correlated with of SCT performance. As such, their enhanced consideration in SCT strategies implementation would be associated with enhanced SCT performance.

Second, extension of socio-technical systems (STS) theory application to SCT. No specific theory was found in the reviewed studies explaining SCT. The adopted theoretical framework was primarily anchored on socio-technical systems (STS) theory. It was to the effect that joint optimization of SCT strategies and their context-appropriateness considerations (largely social) is central to enhanced and optimized industry SCT performance. Additionally, TPB, PIT, resilience theory, and, MLG theory provided a basis of explaining context appropriateness in SCT strategies implementation. It was identified to be a factor of change readiness, socio-spatial sensitivity, resilience, multi-level governance, leveraging MSMEs, and, leveraging IoT-driven big data and BIM. Overall, this study offers a new theoretical lens of looking at SCT.

Third, pioneer empirical investigation of the Kenyan SCT regime (policy and legislative). The resultant findings characterized it as: priorities – environmental sustainability and targeting strategic and tactical implementation levels; instruments – driven by regulations, the constitution, and legislation, as well as codes, guidelines, and, plans, from multiple sources, primarily aimed at regulation and control; and, stakeholder orientation – primarily targeting developers/owners/occupiers and government. The inherent shortcomings, identified for improvement, were: priorities – less focus on SCT socio-economic objectives and operational implementation level; instruments – no centralized database and leveraging other operation mechanisms beyond regulation control; and, stakeholder orientation – less targeting of professional consultants, contractors, suppliers/manufacturers/producers, civil society, and, media.

Lastly, development of original scales for measurement of SCT performance, strategies, and, implementation considerations. This study developed original scales for measurement of industry SCT performance, strategies, and, implementation considerations. This was in the context of the absence of such scales in the previous studies reviewed. The resulting measurement scales achieved acceptable: reliability (Cronbach's alpha>0.8); convergent validity (composite reliability>0.8); and, discriminant validity (HTMT ratios<0.85-0.90). Future studies exploring the said variables could thus make use of these scales in light of their confirmed validity and reliability, sound theoretical basis, and, anchorage in related past studies. The specific indicators additionally offer a better understanding of the said variables beyond general variable concepts.

6.6 Practical Implications of the Findings and Arising Recommendations

With the SCT performance of Kenyan construction industry having been observed to be sub-optimal, the findings were expected to have practical implications. Additionally, these implications are in turn expected to result in recommendations towards comparatively enhanced and optimal SCT performance moving forward. These 2 aspects are discussed in detail in Sections 6.6.1 and 6.6.2 below.

6.6.1 Practical Implications of the Findings

The study findings had several practical implications for industry practice stakeholders (individuals, project teams, and, organizations). First, the model developed outlines three key elements that should be prioritized for enhanced industry SCT performance. That is: SCT strategies (including associated supporting practices at the various implementation levels); SCT change readiness building; and, onboarding associated MSMEs for active involvement. Second, the centrality of SCT strategies and their implementation/context appropriateness considerations (change readiness, and, leveraging MSMEs) joint optimization for enhanced SCT performance is highlighted. Optimization of one of them without the other, sub-optimization, has the potential to increase non-linear and unpredictable relationships including relationships of negative impact to industry SCT performance. Third, though not significant predictors of SCT performance, enhanced SCT socio-spatial appropriateness, resilience building, appropriate multi-level governance, and, leveraging IoT-driven big data and BIM would be associated (association and not causation) with enhanced industry SCT performance. Lastly, For information and consequent action in practice, SCT related policy and legislative instruments were identified, their specific SCT provisions outlined, and, the inherent obligations for the various industry stakeholder holders delineated. This included the pillar(s)/dimension(s)/facet(s) of SCT targeted by each instrument to facilitate decision making.

The study findings also had two practical implications for SCT related policymakers, and, associated stakeholders. One, the shortcomings inherent in the priorities, instruments, and, stakeholder orientation of the Kenyan SCT policy and legislative regime/framework have been highlighted for action. As such respective policymakers and legislators (individuals and institutions) now have a known starting point in enhancing its priorities, instruments, and, stakeholder orientation. This has the potential to boost the regimes effectiveness and efficiency in supporting enhanced industry SCT performance. Lastly, the findings avail empirical evidence on the influences of SCT strategies and their implementation/context appropriateness considerations of change readiness and leveraging MSMEs on industry SCT performance. Consequently, this highlights part of what revisions and crafting of new policies, legislation, and, regulations should consider backing for enhanced industry SCT performance.

6.6.2 Arising Recommendations

Based on the practical implications of the study as discussed in Section 6.6.1 above, several recommendations emerged for enhanced and optimized industry SCT performance in Kenya. These recommendations are differentiated in three implementation levels: short-term; medium-term; and, long-term. This was informed by the identified nature of STs, such as SCT, to take a long time to execute (see Section 2.2.4).

In the short-term:

One, industry professional and trade associations (including relevant SCT related governance institutions such as NCA and KGBS) should embark on awareness drives on SCT strategies, their supporting implementation methods, and, implementation levels targeting key industry stakeholder groups. This would ensure the key industry stakeholder groups have clarity on SCT strategies, how to implement them, and, implementation levels – *research objectives 1 and 2*.

Two, industry professional and trade associations (including relevant SCT related governance institutions such as NCA and KGBS) should also embark on programs aimed at: preparing industry stakeholder groups for SCT (understanding the need, and, fostering requisite commitment and capacity building); and, enhanced onboarding of MSMEs for active involvement in SCT programs – *research objectives 1 and 2*.

In the medium-term:

One, industry professional and trade associations (including relevant SCT related governance institutions such as NCA and KGBS) should have criteria for assessing SCT performance, SCT strategies, SCT readiness, and, onboarding of MSMEs actively in SCT efforts or adopt the ones developed in this study for objective planning, monitoring, and, control of SCT implementation – *research objectives 1 and 2*.

