A REGULATORY AND INSTITUTIONAL FRAMEWORK FOR ENHANCING THE ADOPTION OF INNOVATIVE BUILDING TECHNOLOGIES IN NAIROBI AND METROPOLITAN TOWNS

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A Regulatory and Institutional Framework for Enhancing Adoption of Innovative Building Technologies in Nairobi and Metropolitan Towns

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2024

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

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DEDICATION

This thesis is dedicated to my parents for manifesting the value of a home and the homestead that shelters it. I also extend my gratitude to my family for their unwavering support and to almighty God for giving me good health.

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ACRONYMS AND ABBREVIATIONS

AAK	Architectural Association of Kenya
ABMT	Appropriate Building Materials and Technologies
AHP	Affordable Housing Programme
BMTPC	Building Materials & Technology Promotion Council
CAF	Compressed Agricultural Fiber
CSEBs	Compressed Stabilized Earth Blocks
CSIR	Central Building Research Institute
GOK	Government of Kenya
HABRI	Housing and Building Research Institute
HUDCO	Housing and Urban Development Corporation- India
IBTG	Innovative Building Technology Guide
IBTs	Innovative Building Technologies
ISSB	Interlocking stabilized soil Blocks
KES	Kenya Shillings
MLHUD	Ministry of Land Housing and Urban Development
NHC	National Housing Corporation
SIP	Structural Insulated Panels

SKAT	Swiss Centre for Development Cooperation in Technology and Management
UNCHS	United Nations Centre for Human Settlements

ABSTRACT

Innovative building technologies (IBTs) are often flaunted as a panacea for mitigating housing delivery shortfalls in light of the ever-growing construction costs. However, the adoption of these technologies in Kenya's construction industry is slow and this slackens their probable impact on facilitating affordable housing. The lagged adoption has partly been attributed to rigid institutional framework and unfavorable building laws, which oftentimes are cited to challenge any viable solution to the housing problem. This study aims to formulate a framework that can enhance the adoption of IBTs in the construction industry. The study appreciates government effort to ease barriers to the adoption of IBTs through the housing policy for Kenya, construction industry policy, and planning and building regulations. Multiple legislations and institutions have been noted to bear on IBTs adoption and the probable influence of these laws is discussed in the context thereof. The research relies on interviews, desktop reviews and questionnaires to gather information from industry players broadly classified into IBTs policymakers and disseminators and IBTs technology providers. The researcher assessed the drawbacks in institutional and legal frameworks that derail the adoption of IBTs from the perspective of the industry players. The findings showed that the regulatory and administrative framework in the Kenyan construction industry is not optimally and holistically promoting adoption of IBTs. Specifically, the promotion of IBTs was found to be fragmented amongst the various developers and institutions involved and the linkage between industry and training is weak. Legal provisions in some legislation also present some barriers for the adoption of IBTs but gains have been made in reviewing these laws. Given this, the study recommends intervention mechanisms to mitigate barriers linked to various stages of the IBTs adoptive process. The recommendations are founded on four pillars; technical capacity to fill in the information gap that exists regarding IBTs; institutional interventions geared towards alignment of institutional objectives and building of synergies; social economic interventions that seek to address the bias and affordability challenges and thus bridge the technology acquisition gap; and, finally the government support framework that is geared towards the supportive legal and economic environment to allow utilization of technologies. It is anticipated that the findings of this study will inform a holistic approach for promoting development and adoption of IBTs by focusing on the four areas simultaneously.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The provision of adequate and affordable housing remains a challenge to most countries, particularly those in the developing world. Various governments worldwide pursue diverse strategies to address the problem; key among them is alternative building materials and technologies. Building technologies and services are pivotal in advancing three primary objectives: smart energy infrastructure, climate-smart cities, and sustainable business practice. These objectives drive innovation towards sustainability within the market. According to Frost & Sullivan, sustainable innovation in building technologies and services refers to solutions that enhance environmental sustainability in building operations, promoting eco-friendly outcomes such as energy efficiency, optimal resource utilization, and reduced carbon emissions across the building ecosystem (UN, 2022). According to (IBTG, 2023), technological advancements present ongoing opportunities to enhance building performance. On the other hand, it is argued that most buildings constructed using conventional building materials like natural stone, steel, and mortar are unaffordable to a majority of people in the developing world, thus necessitating the development and adoption of alternative, relatively cheap, decent, and durable on-site produced materials (Kimani, 2010). This resonates with the 1997 Kyoto Agreement, where many countries agreed to reduce the use of reinforcing rods to 80%, aluminum down to 90%, and cement down to 80% by the year 2050 (Atkinson, 2007). Further, the UN-Habitat 2009 stresses the need for continued worldwide investment and innovation particularly in appropriate technologies to meet the need for adequate housing (UN-HABITAT, 2009). In any case, many African countries are endowed with abundant natural resources that can meet their need for building materials production. Despite this, they rely heavily on imported building materials and technologies (Selman, 2011). This means that the spread of those technologies has not been as rapid or as extensive as the dire housing situation requires

Attempts have been made to quantify the cost-saving impact of Innovative Building Technologies (IBT) by looking at the constituent cost of construction output. It is a widely acknowledged concept that a great deal of housing construction costs is directly linked to building materials. The Building Materials & Technology Promotion Council (BMTPC) of India postulates that building materials account for approximately 60% of the total building costs. The benefits of Innovative Building Technologies however go beyond cost savings. They have been lauded for environmental protection, employment generation, and energy conservation (BMTPC, 2021)

On the policy platform at the local level, the problem of housing and the need for appropriate technologies has received considerable attention. The Housing policy for Kenya recognizes the problem of urban housing as characterized by an acute shortage in the number of dwellings, overcrowding in the existing housing stock as well as the existence of sub-standard human settlements such as extensive slums and squatter settlements (G.O.K, 2016). The acute shortage in housing supply has pushed the cost of housing beyond the reach of a majority of low-income earners. The housing policy further observes that the majority of the people in urban areas do not own homes as the level of owner-occupancy has been declining. The Government of Kenya attributes this to; the high cost of building and construction materials; inappropriate building and construction technologies; limited research on low-cost building materials and construction technologies among other contributory factors (G.O.K, 2016). Furthermore, affordable housing has continued to feature in successive government blueprints. These include the national development plans, vision 2030, and more recently, the 'Bottom up economic Transformation Agenda' where the government has committed to deliver a series of ambitious social programs to promote long-term economic development for Kenyan citizens through; affordable housing; universal health coverage; enhancing manufacturing; and food security and nutrition. (G.O.K, 2023).

On specific Government intervention initiatives for the adoption of Innovative Building Technologies, considerable effort can be seen in terms of investments to introduce new, lower-cost materials into the market. The National Housing Corporation, the

implementation arm of the State Department for Housing, has put up a factory to produce polystyrene walling panels. Several other initiatives have been undertaken by the government in the area of research and dissemination of information on low-cost building materials and technologies (NHC, 2019).

However, the paradox on the housing delivery side remains; that the majority of populations remain steeped in traditional construction methods. Despite the high demand for housing especially in the city and the affordability challenges, adoption of IBT is rather subdued. While acknowledged that the use of alternative materials and technologies is promising in Kenya and across most of the world, it is observed that most developers in Kenya stick to stone and cement, and there is no widespread use of any alternative building material. The look and feel of the home are attached to status, and unlike new medical devices or agricultural inputs, when someone purchases a home, they want to put their savings into a reliable structure that looks and feels like the homes of their middle class counterparts. More effort is required to bring appropriate technology at par with conventional technology (CAHF, 2020).

Besides the social aspects, the existing regulatory and administrative framework has been cited as a major deterrent to the adoption of innovative building technologies. The Ministry in charge of Housing & Urban Development and Public Works recognizes and attributes the slow pace of IBT uptake to; lack of harmonized regulatory framework, slow adoption by the built-environment professionals, prevailing research gap as well as inadequate local capacity for driving IBT technology among other factors (G.O.K, 2019). It has been argued that building laws seem to challenge any viable solution to affordable housing (Kimani, 2010). It is further argued that inadequate regulations and management policies impede the achievement of a zero-waste society and exacerbate the development gap in the economy. The construction industry is governed by a plethora of regulations, standards, and norms that vary by location and authority. These regulations' inconsistencies and contradictions might cause confusion and impede the adoption of circular practices (AlJaber, 2023).

On the administrative framework, innovative technologies for housing have not been sufficiently institutionalized, unlike conventional technology whose dissemination has largely been effected through commercial organizations and the profit mechanism. In addition, there has been insufficient emphasis on the development of support structures, political and economic backing, and the implementation machinery hence a constraint that is highly inhibitive to the process of dissemination and full embracing of the technology (Magutu, 2015). Research by Ghansah et al. (2021) highlighted several issues such as the high cost of smart and sustainable materials and equipment, technical complexities during construction processes, inadequate technical skills related to smart technologies and techniques, and reluctance to depart from traditional practices within the Ghanaian construction industry. Similarly, Gobbo et al. (2020) identified significant obstacles in Brazil, including the absence of a supportive regulatory framework for smart building adoption, financial constraints and the lack of incentives for implementing SBT, and challenges in securing skilled and specialized workforce for smart building concepts, devices, and solutions in the social housing sector. This study delves into examining the existing regulatory and administrative framework that bears on the adoption of IBT.

1.2 Statement of the Problem

The provision of affordable housing stands out as one of the priority social programs for promoting long-term economic development. Various initiatives have been pursued over time in an effort to avail affordable houses, especially to the middle and low-income groups. The interventions are geared towards mitigating factors that have been attributed to the high cost of housing. These factors are generally noted to include high cost of land, high cost of finance, and inappropriate and costly building materials among others. IBTs have been touted as the panacea for addressing the aspect of the high cost of building materials. Adoption of these technologies is however lagging behind as most developers remain steeped in Conventional Building Technologies.

Innovative construction methodologies encompass techniques and practices that depart from traditional construction approaches. These methodologies aim to enhance

sustainability and efficiency within a firm's construction processes. In recent years, several popular innovative methodologies have gained traction, such as virtual reality (VR) in development and 3D printing. For instance, hybrid building technologies represent the future of construction by integrating multiple materials such as structural steel, precast concrete, and cast-in-place concrete throughout the structure. This approach not only enhances sustainability but also ensures fiscal responsibility (FocusWorkWith, 2023).

Similarly, while modular construction has been utilized for years, recent technological advancements have elevated it to a leading innovative methodology. Modular construction involves construction components of a building off-site and then transporting and assembling them on-site. Implementing these innovative methodologies offers numerous benefits. They can significantly increase the efficiency of construction operations by reducing air pollution, minimizing waste, and enhancing opportunities for material reuse. Moreover, these methodologies decrease reliance on raw materials during the construction process. Adopting any of these innovative construction methodologies enhances overall performance and efficiency. By leveraging cutting-edge technologies in your building processes, you can expedite project timelines, achieve cost savings, and create structures that perform better in the long run (WorkWithFocus, 2023).

The imbalance between demand and supply of affordable housing exacerbates the energy crisis, leading to continuous increases in electricity and cooking gas prices. According to KPDA (2020), the demand for housing units surpasses 2 million annually, while only 50,000 units are constructed. Housing facilities equipped with energy-efficient features command significantly higher prices than conventional ones, as reported by Russo (2022). Challenges such as limited financial incentives, rising construction costs, and low consumer purchasing power persist across the housing market value chain, hindering the supply of quality housing.

The adoption of Innovative Building Technologies (IBT) in the construction industry has therefore become essential to promote socioeconomic well-being. This includes reducing

household utility bills and improving access to comfortable and healthy indoor air quality. However, the state of adoption and factors influencing the deployment of (IBT) by stakeholders remains varied, as highlighted by Oduho et al. (2022) in their survey on users' awareness and perceptions of innovative building concepts. Factors such as technology costs and the presence of supportive policies significantly influence the growth of IBT. This project aims to provide industry players with opportunities to address these factors and deliver affordable housing by leveraging on IBT effectively.

1.3 Research Questions

In view of the problem, the research aimed to answer the following key questions:

1. What are the perceptions of IBTs producers and regulators on the significance of the various policies and regulations influencing the development and adoption of IBTs in Kenya?
2. How effective are the existing administrative and institutional framework in supporting the development and adoption of IBTs in Kenya?
3. What are the barriers that impede the development and adoption of IBTs in Kenya?
4. What framework can best enhance the development and adoption of IBTs in Kenya?

1.4 Aim and Objectives of the Study

The aim of the study is to develop a model framework that can be used to enhance the adoption of IBTs in construction projects in Kenya. To accomplish this, the study specifically sought to achieve the following objectives:

1. To find out the perceptions of IBTs producers and regulators on the significance of the various policies and regulations influencing the development and adoption of IBTs in Kenya.
2. To establish the effectiveness of the existing administrative and institutional framework in supporting the development and adoption of IBTs in Kenya.

3. To establish regulatory and administrative barriers to the development and adoption of IBTs in Kenya.
4. To formulate a framework for enhancing the development and adoption of IBTs in Kenya.

1.5 Assumptions of the Study

It is assumed that IBTs meet the desired performance standard to match or exceed those of conventional building technologies such that slow adoption is not attributable to poor performance. For the purpose of completion of this research paper, the research put forth the following assumptions: -

a) The participants would be cooperative and will answer the interview questions in an honest and candid manner since they have a sincere interest in participating in my research.
b) The inclusion criteria of the sample are appropriate and therefore, assures that the participants have all experienced the same or similar phenomenon of the study.
c) All the respondents are computer literate individuals, with most basic of knowledge in how to operate a computer.

1.6 Justification of the Study

The rationale for this study is rooted on the need for affordable construction outputs that is manifested in unmet demand that has often been blamed on costs and inappropriateness of conventional construction technologies. The effectiveness of the administrative and instructional interventions put in place to address the challenge cannot be presumed.

1.7 Significance of the Study

Previous studies in the area of appropriate building materials have delved on the production processes, structural suitability, environmental sustainability, and cost-

effectiveness of IBTs and paid little or no attention to influence of policy and administrative aspects of IBTs. It is imperative that if IBTs are to remain relevant as a strategy for addressing housing provision challenges, an in-depth investigation that establishes and explicates the influence of the institutional and administrative framework in the development and adoption of IBTs. Moreover, the government programs that seek to address social economic welfare such as the affordable housing require evaluation of the existing policies, laws and administrative framework to ensure optimal realization of the goals. Findings in this study will inform the design of administrative and regulatory interventions to yield a coherent and coordinated effect in enhancing adoption of IBTs.

1.8 Scope of the Study

While this study acknowledges that there are many IBTs, the sampling was limited to technology producers who are recognized by the relevant state agency and in this case, the State Department of Housing where policies on construction are domiciled. This limitation was mitigated by collecting data from policymakers and regulators besides the technology providers. This in effect generalized the findings as the policymakers do not focus on any particular technology.

The study was carried out within the counties identified as Nairobi metropolis namely Nairobi, Kajiado, Machakos and Kiambu Counties. Information was collected through questionnaires to various IBTs stakeholders particularly the policy makers and disseminators mainly comprising of government agencies and producers of IBTs that are recognized by the State Department for Housing, being the relevant state agency in charge of housing policy. Interviews were also conducted on acknowledged professionals who are known to have involvement in policy formulation in the area of study.

1.9 Limitations of the Study

Limitations are usually factors over which the researcher have no control. A limitation would be anything beyond the ability of the researcher to control that may affect the

internal validity of the study. The following are some of the limitations as observed by the researcher: -

a) The study limited itself only to building professionals in Kenya. For more conclusive results, users of IBTs in Kenya, should have been studied. However, this was not possible due to time and financial constraints.
b) It was not possible to cover a larger number of respondents because getting them required considerable time, resources and other logistics, which unfortunately, were not at the disposal of the researcher.

1.10 Definitions of Terms

a. ABMT - refers to processes, materials, elements and tools that are compatible with the local socio-cultural, economic, physical and ecological environment context of a geographical area. Of importance, the material should be affordable, innovative, safe, environmentally friendly and with socio-economic value. To address poverty, unemployment and affordability challenges among low and middle- income communities, ABMT should ideally be decentralized, locally controlled, people-centered, labor-intensive, cost-effective and sustainable.

b. Expanded polystyrene - is a lightweight rigid material that is made by the polymerization of styrene (EPS Specifier Guide)

c. Hydra form block - is an interlocking compressed earth block made of hydra form press (Hydra form Manual, 2003)

d. Interlocking stabilized soil blocks (**ISSBs) -** dense solid man-made blocks improvised by mixing soil that is moistened slightly with a steel press using lime or cement as the stabilizer after which it is compressed using a manual or hydraulic press machine by forming grooves that interlock either horizontally or vertically (Gbadebo, 2014).

e. Prefabrication - is off-site production of standardized or adapted components or complete structures

f. **Prefabricated -** The manufacture or fabrication of sections of a building at an off-site location, which are delivered to and assembled at the building site.

1.11 Organization of the Study

This research project paper has been organized in the following sections and formats: -

Chapter One

This is the first chapter of the research paper and forms the introduction to the topic of study, the background of the research, problem statement, aim and objectives, research questions, and scope of the study, justification of the study and the organization of the study. This chapter simply puts out the gap that the research paper aims to fulfil.

Chapter Two

This chapter deals with the literature review relevant to the study area, and the theoretical framework that acts as a basis of the research. It is also apportioned in the following subsections; Introduction, literature review, legal framework, summary of literature review, conceptual framework and the conceptual model.

Chapter Three

This chapter deals with the research design and methodology in the following arrangement; introduction, research design, case study area, target population, sampling design, data collection methods, research instruments and the data collection process, data analysis techniques, ethical considerations in research and the summary.

Chapter Four

This chapter will constitute the data analysis and presentation. It presents the responses and analyses of various respondents to whom questionnaires will be administered as well as oral interviews conducted.

Chapter Five

This chapter will contain the summary of the findings, recommendations and the areas of further research and study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter begins with an overview of IBTs. It then delves to discuss trends in promoting the adoption of IBTs in the light of enhancing the provision of low-cost housing. This includes Interventions by various agencies toward the promotion of IBTs both locally and globally. The chapter concludes by laying a conceptual framework for the study.

2.2 Background on Innovative Building Materials and Technologies (ABMTs)

The provision of housing in Kenya has faced challenges such as shortage of supply and dilapidated state of low cost housing. The other factors like economic decline, high poverty levels across the nation, limited access to finance & high cost of finance (interest rates), escalating housing costs and prices, limited research on low-cost housing; building materials and construction technologies have contributed highly to lack of good and decent housing in Kenya (Nabutola, 2004). The president has set out the Big Four Agenda for the republic of Kenya including; Food Security, Affordable Housing, Manufacturing and Affordable Healthcare for all. This study is in line with the president's agenda where he has highlighted the need for identification of the factors that significantly contributes provision of affordable housing especially for the low cost housing schemes.

Kenya's urban housing demand was estimated at about 150,000 units with an estimated 35,000 units being supplied annually in average, while an estimated 300,000 housing units require to be improved annually in rural areas (Government of Kenya, 2016). There is urgent need for both the public and private sector to jointly come with incentives to achieve the envisaged targets by the government of Kenya (GoK). This study will explore the Innovative Building Technologies (IBT) as a way of providing lows cost housing. Low cost housing deficiency can adequately be addressed by incorporation the IBTa which

could be easy to apply and acceptable, and ensuring effective awareness on these techniques (Haselau, 2013).

2.3 Overview of Innovative Building Technologies (IBTs)

IBTs are not universally identified to constitute any particular material or technology rather, their identification is based on the social, economic, and environmental conditions of the location in which they are applied. The Ministry in charge of Housing defines IBTs as building processes, materials, and tools that are cost-effective, safe, innovative, environmentally friendly as well as acceptable to the climate, socio-economic conditions, and natural resources of an area (GOK, 2009).

El Khalifa (2011) defines appropriate technologies as those that respond to the local environment, resources, and economical needs. The appropriateness of technologies employed in construction is determined by the level of technological development the construction industry acquires. Appropriate material has also been separately defined as those providing technical solutions that are appropriate to the economic structure of those influenced; by their ability to finance the activity, their ability to operate and maintain the facility, the environmental conditions involved, and the management capabilities of the population (Betz, 1984). From the foregoing, it is apparent that before any material is classified to be appropriate, a rigorous assessment must be carried out in the context of the area in which the technology is proposed so as to verify its appropriateness.

2.4 Existing Innovative Building Technologies in Kenya

Many technologies have been identified as appropriate and are promoted as such. Some materials are however mere alternatives to conventional technologies or new in the construction industry but are not necessarily appropriate. It is thus apparent that all materials whether new or older need to be subjected to the evaluation criteria to determine appropriateness. The State Department of Housing has identified several technologies that

are deemed appropriate but when evaluated against the criterion, it is evident that most technologies partially meet the scholarly criteria for classification as appropriate.

Some of the IBTs currently in Kenya include; Interlocking Stabilized Soil Blocks (ISSBs), Expanded Polystyrene Panels (EPS), Interlocking Concrete Blocks, Free Span Clay Bricks, Concrete Waffles, Precast Concrete Panels, Compressed Agricultural Fiber panels(CAF), Monolithic Construction, Pre-fabricated Housing and Light Gauge Steel for eco-frames, among others (G.O.K, 2019) These are discussed and depicted in portraits as follows;

2.4.1 Interlocking Stabilized Soil Blocks (ISSB)

Interlocking stabilized Soil blocks are construction blocks made from a mixture of soil and a stabilizing agent compressed by different types of manual or motor-driven press machines with grooves that interlock with other blocks during construction (Lewis, 2009). They compare well with quarry stones in terms of strength. Quarry stone has a compressive strength of between 2 to 5 N/mm^2 depending on the type of stone which varies from region to region. Interlocking Stabilized soil blocks have a compressive strength of $2.5N/mm^2$ and with the application of hydraulic systems, the compressive strength can be enhanced to as high as 7Mpa. (Sangori, 2012) Despite this, a casual look at the existing and upcoming building projects reveals that adoption of the soil blocks is relatively lower than quarry stone. ISSBs have been defined as dense solid man-made blocks made by mixing soil that is moistened slightly with a steel press using lime or cement as the stabilizer after which it is compressed using a manual or hydraulic press machine (Odongo, 2018).

According Odongo (2018) individuals construct higher with thinner walls as a result of the input of soil stabilization. These walls are characterized by improved water resistance and strength. Upon usage of cement as a stabilizer, a four-week curing is advocated for after the blocks have been manufactured. With this period of time applied, the blocks are dry and ready for use as common bricks. It should be noted that a number of stabilizers

can be applied. These stabilizers include chemicals and natural products. However, lime and cement are commonly used. The stabilizers are selected depending on the requirement of a given project and the soil quality.

According to United Nations Habitat, the Interlocking Stabilized Soil Blocks (ISSBs) are products of compacted mixture of soil and lime or cement produced in molds to form grooves in the blocks. This process enables horizontal and/ or vertical interlocking of the blocks. It must also be noted that the constituents within the block and curing of the blocks after its production determines its (ISSB) strength. The survey adds that the composition of these blocks consists of 60 - 70% soil, 20 - 30% coarse sand and 8 - 10% cement (UN Habitat, 2009).

According to UN Habitat (2009), there are two main types of machines used for making ISSBs namely:

i. Hydraulic block making machine
ii. The hand or the manually pressed machine

Below are the major factors that need to be considered when choosing the most appropriate machine:

i. Type and scale of the building or structure to be constructed;
ii. Ease of maintenance of the machine;
iii. Reliability, availability and cost of electricity;
iv. Cost of the product/output.