Two, construction project teams (design and construction phases stakeholders) should only embark on SCT projects when key project stakeholders: demonstrate reasonable SCT strategies, their supporting implementation practices, and, implementation levels literacy; are SCT change ready (understand the need, are committed, and, have requisite capacity); and, have onboarding involved MSMEs for active involvement – *research objectives 1, 2, and, 4*.

In the long-term:

One, SCT related governance entities (government – national and counties, and, its agencies such as NCA) in crafting new and/or revising SCT related policies and legislative instruments, should target improved focus on SCT social and economic objectives including operational level (construction project-level and in the short-term) of SCT implementation – *research objective 3*.

Two, SCT related governance entities (government – national and counties, and, its agencies such as NCA) in crafting new and/or revising SCT related policies and legislative instruments, should target having them also back economic incentives, supporting activities, liability compensation, education and information, voluntary programs, and, management and planning. A centralized database for the SCT instruments should also developed – *research objective 3*.

Three, SCT related governance entities (government – national and counties, and, its agencies such as NCA) in crafting new and/or revising SCT related policies and legislative instruments, should ensure improved targeting of construction industry contractors, suppliers, producers, manufacturers, and, professional consultants (including NGOs, CSOs, and, media). This would ensure that their unique roles in SCT supply chain is leveraged to drive enhanced industry-level SCT performance – *research objective 3*.

Four, SCT related governance entities (government – national and counties, and, its agencies such as NCA) in crafting new and/or revising SCT related policies and legislative instruments, should ensure enhanced support for: SCT strategies, their supporting implementation methods, and, implementation levels; SCT change readiness building; and, onboarding of MSMEs for active involvement in SCT efforts – *research objectives 1, 2, 3, and, 4*.

6.7 Future Research Suggestions

Based on the scope, limitations, delimitations, methodology, and, findings of this study, several possible areas for future studies were identified. One, methodologically, this study adopted regression analysis in modelling the relationship between the study variables. Future studies on the subject can consider using structural equation modelling (SEM) to enrich methodological approaches to the subject. Two, with the developed SCT model accounting for 49.4% of industry SCT performance, there are other industry SCT performance predictors not considered in this study. Future studies can explore their empirical identification in a bid to explain the remaining 50.6% (including exploring any non-linear relationships based on STS theory – see Section 2.6.6). Lastly, given that this study was based on the Kenyan construction industry, replication in other country/countries can be pursued to assess regional/global generalizability of the model developed and validated herein.

6.8 A Reflection on the Study

This section was aimed at reflecting on the research process, problem framing, theoretical and conceptual frameworks, research methodology, findings, and, their implications. While the research objectives of this study were fully achieved and contributions to knowledge realized as highlighted in Section 6.5 above, I am compelled to take stock of the research journey that led to this thesis.

Chapter one, research problem identification and framing, focused on the full scope of SCT, that is economic, environmental, and, social facets jointly. While this approach acknowledges sustainability as a holistic concept, and offers a richer and deeper understanding of SCT, as is expected of a doctoral study, I now realize that this approach has the potential to obscure important nuances specific to each of the three facets individually. Consequently, it would help if future researchers can continue exploring SCT along the three sustainability pillars jointly while others explore them individually. This has the potential to ensure a richer understanding of SCT as an overarching concept but also for its constituent pillars/facets of economic, environmental, and, social.

In Chapter two, a decision, based on pre-set research objectives, was made to work with a theoretical framework (based on established theories) as opposed to target development of a theory for SCT. While this (deductive approach) facilitated the full attainment of research objectives, it is just one of the ways of understanding SCT phenomena. SCT being a nascent research field may also benefit from theory building. This would involve development of concepts, assumptions, and, principles explaining industry SCT performance. Such an approach would offer new knowledge complementing current efforts, such as in this study, relying on established theories. In short, theory-building studies have the potential to complement deductive alternatives to facilitate an enhanced understanding of SCT performance.

Chapter three, research methodology, specifically content analysis of the Kenyan SCT regime (policy and legislative), the coding and themes identification was manually done. This was informed by the fact that specific policies, legislations, and, regulations had only part provisions on SCT and as such analysing an entire document using a textual analysis software such as NVivo would not have been appropriate. I however must note that I now realize that to some extent my construction industry background, experiences, and, assumptions may have to some extent influenced my analysis, findings interpretations, and, assertions presented. That notwithstanding, a sound content analysis methodological approach was adopted and well documented for any future attempts to replicate the study.

Lastly, the study has presented pertinent practical implications of the findings and consequently recommendations in chapter six (summary of chapters four and five). Their potential value towards enhanced SCT performance in the Kenyan construction industry notwithstanding, I cannot help but wonder: will they have unintended consequences? Will they result in the envisaged positive change towards comparatively enhanced and optimal industry SCT performance? Will they be misinterpreted (intentionally or otherwise) to reinforce the status quo? Even with such uncertainty, it is evident that this study avails a better understanding, model, and recommendations that have the potential to lead to a comparatively enhanced industry SCT performance. Nonetheless, I am grateful and humbled for the opportunity to have conducted this study on the SCT ‘droplet’ in the SC ‘ocean’ as I now embark on continued dissemination of the findings through, though not limited to: publications; conferences; and, other construction industry stakeholder forums.

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APPENDICES

Appendix 1: NACOSTI Research Introduction Letter

UNIVERSITY OF NAIROBI

DEPARTMENT OF REAL ESTATE, CONSTRUCTION MANAGEMENT & QUANTITY SURVEYING

P.O. Box 30197 – 00100 Nairobi, Kenya, Tel. No.: +254-782383848
E-mail: recmqs@uonbi.ac.ke

Ref: B80/59029/2021 **Date:** 18th July, 2022

Director General
National Commission for Science,
Technology and Innovation (NACOSTI)
P.O. Box 30623 – 00100
Nairobi

Dear Sir/Madam,

RE: PhD RESEARCH PERMIT/LICENSE – MR. SAMUEL KAMAU JOSEPH

This is to confirm that the above named is a student in the Department of Real Estate, Construction Management and Quantity Surveying pursuing a course leading to a Doctor of Philosophy in Construction Management degree.

He is carrying out research entitled ***"Modelling Sustainability Transition in the Kenyan Construction Industry"*** in partial fulfillment of the requirements for the degree programme. The study will be conducted in Nairobi City County.

The purpose of this letter is to request you to issue him with a permit/license to enable him carry out and access any kind of material he may require to complete his research. The information will be used for research purposes only.

Any assistance accorded to him will be appreciated.

CHAIRMAN
DEPARTMENT OF REAL ESTATE
CONSTRUCTION MANAGEMENT
AND QUANTITY SURVEYING
UNIVERSITY OF NAIROBI

Isabella N. Wachira-Towey, PhD
Chairman & Senior Lecturer
Dept. of Real Estate, Construction Management & Quantity Surveying

Appendix 2: NACOSTI License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **813402**

Date of Issue: **17/August/2022**

RESEARCH LICENSE

This is to Certify that Mr.. Samuel Kamau Mungai of University of Nairobi, has been licensed to conduct research in Nairobi on the topic: Modelling Sustainability Transition in the Kenyan Construction Industry for the period ending : 17/August/2023.

License No: **NACOSTI/P/22/19614**

813402

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Appendix 3: Respondents Research Introduction Letter

UNIVERSITY OF NAIROBI

DEPARTMENT OF REAL ESTATE, CONSTRUCTION MANAGEMENT & QUANTITY SURVEYING

P.O. Box 30197 – 00100 Nairobi, Kenya, Tel. No.: +254-782383848

E-mail: recmqs@uonbi.ac.ke

Ref: B80/59029/2021 **Date:** 18th July, 2022

To Whom It May Concern

Dear Sir/Madam,

RE: RESEARCH LETTER – SAMUEL KAMAU JOSEPH

This is to confirm that the above named is a student in the Department of Real Estate, Construction Management and Quantity Surveying pursuing a course leading to a Doctor of Philosophy in Construction Management degree.

He is carrying out research entitled ***"Modelling Sustainability Transition in the Kenyan Construction Industry"*** in partial fulfillment of the requirements for the degree programme.

The purpose of this letter is to request you to allow him access to any kind of material he may require to complete his research. The information will be used for research purposes only.

Any assistance accorded to him will be appreciated.

CHAIRMAN
DEPARTMENT OF REAL ESTATE
CONSTRUCTION MANAGEMENT
AND QUANTITY SURVEYING
UNIVERSITY OF NAIROBI

Isabella N. Wachira-Towey, PhD
Chairman & Senior Lecturer
Dept. of Real Estate, Construction Management & Quantity Surveying

Appendix 4: Questionnaire Information Sheet

Samuel Kamau Joseph (Reg. No. B80/59029/2021)
Department of Real Estate, Construction Management, and Quantity Surveying
University of Nairobi
P.O. Box 30197 – 00100
Nairobi, Kenya
Contact information: skksamwel@uonbi.ac.ke/0712 679 711

Research Information Sheet

My name is Samuel Kamau Joseph and I am a doctoral candidate at the Department of Real Estate, Construction Management, and Quantity Surveying, University of Nairobi.

My research is entitled: ***Modelling Sustainability Transition in the Kenyan Construction Industry***. It seeks to empirically investigate: extent of sustainable construction transition (SCT); contribution of the various SCT strategies to observed SCT; and, contribution of key SCT strategies implementation considerations (change readiness, spatial sensitivity, resilience thinking, governance, MSMEs, and, select technologies of big data and building information modelling (BIM)) to observed SCT. This is ultimately aimed at developing a model to facilitate enhanced industry SCT.

Your valuable input and insights will go a long way in facilitating this study. If willing to participate, it will take you at about 10 minutes to respond to the attached questionnaire. Additionally, you: can withdraw from this study at any time; your name will not be required to ensure anonymity; only myself and my supervisors will have access to the resulting data; and, the data will be solely used for academic purposes. A softcopy of the completed thesis shall be availed to you on request. Let me know of any questions you may have regarding this study through the contacts above. I look forward to your valued participation.

Yours Sincerely,

Samuel Kamau Joseph

Appendix 5: Questionnaire to Respondents

<u>Kenyan Construction Industry Design Phase Practitioners Questionnaire</u>

Issue Number : …………………………………………………………………......

Date Issued : …………………………………………………………………......

Date Received : …………………………………………………………………......

<u>Section 1: Definition of Sustainable Construction Transition (SCT)</u>

Sustainable Construction Transition (SCT): Radical long-term shift (socially and technically) in the way construction is done – from unsustainable to sustainable practices (environmentally, economically, and, socially) – with corresponding change in stakeholders view of associated products, services, and, system adequacy and using technology to overcome limits to exploitation of natural resources.