Interlocking Stabilized Soil Blocks (ISSBs) are a specific type of Compressed Stabilized Earth Block (CSEB) technology. While ISSBs are made from the same soil/cement ratio of 1:10 as CSEBs, ISSBs present an interlocking form that allows for strong, rapidly assembled systems that do not need cement mortar. Compression machines for brick fabrication can be powered by diesel fuel or electricity, or be operated with hand power. ISSB fabrication is less expensive and requires less energy than conventional brick firing

methods. The cost ISSBs are comparable to CSEBs, varying from 190 - 250 USD/m² for a 1 story home. Construction takes approximately 7 weeks to complete a 40 m² home, from brick production to substantial completion. This includes 7-10 days for curing of the bricks. This technology is more suited for rural areas where large amounts of inorganic soil are present. A small team of masons can be quickly trained to mix material and fabricate the bricks, though a qualified foreman is needed to ensure quality control. An additional consideration is that waterproofing sealant must be applied to the external faces of the brick after completion of the home. This must then be reapplied every 3-5 years to ensure that the wall systems do not succumb to erosive forces.

A further criterion used to gauge the appropriateness of technology is the use of local resources in its production. Soil blocks are made from locally available materials (soil, sand, cement, and water) which decreases the need for expensive imported materials such as steel. The technology is also easy to apply as the block consists of grooves along the side that allow it to be quickly and cheaply assembled. In addition to dramatically reducing construction time, the interlocks increase the structural stability of the wall and reduce the amount of cement needed as mortar. However, when compared to reinforced concrete, the performance in terms of strength is lower as Reinforced concrete has a much higher compressive strength that exceeds 15 to 20N/mm^2 depending on the mix ratio of cement; sand; ballast (Kamau, 2011).

2.4.1.1 Advantages of Interlocking Stabilized Soil Blocks (ISSBs)

UN Habitat, (2009) further opined that the ISSBs has certain advantages and they are as follows:

a. Structural

This refers to the advantages ISSBs have with respect to their capability to withstand various forces and remain stable without their strength being compromised. The advantages include:

ISSB technology ensures uniformity of blocks with greater strength as compared to the fired blocks and concrete blocks. These blocks are heavy and are water resistant because of their high density. Due to the high density and thermal properties of soil, these blocks provide better thermal insulation.

b. Environmental

These are various advantages these materials possess with respect to being eco-friendly i.e. able to be recycled or re-used, low pollution and emissions, durable and low embodied use of energy (UN Habitat, 2009). ISSBs possess the following environmental advantage: ISSBs are cured in the sun hence there is no need for fuel such as wood thus saving the environment from degradation.

c. Economic

This aspect pertains to relative advantage with respect to the overall cost of construction inclusive of various cost factors like materials, labour, equipment and machinery and profits and overheads. Economic advantages of ISSBs include:

i) Far less mortar is used due to the interlocking character of ISSBs, thus saving on construction costs.
ii) Costs associated with their transportation are eliminated since the blocks can be made on site.
iii) Plastering of the walls can be avoided thus reducing the cost of construction due to their appearance.
iv) Since they are largely stacked, using the blocks results to fast construction.

d. Aesthetics

Aesthetics refers to the advantages ISSBs possess in respect to its appearance. It has the following advantage: These blocks have an appealing exterior form with a stylish profile.

It is uniform in size and has appearance similar to that of brick that captivates no need for plastering.

e. **Social**

The advantages of ISSBs to the society include;: A small number of individuals can make the ISSB blocks since it requires low man power and are easy to manufacture and production of these blocks economically empowers the unemployed in the society. This applies especially to the youth and women. They provide both skilled and unskilled labour thus they able to earn a living.

However, the production of these ISSBs has a range of challenges coupled with it. These include; Lack of proper soil for the production of the blocks and the method applied in molding, the moisture content of the mix and quality of the raw materials used in molding determines the quality to be produced. (UN- HABITAT, 2009).

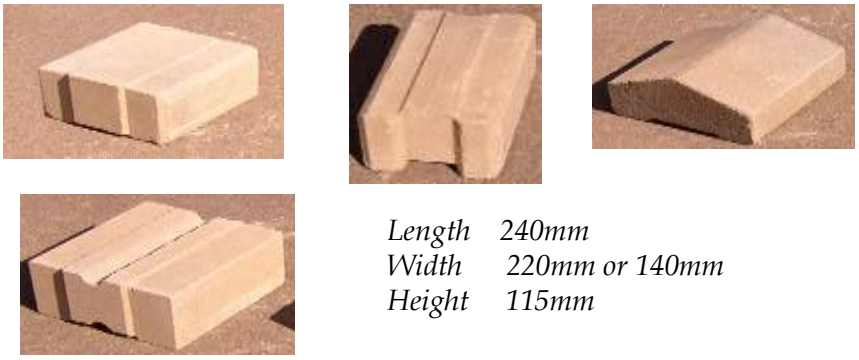

Figure 2.1: Interlocking Stabilized Soil Blocks

Source: GOK, 2009

2.4.1.2 Comparative Analysis of ISSB

The interlocking stabilized soil blocks by far meet the criterion for classification of appropriate material. UN-HABITAT, (2009) enumerates the advantages of ISSB on the following considerations;

On environmental considerations, ISSB provides an alternative to fired brick, which is blamed for grave environmental degradation due to deforestation, and destruction of wetlands. Economy-wise, ISSB are noted to be weatherproof hence no need for plastering save for aesthetic considerations. Due to the interlocking mechanism, no cement is required and construction goes up quickly resulting in labor saving. The technologies, when used in areas where appropriate soils are available also bring about transportation cost-related savings. The technology is also good for durability and aesthetic qualities. UN-HABITAT, (2009) observes that ISSB technology is growing in popularity in Uganda due to its aesthetic qualities, and has been successfully embraced by many communities trained on it. This is more so in view of the fact that it is an earth technology, as most of the common and traditional methods used in Uganda. Structurally, UN Habitat also notes that ISSB technology has proven to be strong and durable when compared with the traditional method of construction. It is suitable for multistory buildings, has good compressive strength, and in many examples has been used for the retaining wall of buildings.

The appropriateness of the technology is however bound to differ from one region to another depending on its competitive advantage relative to other technologies in the region. Abdulrahman (2009) ranks and compares the advantages of building with Interlocking Stabilized Soil Blocks between developing and developed countries as follows.

Table 2.1: Comparative Analysis of ISSB in Developed and Developing Countries

	Developing Countries			Developed Countries		
	Degree of importance to the countries					
	High	Mid	Less	High	Mid	Less
The low cost and availability	X			X		
Limited pollution and depletion of environmental resources			X	X		
Ease of construction with earth material	X					X
Reduced unemployment of unskilled labor	X					X
Variation in constructions techniques		X				X
Savings in transport cost	X				X	
Saving in energy consumption	X			X		
Engineering characteristics of earth material		X			X	
Easing recycled of earth products			X		X	

Source: Abdulrahman, 2009

This comparison serves to broadly show that ISSB may be considered more appropriate in developing countries than in developed countries. The same classification can be applied in various regions in Kenya to determine the relative appropriateness of the technology.

2.4.2 Compressed Stabilized Earth Blocks (CSEBs*)*

Adoption of technologies that have been in existence over a long period of time is favored by a wide knowledge of their application that is gained over time. Rammed earth is an old building material that has been there for centuries. It involves mixing soil with appropriate proportions of gravel, clay, sand, and water into a damp workable mixture. Walls are formed by pouring the mix into a preformed framework where it is rammed down by hand or a machine using a tamper. In building walls construction, the mix is poured into a formed framework and rammed tight using a hand tamper or a mechanical driven one, until the mix is compressed to about half its original depth. The operation is then repeated until the walls are of the desired height and length (Malburg, 2011)**.**

Compressed Stabilized Earth Blocks (CSEBs) are made by mechanically compressing inorganic soil mixed with a small portion of Portland cement (5-10%) into a brick. Walls of CSEB are built using standard bricklaying and masonry techniques including the use of clay or cement mortar. CSEBs require substantially less energy to fabricate than conventionally fired bricks. The cost of production of standard CSEBs can vary from 190 - 250 USD/m² when considering quantities for a conventional one story home. Prices referenced include a complete house and workforce (CSEB walls, concrete foundation and floor, gauge roof, doors and windows) though do not include wiring and plumbing. Construction takes approximately 7 weeks to complete 40 m² house, from brick production to substantial completion. This includes 7-10 days for curing of the bricks, which is a process best accommodated on site. This technology is more suited for rural areas where large amounts of inorganic soil are present. A small team of masons can be quickly trained to mix material and fabricate the bricks, though a qualified foreman is needed to ensure quality control. An additional consideration is that waterproofing sealant must be applied to the external faces of the brick after completion of the home. This must then be reapplied every 3-5 years to ensure that the wall systems do not succumb to erosive forces.

2.4.2.1 Advantages of Compressed Stabilized Earth Blocks

Benefits that render this technology appropriate include; the use of locally available materials with little embodied energy and harmful waste, the soil can be used from the site where the construction takes place which reduces costs for transportation and energy used, it is affordable due to materials being inexpensive or free, allows for buying smaller heating and cooling units and in Kenyan climate natural ventilation may be enough for cooling; also no heating unit required and that with the right type of soil it can last for hundreds of years (CyeKenya, 2013). Other benefits of using rammed earth include energy efficiency, earth-friendly, chemical-free, low maintenance, secure, easily recyclable, and fireproof properties (Alvarez, 2011). With these benefits and the long existence of the technology, one would expect this technology to be widely applied in Kenya.

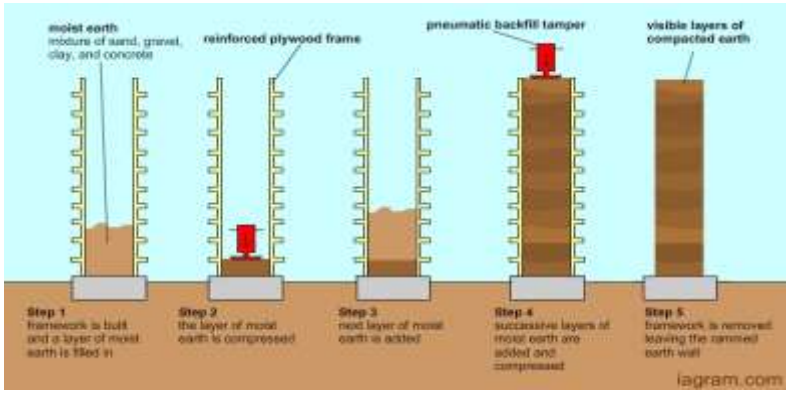

Figure 2.2: Compressed Stabilized Earth Blocks (CSEBs)

Source: Engeye Design Team, 2010

2.4.3 Expanded Polystyrene (EPS) Panels:

The appropriateness of EPS panels is manifested in savings associated with shorter construction time and reduced operation cost of heating or cooling in a building due to its thermal properties. When other factors are considered, EPS may seem inappropriate due to reliance on imported technology and raw materials in production. This has also a ripple effect of increased cost and this dwindles its appropriateness. SIPA (2011) observes that the initial cost of building with EPS is generally about the same as building with wood frame construction when the labor savings resulting from shorter construction time and less job-site waste are considered. Other savings are realized because smaller heating and cooling systems are required with SIP construction. EPS has also the advantage of standardization as they are manufactured under factory-controlled conditions and can be fabricated to fit various building designs. This mitigates the cost of using them in terms of saving construction time and cost and labor. Kamau however deems EPS inappropriate in most areas when compared with conventional stonewalling in view of estimated cost which put the EPS available in the market to cost approx. KES 1800 per m^2 as opposed to masonry wall which is estimated to costs KES 800 without transport and labor (Kamau F. G., 2013).

The appropriateness of EPS is thus derived from other factors apart from cost and these include; high load-bearing capacity at low weight, sound insulation, fire and heat insulation, crash and earthquake resistance, absolute water and vapor barrier, air-tightness for controlled environments, long life, low maintenance, lightweight, fast and economic construction and being the most cost-effective insulation material available. (SIPA, 2011) When the advantages are weighed against disadvantages, EPS may not be considered to be absolutely appropriate and thus adoption of this technology can be expected to vary based on individual developer considerations.

EPS Specifier Guide defines EPS as a versatile and a long-lasting building material with an excellent insulation. It further elucidates that the structure has a component of 98 percent water and its initial thermal properties are perpetually maintained. In building and construction, the basic use of EPS is for thermal insulation of walls, roof and floors (Specifier Briefing, 2019).

Expanded Polystyrene (EPS) technology is a construction system of prefabricated panels that are extremely light and can be easily transported from fabrication to construction sites. Assembled from readymade EPS foam sandwiched between galvanized steel wire mesh, the panels are then tied together on site and plastered over with a cement-based mixture. The panels can be easily modified on site with wire cutting tools, making the system versatile and can be easily incorporated with complimentary construction systems. The cost of construction can vary from 170 - 240 USD/m² for a 1 story house made entirely of EPS panels. Price information referenced considers a complete house and workforce (walls, concrete foundation and floor, gauge roof, doors and windows) and exclude wiring and plumbing costs. The time of construction for a 40m² house is around 32 hours. The spraying of concrete on the panels must be done on-site. After concrete is applied over the whole of the structure, an EPS house presents a durable and resilient final product as a singular continuously insulated reinforced concrete structure. Manufacturers of the system often have additional specialty components available for purchase. These included wall panels of varied thicknesses, floor panels, and stair systems. Under the direction of a licensed engineer, EPS panels can be used to build up to 20 stories.

2.4.3.1 Advantages of Expanded Polystyrene (EPS) Panels

It has the following advantages:

a. Light weight

Various applications in the field of construction and manufacturing technologies experience a light weight remedy as a result of the EPS introduction. This has been achieved due to the EPS's ability to capture 98 percent of air in a spun of two per cent cellular matrix. There are also various economic benefits in terms of transport and on-site handling nature. The EPS additionally minimizes perils associated with health and safety related to heavy lifting of materials. It has also become a substitute for ballast and infill products (EPS Specifier Guide, 2019)

b. High strength and structural stability

A test performed to determine strength of EPS depicts it to possess strength beyond the originally designed strength of 100kPa. It is evident in the guide that the EPS Bridge Foundation reflect a deformation below 1.3% which is barely half as much as theoretical predictions. It is added that it is in rare occasions that the stability of EPS deteriorates within a given time and age (Specifier Briefing, 2019).

c. Economic

The application of EPS has contributed to the reduction of costs and insulation since insulation is cheaper compared to the competing and available materials in the market. Through this, it has an economic advantage. In construction of floor using EPS, only a singular waterproof membrane is installed as opposed to two required for PU form or mineral wool hence savings in terms of labor and use of material (Specifier Briefing, 2019)

d. Insulation

EPS has a reputation due to its insulation feature in construction. Its A-plus grade rated by the BRE signifies its efficiency when considering its application on the wall, under floor and roof when a constant rate of insulation is experienced (Specifier Briefing, 2019)

e. Design versatility

This is defined as the ability to cut and mold with ease. This facilitates making of complex shapes matching design requirements and architectural demands without complicated skills, tools or specialist in cutting (Specifier Briefing, 2019).

f. Accredited performance

The world records accredit EPS as a mechanism of a high performance, standard and records. These records include the BRE Certification and BBA Approval, among other accreditations. The EPS is light in terms of weight, impact in terms of strength, its safety properties, its eco-credential nature and its insulation property makes it preferable in construction (Specifier Briefing, 2019).

g. Resistance to water ingress

EPS samples retrieved from an altitude of 200mm about 30 years later records less than one percent water composition in terms of volume while less than four percent is shown when submerged. These results of performance are higher compared to other building materials (Specifier Briefing, 2019)

h. Safety in installation and use

The EPS guide depicts EPS as non-toxic. In its terms, the EPS is rot-proof, chemically inert and non-irritant. Growth of organisms such as bacteria and fungi cannot be supported on the EPS. EPS is non-hygroscopic, it is rodent proof, it is unattractive to vermin and water: this property of not being affected by water ensures performance is

improved to achieve the best output. Finally, as discussed earlier, EPS is insoluble (Specifier Briefing, 2019) (EPS Specifier Guide, 2019).

i. Sustainability credentials

EPS is suitable for an eco-friendly building preferred in the current generation. This is evident at all stages of EPS production, in its recycling, recovery and overall life cycle. The EPS production processes are in accordance to the environmental regulatory requirements. EPS is also non-aggressive to chemicals and environment and in producing materials the EPS applies no greenhouse gas (Specifier Briefing, 2019).

CSIR - Central Building Research Institute (2017), further outlines the following as the challenges of EPS:

i. Unless designed by a professional engineer, this system can only be used in construction of foundation walls that don't exceed more than four storey.
ii. "Shotcrete dry" or "shotcrete wet" process must be used in application of concrete this is in accordance with ACI 506 R-85, "Guide to Shotcrete,"
iii. A 20 MPa strength in compression of the concrete has to be achieved on minimum.
iv. Allowable stress(fy) of the steel reinforcement shouldn't be less than 415 MPa

Plate 2.1: EPS House in Uriri

Source: KOTO, 2010

Plate 2.2: EPS demonstration unit

Source: NHC, 2009

Plate 2.3: Police Housing at Nyeri Showground Made from EPS

Source: HKBC, 2013

2.4.4 Compressed Agricultural Fiber (CAF)

The appropriateness of CAF panels that are used in walling is not obvious as the technology relies on locally available raw materials in production (wheat or rice straw waste products) but on the other hand, requires a factory setting to compress and produce

the panels. Construction of a wall using the panel also relies on aluminum frames. Advantages that may render the technology appropriate include the capability of rapid construction and aesthetics. The technology appropriateness may thus be gauged on overall construction cost and individual factors. (G.O.K, 2019)

Compressed Agricultural Fiber (CAF) panels are insulated panels made of agriculture waste such as wheat and rice straw. The agro-waste is compressed at a high temperature and sealed with a final layer of cardboard. Prefabricated offsite, the panels are light weight and easily transported to a construction site. While the panels can be self-supporting, the system is best paired with a steel or wood frame structure as a primary structural system. Cost of construction can vary from 190 - 240 USD/m². Price considerations include a complete house and workforce CAF panels, concrete foundation and floor, roof, doors and windows), and exclude wiring and plumbing costs. The time of construction for a complete house is about 4 weeks.

Plate 2.4: CAF Panels Demonstration Unit Outside Ardhi House Nairobi

Source: IGS, 2010

2.4.5 Precast Concrete Panels

The technology requires the use of molds that are factory-made to make concrete panels that are used on walling. The advantages of using the panels include a smooth internal finish that requires no further plastering and rapid construction that saves up to 70% construction time (Boleyn, 2015).

Precast concrete is an offsite construction production method involving the formation of concretes in casts that are reusable. These products, under a regulated environment, undergo curing, followed by transportation and lifting in position at the construction sites.

2.4.5.1 Advantages of Precast Concrete Hollow Wall Panels

a. Design flexibility

It offers more design flexibility as compared to other systems of building due to the capability of producing the panels into various sizes and depths. They are able to accommodate any design requirements, irregular lengths and widths, large openings and a range of wall thickness. Casting can also be done into various shapes that are unique using “curved or radiused panels” and panels are able to be cast with “block outs for windows, ductwork, and electrical, as well as entrance and egress openings” (EnConDesign, 2010)

b. Green Construction

“Precast concrete does not release toxins when burnt. It provides a medium that delays heat transfers via building walls and also controls indoor temperatures and outdoor temperature fluctuations. It also saves on costs by lowering cooling and heating and cooling helps to meet stricter energy requirements. Its insulation property is also great thus reducing further energy consumption and the need for extra insulation” (Wall Panel Design Manual, 2010).

c. Moisture Resistance and Acoustical Control

Precast wall panels prevent penetration of water. Drywall usage is also eliminated, this provides protection from mildew and mold growth. Noise and sound transmission are consequently reduced in cases where insulated panels are used. This ensures privacy is achieved (EnConDesign, 2010).

d. Fire Resistance

It has a two-hour fire rating for a standard 8 hollow core system which varies based on the "equivalent thickness, heat transmission thickness, and cover on the strand and end restraint." Higher fire ratings can however be achieved using gypsum board or applying a spray that is fire resistant on the underneath side, (EnConDesign, 2010).

e. Safety and Security

They ensure blazes are contained since they prevent spread of fire. This helps to provide enough time for detection of fire thus being able to suppress it and also undertake evacuations. It also helps prevent spread to adjacent buildings and this is a requirement in the building code. Among the areas of use of the Foam block outs include penetration in plumbing, Mechanics, and electricity. When the foam blocks are applied, there is minimum drilling thus reducing jobsite risks. There is damage resistance resulting from the natural events such as seismic events since the structural stability of precast concrete is maintained. A room is made dust free and free from other contaminations when the treated wall panels are used in finishing. To research and health institutions and facilities, the named features are essential (EnConDesign, 2010).

Plate 2.5: Precast Concrete Panels

Source: Boleyn, 2015

2.4.6 Interlocking Concrete Blocks (ICB)

Interlocking concrete blocks are made using plastic mold technology and do not require morta joints during construction. They are dry assembled on site thus saving construction time. Depending on the number of molds available, production can be up-scaled for mass housing. (G.O.K, 2019) The blocks are produced in different forms but the cost of concrete blocks is generally considered higher than the quarry stone. Appropriateness of the technology, therefore, differ depending on the factors under consideration for their use.

Plate 2.6: Blocks and Demonstration Unit Made from ICB

Source: Alima Holdings, 2005

2.4.7 Pre-fabricated Housing

Prefabricated houses are made of timber or steel using modular system designs and are suitable for luxurious homes, low-cost modular houses, schools and offices, and emergency housing. The appropriateness of this technology may therefore not be compared to conventional technologies as the target products are different (EHG, 2013).

Plate 2.7: Pre-Fabricated Timber Housing

Source: EHG, 2013

Plate 2.8: Portable Accommodation

Source: Steel Structures Ltd, 1971

2.4.8 Concrete Waffles

These are considered appropriate based on cost-saving as they are estimated to reduce costs in steel reinforcement, construction time, concrete, and formwork by up to 30% of concrete slab costs (G.O.K, 2019)

Plate 2.9: Waffles for Suspended Floors

Source: GOK, 2019

2.4.9 Monolithic Construction

This technology relies on preconfigured steel/aluminum/plastic formwork to cast in-situ concrete works. Instead of the conventional reinforced concrete construction of columns and beams, the walls, floors, slabs, columns, beams, and stairs, together with door and window openings are cast in place monolithically using an appropriate grade of concrete in one operation. Some of the advantages touted in favor of the technology include reduced cost of superstructure and foundation because of reduced dead load, efficiency against earthquake, amenable to fast-track construction, and resulting fine finished surface thereby avoiding expensive plastering and enhancing a relatively water-resistant surface. (BMPTC, 2015)

Plate 2.10: Monolithic Construction Using Preconfigured Formwork

Source: BMTPC, 2012

2.4.10 Light Gauge Steel

Steel frame construction is defined in this analysis as a rapid assembly system that is pre-cast, packaged, and delivered for assembly on site. The primary structural components, extruded steel channels, are made from thin gauge high strength galvanized steel sheets. Sections are joined together using rivets or self-tapping screws to form structural bays and/or roof structures. While entire homes can be packaged for international delivery (typically 4-5 homes per shipping container), portions of homes and individual components (i.e. roofs) can also be designed and packaged for onsite assembly and installation. Additionally, the framing system can be designed to accommodate different infill panels to standard masonry systems. Construction cost can vary from 250 - 350 USD/m² for a steel frame home. The estimated price considers a complete house and workforce (walls, concrete foundation and floor, roof, doors and windows), though does not include wiring and plumbing. While this is the most versatile and most complete home construction system reviewed in this study, companies interviewed indicated that a cured slab of concrete would need to be poured in advance of any onsite assembly. Once this slab is in place, construction of a complete 42 sq. meters. Home can take approximately 7 days. Companies interviewed for this system of construction are based in South Africa and are looking to expand to other regions of Sub-Saharan Africa. While most talking points surrounded the opportunities and challenges of fabrication for international

transport and delivery to Kenya, the possibility of establishing a fabrication plant in Kenya was also offered as a possibility that could be considered.