<u>Section 2: Respondents' General Information</u>

1. Please **tick (✓)** below your current professional category (ies) ***(You may tick more than one box as may be appropriate)***:

   ☐ Architect
   ☐ Interior designer
   ☐ Construction project manager/construction manager
   ☐ Mechanical engineer
   ☐ Electrical engineer
   ☐ Quantity surveyor
   ☐ Civil/structural engineer

2. Please **tick (✓)** below your corresponding experience in the construction industry:

   ☐ 0-5 years ☐ 6-10 years
   ☐ 11-15 years ☐ Over 15 years

3. By **ticking (✓)** the appropriate box/boxes, indicate the construction industry market segment/segments that you mainly deal with ***(You may tick more than one box as may be appropriate)***:

   ☐ Interior design ☐ Architectural ☐ Infrastructural

4. Please **tick (✓)** below the common type (s) of construction projects that you deal with ***(You may tick more than one box as may be appropriate)***:

☐ New works ☐ Refurbishment/renovation works

☐ Redevelopment works

5. By **ticking (✓)** the appropriate box, indicate if your current organization/practice has a sustainability policy/plan:

☐ Yes ☐ No

☐ Not sure

<u>Section 3: Industry Sustainable Construction Transition (SCT) Performance</u>

6. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

   Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Indicators of Industry SCT performance	Responses				
	1	2	3	4	5
There is change in industry stakeholders' perceptions towards support of sustainability compliant processes					
There is change in industry stakeholders' perceptions towards support of sustainability compliant products					
There is use of technology to overcome limits to exploitation of natural resources employed in construction such as water, land, and, building materials					
There is demand for sustainability compliant processes and products					
There is supply of sustainability compliant processes and products					
There is resources (labour, materials, finance, space, plant, and, time) use efficiency					
There is water, land, energy, and, materials conservation					
There is compliance with moral and legal obligations to stakeholders, such as government and site employees					

Section 4: Sustainable Construction Transition (SCT) Strategies

7. Please rate the extent to which the following strategies have been adopted in the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

   Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

SCT Strategies	Responses				
	1	**2**	**3**	**4**	**5**
Labour productivity enhancement					
Development cost efficiency					
Operational cost rationalization					
Demolition and materials recovery cost consideration					
Property value enhancement – Deliberate effort to enhance property value such as through artistic/architectural design					
Water conservation – Water use rationalization					
Land conservation – Geared towards rationalized use of land					
Energy conservation – Aimed at rationalized use of energy					
Materials conservation – Materials use rationalization					
Enhancing human well-being – Protecting health and comfort					
Enhancing resilience against disasters such as fires, floods, earthquakes, and, crime prevention through design					
Enhancing functionality – Ensuring ease of maintenance, layout flexibility, and, ease of access by the abled differently					

Section 5: Sustainable Construction Transition (SCT) Change Readiness

8. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

   Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Indicators of SCT Change Readiness	Responses				
	1	**2**	**3**	**4**	**5**
Individual stakeholder level:					
There are SCT supportive management processes such as organizational socialization and recruitment					

Indicators of SCT Change Readiness	Responses				
	1	2	3	4	5
Individual stakeholder level:					
There is effective sustainable construction change communication					
There is active stakeholders' participation on SCT					
There is SCT supportive leadership influence					
Stakeholders have positive personal attributes such as risk tolerance and positive self-concept					
SCT drive *(in terms of: desire for change; convincing vision; and, practical first steps)* outweigh SCT resistance					
Project team level:					
Typically, there is well articulated project team level sustainable construction change vision					
Project team leadership is conscious to collective emotional response towards sustainable construction change					
There is supportive change climate					
Project team members are able to articulate themselves on SCT without fear of negative consequences related to trust and respect accorded to them by other project team members					
There are supportive emotional reactions to sustainable construction change					
Organizational level:					
Top management has positive attitude regarding change towards sustainable construction					
Organizational culture is characterized by support to development and adaptability					
There are supportive organizational procedures and policies for handling emotional responses to SCT					

Section 6: Sustainable Construction Transition (SCT) Spatial Sensitivity

9. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) next page as appropriate**

   Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Indicators of SCT Spatial Sensitivity	Responses				
	1	2	3	4	5
There is adaptation of generic sustainable construction approaches and tools for local appropriateness					
There is geographical differentiation (local, regional, and, national) and integration of sustainable construction approaches					
There is design of spaces and places for sustainability					
There is incorporation of local decision making in promotion and execution of sustainable construction approaches					
There is intentional effort to assist people negatively affected by: SCT; and, impacts of unsustainable construction practices such as victims of site accidents					
There is engagement of local institutions, *such as learning institutions, professional associations, and, trade associations,* on sustainable construction approaches					
There is creation of sustainable construction value *(health, societal, economic, and, environmental)* locally					
There is flexible and accountable SCT goal setting in relation to change of priorities over the long term					
There is consideration of sustainable change perceptions by the general public					

Section 7: Sustainable Construction Transition (SCT) and Resilience Thinking

10. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

    Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Indicators of Resilience-Driven-SCT	Responses				
	1	2	3	4	5
There are spare/reserve resources (human and non-human) for sustainable construction change					
There is sustainable construction supply chain decentralization					
There is variety of sustainable construction processes and products					
There is sustainable construction scales (industry long-term, organizational medium-term, and, project-level short-term) relationship awareness					
There is sustainable construction indicators monitoring for timely and appropriate planning and action					
There is stakeholders networking for bottom-up SCT					
There is decentralized SCT decision-making					
Stakeholders' have the ability to proactively adapt or reduce vulnerabilities associated with possible future SCT scenarios					
There is creation of new sustainable construction options and ideas through innovation and experimentation					

Section 8: Sustainable Construction Transition (SCT) Governance

11. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

    Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Supportive SCT Governance Indicators	Responses				
	1	2	3	4	5
There is decentralized sustainable construction steering, from primarily state actors towards non-governmental actors					
There is national government driven sustainable construction uptake/compliance					
There is county governments driven sustainable construction uptake/compliance					