Light gauge steel offers walling frames and roofing truss solutions and provides lighter, stronger, safer buildings, fire-rated, termite-resistant, and durability. The benefits of light gauge steel include lower total costs in higher quality structures, and higher strength which further contributes to safer structures that require less maintenance and last longer (Light Gauge steel systems, 2010). It is crucial to note that the raw material here is imported thereby negating the appropriateness when looked at in terms of availability. However, the appropriateness of light gauge steel comes into the limelight when alternative materials are considered. These include timber which is not readily available in some parts of the country.

2.4.11 Aluminum Formwork Technology

Thiyagarajan et al. (2017) defines "aluminium formwork technology as a system for forming the cast in-place concrete structure of a building. It as a system for scheduling and controlling the work of other construction trades. It is used to design and control the job of other construction trades like steel reinforcement, concrete installation, mechanical and electrical works."

He adds that the aluminium panels are a product of strong alloy of aluminium "with the face or contact surface of the panel, made up of 4mm thick plate." This alloy undergoes welding forming a designed formwork. This leads to manufacturing of robust components by forming sections with extruded features (Thiyagarajan et al., 2017)

The following advantages for aluminium formwork technology have been highlighted by Thiyagarajan et al. (2017);

a. Requires less skills while handling for example lifting. It is therefore free from costly equipment requirements for lifting heavy materials.
b. The formwork facilitates fast building and construction. This makes it suitable for

numerous projects to be undertaken simultaneously on one construction site.

c. There is quality and accuracy assurance. This means that there are good finishes of the surface with no plastering and the required dimensions and angles are achieved. This is in terms of door and window openings and from a given appropriate point to another.
d. Durability of the property of the formwork makes it possible to re-use without compromising quality and dimensions accuracy.
e. It is time saving. Time is saved in constructing the walls and plastering since all walls and floor slabs are cast monolithic and simultaneously.

It however has various limitations as noted by Thiyagarajan et al. (2017) and they are stated below;

a. Initial capital is high.
b. It has many components.
c. It is expensive to repair.
d. It has high chances of theft.
e. It requires more space for stocking.

2.4.12 Straw Bales

Straw bales result into light and large building blocks that are ready to use. Skills related to straw bales construction are easy to learn thus making it suitable for most carpenters and other woodwork personnel. There is the formation of a robust wall. This in filled wall upon construction has the ability of receiving lime render finish for both internal and external areas. Straw bales waste products are also biodegradable (Sutton & Black, 2011)

The straw bale is useable when raw contrary to other materials from recycling. It is therefore affordable since it is an end product in a raw state: no processing involved. The straw bales provide insulation, a prerequisite for climate change (Mahendriyani, 2016).

As a product, straw bale has gained high acceptance rate and it is a low impact/carbon building material highly accepted by the public. This however only applies to areas with low level of humidity and less rain (Mahendriyani, 2016)

2.4.12.1 Advantages of Straw Bales

Good air tightness is provided since there is no thermal bridging. This requires simple detailing in construction and it also has good insulation. The material is light thus ensures a reduced load on foundations and high embodied energy materials like concrete use is reduced. It is also less costly, readily and locally available renewable material storing carbon perpetually. There are also simple building skills applied that suites self-building and community building projects. These skills are necessary for "in situ and prefabricated approaches & vapour-permeable construction" envelope (Sutton & Black, 2011).

2.4.12.2 Disadvantages of Straw Bales

"As a horticultural co-item, conflicting properties (for example measurements, thickness and dampness content) can be dangerous during construction, details confined by need to shield the straw from water entrance; cautious specifying required for uncovered areas, restricted to moderately lightweight fixings, constrained water versatility and issues of repair if damaged by water(particularly loadbearing walls), requires protection before finishes can be applied and appropriateness of rendered outside finishes limits application in certain regions " (Sutton & Black, 2011)

2.4.13 Fly Ash Bricks

This material is composed of four components; lime, fly ash, gypsum and sand. They can be used in all construction related activities similar to burnt clay bricks. It is also lighter in weight as compared to burnt clay bricks and also stringer (Kumar et al., 2014)

2.4.13.1 Advantages of Fly Ash Bricks

Kumar et al. (2014) further highlight the following as the advantages.

a. Construction cost savings

Due to its uniformity in size and shape, savings are made in labour during laying the brick by about 15%. This in the long run translates into reduction in labour cost during laying of the bricks.

b. Low water seepage and wall dampness

It has high strength and less water absorption thus there is “less water seepage and dampness” caused in the walls of buildings constructed using this material.

c. Less energy consumption

A lot of energy is used in burning clay bricks. Fly ash bricks on the contrary saves on energy during manufacturing process

d. Reduction in air pollution

Contrary to fly ash bricks, there is use of fossil fuel in burning clay bricks. A lot of greenhouse gases are produced during this process contributing to global warming.

2.4.14 Rice Husk Ash

Rice husk ash contain silica. It hardens and sets just like cement it substitutes when mixed with water and cement. However, it has a low binding capacity. It is strong, less permeable and durable. It also enhances the concretes workability, ensures heat gain reduction through building walls and has increased compressive and flexural strengths (Mahendriyani, 2016).

Table 2.2: Inventory of Appropriate Building Materials and Technologies (ABMT)

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
1.	Interlocking Stabilized Soil Blocks (ISSB)	● Could be made using fully motorized machines (Electric and diesel) ● Plans are underway to build local capacity to produce the machines that are currently largely imported from abroad ● Uses locally available soils (except black cotton) found in most regions ● Where good soils are not available, quarry dust is used as a substitute (Soft quarry dust from limestone) ● Dry assembly saves construction time ● Can do ground +1 story without columns ● Blocks could also be used as in-fills for framed multiple-level structures ● Block chambers range from 1-3 ● Can be produced on small scale on the building site or on a large scale in centralized production units	● Hydraform Ltd (www.hydraform.com) ● Makiga Engineering Ltd (www.makiga-engineering.com) ● Ndume Ltd (www.ndumekenya.com ● Design Production Engineering (www.dpeengineering@dbo.ke)	● Wall construction (E.g. housing, water tanks, perimeter walling, etc.)	● 89ABMT centers built by the Ministry across the country ● Over 2592 IDP housing units, Turkana County ● Nyumbani Village, among others
		● Could be made using manual machines ● Various firms produce different brands with unique features ● A very appropriate technology that has the potential to address poverty and housing affordability challenges facing many Kenyan households due to its moderate price and simplicity ● Uses locally available soils (except black cotton) found in most regions ● Where good soils are not available, quarry dust is used as	● Makiga Engineering Ltd (www.makiga-engineering.com) ● Genetics Engineering ● JKUAT (www.jkuat.ac.ke) ● Ndume Ltd (www.ndumekenya.com ● Femurech Ltd (Comes with soil hopper)		

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
		a substitute (Soft quarry dust from limestone) ● Dry assembly saves construction time ● Makiga Engineering Ltd makes straight and curved interlocking molds ● Can do ground floor only without columns ● Blocks could also be used as in-fills for framed multiple-level structures ● Ideal for small-scale construction on site			
2.	Expanded Polystyrene (Commonly known as Styrofoam)	● Single panels can do ground + 3 stories ● Double panels with internal and external mesh can do multiple stories ● Application of concrete is done on site	● National Housing Corporation (NHC) (www.nhckenya.co.ke)	● Walling ● Slabs ● Floor ● Roofing ● Stairs	● Show house at the NHC factory site in Mlolongo ● 44 police housing units, Ruai among others
		● Hollow and interlocking 150 or 200mm thick wall panels in lengths of 1200 or 1800mm. The panels come in modules of 300mm in height. ● They have hollow cavities ready for easy placement of reinforcing steel and concrete to connect the thickened ground edge-beam via the engineered multiple columns ● Deck panels come in 100mm thickness while roof panels come in 100/125/150mm thickness ● The panels are pre-plastered	● Koto Housing Kenya (www.kotohousingkenya.co.ke)	● Walling ● Columns ● Roofing ● Flooring decks ● Stairs ● Foundation	Show house at the firm's factory site in Mlolongo
		● Lightweight, non-load bearing sandwich and hollow pre-plastered panels	● Hong Kong Building Centre (www.hkbckenya.com)	● Walling ● Roofing	● Police Convalescent Home, Nairobi
		● 140 mm thick composite of EPS and aluminum frames ● Application of concrete is done on site	● Elsek and Elsek Group of Companies (www.elsekgroup.com)	● Walling ● Slabs	● Showhouses in Karen and Mombasa

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
		● Single panels can do ground + 3 stories ● Double panels with internal and external mesh can do ground + 20 stories ● Application of shotcrete is done on site	● Boleyn Magic Wall Panel Ltd (www.boleyngroup.com)	● Walling ● Slabs ● Floor ● Roofing ● Stairs	● Showhouse at the firm's factory site in Kitengela ● 59 housing units in Kitengela
		● Zen house brand ● EPS material embedded in concrete ● Incorporates thermal membrane for temperature regulation	● Zenith Steel Fabricators Ltd (www.zenithsteel.com)	● Walling	● Residential units in Naivasha and Syokimau
3.	Interlocking Concrete Blocks (ICB)	● Using Stumbel Bloc plastic mold ● Dry assembly saves construction time ● Requires modular designs to avoid cutting of blocks as they come in 400 x 200 x 200mm sizes ● The blocks are hollow and convex in shape to provide additional strength for external walling application ● The hollow cavities may be used for plumbing and electrical services or can be concreted through to form columns ● Plaster may not be required	● Mineco Housing Ltd (www.minecohouse.com)	● Wall construction	● Various ●
4.	Interlocking Concrete Blocks (ICB)	● Using Stumbel Bloc plastic mold ● Dry assembly saves construction time ● Requires modular designs to avoid cutting of blocks as they come in 400 x 200 x 200mm sizes ● The blocks are hollow and convex in shape to provide additional strength for external walling application ● The hollow cavities may be used for plumbing and electrical services or can be	● Mineco Housing Ltd (www.minecohouse.com)	● Wall construction	● Various ●

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
		concreted through to form columns ● Plaster may not be required			
5.	Interlocking Concrete Blocks (ICB)	● The brand name is Alpha Block and its interlocking is based on the LEGOS concept ● Dry assembly saves construction time ● Factory production hence can be up-scaled for mass housing ● Requires modular designs to avoid cutting of blocks (400 x 200 x 200mm sizes) ● Plaster may not be required	● Buildmart Solutions Ltd (www.buildmartsolutions.com)		
		● They are cellular lightweight concrete blocks and thus the blocks come in bigger sizes (600 x 300 x 200mm) ● Production involves a combination of air with a non-toxic liquid foaming agent to form a foam that is introduced to regular concrete leaving numerous tiny discrete air pockets within the material ● Can be produced on a large scale in centralized production units	● Alima Holdings Ltd (www.alimaholdings.com)		
		● They are interlocking but not hollow ● Dry assembly saves construction time	● Peakwood Ltd www.peakwoodltd.kbo.co.ke		
6.	Prefabricated Housing	● Houses are made of timber using modular system designs ● Suitable for luxurious homes, low-cost modular houses, schools, and offices ● Suitable for emergency housing ● Can easily be dismantled and translocated	● Economic Housing Group Ltd (www.ehgkenya.com)		
		● Houses are made of steel ● Suitable for emergency housing ● Portable accommodation units made from steel (Portacabin)	● Steel Structures Ltd (www.Steelstructureskenya.com)		

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology	
		● Multi-unit huts suitable for security personnel				
7.	Monolithic Construction	● In situ concrete works using preconfigured steel/aluminum/plastic formwork	Wall and Ties Kenya Ltd (www.wallties.com/distributors/international/kenya.html)		● Walling ● Foundation ● Suspended floors ● Beams ● Columns	● Greenpark Estate, Athi River ● 116 Private Apartments, Langata
8.	Recycled Plastic Products	● Building products made from recycled plastic waste with additives such as sand and sawdust ● They are environmentally friendly ● They are not prone to termite attack	● Continental Renewable Energy Co Ltd (www.coreclimited.com)		● Corec roofing tiles ● Corec fencing posts	● Various
9.	Bio-digester Onsite Sewer System	● Easy to install an onsite sewer system ● Require a few manholes and inspection chambers ● Minimal exhaustion of septic tanks	● Riflo Industries Ltd (www.rifloindustries.com)		● Foul water disposal	● Kitengela International School ● Impala Park Lodges-Kisumu ● Likuyani Sub District Hospital, Eldoret ● Methodist Church, Meru
			● Kenya Cast Products Ltd, Ruiru www.kenyacastproductsltd.com		● Foul water disposal	● Various
			● Vision Drivers Enterprises		● Foul water disposal	● Various
10.	Integrated Bio-digester and Bio-gas System	● An award-winning system that breaks down solid human waste to liquid effluent that could be recycled to flush toilets, for irrigation or channeled to a soak pit, or integrated with wastewater from the kitchen, food waste, or animal dung to produce biogas for cooking and/or lighting	● Wonder Bio-digesters (www.wonderbiodigesters.co.ke)		● Affluent disposal ● Biogas	● Various

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
11.	Concrete Waffles	● Reduces costs in steel reinforcement, construction time, concrete, and formwork (Savings up to 30% concrete slab costs) ● They come in six sizes – 450x450, 450x900, 450x1040, 900x900, 900x1040 and 1040x1040	● Riflo Industries Ltd (www.rifloindustries.com) ● Kizuri Waffles Ltd (www.kizuriwaffles.com) ● Mineco Housing Ltd (www.minecohouse.com)	● Suspended slabs	● Various residential houses across the country
12.	Newbuild Construction Technology	● Uses quarry stones to replace concrete strip foundation and floor slab in a specialized patented methodology. ● Reduces construction costs by eliminating concrete, BRC, steel reinforcement, timber formwork, and reduced water usage. ● A green technology that conserves the environment by eliminating timber products and reduced water usage. ● Simple and easy to understand ● Offers employment to semi-skilled and non-skilled workers ● Can be used to provide low-cost quality housing	● Newbuild Ltd P. O. Box 16454-20100, Nakuru (www.newbuildltd.co.ke)	● Single level buildings ● Foundation strip ● Foundation slab	● Demonstration Unit at Ministry's ABMT Centre, Nakuru County ● Kitchen Block at Bahati District Hospital, Nakuru ● Classrooms at Lady Anne Delamere Girls' Secondary School, Nakuru County ● St. Peter's Elite Primary School, Gilgil, Nakuru ● Seas Motors Complex, Nakuru County ● Agricultural buildings including; Milk Cooling Building, and Njoro Dairy Farmers Co-op. Society, Nakuru County.
13.	Light Gauge Steel	● Components are easy to stack, load, and transport ● Rapid structural integrity cannot be compromised ● Maximum efficiency (waste reduction)	● Space and Style Ltd (Frametech Structures brand) (www.spaceandstyle.co.ke) ● Steel Structures Ltd (Ecoframe brand) (www.Steelstructureskenya.com) ● Mabati Rolling Mills Ltd (www.mabati.com)	● Roofing trusses ● Floor joists ● Side wall frames	● Various commercial and residential houses across the country

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
		• Environmentally friendly (66% of steel is recycled) • Strength to weight ratio is high			
14.	Compressed Agricultural Fiber (CAF)	• Panels are made from wheat or rice straw waste products • Light weight and are in panels of 1.22m x 2.44m • Rapid construction is achievable	• International Green Structure Kenya Ltd (www.igstructures.com)	• Walling • Roofing	• Show houses at Ardhi House and Public Works Yard, Machakos Rd, Industrial Area, Nairobi
15.	Precast Concrete Panels	• Panels are factory-made and pre-stressed • With rubber molds, any decorative pattern for external walls can be achieved • Smooth internal finish that requires no further plastering • Rapid construction that saves up to 70% of construction ti	• Boleyn Magic Wall Panel Ltd (www.boleyngroup.com)	• Foundation; Walling • Slabs • Floor • Roofing • Stairs • Beams • Columns (Pre-stressed)	• The firm is setting up a factory in Kitengela
16.	Bomakazi	This is a copyrighted paradigm that proposes to simultaneously redress shelter, employment, and food supply shortages through: • Self-servicing mortgage for affordable shelter, use of professionally managed ABMT particularly ISSB construction and urban agriculture planned within a 100 units' eco-village to leverage on economies of scale and business thresholds • Peer-trained and autonomous artisan groups rendering services to housing cooperatives and community projects by governmental and non-governmental organizations • Promotion of telecommuting lifestyles • Controlled micro climate as well as physical, social, spiritual, and financial security	• Shadaonline (www.shadaonline.com)	•	•

S/No.	Technology	Key Features	Technology Provider	Areas of Application	Projects Done Using The Technology
		• Provision of a biome water reservoir, alternative energy, eco-sanitation, waste processing & recycling, and water harvesting.			

Source: GOK, 2019

2.5 Comparisons of IBTs and Conventional Materials and Technologies

To justify the promotion of IBTs, it is imperative that their benefits be gauged in light of the conventional technologies. Comparisons made between conventional constructions materials and methods with IBTs reveal mixed results in favor or to discourage IBTs. This is particularly so when the technologies or components are largely imported.

Francis, (2012) estimated the full onboard price for an expanded polystyrene (EPS) panel in China to cost about Kes.300 shillings per square meter. When freight and port charges to Nairobi were added, the price came to around 450 shillings per square meter. This was slightly cheaper than the usual machine–cut stones or Stabilized soil blocks that we have in Kenya whose estimated price was at KES. 550 per square meter. Conversely, a steel structural insulated (SIP) panel when all costs including importation charges are added was estimated to cost KES. 1,350 per meter squire. This was way too high compared to the stone walling and stabilized soil block whose cost was estimated at KES. 550 per square meter. These two scenarios serve to show that importation of technology does not necessary make it more expensive to the locally available technology but rather, a case by case analysis needs to be carried out for each imported technology to benchmark its cost against the equivalent locally available technology. An imported technology that turns out to be cheaper would thus be considered more appropriate to the locally available technology.

For IBTs to have a significant competitive edge against the local materials, a holistic application to cover a wide range of building elements is crucial. According to Kamau (2011), prefabricated housing is limited to only the walls and roofs which constitute 30% of the total construction costs. Holistic solutions that reduce costs in all the elements of construction starting from Foundation to walling, roofing, doors & windows, and finishes offer the most effective solution to construction cost reduction. An example of this approach is the diamond house technology which utilizes a holistic approach in reduction of construction costs by targeting 3 main areas notably;

1. Use of IBTs targeting multiple building elements like the roof, walling, foundation, and window Technology. According to Kamau, this could reduce the cost of the building by about 32%
2. Use of Phased construction. This does not necessary reduce the building cost but the cost can be spread in several stages while ensuring that at every stage, the building is completed to a certain functional state.
3. Use of labor-based Procurement process where the developer buys materials and engages a local fundi/contractor and supply him/her with the materials as the contractor supplies labor.

By emphasizing all the above factors, the *diamond house* technology reduces construction cost using combined approaches rather than relying solely on IBTs.

2.6 Barriers to Adoption of IBTs

The relevance of IBTs as a viable approach for meeting environmental, social, and economic goals in the construction industry has commonly been acknowledged. Nonetheless, the adoption of IBTs has not been smooth in many parts of the world. A review of the literature shows that these barriers coalesce around legal, economic, technological, and social issues.

i. ***Building Laws*:** Building laws present a key barrier to the adoption of IBTs in areas where they apply. Kimani and Musungu (2010) assert that the building code is material-based and has several outdated and inappropriate provisions that are susceptible to multiple interpretations. They further take note of a set of building regulations that were commonly known as Code 95 developed through a government/private sector initiative in 1995 to promote housing standards and procedures. These aimed at reducing building costs through the use of innovative designs and local materials but according to them, no significant success was realized through this initiative due to the failure of most of the local authorities to implement the adaptive by-laws as provided for by these regulations.

Herbling, (2012) postulates that adopting new innovations in the building industry such as the use of pre-fabrications, interlocking bricks, and PVC roofing sheets will facilitate quick and sustainable delivery of affordable housing to meet housing demand. He however terms the current Building Code as too rigid. He cites specifications of 200-millimeter thick construction stone in the building code which is only readily available in areas like Kedowa (near Kericho), Narok and Thika hence huge transport costs to other areas. He goes further to cite government quantity surveyors who for instance opined that strict adherence to the current Building Code put the cost of a classroom at Sh1 million yet by using locally available resources, the bill reduces by half to Sh500,000. Whereas the Building code aims to protect people's health and safety, there is an inadvertent impact on limiting the exploration of different and better building technologies that are cost-effective and environmentally friendly. It is however laudable that there is an ongoing review of the code to make it more performance-oriented rather than material-based.

ii. ***Social Factors*:** A potential problem with appropriate technologies is that even if a technology is effective and meets all the design criteria, it still may not be acceptable to the end users due to sociological issues. Many appropriate technologies of high quality have failed because some local communities have inferior perceptions of such materials and technologies hence hindering their successive adoption (Kpamma, 2014). Hwang and Ng (2013) studied the barriers faced during IBTs project management in Singapore. They identified the following as crucial barriers: lack of interest and communication amongst private firms, lack of research, lack of interest from clients, and market demand.

Noppen (2012) notes that most developers in Kenya stick to stone and cement, and there is no widespread use of any alternative building material. The look and feel of the home are attached to status, and unlike new medical devices or agricultural inputs, when someone purchases a home, they want to put their savings into a reliable structure that looks and feels like the homes of their middle-class counterparts. This essentially points to a conservative attitude exhibited by developers and especially those putting up dwelling homes as they seek to match the neighborhood developments.

iii. ***Economic factors:*** Although a lot of benefits are derived from the use of appropriate technology, the limited availability of the technology is bound to limit its application. Appropriate technology by design seeks to downscale and be controllable at the local level resulting in production capability always being limited, therefore inhibiting the overall potential of people to adopt it (Wicklein, 2001). Kpamma (2014) further argues that though some IBTs were successful and sustainable over time, they are still too small in scope to play a significant role in improving the conditions of the masses who are in need. A technology must be readily available if it is to be applied significantly and consistently over time.

iv. ***Administrative barriers***; Chan et al. (2018) identified a total number of 20 critical barriers to building technology adoption within the Ghanaian construction industry and categorized them into five constructs; government-related barriers (GRB), human-related barriers (HRB), knowledge and information-related barriers (KIRB), market-related barriers (MRB), and cost and risk-related barriers (CRRB). Hwang et al. (2017) identified that lack of government support was the most critical barrier affecting the adoption of IBTs. Since a comprehensive understanding of barriers is necessary for developing appropriate strategies to overcome the barriers and promote the adoption of building technology, the analysis of barriers is worthwhile. Additionally, Darko et al. (2017) identified a total number of 16 key drivers for GBTs adoption inside the Ghanaian construction industry and categorized them into five constructs: environment-related barriers, company-related barriers (CRD), government-related barriers, industry-related drivers, and information related barriers.

2.7 Strategies for Promoting Adoption of IBTs

Various countries have embarked on a range of interventions geared towards increasing the supply of low-cost housing and particularly through building materials and technologies. These interventions include; the establishment of agencies that promote appropriate technologies, the Establishment and facilitation of research centers, and incentive mechanisms.

a) **Establishment of Agencies:** Agencies have also been formed in developing countries like India where two notable agencies with the mandate of promoting IBTs. These agencies have distinct objectives regarding the enhancement of technology adoption. The Building Materials and Technology Promotion Council (BMTPC) of India's mission was to bridge the gap between research and development and the large-scale application of new building material technologies.

b) Incentive mechanisms for the promotion of technology: Another approach that can be borrowed from developed countries in technology promotion is the incentive mechanism that seeks to promote sustainable housing. The national building codes of member countries emphasize the energy efficiency aspect as the countries need to adapt their existing building codes to comply with the EU regulations. Instruments and initiatives that have been proposed, developed, and implemented by EU municipalities to comply with the EU targets include; financial and fiscal incentives which can be in form of taxes, charges, subsidies, and grants (Skinner, 2015) in the local situation, these incentives can be applied to encourage adoption of IBTs.

Hwang and Tan (2012) identified the strategies to encourage green building adoption, including widening the coverage of governmental incentives, educating clients on the green building benefits, developing a green building project management framework, organization of construction tours for educating the public on the green building benefits, and government funding for green building research and development (R&D).

In Hong Kong, Khodadadzadeh (2016) studied a set of factors for facilitating IBTs procurement adoption in building projects. They identified the top three factors from 35 factors: the government’s mandatory environmental regulations, requirements of clients in tendering, and governments and NGOs’ requirements. Moreover, they identified 10 underlying grouped facilitators. At least, they found government regulations and standards, IBTs and lifecycle considerations, and commitment from executive management to be the most important facilitator groups. Chan et al., (2017) discovered

that providing relevant incentives, making better information regarding the IBTs costs and benefits available, and labeling and rating were the most important promotion strategies for IBTs adoption in the US. Li et al., (2014) addressed the problem of how to promote green building in China, arguing that enhancing stakeholders' environmental awareness, strengthening green technology R&D and communication, and formulating green building policies were the three fundamental measures to promote green building. Li et al., (2017), studied the literature on building certification systems and concluded that developing building certification systems plays an important part in nurturing IBTs development internationally. The literature documents several strategies to promote IBTs and practices adoption. These strategies existing in various other countries may not apply to Kenya due to the cultural, economic, and regulatory differences between countries. Thus, carrying out a study specifically focused on the developing country of Kenya is worthwhile.

2.8 Legal Framework for IBTs Adoption in Kenya

The legal framework encompasses the laws and regulations that outline the legal requirements to be met. They are often complemented by policies, standards directives, and guidelines. The legal framework is also the due process of regulation surrounding a single topic that entails all of the relevant legislative documents (Chege, 2013). There is a need for policy support in promoting appropriate technology as the free market economy may otherwise not allow for significant technical innovation. This is more so because potential investors and users of the technologies are averse to risks associated with new technologies. Factors that contribute to this need for government intervention include; the costs or disadvantages of adopting new technology, the government's need to protect inventors' rights and allow innovators to reap the benefits that offset the costs and risks of innovation, Market size and integration influence where government can facilitate the introduction of new technology in small or poorly integrated markets (Lemer, 1992). In Kenya, there is no specific policy or legislative framework that has been promulgated to promote the adoption of IBTs. Policy support for IBTs can be found in various legislations and policies promulgated by the government although the object of these policy documents is often broad as they seek to address wider goals (G.O.K., 2010).

2.8.1 The Constitution of Kenya

Policy actions that stem from or have a linkage to the constitution are bound to merit wide public support and justify the devotion of resources. The significance of IBTs concerning the constitution may be drawn from article 43 of the bill of rights where the right to accessible and adequate housing and reasonable standards of sanitation is provided. Whereas this may not have a direct bearing on IBTs, the affordability challenge that hampers the provision of adequate housing using conventional technologies makes it imperative that the state has to seek alternatives that aim to overcome this hurdle. Further potential for an influence of the Constitution in building technologies can be derived from the fourth schedule which delineates the functions of the National government to include housing policy. County planning and development including Housing and county public works is on the other hand in the realm of the County government functions. The constitution, therefore, sets a foundation for housing policymaking and implementation of which IBTs is paramount.

2.8.2 The Kenya Vision 2030

The vision for housing and urbanization as provided in the Kenya Vision 2030 blueprint is an adequately and decently housed nation in a sustainable all-inclusive environment. The goal of the second medium-term plan for vision 2030 was to increase the annual production of housing units from 35,000 annually to over 200,000. The vision further aimed to achieve better development of and access to affordable and adequate housing. The situation analysis of the third medium-term plan for vision 2030 acknowledges that the Housing sector promoted the use of Appropriate Building Materials and Technologies (ABMT) through establishing 19 Housing Technology Training Centres at the constituency level, training 300 community groups on the use of ABMT, and production of Expandable Polystyrene Panels (EPS). Under the Programs and Projects for 2018-2022, the third medium-term plan targets to conduct Research and Development on Appropriate Building Materials and Technologies (ABMT): This will entail collaborative research, documentation, and technology transfer on building and construction materials; training

of 20,000 new trainees on ABMT; dissemination of appropriate building materials and technologies; and development of 20 ABMT Centers. The plan further targets developing a policy on lowering the cost of housing and improving access to affordable mortgages (GOK, 2012).

2.8.3 Housing Policy in Kenya

The need for anchoring key initiatives to boost the construction industry in government policies cannot be overemphasized. Housing is a construction industry output that is regarded as a basic need and is recognized globally as a human right while in the hierarchy of human needs, shelter is considered third only to food and clothing (G.O.K., 2010). In most developing countries, housing is inadequate and the housing backlog has been increasing rapidly, a situation that has been aggravated by the increase in population sizes in developing countries including Kenya. To address the housing provision challenges, it is significant that policymakers and implementers formulate housing policy that supports the use of sustainable low-cost housing technologies that can provide houses to masses of the population at an affordable cost (Jain, 2012).

The housing policy plays a significant part in the prioritization of approaches geared towards addressing the housing problems in any country. It is imperative that strategies for boosting housing delivery be anchored on a policy framework, especially in a field of multiple players for coordination and consistency. The Housing Policy for Kenya of 2016 lays the policy framework for IBTs as a strategy to provision of low-cost housing right from the basic objectives of the Policy. The policy sets out to encourage research and popularize the use of appropriate building materials that are locally available and low-cost building technologies to reduce the cost of housing. It further acknowledges that the building materials and construction industry constitutes one of the most important sectors in Kenya's economy and that Some of the materials which are produced in some large-scale industries end up being costly due to high costs of production arising mainly from high electricity and transport costs. The materials can be produced on-site using labor-intensive techniques thereby reducing overall costs (G.O.K, 2004).

The anchoring of IBTs on the housing policy for Kenya is crucial in that it guides all important decisions and activities on appropriate IBTs besides attracting devotion of resources to the area. The specific input of the policy concerning IBTs can be traced right from the policy statements for government action that ostensibly aim to increase the production of housing units through the utilization of research findings as well as the use of innovative and cost-effective building materials and technologies. Out of the 16 policy statements listed in the policy document, the majority of the statements are relevant to the promotion of IBTs.

2.8.4 The Construction Industry Policy (Draft)

The Construction Industry Policy aims to create a well-coordinated and developed construction industry that will address the existing needs to contribute to sustainable socio-economic development. Some of the policy statements made towards addressing the aforementioned challenges that relate to IBTs include; Creation of an enabling environment for the local construction industry players to boost the growth of the industry while encouraging international and regional players. This is informed by the recognition that the industry is still a net importer of construction materials, contractors, professional services, and technology.

Policy actions identified for implementation in this regard include promotion of the use of locally manufactured products in the industry; Creation of awareness and enforcement of quality standards in the industry, Nationalization, and harmonization of all construction standards under the agency in charge of standards, Providing a framework for the standardization of informal local construction products and services, domesticate foreign construction and material standards designs to suit local conditions and Fast-track formulation and updating of construction regulations and standards on emerging technologies and best practices.

2.8.5 The Building Code of 1968

The building code of 1968 was anchored on the Local Government Act that was repealed on the advent of devolved governments that took over the functions of the hitherto Local County Councils. As such, it would seem that the code is in limbo but is nevertheless significant since no other building code has been legislated to date. The code has often been castigated as archaic and a barrier to the use of IBTs. For instance, the code recognizes British Standards as a benchmark in non-explicit standards yet the use of BS standards in the United Kingdom was withdrawn in 2010 and the Euro codes started to play an important role in the design and analysis of structures and buildings. Furthermore, the predominant reference to British standards fails to take account of the different conditions experienced in Europe e.g. snow loads on the roofs (Erastus, 2014). IBTs generally take account of the prevailing conditions in the area to which they are applied and as such, Kenya requires its own standards for the quality of materials.

Another overriding criticism of the code is on being material based at the expense of performance requirements. With the introduction of new building materials in the market it's difficult to come up with a well-designed structure based on the code since the design perspective of the code is based on materials and some of the materials were not factored in and the code has not been reviewed since then (Erastus, 2014). The focus on the material instead of the performance requirement undoubtedly portends bias against materials that may meet performance requirements but fail to meet the predetermined material properties.

2.8.6 Draft Planning and Building Regulations of 2009

The draft Planning and Building Regulations were developed under the proposed Built Environment Bill that seeks to establish standards and practices in the built environment relating to building, maintenance, and associated works and to make provisions for matters connected therewith. The regulations also sought to address the drawbacks noted in the Building code which include the prescription of materials based on their physical

properties. To address this, the draft regulations define the performance requirements of the materials with reference to the performance requirement for the particular building element where the material is used.

2.8.7 National Construction Authority Act

The National Construction Authority Act (2010) is an Act of parliament that provides for the establishment of the National Construction Authority and its connected purposes thereof. The influence of this law on IBTs may be looked at in the context of some of the functions of the Authority as set out in Section 5 of the Act. Clause 2 Subsection (g) particularly spells one of the mandates of the agency to include; encouraging the standardization and improvement of construction techniques and materials. Whereas the authority may not have binding implications on the standardization and improvement of building materials and technologies, this function has direct implications on IBTs. Other functions outlined for the authority that could be exploited by the authority to promote IBTs include; promoting and stimulating the development, improvement, and expansion of the construction industry, undertaking or commissioning research into any matter relating to the construction industry, promoting quality assurance in the construction industry

A further avenue for the authority to influence IBTs is provided under section 6 clause C which confers the authority with power subject to the approval of the Minister, to establish or expand, or promote the establishment or expansion of, companies, corporations, or other bodies to carry on any activities related to construction either under the control or partial control of the Authority or independently (G.O.K, 2010). It is apparent that the provisions in the statute do not have a direct bearing on IBTs but rather, the relevance is dependent on the implementation by the National Construction Authority that is established under the Act.

2.8.8 Public Health Act

Any building technology mustn't be hazardous to the environment where it is applied. The Public Health Act CAP 242 of the laws of Kenya sets out to make provisions for securing and maintaining health. Section 118(I) of the Act defines nuisance to include any public or any other building which is so situated, constructed used, or kept to be unsafe, injurious, or dangerous to health. Building materials like asbestos roofing sheets were a popular roofing material but are no longer used largely due to health concerns nowadays. Section 116 empowers local authorities to take all lawful measures to prevent or remedy nuisance. Section 117 empowers Health Authorities with similar powers but specifically cites the erection or occupation of unhealthy dwellings or premises. Summarily, it may be concluded that the Public Health Act endeavors to put checks on construction to avert nuisance wherein, construction materials and technologies are a major component (G.O.K., 1986). The challenge as pertains to IBTs is on parameters used to determine a technology that occasion nuisance. There is need for uniform and objective parameters for use in assessing conventional and IBTs to avoid subjective bias against IBTs.

2.8.9 Science, Technology and Innovation Act

The objectives of Science, Technology and Innovation Act are to facilitate the promotion, coordination, and regulation of the progress of science, technology, and innovation in the country; to assign priority to the development of science, technology, and innovation; to entrench science, technology, and innovation into the national production system and for connected purposes. The Act establishes the Kenya National Innovation Agency whose function entails the development and management of the Kenya National Innovation System. The Act further sets us an Innovation fund whose objective is to facilitate research for the advancement of science, technology, and innovation. (GOK, 2013). However, the general nature of the Act and the extensiveness of the Innovation and Technology field do not guarantee significant involvement of the agency in IBTs. The relevance of this Act is thus dependent on its operationalization by the Kenya National Innovation Agency that is established under the Act.

2.8.10 Standards Act – CAP 496

This Act of Parliament seeks to promote the standardization of specifications for commodities, and establishes the Kenya Bureau of Standards as an agency whose functions include the promotion of standardization in industry and commerce. In this regard, the Kenya Bureau of standards prescribes standards for various commodities including building materials but compliance to these standards applies to manufactured products (GOK, 2013). Further, the Act leaves the onus of obtaining certification on the producer of the material. It is thus apparent that naturally occurring materials and locally produced materials like the stabilized soil blocks do not bear the standard mark of quality but in reality, they may meet prescribed standards. The relevance of this Act on IBTs may however be influenced by the initiatives of the Kenya Bureau of Standards towards the promotion of standardization in industry and commerce.

2.8.11 The Public Procurement and Disposal Act (PPDA)

Section 60 of the PPDA provides that a procuring entity shall prepare specific requirements relating to the goods, works, or services being procured that are clear, that give a correct and complete description of what is to be procured, and that allow for fair and open competition among those who may wish to participate in the procurement proceeding. The Act requires that the technical requirements shall not refer to a particular trademark, name, patent, design, type, producer, or service provider or a specific origin unless there is no other sufficiently precise or intelligible way of describing the requirements; and the requirements allow equivalents to what is referred to. In this regard, the Act removes bias to the use of IBTs in public procurement. However, the conventional building designs and specifications oftentimes specify specific building materials even where there may be suitable alternatives. For instance, the walling materials in most residential buildings are designed to be the conventional 200mm thick masonry stones. This is in spite of other alternatives like the expanded polystyrene panel, stabilized soil blocks, and compressed agricultural fiber (CAF) panels that could perhaps be equally viable or superior to the conventional stones.

2.8.12 The Environmental and Coordination Act (EMCA)

The National Environmental and Coordination Act of 2015 requires proponents undertaking a housing project with more than 30 housing units to prepare a project report stating; the design of the project, the materials to be used, products and by-products, including waste to be generated by the project and the methods of their disposal among other information requirements (GOK, 2015). It is apparent that information is bound to inform approval of the project by the National Environmental Management Authority. The influence of the Act on the use of IBTs is thus certain to large-scale housing developers. IBTs are generally considered to be environmentally friendly and as such the Act would not be said to be adversarial to IBTs.

2.9 Administrative Framework for Adoption of IBTs

The political will and support from the government and its agencies for the dissemination of IBTs are essential. This includes the establishment of institutions and enactment of enabling legislation to remove any planning and building regulations that may hinder the use of alternative building materials and technologies. Lemer (1992) categorizes government activities that are directed at encouraging new building technology to fall into two primary areas. These are identified to include agencies that create a market for new technology and promote research and development to seek improved and cost-effective performance that new technology may offer and secondly, agencies that act as promulgators of policies intended to accomplish broader social goals (e.g., energy efficiency or industrial competitiveness), and to promote the development of new technologies that serve these policies. In Kenya, the government and several nongovernmental organizations are involved in various programs geared toward increased adoption of IBTs albeit in an uncoordinated manner. Some of the key players in the research and promotion of IBTs in Kenya include the Ministry in charge of Housing. Housing and Building Research Institute (HABRI) and several non-governmental agencies key among them the United Nations Centre for Human Settlements UNCHS (HABITAT). Their various roles in promoting IBTs are described as follows;

2.9.1 The State Department for Housing, Urban Development

The fourth schedule of the constitution delineates the national and government functions and the housing policy function is assigned to the national government. Executive order number 1 of 2018 in turn delineates the function of providing policy direction and coordination of all matters related to housing and urban planning and development to the State Department of Housing and Urban Development. Other functions for the department include Housing Policy Management, Development, and Management of Affordable Housing; Management of Building and Construction Standards and Codes, and Building Research Services among other functions. It is thus apparent that the department has great significance in the formulation and implementation of policies on IBTs (G.O.K, 2018)

The State Department has also been involved in spearheading the revision of the Building Code with a view to removing legal barriers to the adoption of IBTs. Other government interventions through the Ministry include the establishment of Appropriate Building Material (ABTs) Centres in all parts of the country and aims at establishing the centers in each constituency. The Ministry has also procured several Hydraform machines for lending to the public and is also involved in training to transfer skills and empower local communities in the construction of affordable houses (GOK, 2009). This intervention by the government is broad in that it seeks to address the policy aspects, research, and dissemination of findings as well as the direct involvement in the promotion of particular technologies.

2.9.2 The National Construction Authority (NCA)

The National Construction Authority is established under the National Construction Authority Act and the mandate of the Authority is to regulate the construction industry and coordinate its development. The functions of the Authority as set out in Section 5 of the Act include; encouraging the standardization and improvement of construction techniques and materials. Whereas the authority may not have binding implications on the standardization and improvement of building materials and technologies, this function has

direct implications on IBTs. Other functions outlined for the authority that could possibly be exploited to promote IBTs include; promoting and stimulating the development, improvement and expansion of the construction industry, undertaking or commissioning research into any matter relating to the construction industry, and promoting quality assurance in the construction industry. The Authority is also Formulating a Construction Industry Policy that provides a further avenue for influencing IBTs (NCA, 2015).

2.9.3 The National Housing Corporation (NHC)

National Housing Corporation is charged with the responsibility of providing subsidized housing and implementing government housing policies and programs through tenant purchase, mortgages, rental and rural housing loans scheme. NHC was formed as part of Kenya's post-colonial housing policy underscoring the importance of providing decent shelter for all urban workers in the country. In its operations, the agency has directly been involved in the production of IBTs and particularly the Expanded Polystyrene Panel that is produced at the Mavoko factory (NHC, 2009).

2.9.4 The National Building Inspectorate

The National Buildings Inspectorate (NBI) is an agency under the State Department of Housing and Urban Development and part of its mandate is to audit buildings for conformity with land registration, planning, zoning, building standards, and structural soundness (NBI, 2018). The buildings audit is critical to an assessment of performance of IBTs during the life cycle of the building.

2.9.5 Kenya Building Research Centre

The Kenya Building Research Centre is domiciled under the Ministry of Transport, Infrastructure, Housing & Urban Development and Public Works and is responsible for; the dissemination of information relating to the building construction industry, researching on building materials and systems to facilitate the availability of innovative and cost-effective building materials and technologies (GOK, 2016).

2.9.6 The County Governments

The fourth schedule of the Kenya Constitution spells the functions of County governments to include county planning and development including Housing, and county public works (G.O.K., 2010). As such, the County Government has a big stake in influencing the Use of IBTs through the enforcement of building policies and regulations besides the various county laws that could be enacted pursuant to these functions.

2.9.7 Kenya Bureau Standards

Kenya Bureau of Standards (KEBS) is a statutory body whose aims and objectives include the preparation of standards relating to products, measurements, materials, and processes and their promotion at national, regional, and international levels; certification of industrial products; assistance in the production of quality goods; improvement of measurement accuracy and circulation of information relating to standards (ISO, 2016). One of the positive steps undertaken by KEBS in the line of enabling legislation is the enactment of guide standards on the application of materials and technologies in 'Special Scheduled Areas' in the major urban centers of Nairobi, Mombasa, Nakuru, Eldoret, Kisumu, and Embu (Magutu, 2015). The Kenya Bureau of Standards also issued a Kenya Standards Number: KS 02-1070 in 1993 on Specifications for Stabilized Soil Blocks. This standard specifies requirements for cement and/or lime Stabilized Soil Blocks for use in general buildings.

2.9.8 Academic Institutions

Academic Institutions establish units that conduct research and develop IBTs. This includes The Jomo Kenyatta University of Agriculture and Technology which established Sustainable Materials Research and Technology Centre. (SMARTEC) The center conducts research, develops innovations, disseminates research findings/innovations through training/extension/consultancy activities, and produces/markets appropriate construction materials/technologies. The Housing and Building Research Institute

(HABRI) was established by the Government of Kenya as a project within the Architecture department at the University of Nairobi. The body is however not in operation at present. The core mandate of HABRI was to research various aspects of low-cost housing and community planning in both rural and urban areas (HABRI, 2007). From its objectives, it is apparent that HABRI sought to link its core mandate of research to the establishment of policy guidelines and training and this augmented its capacity to influence the adoption of IBTs.

2.9.9 Non-Governmental Organizations

Several non-governmental organizations are involved in promoting IBTs.

2.9.9.1 The UN-HABITAT

The United Nations Centre for Human Settlements UNCHS (Habitat) is an international agency mandated by the UN General Assembly to promote socially and environmentally sustainable towns and cities with the goal of providing adequate shelter for all (UN-HABITAT). By focusing on these areas UNHCS approach has the potential to promote the adoption of IBTs through the dissemination of information as well as addresses some of the factors cited as a hindrance to IBTs adoption like the building laws. Magutu, (2015) notes the major achievement of UNHCS to be in the organization of regional workshops in some of the participating countries aimed at supporting the countries in formulating standards and specifications for local low-cost building materials.

2.9.9.2 Practical Action Group

The involvement of the Practical Action group (previously identified as Intermediate Technology Development Group (ITDG) is in promoting the adoption of IBTs through training, promotion, and dissemination of alternative building technologies already developed. The group has particularly been cited to have been involved in the promotion of Fibre Roofing Concrete tiles. The dissemination of technologies is done through seminars, workshops, participation in national agricultural shows and other demonstration

forums, and secondly, the promotion of small private entrepreneurs (Practical Action, 2016). Funding constraints have however been cited as an impediment to the success of the group's projects geared to the promotion of IBTs (Magutu, 2015).

2.9.9.3 Action Aid Kenya (*AAK*)

Action Aid Kenya (AAK) is a non-governmental development agency that seeks to promote basic education in all forms. This is a non-governmental development agency that seeks to promote basic education in all forms. As set out in its mission, AAK works with communities to design, fund, and manage integrated development programs. One of the approaches previously used by the organization through its technical support unit was to channel its assistance through primary schools in form of technical support and building materials. The local communities were expected to offer labor and produce building materials. The assistance by AAK was also conditional in that the communities had to agree to use locally available materials like sun-dried bricks, burnt bricks, stabilized soil blocks, sisal cement tiles, etc., in their building programs (Magutu, 2015).

One of the successes of AAK's involvement in promoting IBTs was with FCR tiles in mid-1984 when they purchased tiles from Intermediate Technology (IT) workshops for their sponsored school projects in Ikanga in Kitui. This led to the acquisition of their tile-making machine for the establishment of their tile plants to meet the high demand for roofing structures with durable low-cost materials. AAK, in particular, has been instrumental in training, financing, and promoting FCR tile technology in Kenya. These activities led to the establishment of several decentralized tile-making groups throughout the country. The notable drawback in achieving a widespread adoption of the IBTs is the number of decentralized groups has been rather too low relative to the potential demand for low-cost roofing materials (Magutu, 2015). This can be attributed to the limited capacity of the organization to spread its promotion initiatives on a significant scale.