Supportive SCT Governance Indicators	Responses				
	1	2	3	4	5
There is private sector actors, *such as: independent consultants, consultancy firms, construction firms, and, suppliers,* driven sustainable construction uptake/compliance					
There is civil society actors, *such as: NGOs; professional associations; trade associations; and, advocacy associations for example Kenya Green Building Society (KGBS)*, driven sustainable construction uptake/compliance					
There is media driven sustainable construction uptake/compliance including: relaying SCT information; supportive SCT opinion shaping; and/or, encouraging SCT related accountability					
There is clarity and awareness of SCT objectives – *resource efficiency, natural resources conservation, and, moral and legal obligations compliance*					
There is a SCT enabling context – *policies (government and corporate); laws and regulations; fiscal measures – tax and grants related; demand; codes, standards, and, (accreditation and certification) schemes; and, government facilitation, enabling, and, enforcement*					
Industry stakeholders' have the capacity to achieve SCT objectives (*resource efficiency, natural resources conservation, and, moral and legal obligations compliance)*					

<u>Section 9: MSMEs and Sustainable Construction Transition (SCT)</u>

12. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

    Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

    <u>Please note:</u> Micro, small and medium enterprises (MSMEs) – Business with number of employees and annual turnover not exceeding 250 and Ksh. 100,000,000 respectively

Role of MSMEs in SCT	Responses				
	1	2	3	4	5
SCT policy development and implementation is in consultation with MSMEs *such as through trade and professional associations*					
There is voluntary sustainable construction adoption by MSMEs					
There is sustainable construction adoption by MSMEs attributed to supply chain pressures					
There is a robust legislative system in support of sustainable construction adoption by industry MSMEs					
There is availability of SCT related market changes information to MSMEs					
MSMEs are engaged on SCT through: on-site visits; face-to-face engagements; networking; guidance helplines; and, value-based relationships *in addition to conventional approaches such as: seminars; internet; and, newsletters*					
There are intentional efforts to counter barriers to sustainable construction adoption by MSMEs *such as lack of market information*					
MSMEs are convinced on sustainable construction value/benefits					

<u>Section 10: Internet of Things (IoT)-Driven-Big Data and Building Information Modelling (BIM) for Sustainable Construction Transition (SCT)</u>

13. Please rate the extent to which the following statements are true for the Kenyan construction industry with reference to the last 5 years (or less as may be the case) of your practice – **Tick (✓) below as appropriate**

    Use the key: 1 = very small; 2 = small; 3 = average; 4 = large; and, 5 = very large

Role of IoT-Driven-Big Data and BIM in SCT	Responses				
	1	2	3	4	5
There is increased use of smart wearables, appliances, and, building management systems					
There is use of real time applications in aligning resources usage with resources, markets, and, behaviour					
There are big data driven prods towards sustainable construction behaviour *such as applications where consumers can compare energy uses in a bid to stimulate behaviour towards energy efficiency*					
There is big data driven collaborative consumption/use of constructed facilities *such as use of Airbnb platform for collaborative use of residences*					
There is BIM driven environmental conscious decision making over the lifecycle of constructed facilities					
There is BIM driven enhanced overall economic viability of constructed facilities *through aspects such as efficient logistics, enhanced productivity, and, waste reduction*					
There is BIM driven enhanced overall well-being of constructed facilities users and the general society *through support of aspects such as enhanced indoor air quality, appropriate waste management, and, stakeholders' engagement*					
There is onboarding of sustainability considerations early in design process and validating them using BIM, through facilities parametric modelling					

The End

Thank You for Your Time and Cooperation

Appendix 6: Interview Schedule Information Sheet

Samuel Kamau Joseph (Reg. No. B80/59029/2021)
Department of Real Estate, Construction Management, and Quantity Surveying
University of Nairobi
P.O. Box 30197 – 00100
Nairobi, Kenya
Contact information: skksamwel@uonbi.ac.ke/0712 679 711

Research Information Sheet

My name is Samuel Kamau Joseph and I am a doctoral candidate at the Department of Real Estate, Construction Management, and Quantity Surveying, University of Nairobi.

My research is entitled: ***Modelling Sustainability Transition in the Kenyan Construction Industry***. It seeks to empirically investigate: extent of sustainable construction transition (SCT); contribution of the various SCT strategies to observed SCT; and, contribution of key SCT strategies implementation considerations (change readiness, spatial sensitivity, resilience thinking, governance, MSMEs, and, select technologies of big data and building information modelling (BIM)) to observed SCT. This is ultimately aimed at developing a model to facilitate enhanced industry SCT.

Your valuable inputs and insights will go a long way in facilitating this study. If willing to participate, it will take you at about 45 minutes for this interview at a time and place convenient for you. Additionally, you: can withdraw from this study at any time; your name will not be recorded to ensure anonymity; only myself and my supervisors will have access to the resulting data; and, the data will be solely used for academic purposes. A copy of the transcript will be available on request and any changes you suggest will be made. A softcopy of the completed thesis shall also be availed to you on request. Let me know of any questions you may have regarding this study through the contacts above. I look forward to your valued participation.

Yours Sincerely,

Samuel Kamau Joseph

Appendix 7: Interview Schedule for Key Informants

Key Informants Interview Schedule

Interview Number : ……………………………………………………………….......

Interview Date : ……………………………………………………………….......

Start Time : ……………………………………………………………….......

End Time : ……………………………………………………………….......

Do you mind if I record this interview for review later? …………………………………..

Section 1: Sustainable Construction Transition (SCT) Definition

Sustainable Construction Transition (SCT): Radical long-term shift (socially and technically) in the way construction is done – from unsustainable to sustainable practices (environmentally, economically, and, socially) – with corresponding change in stakeholders view of associated products, services, and, system adequacy and using technology to overcome limits to exploitation of natural resources ***– to be offered at the beginning of the interview***

Section 2: Respondents General Information

1. Good morning/afternoon/evening? I would like to know a little about: your professional background; organization that you represent; and, whether the organization you represent has a sustainability policy

Section 3: Industry Sustainable Construction Transition (SCT) Performance

2. How would you evaluate the extent to which the Kenyan construction industry has shifted from conventional unsustainable practices to sustainable alternatives?

Section 4: Sustainable Construction Transition (SCT) Strategies

3. How would you evaluate the ways in which sustainable construction is incorporated in construction practices (process and product oriented) in Kenya?

Section 5: Sustainable Construction Transition (SCT) Change Readiness

4. How would you evaluate the extent to which the Kenyan construction industry is ready for SCT at individual stakeholder, project team, and, organization levels?

Section 6: Sustainable Construction Transition (SCT) Spatial Sensitivity

5. How would you evaluate SCT implementation in terms of socio-spatial appropriateness in the Kenyan construction industry?

Section 7: Sustainable Construction Transition (SCT) and Resilience Thinking

6. How would you evaluate the capacity of the Kenyan construction industry to absorb disturbances associated with SCT including appropriately re-organizing?

Section 8: Sustainable Construction Transition (SCT) Governance

7. How would you evaluate the governance of SCT in the Kenyan construction industry?

Section 9: MSMEs and Sustainable Construction Transition (SCT)

8. How would you evaluate the leveraging of MSMEs for enhanced SCT performance in the Kenyan construction industry?

Section 10: Internet of Things (IoT)-Driven-Big Data and Building Information Modelling (BIM) for Sustainable Construction Transition (SCT)

9. How would you evaluate leveraging of IoT-driven-big data and BIM for enhanced SCT performance in the Kenyan construction industry?

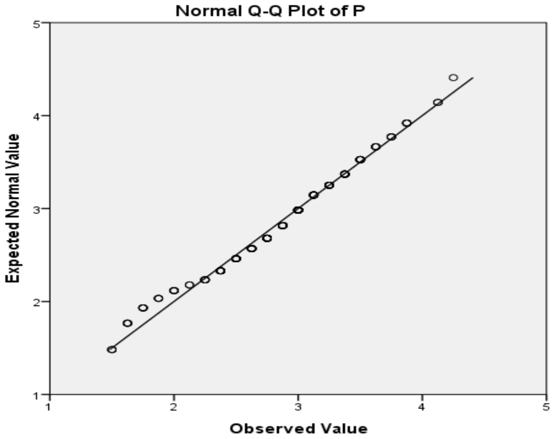
Section 11: Close-Out

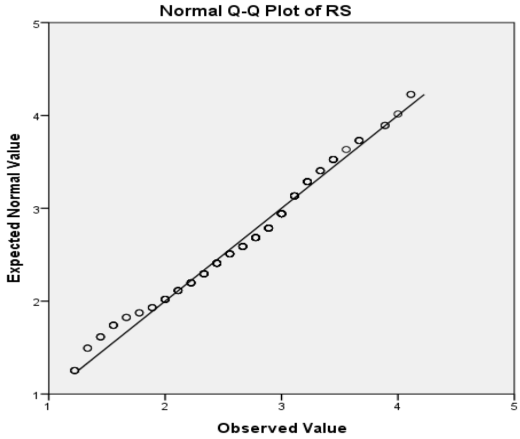
10. Anything else that you would like to add to the foregoing discussion?
11. Would be interested to confirm the resulting findings for validation purposes?

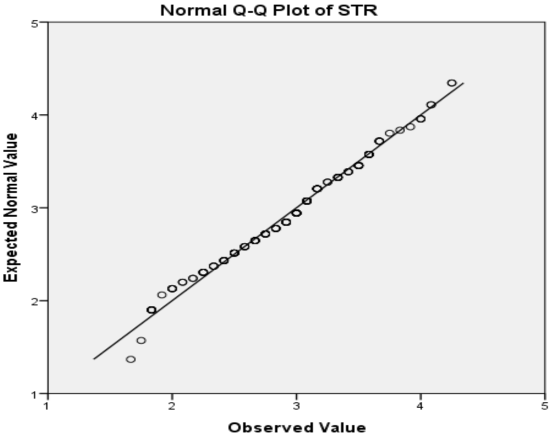
Thank you for your valuable input to this study

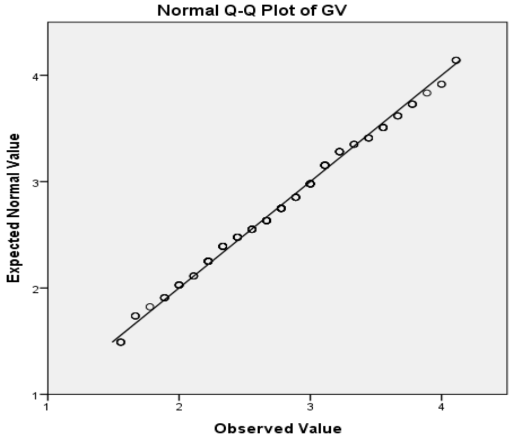
You are free to contact me later for any questions, additional contributions, and/or, concerns that you may have

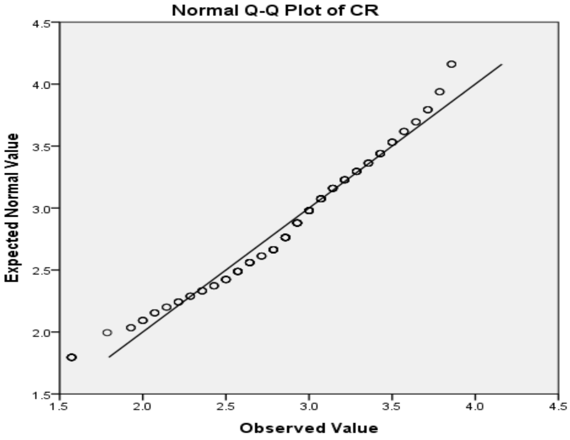
Appendix 8: Quantile-Quantile (Q-Q) Normality Plots