2.10 Theoretical Framework

IBTs are not universally identified to constitute any particular material or technology but rather, their identification is based on the social-economic, and environmental conditions of the location in which they are applied. Factors identified to render a technology appropriate include cost-effectiveness, environmental friendliness, and local availability among others. However, a review of technologies that are deemed appropriate shows that some of the technologies are largely imported. It is rare to find a technology that meets all the parameters that are considered appropriate to be classified as appropriate. This, therefore, necessitates striking a balance such that technologies that reach a certain threshold can be classified as appropriate. However, the cost factor stands out as a key parameter that determines appropriateness more so because there is a close relationship between the overall cost and most of the other factors.

The trends in the promotion of IBTs have glaring similarities both locally and internationally. These include the establishment of agencies with mandates that include the promotion of IBTs through research, training, and policy formulation. The notable difference is that in developed countries, the focus is more on green buildings. In the local contest, some laws have been found to influence the adoption of IBTs although this does not constitute the core object of these laws. These include the constitution of Kenya, the housing policy, the building code of 1968, the national construction authority Act, and the public health Act.

In the institutional setup for the promotion of IBTs, both state and non-government agencies have been found to play a key role in promoting the adoption IBTs. There are also striking similarities in the approach used by most of these agencies where the focus on most agencies includes research and training and policy guidelines. There is however lack of interaction and partnership framework, within which these organizations can co-operate as they have largely tended to work independently.

Barriers to the adoption of IBTs have been identified to coalesce around legal, technological, economic, and social barriers. Some initiatives from both the state and non-state agencies have however been put in place to mitigate these barriers.

2.11 Literature Gap

Some laws have been noted to make provisions that impact IBTs. Researchers in IBTs have however not examined the impetus of these laws in influencing the adoption of IBTs. Similarly, there are multiple organizations involved in IBTs but the relationship among these institutions and their significance towards the adoption of IBTs is unexplored. This is the hallmark of this study.

2.12 Conceptual Framework

From the theory discussed, a conceptual framework for this study can be devised as shown in Figure 3 below. The study perceives that selection and uptake of IBTs is from the onset influenced by technological characteristics, the social context, and the user characteristics. The three broad areas are specific to potential adopters of the technologies and affect their choice on whether to take up technology or not. These factors constitute the independent variables in this study. When these factors are left into play in the construction industry, the uptake of IBTs lags in favor of conventional technologies. This generally so because the conventional technologies have an obvious advantage as potential users have a relatively higher technical knowhow, no social bias and the risk perceptions are lower as they have been in the market for long. However, innovations in construction industry stem out to address drawbacks in construction market associated with factors such as rising materials costs, performance improvement and environmental friendliness. This is what necessitates intervening initiatives in form of enhanced transfer and adoption mechanisms. These intervening mechanisms are instituted in form of creating a conducive policy environment, technology transfer mechanisms (constituted by the institutional framework), and a technology development market. These factors thus constitute

confounding variables of the study as they influence both the dependent variable and independent variable to cause an altered outcome.

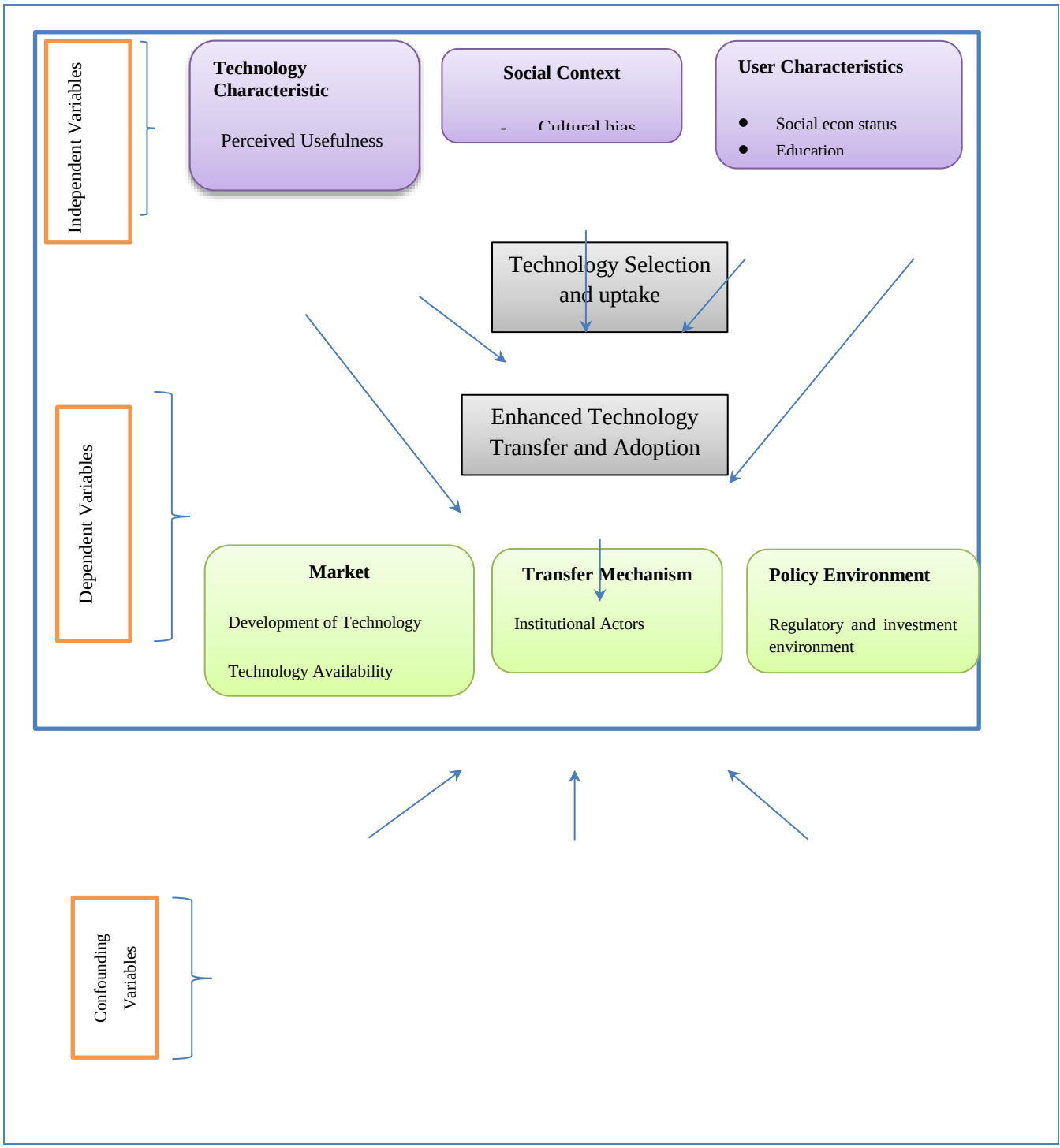

Figure 2.3: Conceptual Framework

Source: Researcher, 2019

2.13 Summary of the Chapter

The high cost of materials is seen as major impediment to supply of adequate housing. IBTs seeks to address the challenge of provision of adequate housing mainly by reducing the building costs. An overview of available IBTs has been made in this chapter including a discussion on their advantages and disadvantages. The barriers to adoption of IBTs have been identified and categorized to fall within social, economic and technological factors. The Institutional setup and the legal framework in Kenya that is often cited to influence adoption of the technologies have been discussed. This includes the provisions in statutes that bear on building technologies and the mandates and roles of various institutions that have capacity to influence IBT development and adoption. The best practices employed to enhance adoption of IBTs internationally has been explored. The chapter concludes by laying a conceptual framework that ties up the barriers of technology adoption with interventions that are used to overcome the barriers so that IBTs can be optimally developed and adopted in the industry.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains how the research was carried out. It discusses research design, the area of the study, the study population, sample size and sampling techniques, sample procedures data collection instruments, data collection procedures, piloting, data analysis procedures, and the ethics guiding the study. This chapter outlines the research methodology that was used in collecting and analyzing the data as well as a brief background to the study population with respect to the subject topic of the research. This is aimed at creating the necessary background on which to base the uniqueness of this research. It is also aimed at building up a mental image of the subject topic with clearly researched intellect projections.

3.2 Study Area

Kenya's main city, Nairobi, is a fast-expanding urban area with a population of more than 4 million. The city has a total size of roughly 696 square kilometers and is situated in the south-central region of the nation. Nairobi is renowned for its rich cultural legacy, energetic city life, and status as the region's economic center. Nairobi is situated 140 kilometers from the equator in the south-central region of Kenya at 1.2921° S, 36.8219° E. The city is located at a height of 1,795 meters above sea level and has a total area of roughly 696 square kilometers. The city's position makes it a key hub for transportation and economic activity.

Nairobi, has a population of about 4 million. Average population density for the city is 5,500 persons per square kilometer. There are many different countries and ethnic groups represented in the population. Over the past few decades, the city's population has grown quickly, increasing demand for property and straining the city's limited land resources.

IBTs application in Kenya has spread to most parts of the Republic of Kenya. As such, awareness and knowledge-based information exist at both the National and County levels albeit in small proportions, with Nairobi City County and the neighboring metropolis counties of Kajiado, Machakos, and Kiambu dominating in terms of information knowledge and access. This study was therefore designed to cover the IBTs among key informants and technology providers in the four counties, which are commonly referred to as the Nairobi Metropolis. The sampling frame was therefore drawn from across the four counties and this enabled sampling and subsequent interviews for completion of this study.

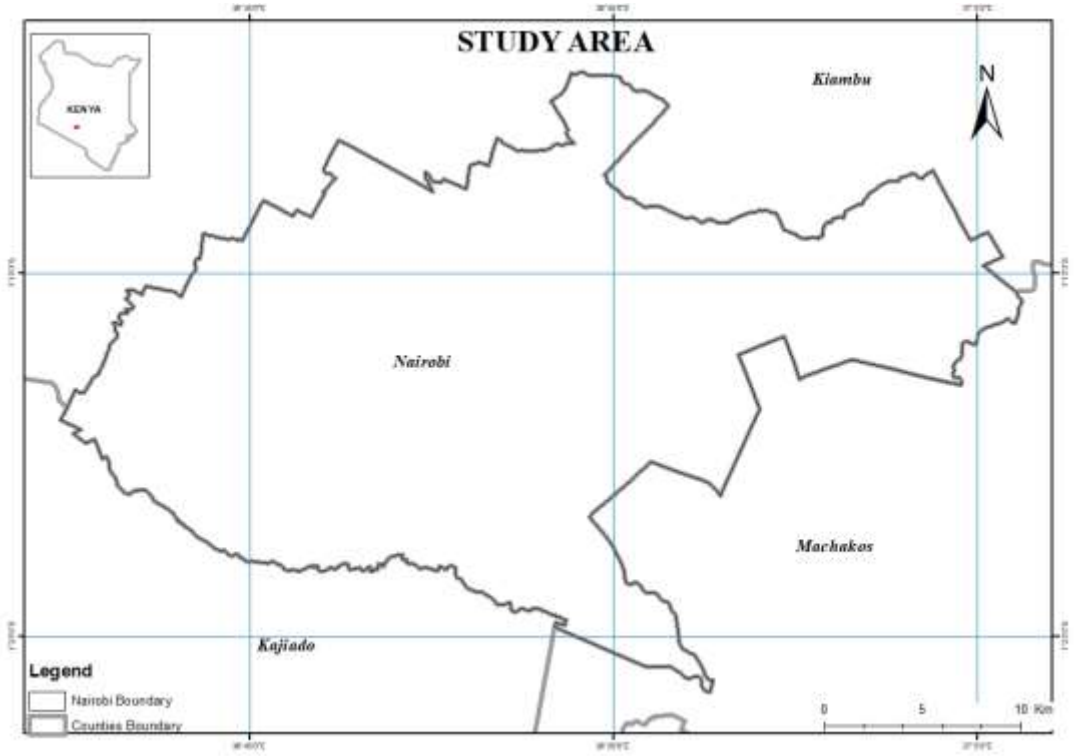

Figure 2.4: Study Area Map

Source: (Field Study, 2021)

3.3 Research Method

The study employed a mixed-method design which utilizes the elements of both qualitative and quantitative techniques (Creswell, 2009). Mixed methods research allows the methods to share the same research questions, gather complementary data, and carry out counterpart analyses (Yin 2006). The mixed method was selected for its ability to allow for triangulation of various data collection sources that the study employs such as questionnaires, key informant interviews, and documentary searches (desk top review). According to Campbell et al. (1999), mixed methods are a powerful way of enhancing the validity of results and any bias inherent in one particular method would be neutralized when used in conjunction with other data sources. Data produced by this design enhanced the validity and reliability of research findings. The quantitative approach that employed the use of questionnaires aimed at getting information from providers of IBTs technology while the qualitative approach used desk top review and key informant interviews with experts.

3.4 Target Population

The population comprised all producers of IBTs and policymakers in the various Government and nongovernmental agencies who influence policy on the development and use of IBTs in Kenya. The producers were majorly drawn from the private sector players and included the IBTs developers who develop and market various IBTs. The Government departments with mandates that influence IBTs through policies and promotion strategies are domiciled in the Ministry of Transport, Infrastructure, Housing, Urban Development, and Public Works (MTIHUDP). Specifically, these include the State Department of Housing and urban development, The National Construction Authority (NCA), National Housing Corporation (NHC), National Building Inspectorate (NBI), and Kenya Building Research Centre (KBRC).

The identified target population is based on the total number of regional offices of respective Government agencies within Nairobi Metropolis. The Ministry of Transport,

Infrastructure, Housing & Urban Development, and Public Works has offices across all counties in the Nairobi metropolis while the presence of other government agencies across the selected 4 counties varies from one agency to another. Some agencies have established offices only in Nairobi. Private sector players who were considered for this study are largely distributed within Nairobi and neighboring counties. This population was determined based on inventory records of IBTs providers in the database of the Ministry of Transport, Infrastructure, Housing & Urban Development, and Public Works.

3.5 Sample Procedures

The study seeks to gather in-depth information as regards the influence of regulatory and institutional frameworks on the adoption of IBTs in Kenya. The study utilized a census survey to collect select participant institutions/organizations. However, study participants from different institutions were selected through purposive sampling as it allowed the researcher to only interview respondents involved in the IBTs function within the organization. Purposive sampling was also used in the selection of desktop materials used and the selection of key informants used in the study.

3.5.1 Sample Size Determination

The population was less than 200 and as such, the study used a census that included all the 54 firms (Mugenda & Mugenda, 2003)

Table 3.1: Composition of the Target Population and Sample Size

Key Informant Category	Identified Target Population	Sample size
Respondents from Ministry of Transport, Infrastructure, Housing & Urban Development and Public Works	4	4
National Construction Authority (NCA)	4	4
County Governments in Nairobi Metropolis	4	4
National Housing Corporation (NHC)	1	1
Kenya Building Research Centre (KBRC)	1	1
Kenya Building Inspectorate (KBI)	1	1
UN-Habitat	1	1
Respondents from Private Sector (IBTs providers)	38	38
Total	54	54

Source: Survey Data, 2021

3.6 Types of Data and Sources

The data collection included both Primary and Secondary data sources. The primary data was obtained from the field through questionnaires and interviews while secondary data was collected through desktop review.

3.7 Data Collection Instruments

The study used self-administered questionnaires, an interview schedule, and a search of documentary data from key informants.

3.7.1 Questionnaires

The questionnaire data collection instrument has been extensively used to solicit professional opinions in building research. In this study, an empirical questionnaire survey was performed to investigate the research objectives. Carrying out a questionnaire survey is advantageous for achieving "quantifiability and objectiveness". The comprehensive literature review laid the basis for the development of the survey questionnaire. A self-administered questionnaire was used to elicit qualitative and quantitative data from

sampled respondents. The questionnaire is shown in appendix II. A semi-structured questionnaire consisting of questions and statements was used to obtain the required information. Closed-ended questions provided answers from which the respondent chose while open-ended questions required the respondent to provide his or her own answer (Mugenda and Mugenda 2003). The questions were brief but exhaustive, logically ordered, and simple with clear instructions to ensure the delivery of necessary data. The researcher administered the questionnaire through respondents' email addresses aided by introductory and follow-up calls to the respondents.

The participants who involved private IBTs producers, government policymakers, and implementers were asked the following:

1. The extent to which the existing policies, regulations, and institutions relate to the adoption of IBTs
2. Respondent's perception on how provisions identified in related literature on regulatory documents have in the past affected the adoption of IBTs
3. Perception of the magnitude of various administrative barriers to the adoption of IBTs Perception of the extent to which various laws and Policy Provisions have stimulated the development and adoption of innovative building technologies and
4. Perception of the effectiveness of interventions by various institutions in influencing the development and adoption of IBTs.

This study adopted the five-point Likert scale, for its advantage of providing results that are easy to interpret.

3.7.2 Desktop Reviews

A desktop review of policy areas designated (or used) to promote the adoption of IBTs in Kenya was carried out by examining the existing policy and legal documents in Kenya. These included; The Constitution of Kenya, Kenya Vision 2030, Sessional Paper number 3 of 2016, the National Housing Policy for Kenya, Building Code of 1968, Urban Areas

and Cities Act (2011), The Physical and Land Use Planning Act 2019 and Physical Planning Handbook and the National Construction Authority Act. The mandates of various institutions relating to IBTs were also reviewed in the contest of achievements made in regard to the mandate. The Institutions included; the State department for Housing and Urban Development, National Housing Corporation, The Kenya Bureau of Standards and the National Construction Authority.

3.7.3 Interviews

Interviews with key informants were carried out with the aid of an interview schedule to complement the questionnaire, particularly for unstructured questions. The interview guide is shown in appendix III and targeted construction professionals in the built environment who have renowned involvement in IBTs through the snowball sampling technique. Six professionals were identified and interviewed in this regard.

3.8 Reliability and Validity

To ensure the data collection methods deployed generated credible data, it was necessary to subject the data collection instruments to reliability and validity tests.

3.8.1 Pilot Testing of the Research Instrument

Before data is collected it is important to conduct pilot tests to test the questionnaire's validity and reliability. According to Mugenda and Mugenda (2003), the sample size of the pilot study should be 10% of the study sample size. However, given the limitation of getting a sample size that befits the pilot study the researcher relied on insights from experts, and practitioners of IBTs in refining the questionnaire. Questionnaire clarity was improved based on the suggestion offered by supervisors and other IBTs experts and practitioners.

3.8.2 Validity of the Research Instrument

Kothari (2010) asserts that validity measures the degree to which a research instrument measures what it was intended to measure. Validity is an indication of how sound one's research is and applies both the design and the methods of one's research. To ensure internal validity, the questionnaire had been reviewed by the research supervisor; while to ensure external validity, data was collected from building professionals in Kenya. The study applied content validity as it concerns the extent to which the questionnaire and key informant guide cover all aspects of the study topic. To ensure this, expert advice from the supervisors was used in the development of the study instrument. The study also sought expert advice from building professionals in Kenya, with their views incorporated in refining the instrument for collecting appropriate data that answers the research objectives.

3.8.3 Reliability Test of the Research Instrument

According to Kothari (2012), measuring reliability establishes whether a research instrument is capable of producing the same results subjected to the same methods over some time. To test reliability, the study performed reliability tests through test-retest on the data collected in the main study. This was because of limitations associated with data collection in the Pilot study. A specific measure is considered reliable if its application on the same object of measurement number of times produces the same results. To ensure reliability of this research, data collected was derived from building professionals in Kenya.

3.9 Data Analysis

The data collected during this study underwent quality and validity processes including; verification of completeness, coding, data entry, cleaning, and processing. The descriptive and inferential statistics tests were processed using the Statistical Package for the Social Sciences (IBM SPSS Statistics Version 26) computer software. For the descriptive

statistics, the mean and standard deviation (SD) were used. For the qualitative data, manual data analysis was used although there are other computer software programs available to assist with qualitative data analysis. The main reason was that the manual method allowed the researcher to get closer to the data and the other reason is that the data from informants were small in number (Creswell, 2012). In this study, the qualitative data was analyzed by thematic analysis. These stages were transcription, initial coding, identifying themes, reviewing the themes, defining and naming the themes, and producing the report. The data collected from this study was analyzed and processed to assist in obtaining information as raw data is not comprehensive in nature. Data collected from this study has also included graphs and charts, which has helped in adding the visual aspect to data to make the data easier and quicker to comprehend.

3.10 Ethical Considerations

Participants in the study were informed about the purpose, procedure, and benefits of the study. They were assured of privacy and confidentiality. The study engaged the participants voluntarily and their consent was sought. Participants were further informed that the information provided would be treated with strict confidentiality and used for academic purposes only. The study was also conducted only after official authorization by the National Commission for Science, Technology, and Innovation and a research permit hitherto granted. A Copy of the research permit is appended to this report.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter presents the findings of the study beginning with a background analysis of the data collected and response rates. Statistics specific to the adoption of IBTs are then generated by the analysis of data collected from identified stakeholders. The chapter has been prepared from an analysis of the primary and secondary data collected and presented in form of tables, pie charts, and graphs.

4.2 Background Information

4.2.1 Response Rate

The questionnaires were administered to 54 private producers, implementers, promoters, and policymakers who deal in IBTs in Kenya. 36 questionnaires were returned giving a response rate of 66%. According to Mugenda and Mugenda (1999), a response rate of 50% is adequate for data analysis and reporting. The study's response rate was thus not only adequate but good for data analysis.

Table 4.1: Response Rate

Questionnaires	Response No.	Percentage response
Filled Questionnaires	36	66.67%
Un-filled questionnaire	18	33.33%
Total	**54**	**100**

Source: Field Survey, 2023

Data obtained through questionnaires was further bolstered by a desktop review of policies and laws as well as on mandates of various institutions that impose on IBTs. The review was also instrumental in formulating the questionnaire where specific content was

subjected to in-depth inquiry to establish the impetus of certain provisions in IBTs. The study further relied on interviews with six professionals in the built environment with extensive involvement in IBTs. These were identified through snowballing.

4.2.2 IBTs Respondents Organizations are involved in

The respondents were asked to identify the IBTs their organizations are involved in. The majority of the organizations utilized Interlocking Stabilized Soil Blocks at 25% followed by Precast Concrete Panels and Prefabricated housing both at 13.9%, and light gauge steel for eco-frames at 8.3%. The least involved in technologies by the organizations are insulated and expanded polystyrene panels, interlocking concrete blocks, concrete waffles, Compressed Agricultural Fiber, and Bio-digester on-site Sewer System all at 5.6% followed by stabilized soil blocks and recycled waste plastic products at 2.8%. No respondent had been involved with Free Span Clay Bricks and monolithic construction. The high involvement in interlocking stabilized soil blocks is attributable to the direct involvement of the Government to promote the technology across all counties through the building of demonstration units and lending the hydraform block-making machine to interested users. Figure 5 below shows the IBTs the respondents' organizations are involved in.