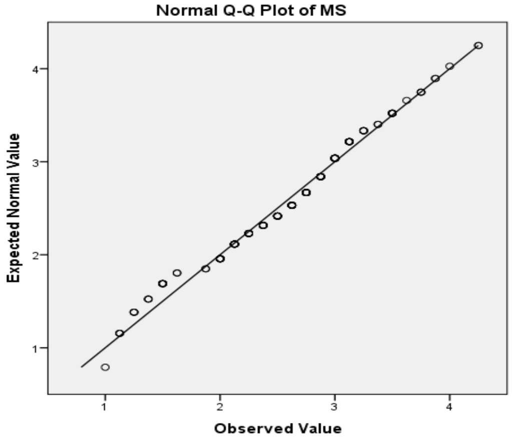


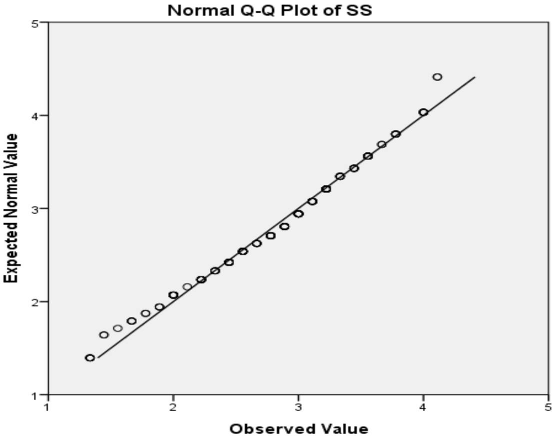


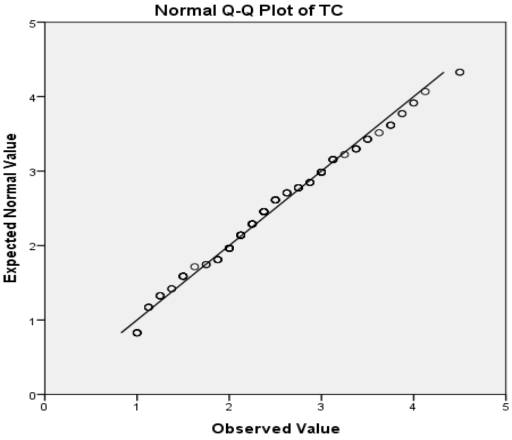




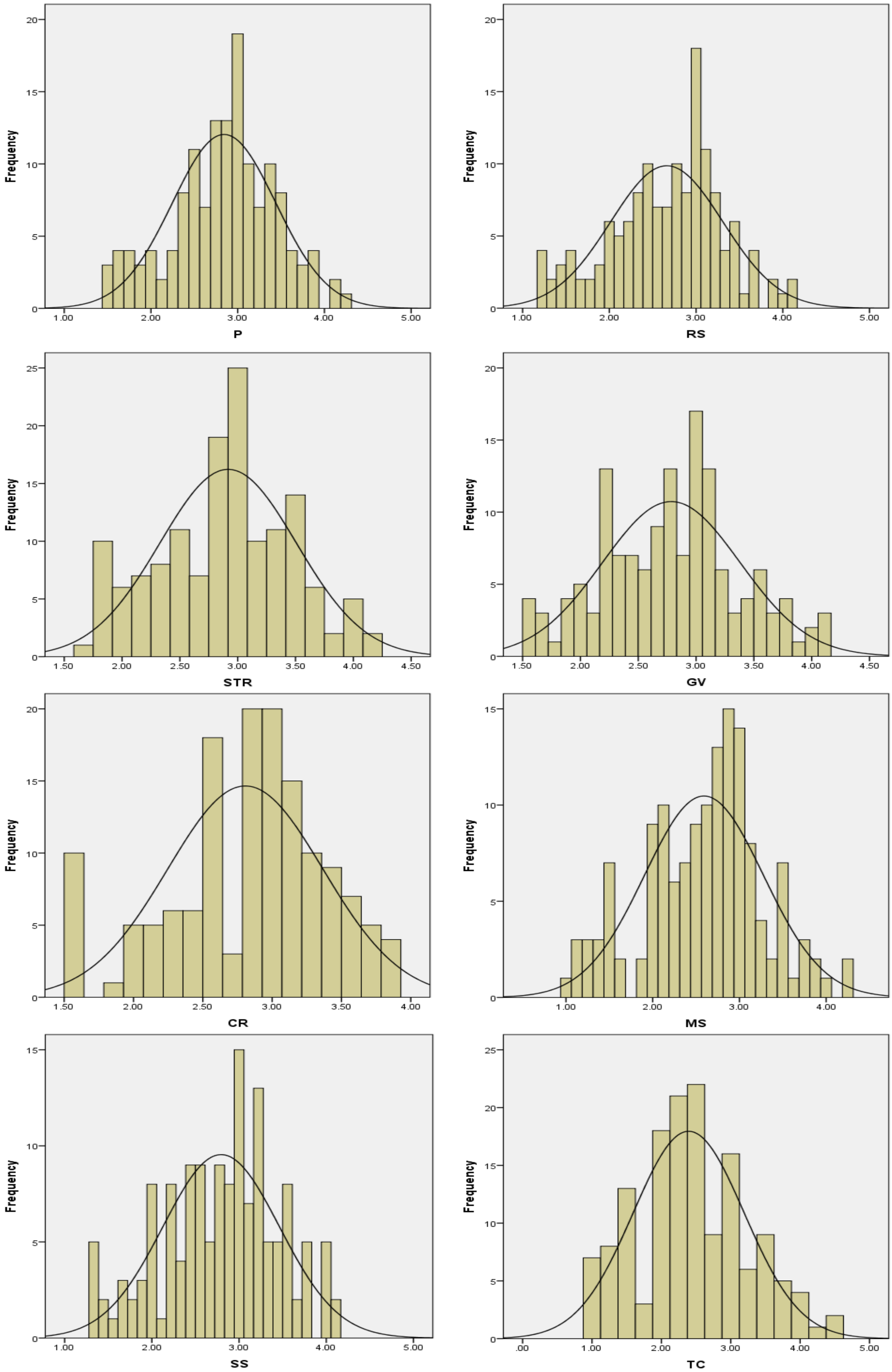






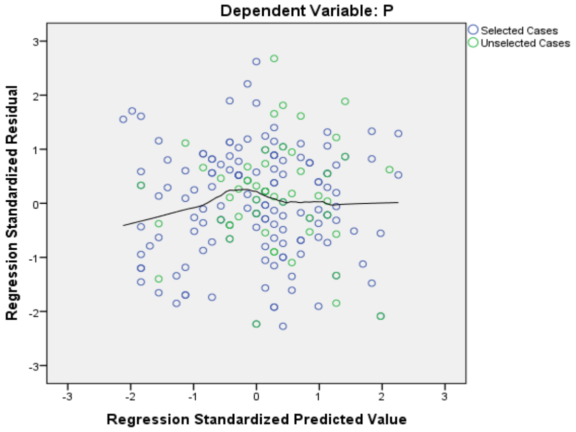


Appendix 9: Histogram Normality Plots

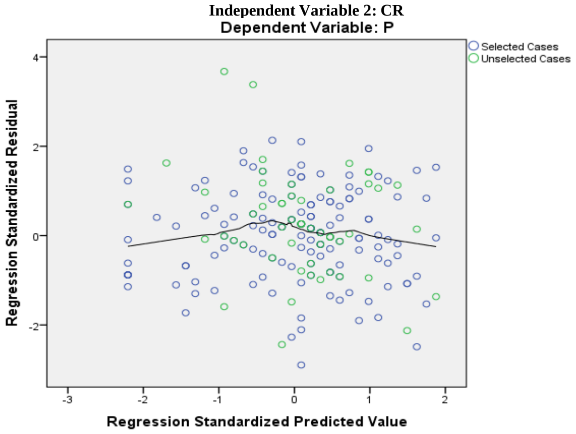


Appendix 10: Homoscedasticity Scatterplots (With Lowess Curves)