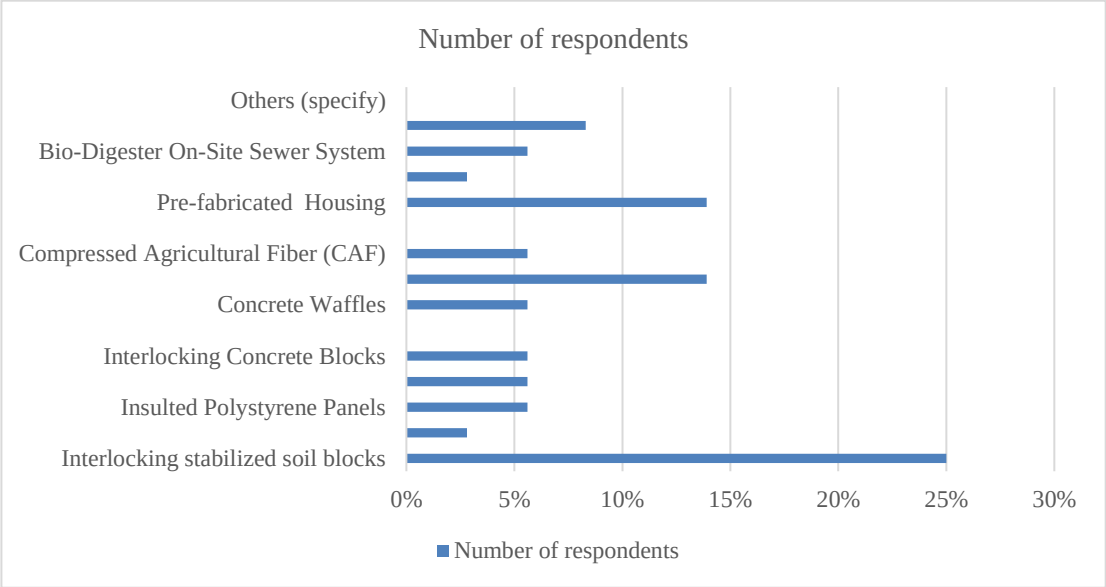

Figure 4.1: IBTs Respondents Organizations are Involved in

Source: Field Survey, 2023

4.2.3 Duration of Involvement with IBTs

The results of the study revealed that the majority of the respondents (69.44%) have dealt in IBTs between 6-10 years, followed by 27.78% who have dealt in the technologies for over 10 years. Only 2.78% of the respondents have dealt with the technologies between 1-5 years while no respondent had dealt with the technologies for less than 1 year. This result points to a trend of continuous entry of organizations into IBTs over the recent past. The roll-out of appropriate building technology centers across the counties and the emergence of new IBTs account for this. A considerable proportion of players have been involved in IBTs for over 10 years. With this distribution in terms of the period of involvement, it is evident that there is considerable growth in the number of organizations that are getting involved in IBTs. Figure 6 below shows the respondents' duration of involvement with IBTs.

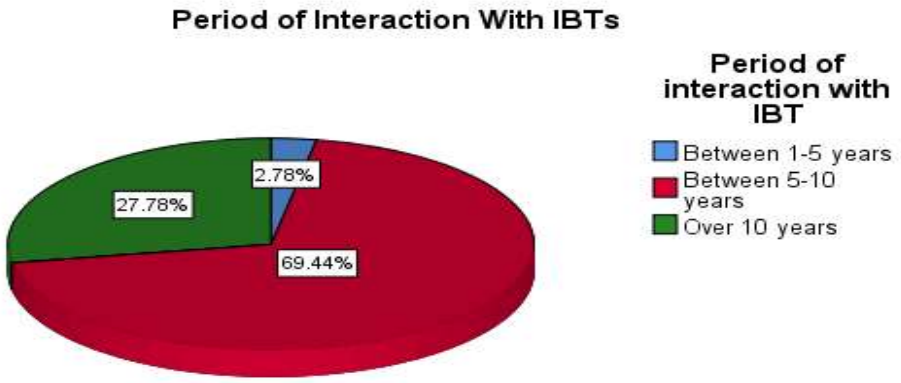

Figure 4.2: Duration of Involvement with IBTs

Source: Field Survey, 2023

4.3 Significance of Various Regulatory Interventions to Adoption of IBTs

To establish policy and regulations that are significant in influencing the development and adoption of IBTs, the research sought to gauge the level of awareness of the regulatory framework and delved further to establish perceptions of the adversity of the same. A content analysis of the various legislations was also done to augment the perceptions of their significance.

4.3.1 Awareness of Policy and Regulatory Provision

The study sought to find out the awareness of the participants on different policies and regulations that affect the adoption of IBTs in Kenya. Results are presented in the table 5 below as follows;

Table 4.2: Awareness of Regulatory Provision that May Impact the Adoption of IBTs

Statements	Aware		Not Aware	
1. The Building Code of 1968	26	72.2%	10	27.8%
2. The Constitution of Kenya (2010)	10	27.8%	26	72.2%
3. Kenya vision 2030	7	19.4%	29	80.6%
4. National Construction Authority Act	28	77.8%	8	22.2%
5. Public Health Act	20	55.6%	16	44.4%
6. The Physical Planning Act	11	30.6%	25	69.4%
7. National Housing Policy (2004)	12	33.3%	24	66.7%
8. Urban Areas and Cities Act (2011)	6	16.7%	30	83.3%
9. Science and Technology Act	3	8.3%	33	91.7%
10. Standard Act	3	8.3%	33	91.7%
11. Public Procurement and Disposal Act	9	25.0%	27	75.0%
12. National Environment and Management Act	20	55.6%	16	44.4%
Average Overall		**35.88%**		**64.11%**

Source: (Field Survey, 2023)

Results indicate that the majority of the participants were aware of the building code of 1968 (72.2%), the national construction authority act (77.8%), the public health act (55.6%), and the national environment and management act (55.6%). Overall, 35.88 % are aware of legislations that bear on IBTs adoption. It is thus deduced that awareness of laws affecting IBTs adoption is limited to a few laws in Kenya.

A follow-up question on the influence of policy and regulations cited provisions in the Building Code, the Standards Act, and the Public Procurement and Disposal Act and Standards Act. Specifically, the Building code specifications on minimum wall thickness; non-recognition of soil blocks; specification on minimum solid material per volume in walling material, and reliance on British standard benchmarks at the expense of local realities were cited as negative influences of the codes on the development and application of IBTs. The Standards Act was cited for reference to manufactured products thereby ignoring locally produced materials to the detriment of locally available IBTs. The Public Procurement Act was cited to have the potential for positive influence by restricting specifications that refer to particular products.

4.3.2 Perceptions of Provisions and Its Effect on Adoption of IBTs

The study further investigated whether different provisions of existing laws and policies impede the adoption of IBTs in Kenya. Some provisions were identified in the literature and thereafter the views of the participants on the identified provisions were sought. Results are shown in the section herein.

Table 4.3: Views on impact of Existing Provisions on the Adoption of IBTs

	N	Minimum	Maximum	Mean	Std.
Reliance on British standards impedes the adoption of IBTs	36	1	5	3.72	1.466
Prohibition on the use of recycled building materials impedes the adoption of IBTs	36	2	5	3.64	0.961
Prescription on minimum wall thickness impedes adoption of IBTs	36	2	5	3.39	0.688
Prescription of material based on composition impedes adoption of IBTs	36	2	4	3.53	0.364
The lack of IBTs building codes and regulations impedes the adoption of IBTs	36	2	5	3.75	1.105

Source: (Field Survey, 2023)

From the results in Table 6, it can be seen that the respondents were in agreement that reliance on British standards (mean=3.72), and the prohibition on the use of recycled materials (mean =3.64) as captured in the 1968 building code, prescription of material based on composition in building code of 1968 (mean = 3.53) and lack of IBTs building codes and regulations in the 1968 building code (mean = 3.75) have greatly affected the adoption of IBTs technology in Kenya. The participants were neutral that prescription on minimum wall thickness (mean =3.39) has affected IBTs adoption in Kenya. From this finding, it is apparent that the detrimental provisions associated with building code focus on ancillary aspects that do not bear on the performance of technologies. The standard deviation ranges on the parameters range from 0.364 to 1.466 indicating that there were generally no extreme perceptions of the variables among respondents.

4.3.3 Regulatory Provisions and their significance to Adoption of IBTs

This section examines the various provisions of law and policy and how these provisions have stimulated and promoted the adoption of IBTs in Kenya. Results are presented in the table below.

Table 4.4: Views on the Role of Legal and Policy Provisions in Adoption of IBTs

Provisions in law/ policy	N	Minimum	Maximum	Mean	Std. Deviation
The Kenya Constitution					
Article 43 on right to housing	36	1	5	2.97	1.183
The Kenya Vision 2030					
Establishment of ABT centers in constituencies	36	2	5	3.78	1.072
The Housing Policy					
Encourage research and popularize the use of appropriate building materials	36	1	5	4.02	1.146
Increased funding for research on building materials and technologies	36	1	5	3.26	1.012
Regular review of building materials taxes	36	1	5	2.34	1.146
Establishment of a National Research Coordination Secretariat	36	1	5	2..15	0.955
Require all research actors to harness and document existing locally available building materials and technologies as well as disseminate this information to the users as appropriate	36	2	5	2.03	0.674
Promote and encourage small-scale enterprises to engage in the production and application of researched materials	36	2	5	2.09	0.762

Provisions in law/ policy	N	Minimum	Maximum	Mean	Std. Deviation
Promote the production of innovative building designs and traditional architecture that is cost-effective and compatible with the use of locally available and affordable materials	36	2	5	4.03	0.546
Promote wider adoption and application of the revised Building By-Law and Planning Regulations	36	2	5	3.03	0.723
Encourage the public, private and voluntary sectors to utilize the research materials in their housing and other development programs	36	3	5	2.97	0.723
Promote intensified training in requisite skills and construction technologies	36	3	5	4.22	0.722
The Public Procurement and Disposal Act (PPDA)					
A requirement in the Act that "technical requirements in specifications shall not refer to a particular trademark, name, patent, design, type, producer"	36	1	5	3.2	0.878

Source: (Field Survey, 2020)

Findings reveal that majority of the participants agreed that IBTs adoption is stimulated by provisions in the Vision 2030 on the establishment of ABT centers in constituencies (mean =3.78). A few provisions in the housing policy were identified with stimulating IBTs notably, encouraging research and popularizing the use of appropriate building materials, promoting the production of cost-effective IBTs and promoting intensified training in requisite skills and construction technologies.

There was neutrality among the respondents that the Housing policy provision on increased funding for research on building materials and technologies (mean = 3.26), promoting wider adoption and application of the revised building By-Law's and Planning

Regulations (mean= 3.03), and encouraging the public, private and voluntary sectors to utilize the research materials in their housing and other development programs (mean =2.97) have contributed to IBTs development in Kenya. This was also the case for the Public Procurement and Disposal Act - provision on the requirement in the Act that "technical requirements in specifications shall not refer to a particular trademark, name, patent, design, type, producer (mean = 3.2).

The respondents expressed disagreement that the Housing policy provision on regular review of building materials taxes (mean = 2.34), the establishment of a National Research Coordination Secretariat (mean = 2.15), requiring all research actors to harness and document existing locally available building technologies (mean = 2.03), promoting and encouraging small-scale enterprises to engage in production and application of researched materials (mean = 2.09) stimulate IBTs adoption. This finding suggests that the promotion of IBTs in Kenya has largely been provided for by policy provisions but this has not been condensed into specific laws provision.

4.3.4 Perceptions on Role of Policies and laws in Adoption of IBTs

The key informants were asked about the policies and laws that are most likely to affect the adoption of IBTs. It emerged from the interviews that building code is considered as holding the greatest impact on the adoption of IBTs. Accordingly, some of the participants stated that the building code contains some provisions that directly affect the use of IBTs adversely. The informants also argued that The National Housing Policy and the National Construction Authority Act can contribute to the use of IBTs. This is because they spell out the mandate of agencies created under them to include promoting the utilization of IBTs through research. Some of the key informants were also of the view that the Constitution of Kenya (2010) and Kenya vision 2030 provides a general framework that if implemented through specific policies can promote the adoption of IBTs. This can be supported by the following statements.

I believe that building code holds a significant influence on the adoption of IBTs only that the code needs to be updated and anchored on existing legislation. This is because the Act under which it was to be enforced (Local Government Act) was repealed.

Although there was a general consensus amongst the key informant on the potential contribution of the policy on the adoption of IBTs in Kenya it was agreed that there is a need for policy improvements. The existing policy it was argued by some interviewees has not provided clear provisions for the promotion of IBTs technologies by the government. Hence any promotion activities through the existing policies can only be made through the generalities of the policy rather than its specificity.

Another key concern that emerged from the interviews was the consensus that policy specificity is not a problem as even within the framework of existing regulation, IBTs can be promoted. To this extent, some of the interviewees believed that policy implementation is the key to the successful adoption of IBTs in Kenya. Hence implementation of existing policies is considered more important in promoting the adoption of IBTs rather than the development of IBTs policy.

4.4 Effectiveness of administrative framework in supporting adoption of IBTs

This section examines whether various administrative interventions and existing institutional frameworks have been effective in promoting the development and adoption of IBTs in Kenya.

4.4.1 Administrative Interventions in Promoting the Adoption of IBTs

On administrative interventions, the study identified and analyzed specific interventions initiated by various institutions to gauge their effectiveness in spurring the development and adoption of IBTs.

Table 4.5: Effectiveness of Administrative Interventions to IBTs

	N	Minimum	Maximum	Mean	Std. Deviation
State Department of Housing & Urban Development (SDHUD)					
The lending of Hydraform Machines for brick production	36	2	5	3.97	0.546
Training in Technology Development	36	2	5	4.36	0.762
Establishment of Appropriate Building Material (IBTs) Centers	36	3	5	4.42	0.649
Housing Policy Management	36	1	5	2.67	1.014
Research Services and dissemination	36	1	4	2.44	0.843
Kenya Building Research Center (KBRC)					
Research on building materials and systems	36	1	4	2.94	0.86
Dissemination of information relating to the building Construction industry	36	1	4	2.56	0.998
National Housing Corporation (NHC)					
Production and sale of Expanded Polystyrene Panels	36	1	5	3.56	0.998
National Construction Authority (NCA)					
Encouraging the standardization and improvement of construction techniques and materials	36	2	5		3.920.874
Research on building materials and technologies	36	1	5	4.11	0.926
Kenya Bureau of Standards (KEBS)					
Enactment of guide standards on the application of materials and technologies in 'Special Scheduled Areas'	36	1	4	2.47	0.546
Issue of a Kenya Standards Number: KS 02-1070 on Specifications for Stabilized Soil Blocks	36	2	5	4.03	0.546
County Government					
Enactment of County laws	36	1	5	3.75	1.131
Enforcement of regulations pertaining to building technologies	36	1	5	3.06	0.955
Academic Institutions					

	N	Minimum	Maximum	Mean	Std. Deviation
Research on Building Technologies	36	1	4	2.94	0.86
Development of IBTs	36	1	4	2.47	0.81
Dissemination of Building Technology research findings/innovations	36	1	4	2.56	0.998
Production/marketing of appropriate construction materials/technologies	36	1	4	2.47	0.81
KIRDI					
Research and Development in Building Materials	36	1	4	2.94	0.86
Transfer of Developed Technologies	36	1	4	2.22	0.797
UN-Habitat and Other NGOs					
Assisting member Governments in formulating and adopting implementable policies and strategies for sustained growth of the building materials sector	36	1	5	3.14	0.762
Creating increased awareness and knowledge among professionals and decision-makers on available, innovative, and cost-effective technological options	36	1	4	2.33	0.894
Stimulating and arranging inter-country, regional and interregional cooperation for facilitating the transfer and absorption of appropriate technologies	36	1	4	2.33	0.894
Direct technical assistance to developing countries through operational activities;	36	1	5	2.58	1.052
Promoting or modifying building codes, regulations, standards, and specifications to make them adaptable to local conditions	36	1	5	3.06	1.393
Research and dissemination of Research findings	36	1	4	2.56	0.998

	N	Minimum	Maximum	Mean	Std. Deviation
Training, promotion, and dissemination of alternative building technologies already developed	36	1	5	2.72	1.137
Technical support and building materials	36	1	5	2.5	1.082

Source: (Field Survey, 2023)

Table 8 gives a summary of the results obtained from the respondents. From the findings, a majority of the respondents agreed that the following institutions with their corresponding administrative roles are effective in promoting the adoption of IBTs in Kenya: SDHUD- Lending of hydra form machines for brick production(mean =3.97), training on technology development (mean =4.36), and establishment of Appropriate Building Material (ABT) centers (mean = 4.42); NHC- production, and sale of expanded polystyrene panels (mean =3.56); NCA- encouraging the standardization and improvement of construction techniques and materials (mean =3.92) and research on building materials and technologies (mean =4.11); KEBS- issuing of a Kenya Standards Number: KS 02-1070 on specifications for Stabilized Soil Blocks (mean = 4.03); and the County Government- enactment of County laws on matters relating to IBTs (mean = 3.75).

However, they disagreed that research services and dissemination by SDHUD, enactment of guide standards on the application of materials and technologies in 'Special Scheduled Areas' by KEBS, development of building technology innovations, and production/marketing of appropriate construction materials/technologies by academic institutions, transfer of Developed Technologies by KIRDI, creating increased awareness and knowledge among professionals and decision-makers on available, innovative, and cost-effective technological options and stimulating and arranging intercountry, regional, and interregional cooperation for facilitating the transfer and absorption of appropriate technologies by UN-Habitat and Other NGOs is effective in the promotion of IBTs in Kenya.

The respondents were neutral to the claims that the following were effective in promoting the adoption of IBTs in Kenya: housing policy management (mean =2.67), research on building materials and systems (mean =2.94) and dissemination of information relating to the building construction industry (mean =2.56) by KBRC, enforcement of regulations pertaining to building technologies (mean = 3.06) by the County Government, research on building technologies (mean = 2.94), and dissemination of building technology research findings/innovations (mean =2.56) by academic institutions, research and development in building materials (mean =2.94) by KIRDI, and assisting member Governments in formulating and adopting implementable policies and strategies for sustained growth of the building materials sector (mean =3.14), promoting or modifying building codes, regulations, standards, and specifications to make them adaptable to local conditions (mean = 3.06), providing direct technical assistance to developing countries through operational activities(mean = 2.58), promoting research and dissemination of research findings(mean = 2.56), training, promotion and dissemination of alternative building technologies already developed (mean =2.72) and provision of technical support and building materials (mean =2.5) by UN-Habitat and other NGOs.

4.4.2 Analysis of Contribution of Policies and Laws to Adoption of IBTs

Analysis was conducted through content analysis of provisions in policy and laws to question: how policy provision has influenced the development or application of IBTs in Kenya. This was compared with effects deduced from the provisions towards adoption of IBTs.

Table 4.6: Content Analysis of Policy and Laws that Impact IBTs

	Relevant Provisions as they relate to IBTs	**Inferred or documented Effects of the Provisions on IBTs**
The Constitution of Kenya	Article 43 of the bill of rights where the right to accessible and adequate housing and reasonable standards of sanitation is provided. Article 2 (11) (b) and (c) of the (CoK,2010) requires the State to recognize the role of science and indigenous technologies in the development of the	Offers indirect impetus for IBTs as a means of realizing this right. The effects of the constitution on IBTs is rather indirect but may be traced in informing policies and other laws as they relate to building technologies. One of the

	Relevant Provisions as they relate to IBTs	Inferred or documented Effects of the Provisions on IBTs
	nation and to promote the intellectual property rights of the people of Kenya	objectives of the housing policy is to Put in place mechanism for the provision of adequate and affordable housing in order to facilitate progressive realization of the right to housing.
Kenya Vision 2030	The vision for housing and urbanization as provided in the Kenya Vision 2030 blueprint is an adequately and decently housed nation in a sustainable all-inclusive environment	The vision 2023 Sector Progress Projects update Report of 2018 recognizes progress in regard to housing to include establishment of 19 Housing Technology Training Centers at the constituency level, training 300 community groups on use of ABMT, and production of Expandable Polystyrene Panels (EPS).
Sessional Paper number 3 of 2016: National Housing Policy for Kenya	● Identifies Limited research on low cost building materials and construction technologies as one of the housing challenges ● Acknowledges that the Government is promoting use of locally available low cost appropriate building materials and technologies through establishment of ABMT Centers countrywide. ● On emerging Housing, "The Government shall establish mechanisms that will proactively plan for emergency housing by encouraging use of appropriate technologies as a way of ameliorating the challenges of the citizens who require emergency housing" ● Functions of the Ministry responsible for housing is mitigation against the high building costs in order to facilitate the realization of the right to housing as enshrined in the Constitution by promoting collaborative research, development and utilization of ABMT	No documentation or reporting has been done to gauge the extent of actualization of policy statements towards promotion of Appropriate Building Technologies
Building Code of 1968	Part III of the code specifically deals with Building materials and stipulates that no person shall use or permit or cause to be used in the erection of a building any material which is not; of suitable nature and quality for purposes for which it is used. The code however relies on physical attributes of material to determine suitability.	The Code proscribe some building materials based on physical attributes and therefore portends obvious bias against IBTs
Urban Areas and Cities Act (2011)	Section 56 of the Act which is a transition clause validates the by-laws made under the local Government Act until their expiry, amendment, or repeal.	This, validates the building code of 1968 which is anchored on the repealed local government Act and as such, the building code provisions as they relate to building materials is deemed applicable in spite of repeal of Local Government Act
The Physical and Land Use Planning Act 2019 and Physical	Part IV of the act provides for development control and part of the objectives of the control includes ensuring orderly and planned building development, planning, design, construction, operation, and maintenance. The handbook further cites objectives for Development	The aspect of design may be inferred to have effect on IBTs but ultimately, the parameters of design considered for approval have potential to affect IBTs either negatively or positively

	Relevant Provisions as they relate to IBTs	Inferred or documented Effects of the Provisions on IBTs
Planning Handbook	Control include: to guard against injurious development to both man and the physical environment by carefully assessing and processing all development applications.	The handbook cites general considerations for development control to include; Note whether the details of the design of the buildings and any landscaping are satisfactory. The satisfactory nature of design is rather subjective but this cannot be construed to occasion bias
National Construction Authority Act	Provides for the establishment of the National Construction Authority. The functions of the Authority include; encouraging the standardization and improvement of construction techniques and materials.	The aspect of improvement of construction techniques and materials have potential to promote the development and adoption of alternative building technologies.

Source: (Field Survey, 2023)

From the forgoing findings, it is apparent that there are no specific provisions that cite IBTs in laws that are touted to influence their development and application. Direct reference to IBTs is only made in the National Housing Policy and the sector progress and projects update report of Vision 2030. In view of this, it inferred that regulatory influence on development and adoption of IBTs is not explicit but rather derived from the implementation of the specific policies and legislations.

4.4.3 Analysis of the Existing Institutional Mandates for Adoption of IBTs

Analysis was conducted through content analysis for contribution of various institutions in enhancing adoption of IBTs. This involved examining the mandates spelt out in respective establishing instruments as well as documented achievements by the institutions. This was geared to establish how institutional roles have influenced the development or application of IBTs. The results are presented in Table 10.

Table 4.7: Analysis of Contributory Role of Institutions on Adoption of IBTs

Institutions	Mandate that relates to IBTs as per establishing instruments	Initiatives on Development/Application of IBTs
State Department for Housing	The Executive order number 1 of 2018 delineated the function of providing policy direction and coordination of all matters related to housing and urban planning and development Its function also involves Housing Policy Management, Development, and Management of Affordable Housing; Management of Building and Construction Standards and Codes, and Building Research Services among other functions	The State Department has set up several Appropriate Building technology centers across the country. Also lends Hydra form machine that is used in the production of Interlocking stabilized soil blocks to interested building developers free of charge
Kenya Bureau of Standards	As per the Standards Act CAP 486; the Functions of the Bureau include; - To prepare, frame, modify or amend specifications and codes of practice; - To provide for the testing at the request of the Minister, and on behalf of the Government, of locally manufactured and imported commodities	Has played a key role in the enactment of guide standards on the application of materials and technologies in 'Special Scheduled Areas' in the major urban centers of Nairobi, Mombasa, Nakuru, Eldoret, Kisumu, and Embu (Magutu, 2015). The Kenya Bureau of Standards also issued a Kenya Standards Number: KS 02-1070 in 1993 on Specifications for Stabilized Soil Blocks. This standard specifies requirements for cement and/or lime Stabilized Soil Blocks for use in general buildings
National Construction Authority	The mandate of the Authority is to regulate the construction industry and coordinate its development. The functions of the Authority as set out in Section 5 of the Act include; encouraging the standardization and improvement of construction techniques and materials such as IBTs	Published the National Construction Research Agenda Report 2014-2017 Holds International Construction Research Exhibition and Conference (ICoRCE) every 2 years bringing together industry experts towards business development in the region

Source: (Field Survey, 2023)

From the forgoing findings on the mandate of institutions it can be deduced that administrative roles that are instituted for promoting the adoption of IBTs are mainly; direct provision of technologies, training on technology development, the establishment

of Appropriate Building Material (ABT) centers, direct involvement in production and sale of technologies, sensitization and research on building materials and technologies, issuing of Standards and enactment of County laws on matters relating to IBTs. These results complement data obtained through the questionnaire as presented in Table 4.4 in establishing the interventions that bring significant impact to promoting the adoption of IBTs.

4.4.4 Insights from Informants on the Role of Institutions in Adoption of IBTs

Interviews with the key informants on the influence of institutions that are involved in promoting the adoption of IBTs revealed a near agreement among the interviewees. There was a consensus that the state department of housing plays the main role in promoting the adoption of IBTs. Two reasons were given for the key role played by this state department. The first role is regarding its role in policy development and implementation, particularly on the relevant policy that can enhance IBTs adoption.

The second reason highlighted was its relevance in mobilizing resources at the government level, with these resources used in policy implementation and carrying out activities to promote the adoption of IBTs technology. Related to the role of institutions, most interviewees believed that the existing institutions apart from the state department of housing only play a supportive or complimentary role to the work of the state department. This finding suggests that the key informants strongly believe that government institutions play a key role in promoting IBTs in Kenya. It is also apparent that policy formulation role and mobilizing of resources are considered to be very significant to IBTs promotion.

4.5 Regulatory and Administrative Barriers to Adoption of IBTs

This section examined the regulatory and administrative barriers to the adoption of IBTs in Kenya. This was done through descriptive statistics and qualitative data from key

informants. The first section focuses on descriptive statistics while the second section focuses on the data from key informants.

4.5.1 Regulatory and Administrative Barriers to Adoption of IBTs

Respondents were asked to rank factors identified in various literature as barriers to adoption of IBTs and the results in this regarded are tabulated in in table 11 below.

Table 4.8: Views on Regulatory and Administrative Barriers to Adoption of IBTs

Government Support	N	Minimum	Maximum	Mean	Std. Deviation
Lack of government incentives	36	2	5	4.19	0.951
Inadequate IBTs s promotion by the government	36	2	5	4.19	0.889
Lack of IBTs building codes and regulations	36	3	5	4.44	0.362
Social Cultural & Economic Factors					
Lack of interest from clients and market	36	3	5	4.53	0.609
Unavailability of IBTs in the local market	36	1	5	2.11	1.237
Resistance to change	36	1	5	4.19	1.091
Unavailability of IBTs suppliers	36	1	5	2.11	1.237
Higher costs of IBTs	36	1	5	3.94	1.12
Lack of financing schemes (e.g., loans)	36	1	5	3.44	1.275
Lack of databases and information on IBTs	36	1	5	4.08	1.025
Adoption of IBTs is time-consuming and causes project delays	36	1	5	3.81	1.283
Risks and uncertainties	36	1	5	4.28	1.031
Technical Support					
The unfamiliarity of construction professionals with IBTs	36	1	5	2.67	1.242
Limited professional knowledge and expertise in IBTs	36	1	5	3.94	1.145
Lack of Innovative building technological training for project staff	36	2	5	4.36	0.798
Lack of information on maintenance and life cycle costing	36	1	5	4.03	1.082
Lack of a variety of benchmarking projects	36	2	5	4.19	0.856
Lack of demonstration projects	36	2	5	3.83	1
Lack of local institutes and facilities for research and development (R&D) of IBTs	36	1	5	3.72	1.111

Source: (Field Survey, 2023)

The results reveal that the participants were in agreement that the following factors have hampered the adoption of IBTs in Kenya: lack of government incentives (mean = 4.19), inadequate IBTs promotion by government (mean =4.19), lack of IBTs building codes and regulations (mean =4.44), lack of interest from clients and market (mean= 4.53),resistance to change from the use of traditional technologies (mean =4.19), higher costs of IBTs (mean = 3.94), lack of databases and information on IBTs (mean = 4.08), adoption of IBTs is time consuming and causes project delays (mean =3.81), risks and uncertainties involved in adopting new technologies (mean =4.28), limited professional knowledge and expertise in IBTs (mean =3.94), lack of Innovative building technological training for project staff (mean =4.36), lack of information on maintenance and life cycle costing (mean =4.03), lack of a variety of benchmarking projects (mean =4.19), lack of demonstration project (mean =3.72) and lack of local institutes and facilities for research and development (R&D) of IBTs (mean =3.72). The participants showed neutrality on lack of financing schemes (mean = 3.44), and unfamiliarity with construction professionals with IBTs (mean =2.67). The participants also disagreed that the unavailability of IBTs in the local market (mean =2.11) and the unavailability of IBTs suppliers (mean =2.11) are barriers to the adoption of IBTs in Kenya. These findings demonstrate that barriers to the adoption of IBTs in Kenya run across government support, socio-economic aspects, and professional and academic support.

4.5.2 Perceptions on Impediments to IBTs Development and Adoption

The key informants were asked to expound on impediments occasioned by existing regulatory and administrative barriers to IBTs development and adoption. It emerged existing policies and legislations seeks to address other wider objectives and have no primary objective of spurring the development and use of IBTs in Kenya. Similarly, there is no single institution with a core mandate for research, development, and promotion of IBTs. IBTs are thus seen as auxiliary functions to multiple institutions and as such, this function could easily be ignored depending on the institution's priorities.

The other challenges identified were that institutions are uncoordinated and the legal framework is comprised of some legislation that contains archaic provisions that are detrimental to the use of IBTs. Other relevant legislations are subdued in terms of providing a legislative framework that would safeguard the adoption of IBTs. Specific challenges identified in relevant legislations and Institutions included;

1. **Outdated and Inadequate Legislative Support**

It was for instance pointed out that the relevance of IBTs has often been ignored in the enactment of legislations that affect the choice of building materials. The Standards Act for instance was noted to focus on standardization for manufactured commodities and this may likely be interpreted to mean naturally occurring building materials or any other material with no prescribed standards is inferior.

2. **Lack of linkages and Coordination among Institutions**

It was, for instance, pointed out that multiple institutions are engaged in diverse areas of IBTs including research and training, policy formulation, and development but these institutions remain largely uncoordinated and at times work at cross purposes. A case in point cited in this regard is the devolvement of functions between the county and National Government in the fourth schedule of the constitution where the national Government is vested with the National Housing Policy while the county Governments are vested with the function of county planning and development including housing and county public works.

This separation means the County Governments have a big stake in housing policy implementation. Whereas the national government policies generally seek to promote IBTs, it was argued that this may not feature top in County Government priorities and the policy may just remain on paper. Another weakness identified pertaining to coordination between institutions was the linkage between research and incubation of the technologies. As such, it was felt that the transition between researched technologies and incubation of

workable technology is poor. Moreover, the Assimilation of technologies developed by institutions in most tertiary institutions is slow and done piecemeal.

3. Generalities of Institutional Objectives

The aspect of development and promotion of IBTs in the objects of Institutions was cited to at times be overshadowed by the other wider objects pursued by institutions. For instance, the mandate of the National Construction Authority in the standardization and improvement of construction techniques and materials could be exploited to enhance IBTs but this mandate is broad as it covers conventional and IBTs and as such, it does not guarantee significant attention to IBTs. This holds also for other functions of the authority which include; promotion and stimulation of the development, improvement and expansion of the construction industry, undertaking or commissioning research into any matter relating to the construction industry, promote quality assurance in the construction industry are subject to varying interpretation. Similarly, other legislations like the Science and Innovation Act are general thereby leaving the involvement of the Innovation agency in IBTs to its construal and discretion.

4. Inadequate Policy Implementation Framework

It was argued that the implementation framework to actualize the extensive policy objectives set out in the Housing Policy for Kenya and the draft construction Industry policy is lacking.

Moreover, the hitherto Local Governments and the present day County Government which have the mandate of regulating and implementing the existing policies and legislations have often failed in many areas.

5. The bias of IBTs Projects by Financing Institutions

It was contended that many Financial Institutions consider IBTs Projects to be risky and as such, they attach a high premium in terms of interest rate in financing IBTs projects.

4.6 Insights from Interviews on ways of Enhancing Adoption of IBTs

It was contended that the initiatives to enhance adoption of IBTs have to be require to be coupled with appropriate implementation strategies in order to produce intended results have to be put in place and hence the need for a framework. To conceptualize a framework for enhancing adoption of IBTs, the study relied on factors that were identified as inhibitors to IBTs adoption as discussed in section 4.5 before. The Inhibitors of IBTs adoption have broadly been classified to fall in areas of Technical, Administrative, Social-Economic barriers, and Government Support framework where the incentives and regulations fall.

In order to enhance the adoption of IBTs, significant and progressive steps need to be taken successively in these areas. This must go along with a review of the regulatory framework and capacity-building initiatives for various institutions involved in the IBTs adoption process as analyzed in sections 4.3 and 4.4 respectively. The framework for enhancing the adoption of IBTs is therefore founded on the removal or mitigation of barriers across the various stages of the adoption cycle which have broadly been identified as; the information stage, Analysis stage, Acquisition Stage, and Utilization stage.

4.6.1 Technical Barriers

Technical Barriers have been associated with the information phase in the IBTs adoption cycle.

Particular barriers that were categorized to constitute technical barriers included; limited professional knowledge and expertise on IBTs, lack of elaborate training on IBTs, limited information on life cycle costing, and limited benchmarking projects among others. Proposed interventions to overcome these barriers include the Integration of IBTs in professional training programs/curriculum and research for life cycle costing.

4.6.2 Administrative Barriers

Administrative barriers come to the fore at the analysis stage and these have been identified to include institutional-related barriers like lack of coordination and linkages among various institutional stakeholders in IBTs. Lack of specific objectives that border on IBTs has also been identified as an administrative barrier. Proposed interventions here include; Establishment of Specialized bodies mandated to champion for the adoption of IBTs and the development of an Industry model to evaluate and coordinate the IBTs program.

4.6.3 Social Economic Barriers

The social-economic barriers have been associated with the acquisition phase and the hurdles identified here include; Unfavorable financing terms, social bias risk, and uncertainties. Subsidies and incentives will mainly ease the economic barriers to IBTs adoption. The initial cost of some IBTs is high, especially where machines are used in their production. In any case, IBTs are not necessarily cheaper than conventional technologies but come with other advantages like environmental aspects. Other aspects that can be addressed by subsidies and incentives include user perceptions and risk perceptions associated with IBTs.

4.6.4 Government Support

The fourth stage in the adoption of technologies is the utilization stage and this has been pitted against Government support-related barriers that will guarantee long-term sustainability. These have specifically been identified to include; Unsupportive policy and legal framework, a lack of incentives, and an inadequate Policy Implementation framework. Intervention mechanisms include; harmonization of policy documents, repeal of the building code, subsidy and incentives, and review of building laws and policies to distinguish IBTs from other technologies in policy and laws relating to technology

promotion. Expansion of scope in Standards law to address naturally occurring building materials like coral stones would also be incorporated in the review of laws.

4.6.5 Propositions for Supportive Framework for IBTs Adoption

Respondents were asked to suggest possible areas of improvement to stimulate the development and use of IBTs. Suggestions put forward were classified under three categories namely policy, legislation, and institutional reforms as discussed below;

a) Policy

Harmonization of policy documents was recommended for instance in the Vision 2030 for Kenya where the measuring of achievements needs to be in relation to provided targets. It was for instance noted that the 2nd term achievements are not anchored on corresponding 2nd term plan targets. It was further suggested that the policies need to provide incentives for the adoption of IBTs until a time when there is near perfect awareness of the IBTs as is the case for conventional technologies.

b) Legislation

One key suggestion for legislative reforms geared towards IBTs promotion was the adoption of the Proposed Planning and Building regulations of 2009 and anchoring them to relevant law. It was argued that these regulations emphasize material performance as opposed to the material composition which was cited as a major detriment to the Building Code of 1968. In the Science, Technology and Innovation Act, it was felt that the legislation needs to distinguish IBTs and support it specifically as a priority agenda for research and Innovation.

While for the Standards Act, it was suggested there is a need to expand its scope to address naturally occurring building materials like coral stones, building sand, and ballast. Regarding the Public Procurement Act, it was pointed out that there is a need to sensitize professionals on the import of the Act in restricting specifications that refer to a specific

brand in their project designs. In this regard, construction professionals would be encouraged to provide designs for all viable technologies as opposed to the current situation where only conventional materials are considered.

c) **Institutions**

Institutional-related reforms that were suggested for stimulation of IBTs development and adoption included; the establishment of an institution with a specific mandate of continuous review and implementation of the IBTs policies; Financial Sector intervention mechanisms to guarantee favorable financing terms for IBTs projects; integration of IBTs in professional training programs/curriculum.

4.7 Discussion of Findings

The findings in this study show that the regulatory and administrative framework in the Kenyan construction industry is not optimally and holistically promoting IBTs. Specifically, the promotion of IBTs was found to be fragmented amongst the various developers and institutions involved and the linkage between industry and training is weak. The actualization of policy objectives that support IBTs as provided in the various policy documents is weak in practice. Legal provisions in some legislation also present some handicaps for the adoption of IBTs. Given this, the study recommends an intervention mechanism to mitigate barriers linked to four stages of the IBTs adoptive process.

These include technical barriers that are associated with the information phase, Administrative barriers associated with the analysis phase, Social-economic barriers linked to the acquisition phase, and Government support that is key in the utilization phase. Previous studies have explored innovation adoption trends, and factors that influence adoption and evaluation of the performance of IBTs. For instance, Ngige (2019), evaluated the performance of houses built using alternative construction technologies (ACTs) in Kenya. This included assessment of the characteristics, quality, and

performance of building elements built with ACTs; establishing the social and economic impacts of the ACTs; and gauging the adoption rate of ACTs by developers, consultants, and contractors.

The study identified the high cost of raw materials as a hindrance to the adoption of the ACTs. It however identified advantages of ACTs to include savings on the speed of construction, waste reduction, labor reduction, efficiency, and quality production. The study however deduced that the impacts of ACTs are not aggressively propagated or articulated to the general public. Sagini (2020) Investigated factors that affect the adoption of IBTs in Nairobi. The findings revealed that lack of integration within the industry, lack of adequate information on innovations, traditional procurement systems, and building codes had the greatest hindrance to the adoption of IBTs. These findings agree with this study.

The findings in this study largely correspond to the forgoing studies in that this study established promotion of IBTs is fragmented amongst the various developers and institutions involved and the linkage between industry and training is weak. This study however delved further into establishing perceptions on the significance of the various policies and regulations influencing the development and adoption of IBTs. The findings, in this case, were that most of the existing laws and policies are deemed insignificant in promoting the adoption of IBTs in Kenya.

Further, the promotion of IBTs has largely been provided for in policy but this has not been condensed into specific laws provision. This study also investigated the effectiveness of the existing institutional framework in supporting IBTs. It established that whereas there are multiple institutions with the mandate that touch on IBTs, limited institutions play a significant role in promoting their adoption in Kenya. The lack of linkages for institutions to leverage the achievements of the other was also established. This culminated in the formulation of a framework to address weakness in propagating IBTs at various stages of the IBTs adoption process.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study draws conclusions and recommendations based on the findings and objectives of the study. The first objective is to find out the perceptions of IBTs producers and regulators on the significance of the various policies and regulations influencing the development and adoption of IBTs in Kenya.

The study further sought to establish the effectiveness of the existing administrative and institutional framework in supporting the development and adoption of IBTs. The third objective was to establish regulatory and administrative barriers to the adoption of IBTs. Leveraging on the findings in forgoing objectives, the fourth objective was formulating a framework for enhancing the adoption of IBTs in Kenya. The study conclusions are drawn from data collected from practitioners, interviews held with government officials, and document reviews. Conclusions and recommendations are presented in line with the objectives.

5.2 Conclusions

The first objective of the study investigated the perceptions of IBTs producers and regulators on the significance of the various policies and regulations influencing the development and adoption of IBTs in Kenya. Findings indicate that urban areas and cities acts and building codes are considered the most significant. The awareness of policy and regulations affecting IBTs is generally low save for some specific legislation. Detrimental provisions associated with laws focus on ancillary aspects that do not bear on the performance of the technologies. Based on the findings it can be concluded that most of the existing laws and policies are deemed not important in promoting the adoption of IBTs in Kenya. Further, the promotion of IBTs in Kenya has largely been provided for by policy provisions but this has not been condensed into specific laws provision.

The second objective delved into establishing the effectiveness of the existing administrative and institutional framework in supporting the development and adoption of IBTs. Institutional analysis findings reveal that only the State Department of Housing; National Housing Corporation and National Construction Authority are seen as significant in promoting the adoption of IBTs. This suggests that whereas there are multiple institutions with the mandate that touch on IBTs, limited institutions play a significant role in the promotion the adoption of IBTs in Kenya. There are also no linkages for institutions to leverage on the achievements of the other and as such, efforts of the institutions with insignificant input have not been harnessed. Institutional functions that are effective in promoting the adoption of IBTs have been identified to include; direct provision of technologies, training on technology development, the establishment of Appropriate Building Material (ABT) centers, direct involvement in the production and sale of technologies, sensitization and research on building materials and technologies, issuing of Standards and enactment of County laws on matters relating to IBTs.

The third objective was to establish regulatory and administrative barriers to the adoption of IBTs. The results revealed that the following factors have hampered the adoption of IBTs in Kenya: lack of government incentives, inadequate IBTs promotion by the government, lack of IBTs building codes and regulations, lack of interest from clients and market, resistance to change from the use of traditional technologies, higher costs of IBTs), lack of databases and information on IBTs, time-consuming, risks and uncertainties involved in adopting new technologies, limited professional knowledge and expertise in IBTs, lack of IBTs training for project staff, lack of information on maintenance and life cycle costing, lack of a variety of benchmarking projects, lack of demonstration project and lack of local institutes and facilities for research and development (R&D) of IBTs.

The fourth objective of the study was to formulate a framework for enhancing the adoption of IBTs in Kenya. The formulation was based on the findings of the three objectives and the suggestions put forward in addressing inherent weaknesses in policies, regulations, and administrative framework. The results reveal that the practitioners considered incentives, enforcement of existing regulations and policies, loans, and subsidies as

important strategies that can be used in the promoting adoption of IBTs in Kenya. This shows for the promotion of IBTs adoption to be realized, the government needs to play a more proactive role than they currently do. Further, the framework categorized the barriers to fall in four areas namely; Technological, Administrative, Social Economic barriers, and Government Support framework. These were affiliated with four stages of technology adoption phases namely; Information, analysis, acquisition, and utilization phases respectively. Corresponding interventions that were put forward for mitigating the barriers were matched with the barriers and thus resulted in a framework that proposes interventions that would address each category of barriers.

5.3 Recommendations

Findings on the first objective show that several existing laws and policies are perceived not important in promoting the adoption of IBTs in Kenya. Further, the promotion of IBTs in Kenya has largely been provided for by policy provisions but this has not been condensed into specific laws provision.

In relation to these findings the following recommendations are made: -

(i) Consolidation of building laws to bring about consistency and coherence in the regulation of choice of the building material. Underlying principles need to focus on the performance of the material rather than the composition or physical properties of the material. This could be achieved by the adoption of Proposed Planning and Building regulations and anchoring them to relevant law. The mandate of implementing the proposed code of practice should be given to another authority that is solely responsible for dealing with buildings and housing as proposed in the Planning and building regulations

(ii) The existing housing policy needs Implementation through law reviews and enactment including the development of guidelines and policies for the enforcement of IBTs

The second objective findings revealed that whereas multiple institutions have some mandates that touch on IBTs, limited institutions play a significant role in the promotion the adoption of IBTs. Administrative roles that are significant in promoting the adoption of IBTs were identified. Based on these findings the study makes the following recommendations concerning promotional strategies.

i. Capacity building and coordination between various institutions involved in IBTs production, policy, and dissemination.
ii. Establishment of an agency with a core mandate of integrating IBTs in the construction Industry. Such agency to coordinate and leverage state and non-state agencies involved in IBTs
iii. Ensuring that there is strong collaboration between the public and private sector in the process of adoption of IBTs
iv. Improving the management system of the institutions involved in the promotion of IBTs
v. Promotion of development of business enterprises model with various SMEs at grass root levels in the republic and provision of incentives to motivate the participation of more private sector players in IBTs adoption
vi. Regulatory bodies to weave IBTs into organizational policies.

The third objective findings revealed regulatory and administrative barriers to the adoption of IBTs. These were classified to fall into four broad categories namely, Technological barriers, Administrative barriers, Social-economic and barriers related to the Government support framework. Arising from this, recommendations are made according to the categorization of the barriers as follows;

Technological barriers have to be mitigated by building the technical capacity of various stakeholders including training, demonstration projects, and research and this intervention seeks to address the information gap. Administrative barriers need to be addressed to remove bottlenecks and harness synergies amongst various players. Social economic barriers require interventions that make technologies affordable and socially appealing

while a Government support framework is required to give policy and legislative support for sustainability. Specific interventions under the forgoing pillars will include:

i. Finance institutions like banks should be encouraged to strengthen their financial capacity and redesign their financing process to support developers and end users.

ii. Professional institutions need to strengthen their knowledge and training in such a way to create specialists for the IBTs sector to be able to provide contemporary consultancy services including the technical feasibility of Alternative Building Technologies.

iii. Review of training institutions and programs to give attention to IBTs at the same level that is given to conventional building technologies. A decentralized approach needs also to be applied to ensure technologies are appropriate to specific areas in which they are being advocated.

iv. Affirmative action to the construction of public buildings using IBTs can serve to give confidence to the public as to the use of the technologies. Awareness could also be heightened by the involvement and active participation of 'Target Groups' through the concept of 'Self-help', by way of production and use of alternative technologies.

v. Subsidy and incentives are intended to mitigate the risks associated with IBTs. They further serve to address social-economic concerns of potential users of technologies. There is a need for Governments to define specific tax regulation frameworks with the necessary tax incentive for developers, buyers, and other professionals. Provision of incentives to motivate the participation of more private sector players in IBTs adoption need to be spiraled up by, for instance, Provision of equipment like the hydraform machine used in making stabilized soil blocks to local communities for production.

   A ban or imposition of tax on importation materials that compete with those locally available can also serve as an incentive to available IBTs.