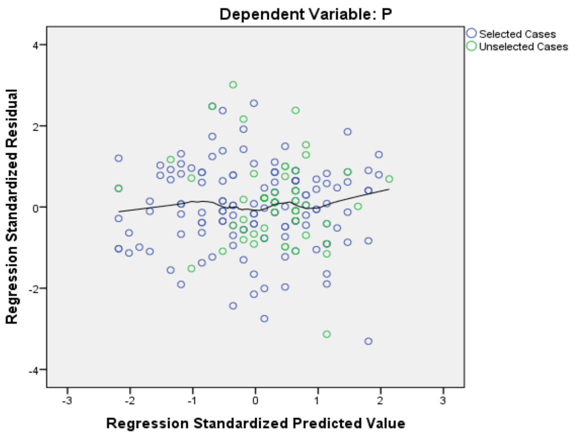
Independent Variable 1: STR



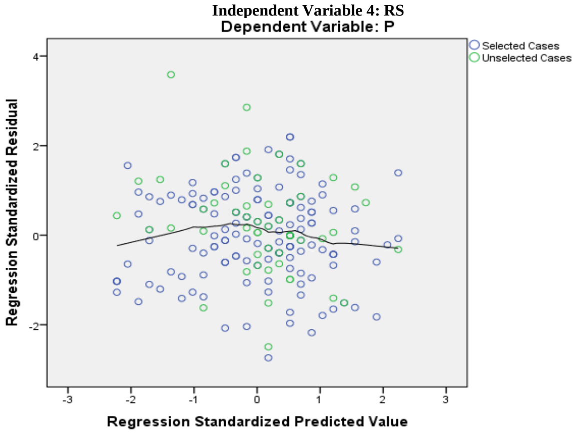
Independent Variable 2: CR



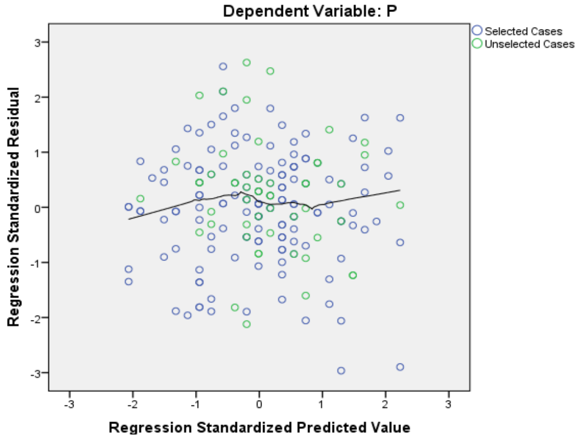
Independent Variable 3: SS



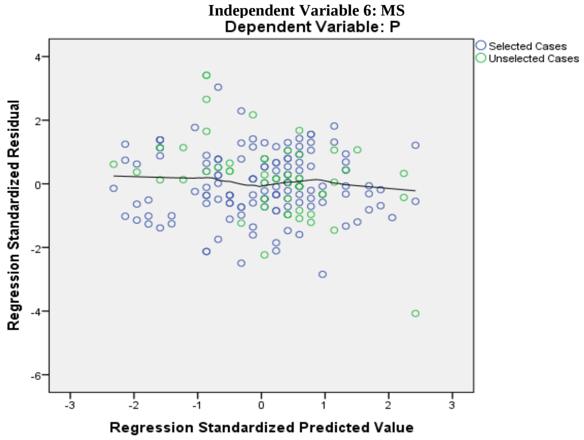
Independent Variable 4: RS



Independent Variable 5: GV



Independent Variable 6: MS



Independent Variable 7: TC