The fourth objective was geared at proposing a framework for enhancing the adoption of IBTs. The recommendation here is founded on the need to have a holistic approach that recognizes the uniqueness of various barriers and corresponding intervention mechanisms that are necessary. Accordingly, the framework identifies four pillars: 1) Technical capacity to fill in the information gap that exists regarding IBTs, 2) Administrative arrangement geared towards alignment of institutional objectives and building of synergies 3) Social Economic Pillar that seeks to fill the bias and affordability gap and thus bridge the technology acquisition gap and finally the Government Support framework pillar that is geared towards the supportive legal and economic environment to allow utilization of technologies. A diagrammatic representation of the recommended framework is presented in figure 7.

Barrier Categorization				Interventions proposed	Actors
Technological Barriers	**Administrative/ Institutional Barrie**	**Social Economic Barriers**	**Government Support Barriers**		
			• Unsupportive policy and legal framework • Lack of incentives • Inadequate Policy Implementation Framework	➢ Harmonization of policy documents ➢ Repeal of building code ➢ Subsidy and Incentives ➢ The distinction of IBTs from other technologies in policy and laws relating to technology promotion ➢ Expansion on scope in Standards law to address naturally occurring materials like coral stones	Government (State Agencies)
		• Unfavorable financing terms • Social Bias • Risk and uncertainties		➢ Financial Sector intervention mechanisms to guarantee favorable financing terms for IBTs projects; ➢ Sensitization and awareness creation ➢ Subsidy and Incentives	Financial institutions Government

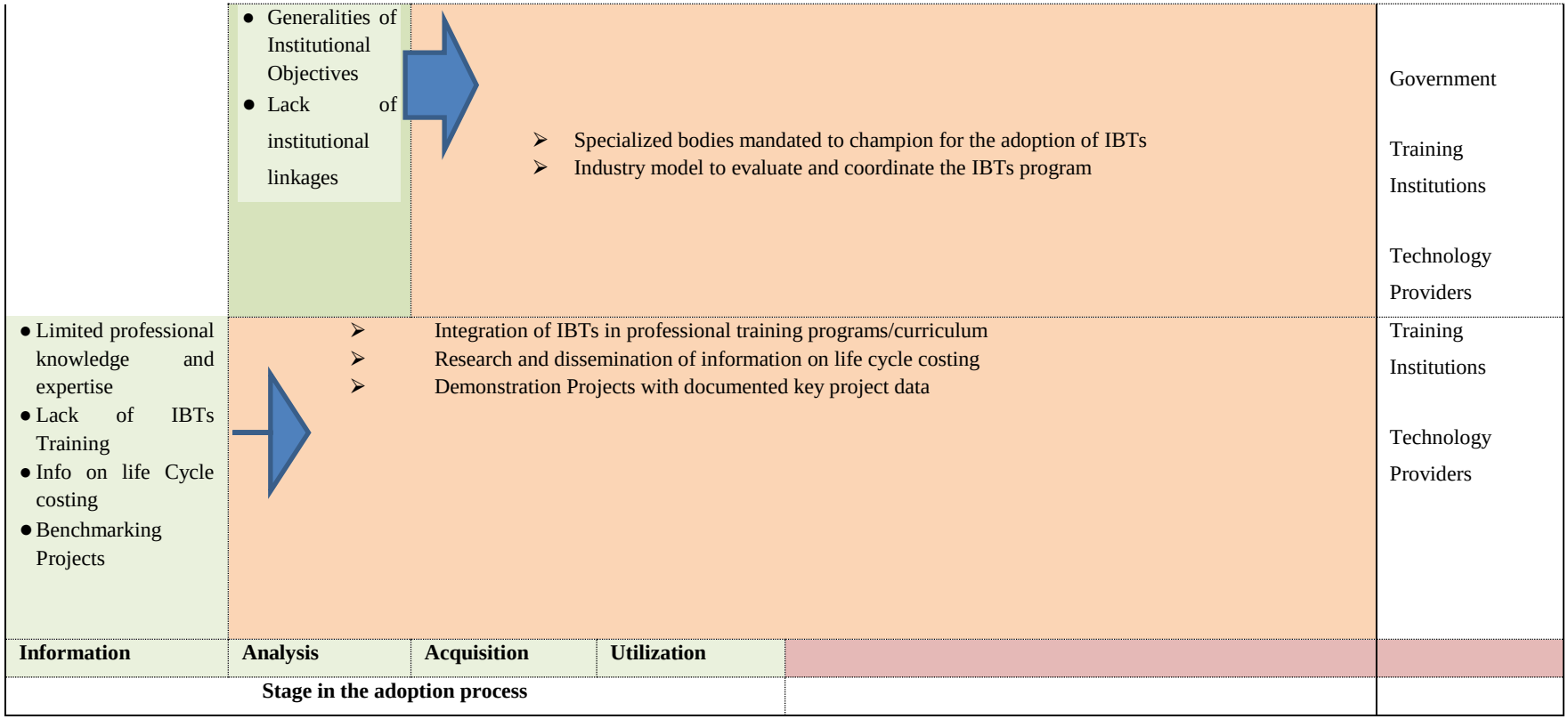

Figure 5.1: Framework for Enhancing Adoption of IBTs in the Construction Industry

Source: (Researcher, 2022)

Table 5.1: Summary of Findings and Recommendations

	Objective	Finding	Recommendation
1	Establishing perceptions of IBTs producers and regulators on the significance of the various policies and regulations influencing the development and adoption of IBTs in Kenya	Most of the existing laws and policies are deemed insignificant in promoting the adoption of IBTs in Kenya. Further, the promotion of IBTs has largely been provided for in policy but this has not been condensed into specific laws provision.	Review and consolidate building laws to bring about consistency and coherence in fostering construction standards. The emphasis on standards should be the performance of the material rather than the composition or physical properties. This should go along with an appropriate institutional framework for implementation
2	Establishing the effectiveness of the existing administrative and institutional framework in supporting the development and adoption of IBTs in Kenya.	Whereas there are multiple institutions with the mandate that touch on IBTs, limited institutions play a significant role in promoting their adoption in Kenya. There are no linkages for institutions to leverage on the achievements of the other and as such, efforts of the institutions with insignificant input have not been harnessed. Institutional initiatives that are effective in promoting the adoption of IBTs have been identified to include; direct provision of technologies, training on technology development, the establishment of Appropriate Building Material (ABT) centers, direct involvement in the production and sale of technologies, sensitization and research on building materials and technologies, issuing of Standards and enactment of County laws on matters relating to IBTs	Capacity building and coordination between various institutions involved in IBTs production and policy; Establishment of an agency with a core mandate of integrating IBTs in the construction Industry; development of business enterprises model with various SMEs at grass root levels; provision of incentives to motivate the participation of more private sector players; weaving of IBTs into organizational policies.

	Objective	Finding	Recommendation
3	Establishing regulatory and administrative barriers to the adoption of IBTs in Kenya	Significant factors that have hampered the adoption of IBTs in Kenya were identified as: lack of government incentives, inadequate IBTs promotion by the government, lack of IBTs building codes and regulations, lack of interest from clients and the market, resistance to change from the use of traditional technologies, higher costs of IBTs, lack of databases and information on IBTs, time-consuming, risks and uncertainties involved in adopting new technologies, limited professional knowledge and expertise in IBTs, lack of IBTs training for project staff, lack of information on maintenance and life cycle costs, lack of a variety of benchmarking projects, lack of demonstration project and lack of local institutes and facilities for research and development (R&D) of IBTs.	
4	Formulation of a framework for enhancing the adoption of IBTs in Kenya.	Proposed interventions which include legislative reform, incentives, capacity building, and subsidies need to be pitted against identified barriers and the stages at which the barriers are encountered. These are notably; the Information, analysis, acquisition, and utilization stages.	

5.4 Areas for Further Research

This study focused on the materials and technologies component of IBTs which is one of the components in construction inputs. The literature reviewed however built a case for initiatives, which not only focuses on the innovative materials but also explores the innovation in the labor and design component. The study, therefore, proposes further research on the adoption of innovative design and construction delivery approaches in the construction industry of Kenya.

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APPENDICES

Appendix I: Sampling Frame

List of Identified IBTs Technology Providers in Kenya

S/No.	**Name of Technology Provider**	**Technology Provided**	**Email / Web link**
1.	National Housing Corporation NHC	Expanded polystyrene panels	www.nhckenya.co.ke
2.	Koto Housing Kenya	Prefabricated light weight panels	www.kotohousingkenya.co.ke
3.	Hong Kong Building Centre	Light weight non-load bearing sandwich and hollow Pre-plastered panels	www.hkbckenya.com
4.	Elsek and Elsek Group of Companies	Prefabricated building systems using fiber-cement and galvanized steel	www.elsekgroup.com
5.	Boleyn Magic Wall Panel Ltd	Precast Concrete panels	www.boleyngroup.com
6.	Zenith Steel Fabricators Ltd	Zen house brand , EPS material embedded in concrete	www.zenithsteel.com
7.	Buildmart Solutions Ltd	Interlocking concrete Blocks (LEGOS concept)	www.buildmartsolutions.com
8.	Alima Holdings Ltd	Lightweight Interlock Concrete block	www.alimaholdings.com
9.	Peakwood Ltd	Interlocking bricks	www.peakwoodltd.kbo.co.ke
10.	Economic Housing Group Ltd	Timber prefabricated houses and flat packed furniture	www.ehgkenya.com
11.	Wall and Ties Kenya Ltd	Monolithic construction – insitu conc with preconfigured steel/aluminium formwork	www.wallties.com/distributors/international/kenya.html
12.	Eco post Limited	Recycled plastic products	www.ecopost.co.ke
13.	Continental Renewable Energy	Recycled plastic products	www.coreclimited.com
14.	Ramji Haribhai Devani Ltd	Recycled plastic products	www.rhdevani.com

15.	Riflo industries Ltd	Bio digester on site sewer system Concrete waffles	www.rifloindustries.com
16.	Kenya Cast Products Ltd, Ruiru	Bio digester on site sewer system	www.kenyacastproductsltd.com
17.	Vision Drivers Enterprises	Bio digester on site sewer system	
18.	Kizuri Waffles Ltd	Concrete waffles	www.kizuriwaffles.com
19.	Mineco Housing Ltd	Interlocking Hollow blocks (Stambel blocks; Conc waffles	www.minecohouse.com
20.	Newbuild Ltd	Uses quarry stone to replace concrete strip foundation and floor slab in specialized patented methodology	www.newbuildltd.co.ke
21.	Space and Style Ltd	Light gauge steel	www.spaceandstyle.co.ke
22.	Steel Structures Ltd	Multi-unit, Porta cabin, Skylite polycarbonate panels/sheets	www.Steelstructureskenya.com
23.	International Green Structure Kenya Ltd	Rice Husk panels	www.igstructures.com
24.	Hydraform Ltd	Interlocking Stabilized Soil block (ISSB)	www.hydraform.com
25.	Makiga Engineering Ltd	SSB making machines (Manual hydraulic)	www.makiga-engineering.com
26.	Ndume Ltd	Interlocking Stabilized soil blocks	www.ndumekenya.com
27.	Design Production Engineering	Manual and automated single and double/triple block making machine	www.dpeengineering@dbo.ke
28.	Genetics Engineering	Manual and automated single and double block making machine	
29.	Femurech Ltd	Improved manual block making machine	
30.	Housing Solutions International Ltd	Stelete Building System	
31.	Jungle Nuts	Jungle housing- ISSB making project	

32.	Thermoteq Limited:	Prefabricated Housing	www.thermoteq.co.ke,
33.	Nextgen Solutions	EPS Panels	nextgensolutions.co.ke
34.	DMS Africa	Prefab Buildings	dms-africa.com
35.	Squire Apple	Concrete wall panels	https://squareapple.co.ke/
36.	Eco Homes Ltd	Prefabricated Buildings & Houses	ecohomeskenya.com
37.	Ankar prefab Solutions	Prefabricated Panels	

Government and Non-Governmental Agencies involved in IBTs Policy formulation and implementation

S/NO	AGENCY/COUNTY	Number
1.	Ministry of Transport, Infrastructure Housing Urban Development and Public Works	4
2.	National Construction Authority	4
3.	County Government	4
4.	National Housing Cooperation	1
5.	Kenya Building Research Centre	1
6.	Kenya Building Inspectorate	1
7.	Un Habitat	1
	Total	16

Appendix II: Field Questionnaire

KEY INFORMANT QUESTIONNAIRE

An Evaluation of Regulatory and Administrative Framework for enhancing adoption of IBTs for Housing in Kenya

I am a student at the Department of Construction Management at Jomo Kenyatta University of Agriculture and Technology conducting a research thesis as part of my postgraduate program leading to the award of a Master's degree in Construction Project Management.

Pursuant to my research thesis, I am collecting data from policymakers, implementers, researchers, and entrepreneurs to evaluate the influence of Policy, Legal and Institutional frameworks on the adoption of Innovative Building Technologies in Kenya.

This is to kindly request your voluntary participation in this research by answering a few questions relating to the subject matter. The information provided will be treated with strict confidentiality and will be used for academic purposes only.

SECTION A: GENERAL INFORMATION

1. Category of Institution of the respondent (Tick as appropriate).

    1. Public [ ] 2. Private [ ]

2. Specify the county of residence……. ……

3. Please specify the Innovative Building Technologies your organization is involved in (***you can select more than one. Tick as appropriate).***

a) Interlocking Stabilized Soil Blocks (ISSBs) [ ]
b) Stabilized Soil Blocks (SSBs) [ ]
c) Insulted Polystyrene Panels [ ]

d) Expanded Polystyrene Panels [ ]
e) Interlocking Concrete Blocks [ ]
f) Free Span Clay Bricks [ ]
g) Concrete Waffles [ ]
h) Precast Concrete Panels [ ]
i) Compressed Agricultural Fiber (CAF) [ ]
j) Monolithic Construction [ ]
k) Pre-fabricated Housing [ ]
l) Recycled Waste Plastic Products [ ]
m) Bio-Digester On-Site Sewer System [ ]
n) Light Gauge Steel for eco-frames [ ]
o) Others (specify)…….

4. Please tick the nature of your involvement in the selected technology (ies) in no. 3 above.

1. Regulation [ ] 2. Production [ ] 3. Promotion [ ] 4. Design [ ]

5. Distribution [ ] 6. Not aware [ ] 7. Other (specify…….)

5. State the period you have dealt in with the technology. (*Tick as appropriate)*

1. Less than 1 year [ ] 2. Between 1-5yrs [ ] 3. Between 5-10 yrs [ ]

4. Over 10 years [ ]

SECTION B:

This section seeks to establish the extent to which the existing policies, regulations, and institutions relate to the adoption of IBTs in Kenya.

6. Are you aware of provisions that bear on Building Technologies in the following policy and regulatory documents? (*Please tick as appropriate*)

S/No.	**Regulation/Policy**	**Aware**	**Not Aware**
1.	The Building Code of 1968		
2.	The Constitution of Kenya (2010)		
3.	Kenya Vision 2030		
4.	National Construction Authority Act		
5.	The Public Health Act		
6.	The Physical Planning Act		
7.	National Housing Policy (2004)		
8.	Urban Areas and Cities Act (2011)		
9.	Science and Technology Act		
10.	Standards Act		
11.	The Public Procurement and Disposal Act		
12.	National Environmental Management Act		

7. If you are aware of provisions that bear on Building Technologies in the above documents, please highlight any influence of the provisions on the development or application of Innovative Building Technologies.

_____

_____

_____

Question 8 relates to respondents' perception of how the application of provisions identified in related literature on regulatory documents has in the past affected the adoption of IBTs in Kenya.

8. Indicate your level of agreement with the statement that '*the provisions in Laws below have impeded adoption IBTs in Kenya'* on the Likert Scale provided below of 1-5 where 5 strongly agrees and 1 strongly disagrees.

Building Code

S/No.	**Provisions**	**Strongly Agree (5)**	**Agree(4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
a.	Reliance on British standards as a benchmark for building code					
b.	Prohibition on the use of recycled building materials					
c.	Prescription on minimum Wall thickness					

d.	Prescription of material based on composition					
e.	Lack of IBTs building codes and regulations					

Administrative Barriers to Adoption of IBTs

Question 9 relates to respondents' perception of the magnitude of various administrative barriers to the adoption of IBTs in Kenya.

9. Indicate your level of agreement with the statement that '*the factors below adversely influence the development and adoption of IBTs in Kenya'* on the Likert Scale provided below of 1-5 where 5 strongly agrees and 1 strongly disagrees.

Government Support		**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
A	Lack of government incentives					
B	Inadequate IBTs promotion by the government					
C	Lack of IBTs building codes and regulations					

Social Cultural and Economic Factors						
D.	Lack of interest from clients and market demand					
E.	Unavailability of IBTs in the local market					
F.	Resistance to change from the use of traditional technologies					
G.	Unavailability of IBTs suppliers					
H.	Higher costs of IBTs					
I.	Lack of financing schemes (e.g., bank loans)					
J.	Lack of databases and information on IBTs					
K.	Adoption of IBTs is time-consuming and causes project delays					
L.	Risks and uncertainties involved in adopting new technologies					

Professional and Academic Support						
M.	The unfamiliarity of construction professionals with IBTs					
N.	Limited professional knowledge and expertise in IBTs					
O.	Lack of Innovative building technological training for project staff					
P.	Lack of information on maintenance and life cycle costing					
Q.	Lack of a variety of benchmarking projects					
R.	Lack of demonstration projects					
S.	Lack of local institutes and facilities for research and development (R&D) of IBTs					

10. Please expound on impediments occasioned by existing laws and administrative barriers on IBTs development and adoption

_____

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_____

Question 11 relates to respondents' perception of the extent to which various laws and Policy Provisions have stimulated the development and adoption of IBTs in Kenya.

11. Indicate your level of agreement with the statement that '*the provisions in Laws Stimulates*

adoption of IBTs in Kenya' on the Likert Scale provided below of 1-5 where 5 strongly agrees and 1 strongly disagrees.

The Kenya Constitution

	Article 43 (Right to Housing)					

The Kenya Vision 2030

1.	Establishment of ABT centers in constituencies					

The Housing Policy for Kenya

A.	Encourage research and popularize the use of appropriate building materials					
B.	Increased funding for research on building materials and technologies					
C.	Regular review of building materials taxes					
D.	Establishment of a National Research Coordination Secretariat					
E.	Require all research actors to harness and document existing locally available building materials and technologies as well as disseminate this information to the users as appropriate					
F.	Promote and encourage small-scale enterprises to engage in the production and application of researched materials					
G.	Promote the production of innovative building designs and traditional architecture that is cost-effective and compatible with the use of locally available and affordable materials					
H.	Promote wider adoption and application of the revised Building By-Law and Planning Regulations					
I.	Encourage the public, private and voluntary sectors to utilize the research materials in their housing and other development programs					
J.	Promote intensified training in requisite skills and construction technologies					

The Public Procurement and Disposal Act (PPDA)

	A requirement in the Act that "technical requirements in specifications shall not refer to a particular trademark, name, patent, design, type, producer"					

12. Provide any weaknesses inherent in the policies and regulatory framework toward the development and adoption of IBTs in Kenya.

……

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……

……

……

13. Please suggest possible areas of improvement to make the policies/ laws supportive to IBTs development and adoption

_____

_____

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_____

Question 14 relates to respondents' perception of the effectiveness of interventions by various institutions in influencing the development and adoption of IBTs in Kenya.

14. Indicate your level of agreement with the statement that '*the Institutions listed in no. 9 above are effective in influencing the adoption of IBTs in Kenya'* on the Likert Scale provided below of 1-5 where 5 strongly agrees and 1 strongly disagrees.

Institution		**Intervention**	**Strongly Agree (5)**	**Agree (4)**	**Neutral (3)**	**Disagree (2)**	**Strongly Disagree (1)**
State Department for Housing and Urban Development	A.	The lending of Hydra-form Machines for brick production					
	B.	Training in Technology Development					
	C.	Establishment of Appropriate Building Material (IBTs) Centers					
	D.	Housing Policy Management					
	E.	Research Services and dissemination					

Kenya Building Research Centre	F.	Research on building materials and systems					
	G.	Dissemination of information relating to the building Construction industry					
National Housing Corporation	H.	Production and sale of Expanded Polystyrene Panels					
National Construction Authority (NCA)	I.	Encouraging the standardization and improvement of construction techniques and materials					
	J.	Research on building materials and technologies					
Kenya Bureau of Standards (KEBS)	K.	Enactment of guide standards on the application of materials and technologies in 'Special Scheduled Areas'					
	L.	Issue of a Kenya Standards Number: KS 02-1070 on Specifications for Stabilized Soil Blocks					
County Governments	M.	Enactment County laws					
	N.	Enforcement of regulations pertaining to building technologies					
Academic Institutions	O.	Research on Building Technologies					
	P.	Development of Building Technology Innovations					
	Q.	Dissemination of Building Technology research findings/innovations					
	R.	Production/marketing of appropriate construction materials/technologies					
KIRDI	S.	Research and Development in Building Materials					
	T.	Transfer of Developed Technologies					
UN-Habitat and Other NGOs	U.	Assisting member Governments in formulating and adopting implementable policies and strategies for sustained growth of the building materials sector					
	V.	Creating increased awareness and knowledge among professionals and decision-makers on available, innovative, and cost-effective technological options					
	W.	Stimulating and arranging inter-country, regional and interregional cooperation for facilitating the transfer and absorption of appropriate technologies					

	X.	Direct technical assistance to developing countries through operational activities;					
	Y.	Promoting or modifying building codes, regulations, standards, and specifications to make them adaptable to local conditions					
	Z.	Research and dissemination of Research findings					
	AA.	Training, promotion, and dissemination of alternative building technologies already developed					
	BB.	Technical support and building materials					

15. Please identify some of the weaknesses exhibited by the above institutions that derail the effective development and adoption of IBTs in Kenya.

_____

_____

_____

_____

16. Suggest ways to address the weaknesses in the following areas:

a) Policy

_____

_____

_____

_____

_____Regulations

_____

_____

_____

_____

_____

b) Institutions

_____

_____

_____

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_____

Question 17 addresses strategies to promote IBTs in Kenya.

17. Please give suggestions on ways that can be used to up-scale the adoption of IBTs in Kenya.

_____

_____

_____

_____

----------Thank You! ----------

Appendix III: Interview Schedule /Guide

An Evaluation of Regulatory and Administrative Framework for enhancing adoption of IBTs for Housing in Kenya

1. Professional Background of the respondent
2. Experience with innovative construction technologies
3. Policies and laws that are most likely to affect the adoption of innovative building technology
    - Adversarial influence
    - Supportive influence
4. Views on the role of Policies in the Adoption of Innovative Building Technology
5. Role of Institutions in Adoption of Innovative Building Technology
6. What areas of improvement can be made to support IBTs development and adoption in;
    b. Policies
    c. Laws
    d. Institutions

7 What setup would best be used to enhance the adoption of innovative building technologies?

Appendix IV: Research Permit

THIS IS TO CERTIFY THAT:
MR.EDWIN KATHURIMA KABURU
of JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, 0-20115 Egerton,has been permitted to conduct research in *All Counties*

on the topic: *DEVELOPING A FRAMEWORK FOR ENHANCING ADOPTION OF INNOVATIVE BUILDING TECHNOLOGIES IN KENYA*

for the period ending:
6th December,2018

.....
Applicant's Signature

Permit No : NACOSTI/P/17/53917/20341
Date Of Issue : 7th December,2017
Fee Recieved :Ksh 1000

.....
Director General
National Commission for Science, Technology & Innovation